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WATER QUALITY IN THE AMUDARYA AND SYRDARYA RIVER BASINS

Analytical Report

Scientific-Information Center
Interstate Commission for Water Coordination
in Central Asia
(SIC ICWC)

United Nations Economic Commission for Europe (UNECE)

Central Asian Regional Environmental Center (CAREC)

WATER QUALITY IN THE AMUDARYA AND SYRDARYA RIVER BASINS

Analytical Report

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CONTENTS

Introduction

Central Asia is one of the ancient regions from where irrigated farming originates. Irrigated farming was practiced in the Aral Sea basin as far back as four thousand years before Christ. The local population had used the spring areas, deltas and floodplains of small and medium rivers and mountainous small rivers for their farming since these territories did not need complex structures and long large canals for diversion of water. The total irrigated area has been more than 3 Mha by the early 20th century.

Development of land in the Aral Sea basin initiated by the Tsarist Russian Empire in the late 19th century has gained in scope since establishment of soviet power in Central Asia. Before 1913, the total irrigated area has been 3250 thousand ha, whereas it amounted to 4.3 Mha in 1940 and 5 Mha in 1960. This area was comprised of both fallow land in old irrigated areas of oases and new irrigated desert areas, such as the Golodnaya and Dalverzin Steppes, the Ferghana, Vakhsh, and Chu Valleys, as well as the South Kazakhstan and Turkmenistan. Moreover, irrigation was developed in large geomorphologic and hydrogeological formations characterized by complex and very complex natural-climatic conditions: river valleys, intermountain troughs, lower and upper river terraces, talus trains, and deltas of large rivers. Irrigation of such lands required that big and complex challenges related to water-resources development and land reclamation be addressed, such as regulation of river flow by reservoirs and intake structures; construction of high-capacity and long main inter-farm canals, drainage systems and their structures.

Intensive development of irrigated farming and land drainage in Central Asia along with growing water use for industrial and household needs resulted in increased abstraction of fresh water and discharges of polluted return flow into water bodies. The main pollution sources are agrochemicals that are washed out into drainage systems and mixed with river water. The second-ranking source in terms of impact on the quality of water resources is the effluent from municipal and industrial sewers. An increased contamination of groundwater due to substandard management of municipal and industrial waste sites, especially in the mining industry is noted also.

River quality statistics for the past 40 years confirm trends of an increased salinity, both over time and along the length of the rivers affected. The possibility of using water for irrigation depends not only on the salinity but also on the chemical content. Thus, a consistent trend has developed for changes in the ionic composition of salts in the water toward a dangerous increase in alkalinity. Until now, due to a high content of gypsum in soils and $CaSO4$ in water, the alkalinity (SAR) has remained below the maximum allowable level, yet soil reserves of gypsum are expected to diminish, leading to leaching and increasing concentrations of sodium carbonate.

The increasing salinity of water in rivers and the intensity of drainage from irrigated land substantially affect the dynamics of salinization and increase the need for reclamation of irrigated areas.

The above-mentioned indicates to the significance of water quality control.

Given report summarizes information on water quality in the Amudarya and Syrdarya basins, which is available on the Internet, and serves as a certain indicator of accessibility and completeness of such information. While drawing up this report, we were not aiming at verifying whether used quantitative indicators were adequate or not. Therefore, these indicators are presented in initial form as in their sources.

Information on water quality data that are available on the portal of knowledge on water resources and environment in Central Asia - CAWater-Info - is given as well.

The authors express hope that dissemination of given report would contribute to improved system aiming to ensure good water quality and strengthened cooperation in this field in Central Asia.

Problems of water resource quality[1]

Intensive development of irrigation and land drainage in the Aral Sea basin had two major consequences that affected the river water – an increased abstraction of fresh water and discharges of polluted return flow, with toxic salts being the main pollutants. As a result, the river water quality has deteriorated due to discharges of saline and polluted drainage water and agrochemicals that were washed out into drainage systems and mixed with river water. Besides this non-point agricultural pollution by toxic salts and agrochemicals, there are point pollution sources of industrial and municipal sewage, especially from metropolitan area.

The water resource quality in the Aral Sea basin is affected by intensive abstractions from water sources, on the one hand, and by discharges into water bodies and waterways of under-purified sewage water from plants, municipal sector, etc. or untreated waste water from agriculture.

The Amudarya is the largest river in the basin. During the relatively natural regime of river's existence, its water fell under the hydrocarbonate category, with salinity of 0.3-0.5 g/dm^3. With growing anthropogenic load and increasing diversions from the river and discharges of untreated drainage water, the water quality in the river has deteriorated. This process was more intensive in the mid 70s and the early 80s. Increased river water content in the early 90s made the process slower and even led

[1] Source: (1) Central Asia Environmental Review / Tajik Youth EcoCenter - www.tabiat.narod.ru (2) The Uzbek National Coordination Center, Clearing House Mechanism of the Convention on Biodiversity - www.cbd.uz (3) Knowledge Base «Water and Land Resources Use in the Aral Sea Basin» - www.cawater-info.net/bk/water_land_resources_use/

to downward trends in terms of salinity and pollution of both river and drainage waters. The key main collector-drains in the middle reaches were constructed in the 60s-70s. At the initial stage of the development of saline land, the salinity of drainage water was 6-10 g/dm^3. Because of leaching irrigation, the salinity decreased and currently is stabilized within 3-6 g/dm^3. Water quality in the flow formation zone of the Amudarya practically does not change, showing only small fluctuations due to variation of flow probability. As a result of discharge of drainage water into the Amudarya, the water salinity varies within 0.4-1.7 g/dm^3 in the middle and lower reaches; whereas, the mean annual salinity is 0.8-1.1 g/dm^3. In dry years, salinity may reach up to 2 g/dm^3 in the estuary, with dominating recharge from groundwater.

The chemical composition of water in the main river of the Amudarya basin is determined by agricultural wastewater flowing into the river from the Turkmen and Uzbek territories.

In terms of the Water Pollution Index (WPI), the Amudarya water quality in the Termez control section remains unchanged under the II class (clean water) at the level of the year 2000, while water quality in other sections is of the III class (moderately polluted water) and II class as it was in 2001-2002.

Part of flow in the Surkhandarya river is generated in Tajikistan. The chemical composition of the river water is formed by effluents from industrial and municipal sectors of Denou and Termez cities, Shirtchi urban village and by agricultural runoff. As to WPI, water quality in this river from its head to the mouth varies from the II class (clean water) to the III class (moderately polluted water). This corresponds to water quality of the year 1996.

The Zaravshan river is most subjected to a transboundary impact. Mining and processing works are located in the river flow formation zone in Tajikistan and pollute the river water by toxic metals, antimony, and mercury. Antimony is found in groundwater (Pervomayskaya dam site) - 0.001-0.11 mg/l - and in Chupanata and other intakes - 0.001-0.008 mg/l (MAC – 0.05 mg/l).

Antimony content diminishes downstream the river. Monitoring of specific components, such as antimony, mercury, cadmium, strontium, etc. has been conducted since 2002. As a result of implemented environmental measures and strengthened control over wastewater discharges, water quality was improved, and, in terms of the water pollution index, water in the sites bordering with Tajikistan and along the river channel (except for a section after the city of Samarkand) falls under the II class in 2004.

The Syrdarya river basin comprises many rivers, the main of which are the Syrdarya, Naryn, Karadarya, Chirchik, and Akhangaran.

In the flow transit zone, salinity in the Syrdarya river increases over time and in terms of the length of the river. The mean annual salinity of the Syrdarya in the section of Kal’ village virtually doubles as compared to that of the Naryn river. Further, toward Nadejda village, salinity increases additionally by 20%. Further downstream, salinity grows slower because of intrusion of less saline water from the Chirchik river basin.

Water in the lower reaches of Syrdarya is treated now as moderately polluted one for most of the year.

The last years' hydrological and hydrochemical situation keeps changing. The shift in operation of a number of reservoirs to energy-generation regime has led to changes in hydrological conditions in the middle reaches of Syrdarya. The period of operation of reservoirs when they are full was extended, and winter water releases from the reservoirs were increased.

The maximum flow rates in the middle reaches of Syrdarya started to occur in winter and spring instead of the growing season that was typical for natural conditions of the river. In the last years, maximum flow rates in winter well exceeded the summer ones and were comparable only in humid years.

Earlier filling of reservoirs and higher inflow in winter months, as well as insufficient capacity of the Syrdarya channel in its lower reaches have resulted in recommencement of regular discharges into Arnasay.

The changes in hydrological regime and water quality worsened the spawning conditions, reduced and depleted the fish species composition. The Syrdarya's water even changed from moderately polluted category into polluted one in the inflow points of collector drains.

The Chirchik river is the largest right-bank tributary in the middle reaches of Syrdarya. The river flows through the Uzbek territory downstream the Charvak reservoir. The river water is used for irrigation, industrial and urban water supply of Chirchik-Angren irrigation district (CHAKIR). Big cities (Tashkent, Chirchik, Angren) and mining, processing, and chemical plants are located in this district. As a result of overregulation of the river's regime, the minimum flow rates in the middle and lower reaches occur in summer. The decreased flowage and water exchange during this period of time lead to intensive heating and primary production. After die-off of producers, the organic matters decay, thus causing secondary pollution. Water is considered as polluted one during this period of time. The development of water hyacinth and duckweed populations, i.e. typical dwellers in polluted and eutrophic waters, in the lower reaches of the Chirchik is an indication of those processes. Significant difference in water levels in the river was the cause of suppressed riverside hydrophilous vegetation. Fish resources in water bodies have depleted as well.

The Karadarya river, one of the Syrdarya's tributaries, has been bringing water of the III class quality (moderately polluted) to Uzbekistan's area in the last 3 years. The effluents discharged from such Uzbek cities as Andizhan, Asaka, and Khanabad, as well as the discharges of drainage water do not make the river water worse.

Small watercourses in the Fergana Valley have water quality of II class (clean water) within Uzbekistan and are used for irrigation.

As to WPI, the water quality in all sections along the Syrdarya river refers to the III class. In 2001, in the section upstream of Bekabad city, water quality deteriorated and changed from the II class of clean water to the III class of moderately polluted one.

There is a risk of river pollution by toxic radioactive wastes through the Maily-Suu river, where uranium tailing pits and dumps are located in the territory bordering Kyrgyzstan.

Water quality of the Syrdarya river within the boundaries of Kazakhstan is formed by pollutants coming into the river from the Uzbek territory. Within the site of Kokbulak village (boundary section), water contains nitrites and phenols, the mean annual values of which reach 4 MAC, iron and oil products up to 1 MAC. The nitrite content is higher than the norm in most analyzed samples; however, typically, high pollution levels in terms of this parameter are not observed. Instead, significant pollution by pesticides is recorded during the growing season.

Downstream of Chardara reservoir, the pesticide content in water lowers significantly, while concentration of other pollutants is the same as in the upstream sections.

The level of pollution by pesticides increases in the lower reaches and is highest in the area of current delta (Kazalinsk). Besides, higher concentrations of oil products, nitrite nitrogen and organic matters are recorded regularly in this river reach.

According to water pollution index and saprobity, the Syrdarya river falls under the category of moderately polluted water bodies (III class water quality) along its whole length.

As to the upper reaches of the Keles river, the basic water quality indicators are within the norm, except for nitrite nitrogen. Further to the river mouth, the water quality is significantly deteriorated - the contents of organic matters, phenols, and oil products regularly exceed the MAC.

Since the Arys river is located in the area of irrigated farming and intensive animal breeding, its water quality is formed by surface runoff. Some samples show excess over MAC for concentrations of organic matters, phenols, and oil products.

For the Badam river, slightly higher concentrations (against MAC) of organic matters and nitrites are observed in the baseline section of Mikhaylovka village.

In the area of Chimkent city, the mean annual concentrations of copper and nitrites reach 4 MAC; sometimes zinc and nitrite contents are above the norm.

The mean annual concentrations of nitrite, phosphate, and total phosphorus are observed in the river mouth (the section of Obrutchevka village).

The water quality refers to the III class of moderately polluted water.

Up to 20 billion m^3 of collector-drainage water (CDW) is formed annually in the region. Moreover, 50% of this flow is discharged mainly into a desert depression. Such discharges of CDW damage the environment, since, besides higher salt concentrations, this water contains pesticides, defoliants, chemical fertilizers, and heavy metals. Most of drainage water returns back to rivers and irrigation sources, thus deteriorating the quality of river and irrigation waters. For example, water resources in the Amudarya river, mainly in the lower reaches, contain much salt (1.5-2.7 MAC), hazardous heavy metals, such as manganese (1.3-2.0 MAC), iron (1.5-3.3 MAC), lead (5-10 MAC), cadmium (6-8 MAC), harmful organics: synthetic surfactants (4-8 MAC), oil products (36-46 MAC), phenol (400-1000 MAC) and other toxic matters that cause serious damage to human.

Table 1

Water salinity in Central Asian rivers

River	Mean annual salinity, mg/l	
	Upper reaches	Tail
Amudarya	700 (Termez city)	1200
Surkhandarya	385	900
Kashkadarya	270	1600
Zaravshan	255	1500
Garagumdarya	700	900
Syrdarya	650	1400
Naryn	250	500
Karadarya	345	520
Akhangaran	140	660

[1] Sources: (1) Central Asia Environmental Review / Tajik Youth EcoCenter - www.tabiat.narod.ru, processed by SIC ICWC

Problems of Water Resource Quality in the Amudarya River Basin[2]

An anthropogenic load was well heightened in the Amudarya basin over the last 25 years. The large-scale development of urban areas, industry, agriculture and the insufficient investing in the environment have led to the increased pollution of natural water resources throughout the basin. Light, food, textile, coal, iron, nonferrous, chemical and other industries are focused there. Industrial and municipal effluents, the parameters of which exceed the quality targets to a factor of ten, are finally discharged into surface and ground water bodies.

The analysis of data on water use and disposal of industrial and municipal enterprises in the basin over 1988-1990 shows that the industry uses from 3.2 to 3.8

[2] Sources: (1) Central Asia Environmental Review / Tajik Youth EcoCenter - www.tabiat.narod.ru (2) Report "Developing the scientific and technological basis for the improvement of integrated irrigation-energy regulation of water resources and hydraulic systems in the Syrdarya and Amudarya (under conditions of water shortage and increased highly saline return water), as well as the mathematical models, algorithms, and programs for optimal management of water resources and control of existing river and in-channel reservoirs for seasonal and long-period regulation in the Central Asian river basin "

km^3 on average, while it discharges 70-80% of used water, of which about 10-15% of untreated wastewater is discharged into water bodies.

The municipal sector uses about 1.0 km^3 of water and discharges about 50% of used water, of which up to 30% is the untreated sewage. The agricultural water use varies from 0.5 to 0.6 km^3, while wastewater discharge from the agriculture is about 45-50%, of which 50-60% is untreated one.

The main pollutants in the wastewater are organic matters (BOD, COD), oil products, nitrogen compounds, synthetic surfactants, salinity, sulphates, chlorides, heavy metals, and phenols.

Another sizable source of water pollution in the Amudarya basin is the collector-drainage water discharged both into tributaries and the Amudarya river itself. The volume of the discharged water is ten times higher than that of industrial and municipal sectors. Thus, currently the total water withdrawal from the Amudarya river is 61 km^3, of which about 41 km^3 are used for irrigation. Besides, 15-18% of this withdrawn water is returned back into the river, i.e. 9-11 km^3/year.

The Vakhsh oasis (Tajikistan) is the upper irrigation project in the Amudarya basin. Here, the mean annual salinity of CDW varies from 1.0 to 2.0 g/dm^3; though in some periods of time, the sum of ions in water flowing in a number of collector drains with a rate of 1-2.6 m^3/s amounts to 5 g/dm^3 (Yavan district). There are about 20 collector drains in total in this project.

The lands in the Pyandj river basin are less saline than in the Vakhsh river basin. Therefore, generally, CDW salinity is not high - 0.5-1.0 g/dm^3. Only in the Vosa district CDW salinity was 2.0 g/dm^3 in certain periods of time. In total, there are 20 large collector drains, the discharge of which is 2.0 m^3/s.

Irrigated areas in the Kafirnigan river basin are also low saline as in the Pyandj river basin. There are also 20 collector drains and spillways that divert CDW to the river. The mean annual salinity of CDW is 0.35 to 0.70 g/dm^3. Water salinity reaches 0.7-0.9 g/dm^3 in some of the collector drains.

In terms of salinization, the irrigated areas in Sherabad and Surkhandarya basins are varied. This impacts the salinity of CDW.

Thus, the CDW salinity is the lowest and varies from 0.2 to 0.7 g/dm^3 in submountain zones, then ranges within 0.7-2.3 g/dm^3 in the middles reaches of the rivers, and is from 2.3 to 8.7 g/dm^3 in the lower reaches, amounting to 10 g/dm^3 in some months. Currently, the basin comprises more than 70 collector drains, including 30 ones directly flowing into the Surkhandarya river.

Chardjow, Tashauz, and Khorezm oases are located further downstream of the Amudarya river. Collector drains located in the first two oases have water salinity varying from 1.3 to 3.5 g/dm^3, while their discharge is from 1.3 to 45 m^3/s.

The middle reaches of the Amudarya river accommodate the Karshi Steppe, the irrigated area of which is about 315 thousand ha. CDW are collected in the South main collector drain, its branches and first-order collector drains. The mean monthly salinity of CDW varies from 4.3 to 12 g/dm^3 and amounts to 18 g/dm^3 in some months.

Irrigated lands in the Khorezm province are mainly highly and medium salinized. Existing collector drains flow towards the Sarykamysh depression (Ozerniy and Daryalyk collector drains). The mean annual salinity in inter-farm collector drains ranges from 2.9 to 18 g/dm^3, while in inter-republican ones it ranges from 2.3 to 8.0 g/dm^3.

Irrigated lands in the Zaravshan river basin are non-salinized mainly, and CDW salinity is not higher than 1.9 g/dm^3 in the most collector drains and amounts to 3.1 g/dm^3 only in Pakhtachi district.

The collector-drainage network is well developed in the Bukhara irrigation district. Collector drains and spillways discharge their water into natural depressions and Solyonoye Lake. Since 1973, after overfilling of the lake, CDW has been discharged into the Amudarya river via Parsankul spillway. CDW salinity is 2.5-4.5 g/dm^3 in most collector drains and reaches maximum of 14.5 g/dm^3 is some of the drains.

Up to 2.0 km^3 of CDW is formed in the lower reaches of the Amudarya river (Karakalpakstan). This water is discharged either into such recipients as Sudochie, Aychikul, and Khodjikul lakes, Aral Sea or into the Amudarya river directly. The mean annual salinity ranges from 2.8 to 5.7 g/dm^3 in the main collector drains and is 1.1-9.5 g/dm^3 in the collector drain K-12 (right bank).

Thus, CDW discharged into the Amudarya river cause considerable changes in the river's water-salt regime, especially in the middle and lower reaches.

The hydrochemical conditions of the river's tributaries forming water quality in the flow formation zone largely depend on hydrological regime. The upland reaches of such tributaries as the Vakhsh, Pyandj, and Kafirnigan rivers are located in this zone.

The general dynamics of river water salinity in this zone depends inversely on the flow rates of these rivers.

Among the above-mentioned tributaries the Kafirnigan river shows better water quality. Except for turbidity, all indicators do not exceed MAC values along the whole length of the river. As to turbidity, it is higher than the norm (MAC is 1.5 mg/dm^3 for drinking and household uses) in all water bodies in the Amudarya basin.

Water in the Pyandj river contains more dissolved salts than water in the Kafirnigan river. Moreover, the content of dissolved salts increases from the upper to the lower reaches. For example, water salinity ranges from 0.2 to 0.4 g/dm^3 in the upper reaches, while it varies within 0.3-0.8 g/dm^3 in the lower reaches (Lower Pyandj section). The maximum salinity is observed in September-April.

Water salinity is higher in the Vakhsh river as compared to the Pyandj river. Salinity ranges from 0.3 to 0.7 g/dm^3 in the upper reaches (Komsomolabad village) and from 0.5 to 1.1 g/dm^3 in the lower reaches (Tigrovaya balka).

The most polluted tributary of the Amudary is the Surkhandarya river. It is subjected to anthropogenic influence along the whole length, and this significantly affects on river's hydrochemical regime and water quality. Thus, water salinity is not higher than 0.5-0.7 g/dm^3 in the upstream section (Denou town), whereas it is 1.2-1.4 g/dm^3 downstream (Shurtchi town) and even exceeds MAC 1.5 times in the mouth area (Manguzar village).

Let us consider water quality dynamics in more details in the Amudarya basin (Fig. 1).

As Table 2 shows, flow salinity in terms of salt content under natural conditions (non-irrigation) varies within 0.3-0.35 g/l, but in the sixties, after discharge of salts of natural run-off and of return water formed in Tajikistan, the salinity averaged as much as 0.51 g/l in Termez section. By the seventies, water salinity in this section has increased to 0.6-0.65 g/l and, virtually, remains at this level, with some variations depending on flow probability.

The situation in the Kerki section changes drastically after diversion of water by Karakum canal and especiall Karshi canal; salinity increases against the Termez section to 0.65 and then, depending on intensity of runoff from Surkhandarya irrigation project and Turkmen right bank, and after significant diversion in 1981-1985, salinity in this section differed by 0.05 g/l from that in Termez section.

Runoffs from Karshi irrigation project and Bukhara oases, as well as from the Turkmen coast in area of Chardjow further change water quality in Il'chik and Darganata sections, where salinity exceeds MAC, and then salinity practically does not change to the Chatlov section. Since the surge of salinity in the dry year 1989, the mean annual salt content has been close to the norm in the downstream sections of Samanbay and Kyzyldjar as well.

The increase in river water salinity and likewise in intensity of drainage from irrigated lands affects salt regime and status of irrigated lands that is dependent on water-salt balance of both the river and irrigated areas. Table 3 shows this balance, from which it is evident that only about half of the more than 50 million tons of salt annually ending up in the river stem from a natural run-off, with the rest formed by run-off from the drained return flow. An analysis of the salt balance in rivers and irrigated lands makes it possible to pinpoint salt accumulation areas in terms of reclamation needs of irrigated lands whose productive capacity is either diminishing or remains at the lowest level of safety due to lack of draining or insufficient leaching regime. Such areas include (Table 3) the Turkmen coast, Tashauz, and Karakalpakstan.

