

ANALYSIS OF HYDROLOGICAL CONDITIONS IN THE SYR DARYA AND AMU DARYA RIVER BASINS OVER THE GROWING SEASON 2021

1 Syr Darya River basin

The actual inflow to the upstream reservoirs in the Syr Darya basin (Toktogul, Andizhan, and Charvak reservoirs) was 14.3 km³ or 99.8% of the forecast and 78% of the norm for the growing season. The total lateral inflow to the Naryn and the Syr Darya (in the reaches up to the Shardara reservoir) was 6.8 km³, including 1.41 km³ from the Karadarya River, 0.23 km³ from the Chirchik River, and 5.19 km³ from collector-drainage flow, CDF (return flow) and small rivers.

By the beginning of the growing season, the upstream reservoirs have accumulated 10.04 km³. By the end of the growing season, the total water volume in the upstream reservoirs was 14.05 km³, i.e. 4.01 km³ were diverted from the rivers.

Inflow from the Naryn River to the Toktogul reservoir was 8.76 km³. This is by 0.59 km³ more than the forecast and was 91% of the norm. Outflow from the reservoir was 5.17 km³ or 101% of the reservoir release schedule of BWO Syr Darya. Water diversion into the reservoir from the Naryn River amounted to 3.6 km³, which is by 17% more than the schedule.

Water storage in the Bakhri Tochik reservoir was 3.46 km³ by the beginning of the growing season and 1.59 km³ by the end of the growing season. Inflow to the Bakhri Tochik reservoir amounted to 5.28 km³ and the outflow was 6.38 km³. Analysis of operation of the Bakhri Tochik reservoir showed that the inflow to the reservoir was 0.23 km³ more than planned by BWO Syr Darya's schedule, and, accordingly, the outflow from the reservoir was 0.25 km³ more than scheduled. Water losses from the reservoir, calculated by the water balance method, amounted to 0.35 km³, which almost coincided with the forecast volume.

In the Shardara reservoir, water volume was 5.07 km³ by the beginning of the growing season and 0.67 km³ by the end of the growing season. Inflow to the Shardara reservoir was only 2.31 km³ or 68% of the forecast; outflow from the reservoir was 5.14 km³, including 4.26 km³ into the river; and 0.08 km³ of water

was discharged into the Arnasay reservoir from the Shardara hydroscheme. The reservoir's water balance discrepancy was -1.57 km^3 , which indicates to water losses in the reservoir and perhaps to inaccurate accounting of the flow at gauging stations.

According to the Aral-Syrdarya Basin Water Administration's data, the Koksaray reservoir was filled with 333 Mm^3 of water in April. $1,933 \text{ Mm}^3$ were drawn down from April till July.

Water supply to Aral and the Aral Sea region (Karateren GS) amounted to 0.321 km^3 by the data from KazHydromet and 0.201 km^3 , according to BWO Syr Darya and the Committee for Water Resources of the Republic of Kazakhstan. The latter figure was used in the calculations of the river water balance.

The total water withdrawal from the Naryn River and the Syr Darya River was 9.95 km^3 or 84% of the limit in the reaches up to the Shardara reservoir. Over the growing season 2021, water withdrawal was 1.91 km^3 less than planned, based on water withdrawal limits approved by the ICWC meeting.

Water withdrawal from the Dustlik canal was 0.7 km^3 for the Republic of Kazakhstan, 0.14 km^3 for the Kyrgyz Republic, 1.49 km^3 for the Republic of Tajikistan, and 7.61 km^3 for the Republic of Uzbekistan.

Analysis of reservoir water balances in the Amu Darya basin (Table 1.3) has revealed negative balance discrepancy (losses) of -1.62 km^3 in total. River water balance discrepancy in the Toktogul-Shardara reach was 0.84 km^3 or 6% of regulated Syr Darya flow. Thus, the total water losses in the Syr Darya River basin are estimated from the water balance discrepancy at 2.46 km^3 . It should be noted that this estimation is given under the assumption that there are no errors in accounting of river flow at the boundaries of the balancing sites; otherwise, water losses can be estimated as lower.

In the lower reaches of the Syr Darya River, runoff utilization is estimated at 5.65 km^3 (including water withdrawal, losses, minus lateral inflow).

