PROJECT

Transboundary Water Management Adaptation in the Amudarya Basin to Climate Change Uncertainties

Report
2.1. ASBmm adjustment

c) Assessment of water losses in river channel and return flow in Amudarya river reaches - assessment 2010-2014

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Executor A.Nazariy

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1. Research objective and tasks

Stage 1: Preparation
Collection, processing and analysis of data (Point 1.3, ToR)
Stage 2: Research
Adjustment of ASBmm (Point 2.1, ToR)
Refinement of PZ water balance components by basin section, including water losses in river channel, return flow (Point 2.1.1, ToR)

2. Research methodology

Correlation analysis of return flow, construction of relationships between the water losses in river channel and the flow in Amudarya.

3. Data

The data were got from the Uzbek Ministry of Agriculture and Water Resources, DB of BWO Amudarya and its territorial divisions:

- Upper Darya division in Tajikistan
- Middle Darya division in Turkmenistan
- Amudarya Inter-republican Canals Division (UPRADIK) in Uzbekistan
- Lower Darya division in Uzbekistan

4. Results

The results of the analysis of return water and losses are shown below.

Return flow by river reach of Amudarya

Relationship between the total collector-drainage outflow and the total water withdrawal of planning zones of the Amudarya River Basin

Planning zone	Growing season	Non-growing season	Hydrologic year
Republic of Uzbekistan			
Karshi	y=0.113x+56.147	y=0.1857x+45.226	y=0.1118x+55.999
	R2= 0.6039	R2= 0.6009	R2= 0.6018
Surkhandarya	y=0.1031x+61.589	y=0.1225x+73.146	y=0.0951x+75.548
	R2= 0.6218	R2= 0.6	R2= 0.6204
Bukhara	y=0.1825x+77.245	y=0.4228x+69.444	y=0.3407x+79.039
	R2= 0.6208	R2= 0.6017	R2= 0.6227
Khorezm	y=0.2305x+153.15	y=0.3244x+114.85	y=0.3326x+122.22
	R2= 0.7156	R2= 0.7023	R2= 0.7124
Southern Karakalpakstan	y=0.1043x+45.948	y=0.1832x+24.179	y=0.1575x+31.697
	R2= 0.7383	R2= 0.7217	R2= 0.7594
Northern Karakalpakstan	y=0.1118x+100.8	y=0.2215x+49.09	y=0.1521x+73.926
	R2= 0.7404	R2= 0.7102	R2= 0.7317
Turkmenistan			
Akhal	y=0.0272x+30.547	y=0.036x+28.586	y=0.0305x+29.007
	R2= 0.627	R2= 0.6154	R2= 0.6378
Mary	y=0.1251x+35.283	y=0.1303x+43.682	y=0.1276x+30.192
	R2= 0.6185	R2= 0.6105	R2= 0.622
Lebap	y=0.1665x+128.47	y=0.3639x+61.462	y=0.2525x+81.729
	R2= 0.7179	R2= 0.7044	R2= 0.7197
Dashoguz	y=0.169x+57.211	y=0.1862x+21.498	y=0.1929x+29.785
	R2= 0.8103	R2= 0.8683	R2= 0.8106
Republic of Tajikistan			
Gorno-Badakhshan	y=0.0864x-0.7691	y=0.0405x-0.773	y=0.0833x-0.4138
	R2=0.965	R2=0.8859	R2=0.9878
Lower Kafirnigan	y=0.1084x-0.1211	y=0.1212x-1.0805	y=0.1125x-0.8378
	R2=0.9637	R2=0.9579	R2=0.9913
Upper Kafirnigan	y=0.1084x-2.3603	y=0.0833x-1.9655	y=0.1135x-3.0286
	R2=0.9231	R2=0.8538	R2=0.959
Vakhsh	y=0.1084x-0.3371	y=0.1212x-3.0091	y=0.1125x-2.3331
	R2=0.9637	R2=0.9579	R2=0.9913
Pyandj	y=0.1084x-0.2456	y=0.1212x-2.1924	y=0.1125x-1.6999
	R2=0.9637	R2=0.9579	R2=0.9913
Karatag-Shirkent	y=0.1084x-0.6415	y=0.0835x-0.5255	y=0.1135x-0.8232
	R2=0.9231	R2=0.858	R2=0.959
Garm	y=0.1084x-0.7954	y=0.0831x-0.6553	y=0.1135x-1.0207
	R2=0.9231	R2=0.858	R2=0.959