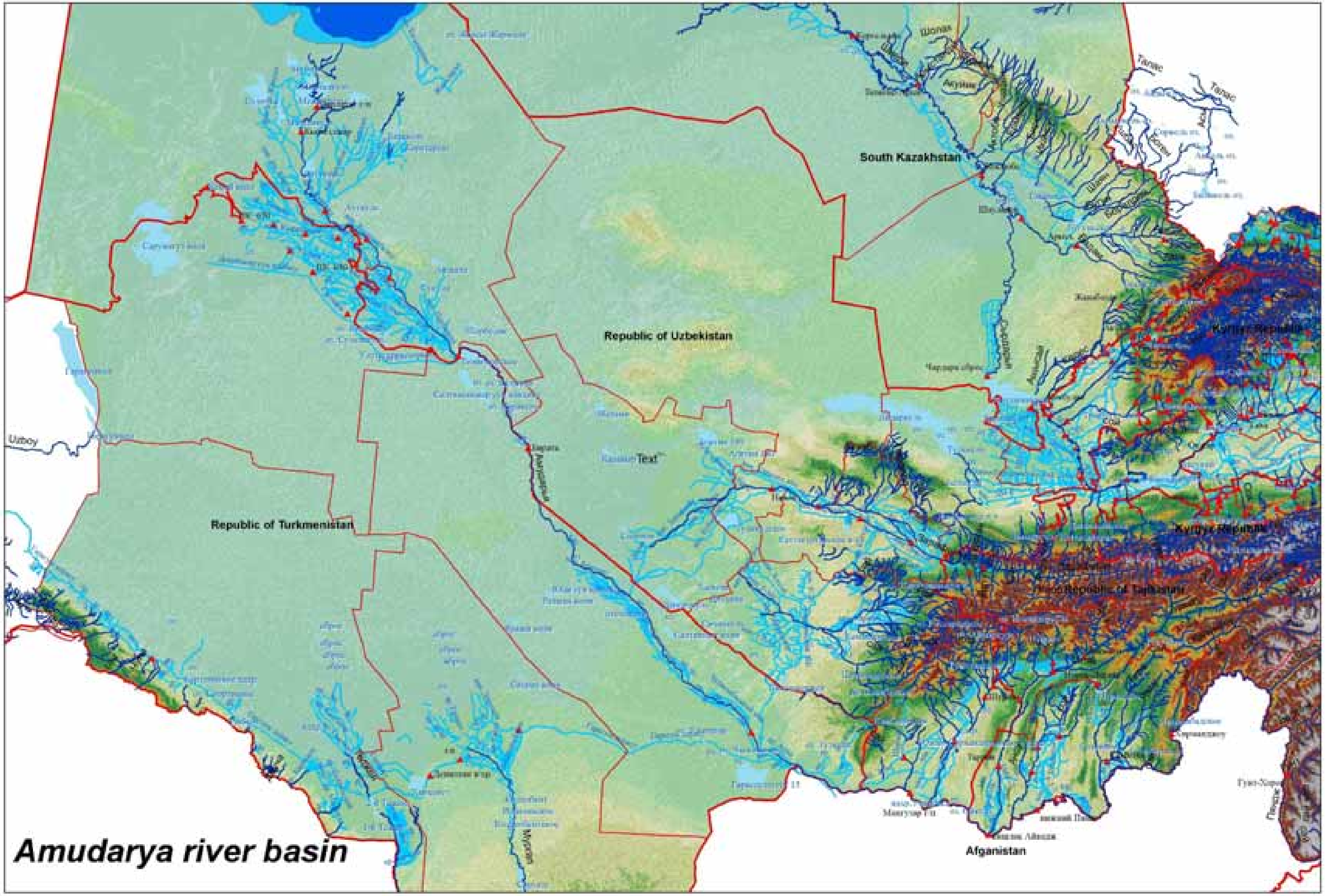


Fig. 1. Amudarya river basin
(source: CAREWIB IS)

Table 2.1

Dynamics of average annual salinity in the Amudarya river (g/l)

Period	Representative sections								
	Termez	Kerki	Il'chik*	Darganata	Tuyamuyun	Kipchak	Chatly*	Samanbay	Kyzyldjar
1960-1970	0.51-0.57	0.56	0.61-0.62	-	-	-	0.60-0.65	0.50-0.51	0.54-0.57
1971-1980	0.60-0.65	0.67-0.73	0.70-0.73	0.88	0.68-0.89	1.1	0.72-0.93	0.69-0.84	0.75-0.85
1981-1990	0.57-0.62	0.73-0.78	0.91	1.05-1.15	0.91-1.07	1.08-1.118	1.1-1.15	1.09-1.41	1.17-1.34
1991-1995	0.65	0.70	-	0.78	0.81	1.001	-	1.02	0.97

* Note: currently closed gauging stations (g/s)
** empty cells - no observations
Source: Knowledge Base «Water and Land Resources Use in the Aral Sea Basin»

Table 2.2

Dynamics of average annual salinity in the Amudarya river (g/l)

Year	g/s Kelif	g/s Kerki	g/s Chardjow	g/s Darganata	g/s Kipchak	g/s Takhiatash	g/s Samanbay
	Water salinity, average annual values						
1991	0.649	0.694	0.823	0.990	1.008	1.218	1.126
1992	0.451	0.494	0.671	0.703	1.083	1.156	1.095
1993	0.526	0.499	0.689	0.792	0.914	1.031	1.011
1994	0.440	0.467	0.643	0.681	0.978	1.058	1.066
1995	0.458	0.488	0.657	0.749	1.028	1.065	1.034
1996	0.490	0.491	0.601	0.701	0.941	0.956	0.949
1997	0.488	0.526	0.623	0.784	1.293	1.190	1.231
1998	0.445	0.460	0.630	0.655	1.324	1.376	1.288
1999	0.449	0.454	0.649	0.668	1.397	1.446	1.399
2000	0.453	0.492	0.630	0.850	1.509	1.562	1.460

Year	g/s Kelif	g/s Kerki	g/s Chardjow	g/s Darganata	g/s Kipchak	g/s Takhiatash	g/s Samanbay
	Water salinity, average annual values						
2001	0.488	0.511	0.659	0.850	1.572	1.521	1.662
2002	0.459	0.479	0.621	0.705	1.305	1.245	1.266
2003	0.490	0.507	0.639	0.690	1.203	1.162	1.275
2004	0.481	0.501	0.573	0.769	1.080	1.090	1.072
2005	0.469	0.517	0.649	0.724	0.815	0.879	0.783
2006	0.448	0.461	0.623	0.686	0.966	0.970	1.108
2007	0.449	0.456	0.598	0.660	1.009	1.109	1.059
2008	0.455	0.487	0.621	0.701	0.943		
2009	0.479	0.489	0.644	0.660	0.804		
2010	0.497	0.515	0.646	0.658	0.750		
Average long-term over 1991-2010	0.48	0.50	0.64	0.73	1.10	1.18	1.18
min	0.440	0.454	0.573	0.655	0.750	0.879	0.783
max	0.649	0.694	0.823	0.990	1.572	1.562	1.662

Source: data of BWO «Amudarya» processed by SIC ICWC

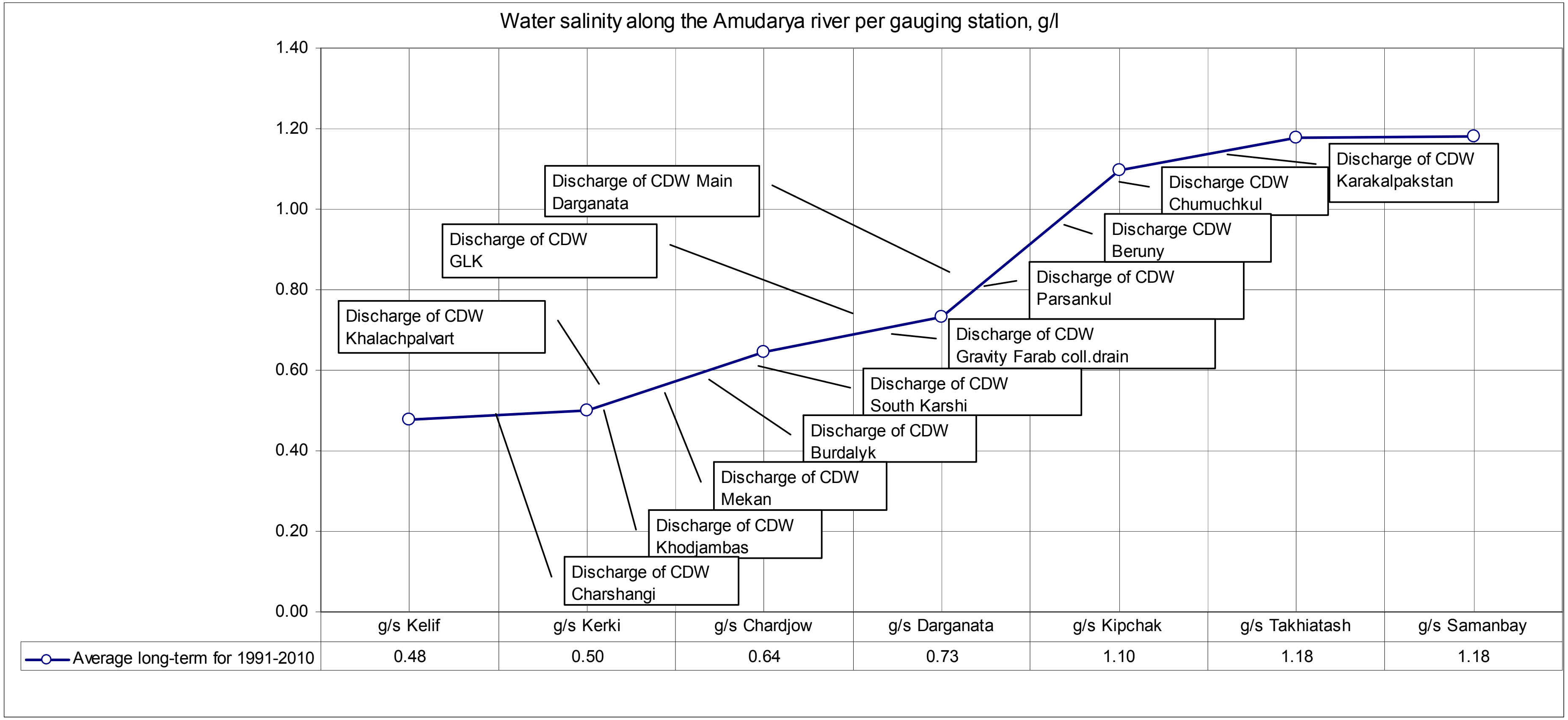


Fig. 2. Water salinity along the Amudarya river per gauging station

Table 3

Salt balance in the Amudarya basin (Mt)

Irrigation district	Country	Irrigated area, thousand ha	Salt influx to Amudarya stem stream				Salt outflux wth diversion from Amudarya	Salt mobilization in Amudarya stem stream	Salt mobilization in irrigated lands of irrigation districts		Salt influx from ground water per 1 ha (ton)	Salt accumula tion per 1 ha (ton)
			total	of which: with natural run-off	of which: with CDW	% of CDW salts out of total			total	per 1 ha		
Vakhsh Pyandj Kafirnigan	Tajikistan	467	29.4	24.4	5	17	-	29.4	-1.7	-3.64	1.2	-2.44
Surkhansherabat	Uzbekistan	310	8.4	5.78	2.62	31.2	1.61	6.79	-3.49	-11.3	5.2	-6.1
Kayrakum	Turkmenistan	620	-	-	-	-	6.78	-6.78	-14.2	-22.9	10.6	-12.3
Karshi	Uzbekistan	450.8	6.66	-	6.66	100	2.67	3.99	-3.99	-8.9	5.4	-3.5
Bukhara	Uzbekistan	254	3.92	-	3.92	100	3.57	0.35	3.16	-12.4	6	-6.4
Turkmen coast	Turkmenistan	300	7.92	-	7.92	100	3	4.92	-5.3	17.7	12.3	30
Khorezm	Uzbekistan	225	-	-	-	-	4.96	-4.96	-5.7	-25	20.1	-4.9
Tashauz	Turkmenistan	260	-	-	-	-	5.32	-5.32	0.5	1.9	8.6	10.5
Karakalpak	Uzbekistan	402	1.34	-	1.34	100	12.47	-11.13	4.55	11.3	12.1	23.4

Source: Central Asia Environmental Review / Tajik Youth EcoCenter

Let us analyze, where we have excess of salts in the river above the maximum allowable content (1 g/l). As is seen, the largest excess of salts of 10.5 Mt/year is observed in the Darganata section. The closest value (+9.3 Mt) was observed in 1987, while other values were well lower. Thus, if we reduced the salt load by 10-11 Mt a year in the river, we would achieve good quality of water along the whole length of the river. Evidently, the most adequate approach in this context, along with the planned project of Right-bank collector and disposal of collector-drainage water outside the river, would be to set restrictions (limits) on discharge of total quantity of pollutants, an excess of which would be advisable to spread proportionally to amount of salt influx with CDW into the river (Table 4).

Table 4

Setting of limits of salt discharge with collector-drainage water into the river

Irrigation district	**Country**	**Salt discharge with drainage flow**	**% of the total discharge**	**Necessary reduction of discharge against allowable concentration**	**% of reduction**
		Mt	**%**	**Mt**	**%**
Vakhsh Pyandj Kafirnigan	Tajikistan	5.0	18	1.9	6.5
Surkhandarya	Uzbekistan	2.62	9.5	1.0	11.9
Kayrakum	Turkmenistan	0	0	0	0
Karshi	Uzbekistan	6.66	24.2	2.54	38.2
Bukhara	Uzbekistan	3.92	14.27	1.49	38.2
Turkmen coast	Turkmenistan	7.92	29.28	3.08	38.2
Khorezm	Uzbekistan	0	0	0	0
Dashkhovuz	Turkmenistan	0	0	0	0
Karakalpak	Uzbekistan	1.34	4.88	0.5	38.2
Total		27.46	100	10.5	

Source: Central Asia Environmental Review / Tajik Youth EcoCenter

The change in water diversion regimes and the reduction of salt discharges with water should be made consistently so that before optimization of land-reclamation regime and lessening of salt influx from groundwater to the aeration zone, the salt discharge could be reduced only through modification of discharges from the Amudarya into other salt recipients but in no way through further decrease of the leaching norm.

Similarly, limits on other pollutants can be set by reducing certain types of industrial effluents through the analysis of cumulative amount of pollution against the allowable quantity along the river as a whole in all control sections.

Figure 3 and Table 5 show dynamics of annual salt flux along the Amudarya river for different flow probabilities.

Tables 6-7 and Figures 4a-c, 5a-c show changes affecting the middle and lower reaches of the Amudarya river.

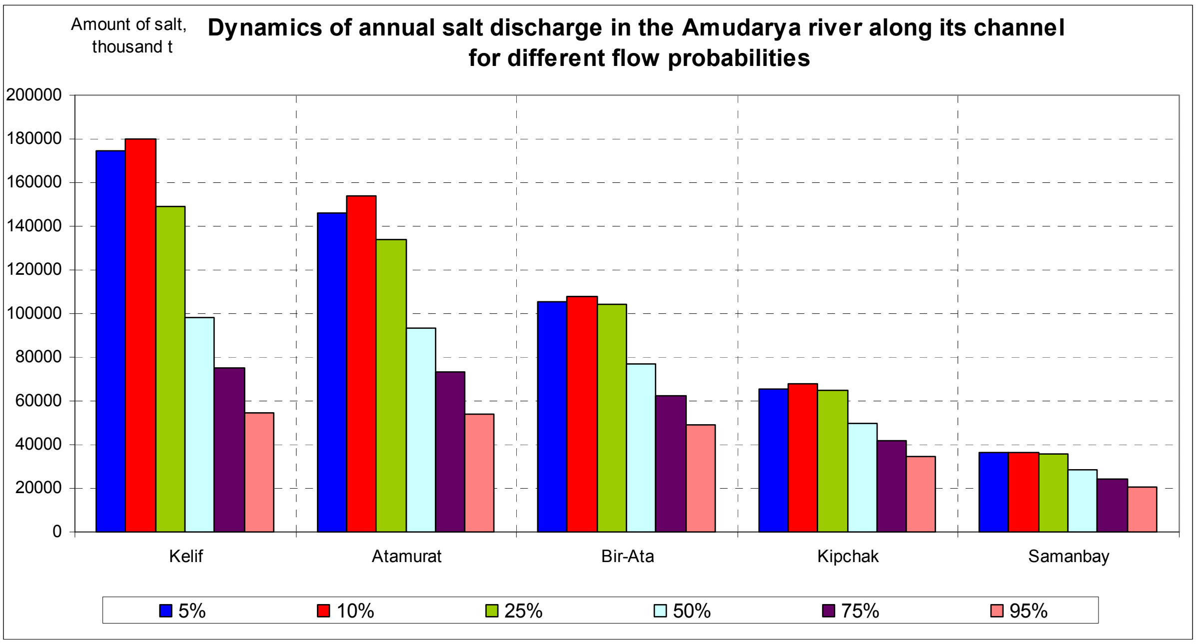


Fig. 3

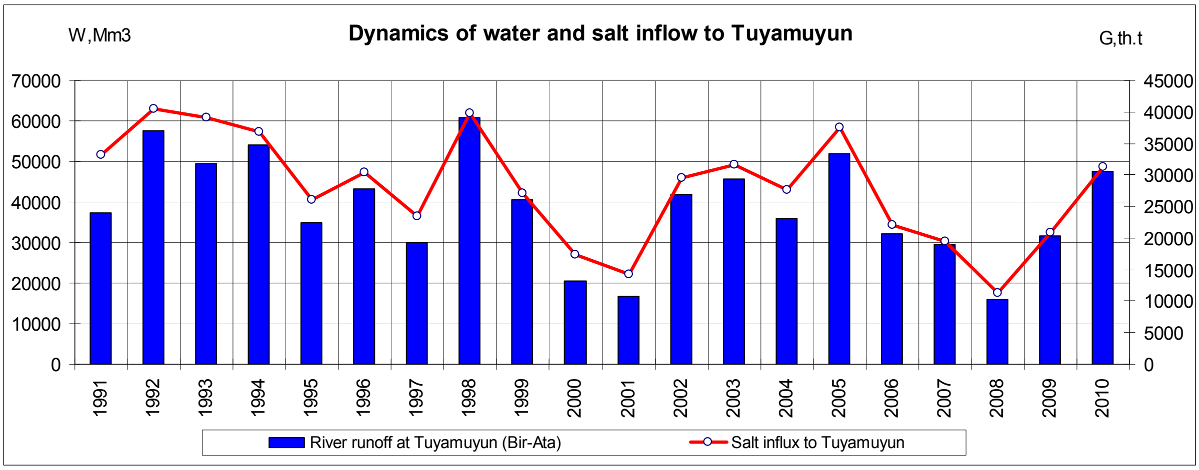


Fig. 4a

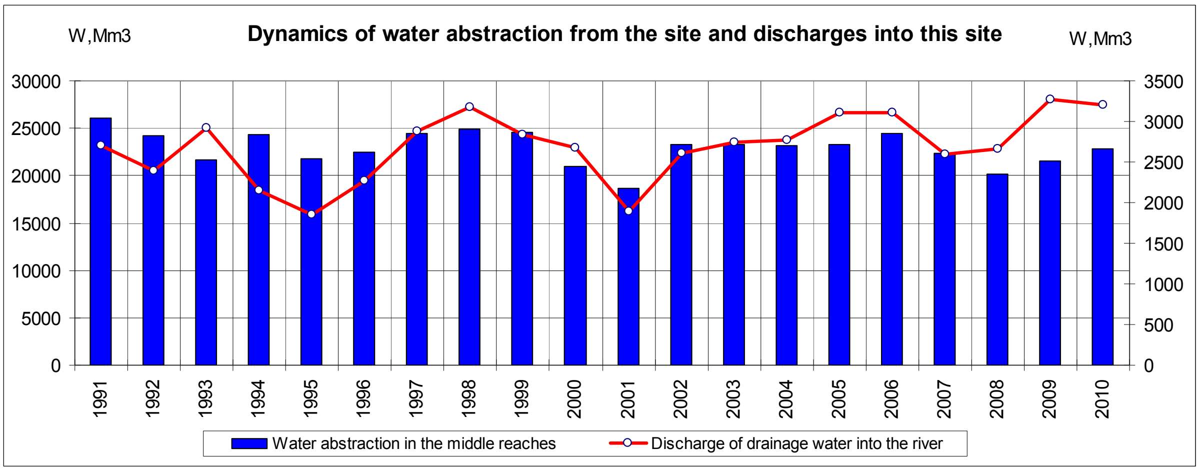


Fig. 4b

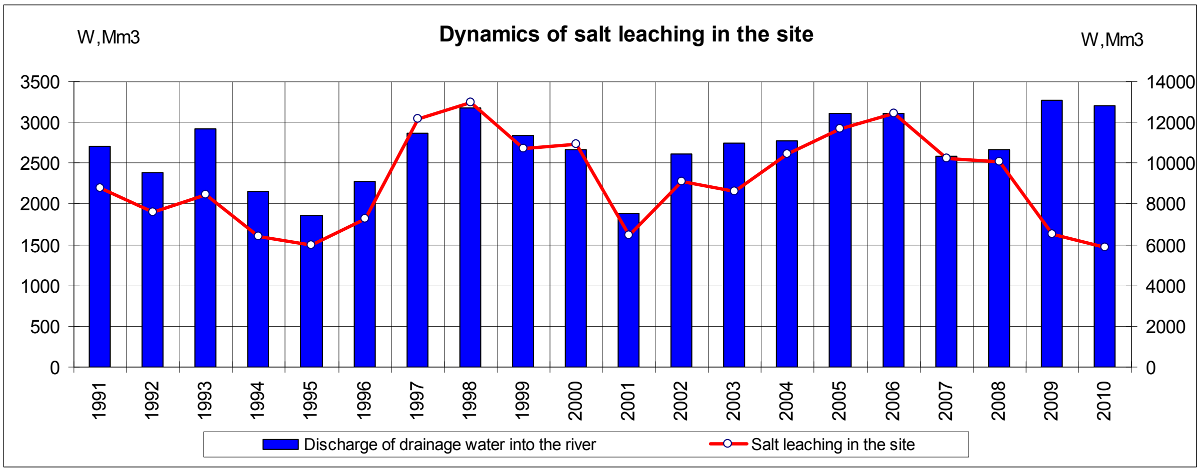


Fig. 4c

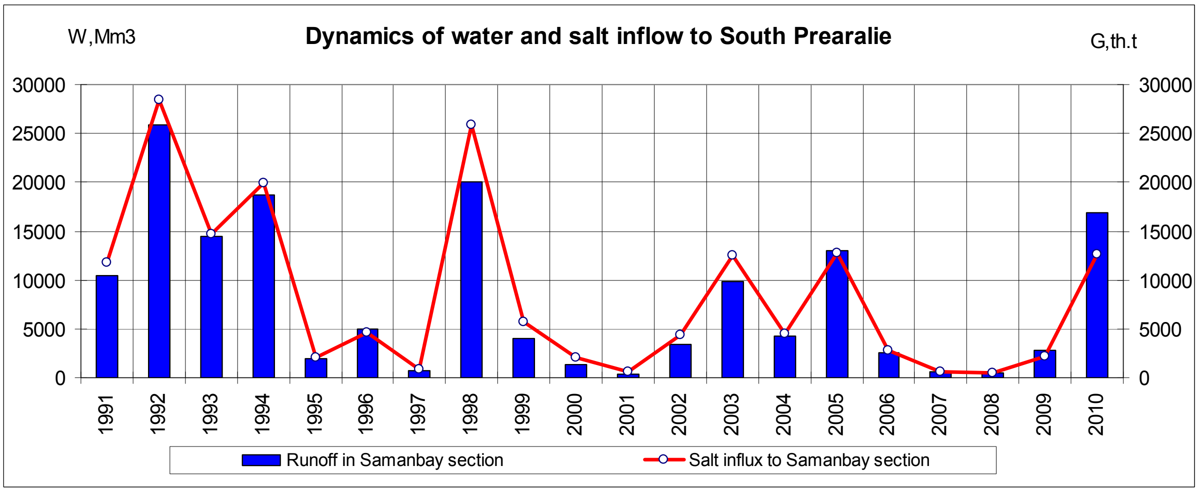


Fig. 5a

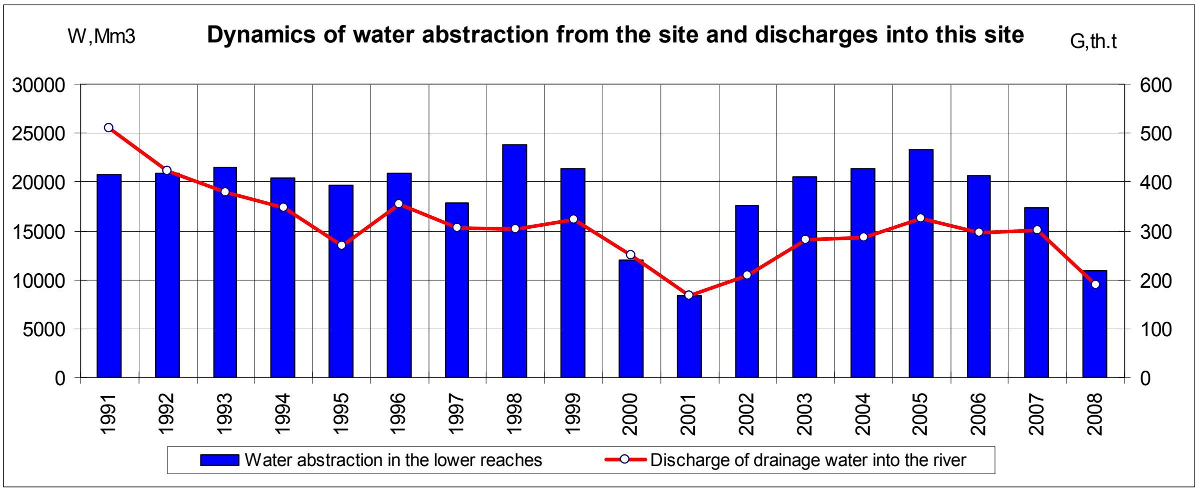


Fig. 5b

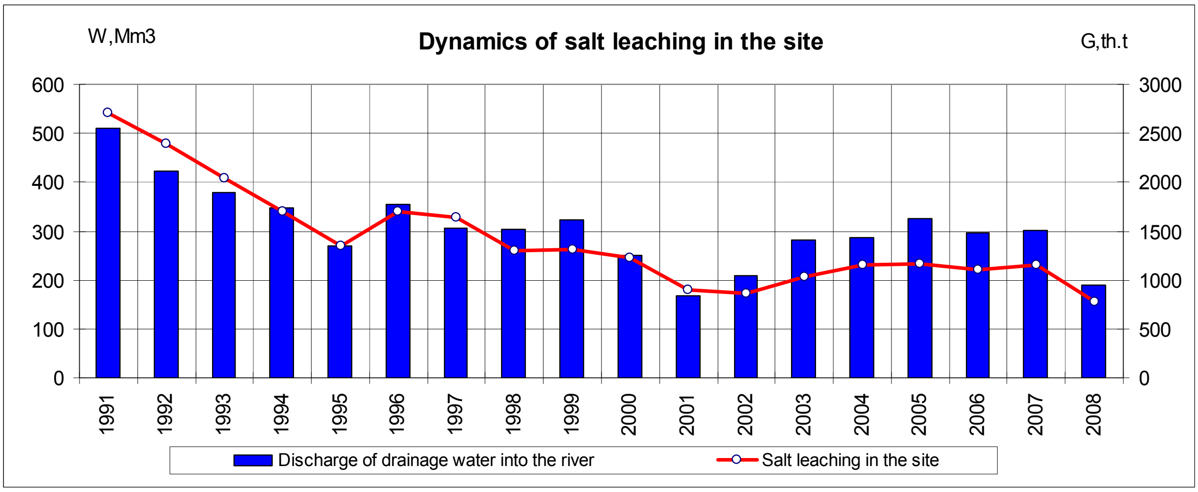


Fig. 5c

Information processed by SIC ICWC using the data of BWO "Amudarya"

Table 5

Dynamics of annual salt flux along the Amudarya river for different flow probabilities

Period	Characteristics	Gauging station	Flow probability					
			5%	10%	25%	50%	75%	95%
Year	Flow	Kelif	81122	80733	71977	63367	53664	41688
	Salinity		0.446	0.451	0.497	0.450	0.448	0.489
	Amount of salts, thousand t		36176	36424	35787	28498	24068	20373
	Flow	Atamurat	64278	63406	56386	46662	38265	27843
	Salinity		0.460	0.494	0.517	0.454	0.461	0.511
	Amount of salts, thousand t		29545	31307	29172	21186	17633	14215
	Flow	Bir-Ata	60687	57497	49438	40594	31660	16759
	Salinity		0.655	0.703	0.792	0.668	0.660	0.850
	Amount of salts, thousand t		39744	40433	39131	27102	20884	14243
	Flow	Kipchak	37434	34628	30823	17492	13175	5637
	Salinity		1.083	1.324	0.978	0.941	0.804	0.943
	Amount of salts, thousand t		40557	45859	30145	16466	10595	5314
	Flow	Samanbay	25922	20068	14478	4925	1944	596
	Salinity		1.095	1.288	1.011	0.949	1.034	1.059
	Amount of salts, thousand t		28388	25851	14642	4673	2010	631

