ANALYSIS OF HYDROLOGICAL CONDITIONS IN THE SYRDARYA AND AMUDARYA RIVER BASINS OVER THE GROWING SEASON 2019

1 Syrdarya River basin

The actual inflow to the upstream reservoirs in the Syrdarya basin (Toktogul, Andizhan, and Charvak reservoirs) was 17 km³ or 97% of the forecast and 93% of the norm for the growing season. The total lateral inflow to the Naryn and Syrdarya Rivers (in the reaches up to the Shardara reservoir) was 10 km^3.

By the beginning of the growing season, the upstream reservoirs (Toktogul, Andizhan, and Charvak) have accumulated 15.1 km³. By the end of the growing season, the total capacity in the upstream reservoirs was 19.67 km³ or 98% of the value scheduled by BWO Syrdarya. In the Toktogul reservoir, the total capacity was 17.21 km³ and the active capacity - 11.71 km^3. Water releases from the Toktogul reservoir were 5.14 km³ or 94 % of the BWO Syrdarya schedule. Analysis of operation of the Toktogul reservoir shows that water supply to the reservoir was 0.53 km³ less than the forecast and amounted to 92% of the norm during the growing season. Water releases from the reservoir were 0.33 km³ less than scheduled (planned) by BWO Syrdarya.

Water storage in the Bakhri Tochik reservoir was 2.83 km³ by the beginning of the growing season and 2.15 km³ by the end of the growing season. The inflow to the Bakhri Tochik reservoir and water discharge into the river amounted to 6.29 km³ and 6.22 km³, respectively. Analysis of operation of the Bakhri Tochik reservoir showed that water supply to the reservoir was 0.02 km³ less than planned by BWO Syrdarya, and water releases from the reservoir were 0.2 km³ less than scheduled by BWO Syrdarya.

In the Shardara reservoir, water storage was 5.18 km³ by the beginning of the growing season and 1.13 km³ by the end of the growing season. The inflow to the Shardara reservoir was 5.24 km³; water releases from the reservoir were 8.49 km³, including 7.39 km³ into the river; 0.41 km^3 of water was released into the Arnasay reservoir from the Shardara hydroscheme. Water losses amounted to 0.79 km³ in the reservoir.

According to the Aralo-Syrdarya Basin Water Administration's data, the Koksarai reservoir accumulated water in the amount of 255 Mm^3 only in April and May, while 2,317 Mm^3 were drawn down from April till July.

The total water withdrawal from the Naryn and Syrdarya Rivers was 8.96 km³ or 76% of the limit in the reaches up to the Shardara reservoir; last season it was 10.7 km^3 (92 %). Over the growing season 2019, water withdrawal was 2.91 km^3 less than planned by BWO Syrdarya. Water shortage was estimated in the amount of 316 Mm^3 in the Republic of Kazakhstan (along the Dustlik canal), 82 Mm^3 in the Kyrgyz Republic, 348 Mm^3 in the Republic of Tajikistan, and 2,161 Mm^3 in the Republic of Uzbekistan; last season it was 505 Mm^3. Water availability was uneven by state and river reach (Table 1.1). The greatest relative water shortage (% of the limit) was observed in the middle reaches in the Bakhri Tochik -

Shardara reservoir site – 34 % (Table 1.4). The water shortage situation is described as follows by ten-day:

- In Kazakhstan, water shortage amounted to 66-76 % in the third ten-day of April-second ten-day of May. From the third ten-day of June till the first ten-day of July, water shortage varied between 53 and 58%.
- Water shortage in Tajikistan was 63% in the beginning of May.
- In Uzbekistan, water shortage varied between 36% and 44 % in June and 31% and 41% in July.

Water availability was estimated at 75% for the Republic of Uzbekistan, 66% for the Republic of Kazakhstan, and 67% for the Kyrgyz Republic. Water availability in the Republic of Tajikistan was higher than in other countries but very uneven by river reach: 1) Toktogul-Uchkurgan – 51%; 2) Uchkurgan-Bakhri Tochik – 121%; 3) Bakhri Tochik-Shardara – 73% (Table 1.1).