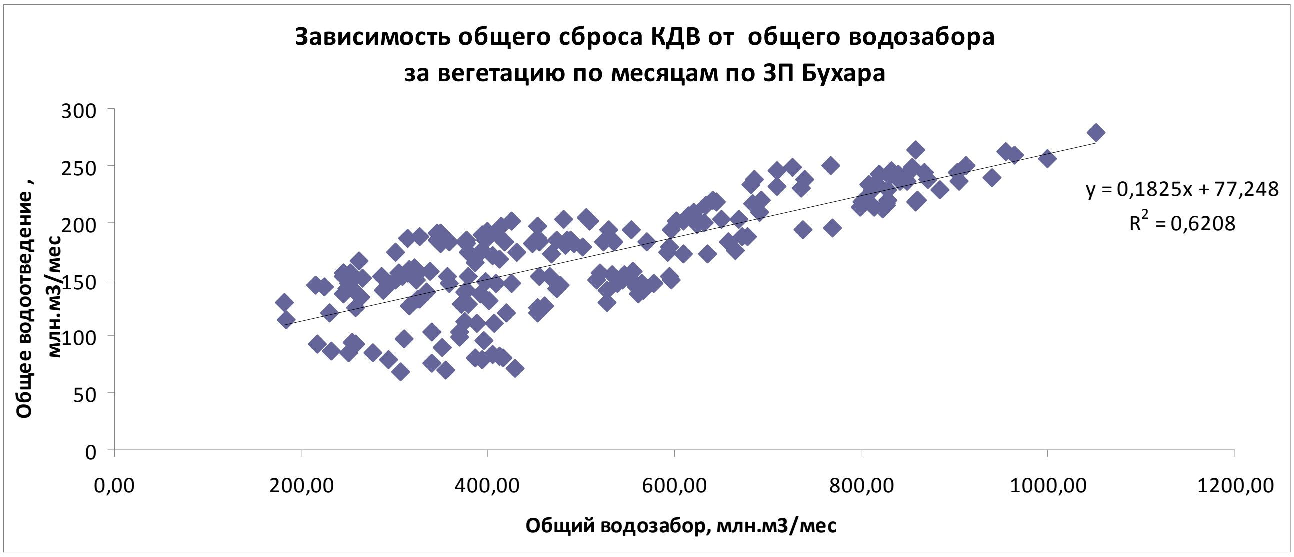

Fig.1. Relationship between the total CDW discharge and the total water intake in the growing season, by month, Bukhara PZ

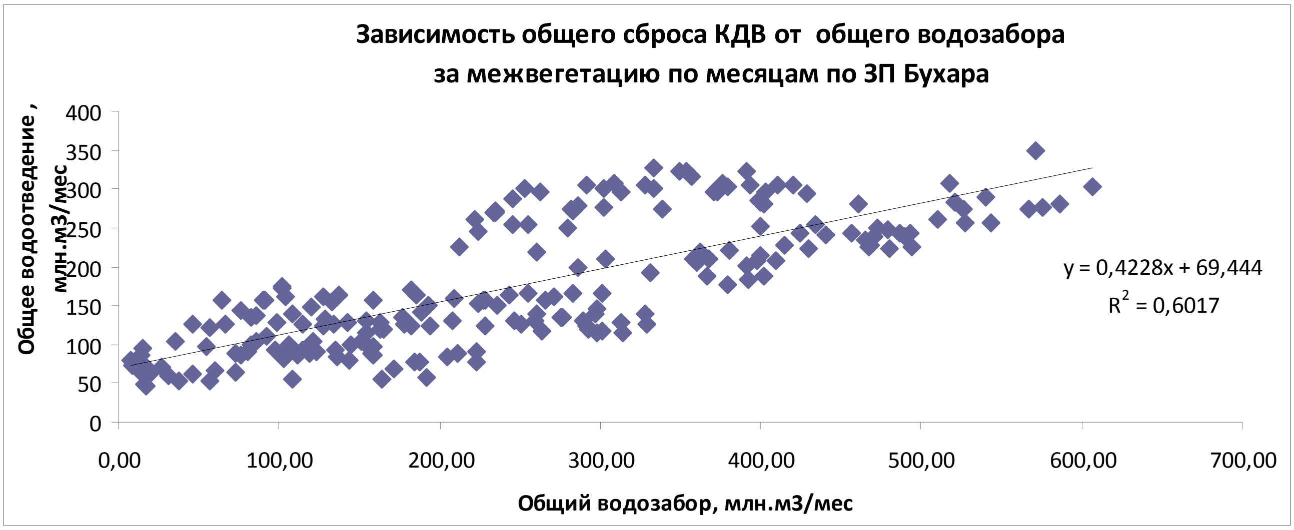

Fig.2. Relationship between the total CDW discharge and the total water intake in the non-growing season, by month, Bukhara PZ