Source: data of BWO «Amudarya» processed by SIC ICWC

Table 6

Changes affecting the middle reaches of the Amudarya river

Factor	Unit	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Irrigated area	Th.ha	1837	1843	1992	2078	2103	2057	2089	2063	2082	2171	2172	2171	2199	2238	2276	2315	2288	2302	2316	2315
River flow in Kerki section	Mm^3	45109	63406	54052	59969	42101	49295	36131	64278	46662	31575	27843	48569	51686	42770	56386	38265	36192	21145	40642	57128
Salinity in Kerki section	g/l	0.694	0.494	0.499	0.467	0.488	0.491	0.526	0.46	0.454	0.492	0.511	0.479	0.507	0.501	0.517	0.461	0.456	0.487	0.489	0.515
Salt export in Kerki section	Th.t	31319	31307	26975	28033	20560	24207	18994	29545	21186	15549	14215	23242	26212	21409	29172	17633	16515	10291	19884	29447
Water diversion in the middle reaches	Mm^3	26045	24161	21624	24269	21780	22519	24410	24889	24598	20921	18631	23302	23229	23207	23306	24466	22354	20143	21544	22845
Salt accommodation in the site	Th.t	18084	11929	10791	11345	10636	11058	12832	11440	11168	10303	9513	11151	11780	11616	12058	11275	10201	9803	10541	11776
Drainage inflow in the river	Mm^3	2703	2389	2918	2147	1857	2271	2873	3170	2841	2672	1891	2610	2745	2777	3104	3104	2590	2659	3273	3201
Salinity of drainage flow	g/l	3.25	3.178	2.888	2.995	3.213	3.202	4.237	4.092	3.769	4.087	3.429	3.477	3.133	3.757	3.77	4.014	3.953	3.786	1.983	1.838
Salt export to the site	Th.t	8785	7592	8427	6432	5966	7273	12170	12973	10706	10920	6486	9076	8600	10434	11702	12459	10236	10067	6490	5884
River flow at Tuyamuyun (Bir-Ata)	Mm^3	37196	57497	49438	54049	34800	43361	29978	60687	40594	20497	16759	41964	45790	35964	51829	32148	29585	16064	31660	47447
River salinity at Tuyamuyun (Bir-Ata)	g/l	0.890	0.703	0.792	0.681	0.749	0.701	0.784	0.655	0.668	0.85	0.85	0.705	0.69	0.769	0.724	0.686	0.66	0.701	0.66	0.658
Salt influx to Tuyamuyun	Th.t	33105	40433	39131	36802	26048	30389	23492	39744	27102	17413	14243	29567	31587	27645	37500	22061	19517	11264	20884	31225

Source: data of BWO «Amudarya» processed by SIC ICWC

Table 7

Changes affecting the lower reaches of the Amudarya river

Factor	Unit	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
IIrrigated area	Th.ha	1103	1126	1150	1180	1187	1189	1185	1181	1184	1187	1188	1188	1189	1191	1193	1197	1192	1192	1196	1201
River flow in Tuyamuyun section	Mm^3	34235	51163	45642	42083	21808	28039	16900	47182	24810	11707	10467	24303	32628	23639	40065	21495	17169	11095	20343	37715
Salinity in Tuyamuyun section	g/l	0.849	0.802	0.884	0.826	0.906	0.856	1.103	1.23	0.981	1.125	1.219	0.754	0.815	0.904	0.728	0.909	0.914	0.863	0.757	0.700
Salt export in Tuyamuyun section	Th.t	29052	41035	40367	34752	19748	23997	18638	58057	24344	13166	12760	18315	26598	21370	29179	19540	15693	9578	15407	26401
Water diversion in the lower reaches	Mm^3	20731	20844	21461	20433	19686	20859	17816	23818	21395	12052	8366	17584	20528	21386	23288	20698	17383	10900	18073	21139
Salt accommodation in the site	Th.t	17593	16718	18981	16874	17826	17852	19649	29308	20993	13555	10198	13251	16734	19333	16960	18816	15888	9409	13688	14797
Drainage inflow in the river	Mm^3	509	424	378	346	270	354	306	303	324	251	168	209	281	286	326	296	302	190	**	**
Salinity of drainage flow	g/l	5.306	5.641	5.378	4.924	4.999	4.801	5.362	4.286	4.034	4.911	5.323	4.12	3.654	4.043	3.584	3.729	3.808	4.101	**	**
Salt export to the site	Th.t	2703	2391	2034	1706	1349	1701	1639	1299	1307	1231	894	860	1027	1158	1168	1103	1151	780	**	**
Salt export to the site	Mm^3	10484	25922	14478	18706	1944	4925	683.2	20068	4039	1378	394.4	3424	9801	4217	13000	2566	596.2	470.6	2739	16919
River flow in Samanbay section	g/l	1.126	1.095	1.011	1.066	1.034	0.949	1.231	1.288	1.399	1.459	1.662	1.266	1.275	1.072	0.983	1.108	1.059	0.943	0.804	0.750
Salt influx to Samanbay section	Th.t	11806	28388	14642	19946	2010	4673	840.9	25851	5652	2011	655.6	4336	12499	4519	12779	2842	631.2	443.6	2203	12690

Source: data of BWO «Amudarya» processed by SIC ICWC

Problems of Water Resource Quality in the Syrdarya River Basin[3]

Similar changes in water content have occurred in the Syrdarya basin. Annually, 20 millions tons of salt is washed into the Syrdarya river by drained return flow. This raises water salinity in the river from 300-600 mg/l in the upper reaches to 3000 mg/l[4] in the lower reaches of Fergana Valley, with prevalent $MgSO_4$, $Ca(HCO_3)_2$, NaCl, and CaSO4 in salt composition. At the same time, the coliform index increases significantly up to 25 000, and concentrations of phenols and anthropogenic pollutants grow as well. Further downstream, where the river exits from the Fergana Valley, water quality is deteriorating largely and remains unsatisfactory right down to the delta and the point of entrance to the northern Aral Sea.

Water salinity has increased from 1960-1970 levels in all controlled sections. The increases in the overall salinity are accompanied by higher concentrations of magnesium, copper, iron, sulphates, chlorides, etc. As a result, not only lower reaches but also the medium course of the Syrdarya contain water that is unacceptable for drinking and its significant pollution quite often leads to increased morbidity of the local people. Prevailing diseases are related to the quality of drinking water and include hepatitis, typhoid and gastrointestinal disorders.

Along the course, the Syrdarya rivers receives both polluted water from its main tributaries and polluted return flow discharged from numerous collector drains, the largest ones being SBK, Shuruzyak, and KPK-C. Under present conditions, the total amount of the collector and drainage waters (CDW) in the Syrdarya Basin comes to 22.4 km^3/year: 0.22 km^3/year in the upper course (Naryn); 9.4 km^3/year in the Fergana Valley; 3.5 km^3/year in the middle course; 2.8 km^3/year in CHAKIR; and, 5.5 km^3/year in the lower course. Out of this amount 14.1 km^3/year are returned back into basin's rivers and 5.5 km^3/year are carried away to natural depressions and sands (Table 8).

[3] Sources: (1) The Uzbek National Coordination Center, Clearing House Mechanism of the Convention on Biodiversity - www.cbd.uz (2) Toryanikova R.V. Water Quality Assessment and Management in the Syrdarya River Basin / EPIC-USAID, ftp://ftp.crwr.utexas.edu/pub/outgoing/mckinney/EPIC

[4] According to the expert Z.Yarullina (State Committee for Nature Conservation of the Republic of Uzbekistan), the maximum water salinity was 1880 mg/l in 2009

Table 8

Collector and drainage waters flowing into the
Syrdarya river under present conditions

Basin, irrigation district	Amount of CDW incoming to the river and its tributaries, Mm^3/year	Average salinity of CDW, g/l	Salt content incoming to the river, Mt/year
Syrdarya from the river source to Toktogul waterworks facility	190	0.75	0.143
Syrdarya from Toktogul waterworks facility to Kairakkum reservoir	8680	2.205	19.139
Syrdarya from Kairakkum reservoir to Chardara reservoir	3360	3.005	10.097
Syrdarya from Chardara reservoir to the river mouth	1860	3.20	5.952
TOTAL on the Syrdarya river	**14090**		**35.331**

Sources: (1) The Uzbek National Coordination Center, Clearing House Mechanism of the Convention on Biodiversity - www.cbd.uz (2) Toryanikova R.V. Water Quality Assessment and Management in the Syrdarya River Basin / EPIC-USAID, ftp://ftp.crwr.utexas.edu/pub/outgoing/mckinney/EPIC

CDW salinity varies within 1.0-2.68 g/l in upper reaches, 2.0-5.6 g/l in middle reaches, and 1.2-5.2 g/l in lower reaches.

Under present-day conditions, moving away from the flow formation zone, with diversion of river water for irrigation, the river runoff decreases and its quality changes, i.e. a share of return water in the river increases and, consequently, river water salinity is growing, its ionic and biogenic composition degrades.

Thus, the Syrdarya river and its constituent catchment basins should be considered as different interrelated transit ecosystems, where water quality and environmental conditions in catchment sites fit the natural (background) state or are subjected to a change in a varying degree under anthropogenic impact.

The quality of water resources is assessed by using MAC criteria (maximum allowable concentration). MAC is the maximum concentration of a harmful substance in the unit water, which when exerting a continuous impact does not cause adverse changes in the living organism and its generation. MAC is based on a conception that chemical characteristics of the water body changed as a result of pollution may have a direct or indirect adverse impact on people’s health and aquatic biota due to deterioration of water quality.

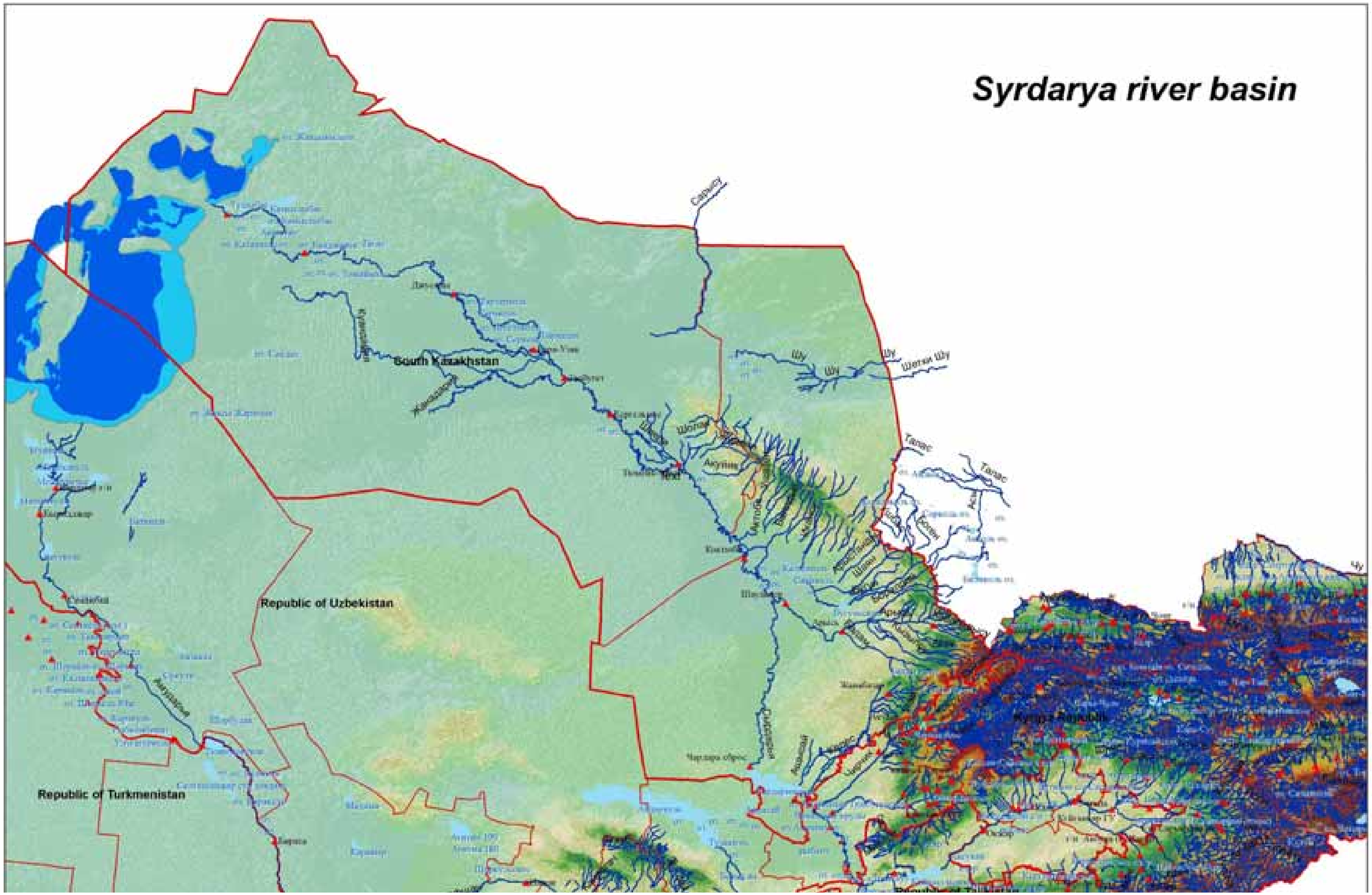


Fig. 6. Syrdarya river basin
(source: CAREWIB IS)

The national hydrometeorological services (Hydromets) in their chemical assessment of surface water quality use a system of MACs for fishery waters, which puts higher requirements with respect to water quality and currently is closer to environmental requirements than hygienic MACs. Thus, by observing MACs for fishery, one guarantees the potentially high water quality for all water uses. In the assessment of water quality in the Syrdarya river basin we used, besides MACs, a notion of background concentration, i.e. of substance content, which depends on global, regional, and intra-basin natural processes. From the methodological point of view, this makes the assessment more correct since it takes into account an initial quality of surface waters. Such assessment is especially important for the components and substances that often have increased natural concentrations in surface water, for example, heavy metals, phenols, and natural hydrocarbon (defined as oil products).

Based on an analysis of the operating materials, in total, 15 standardized chemical ingredients which concentrations generally exceed the MAC values in transboundary waters and 3 standardized integral hydrochemical characteristics, such as dissolved oxygen concentration, BOD5, and COD, were selected for characterizing of water quality (Table 9). According to the adopted procedure, the chemical quality of surface water in the Syrdarya river basin is described on the basis of their genesis. First, the background concentrations of components and indicators typical for the flow formation zone (FFZ) are considered. Then, description of water quality is made successively for the main tributaries of the Syrdarya river (Naryn, Karadarya) from their transboundary to mouth reaches, as well as of the Syrdarya river itself – all these refer to the zone of intensive flow consumption (ZIFC).

Table 9

Priority indicators of water quality in the Syrdarya river basin

№№	Indicator	Unit	MAC 1	MAC 2	MAC 3
1.	Oxygen	mg/l	6.0	-	0.005
2.	BOD	mgO_2/l	3.0	-	6.0
3.	COD	mgO_2/l	15.0	-	-
4.	Nitrite nitrogen	mg/l	0.02	-	3.0
5.	Salinity	mg/l	1000	-	up to 1000
6.	Chlorides	mg/l	300	350	350
7.	Sulphates	mg/l	100	-	500
8.	Magnesium	mg/l	40	-	< 40
9.	Sodium	mg/l	120	-	120
10.	Total hardness	ml/l	7.0	7.0	7.0
11.	Copper	μg/l	1.0	1.0	1.0
12.	Zinc	μg/l	10.0	5.0	1.0
13.	Chrome VI	μg/l	1.0	-	0.5
14.	Phenols	mg/l	0.001	-	no more 0.01
15.	Oil products	mg/l	0.05	-	no more 0.05
16.	Fluoride	mg/l	0.75	1.5	1.5
17.	α-HCH	μg/l	-	-	-

№№	Indicator	Unit	MAC 1	MAC 2	MAC 3
18.	γ-HCH	µg/l	-	-	-
Note: MAC 1 – for fishery waters					
MAC 2 – for drinking water					
MAC 3 – for water in open water bodies served for drinking					

[1] Toryanikova R.V. Water Quality Assessment and Management in the Syrdarya River Basin / EPIC-USAID, ftp://ftp.crwr.utexas.edu/pub/outgoing/mckinney/EPIC

Surface Water Quality in the Flow Formation Zone[5]

Water quality in the flow formation zone (FFZ) is mainly determined by the lithology of rocks forming the drainage basins and by the conditions of flow formation. Water resources in the rivers of this zone are low and medium saline. The maximum salinity is observed during the low water period, while the minimum one is reached at the time of recession of flood. The salinity increases greatly at the peak of flood.

Generally, the excess over MAC is typical for the ingredients with increased geochemical background, namely heavy metals, such as copper, zinc, and chrome (Table 10).

Table 10

Average indicators (1986 - 1996) of the river water chemistry in the flow formation zone

Indicator	Unit	Range of indicators in river basins				
		Right-bank tributaries of Syrdarya in Fergana Valley	Left-bank tributaries of Syrdarya	Akhangaran	Chirchik	Naryn
Salinity	mg/dm^3	135-360	180-400	130-520	110-240	360
Hardness	Mmole/dm^3	1.7-4.4	2.3-6.2	1.6-6.7	1.5-3.0	3.4-3.7
COD	mgO/dm^3	4.5-6.0	3.7-6.7	4.0-7.0	2.7-9.5	6.8-7.8
BOD_5	mgO/dm^3	0.5-1.6	0.3-2.3	1.4-2.6	0.5-2.2	1.0-1.8
Fe	mg/dm^3	0.01-0.04	0.01-0.05	0.02-0.04	0.02-0.19	0.02-0.04
NH_4	mgN/dm^3	0.02-0.10	0.02-0.15	0.01-0.13	0.01-0.56	0.02-0.06
NO_3	mgN/dm^3	0.77-1.85	0.45-1.66	0.29-1.46	0.28-2.09	0.71-1.10
NO_2	mgN/dm^3	0.002-0.013	0.004-0.026	0.007-0.039	0.002-0.190	0.004-0.13
Mineral phosphorus	mg/dm^3	0.003-0.012	0.002-0.037	0.005-0.018	0.001-0.018	0.005-0.011
Oil products	mg/dm^3	0.0-0.04	0.0-0.04	0.02-0.09	0.01-0.10	0.03-0.05
Phenols	mg/dm^3	0.001-0.003	0.001-0.006	0.001-0.006	0.001-0.005	0.002-0.005
Hexachloran	µg/dm^3	0.0-0.089	0.008-0.110	0.007-0.253	0.002-0.037	0.015-0.025
Lindane	µg/dm^3	0.0-0.067	0.002-0.057	0.005-0.042	0.001-0.037	0.007-0.026
Rogor	µg/dm^3	0.0-15.5	-	0.13-0.56	-	0.073-1.374
Al	µg/dm^3	1.4-8.1	1.8-9.8	3.5-15.6	2.3-22.2	3.5-8.1
Mn	µg/dm^3	0.6-4.5	0.5-6.7	6.0-6.1	0.0-6.6	0.0-1.1
As	µg/dm^3	-	-	0.0-8.1	1.68-5.44	0.5-6.4

[5] Toryanikova R.V. Water Quality Assessment and Management in the Syrdarya River Basin / EPIC-USAID, ftp://ftp.crwr.utexas.edu/pub/outgoing/mckinney/EPIC

Indicator	Unit	Range of indicators in river basins				
		Right-bank tributaries of Syrdarya in Fergana Valley	Left-bank tributaries of Syrdarya	Akhangaran	Chirchik	Naryn
Ti	μg/dm^3	1.6-3.0	0.0-2.3	1.0-3.2	0.0-8.1	0.6-2.1
Fluoride	μg/dm^3	-	-	0.33-0.62	0.0*-1.5*	0.34-0.39
Cyanides	μg/dm^3	-	-	0.003-0.006	-	-
Cu	μg/dm^3	0.0-10.1	0.0-5.7*	0.0-3.87	0.0*-6.3*	0.0-7.85
Zn	μg/dm^3	0.6-22.8	0.0*-9.6	5.84-13.9	0.9*-15.4	0.0-13.1
Pb	μg/dm^3	0.0-3.1*	0.0-0.76	0.0-4.74	0.0-12.6	0.0-1.2
Hg	μg/dm^3	-	-	0.10*-0.17	0.06-0.10	0

Note: * - single observations
[1] Toryanikova R.V. Water Quality Assessment and Management in the Syrdarya River Basin / EPIC-USAID, ftp://ftp.crwr.utexas.edu/pub/outgoing/mckinney/EPIC

As to the organic ingredients, the general MAC excess is typical for phenols and, to a lesser degree, for oil products (natural hydrocarbons) that is evidently due to natural biochemical processes of the organic substance transformation in the river waters of the region. Apparently, isolated cases of MAC exceeding by nitrites also have a similar character although they are found considerably more rarely than for the aforesaid ingredients.

As a whole, the surface water quality in the FFZ may be considered as the good one and suitable for all water uses; however, the tendency toward deterioration of water quality may be traced in small watercourses of the flow formation zone.

Quality of Transboundary Water in the Zone of Intensive Flow Consumption[6]

The main constituents of the Syrdarya river - the Naryn and Karadarya Rivers - are formed in the territory of Kyrgyzstan. According to the data of the Kyrgyz Hydromet, water resources in the Naryn (the sections located upstream and downstream of Naryn town, Uchterek gauging station, and upstream and downstream of Tashkumyr town) and the Karadarya (the sections located upstream and downstream of Uzgen town) are of good quality.

For these transboundary river reaches the average annual concentrations of the dissolved oxygen amount to 8.3 - 10.3 mg/l, BOD_5: 1.5 - 2.1 mgO_2/l, nitrite nitrogen: 0.002 - 0.025 mg/l, and salts - up to 300 mg/g. No MAC excess was recorded for all mineral components. Contents of metals, phenols, oil products and pesticides don’t exceed the background values.

Within the boundaries of Uzbekistan, from the transboundary point (town of Uchkurgan) to the mouth of the Naryn River the water salinity increases in average up to 432 - 602 mg/l basically because of sulfates, the average concentration of which exceed MAC 1.2 - 2.0 times (121 -211 mg/l). Again the average annual concentration of nitrite nitrogen considerably increases: up to 0.022 - 0.025 mg/l (MAC 1.1 - 1.2). Concentrations of other ingredients are within the limits of the

[6] Toryanikova R.V. Water Quality Assessment and Management in the Syrdarya River Basin / EPIC-USAID, ftp://ftp.crwr.utexas.edu/pub/outgoing/mckinney/EPIC

background values. Prior to 1993, the residual quantities of pesticides (in average up to 0.040 mcg/l) were found in the Naryn River but since 1994 they have not been observed.

For the Karadarya river, within the boundaries of Uzbekistan, from the settlement of Karabagish to the river mouth (Uchtepe town) a similar tendency may be traced as for the Naryn river regarding the water quality changes. The content of organic matter increases. This is backed by an increase of the BOD_5 and COD values, the growth of salinity in average up to 545 mg/l basically because of sulfates and magnesium which average concentrations exceed MAC and amount to 206 and 48 mg/l, respectively. The water hardness increases up to 7.92 µg/l (1.1 MAC). Concentrations of heavy metals also grow and exceed MAC 1.5 -2.7 times but remain within the limits of the background values.

The average annual concentrations of phenols are also increased (3-5 times over MAC) but remain within the limits of the background values. The average concentrations of oil products are lower or equal to MAC. The fluoride content increases towards the river mouth but their average annual concentrations don't exceed MAC.

The Syrdarya river is formed on the territory of Uzbekistan through the confluence of the Naryn river and the Karadarya river.

The oxygen regime of the river along the whole length is satisfactory, basically without pronounced spatial and long-term trends. Nevertheless, one should note some decrease of the average annual concentrations of oxygen, increase in the water contamination level in the lower reaches of the Syrdarya river in the territory of Kazakhstan downstream of Kyzyl-Orda city, and growth of BOD_5 and nitrite nitrogen concentration.

As a whole, a certain positive trend in the values of BOD_5, COD and nitrite nitrogen downstream the Syrdarya river is noted. Therewith, the average annual value of BOD_5 and COD don't exceed MAC, whereas the average concentrations of nitrite nitrogen in the most cases are higher than MAC and have the highest values at the points downstream of the places where collector-drainage waters flow into the river and after the big settlements (downstream of SBK, Bekabad, Chinaz, Kyzyl-Orda, and Kazalinsk).

In longer period (1990-1997), a slight negative trend in BOD_5, COD and nitrite nitrogen concentration is observed in the transboundary tailing reach located in Uzbekistan in the Chinaz town. This indicates indirectly to lessening of organic pollution in the Syrdarya river in the last years.

The river water is characterized by quite high salinity as early as in the place of river origin. Depending on flow probability, the average annual salinity varies within 445-906 mg/l but does not exceed MAC. Further downstream the average annual salinity changes from the values closer to MAC to the values higher than MAC: increased salinity in the points, where large collector drains discharge their water, and decreased salinity in the sites, where Syrdarya's water is dissolved by less saline river water from its main tributaries. The river water salinity ranges from 500-950 mg/l

during flood period and to 960-2000 mg/l in the low water time. In general, a positive spatial trend of salinity growth is observed downstream the river channel.
Dynamics of the average annual salinity along the length is shown in Table 11.

Table 11

Average annual salinity in the Syrdarya river, g/l

Year	Section				
	Kal’	Bekabad	Nadejdinsky	Kzyl-Orda	Kazalinsk
1950	0.532	-	0.784	0.745	0.745
1955	0.522	0.514	0.782	0.735	0.726
1960	0.500	0.558	0.681	0.712	0.694
1965	0.589	1.102	0.980	0.861	0.803
1970	0.571	1.014	1.152	1.044	1.075
1975	0.755	1.053	1.139	1.667	1.638
1980	0.624	1.180	1.309	1.360	1.588
1985	0.718	1.172	1.320	1.356	1.632
1990	0.554	1.189	1.237	*	*
1993	0.744	1.133	1.315	*	*
1994	0.652	1.101	1.150	*	*
1997	0.532	1.168	1.425	1.307	1.488
* - no data					

[1] Toryanikova R.V. Water Quality Assessment and Management in the Syrdarya River Basin / EPIC-USAID, ftp://ftp.crwr.utexas.edu/pub/outgoing/mckinney/EPIC

The positive spatial salinity trend is explained by an increase in concentrations of all mineral components downstream the Syrdarya river that, like salinity itself, naturally grow downstream of the points, where collector drains discharge their water into the river, and decrease downstream of the inflow points of large tributaries. Moreover, the annual concentration of chlorides and sodium is within MAC, whereas the concentration of sulphate and magnesium exceeds MAC 2-6 times along the whole length of the Syrdarya river.