Analysis of water balance in basin's reservoirs (Table 1.3) has revealed balance discrepancy (taking into account water losses in reservoirs) 1.58 km³ in total, including 0.79 km^3 in the Shardara reservoir, 0.32 km^3 in the Bakhri Tochik reservoir, and 0.43 km³ in the Charvak reservoir.

Open river channel balance discrepancy in the Toktogul-Shardara reach was 0.87 km³ or 6% of regulated Syrdarya runoff in the growing season.

In the lower reaches, runoff utilization was 8.38 km^3 (including water withdrawal, losses, minus lateral inflow).

Water supply to the Aral Sea and Prearalie (Karateren GS) amounted to 0.72 km³ in the growing season by KazHydroMet's data and 1.08 km³ according to the Kazakh Committee for Water Resources.

Table 1.1

Water availability in the Syrdarya River basin countries over the growing season 2019

Water user	Water volume, km^3		Water availability, %	Deficit (-), surplus (+) km^3
	BWO schedule/ limit	Actual	Season	Season
1 Total water withdrawal up to the Shardara reservoir	11.87	8.96	76	-2.91
2 By state:				
– *Kyrgyz Republic*	0.25	0.16	67	-0.08
– *Republic of Uzbekistan*	8.80	6.64	75	-2.16
– *Republic of Tajikistan*	1.91	1.56	82	-0.35
– *Republic of Kazakhstan*	0.92	0.60	66	-0.32
3 By river reach				
3.1 Toktogul reservoir – Uchkurgan hydroscheme	3.95	3.36	85	-0.59
of which:				
– *Republic of Uzbekistan*	0.16	0.10	59	-0.07
– *Republic of Tajikistan*	0.24	0.12	51	-0.12
– *Republic of Kazakhstan*	3.55	3.14	89	-0.41
3.2 Uchkurgan hydroscheme – Bakhri Tochik reservoir	1.08	1.08	101	0.01
of which:				
– *Republic of Uzbekistan*	0.08	0.07	82	-0.02
– *Republic of Tajikistan*	0.45	0.54	121	0.09
– *Republic of Kazakhstan*	0.54	0.47	87	-0.07
3.3 Bakhri Tochik reservoir-Shardara reservoir	6.85	4.52	66	-2.32
of which:				
– *Republic of Uzbekistan*	0.92	0.60	66	-0.32
– *Republic of Tajikistan*	1.22	0.89	73	-0.33
– *Republic of Kazakhstan*	4.71	3.03	64	-1.68
4 In addition:				
– Inflow to the Shardara reservoir	4.60	5.24	114	0.64

Water user	Water volume, km^3		Water availability, %	Deficit (-), surplus (+) km^3
	BWO schedule/ limit	Actual	Season	Season
– Discharge into Arnasay	0.00	0.41		0.41
– Supply to the Aral Sea and Prearalie*	1.41	1.08	76	-0.33

* Committee for Water Resources of the Ministry of Ecology, Geology, and Natural Resources of the Republic of Kazakhstan

Table 1.2

Syrdarya River channel water balance in the growing season 2019

Balance item	Water volume, km^3		Deviation (actual-plan)	
	Forecast/ plan	Actual	km^3	%
1 Inflow to the Toktogul reservoir	9.33	8.81	-0.53	6
2 Lateral inflow to the river reach of Toktogul reservoir – Shardara reservoir (+)	9.78	10.01	0.23	2
of which:				
– *Discharge from the Karadarya river*	1.54	1.75	0.21	13
– *Discharge from the Chirchik river*	0.89	1.04	0.15	17
– *Lateral inflow from CDF and small rivers*	7.35	7.22	-0.13	2
3 Flow regulation in the reservoirs: inflow (+) or withdrawal (-)	-3.76	-3.74	0.02	1
including:				
– *Toktogul reservoir*	-3.87	-3.67	0.20	5
– *Bakhri Tochik reservoir*	0.11	-0.07	-0.18	168
4 Regulated runoff (1+2+3)	15.35	15.07	-0.28	2
5 Water withdrawal in the Toktogul – Shardara reach (-)	-11.87	-8.96	2.91	24
6 **Discrepancy:** water losses (-) or unrecorded inflow to the river channel (+) in the Toктogul-Shardara reach	1.12	-0.87	-1.99	177
Including % of regulated runoff	7	6		