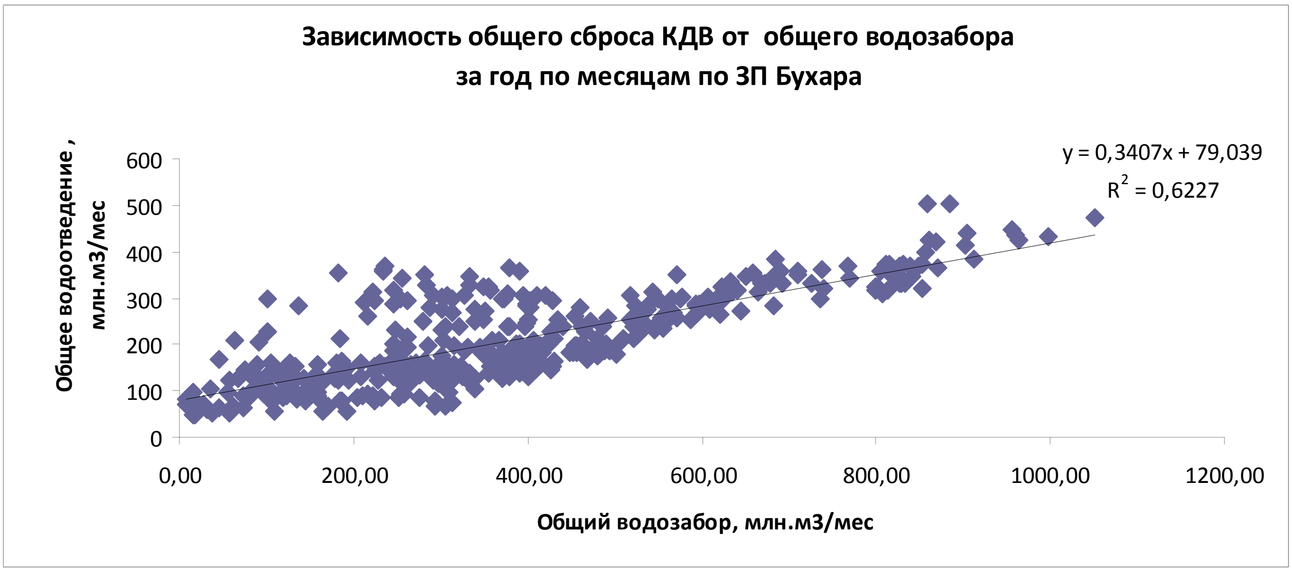

Fig.3. Relationship between the total CDW discharge and the total water intake in hydrologic year, by month, Bukhara PZ