In the Syrdarya river basin, where water resources are practically exhausted and diversion of flow in the 1990s was governed only by flow probability, the time trends of growing salinity and its mineral components are not pronounced.

Water in the Syrdarya river is increasingly hard along the whole its length. The rise and fall of the hardness is synchronic with fluctuations of salinity and, as a whole, follow a positive spatial trend along the river.

The content of the toxic metals, such as ions of copper, zinc, and hexavalent chromium exceeds MAC along the whole length of the river and has a slightly pronounced positive spatial trend.

Concentrations of heavy metals in the ZIFC are basically within the limits of the background values, but in industrial and urban agglomerations the former may exceed MAC by dozens of times in both collector drains and tributaries, thus causing impulsive and multiple increase of heavy metal content in some reaches of the Syrdarya river. Moreover, the maximum concentrations of those ingredients may be much higher than the observed background values. In terms of temporal course, in the last eight years a certain negative trend of these concentrations is observed in transboundary waters, probably, due to setback in industrial production.

Content of phenols is high along the whole length of the river and does not show apparent spatial and temporal trends.

The spatial trend of oil product concentrations along the Syrdarya river is not pronounced as well. The local rise over MAC in their concentrations is typically observed in industrial and urban agglomerations and downstream of the point, where the SBK collector drain inflows to the river. The multi-year trend of oil product concentrations in transboundary waters of the Syrdarya is not apparent.

The excessive concentrations of fluorides in the Syrdarya river are typical mainly in the Fergana Valley and in an irrigation project in the Golodnaya Steppe, i.e. in the zone of inflow of drainage water. The temporal multi-year trend of fluoride content is not pronounced.

Thus, there are the upward trends of salinity and its mineral components (chloride, sulphate, magnesium, sodium), of organic pollution (BOD_5, COD, nitrite nitrogen), hardness, heavy metal (copper, zinc, chromium) and phenol contents in the Syrdarya river basin from the FFZ to the ZIFC and along the main transboundary rivers, such as Naryn and Karadarya, and the Syrdarya river as a whole.

The poor quality of the transboundary waters is caused, first of all, by an increased content (against the background and the MAC) of sulfates, magnesium, nitrite nitrogen, fluorides, the excessive water hardness, and higher content of pesticides. The content of phenols, oil products and heavy metals is basically within the limits of the background values typical for the FFZ, with impulsive and multiple increase in the zones of high anthropogenic loads, namely in the reaches affected by industrial populated localities and big collector drains in the irrigated zones. Principally, the average annual COD values are within the limits of MAC but they are considerably higher than the background characteristics, particularly, in the zones of high anthropogenic loads, where the average and maximum values of this indicator amount to 1 -1.5 MAC.

National diagnostic reports indicate that a certain reduction in the salinity that occurred in the late 1990s in interstate rivers was due to a temporary slowdown in water use for irrigation and by industries. In the meantime, contamination of groundwater has become widespread. For some pollutants, content levels exceed maximum allowable concentrations by dozens – and, in some areas, by hundreds of times. The highest incidence of groundwater contamination has been recorded around large settlements, chemical, oil refining and non-ferrous metallurgical plants, etc. Statistics for 1995-2001 indicate that, on average, 8-15% of water samples fail to satisfy bacteriological requirements and 20-40% fall short of physical and chemical standards. National experts voice concern over the unsatisfactory technical condition of sewage disposal facilities (in 60-70% of all cases) that fail to provide efficient treatment of sewage and industrial effluent.

In general, dynamics of the average annual water salinity in the representative sections of the Syrdarya river is shown in Table 12.

Table 12.1

Dynamics of average annual salinity in the Syrdarya river (g/l)

Period	Representative sections			
	Bekabad	Shardara	Kzylorda	Kazalinsk
1960 - 1970	0.64-0.97	0.68-0.94	0.70-0.98	0.95-1.01
1971-1980	0.97-1.38	0.94-1.55	0.98-1.74	1.01-1.72
1981 - 1990	1.38-1.48	1.55-1.46	1.74-1.69	1.72-1.87(2.26)
1991 - 1999	1.48-1.35	1.46-1.24	1.69-1.33	1.87-1.57

Note: Empty cells mean no observations available.
Source: Knowledge Base «Water and Land Resources Use in the Aral Sea Basin»

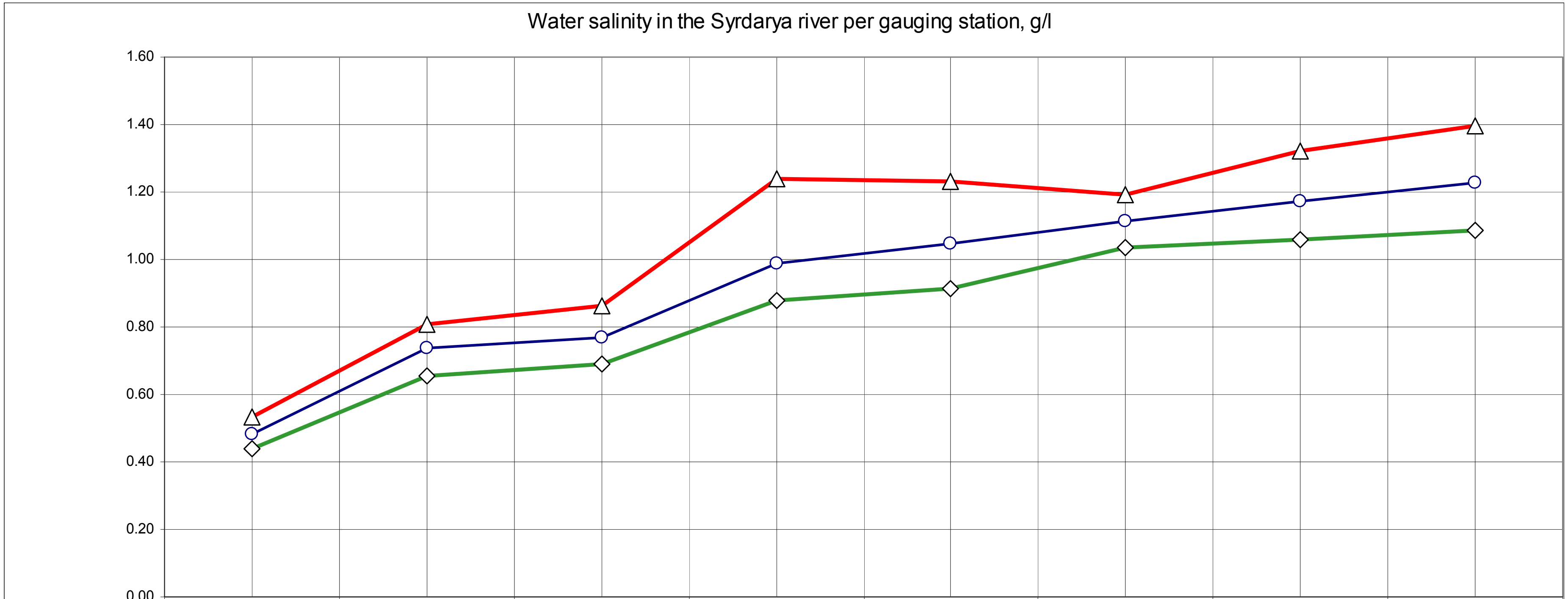
Table 12.2

Dynamics of average annual salinity in the Syrdarya river (g/l)

Year	Uchkurgan waterworks	g/s Kal'	g/s Akdjar	g/s Chilmakhram	g/s Kzylkishlak	Farkhad waterworks	g/s Nadejdenskiy	Mouth of Keles river
	Salinity, average annual values, g/l							
1990				1.239	1.232			
1991				1.028	1.166	1.127		1.189
1992				1.012	1.049	1.111		1.185
1993				0.882	0.921	1.035		1.086
1994				0.960	1.042	1.106		1.167
1995				0.879	0.912	1.177		1.129
1996				1.026	1.071	1.192		1.168
1997				0.892	0.980	1.041	1.162	1.087
1998							1.144	1.232
1999							1.293	1.349
2000							1.320	1.395

Year	Uchkurgan waterworks	g/s Kal'	g/s Akdjar	g/s Chilmakhram	g/s Kzylkishlak	Farkhad waterworks	g/s Nadejdenskiy	Mouth of Keles river
	Salinity, average annual values, g/l							
2001		0.656	0.744				1.058	1.234
2002	0.535	0.809	0.812				1.184	1.270
2003		0.704	0.691				1.166	1.285
2004	0.440	0.672	0.705				1.177	1.283
2005	0.473	0.782	0.864				1.177	1.267
2006	0.490	0.802	0.783				1.158	1.280
2007	0.455	0.731	0.756				1.170	1.280
2008	0.502	0.754	0.779				1.084	
Average long-term	0.48	0.74	0.77	0.99	1.05	1.11	1.17	1.23
min	0.44	0.66	0.69	0.88	0.91	1.03	1.06	1.09
max	0.54	0.81	0.86	1.24	1.23	1.19	1.32	1.39

Source: data of BWO «Syrdarya» processed by SIC ICWC



	g/s Uchkurgan	g/s Kal	g/s Akdjar	g/s Chilmakhram	g/s Kzylkishlak	Farkhad w aterw orks	g/s Nadejdinsky	Keles river mouth
Average annual	0.48	0.74	0.77	0.99	1.05	1.11	1.17	1.23
min	0.44	0.66	0.69	0.88	0.91	1.03	1.06	1.09
max	0.54	0.81	0.86	1.24	1.23	1.19	1.32	1.39

Fig. 7. Salinity at gauging stations of the Syrdarya river

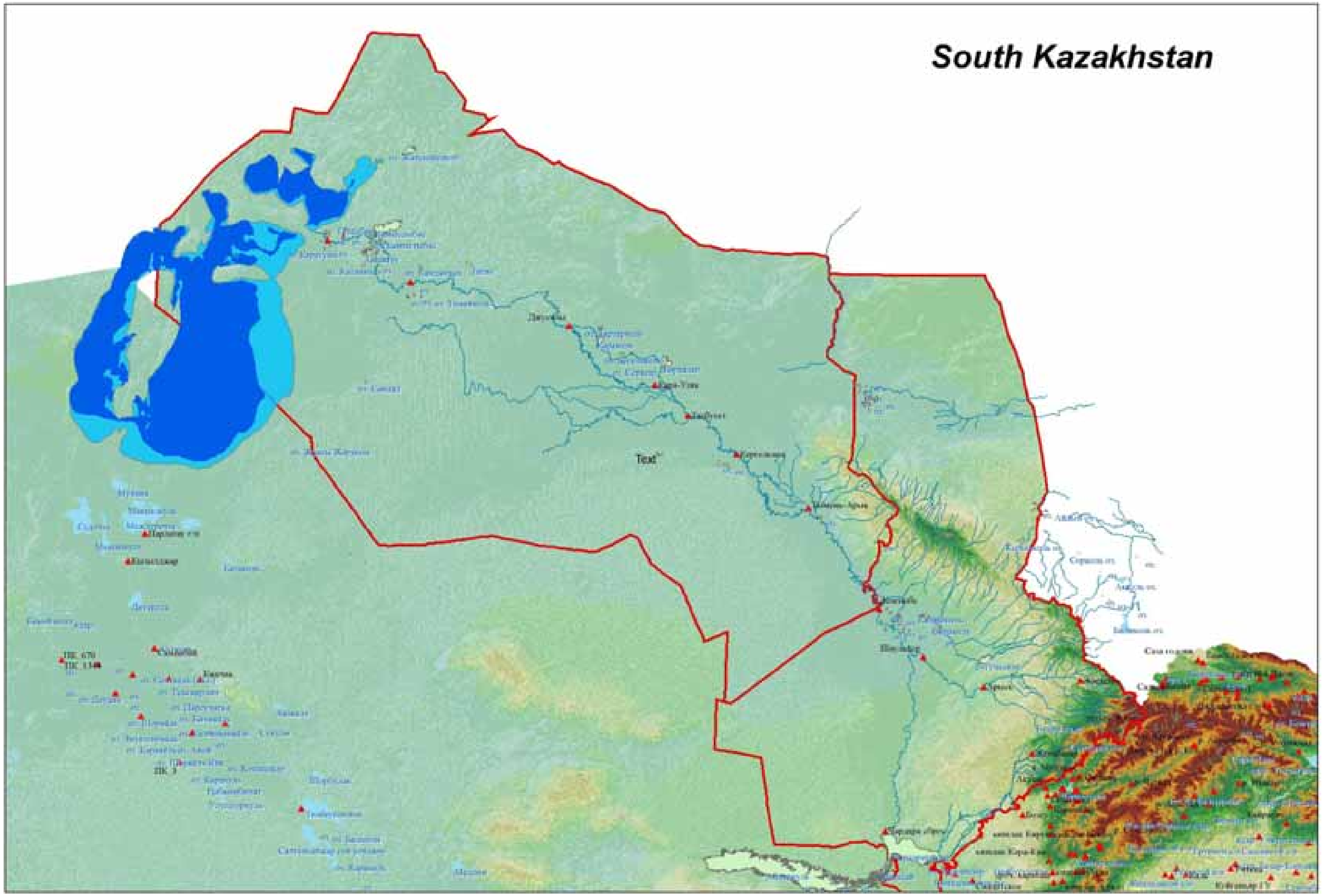


Fig. 8. Layout of gauging stations in South Kazakhstan
Source – CAREWIB IS

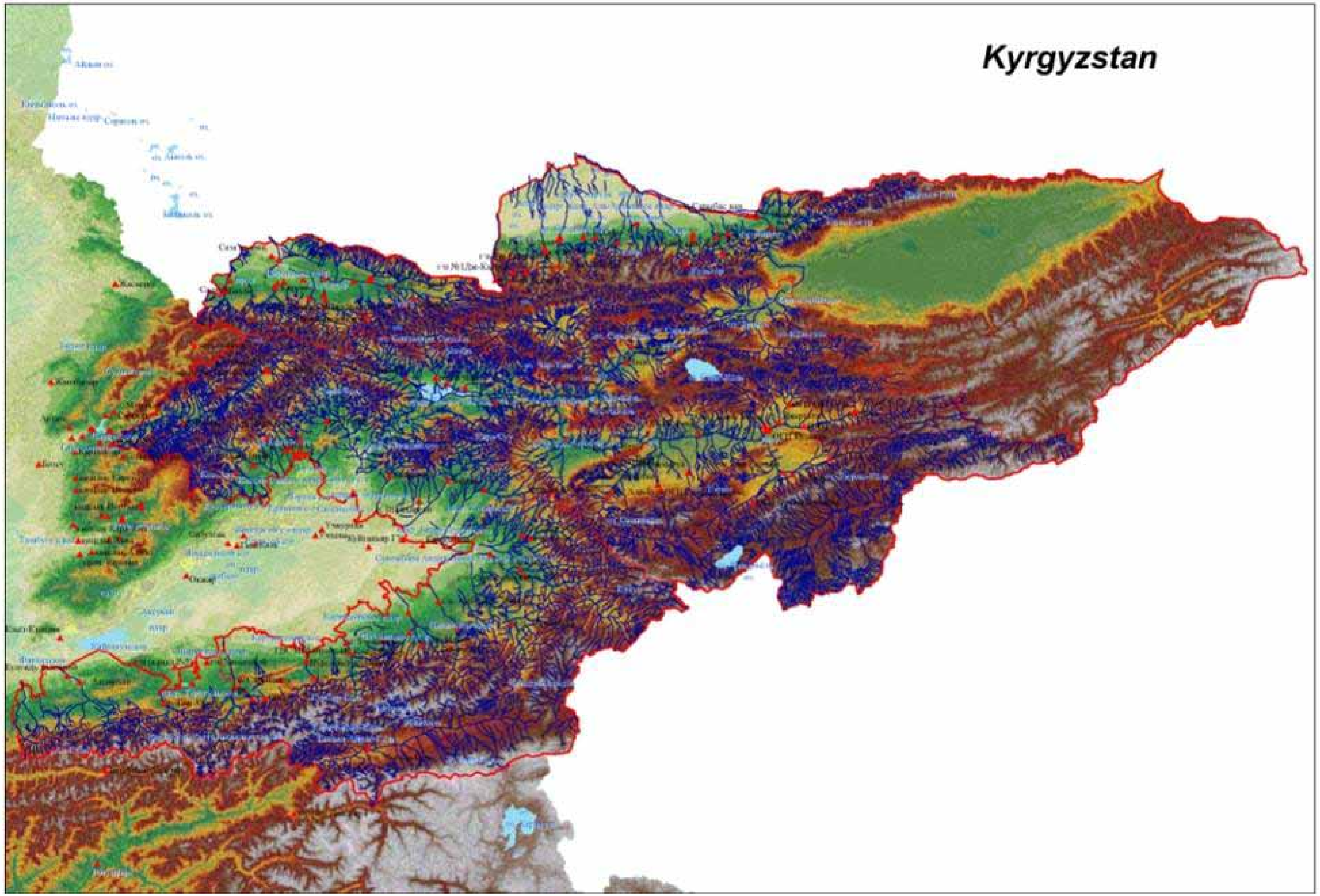


Fig. 9. Layout of gauging stations in Kyrgyzstan
Source – CAREWIB IS

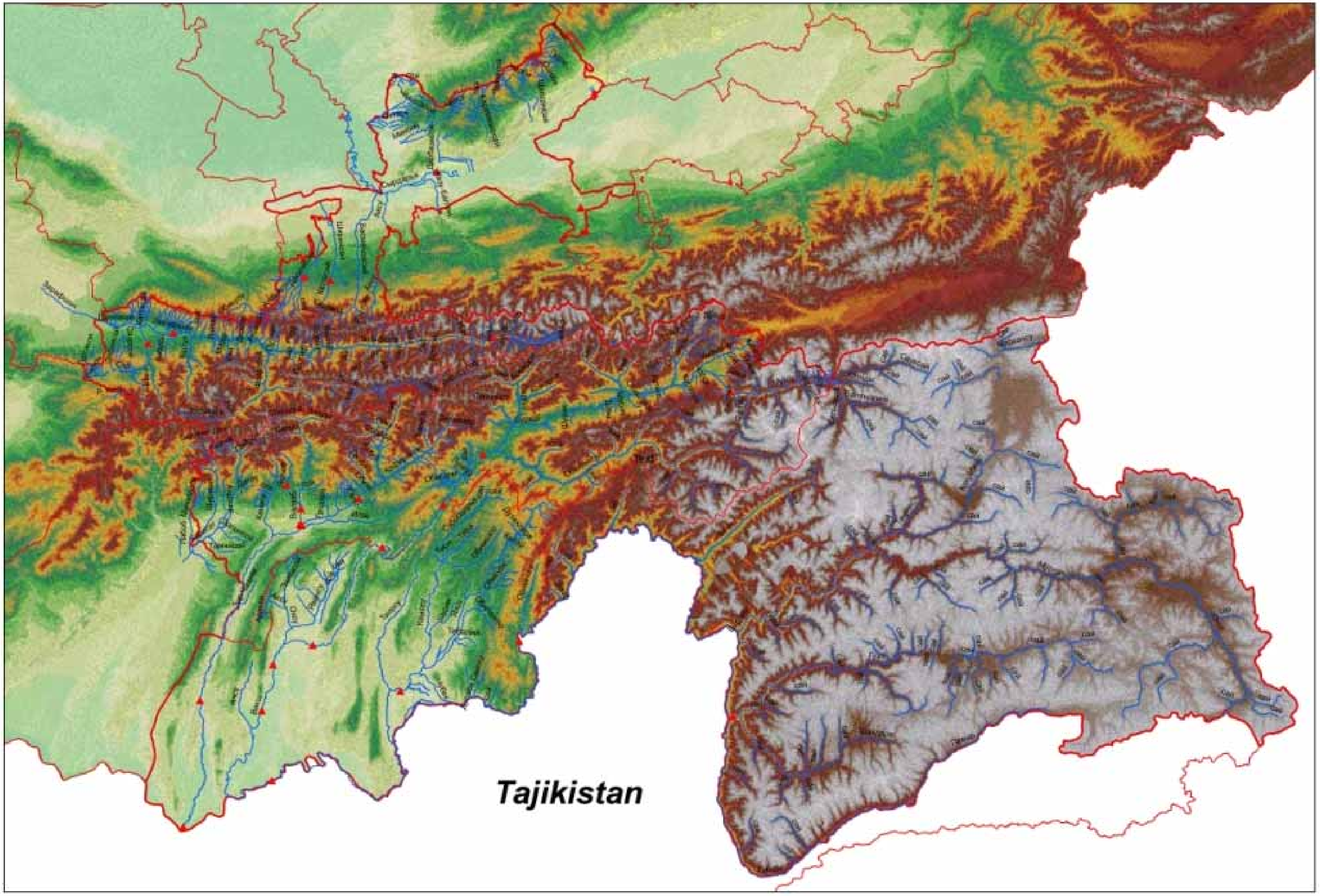


Fig. 10. Layout of gauging stations in Tajikistan
Source – CAREWIB IS

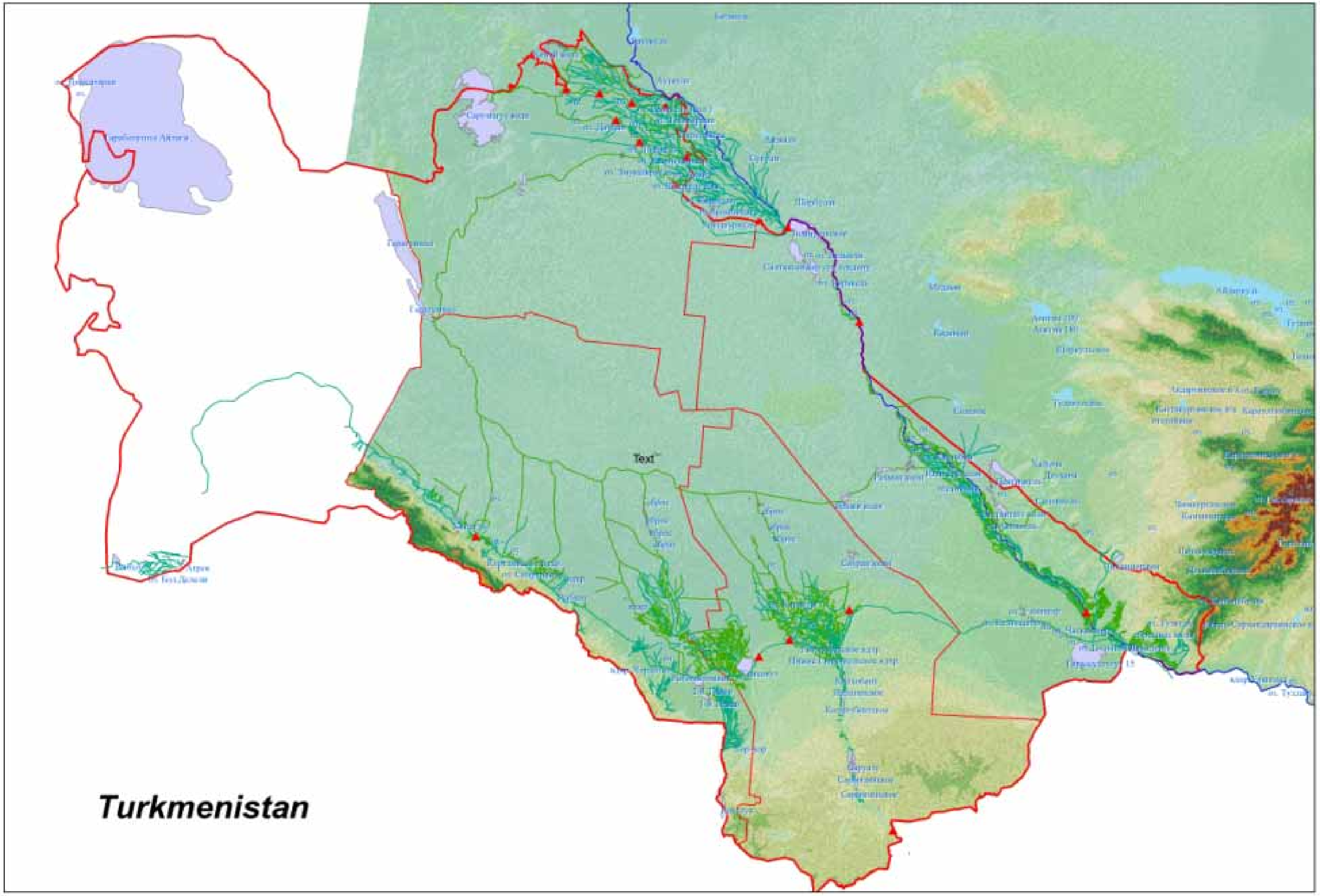


Fig. 11. Layout of gauging stations in Turkmenistan
Source – CAREWIB IS

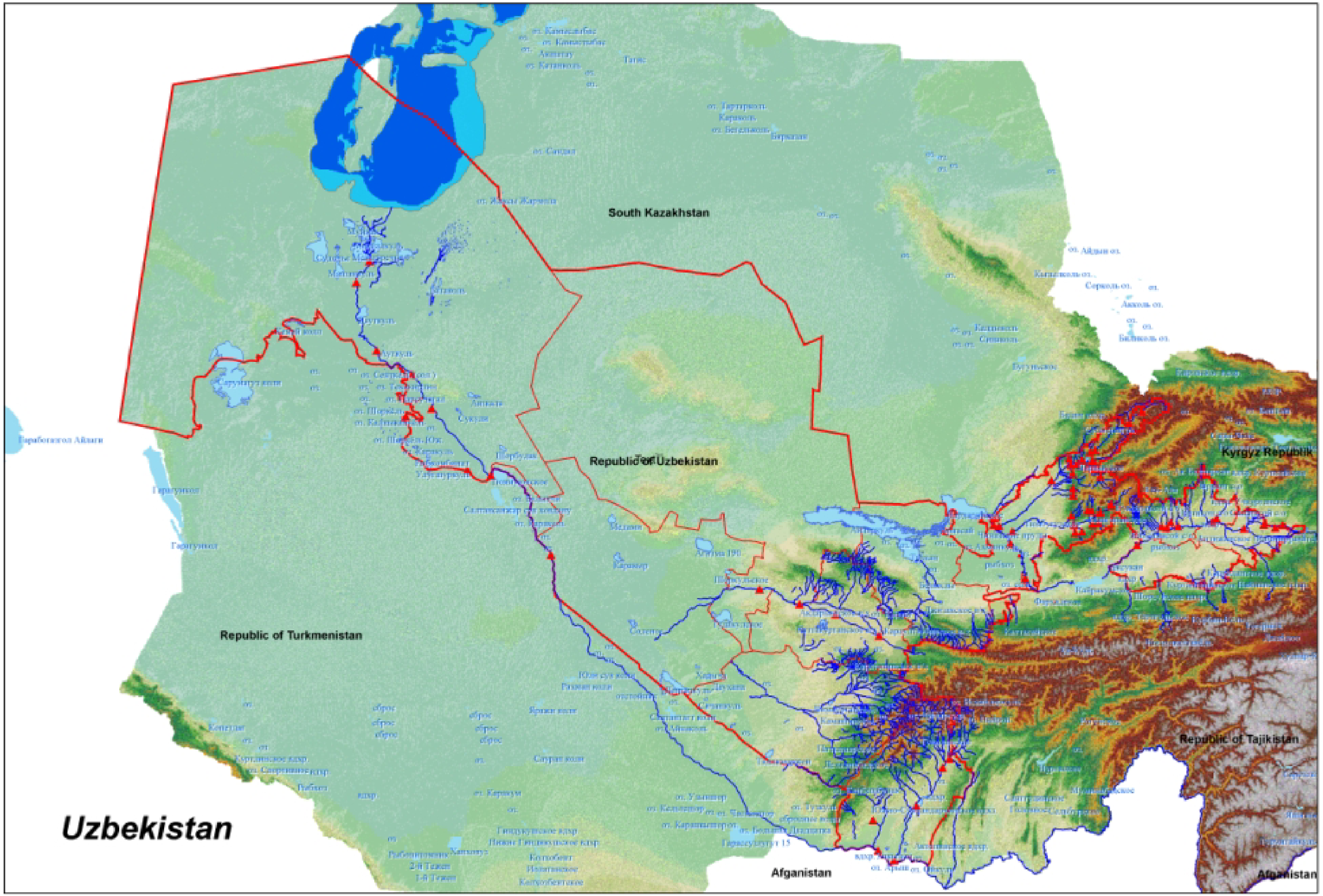


Fig. 12. Layout of gauging stations in Uzbekistan
Source – CAREWIB IS

The following priority measures have been proposed to address the water quality problem:

- Restricting the volumes of return flow discharged into rivers and the volume of specific pollutants discharge for various points and areas;
- Introduction of the “polluter pays” principle (for discharge in excess of established limits) as a norm of interstate relations;
- Strengthening measures for water quality control;
- Identifying levels of environmentally sound discharges in interstate rivers for different annual water levels and various periods;
- Developing tools and methods for water quality monitoring;
- Participation of the countries concerned in the funding and execution of programmes seeking to prevent and eliminate the consequences of the pollution of interstate rivers.