Balance item		Water volume, km^3		Deviation (actual-plan)	
		Forecast/ plan	Actual	km^3	%
7	Inflow to the Shardara reservoir	4.60	5.24	0.64	14
8	Flow regulation in the Shardara reservoir: inflow (+) or withdrawal (-)	3.12	3.25	0.14	4
9	Water releases from the Shardara reservoir	7.72	8.49	0.77	10
10	Including water releases into the river	6.79	7.39	0.60	9
11	Flow regulation in the Koksaray reservoir: inflow (+) or withdrawal (-)	1.68	2.06	0.38	23
12	Runoff utilization (water withdrawal-lateral inflow+losses) (-)	-7.07	-8.38	-1.31	19
13	Supply to the Aral Sea and Prearalie	1.41	1.08	-0.33	24

Table 1.3

Water balance of the Syrdarya River basin reservoirs in the growing season 2019

Balance item	Water volume, km^3		Deviation (actual-plan)	
	Forecast /plan	Actual	km^3	%
1.Toktogul reservoir				
1.1 Inflow to the reservoir	9.33	8.81	-0.53	6
1.2 Water volume in the reservoir:				
– beginning of the season (1 April 2019)	13.56	13.56	0.00	0
– end of the season (1 October 2019)	17.37	17.21	-0.16	1
1.3 Water releases from the reservoir	5.47	5.14	-0.33	6
1.4 **Discrepancy:** unrecorded inflow (+) or losses (-)	-0.05	-0.02	0.04	68
% of inflow to the reservoir	1	0	0	
1.5 **Flow regulation:** flow inflow (+) or withdrawal (-)	-3.87	-3.67	0.20	5
2.Andizhan reservoir				
2.1 Inflow to the reservoir	2.68	1.94	-0.74	27
2.2 Water volume in the reservoir:				
– beginning of the season (1 April 2019)	0.97	0.97	0.00	0
– end of the season (1 October 2019)	1.11	0.71	-0.40	36
2.3 Water releases from the reservoir	2.55	2.19	-0.35	14
2.4 **Discrepancy:** unrecorded inflow (+) or losses (-)	0.00	-0.01	-0.02	894
% of inflow to the reservoir	0	1	1	
2.5 **Flow regulation:** flow inflow (+) or withdrawal (-)	-0.13	0.25	0.38	284
3.Charvak reservoir				
3.1 Inflow to the reservoir	5.46	6.24	0.78	14
3.2 Water volume in the reservoir:				
– beginning of the season (1 April 2019)	0.55	0.55	0.00	0
– end of the season (1 October 2019)	1.67	1.75	0.08	5
3.3 Water releases from the reservoir	4.42	4.61	0.19	4
3.4 **Discrepancy:** unrecorded inflow (+) or losses (-)	0.07	-0.43	-0.51	682