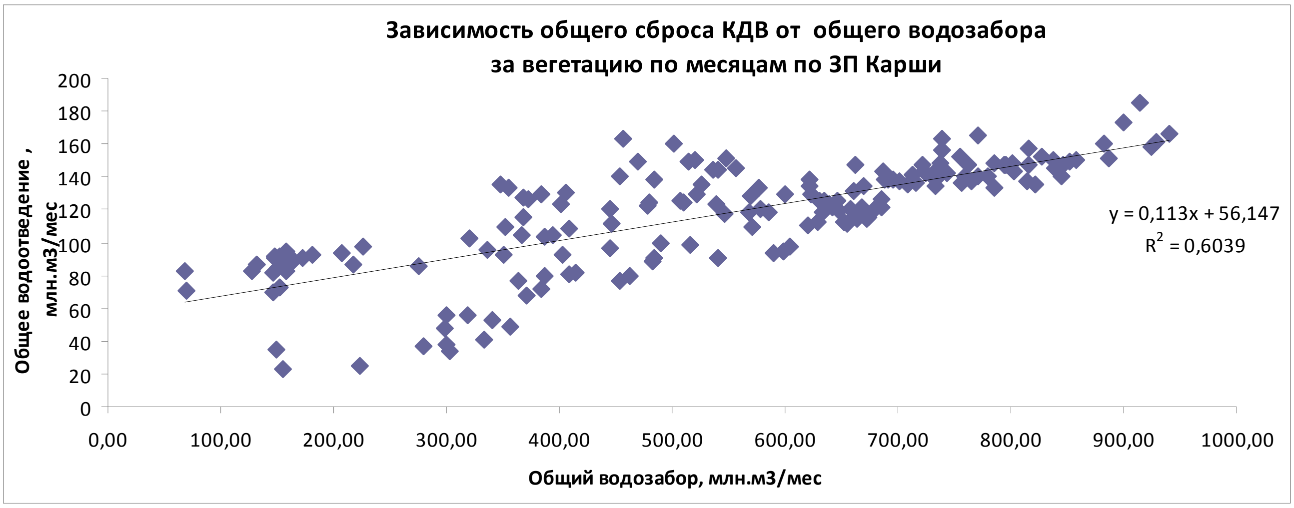

Fig.4. Relationship between the total CDW discharge and the total water intake in the growing season, by month, Karshi PZ

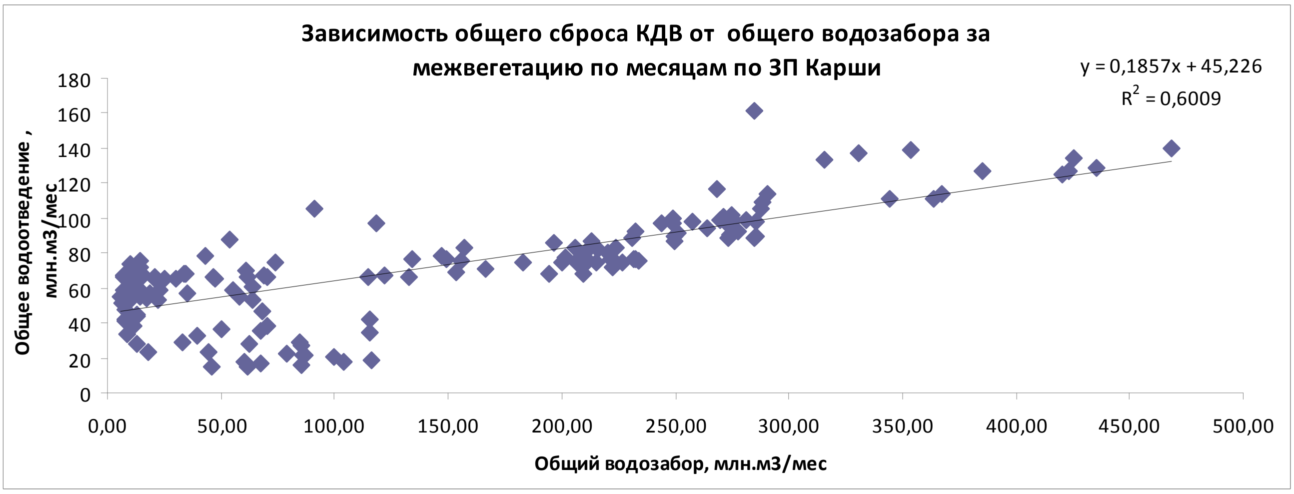

Fig.5. Relationship between the total CDW discharge and the total water intake in the non-growing season, by month, Karshi PZ