Information on water quality available on the CAWater-Info portal

Knowledge Base

E-Library

Aral Sea Basin Initiative: Towards a strategy for sustainable irrigated agriculture with feasible investment in drainage - Synthesis Report (FAO IPTRID, in Russian published by SIC ICWC), 2006

This report synthesizes a number of research works conducted by various organizations that was mobilized by the IPTRID Secretariat.

The report includes 14 chapters. Water quality issues are discussed in chapters three (Hydrogeology and salt in ASB) and four (Drainage in ASB).

www.cawater-info.net/library/books.htm

Collected works on the issues of ecology, drinking water, land reclamation, energy, pumping irrigation in the area of pilot canals (2006)

The analysis pinpoints the following pressing issues for the pilot canals:

1. Water-protection zones (WPZ). Political, legal, and financial problems prevent from clear delimiting and determining of ownership and responsibilities for WPS of a pilot canal. As a consequence we have:
    a. Polluted WPZ (using as trash, wash, toilet, pumps, and garage places);
    b. Unauthorized acquisition of land in WPZ;
    c. Deteriorated water quality (trash, dead animals and drowned, diseases).
2. Supply of population and domestic animals with water during both growing and especially non-growing seasons. This issue is very topical in light of significant shortage of drinking water in the area of pilot canals.
3. Land reclamation: groundwater rise in downstream plots due to inefficient water use there.

The collection consists of 3 parts (Part 1 - South Fergana Canal; Part 2 - Aravan-Akbura Canal; and, Part 3 - Khodja-Bakirgan Canal).

www.cawater-info.net/library/books.htm

Irrigation management for combating desertification in the Aral Sea basin. Assessment and tools (2005)

This book is a compilation of scientific and technical texts purposefully prepared to present the main results of the cooperative research project “Crop irrigation management for combating irrigation induced desertification in the Aral Sea Basin”, funded by the European Union, INCO-Copernicus Program.

The application perspective, the implementation conditions and the usefulness for the end users were always present in this research.

The book consists of 6 parts, the water quality issues being addressed in the 4^{th} Part (Chapter 15. Drainage and salinity control: review of related problems in Central Asia).

www.cawater-info.net/library/books.htm

Transition to integrated water resources management (IWRM) in the lowlands and deltas of the Amudarya and Syrdarya (2005)

The IWRM, as understood in the CAR refers to a water management system that includes all available water resources and water sources, needing to be used conjunctively, involves coordination of interests of different industries and all levels of water management hierarchy, using a hydro-geographical unit as a basis for the management, and participation of water users and stakeholders in the management process. As such, rational water use and reliable water supply for the population and sectors of the economy can be achieved, with viable ecological systems preserved.

The project also focuses on sustainability of water supply to the lowlands and deltas in terms of quantity and quality, depending on water availability.

This report consists of 5 chapters, and water quality is dealt with in the first chapter.
www.cawater-info.net/library/books.htm

Comprehensive solution of the issues related to water and land use in EECCA (collection of scientific papers) (2010)

This collection describes the results of 13 research efforts aimed to achieve efficient water use, ensure environmental protection and find ways to overcome obstacles in implementing IWRM.

Water quality is described in the work titled «Problems of water quality and public health in the Aral Sea coastal area - Prearalie»

www.cawater-info.net/library/books.htm

Central Asia Environmental Assessment Reports (2006) – ICSD publications
This book contains 5 reports. Water quality issues are considered in the “Assessment report on transboundary water pollution in Central Asia“.

www.cawater-info.net/library/icsd.htm

Indicator-based environmental review for Uzbekistan (2008)

This environmental review was prepared by the joint Project of the Government of Uzbekistan and the United Nations Development Program “Enhancement of the Environmental Indicators Database with GIS application to monitor the state of the environment in Uzbekistan”.

This book gives the analysis of the current state of the basic nature elements (atmosphere, water and land resources) and the main environmental problems (climate change, pollution by industrial and domestic wastes, Aral Sea shrinkage) and assesses the state of biodiversity and the processes of desertification. One section discusses the environmental impact on the public health in the Republic.

The book consists of 7 chapters, the water quality issues being discussed in Chapter 3 (water quality, water quality in the flow formation zone, and surface water pollution).

www.cawater-info.net/library/icsd.htm

Environmental Atlas of Uzbekistan (2008)

This Atlas was prepared by the joint Project of the Government of Uzbekistan and the United Nations Development Program “Enhancement of the Environmental Indicators Database with GIS application to monitor the state of the environment in Uzbekistan”.

The analysis of the current environmental situation and trends is based on environmental indicators reflecting national environmental priorities in line with the international environmental approaches, based on ongoing observations and reliable information that enables predicting effectiveness of the undertaken measures.

The selected indicators describe national prioritized environmental issues related to climate change, atmospheric air, water and land resources, biodiversity, public health, current state of the Aral Sea, and waste management.

Thematic maps, tables, and graphs are prepared based on the analysis of information in the Database of environmental indicators for 1991-2006 using GIS-technology.

Water quality is touched upon on pages 16, 26-31, 51, 58-60.

www.cawater-info.net/library/icsd.htm

Fundamental principles of national water legislation in area of water quality regulation in the Central Asian countries, Volume 1 (2011)

This collection contains legal texts on water quality regulation in the Kyrgyz Republic and in the Republic of Tajikistan:

- Law of the Kyrgyz Republic about environmental protection
- Law of the Kyrgyz Republic about drinking water

- Law of the Kyrgyz Republic about sanitary and epidemiological welfare of the population
- Law of the Republic of Tajikistan about provision of sanitary and epidemiological safety of the population
- Law of the Republic of Tajikistan about technical rate setting
- Law of the Republic of Tajikistan about drinking water and its supply

www.cawater-info.net/library/carewib.htm

Fundamental principles of national water legislation in area of water quality regulation in the Central Asian countries, Volume 2 (2011)

This collection contains legal texts on water quality regulation in the Republic of Kazakhstan and Turkmenistan:

- Law of the Republic of Kazakhstan about sanitary and epidemiological welfare of the population
- Law of the Republic of Kazakhstan about technical regulation
- Sanitary an epidemiological rules and standards «Sanitary epidemiological requirements of operation and maintenance of the centralized hot-water supply system»
- Sanitary an epidemiological rules and standards «Sanitary epidemiological requirements of water quality in the centralized drinking water supply systems»
- Law of Turkmenistan about nature protection
- Law of Turkmenistan about drinking water

www.cawater-info.net/library/carewib.htm

Fundamental principles of national water legislation in area of water quality regulation in the Central Asian countries, Volume 3 (2011)

This collection contains legal texts on water quality regulation in the Republic of Uzbekistan:

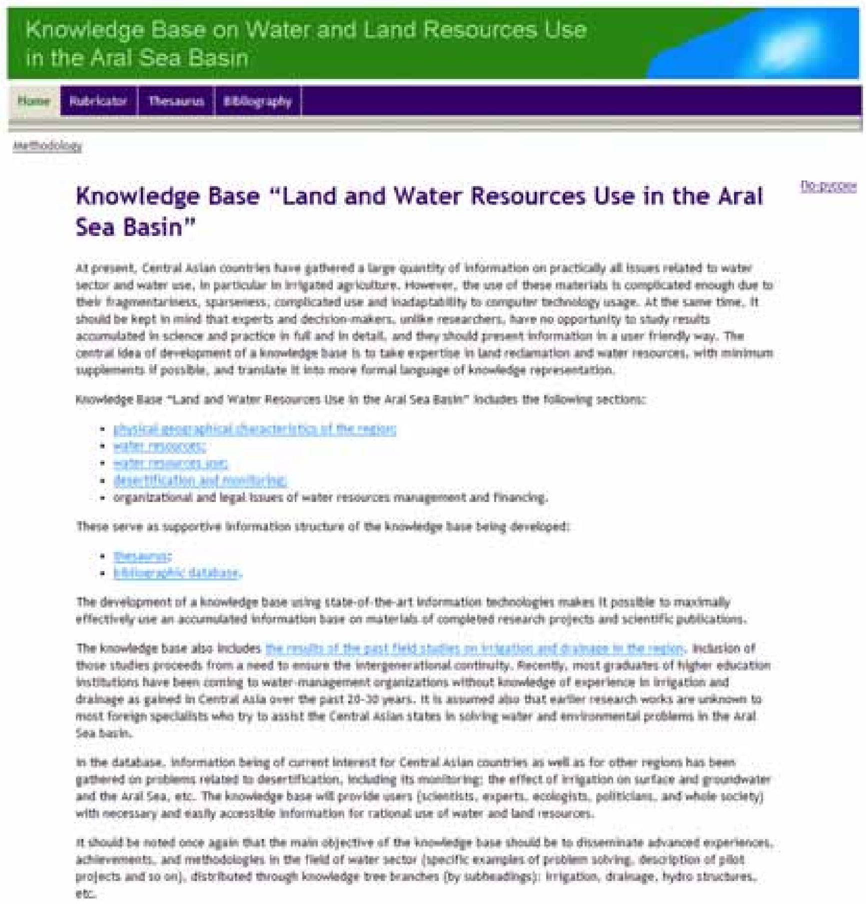
- Law of the Republic of Uzbekistan about water and water use
- Law of the Republic of Uzbekistan about amendments of some legislative enactments of the Republic of Uzbekistan due to deeper economic reforms in agriculture and water sector
- Law of the Republic of Uzbekistan about state sanitary control
- Law of the Republic of Uzbekistan about nature protection
- Law of the Republic of Uzbekistan about amendments of the law on nature protection

www.cawater-info.net/library/carewib.htm

Knowledge Base «Water and Land Resources Use in the Aral Sea Basin»

The Knowledge base covers the following categories:

- physical-geographic characteristics of the region;
- water resources;
- water use;
- desertification and its monitoring;
- institutional and legal aspects of water management and financing.



Knowledge Base on Water and Land Resources Use
in the Aral Sea Basin

Home | Rubricator | Thesaurus | Bibliography

Methodology

По-русски

Knowledge Base "Land and Water Resources Use in the Aral Sea Basin"

At present, Central Asian countries have gathered a large quantity of information on practically all issues related to water sector and water use, in particular in irrigated agriculture. However, the use of these materials is complicated enough due to their fragmentariness, sparseness, complicated use and inadaptability to computer technology usage. At the same time, it should be kept in mind that experts and decision-makers, unlike researchers, have no opportunity to study results accumulated in science and practice in full and in detail, and they should present information in a user friendly way. The central idea of development of a knowledge base is to take expertise in land reclamation and water resources, with minimum supplements if possible, and translate it into more formal language of knowledge representation.

Knowledge Base "Land and Water Resources Use in the Aral Sea Basin" includes the following sections:

- physical-geographical characteristics of the region;
- water resources;
- water resources use;
- desertification and monitoring;
- organizational and legal issues of water resources management and financing.

These serve as supportive information structure of the knowledge base being developed:

- thesaurus;
- bibliographic database.

The development of a knowledge base using state-of-the-art information technologies makes it possible to maximally effectively use an accumulated information base on materials of completed research projects and scientific publications.

The knowledge base also includes the results of the past field studies on irrigation and drainage in the region. Inclusion of those studies proceeds from a need to ensure the intergenerational continuity. Recently, most graduates of higher education institutions have been coming to water-management organizations without knowledge of experience in irrigation and drainage as gained in Central Asia over the past 20-30 years. It is assumed also that earlier research works are unknown to most foreign specialists who try to assist the Central Asian states in solving water and environmental problems in the Aral Sea basin.

In the database, information being of current interest for Central Asian countries as well as for other regions has been gathered on problems related to desertification, including its monitoring; the effect of irrigation on surface and groundwater and the Aral Sea, etc. The knowledge base will provide users (scientists, experts, ecologists, politicians, and whole society) with necessary and easily accessible information for rational use of water and land resources.

It should be noted once again that the main objective of the knowledge base should be to disseminate advanced experiences, achievements, and methodologies in the field of water sector (specific examples of problem solving, description of pilot projects and so on), distributed through knowledge tree branches (by subheadings): irrigation, drainage, hydro structures, etc.

The water quality issues are touched upon in the following sections

- Water quality
- Water quality criteria
- Drinking water quality
- Surface water quality
- Groundwater quality
- Wastewater quality
- Water quality management

The knowledge base also contains the electronic thesaurus "Hydrochemistry". The background materials on hydrochemistry are structured in such a way that the user can have information on physical-chemical properties, forms of migration, main regulated indicators ($MAC_{water\ bodies}$ and $MAC_{fishery\ bodies}$), as well as information on potential sources of pollutants for water bodies.

The thesaurus lists the general, aggregate, and individual indicators of water quality reflecting the existing gradation and obligatory parameters for observation programs, mainly those conducted by Hydromets.

www.cawater-info.net/bk/water_land_resources_use/

Database

Analytical tools

Regional Information System on Land and Water Resources

The regional information system on water and land resources in the Aral Sea Basin, first of all, is designed to support decision-making in the water sector of Central Asia.

The main objective of IS to serve as a common tool for accounting land and water resources in the Aral Sea basin, including capacities for assessment of diverse aspects of these resources use and effectiveness and for forecasting. It should facilitate sustainable management and control of water resources use.

The system gives an opportunity to steadily evaluate water effectiveness in all uses and identify the non-productive losses.

The information system shared by all riparian states encourages confidence, solidarity and a sense of mutual responsibility.

Available data series since 1980 (time interval: year/season [growing, non-growing]/month).

As a whole, the information system includes more than 150 parameters

A new section "**Water quality**" was added to IS during implementation of the project "Water Quality in Central Asia".

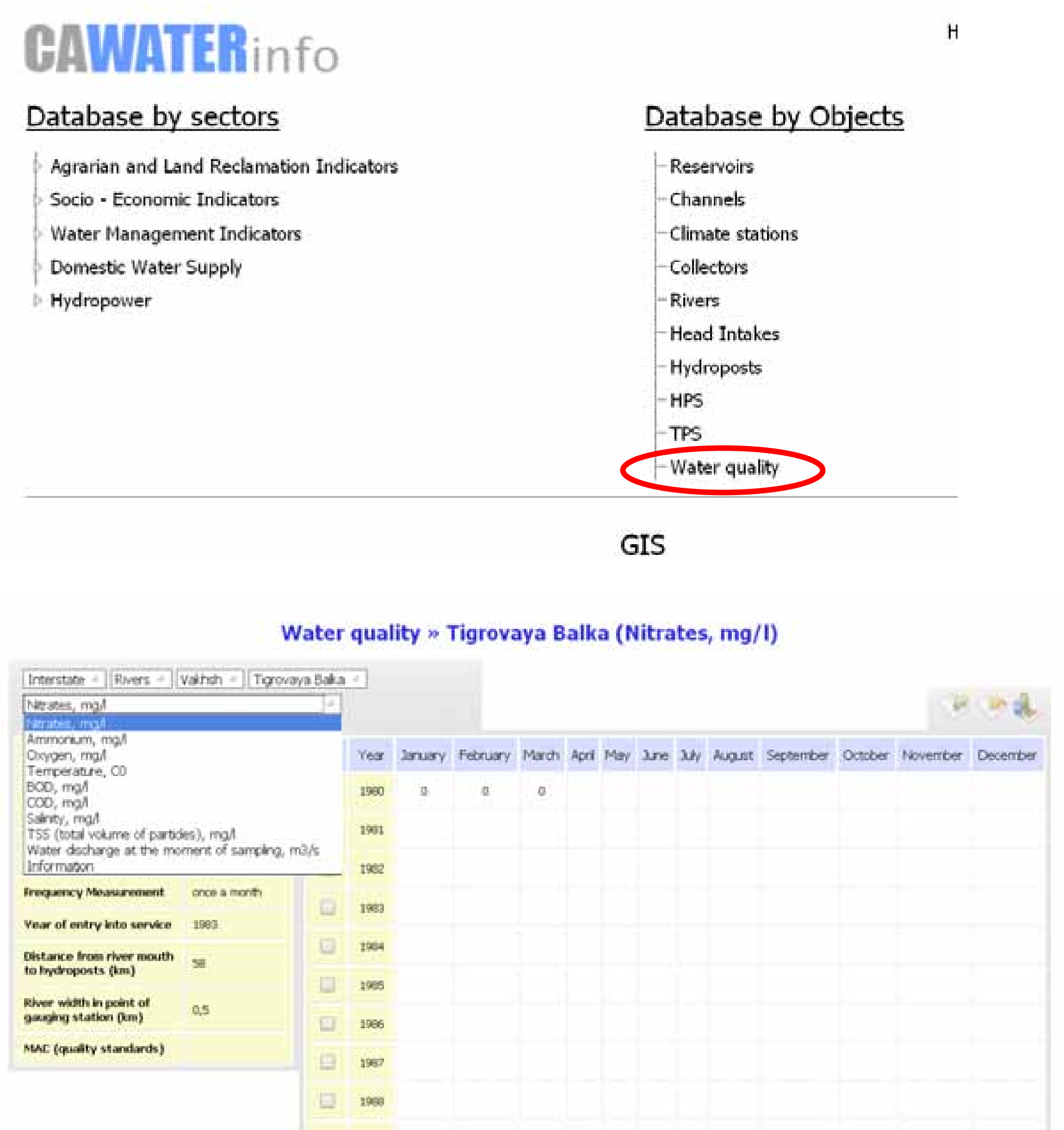


Fig. 13

www.cawater-info.net/data_ca/

Database on the Amudarya river basin

This section contains the following data on water quality

In the tabular form:
- The reach from Kelif gauging station to Tuyamuyun reservoir
  - Collector-drainage water flowing into the Amudarya river
  - Salinity of CDW flowing into the Amudarya river

- The reach from Tuyamuyun reservoir to Samanbay gauging station
  - Collector-drainage water flowing into the Amudarya river
  - Salinity of CDW flowing into the Amudarya river

- The reach from Samanbay gauging station to the Aral Sea
  - Collector-drainage water flowing into Prearalie
  - Salinity of CDW flowing into the Amudarya river

- Dynamics of annual salt influx in the Amudarya along its stem stream for different flow probabilities
- History of changes that influence the lower reaches of the Amudarya
- History of changes that influence the middle reaches of the Amudarya

In the graphical form:
- Dynamics of annual salt influx in the Amudarya along its stem stream for different flow probabilities
- Dynamics of water and salt inflows in South Prearalie
- Dynamics of water and salt inflows to Tuyamuyun

www.cawater-info.net/amudarya/

Database on the Syrdarya river basin

This section contains the following data on water quality:
- Dynamics of average annual water salinity in Syrdarya

www.cawater-info.net/syrdarya/

Database on the Aral Sea

Water quality is touched upon in the following pages of this section:

Bathymetry of the Aral Sea (1950-2009)

Salt influx in the Aral Sea

www.cawater-info/aral/data/

Database «Indicators of sustainable development for the Central Asian countries»

This section, which was developed together with the Interstate Commission for Sustainable Development, contains data on the indicators of sustainable development for the Central Asian countries. The water quality issues are dealt with in the indicator section "Water resources".

www.cawater-info/ecoindicators/

Annex

List of abbreviations

BOD	biochemical oxygen demand
BOD_5	biochemical oxygen demand for 5 days
ZIFC	zone of intensive flow consumption
FFZ	flow formation zone
WPI	water pollution index
CDW	collector drainage water
CDF	collector drainage flow
MAC	maximum allowable concentration
$MAC_{water\ bodies}$	MAC for water bodies
$MAC_{fishery\ bodies}$	MAC for fishery water bodies
COD	chemical oxygen demand
CHAKIR	Chirchik-Angren irrigation district

Salinity of CDW flowing into the Amudarya river, the reach from Kelif gauging station to Tuyamuyun reservoir, g/l

Collector drain	Year	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average
Main left-bank collector drain	1990-1991				2.88	2.88	5.70	5.70	3.10	2.23	2.55	2.55	2.58	3.23
	1991-1992	2.70	2.70	3.20	3.20	3.30	2.35	2.45	2.45	2.71	2.08	1.80	1.78	2.54
	1992-1993	1.83	2.65	2.38	2.65	2.06	2.40	2.68	2.68	2.12	1.97	1.97	0.92	2.17
	1993-1994	2.01	2.34	2.24	3.15	2.07	2.37	2.60	2.42	2.21	2.27	1.61	2.85	2.32
	1994-1995	2.84	2.34	2.43	2.76	2.03	2.10	2.02	2.58	2.14	1.96	1.99	2.01	2.26
	1995-1996	2.38	2.33	2.54	2.24	2.29	2.09	2.18	2.22	2.53	1.73	1.76	2.07	2.18
	1996-1997	2.03	2.06	2.06	2.27	2.03	2.31	2.42	2.34	1.82	1.82	2.10	1.01	2.05
	1997-1998	1.99	2.10	2.35	2.18	1.87	2.13	2.14	2.50	1.93	1.78	1.81	1.79	2.06
	1998-1999	1.87	1.92	1.96	2.33	2.44	2.41	2.30	2.33	2.08	1.76	1.80	2.43	2.14
	1999-2000	2.27	2.58	1.86	2.04	2.16	2.20	2.26	2.20	2.12	1.98	1.95	1.97	2.13
	2000-2001	1.99	1.96	1.96	1.92	2.07	2.11	2.14	2.62	2.37	2.12	2.42	2.75	2.20
	2001-2002	2.54	1.81	1.87	1.97	1.86	1.81	1.87	2.08	2.14	2.32	1.94	1.25	1.94
	2002-2003	1.76	2.10	1.93	1.66	1.68	1.45	1.96	1.94	1.96	1.84	1.80	1.76	1.83
	2003-2004	1.76	2.26	2.28	2.20	1.98	2.01	2.00	2.00	1.93	1.89	1.80	1.87	1.97
	2004-2005	1.77	1.70	1.74	2.23	2.13	2.08	1.82	1.33	1.34	2.01	2.00	2.00	1.83
	2005-2006	2.10	1.58	1.68	2.30	2.12	2.20	2.20	2.57	2.61	2.60	2.05	1.70	2.17
	2006-2007	2.03	1.70	1.56	1.84	2.58	1.82	1.78	1.88	1.85	1.83	1.78	2.00	1.85
	2007-2008	2.12	2.00	1.92	1.79	2.02	2.50	2.44	2.33	2.21	2.07	1.92	1.85	2.09
	2008-2009	1.63	1.85	1.85	1.82	1.82	2.06	2.05	1.78	1.63	1.66	1.89	1.94	1.84
	2009-2010	1.63	1.68	1.76	1.56	1.69	1.87	1.80	1.36	1.24	1.33	1.47	1.48	1.58
	2010-2011	1.43	1.54	1.56	1.72	1.84	2.14							
Gravity Farab	1990-1991				5.03	5.03	5.03	5.30	2.80	3.24	3.24	3.24	2.76	3.72
	1991-1992	3.10	3.10	3.71	4.70	4.60	2.65	2.67	2.50	2.50	2.88	2.38	3.13	3.12
	1992-1993	3.18	3.43	3.09	2.07	4.72	3.20	3.23	3.23	2.76	2.81	2.81	2.65	3.05
	1993-1994	3.61	3.82	3.25	5.33	3.52	2.45	2.78	3.16	3.50	2.63	2.64	2.92	3.19
	1994-1995	3.24	3.82	2.96	5.88	5.21	2.15	2.30	2.74	3.12	2.90	2.64	2.75	3.28
	1995-1996	2.93	3.24	4.56	5.03	5.03	5.03	5.30	2.80	3.24	3.24	3.24	2.76	3.82
	1996-1997	3.10	3.10	3.71	4.65	4.88	4.40	4.00	3.63	3.53	3.35	3.12	3.00	3.69
	1997-1998	3.00	2.85	3.42	4.22	4.68	3.34	2.79	2.62	4.30	4.80	8.14	2.11	3.97
	1998-1999	2.19	2.06	2.06	2.85	3.53	3.16	2.70	2.65	2.11	2.05	2.43	2.67	2.51
	1999-2000	4.14	4.75	4.30	4.85	3.90	3.40	3.72	2.51	2.37	2.99	3.43	3.53	3.66
	2000-2001	3.20	3.99	3.54	2.39	2.45	2.37	2.62	2.41	2.50	2.70	2.68	2.47	2.78
	2001-	2.23	2.06	2.09	2.10	2.94	2.90	2.83	2.85	2.11	2.15	2.11	2.20	2.36