Balance item	Water volume, km^3		Deviation (actual-plan)	
	Forecast /plan	Actual	km^3	%
% of inflow to the reservoir	1	7	6	
3.5 **Flow regulation:** flow inflow (+) or withdrawal (-)	-1.05	-1.63	-0.59	56
4 Bakhri Tochik reservoir				
4.1 Inflow to the reservoir	6.32	6.29	-0.02	0
4.2 Lateral inflow	0.30	0.24	-0.06	19
4.3 Water volume in the reservoir:				
– beginning of the season (1 April 2019)	2.83	2.83	0.00	0
– end of the season (1 October 2019)	2.00	2.15	0.15	8
4.4 Water releases from the reservoir	7.02	6.88	-0.14	2
including*:*				
– *Water releases into river*	6.42	6.22	-0.20	3
– *Water withdrawal from reservoir*	0.60	0.66	0.06	10
4.5 **Discrepancy:** unrecorded inflow (+) or losses (-)	-0.41	-0.32	0.09	22
% of inflow to the reservoir	7	5	1	
4.6 **Flow regulation**: inflow (+) or withdrawal (-)	0.11	-0.07	-0.18	168
5 Shardara reservoir				
5.1 Inflow to the reservoir	4.60	5.24	0.64	14
5.2 Lateral inflow	0.00	0.00	0.00	
5.3 Water volume in the reservoir:				
– beginning of the season (1 April 2019)	5.18	5.18	0.00	0
– end of the season (1 October 2019)	1.41	1.13	-0.28	20
5.4 Water releases from the reservoir	7.72	8.49	0.77	10
including:				
– *Discharge into Arnasay*	0.00	0.41	0.41	
– *Water releases into river*	6.79	7.39	0.60	9
– *Water withdrawal from reservoir*	0.93	0.69	-0.24	26
5.5 **Discrepancy:** unrecorded inflow (+) or losses (-)	-0.64	-0.79	-0.14	22
% of inflow to the reservoir	14	15	1	
5.6 **Flow regulation**: inflow (+) or withdrawal (-)	3.12	2.15	-0.96	31

Balance item	Water volume, km^3		Deviation (actual-plan)	
	Forecast /plan	Actual	km^3	%
TOTAL Flow regulation by reservoirs: inflow (+) or withdrawal (-)	-1.82	-2.97	-1.15	63
TOTAL losses (-), unrecorded inflow (+)	-1.04	-1.58	-0.54	52

Table 1.4

Country water deficit in the Bakhri Tochik-Shardara reach, growing season 2019

Water balance item		April			May			June			July			August			September			Total for growing season, Mm^3
		I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	
Total water withdrawal at the reach	Limit, m^3/s	288	355	382	366	370	410	535	611	649	672	674	672	562	471	352	199	121	92	**6,845**
	Actual, m^3/s	152	103	40	127	218	297	333	407	379	403	478	472	473	419	320	186	138	181	**4,522**
	Deficit, %	**47**	**71**	**90**	**65**	**41**	**28**	**38**	**33**	**42**	**40**	**29**	**30**	**16**	**11**	**9**	**7**	**-**	**-**	**34**
Kazakhstan	Limit, m^3/s	20	20	20	25	25	35	55	75	105	120	120	120	110	100	75	15	0	0	**918**
	Actual, m^3/s	20	20	5	8	9	26	39	53	45	57	78	74	78	71	60	36	7	0	**602**
	Deficit, %	**-**	**-**	**76**	**69**	**66**	**26**	**30**	**29**	**58**	**53**	**35**	**38**	**30**	**30**	**21**	**-**	**-**	**-**	**34**
Tajikistan	Limit, m^3/s	10	60	81	82	82	89	92	96	96	96	96	96	96	96	82	60	40	35	**1,220**
	Actual, m^3/s	0	0	0	30	59	75	78	74	75	79	83	84	82	79	73	53	45	40	**893**
	Deficit, %	**100**	**100**	**99**	**63**	**28**	**16**	**16**	**23**	**22**	**18**	**13**	**13**	**14**	**17**	**11**	**12**	**-**	**-**	**27**
Uzbekistan	Limit, m^3/s	258	275	281	259	263	286	388	440	448	456	458	456	356	275	195	124	81	57	**4,707**
	Actual, m^3/s	132	83	35	89	150	196	217	280	259	267	317	314	313	269	188	97	86	140	**3,027**
	Deficit, %	**49**	**70**	**88**	**66**	**43**	**31**	**44**	**36**	**42**	**41**	**31**	**31**	**12**	**2**	**4**	**22**	**-**	**-**	**36**

2 Amudarya River basin

The actual water content in the Amudarya River at the nominal Atamyrat gauging station (upstream of intake to Garagumdarya) was 47.28 km³ or 3 km³ less than expected by the BWO Amudarya (Table 2.2). The inflow to the Nurek HPP amounted to 17.44 km³ and turned to be lower of the forecast by 0.44 km³. Water releases from the reservoir were 13.61 km³ or 1.07 km³ more than scheduled by BWO Amudarya. Water withdrawal from the river through accumulation in the Nurek reservoir amounted to 3.89 km³. Water storage in the reservoir of the Nurek HPP was 4.47 km3. Unrecorded inflow to the reservoir was estimated at 0.64 km^3 (Table 2.3).