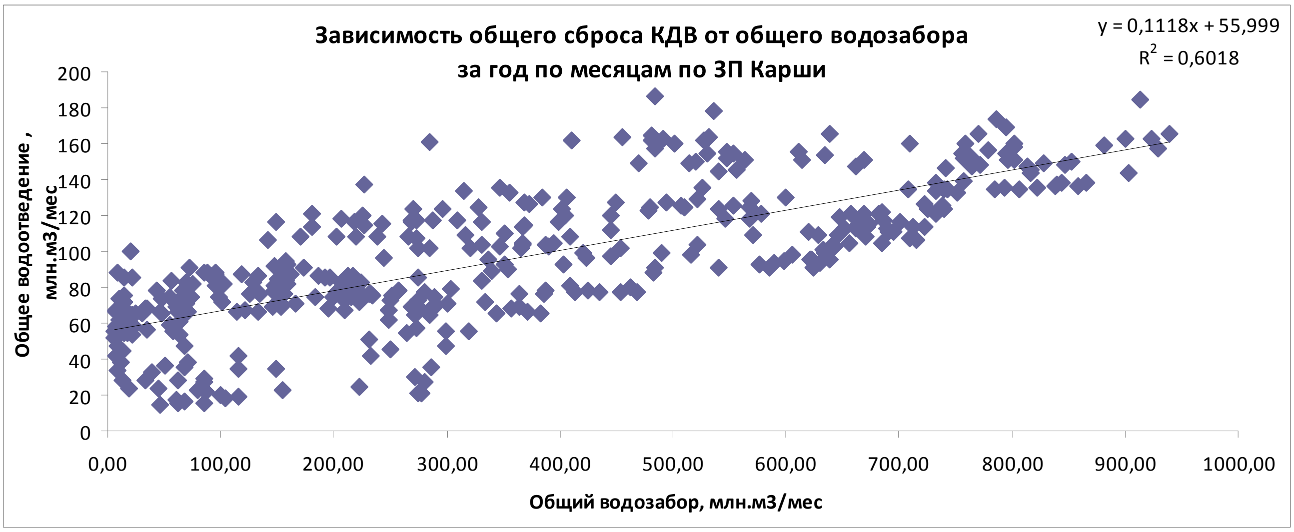

Fig.6. Relationship between the total CDW discharge and the total water intake in hydrologic year, by month, Karshi PZ

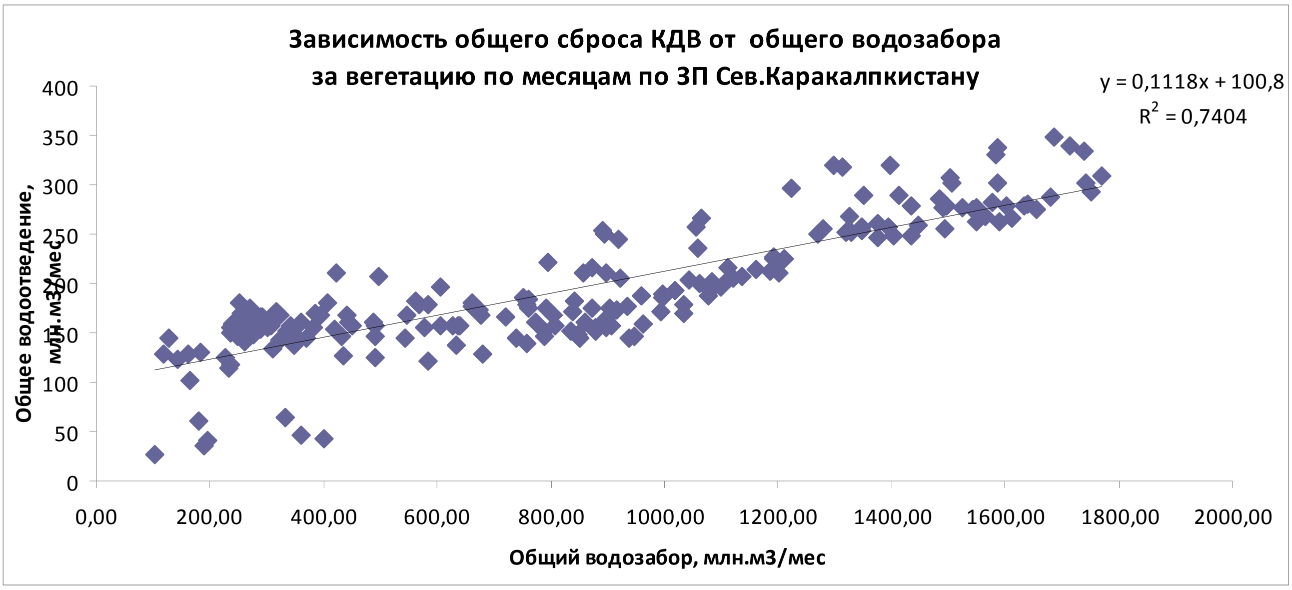

Fig.7. Relationship between the total CDW discharge and the total water intake in the growing season, by month, Northern Karakalpakstan PZ