Table 1.1

Water availability indicators in the Syr Darya River basin countries over the growing season 2021

Water consumer	Water volume, km ³	
	BWO schedule /limit	Actual
1 Total water withdrawal up to the Shardara reservoir	11.85	9.95
2 By state:		
– Kyrgyz Republic	0.25	0.14
– Republic of Uzbekistan	8.80	7.61
– Republic of Tajikistan	1.91	1.49
– Republic of Kazakhstan	0.90	0.70
3 By river reach		
3.1 Toktogul reservoir – Uchkurgan hydroscheme	3.95	3.44
of which:		
– Kyrgyz Republic	0.16	0.08
– Republic of Tajikistan	0.24	0.10
– Republic of Uzbekistan	3.55	3.27
3.2 Uchkurgan hydroscheme-Bakhri Tochik reservoir	1.08	1.12
of which:		
– Kyrgyz Republic	0.08	0.07
– Republic of Tajikistan	0.45	0.50
– Republic of Uzbekistan	0.54	0.54
3.3 Bakhri Tochik reservoir-Shardara reservoir	6.83	5.39
of which:		
– Republic of Kazakhstan	0.90	0.70
– Republic of Tajikistan	1.22	0.89
– Republic of Uzbekistan	4.71	3.80
4 In addition:		
– Inflow to the Shardara reservoir	4.08	2.31
– Discharge into the Arnasay	0.00	0.08
– Water supply to the Aral Sea and Aral Sea region ⁹	1.26	0.20

⁹ Committee for Water Resources of the Republic of Kazakhstan

Table 1.2

Syr Darya River water balance in the growing season 2021

Balance item	Water volume, km ³		Discrepancy (actual-plan)	
	Forecast /plan	Actual	km ³	%
1 Inflow to the Toktogul reservoir	8.18	8.76	0.59	7
2 Lateral inflow in the Toktogul reservoir – Shardara reservoir (+) reach	9.18	6.83	-2.35	26
of which:				
– Discharge from the Karadarya river	1.40	1.41	0.02	1
– Discharge from the Chirchik river	0.44	0.23	-0.21	48
– Lateral inflow from CDF and small rivers	7.35	5.19	-2.15	29
3 Flow regulation in the reservoirs: addition to the flow (+) or withdrawal (-)	-1.99	-2.50	-0.51	26
of which:				
– Toktogul reservoir	-3.07	-3.60	-0.53	17
– Bakhri Tochik reservoir	1.08	1.10	0.02	2
4 Regulated flow (1+2+3)	15.37	13.10	-2.27	15
5 Water withdrawal in the Toktogul – Shardara reach (-)	-11.85	-9.95	1.91	16
6 Water balance discrepancy: water losses (-) or unrecorded inflow to the river channel (+) in the Toktogul-Shardara reach	0.57	-0.84	-1.41	247
including % of regulated flow	4	6		
7 Inflow to the Shardara reservoir	4.08	2.31	-1.77	43
8 Water releases from the Shardara reservoir (into the river and water withdrawal)	3.89	2.83	-1.06	27
9 Flow regulation in the Koksaray reservoir: addition to the flow (+) or withdrawal (-)	7.97	5.14	-2.83	35
10 Runoff utilization (water withdrawal-lateral inflow+losses)	6.76	4.26	-2.51	37
11 Supply to the Aral Sea and Aral Sea region	1.68	1.60	-0.08	5