According to measurements at the Bir-Ata gauging station, inflow to the Tuyamuyun hydroscheme (TMHS) was 30.2 km³ or 2.62 km³ more than expected. This allowed accumulating 2.5 km³ in TMHS reservoirs. Water volume in TMHS reservoirs was only 5.04 km³ by the end of the growing season. Water releases from TMHS were 2.1 km³ more than planned and amounted to 20.06 km³. Balance discrepancy amounted to 7.64 km3 in the reach Bir-Ata GS – Tuyamuyun GS in the growing season. Possible causes for balance discrepancy of TMHS reservoirs are: inaccuracies in measurements of water discharge at the Amudarya River gauging stations, inaccuracies in calculation of water volumes in reservoirs (by bathymetric curves depending on measured water levels), and inaccuracies in control of water withdrawals in the river reach and reservoirs.

Given such hydrological conditions, the established limit of water withdrawal into canals in the Amudarya River basin was 91% provided (Table 2.1). The total water withdrawal amounted to 36.12 km³, including 29.4 km³ downstream of the Atamyrat gauging station (starting from intake to Garagumdarya). During the growing season, the average water availability was 86% in the Republic of Tajikistan, 95% in Turkmenistan, and 90% in the Republic of Uzbekistan; in the lower reaches, water availability was 96% in Turkmenistan, 95% in the Republic of Uzbekistan, and 62% in Surkhandarya province (Table 2.1).

Open channel balance discrepancy of the Amudarya River was 0.09 km^3 in the reach Atamyrat GS (nominal) – Bir-Ata GS or at about 0.2% of river runoff at the nominal Atamyrat reach and 4.36 km^3 in the lower reaches (Tuyamuyun GS-Samanbay GS reach) or 29% of river runoff at Tuyamuyun GS.

The amount of 1.94 km^3 was supplied to Prearalie and the Aral Sea during the growing season (Amudarya River runoff along the Samanbay GS plus discharged collector-drainage water) or 93 % of BWO's schedule.

Table 2.1

Water availability in the Amudarya River basin countries over the growing season 2019

Water user	Water volume, km³		Water availability %	Deficit (-), surplus (+) km³
	Limit/ Schedule	Actual	Season	Season
1. Total water withdrawal	**39.67**	**36.12**	**91**	**-3.5**
2. By state:				
Kyrgyz Republic	-	-	-	-
Republic of Tajikistan	7.0	6.0	86	-1.0
Turkmenistan	15.5	14.7	95	-0.8
Republic of Uzbekistan	17.2	15.4	90	-1.8
3. Downstream of Atamyrat g/s *)	**31.5**	**29.4**	**93**	**-2.1**
of which:				
Turkmenistan	15.5	14.7	95	-0.8
Republic of Uzbekistan	16.0	14.7	92	-1.3
4. By river reach:				
Upper reaches	**8.15**	**6.74**	**83**	**-1.4**
of which:				
Kyrgyz Republic	-	-	-	-
Republic of Tajikistan	6.95	6.00	86	-1.0
Surkhandarya province, Uzbekistan	1.20	0.74	62	-0.5
Middle reaches	**16.207**	**14.77**	**91**	**-1.4**
of which:				
Turkmenistan	10.47	9.86	94	-0.6
Republic of Uzbekistan	5.73	4.92	86	-0.8
Lower reaches	**15.31**	**14.61**	**95**	**-0.7**
of which:				
Turkmenistan	5.03	4.84	96	-0.2
Republic of Uzbekistan	10.285	9.77	95	-0.5
5. In addition:				
Emergency and environmental water releases into canals in lower reaches	0	0		

Water user	Water volume, km³		Water availability %	Deficit (-), surplus (+) km³
	Limit/ Schedule	Actual	Season	Season
of which:				
Turkmenistan	0	0		
Republic of Uzbekistan	0	0		
Supply to the Aral Sea and Prearalie **	2.10	1.94	93	-0.2