Collector drain	Year	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average
	2002													
	2002-2003	2.18	2.12	2.25	1.53	1.86	1.94	2.24	2.74	2.49	2.31	1.77	1.83	2.11
	2003-2004	2.09	3.83	2.88	3.23	2.07	2.21	2.20	2.00	2.22	2.23	1.89	1.92	2.30
	2004-2005	1.99	2.10	2.10	2.70	0.00	2.12	2.18	2.13	2.00	2.02	1.93	1.96	1.95
	2005-2006	1.78	1.75	2.13	2.65	2.38	2.43	2.69	2.95	2.83	2.26	2.20	2.19	2.38
	2006-2007	1.95	2.00	1.96	2.10	2.03	2.01	2.18	2.84	3.00	2.86	3.56	3.98	2.51
	2007-2008	3.92	3.56	3.50	1.87	2.06	1.68	1.16	2.36	2.06	2.93	1.96	1.93	2.32
	2008-2009	1.98	1.83	2.06	1.87	3.24	2.10	2.20	1.90	1.85	1.92	1.95	2.40	2.09
	2009-2010	2.61	2.78	2.70	1.98	2.11	2.29	3.40	2.13	2.00	1.70	1.67	1.87	2.29
	2010-2011	2.16	2.09	2.02	1.91	2.47	2.02							
Main Darganata	1990-1991				4.25	4.25	3.85	3.85	3.30	4.63	3.96	3.96	3.53	4.05
	1991-1992	4.81	4.81	4.15	5.00	5.10	4.57	2.61	2.50	2.50	3.27	2.71	2.85	3.57
	1992-1993	2.47	4.69	3.89	4.22	4.23	3.38	4.35	4.35	2.65	2.91	2.91	2.99	3.57
	1993-1994	5.53	4.97	3.62	4.47	4.48	3.45	3.37	3.08	3.20	4.24	3.34	2.82	3.79
	1994-1995	4.56	4.97	3.80	6.75	4.79	3.09	3.30	4.04	3.12	2.28	2.23	2.27	3.75
	1995-1996	3.03	3.24	5.00	4.32	5.10	1.41	2.81	3.45	2.95	2.10	2.37	2.66	3.17
	1996-1997	2.95	3.26	3.29	3.56	3.50	3.70	4.38	4.62	4.28	4.34	4.20	3.90	3.97
	1997-1998	4.47	6.12	5.55	6.76	3.57	3.84	2.26	2.14	2.20	2.39	2.18	3.68	3.03
	1998-1999	2.49	3.57	3.57	2.91	2.50	3.21	3.53	1.83	2.50	1.95	2.20	2.15	3.00
	1999-2000	2.84	3.41	3.92	3.00	2.43	2.14	2.53	3.22	2.12	2.14	2.27	2.34	2.68
	2000-2001	2.32	2.33	0.00	3.86	2.99	3.25	3.04	3.55	2.91	3.20	3.34	3.62	2.93
	2001-2002	3.90	3.00	0.00	0.00	3.25	2.49	2.49	3.23	3.12	3.56	3.22	1.46	2.74
	2002-2003	1.67	1.46	0.00	4.27	3.68	2.55	2.29	2.52	1.82	1.43	1.07	1.00	1.96
	2003-2004	1.90	2.22	1.05	2.26	2.12	3.06	3.29	3.41	3.45	3.56	3.83	3.21	2.65
	2004-2005	3.51	3.79	3.79	3.99	5.19	4.65	4.88	2.32	2.74	1.23	1.16	1.44	2.88
	2005-2006	3.71	4.40	4.00	2.88	3.58	5.98	3.54	4.30	2.25	5.94	5.89	5.25	4.79
	2006-2007	4.29	3.93	3.39	4.62	4.43	4.13	4.25	4.46	4.43	3.67	3.18	2.80	3.86
	2007-2008	3.57	3.20	2.87	3.16	3.12	3.91	1.77	1.80	3.00	3.65	4.42	4.80	3.21
	2008-2009	2.20	2.09	5.05	2.35	4.17	2.60	3.32	5.60	2.75	4.37	3.30	4.00	4.00
	2009-2010	4.20	4.10	4.00	4.31	4.15	3.64	4.29	3.93	3.90	4.50	4.63	4.57	4.20
	2010-2011	4.88	4.11	3.25	3.27	3.81	3.38							
	1990-1991				1.52	1.52	1.36	1.36	1.40	1.40	1.44	1.44	1.24	1.35
	1991-1992	1.10	1.10	1.30	1.20	1.20	1.36	1.36	1.33	1.33	1.13	1.19	1.00	1.25
	1992-1993	1.20	1.14	1.26	1.13	1.04	0.94	1.27	1.27	1.40	1.00	1.00	4.81	1.58
	1993-1994	1.00	2.05	1.23	1.67	1.21	1.18	1.02	1.22	1.12	1.15	1.18	1.13	1.26

Collector drain	Year	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average
Khalach	1994-1995	1.21	2.05	1.12	1.43	1.60	1.30	1.06	0.98	1.57	1.12	1.10	1.24	1.31
	1995-1996	1.24	1.09	1.26	1.37	1.39	1.45	1.41	1.33	1.19	1.13	1.26	1.05	1.27
	1996-1997	1.05	1.28	1.28	4.54	1.44	1.23	1.45	1.18	1.71	1.15	2.13	1.01	1.60
	1997-1998	1.12	1.19	2.35	1.27	1.51	1.23	1.42	3.20	2.38	1.27	1.25	1.16	1.60
	1998-1999	1.37	1.38	1.38	1.77	1.20	1.32	1.20	3.27	1.11	3.96	1.20	1.27	1.73
	1999-2000	1.53	1.51	1.41	1.26	0.92	0.95	0.99	1.07	0.11	1.05	1.05	0.99	1.11
	2000-2001	1.01	1.03	1.07	1.14	1.23	1.12	1.14	1.28	1.23	1.09	0.76	1.00	1.07
	2001-2002	0.98	1.17	1.20	1.51	1.54	1.60	1.26	1.33	1.15	1.23	0.67	1.49	1.27
	2002-2003	1.83	1.95	1.90	1.54	2.62	2.31	1.37	1.82	2.60	3.06	2.96	3.06	2.16
	2003-2004	3.21	3.04	3.03	1.20	1.25	1.33	1.40	1.42	1.07	1.12	1.16	1.01	1.55
	2004-2005	1.07	1.13	1.20	1.52	1.29	1.44	1.24	1.45	1.15	1.17	1.10	1.05	1.24
	2005-2006	1.20	1.10	1.20	1.07	1.00	1.36	1.38	1.44	1.55	1.10	1.31	0.97	1.26
	2006-2007	1.14	1.00	0.98	1.54	1.14	1.49	1.09	1.16	1.25	1.01	0.92	1.38	1.17
	2007-2008	1.68	1.05	1.00	1.15	1.26	1.34	1.37	1.05	1.00	1.16	1.07	0.96	1.17
	2008-2009	1.19	0.96	1.26	1.06	1.25	1.31	1.22	1.12	1.08	0.97	1.02	1.05	1.11
	2009-2010	1.05	1.25	1.14	1.14	1.12	1.17	1.25	1.16	1.21	1.12	1.12	0.94	1.14
	2010-2011	1.18	0.98	1.34	1.12	1.21	1.27							
Burdalik	1990-1991				2.11	2.11	1.98	1.35	1.13	2.08	1.95	1.95	1.68	1.78
	1991-1992	2.20	2.02	1.83	2.14	2.20	1.97	1.64	1.50	1.50	1.43	1.54	1.45	1.82
	1992-1993	1.47	1.89	1.72	1.74	1.70	1.12	1.78	1.78	1.70	1.54	1.54	3.56	1.78
	1993-1994	1.75	1.47	1.58	1.64	2.27	1.72	2.18	2.21	1.76	1.78	1.44	1.58	1.79
	1994-1995	1.66	1.47	1.67	1.89	1.58	1.87	1.80	1.91	2.06	1.55	1.67	1.37	1.68
	1995-1996	1.59	1.75	1.82	1.40	2.04	1.77	1.97	1.96	1.76	1.57	1.44	1.68	1.75
	1996-1997	1.75	1.84	1.84	1.87	1.78	1.91	1.79	1.85	1.44	1.43	1.69	1.63	1.71
	1997-1998	1.62	2.21	2.05	2.14	1.58	2.37	2.67	2.08	2.00	1.85	1.55	2.17	1.99
	1998-1999	2.23	2.05	2.05	1.64	2.33	2.37	2.15	2.35	2.48	1.88	2.33	1.98	2.14
	1999-2000	2.03	2.05	1.95	1.79	1.82	1.93	1.90	1.88	1.90	1.95	1.95	1.96	1.92
	2000-2001	1.96	1.90	1.96	1.59	0.88	1.08	0.88	1.16	2.01	1.30	1.66	1.43	1.50
	2001-2002	2.10	2.00	1.90	1.51	1.54	1.60	1.26	1.33	1.15	1.23	0.67	1.49	1.59
	2002-2003	1.83	1.95	2.00	1.16	1.23	1.35	1.29	1.32	1.34	1.56	1.63	1.61	1.56
	2003-2004	1.57	1.71	2.08	1.78	1.67	1.46	1.47	1.33	1.80	1.84	1.85	1.86	1.70
	2004-2005	1.88	1.88	1.88	1.78	1.35	1.51	1.96	1.44	0.34	1.78	1.39	1.76	1.49
	2005-2006	1.98	2.46	2.69	1.85	2.00	2.47	2.25	1.85	1.80	1.76	1.60	2.19	2.04
	2006-2007	1.39	2.36	1.81	1.71	1.61	2.01	1.82	3.37	2.43	1.27	1.92	1.68	1.98

	2007-2008	1.70	2.02	2.23	1.92	1.88	1.64	1.71	1.64	1.48	2.16	1.03	1.65	1.69
	2008-2009	1.90	1.68	1.88	2.02	1.40	1.50	1.57	1.50	1.44	1.16	1.46	3.78	1.73
	2009-2010	3.29	2.90	1.81	1.77	2.07	1.37	1.84	2.00	2.23	4.87	3.19	3.37	2.57
	2010-2011	3.97	4.78	2.95	1.90	1.78	1.50							
	1990-1991				0.97	1.20	3.50	3.50	3.08	3.45	4.33	4.33	3.70	3.22
	1991-1992	3.60	3.65	3.22	3.60	3.70	4.65	4.45	4.36	4.35	4.84	4.64	4.57	4.16
	1992-1993	4.38	4.41	4.29	3.12	3.12	4.90	5.44	5.44	5.67	5.44	5.44	4.57	4.96
	1993-1994	5.08	4.80	5.00	2.81	4.07	3.96	3.36	4.09	4.48	4.39	3.45	2.52	4.08
	1994-1995	3.10	2.65	4.69	5.01	5.45	12.04	5.51	4.17	3.86	8.86	4.35	4.87	5.47
	1995-1996	4.52	10.11	4.14	4.91	7.67	3.83	9.60	4.03	3.84	7.11	5.09	1.97	5.57
	1996-1997	3.72	5.56	5.56	4.16	4.30	4.50	4.69	4.68	4.74	4.15	4.75	4.18	4.55
	1997-1998	1.60	4.80	4.45	4.37	5.00	4.72	4.98	5.35	4.41	4.84	4.85	3.94	4.58
	1998-1999	4.06	4.10	4.10	4.77	5.11	5.58	4.29	3.48	6.76	5.61	4.57	4.93	4.71
	1999-2000	4.11	3.78	3.59	4.00	4.91	5.00	4.19	4.00	4.53	5.24	5.80	5.94	4.55
Charshangi	2000-2001	4.53	4.04	4.38	3.96	4.05	4.15	4.02	3.22	2.41	2.89	3.94	4.98	3.94
	2001-2002	3.59	3.44	3.29	3.87	3.97	4.08	4.15	4.07	4.11	4.08	4.18	3.92	3.92
	2002-2003	3.68	3.29	3.20	3.81	3.11	2.64	1.83	2.84	3.87	5.52	5.64	5.89	3.69
	2003-2004	6.05	11.43	6.96	3.90	3.90	4.05	4.17	3.80	3.78	3.90	4.00	6.60	4.90
	2004-2005	4.99	4.73	4.73	2.85	3.34	5.78	4.38	8.81	4.29	4.43	3.82	3.94	4.81
	2005-2006	3.71	3.91	3.44	2.85	3.39	5.78	4.38	8.81	4.29	4.43	3.82	3.94	4.82
	2006-2007	3.71	3.91	3.44	3.34	4.74	3.40	4.57	6.05	4.77	3.54	6.15	4.24	4.27
	2007-2008	3.96	4.97	4.86	5.04	4.60	3.75	4.10	4.10	4.02	3.55	3.39	4.11	4.13
	2008-2009	4.29	4.68	4.51	4.09	6.52	4.00	3.98	3.83	5.38	4.61	5.04	5.82	4.78
	2009-2010	8.06	7.00	6.27	5.74	5.51	6.35	4.42	4.24	3.50	2.40	5.46	4.05	5.13
	2010-2011	3.51	5.12	5.04	4.96	5.54	4.70							
	1990-1991				3.26	3.26	0.57	3.64	0.79	2.93	3.16	3.16	2.02	2.47
	1991-1992	2.65	2.67	3.24	3.20	3.25	3.19	2.06	2.00	2.00	2.19	2.60	2.35	2.58
	1992-1993	2.84	1.71	2.53	1.69	1.69	1.98	2.03	2.03	2.38	2.68	2.68	1.95	2.19
	1993-1994	1.24	1.90	2.10	6.97	1.88	3.18	2.79	2.77	1.08	1.10	1.42	1.18	2.12
	1994-1995	3.99	1.90	2.39	2.38	5.00	4.60	3.29	4.44	1.52	1.00	1.63	4.16	3.12
	1995-1996	2.56	1.60	1.99	1.89	5.40	1.95	4.13	4.31	2.69	3.45	3.36	3.25	3.08
	1996-1997	4.54	4.44	4.44	2.13	2.85	2.23	2.50	2.43	1.03	3.15	2.41	2.89	2.86
	1997-1998	1.69	1.80	1.96	1.61	2.06	2.67	3.93	3.34	1.58	2.12	2.45	2.87	2.39
	1998-1999	4.09	1.56	1.56	1.61	1.99	3.04	2.83	2.73	2.61	2.49	2.64	2.01	2.48
	1999-2000	2.16	2.79	2.83	2.12	2.18	2.32	2.55	2.90	2.81	2.75	2.84	2.92	2.54
Khodjamba	2000-2001	3.00	3.02	3.04	1.64	2.24	2.25	2.23	1.68	2.49	2.05	2.11	2.39	2.35

	2001-2002	2.70	2.60	2.44	1.50	2.79	1.53	1.05	2.84	2.48	2.53	2.55	1.90	2.22
	2002-2003	1.64	1.53	1.71	1.54	2.62	2.31	1.37	1.88	2.56	3.06	2.96	3.06	2.15
	2003-2004	3.21	3.04	3.03	1.84	1.80	1.73	1.70	1.64	1.70	1.72	1.57	1.90	2.03
	2004-2005	1.90	1.99	1.79	1.76	2.35	3.82	4.26	3.76	3.64	4.24	1.39	1.35	2.96
	2005-2006	1.80	3.59	2.69	3.07	4.32	4.60	2.29	3.65	3.22	2.95	2.12	2.56	3.11
	2006-2007	2.80	3.37	3.78	5.55	4.14	7.90	2.90	4.31	3.68	4.22	3.79	3.46	4.09
	2007-2008	2.22	2.11	2.57	2.31	2.05	1.60	4.07	4.10	3.35	3.41	3.19	3.53	3.00
	2008-2009	3.20	3.22	2.12	1.95	1.04	1.49	2.66	3.26	3.81	3.49	4.51	3.82	2.94
	2009-2010	5.19	6.03	5.87	3.33	2.10	5.57	4.21	1.91	4.33	4.85	3.17	5.32	4.33
	2010-2011	4.05	4.69	3.17	2.53	1.73	2.89							
Mekan	1990-1991				1.35	1.35	1.62	1.14	1.77	1.60	1.73	1.73	1.24	1.55
	1991-1992	2.10	1.86	1.62	1.70	1.80	1.49	1.52	1.45	1.45	1.49	1.43	1.51	1.62
	1992-1993	1.98	1.50	1.57	1.55	1.67	1.70	1.15	1.15	1.61	1.57	1.57	2.14	1.58
	1993-1994	1.26	1.40	1.47	1.54	1.54	2.01	1.51	1.17	1.70	1.51	1.61	1.76	1.55
	1994-1995	1.49	1.40	1.56	2.82	2.14	1.68	2.44	1.57	2.03	1.72	1.40	1.05	1.77
	1995-1996	1.23	1.55	2.19	1.55	2.66	1.52	1.90	1.89	1.89	1.78	1.66	2.08	1.83
	1996-1997	1.62	1.57	1.57	1.92	1.41	1.94	1.96	1.87	1.72	1.28	1.80	1.79	1.72
	1997-1998	1.68	1.73	1.83	1.95	1.89	0.29	0.22	0.20	1.69	2.30	1.81	1.88	1.46
	1998-1999	1.75	1.75	1.75	1.92	1.98	2.11	2.25	2.06	1.95	1.82	1.87	1.82	1.92
	1999-2000	1.76	1.86	1.96	1.77	1.71	1.75	1.74	1.72	1.69	1.61	1.62	1.64	1.75
	2000-2001	1.75	1.79	0.00	1.47	1.62	1.95	1.38	1.52	1.62	1.73	1.69	1.65	1.68
	2001-2002	1.75	1.81	1.83	1.00	1.56	1.81	2.06	1.87	1.76	1.93	1.61	1.40	1.65
	2002-2003	1.32	1.63	1.65	1.67	1.50	1.47	1.70	1.76	1.76	1.68	1.63	1.51	1.58
	2003-2004	1.39	2.57	3.17	1.95	1.95	2.11	2.00	1.81	1.70	1.64	1.55	1.62	1.87
	2004-2005	1.71	1.80	1.80	1.75	1.84	1.66	1.67	1.89	1.69	1.81	1.71	1.49	1.75
	2005-2006	1.61	1.58	2.04	1.79	1.52	1.63	2.06	2.21	1.93	1.71	1.94	1.64	1.82
	2006-2007	1.40	2.31	1.72	1.38	1.32	1.35	1.47	1.73	2.40	2.50	1.27	1.01	1.69
	2007-2008	1.36	1.13	1.82	2.05	2.04	1.80	1.30	2.92	2.27	3.53	3.09	2.76	2.16
	2008-2009	1.23	1.04	2.16	1.61	1.48	1.85	3.20	2.00	1.61	3.19	4.52	3.92	2.56
	2009-2010	3.10	3.97	3.93	5.70	1.98	5.61	4.32	1.77	3.84	4.91	2.61	3.39	3.77
	2010-2011	3.51	4.92	3.17	3.12	1.83	3.09							

Parsankul	1990-1991				4.16	5.43	5.14	4.96	5.27	5.34	4.22	4.32	5.65	5.09
	1991-1992	4.71	5.14	4.92	4.32	4.80	4.59	4.20	4.73	5.02	4.18	4.86	4.26	4.64
	1992-1993	4.93	4.99	5.42	4.35	4.14	4.09	4.82	4.19	4.02	5.02	4.42	4.73	4.40
	1993-1994	4.55	5.00	4.28	4.78	4.96	4.64	4.06	4.04	4.41	4.48	4.43	4.41	4.52

	1994-1995	4.06	3.80	4.00	4.89	6.49	4.69	4.32	4.48	5.41	5.90	6.48	5.66	5.12
	1995-1996	4.94	4.71	4.41	5.30	4.86	4.22	4.86	4.00	4.04	4.59	4.55	4.40	4.53
	1996-1997	4.35	5.96	5.33	5.24	5.90	4.81	5.14	5.93	4.97	5.48	5.45	4.84	5.27
	1997-1998	5.42	4.03	5.05	4.96	4.04	4.47	5.03	4.66	4.04	4.39	5.58	4.91	4.63
	1998-1999	5.16	4.70	4.55	4.09	4.71	4.30	4.42	4.49	4.09	4.50	4.71	4.16	4.49
	1999-2000	3.74	2.97	4.61	4.09	4.17	4.65	6.00	4.96	4.91	3.89	4.79	4.96	4.58
	2000-2001	5.53	5.16	5.68	4.78	4.52	4.03	4.84	4.87	4.72	5.06	5.11	5.55	4.74
	2001-2002	5.77	5.90	4.66	4.37	4.55	4.15	4.62	5.29	4.52	5.95	4.97	5.58	4.83
	2002-2003	4.21	4.63	4.73	4.25	4.61	4.73	4.67	4.49	4.49	4.90	4.95	5.29	4.66
	2003-2004	4.42	4.44	5.33	5.37	5.60	5.88	4.01	4.17	4.70	4.42	4.47	4.42	4.88
	2004-2005	5.37	5.06	3.21	4.85	3.27	4.98	4.34	4.43	4.58	4.64	4.93	4.77	4.47
	2005-2006	4.22	4.65	4.90	4.57	4.19	4.81	5.81	4.94	4.16	4.50	5.37	4.81	4.77
	2006-2007	4.65	5.16	5.19	4.47	3.66	4.19	5.73	4.90	4.89	4.24	4.37	4.62	4.54
	2007-2008	4.34	4.88	4.45	4.71	4.61	4.64	4.76	5.12	5.84	5.06	5.61	4.58	4.84
	2008-2009	3.90	4.56	4.13										
	2009-2010													
	2010-2011													
	1990-1991													
	1991-1992													
	1992-1993													
	1993-1994													
	1994-1995													
	1995-1996				7.13	6.25	5.37	6.96	6.71	6.79	4.45	4.49	5.00	
	1996-1997	4.44	4.63	4.63	7.23	6.87	5.88	4.95	5.10	5.21	7.04	6.85	7.59	6.15
	1997-1998	7.00	6.94	7.03	7.60	6.87	5.88	5.39	7.20	6.35	6.28	5.30	6.86	6.53
	1998-1999	7.12	6.55	6.55	6.34	7.61	7.31	5.27	6.18	5.82	6.28	6.29	6.81	6.40
	1999-2000	7.54	6.47	6.23	5.99	6.08	5.95	6.03	6.77	6.52	5.08	8.13	7.93	6.88
South Karshi	2000-2001	7.66	7.32	0.00	6.56	6.95	6.05	7.85	8.94	10.03	9.84	7.84	7.45	7.91
	2001-2002	7.32	7.19	6.96	5.90	4.58	4.57	4.90	2.86	1.68	7.60	7.46	7.23	5.33
	2002-2003	0.00	6.88	0.00	2.97	3.14	3.31	2.89	1.92	2.50	2.04	1.17	1.70	2.27
	2003-2004	1.20	1.27	1.05	6.82	6.76	6.41	6.56	6.66	6.46	6.36	6.28	6.52	6.43
	2004-2005	4.94	5.84	5.82	6.32	6.25	5.97	6.39	5.96	6.11	6.20	6.10	6.42	6.14
	2005-2006	6.67	6.21	5.68	6.02	5.66	6.50	7.08	7.04	7.56	8.04	7.80	6.87	7.09
	2006-2007	6.03	6.00	5.95	6.15	5.89	6.35	6.17	8.04	7.50	7.00	7.34	7.58	7.04
	2007-2008	6.59	6.25	6.11	6.00	6.00	5.73	6.63	7.45	7.07	6.97	7.28	7.18	6.93
	2008-2009	7.09	7.14	5.98	5.27	5.65	5.24	5.72	6.38	6.44	7.22	7.22	7.00	6.62

	2009-2010	7,09	7,18	6,93	6,27	5,98	3,36	5,77	6,03	5,91	5,87	3,82	5,85	5,62
	2010-2011	6,31	5,99	5,94	5,85	5,88	4,78							

Source: Database of BWO “Amudarya”

Salinity of CDW flowing into the Amudarya river, the reach from Tuyamuyun reservoir to Samanbay gauging station, g/l