Table 1.3

Water balance of the Syr Darya River basin reservoirs in the growing season 2021

Balance item	Water volume, km ³		Discrepancy (actual-plan)	
	Forecast/ plan	Actual	km ³	%
1. Toktogul reservoir				
1.1 Inflow to the reservoir	8.18	8.76	0.59	7
1.2 Water volume in the reservoir:				
– beginning of the season (1 April 2021)	8.71	8.71	0.00	0
– end of the season (1 October 2021)	11.65	12.30	0.65	6
1.3 Outflow from reservoir	5.11	5.17	0.06	1
1.4 Discrepancy: unrecorded inflow (+) or water losses (-)	-0.13	0.00	0.13	
<i>% of inflow to the reservoir</i>	2	0	2	
1.5 Flow regulation: addition to the flow (+) or withdrawal (-)	-3.07	-3.60	-0.53	17
2. Andizhan reservoir				
2.1 Inflow to the reservoir	1.77	1.72	-0.05	3
2.2 Water volume in the reservoir:				
– beginning of the season (1 April 2021)	0.76	0.76	0.00	0
– end of the season (1 October 2021)	0.70	0.50	-0.20	29
2.3 Outflow from reservoir	1.83	2.00	0.17	9
2.4 Discrepancy: unrecorded inflow (+) or water losses (-)	0.00	0.01	0.01	
<i>% of inflow to the reservoir</i>	0	1	1	
2.5 Flow regulation: addition to the flow (+) or withdrawal (-)	0.06	0.28	0.22	
3. Charvak reservoir				
3.1 Inflow to the reservoir	4.43	3.86	-0.57	13
3.2 Water volume in the reservoir:				
– beginning of the season (1 April 2021)	0.56	0.56	0.00	0
– end of the season (1 October 2021)	1.57	1.25	-0.32	20
3.3 Outflow from the reservoir	3.44	3.46	0.02	1
3.4 Discrepancy: unrecorded inflow (+) or water losses (-)	0.0	0.29	0.27	
<i>% of inflow to the reservoir</i>	0	7	7	
3.5 Flow regulation: addition to the flow (+) or withdrawal (-)	-0.99	-0.40	0.59	59
4 Bakhri Tochik reservoir				
4.1 Inflow to the reservoir	5.05	5.28	0.23	5
4.2 Lateral inflow	0.30	0.20	-0.10	33

Balance item	Water volume, km ³		Discrepancy (actual-plan)	
	Forecast/ plan	Actual	km ³	%
4.3 Water volume in the reservoir:				
– beginning of the season (1 April 2021)	3.46	3.46	0.00	0
– end of the season (1 October 2021)	1.60	1.59	-0.02	1
4.4 Outflow from the reservoir	6.73	7.017	0.28	4
of which:				
– discharge into the river	6.13	6.38	0.25	4
– water withdrawal from reservoir	0.60	0.63	0.03	5
4.5 Discrepancy: unrecorded inflow (+) or water losses (-)	-0.48	-0.35	0.13	27
<i>% of inflow to the reservoir</i>	9	7	3	
4.6 Flow regulation: addition to the flow (+) or withdrawal (-)	1.08	1.10	0.02	2
5 Shardara reservoir				
5.1 Inflow to the reservoir	4.08	2.31	-1.77	43
5.2 Lateral inflow	0.00	0.00	0.00	
5.3 Water volume in the reservoir:				
– beginning of the season (1 April 2021)	5.07	5.07	0.00	0
– end of the season (1 October 2021)	0.98	0.67	-0.31	32
5.4 Outflow from reservoir	7.97	5.14	-2.83	35
of which:				
– discharge into Arnasay	0.00	0.08	0.08	
– discharge into the river	6.76	4.26	-2.51	37
– water withdrawal from the reservoir	1.21	0.80	-0.40	33
5.5 Discrepancy: unrecorded inflow (+) or water losses (-)	-0.20	-1.57	-1.37	
<i>% of inflow to the reservoir</i>	5	68	63	
5.6 Flow regulation: addition to the flow (+) or withdrawal (-)	3.89	1.94	-1.94	50
TOTAL flow regulation by reservoirs: addition to the flow (+) or withdrawal (-)	0.97	-0.68	-1.65	
TOTAL losses (-), unrecorded inflow (+)	-0.79	-1.62	-0.83	

2 Amu Darya River basin

The actual water content in the Amu Darya River at the nominal Atamyrat gauging station (upstream of intake to Garagumdarya) was 41.16 km³ or 0.46 km³ less than expected, estimated figure in BWO Amu Darya's schedule (Table 2.2).

Inflow to the Nurek HPP amounted to 15.46 km³ and turned to be higher of the forecast flow by 0.35 km³. Outflow from the reservoir was 11.83 km³ or by 0.37 km³ higher than in BWO Amu Darya's schedule. Water withdrawal from the river for accumulation of water in the Nurek reservoir amounted to 3.64 km³. Using the water balance method, a positive discrepancy of 0.55 km³ was found. This may be attributed to unrecorded inflow to the Nurek reservoir and possibly inaccurate data on outflow from the reservoir (Table 2.3).

According to measurements at the Bir-Ata gauging station, inflow to the Tuyamuyun hydroscheme (TMHS) was 18.86 km³ or by 1.84 km³ less than expected. This did not allow accumulating planned volume of 3.2 km³ in TMHS reservoirs; the delay from schedule was 0.83 km³. Water volume in TMHS reservoirs amounted to 2.37 km³ only by the end of the growing season. Outflow from TMHS was 4.59 km³ less (!) than planned and amounted to 13.18 km³. The balance method determined a negative discrepancy of 5.96 km³ in the Bir-Ata – Tyuyamuyun reach. This indicates to both water losses from TMHS reservoirs and possible inaccurate flow measurement at gauging stations.