***)** Atamyrat g/s nominal – section of the Amudarya River upstream of water intake to Garagumdarya

**) including the discharged collector-drainage water

Table 2.2

Amudarya River channel water balance in the growing season 2019

Balance item	Water volume, km^3		Deviation (actual-plan)	
	Forecast /Plan	Actual	$км_3$	%
1. Water content in the Amudarya River - non-regulated flow at Atamyrat g/s nominal*	50.26	47.28	-2.99	6
2. Flow regulation in the Nurek reservoir: accumulation (+) or withdrawal (-)	-4.47	-3.83	0.64	14
3. Water withdrawal in the middle reaches (-)	-16.21	-14.77	1.43	9
4. Return flow (collector-drainage) in middle reaches (+)	1.76	1.62	-0.13	8
5. Water losses (-) or unrecorded inflow to the river channel (+)	-3.77	-0.09	3.68	98
% of flow at Atamyrat g/s nominal	7	0	-7	
6. River flow at Bir-Atal g/s	27.58	30.20	2.62	10
7. Flow regulation in Tuyamuyun hydroscheme: accumulation (+) or withdrawal (-)	-11.11	-15.38	-4.26	38
8. Releases from Tuyamuyun hydroscheme (including withdrawal from reservoir)	22.16	20.06	-2.10	9
9. Withdrawal in lower reaches, including withdrawal from Tuyamuyun hydroscheme (-)	-15.31	-14.61	0.70	5
10. Return flow (collector-drainage) in lower reaches (+)	0.00	0.00	0.00	
11. Emergency and environmental water releases into canals (-)	0.00	0.00	0.00	
12. Flow losses (-) or unrecorded inflow to the channel (+)	1.66	-4.36	-6.02	363
% of flow at Tuyamuyun g/s	10	29	19.32	
13. Supply to Prearalie and the Aral Sea (Samanbay g/s)	2.81	1.10	-1.71	61
TOTAL losses:	-2.11	-4.45	-2.34	111
% of river water content	4	9	5	

*****Amudarya River runoff upstream of the intake to Garagumdarya, given the calculated natural flow at the Nurek HPP (without regulation of the Vakhsh River runoff)

Table 2.3

Water balance of the Amudarya River basin reservoirs in the growing season 2019

Balance item	Water volume, km^3		Deviation (actual-plan)	
	Forecast /plan	Actual	km^3	%
1 Nurek reservoir				
1.1. Inflow to the reservoir	17.00	17.44	0.44	3
1.2. Water volume in the reservoir:				
– beginning of the season (1 April 2019)	6.10	6.10	0.00	0
– end of the season (1 October 2019)	10.57	10.57	0.00	0
1.3. Water releases from the reservoir	12.54	13.61	1.07	9
1.4. **Balance discrepancy:** unrecorded inflow (+) or losses (-)	0.00	0.64	0.64	
% of inflow to the reservoir	0	4	3.66	
1.5. **Flow regulation**: accumulation (+) or withdrawal (-)	-4.47	-3.83	0.64	14
2 TMHS reservoirs				
2.1 Runoff at Bir-Ata g/s	27.58	30.20	2.62	10
2.2 Water volume in the reservoirs:				
– beginning of the season (1 April 2019)	2.54	2.54	0.00	0
– end of the season (1 October 2019)	4.81	5.04	0.23	5
2.3 Water releases from the hydroscheme	22.16	20.06	-2.10	9
of which:				
– releases into the river	16.47	14.83	-1.64	10
– withdrawal	5.69	5.24	-0.46	8
2.4 **Balance discrepancy:** unrecorded inflow (+) or losses (-)	-3.15	-7.64	-4.49	142
Including % of inflow to the reservoir	11	25	14	
2.5 **Flow regulation**: accumulation (+) or withdrawal (-)	-11.11	-15.38	-4.26	38
TOTAL flow regulation by the reservoirs: accumulation (+) or withdrawal (-)	-15.58	-19.21	-3.63	23
TOTAL losses (-),unrecorded inflow (+)	-3.15	-7.00	-3.85	122