Collector drain	Year	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average
Beruny	1990-1991				6.81	5.91	6.02	6.13	5.49	5.02	4.77	3.92	5.35	5.31
	1991-1992	5.19	5.10	5.12	5.88	6.36	6.33	6.55	8.12	5.02	4.85	3.47	3.96	5.53
	1992-1993	5.37	8.00	4.71	8.80	7.24	6.48	6.33	5.21	5.87	4.80	3.77	4.54	5.53
	1993-1994	4.76	4.73	4.53	4.57	5.94	4.99	6.44	4.73	4.81	4.57	5.21	4.43	5.03
	1994-1995	3.38	3.51	4.88	4.74	4.62	5.27	6.25	5.15	5.30	5.06	4.90	4.45	4.98
	1995-1996	4.36	4.16	3.70	3.91	4.83	5.57	5.19	6.28	5.67	5.50	3.47	4.12	4.86
	1996-1997	3.80	4.58	3.85	4.93	5.66	6.42	6.49	5.76	4.14	5.36	5.84	5.12	5.20
	1997-1998	4.81	4.45	4.36	4.46	5.32	4.92	5.77	5.01	4.34	4.32	2.55	3.12	4.43
	1998-1999	3.74	3.47	3.80	5.36	3.94	4.82	4.54	3.90	4.93	3.22	3.98	4.46	4.18
	1999-2000	2.47	3.93	3.58	5.35	5.42	4.06	5.54	5.15	4.84	6.46	4.27	3.12	4.50
	2000-2001	5.37	4.61	4.23	4.53	5.73	4.85	5.38	5.39	4.88	4.31	6.61	7.02	5.16
	2001-2002	5.50	5.40	5.44	5.48	5.37	5.45	6.12	5.09	3.86	2.64	2.65	3.17	4.34
	2002-2003	3.68	3.96	4.18	3.85	3.89	3.85	3.86	4.24	3.23	2.42	2.47	3.32	3.49
	2003-2004	4.61	6.36	3.34	5.21	4.19	4.74	4.59	4.49	3.46	2.94	2.85	3.54	4.07
	2004-2005	4.78	4.71	4.50	3.41	4.47	3.88	4.04	3.35	3.61	2.77	2.71	3.78	3.72
	2005-2006	2.90	4.61	3.97	4.42	4.94	3.37	5.23	3.85	3.77	2.92	2.81	3.84	3.75
	2006-2007	4.65	4.22	2.99	4.02	5.09	4.07	4.47	3.74	2.76	2.76	2.98	4.32	3.74
	2007-2008	3.40	4.40	4.31	3.84	3.97	5.02	3.78	4.56	4.42	3.46	3.01	3.51	4.12
	2008-2009 *	3.67	4.11	3.76										

* The collector flows towards Prearalie into lakes. Source: Database of BWO “Amudarya”

Salinity of CDW flowing into the Amudarya river, the reach from Samanbay gauging station to the Aral Sea, g/l

Collector drain	Year	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average
KC - 1	1990-1991				4.46	5.48	3.19	4.30	2.40	2.87	3.37	2.09	2.79	2.99
	1991-1992	2.37	2.14	2.20	2.96	3.74	4.06	4.13	4.67	2.32	2.19	2.75	2.72	2.69
	1992-1993	8.11	9.11	2.79	4.29	5.59	4.68	3.89	3.07	2.88	2.31	2.09	4.06	3.21
	1993-1994	2.82	3.40	2.38	2.94	1.60	3.08	4.52	3.56	2.17	2.31	2.42	2.83	2.62
	1994-1995	2.83	3.28	1.75	3.17	2.58	3.31	5.63	3.18	3.58	3.42	2.67	2.80	3.19
	1995-1996	2.97	3.20	2.03	3.28	1.87	2.83	3.54	3.01	2.26	2.20	2.25	2.50	2.54
	1996-1997	4.03	3.33	3.50	4.28	4.34	4.54	5.57	2.60	3.28	3.36	3.46	3.67	3.79
	1997-1998	4.15	4.56	4.11	1.70	2.87	3.17	3.30	3.89	1.57	1.56	1.67	3.42	2.48
	1998-1999	4.38	2.37	3.03	3.05	3.91	2.86	5.04	2.49	2.52	2.15	2.06	2.75	2.93
	1999-2000	3.19	4.18	3.36	4.28	4.18	3.44	3.21	6.60	4.20	5.69	5.98	4.24	4.16
	2000-2001	4.20	4.35	3.74	3.21	3.09	3.62	4.05	4.25	3.56	3.69	4.80	4.35	3.87
	2001-2002	0.00	0.00	0.00	0.00	0.00	3.27	3.90	3.00	2.07	1.65	2.13	2.44	2.07
	2002-2003	3.13	2.25	2.55	2.56	1.90	2.64	4.18	4.92	1.78	2.77	2.04	2.50	2.88
	2003-2004	3.05	2.62	2.05	2.85	4.85	2.94	3.01	3.28	2.18	1.87	1.95	2.28	2.49
	2004-2005	2.40	3.24	3.91	2.66	3.36	2.45	3.56	2.96	2.24	1.61	1.80	2.56	2.34
	2005-2006	2.52	2.22	1.75	2.87	2.68	4.89	4.33	3.64	1.95	2.25	2.70	2.96	2.72

Collector drain	Year	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average
	2006-2007	4.43	4.36	2.44	3.89	4.87	4.49	5.56	3.56	2.43	2.31	2.40	2.67	3.48
	2007-2008	3.18	3.13	2.55	3.46	3.24	3.39	3.83	4.84	4.34	2.99	3.17	2.97	3.38
	2008-2009	3.04	2.67	3.16										
	2009-2010				3.27	3.15	4.35	0.00	2.87	2.19	2.80	1.79	1.44	
	2010-2011	3.17	2.07	1.68	3.11	4.09	4.09							
	1990-1991				5.15	4.56	4.73	5.80	1.69	2.63	2.64	2.57	3.53	3.27
	1991-1992	3.62	3.15	4.27	4.85	2.46	5.56	5.51	4.57	3.76	3.02	2.47	2.63	3.34
	1992-1993	3.94	2.82	3.47	4.96	4.07	4.37	4.13	3.09	3.01	2.80	3.22	4.03	3.49
	1993-1994	4.84	2.45	3.80	3.69	3.33	3.72	3.74	4.04	3.09	2.16	2.13	2.46	2.95
	1994-1995	1.90	3.70	2.55	5.56	3.97	4.20	5.06	4.14	4.14	3.34	2.45	2.95	3.58
	1995-1996	3.60	5.25	3.96	4.70	3.88	3.89	4.17	4.12	3.11	3.14	2.24	3.51	3.42
	1996-1997	3.39	3.67	4.75	4.47	4.67	4.81	6.06	5.01	4.72	4.94	4.30	3.17	4.55
	1997-1998	5.07	4.96	8.68	6.89	5.68	3.05	4.53	4.25	2.38	2.41	2.13	4.42	3.61
	1998-1999	4.61	2.16	2.94	4.36	4.98	3.32	5.14	3.54	3.09	2.50	2.41	2.63	3.32
	1999-2000	4.86	4.66	2.97	4.94	4.90	4.30	5.18	6.91	6.45	3.25	11.34	0.00	5.03
KC - 3	2000-2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2001-2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.11	1.61	1.84	1.90	1.97
	2002-2003	2.47	2.55	3.32	4.00	4.25	3.97	3.73	3.99	3.38	1.85	2.21	2.46	2.81
	2003-2004	5.79	2.66	2.19	3.32	5.05	6.92	6.18	3.63	2.90	2.20	3.33	4.26	3.71
	2004-2005	3.53	5.77	5.11	3.91	4.35	3.26	5.57	4.53	3.18	2.31	2.68	3.81	3.70
	2005-2006	3.09	3.33	3.51	4.73	5.73	4.82	5.23	4.46	3.79	2.78	3.43	3.42	3.86
	2006-2007	6.05	5.06	3.60	4.03	6.22	4.58	6.23	5.85	4.84	3.00	4.52	2.83	4.62
	2007-2008	5.27	3.78	3.78	3.12	4.90	4.52	4.16	2.95	6.94	8.37	2.88	6.24	4.76
	2008-2009	5.70	5.42	5.55										
	2009-2010				5.57	4.72	4.84	0.00	5.46	4.01	3.06	4.18	4.67	
	2010-2011	4.04	2.11	0.81	4.05	3.40	3.40							
	1990-1991				4.13	4.30	3.50	3.66	2.70	2.55	2.49	1.94	2.36	2.40
	1991-1992	3.08	1.66	2.11	3.74	1.80	2.93	4.83	3.74	2.39	2.31	2.38	2.27	2.51
	1992-1993	3.56	3.74	3.57	2.73	2.10	4.35	2.50	2.29	2.05	1.96	1.64	2.28	2.06
	1993-1994	3.75	3.04	3.21	3.23	1.74	2.11	2.23	2.40	3.12	1.73	1.98	2.29	2.30
	1994-1995	2.89	2.97	2.20	2.09	1.97	2.76	4.12	2.82	2.76	2.89	2.25	2.57	2.69
	1995-1996	3.25	4.70	1.99	2.22	3.65	2.33	2.83	2.94	2.78	2.52	2.90	2.31	2.73
	1996-1997	2.83	2.49	2.58	2.59	2.55	2.12	3.10	2.95	2.72	3.18	3.18	2.65	2.83
	1997-1998	2.07	3.11	3.38	3.53	1.57	2.64	3.20	2.19	2.11	2.74	1.88	2.09	2.27
	1998-1999	2.99	3.77	3.54	3.26	3.88	3.65	3.42	3.26	2.10	2.67	2.06	3.20	2.98
	1999-2000	3.44	2.66	2.72	3.78	2.43	3.17	4.27	5.28	5.21	6.11	6.03	4.51	4.25
KC - 4	2000-2001	3.80	4.66	4.86	5.09	4.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.39
	2001-2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.28	1.75	1.70	1.59	2.24	1.84
	2002-2003	1.12	1.05	2.58	2.76	3.74	2.46	2.42	2.76	2.22	1.93	2.21	2.47	2.27
	2003-2004	1.74	2.77	3.33	2.28	2.18	2.37	3.05	2.42	2.60	2.51	1.43	1.44	2.18
	2004-2005	1.57	2.77	2.93	3.24	3.44	1.61	3.22	3.74	4.01	2.54	0.88	1.21	2.25
	2005-2006	1.63	1.57	1.18	1.55	1.17	2.57	2.86	1.38	2.02	1.75	1.79	2.00	1.87
	2006-2007	2.07	2.31	2.22	2.28	3.27	3.58	3.45	2.71	2.87	2.62	2.91	1.86	2.60
	2007-2008	2.57	2.92	2.67	4.40	3.82	3.83	3.88	2.34	5.35	4.81	4.98	0.00	3.64
	2008-2009	0.00	0.00	0.00										
	2009-2010				2.62	3.38	3.60	0.00	1.68	1.84	1.57	1.65	2.03	
	2010-2011	1.20	1.71	0.97	2.95	1.96	2.62							
	1990-1991				4.91	4.86	4.02	4.84	4.26	2.91	2.59	2.27	3.07	3.51
	1991-1992	4.08	4.49	4.03	4.28	4.60	4.82	4.54	5.13	3.96	3.39	2.84	2.00	3.79
	1992-1993	3.07	3.12	3.46	4.50	4.59	4.66	3.96	3.79	3.50	3.72	2.20	3.52	3.60
	1993-1994	3.26	2.99	3.93	4.77	3.92	3.32	2.76	4.63	3.72	2.47	2.51	2.86	3.26
	1994-1995	2.62	3.13	2.57	3.28	4.58	4.23	4.95	3.92	4.63	4.37	4.46	3.10	4.01
	1995-1996	3.78	4.46	3.86	4.71	4.61	4.09	4.23	5.29	4.50	2.30	2.72	3.33	3.70
	1996-1997	4.92	3.13	2.82	2.72	3.41	4.15	5.42	4.54	3.89	4.29	4.21	3.17	3.96
	1997-1998	3.95	4.78	2.34	3.78	4.16	3.78	4.50	4.48	3.40	2.26	2.34	2.16	3.31

	1998-1999	3.13	2.84	2.80	2.63	3.66	4.35	4.62	3.47	3.44	2.76	2.06	2.52	3.06
	1999-2000	3.42	4.79	3.39	3.66	4.47	3.71	5.32	5.44	4.47	5.52	5.42	5.40	4.33
KKC	2000-2001	5.06	4.49	4.53	6.21	6.75	6.66	4.71	7.62	5.47	5.07	5.92	6.23	5.75
	2001-2002	6.45	4.49	4.61	5.15	6.16	5.92	6.17	5.37	4.45	3.98	2.40	1.38	3.53
	2002-2003	1.99	1.92	2.59	3.38	4.05	3.06	2.90	3.67	2.97	2.08	1.83	1.86	2.41
	2003-2004	3.17	3.18	2.60	3.08	4.18	3.65	4.84	5.17	3.60	1.93	2.11	2.68	3.34
	2004-2005	2.50	4.09	2.61	2.97	3.50	3.40	3.84	3.76	3.14	2.01	2.15	2.24	2.91
	2005-2006	2.87	1.72	2.31	2.85	4.31	2.91	4.19	4.12	3.65	2.21	2.26	2.41	2.93
	2006-2007	3.92	4.62	4.20	2.93	4.32	3.68	5.02	6.83	3.74	2.45	4.17	2.46	3.88
	2007-2008	3.11	2.37	4.30	3.12	3.58	3.90	3.05	4.69	3.27	3.20	2.96	3.71	3.47
	2008-2009	3.65	3.68	3.77										
	2009-2010				2.32	2.11	3.40	0.00	4.00	2.40	2.85	2.52	2.40	
	2010-2011	1.99	1.32	1.20	1.95	2.17	2.50							

	1990-1991				0.00	0.00	0.00	0.00	2.23	2.52	1.59	1.69	2.61	1.96
	1991-1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.02	1.54	2.05	1.20	4.73	1.86
	1992-1993	4.14	0.00	2.20	0.00	0.00	0.00	0.00	0.00	2.04	2.32	2.53	1.93	2.03
	1993-1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.27	2.29	1.33	1.96	1.95	1.85
	1994-1995	0.00	0.00	0.00	0.00	1.70	2.02	2.74	1.94	3.10	2.89	2.69	3.12	2.50
	1995-1996	0.00	0.00	0.00	0.00	2.35	1.44	3.85	2.16	2.20	2.31	2.18	1.70	2.27
	1996-1997	0.00	1.05	2.20	0.00	0.00	1.89	0.00	2.92	2.75	2.86	2.50	2.01	2.36
	1997-1998	0.00	0.00	0.00	0.00	0.00	3.42	2.82	1.93	1.09	1.31	1.17	2.53	1.49
	1998-1999	2.37	1.62	2.42	0.00	3.62	3.66	0.00	2.69	1.74	2.51	2.07	3.46	2.35
	1999-2000	3.61	4.07	2.78	3.29	3.25	2.04	3.51	0.00	0.00	0.00	0.00	0.00	2.83
Ustyurt	2000-2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2001-2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.10	2.18	1.88	1.22	1.79
	2002-2003	1.43	0.95	1.45	0.00	2.62	0.00	0.00	0.00	0.00	1.30	0.00	1.24	0.63
	2003-2004	0.00	0.00	0.00	2.60	4.18	2.80	4.51	0.00	2.56	2.16	2.19	2.07	2.37
	2004-2005	1.86	0.00	0.00	1.57	3.69	2.88	2.75	3.78	1.58	1.40	1.49	2.05	1.90
	2005-2006	0.00	2.12	1.93	1.40	1.03	4.19	3.24	2.79	2.94	1.67	1.62	1.76	2.17
	2006-2007	4.05	0.00	2.95	2.27	2.82	2.55	1.71	2.84	2.52	2.52	2.70	2.62	2.58
	2007-2008	0.00	0.00	2.99	2.21	0.00	2.65	3.06	0.00	0.00	0.00	0.00	0.00	2.86
	2008-2009	0.00	0.00	0.00										
	2009-2010				2.54	0.00	3.15	0.00	3.03	1.58	2.26	1.92	1.12	
	2010-2011	1.38	0.00	1.37	1.15	2.18	2.12							

Source: Database of BWO “Amudarya”

Bathymetry of the Aral Sea (1950-2009)

Year	Inflow from the river, km^3/yr				Rainfall, km^3	Evaporation, km^3	Level, m (BS)	Water mass, km^3	Water surface area, km^2	Salinity, g/l
	Amudarya		Syrdarya							
	s	Q	s	Q						
1950	0.47	41.0	0.58	11.9	9.22	66.06	52.90	1058.0	65607	10.17
1951	0.52	33.4	0.55	13.2	8.07	59.19	52.77	1049.0	64914	9.74
1952	0.41	55.2	0.46	18.8	8.78	62.62	52.79	1050.0	64964	10.67
1953	0.41	54.8	0.45	19.5	9.63	64.11	52.94	1059.0	65706	9.82
1954	0.41	55.1	0.43	21.1	10.87	62.87	53.21	1076.0	67042	10.21
1955	0.47	41.9	0.49	16.7	9.17	66.13	53.27	1079.0	67290	10.13
1956	0.44	48.0	0.50	16.4	9.30	67.20	53.32	1082.0	67537	10.19
1957	0.54	30.9	0.63	9.5	8.51	68.11	53.27	1080.0	67389	10.01
1958	0.42	52.3	0.60	10.9	7.94	68.93	53.23	1078.0	67240	10.42
1959	0.45	46.3	0.47	18.3	9.92	70.05	53.39	1086.0	67884	10.19
1960	0.47	42.0	0.43	21.1	9.41	71.13	53.50	1093.0	68478	9.93
1961	0.57	31.1	1.14	8.9	6.59	70.43	53.38	1087.0	67983	9.97
1962	0.51	38.4	1.60	4.0	8.63	70.93	53.07	1067.0	66350	10.80
1963	0.56	31.8	1.28	7.0	11.56	70.64	52.72	1045.0	64568	10.58
1964	0.51	39.2	1.10	9.4	8.12	64.04	52.58	1038.0	63974	10.13
1965	0.62	25.3	1.71	3.2	8.48	66.35	52.40	1026.0	63308	10.81
1966	0.53	35.6	1.33	6.4	6.64	71.13	51.98	1000.0	62014	11.81
1967	0.58	29.3	1.38	5.9	7.51	57.82	51.66	980.9	61060	11.02
1968	0.54	34.4	1.49	4.9	6.03	67.35	51.35	960.7	60299	11.49
1969	0.36	70.6	1.03	10.6	9.06	52.31	51.39	963.7	60408	10.91
1970	0.56	32.4	1.32	6.5	7.22	62.03	51.44	971.7	60692	11.20
1971	0.65	20.6	1.04	5.6	5.81	59.83	51.11	949.0	59885	11.38
1972	0.59	24.2	1.15	4.8	5.78	55.34	50.65	917.8	58935	11.95
1973	0.40	43.5	0.99	6.0	8.95	56.45	50.32	898.9	58494	11.95
1974	1.01	6.9	2.16	1.3	4.75	60.18	49.92	874.4	57924	13.02
1975	0.92	9.2	2.47	0.8	4.43	59.99	49.09	824.2	56757	13.40
1976	0.85	11.3	2.88	0.3	5.79	51.09	48.36	785.3	55718	14.57
1977	0.99	7.2	2.98	0.2	5.04	45.75	47.74	749.2	54792	15.44
1978	0.68	18.9	2.79	0.4	6.42	52.52	47.06	717.6	53981	14.97
1979	0.87	10.9	1.80	2.1	4.87	52.14	46.45	683.4	52989	15.09
1980	0.92	9.3	1.96	1.7	9.73	50.24	45.76	648.7	51743	16.80
1981	1.33	6.9	2.03	1.7	11.92	47.11	45.19	620.0	50714	17.70
1982	2.75	0.3	2.31	1.3	8.52	38.50	44.39	579.8	49270	18.80
1983	2.06	2.4	3.20	0.5	4.51	47.59	43.55	537.5	47753	20.30
1984	1.23	8.0	3.53	0.3	5.99	44.33	42.75	502.7	46243	21.90
1985	2.11	2.2	3.53	0.3	7.19	42.52	41.95	475.0	44382	22.90
1986	2.69	0.46	3.73	0.20	0.11	0.98	41.94	448.00	41047	22.9
1987	1.17	8.68	2.58	1.00	0.10	1.00	41.10	432.00	38831	23.9
1988	0.72	17.81	1.01	5.00	0.11	0.94	40.29	401.00	37410	25.0
1989	2.30	1.51	1.42	3.10	0.15	0.97	39.75	380.00	36562	28.0
1990	1.33	6.89	1.67	2.41	0.70	1.04	39.08	354.00	35349	30.0
1991	1.33	10.48	1.89	2.58	0.80	1.06	38.24	323.00	33831	32.0
1992	0.78	24.27	1.73	3.34	0.10	0.92	37.56	299.00	32649	34.0
1993	1.06	15.52	1.17	7.50	0.90	0.83	37.20	286.00	32017	35.0
1994	0.93	18.72	1.09	8.46	0.12	0.97	36.95	278.00	31564	36.0
1995	2.13	3.24	1.52	4.53	0.90	0.98	36.60	266.00	30879	37.0
1996	1.87	4.92	1.47	4.89	0.19	0.97	36.11	250.00	29872	42.0
1997	2.68	0.73	1.64	3.82	0.24	0.93	35.48	230.00	28530	43.5
1998	0.89	20.07	1.18	7.41	0.17	0.88	34.80	210.00	26959	49.8
1999	1.97	4.17	1.32	6.03	0.90	1.00	34.24	194.00	25519	50.6
2000	2.51	1.37	1.83	2.86	0.13	0.96	33.80	181.00	24266	55.8
2001	2.87	0.09	1.79	3.03	0.16	0.95	33.30	169.00	22745	58.6
2002							30.90			70.0

Year	Inflow from the river, km^3/yr				Rainfall, km^3	Evaporation, km^3	Level, m (BS)	Water mass, km^3	Water surface area, km^2	Salinity, g/l
	Amudarya		Syrdarya							
	s	Q	s	Q						
2003							30.34			78.7
2004							30.51			86.3
2005							30.33	125	19600	90.0
2006							30.08			92.1
2007							29.51			95.3
2008							28.31			97.6
2009							27.53	105	13500	102