Given such hydrological conditions, the established limit of water withdrawal into canals in the Amu Darya River basin was provided by 79% (Table 2.1). The total water withdrawal amounted to 31.38 km³, including 24.54 km³ downstream of the Atamyrat gauging station (starting from intake into Garagumdarya). During the growing season, the average water availability was 90% in the Republic of Tajikistan, 84% in Turkmenistan, and 71% in the Republic of Uzbekistan; in the lower reaches, water availability was 68% in Turkmenistan, 63% in the Republic of Uzbekistan, including 50% in Surkhandarya province.

Water availability decreased from the middle to the lower reaches by 25%, including by 23% in Turkmenistan and by 25% in Uzbekistan. Table 2.1.1 shows the data on ten-day water availability in the lower reaches of the Amu Darya River, which were most affected by uneven distribution of water deficit in the basin.

Discrepancy of the Amu Darya River water balance was negative in the Atamyrat GS (nominal) – Bir-Ata GS reach (which indicates to water losses) and estimated at 5.6 km³ or about 15% of river runoff at the nominal Atamyrat

reach and 2.93 km³ in the lower reaches (Tuyamuyun GS-Samanbay GS reach) or 30% of river runoff at Tuyamuyun GS.

Water in the amount of 0.63 km³ was delivered to the Aral Sea region and the Aral Sea during the growing season (Amu Darya River runoff at the Samanbay GS plus discharged collector-drainage water) or 30% of BWO's schedule.

Table 2.1

**Water availability indicators in the Amu Darya River basin countries
over the growing season 2021**

Water consumer	Water volume, km ³		Water availability, %	Deficit (-), surplus (+) km ³
	Limit/Schedule	Actual	Season	Season
1. Total water withdrawal	39.67	31.38	79	-8.3
2. By state:				
Republic of Tajikistan	7.0	6.2	90	-0.7
Turkmenistan	15.5	13.0	84	-2.5
Republic of Uzbekistan	17.2	12.2	71	-5.1
3. Downstream of Atamyrat g/s*)	31.520	24.54	78	-7.0
of which:				
Turkmenistan	15.5	13.0	84	-2.5
Republic of Uzbekistan	16.0	11.6	72	-4.5
4. By river reach:				
Upper reaches	8.153	6.839	84	-1.3
of which:				
Republic of Tajikistan	6.95	6.24	90	-0.7
Surkhandarya province, Uzbekistan	1.20	0.60	50	-0.6
Middle reaches	16.207	14.650	90	-1.6
of which:				
Turkmenistan	10.47	9.58	91	-0.9
Republic of Uzbekistan	5.73	5.07	88	-0.7
Lower reaches	15.313	9.895	65	-5.4
of which:				
Turkmenistan	5.03	3.41	68	-1.6
Republic of Uzbekistan	10.285	6.49	63	-3.8
5. In addition:				
Emergency-environmental flow into canals in lower reaches	0	0		
of which:				
Turkmenistan	0	0		
Republic of Uzbekistan	0	0		
Water supply to the Aral Sea region and Aral Sea**	2.10	0.63	30	-1.5

*) Atamyrat g/s nominal – section of the Amu Darya River upstream of water intake into Garagumdarya

***) including the discharged collector-drainage water

Table 2.1.1

Water availability in provinces in the lower reaches of the Amu Darya River

Month	Ten-day	Dashoguz (Turkmenistan)			Khorezm (Uzbekistan)			Republic of Karakalpakstan		
		Water limit, m ³ /s	Water withdrawal, m ³ /s	Water availability, %	Water limit, m ³ /s	Water withdrawal, m ³ /s	Water availability, %	Water limit, m ³ /s	Water withdrawal, m ³ /s	Water availability, %
Apr	1	293	160	55	130	92	71	250	124	50
	2	300	186	62	150	93	62	300	168	56
	3	305	157	51	150	65	44	300	156	52
May	1	311	116	37	150	46	31	300	86	29
	2	306	241	79	150	128	85	400	254	64
	3	268	326	122	180	162	90	450	291	65
June	1	268	281	105	210	150	71	500	280	56
	2	298	294	99	250	226	91	550	472	86
	3	324	250	77	280	174	62	600	346	58
July	1	330	216	65	300	153	51	650	336	52
	2	336	214	64	320	152	47	650	332	51
	3	340	211	62	320	153	48	645	332	51
Aug	1	344	205	60	300	145	48	600	335	56
	2	356	212	60	270	142	53	500	342	68
	3	384	216	56	252	139	55	460	285	62
Sep	1	369	203	55	190	119	63	300	276	92
	2	304	190	62	170	113	66	200	290	145
	3	287	191	66	146	109	75	100	309	308
Total, Mm ³		5028	3406	68	3450	2079	60	6835	4409.5	65