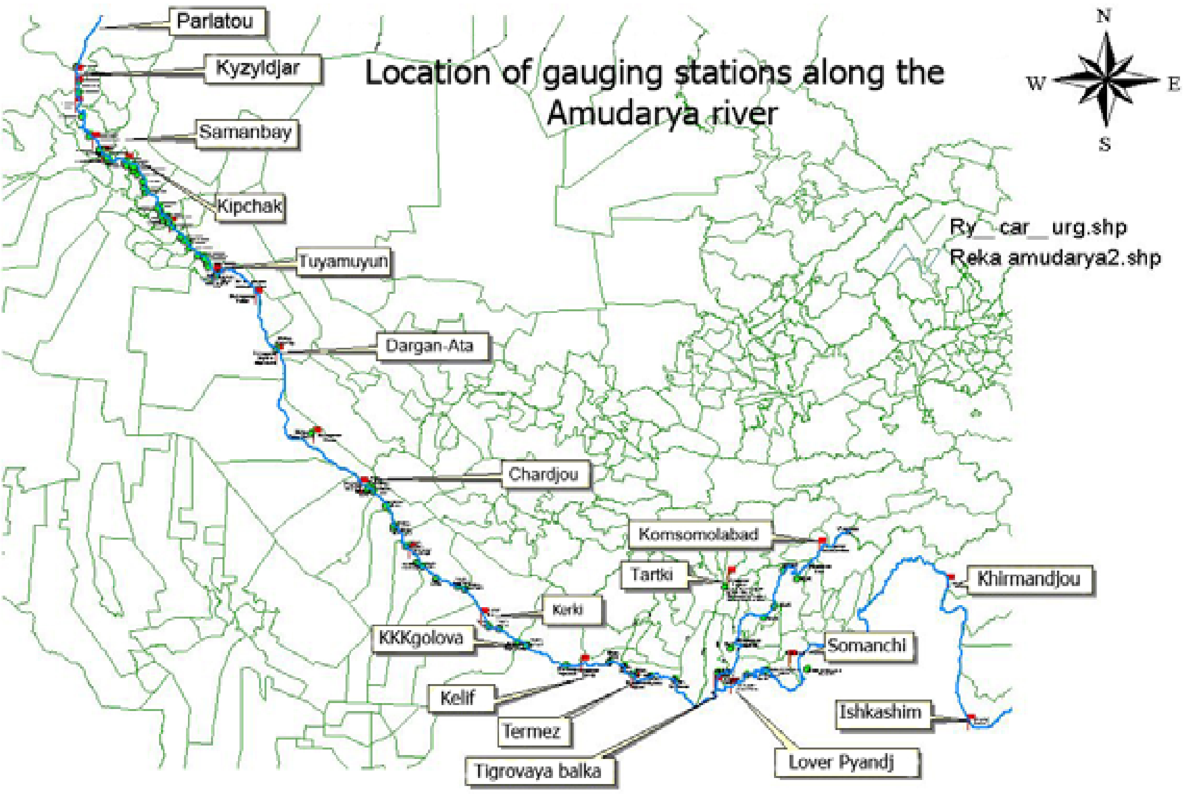
Source: INTAS-0511 REBASOWS PROJECT

Salt influx in the Aral Sea

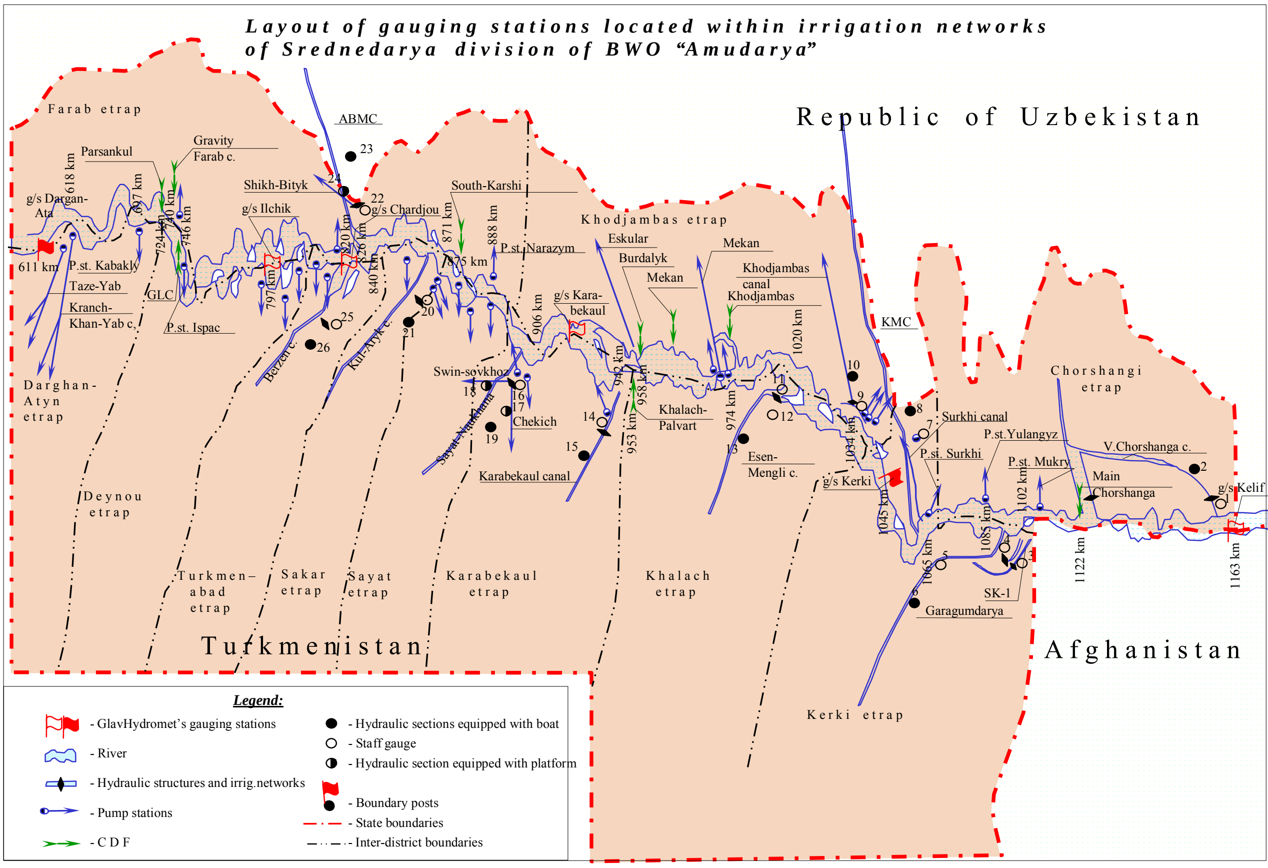
Year	Volume of water body, km^3	Salt mass, Mt	Salinity, g/l	Mass of precipitating salts, Mt			
				Sedimentation	Precipitation in the coastal zone	Ice	Sum
1950	1058	10760	10.17	9.97	0.00	13.93	23.90
1951	1049	10217	9.74	8.77	0.08	14.56	23.41
1952	1050	11204	10.67	14.11	0.03	14.85	28.98
1953	1059	10399	9.82	13.97	-0.24	16.84	30.56
1954	1076	10986	10.21	14.10	-0.55	18.64	32.19
1955	1079	10930	10.13	10.73	-0.01	14.75	25.47
1956	1082	11026	10.19	11.83	-0.02	12.63	24.45
1957	1080	10811	10.01	7.37	0.05	14.68	22.10
1958	1078	11233	10.42	13.14	0.03	14.17	27.34
1959	1086	11066	10.19	12.10	-0.06	15.89	27.94
1960	1093	10853	9.93	11.63	-0.01	17.50	29.13
1961	1087	10837	9.97	8.24	0.28	15.16	23.69
1962	1067	11524	10.80	8.40	0.80	14.74	23.94
1963	1045	11056	10.58	8.13	0.69	11.70	20.52
1964	1038	10515	10.13	10.56	0.03	15.56	26.14
1965	1026	11091	10.81	5.82	0.63	14.40	20.85
1966	1000	11810	11.81	9.21	1.31	14.91	25.42
1967	981	10810	11.02	7.75	0.53	15.30	23.58
1968	961	11038	11.49	8.76	1.06	17.39	27.22
1969	964	10514	10.91	18.42	-0.35	18.50	36.57
1970	972	10883	11.20	8.65	-0.27	14.94	23.32
1971	949	10800	11.38	5.88	1.31	12.89	20.08
1972	918	10968	11.95	6.62	0.70	14.89	22.20
1973	899	10742	11.95	11.58	0.01	14.46	26.04
1974	874	11385	13.02	2.24	0.44	16.98	19.66
1975	824	11044	13.40	2.14	2.08	14.92	19.14
1976	785	11442	14.57	2.81	1.87	17.83	22.52
1977	749	11568	15.44	1.76	2.12	19.23	23.11
1978	718	10742	14.97	5.30	1.39	18.03	24.72
1979	683	10313	15.09	3.54	1.08	18.02	22.64
1980	649	10898	16.80	3.10	0.66	22.08	25.84
1981	620	10974	17.70	2.42	0.95	16.29	19.66
1982	580	10900	18.80	0.32	5.33	21.89	27.53
1983	538	10911	20.30	0.70	6.77	13.62	21.09
1984	503	11009	21.90	2.92	1.71	27.52	32.15
1985	475	10878	22.90	0.68	3.83	21.99	26.50
1986	432.00	10325	23.90	0.04	8.29	23.71	32.05
1987	401.00	10025	25.00	3.57	4.14	23.16	30.87
1988	380.00	10640	28.00	10.13	1.32	20.40	31.85
1989	354.00	10620	30.00	1.07	5.75	20.88	27.70
1990	323.00	10336	32.00	3.87	6.87	21.25	31.99
1991	299.00	10166	34.00	6.59	3.87	24.14	34.60
1992	286.00	10010	35.00	15.28	0.38	23.17	38.83
1993	278.00	10008	36.00	11.40	1.13	29.89	42.42
1994	266.00	9842	37.00	15.99	1.18	30.28	47.45
1995	250.00	10500	42.00	3.00	5.27	25.37	33.64

Year	Volume of water body, km^3	Salt mass, Mt	Salinity, g/l	Mass of precipitating salts, Mt			
				Sedimentation	Precipitation in the coastal zone	Ice	Sum
1996	230.00	10005	43.50	3.74	6.20	33.76	43.70
1997	210.00	10458	49.80	1.89	9.60	27.18	38.67
1998	194.00	9816	50.60	17.86	3.34	33.19	54.40
1999	181.00	10100	55.80	10.14	5.61	33.65	49.41
2000	169.00	9903	58.60	0.63	11.23	27.43	39.28

Source: INTAS-0511 REBASOWS PROJECT



Source: BWO «Amudarya»



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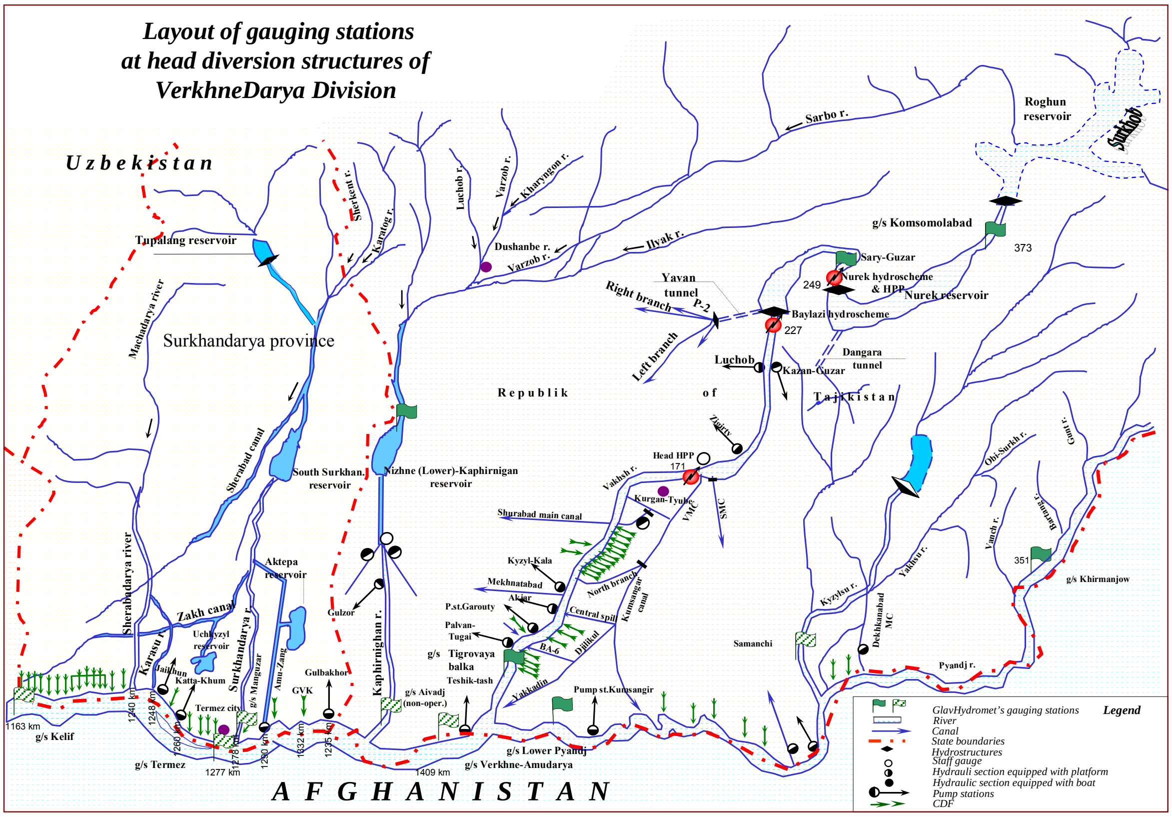

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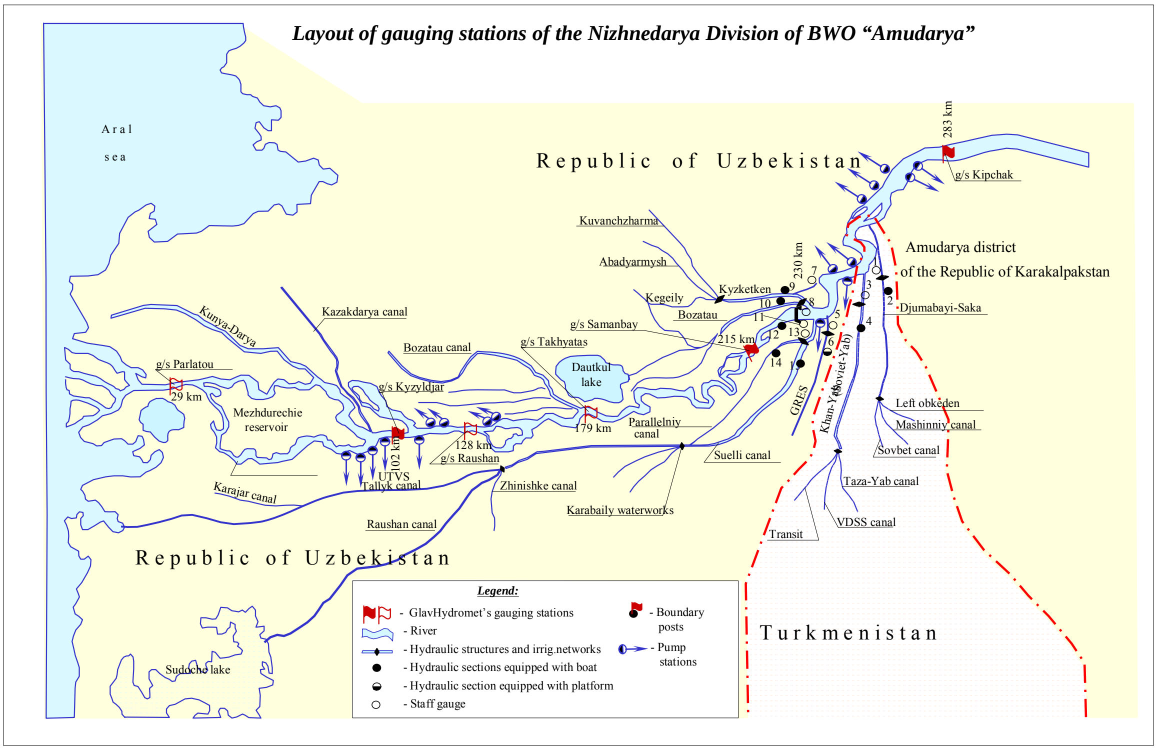

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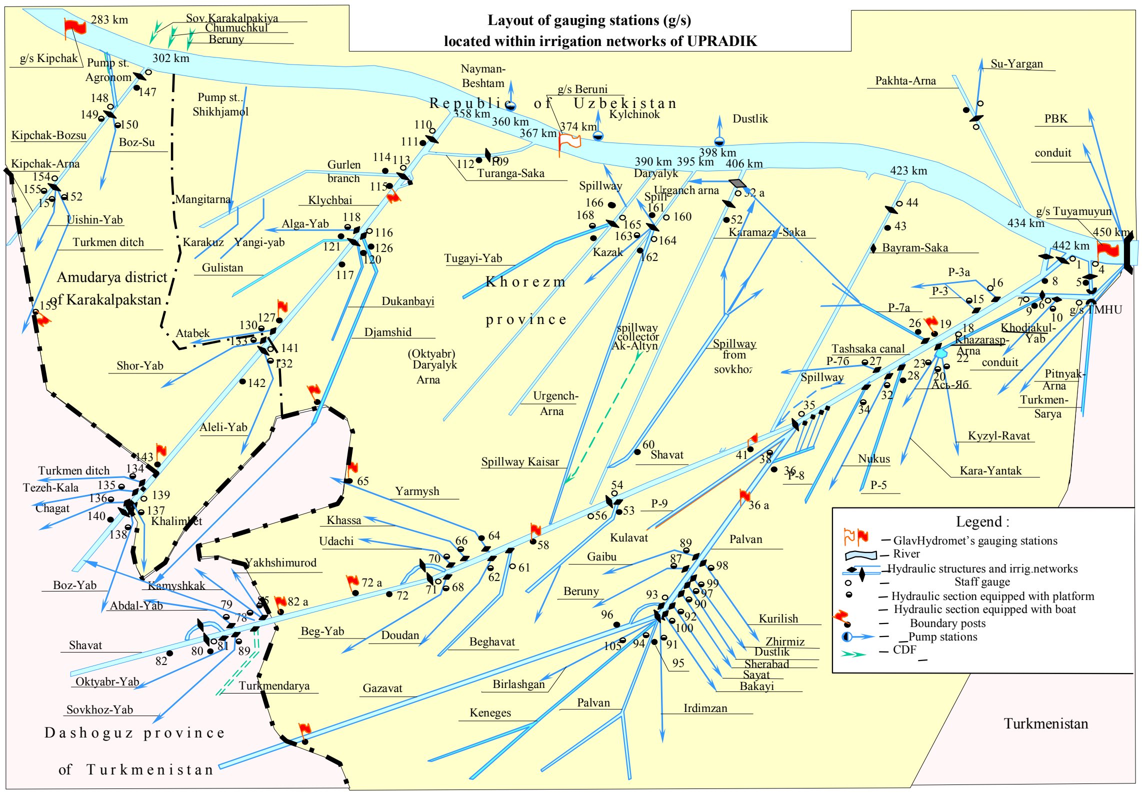

Source: BWO «Amudarya»

Source: BWO «Syrdarya»

Environmental indicators

Kazakhstan – Water resources

Indicator	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Impact indicators																				
Annual diversion of groundwater and surface water (Mm3)	36.6	36.1	34.02	33.67	31.91	28.80 7	26.48 3	24.978	23.11 8	20.74 8	19.83	19.69	21.1	21.85	26.42	24.8	21.24	22.81	20.47	21.54
Amount of discharged wastewater (Mm3), incl. CDW			8.7	8.3	7.7	7.1	6.1	5.3	4.2	3.8	3.6	3.6	3.7	3.3	3.9					
Annual water use (km3):	30.2	28.4	27.4	26.9	24.9	23.4	20.5	18.3	16	14.2	14.7	14.6	14.9	15.2	20.2					
domestic,%	4.5	4.5	4.7	4.2	6.8	5.3	5.2	4.9	7.8	7.9	7.4	7.2	5	5	4	4				
industrial,%	23.8	16.9	19.3	17.8	16.2	24.1	22.2	22.4	22.4	23.6	24.4	25.4	25	26	21					
agricultural,%	71.7	75.6	76.8	78	77	70.6	72.6	72.7	69.8	68.5	68.2	67.4	70	63	75					
Status indicators																				
Per capita water use (m3)	83.49	80.3	81	81.01	81.51	77.81	72.81	53.38	48.8	43.45	41.89	40.57	39.9	40	44.1					
Per capita use of tap water (m3):	4300-6000																			
Share of population having access to drinking water (%)	75.6	75.2	75.4	75.9	75.3	75	75.1	75.2	75.2	75.1	73	74	73.7	75.1	76.4	77.4	78.7	79.4	82	82
Share of population having access to sanitation (%)	44.1	48.1	46.7	45.2	43	42.5	49.1	48.5	44.2	46.8	47.1	42.1	44.1	43.1	41.1					
% of deviation of analyzed drinking water samples from the State Standard					9.1	11.5	10.5			7.9	9	8.5	7.2	4.7	4.3					

Indicator	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Biochemical oxygen demand (BOD) in water	0.3	0.3	1.3	1.2	0.8	1.1	1.1	1.1	1.1	1.6	1.6	1.5	1.4	1.3	1.4					
Response indicators																				
Amount of treated wastewater (Mm3)	256	289	263	227	210	203	164	142	254	228	212	212	217	253	188					

Source: http://ecoportal.kz, www.stat.kz, www.cisstat.com, http://web.worldbank.org, http://unfccc.int1

Kyrgyzstan – Water resources

INDICATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Impact indicators																				
Annual diversion of groundwater and surface water (Mm3)	11.12	11.15	11.5	11.41	10.92	9.31	9.6	8.47	8.32	9.18	8.03	10.39	8.46	7.56	7.85	7.89	80.07	85.3	84.7	7.6
Amount of discharged wastewater (Mm3), incl. CDW	1.17	1.36	1.35	1.34	1.31	1.18	1.00	0.73	0.93	0.93	0.8	1.16	2.27	1.49	1.51	0.77	0.70	1.04	1.02	0.18
Annual water use (km3):	8.99	8.95	8.95	8.54	8.26	6.94	6.87	6.16	6.42	5.25	4.98	5.75	5.42	4.56	4.54	4.48	4.53	5.55	5.32	4.73
domestic,%	3.3	3.0	2.8	3.5	3.4	3.9	4.3	2.2	5.2	6.6	4.3	3.6	2.2	1.7	1.9	8.5				
industrial,%	7.8	7.5	5.9	3.5	3.7	3.8	3.3		2.2	2.1	1.2	1.0	1.7	2.6	2.7	11.8				
agricultural,%	88.9	89.5	91.3	93.0	92.9	92.3	92.4	92.6	92.6	91.3	94.5	95.4	96.1	95.7	95.4	79.7				
Status indicators																				
Per capita water use (m3)	66.5	64.3	62.5	70	68.1	60.9	61.2	66.9	66.9	64.4	42.8	37	25.1	18.5	17.2					
Per capita use of tap water (m3):	2534	2504	2572	2576	2453	2064	2101		1805	1748	1893	1634	2095	1697	1501	1523				

INDICATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Share of population having access to drinking water (%)						81.8	81.3	82.6	82.6	86.5	85.9	81.5	80.6	84.2	78.6	84.4	89.8	93.0	90.4	90.4
Share of population having access to sanitation (%)						21.3	24.4	23.3	23.3	27.5	27.8	32.8	31.4	30.3	25.9	25.1	23.9	24.2	23.5	25.2
% of deviation of analyzed drinking water samples from the State Standard	13	13	12	11	12.5	11	15	14.5	14.5	15	15.1	12.4	13.1	13.1	13.1	13.1				
Biochemical oxygen demand (BOD) in water						0.95	0.95	1	1	1.1	1.2									
Response indicators																				
Amount of treated wastewater (Mm3)	131	177	176	186	140	136	122	111	111	117	150	137.7	134	108	86	158				

Source: http://ecoportal.kz, www.cisstat.com, www.stat.kg, http://europeandcis.undp.org, http://hdr.undp.org

Tajikistan – Water resources

INDICATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Impact indicators																				
Annual diversion of groundwater and surface water (Mm3)	13662.43	1371 0	12803.6 3	13135.35	13566.1 8	12909.01	13168 .14	13379. 08	13152. 42	10699 .99	12609. 3	1257 7.88	12469 .74	12554. 21	12316 .09					
Amount of discharged wastewater (Mm3), incl. CDW	4549.85	4732	4854.7	4804.77	4921.75	3709.02	4090. 55	4372.4 7	4809.2 8	3581. 43	4706.1	4761. 19	4693. 23	47539. 47	47939 .87					
Annual water use (km3):	12044.08	1185 4	10944.5 7	10998.57	11529.2 4	11873.19	11043 .38	10197. 58	9938.7 6	8817. 21	9569.9 2	8475. 89	9306. 08	9268.7 0	9099. 58					
domestic,%	484.77	447.5	455.65	484.31	412.1	611.84	413.6 9	383.97	234.07	383.4 4	404.75	356	372.2 4	370.74	363.9 8					

INDICATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
industrial,%	594.01	593.2	530.16	536.04	501.3	943.87	922.0 8	535.12	454.16	525.5 4	477.31	428.4 6	465.3	465.3	454.9 7					
agricultural,%	695.71	536.8	571.93	408.2	622.63	658.59	608.4 8	601.97	533.28	439.6 9	554.18	461.3 3	651.3 9	646.9	818.9 3					
Status indicators																				
Per capita water use (m3)	91.5	82.5	82.4	86.8	73.4	167.8	75.3	65.9	39.4	63.1	64.2	56.5	59.1	63.9	63.7					
Per capita use of tap water (m3):	2509	2490	2500	2354	2480	2264	2282	2277	2192	1746	1837	1851	1837	1849	2001					
Share of population having access to drinking water (%)	60	60	55.1	55.1	53.3	52	48.5	43.8	43.3	43.7	44.3	47.1	47.3	46.9	47.4					
Share of population having access to sanitation (%)	70.3	70.1	69.5	61.4	58.3	45.3	33	30	38.7	64.8	64.4	69.8	69.8	69.6	69.3					
% of deviation of analyzed drinking water samples from the State Standard	8	7	12	21	31	32	39	45	47	51	48	39	38	46	47					
Biochemical oxygen demand (BOD) in water	3.8	5	4.1	4.7	3.8	3.7	5.6	6.3	5.2	5.3	6.1	6.3	6.3	6.2	6.3					
Response indicators																				
Amount of treated wastewater (Mm3)	4.49	4.62	4.76	4.73	4.88	4.49	4.41	4.35	4.78	3.55	3.58	3.61	3.69	3.57	3.63					

Source: www.cisstat.com, http://hdrstats.undp.org, http://hdr.undp.org

Turkmenistan – Water resources

INDICATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Impact indicators																				
Annual diversion of groundwater and surface water (Mm3)	24.82	26.12	24.93	25.71	25.97	27.61	26.35	24.21	25.95	27.60	21.94	24.92	27.15	26.67						
Amount of discharged wastewater (Mm3), incl. CDW	6.5					5.7	6.2	6.0	6.0	6.7	6.1	3.9	5.9	6.6						
Annual water use (km3):																				
domestic,%	1.23	1.50	1.30	1.46	1.49	2.00	2.00	2.00	2.00	2.00	2.48	3.10	2.49	2.34						
industrial,%	7.77	6.60	8.80	8.54	7.78	7.00	7.00	8.00	7.00	6.00	7.75	8.39	7.46	7.71						
agricultural,%	91	91.90	89.90	90.0	90.73	91.0	91.00	90.00	91.00	92.00	89.77	88.51	90.03	89.93						
Status indicators																				
Per capita water use (m3)	63.4	78.76	70.5	68.8	67.4	64.5	63.7	61.9	80.1	76.9	72.7	83.1	80.7	80.5						
Per capita use of tap water (m3):	6464	6538	6007	5950	5796	6018.2	5594	4994	5197.4	5306.7	4086	4295	4571	4234						
Share of population having access to drinking water (%)								42.82	56.78	61.95	54.2	54.7	54.19	55						
Share of population having access to sanitation (%)						56.5	56.8	58.1	57.6	58.6										
% of deviation of analyzed drinking water samples from the State Standard																				
Biochemical oxygen demand (BOD) in water (Amudarya, Lebap)																				

INDICATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Response indicators																				
Amount of treated wastewater (Mm3)	13.3	13.3	13.4	13.5	13.5	18.3	19.3	19.1	19.1	18.3	18.4	18.0								

Source: http://geodata.grid.unep.ch, http://hdrstats.undp.org, http://hdr.undp.org 1

Uzbekistan – Water resources

INDICATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Impact indicators																					
Annual diversion of groundwater and surface water (Mm3)	52.4	56.2	61.5	61.5 1	58.7	60.6	60.3	59.2	59.2	60.7	48.1	44	50.3	56.5	58.5						
Amount of discharged wastewater (Mm3), incl. CDW			26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9										
Annual water use (km3):	52.4 0	51.4	51.4	50.2	53.3	52.2	52.2	52.1	51.6	50.6	46.9	44	50.2	51.2	**58.4**	**59.5**	**58.6**	**53**	**43.9**	**50.2**	
domestic,%				5.7			4.5				5	4.8	6.1	6.1	6.1						
industrial,%				1.6			1.5				1.5	1.8	2.2	2.2	2.2						
agricultural,%				90.7			92.7				92.4	92.5	90.2	90.2	90.2						
Status indicators																					
Per capita water use (m3)																					
Per capita use of tap water (m3):											87.1	87.4	89.2	91	90.7	88.5	86.6	85.8			

INDICATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Share of population having access to drinking water (%)		65.8	66.5	67.7	68.6	70	71.1	73.7	74.4	75.1	77.1		-						87		
Share of population having access to sanitation (%)				58.1	72.1	72.5	72.4	72.05	71.5	68.7			-								
% of deviation of analyzed drinking water samples from the State Standard																					
Biochemical oxygen demand (BOD) in water (Salar canal, downstream of Tashkent; Chirchik river)	3.38	4.41	4.72	4.35	3.77	3.53	3.68	4.05	4.87	4.56	-	-									
Response indicators																					
Amount of treated wastewater (Mm3)	1209	-	-	-	-	-	1221.7	1220	1159.7	1137.2	1101.4	1053.4	1070.8	1053	922.3						

Source: 1) National report on environmental status and natural resources use in the Republic of Uzbekistan; 2) Progress report on Agenda 21 in the Republic of Uzbekistan.