Table 2.2

Amu Darya River water balance in the growing season 2021

Balance item	Water volume, km ³		Deviation (actual-plan)	
	Forecast /plan	Actual	km ³	%
1. Water content in the Amu Darya River - non-regulated flow at Atamyrat g/s nominal*	41.61	41.16	-0.46	1
2. Flow regulation in the Nurek reservoir: addition to the flow (+) or withdrawal (-)	-3.66	-3.64	0.02	1
3. Water withdrawal in the middle reaches (-)	-16.21	-14.65	1.56	10
4. Return (collector-drainage) flow in middle reaches (+)	1.62	1.60	-0.02	1
5. Water losses (-) or unrecorded inflow to the river (+)	-2.66	-5.60	-2.94	110
<i>% of flow at nominal Atamyrat g/s</i>	7	15	8	
6. River flow at Bir-Ata g/s	20.70	18.86	-1.84	9
7. Outflow from Tuyamuyun hydroscheme (including withdrawal from reservoir)	17.77	13.18	-4.59	26
8. Withdrawal in lower reaches, including withdrawal from TMHS (-)	-15.31	-9.89	5.42	35
9. Return (collector-drainage) flow in lower reaches (+)	0.00	0.00	0.00	
10. Emergency-environmental flow into canals (-)	0.00	0.00	0.00	
11. Flow losses (-) or unrecorded inflow to the river (+)	-1.74	-2.93	-1.19	69
<i>% of flow at Tuyamuyun g/s</i>	14	30	15.95	
12. Supply to the Aral Sea region and Aral Sea (Samanbay GS)	0.72	0.35	-0.37	51
TOTAL losses:	-4.40	-8.54	-4.13	94
<i>% of river water content</i>	11	21	10	

* Amu Darya River runoff upstream of the intake into Garagumdarya, taking into account the estimated natural flow at the Nurek HPP (without regulation of the Vakhsh River runoff).

Table 2.3

Water balance of the Amu Darya River basin reservoirs in the growing season 2021

Balance item	Water volume, km ³		Discrepancy (actual-plan)	
	Forecast /plan	Actual	km ³	%
1 Nurek reservoir				
1.1. Inflow to the reservoir	15.11	15.46	0.35	2
1.2. Water volume in the reservoir:				
– beginning of the season (1 April 2021)	6.38	6.38	0.00	0
– end of the season (1 October 2021)	10.52	10.57	0.05	1
1.3. Outflow from the reservoir	11.45	11.83	0.37	3
1.4. Balance discrepancy: unrecorded inflow (+) or losses (-)	0.48	0.55	0.07	
<i>% of inflow to reservoir</i>	3	4	0.41	
1.5. Flow regulation: addition to flow (+) or withdrawal (-)	-3.66	-3.64	0.02	1
2 TMHS reservoirs				
2.1 Flow at Bir-Ata g/s	20.70	18.86	-1.84	9
2.2 Water volume in the reservoirs:				
– beginning of the season (1 April 2021)	2.65	2.65	0.00	0
– end of the season (1 October 2021)	3.20	2.37	-0.83	26
2.3 Outflow from hydroscheme	17.77	13.18	-4.59	26
Of which:				
– outflow into the river	12.81	9.93	-2.88	22
– water withdrawal	4.96	3.25	-1.71	34
2.4 Balance discrepancy: unrecorded inflow (+) or losses (-)	-2.38	-5.96	-3.59	151
<i>Including % of inflow to the reservoir</i>	11	32	20	
2.5 Flow regulation: addition to flow (+) or withdrawal (-)	-7.89	-8.94	-1.04	13
TOTAL flow regulation by the reservoirs: addition to flow (+), withdrawal (-)	-11.55	-12.57	-1.02	9
TOTAL losses (-), unrecorded inflow (+)	-1.90	-5.41	-3.51	185