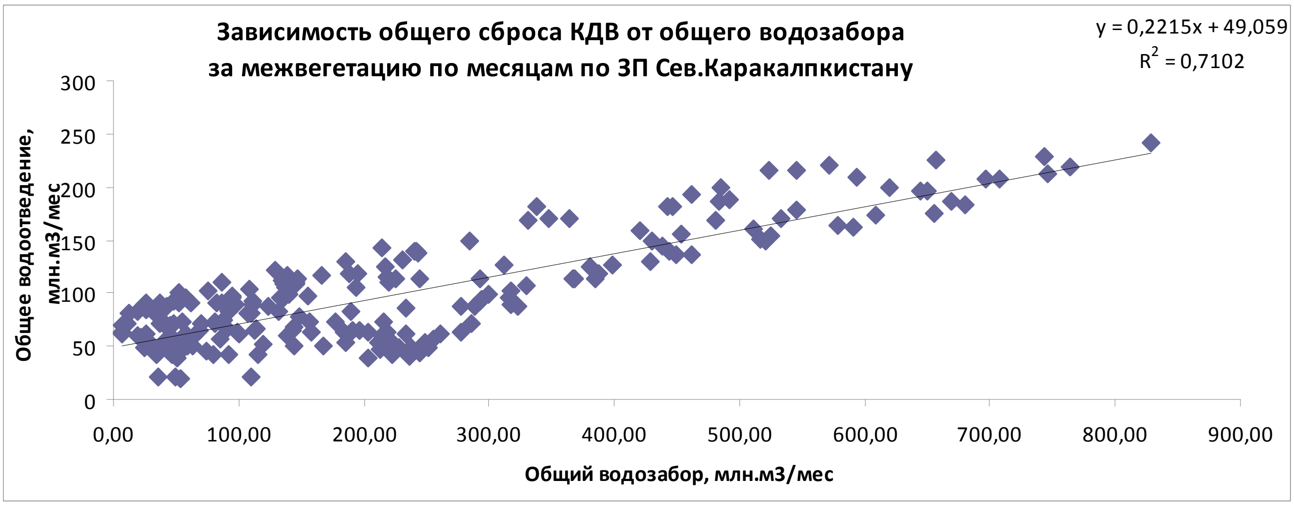

Fig.8. Relationship between the total CDW discharge and the total water intake in the non-growing season, by month, Northern Karakalpakstan PZ

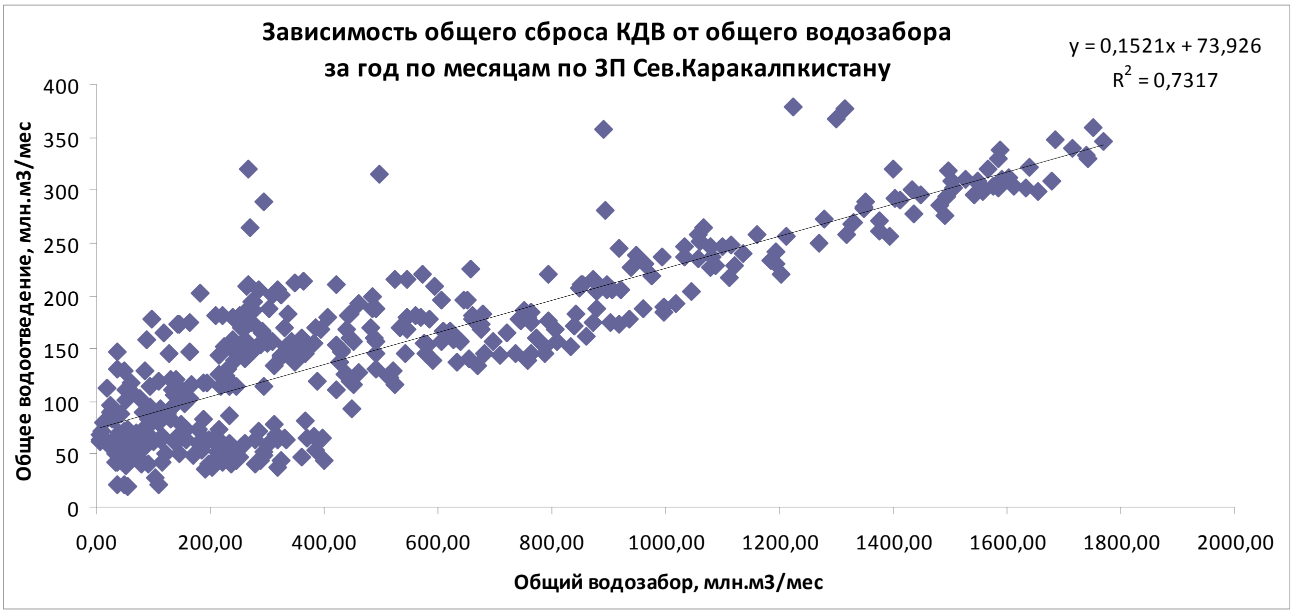

Fig.9. Relationship between the total CDW discharge and the total water intake in hydrologic year, by month, Northern Karakalpakstan PZ

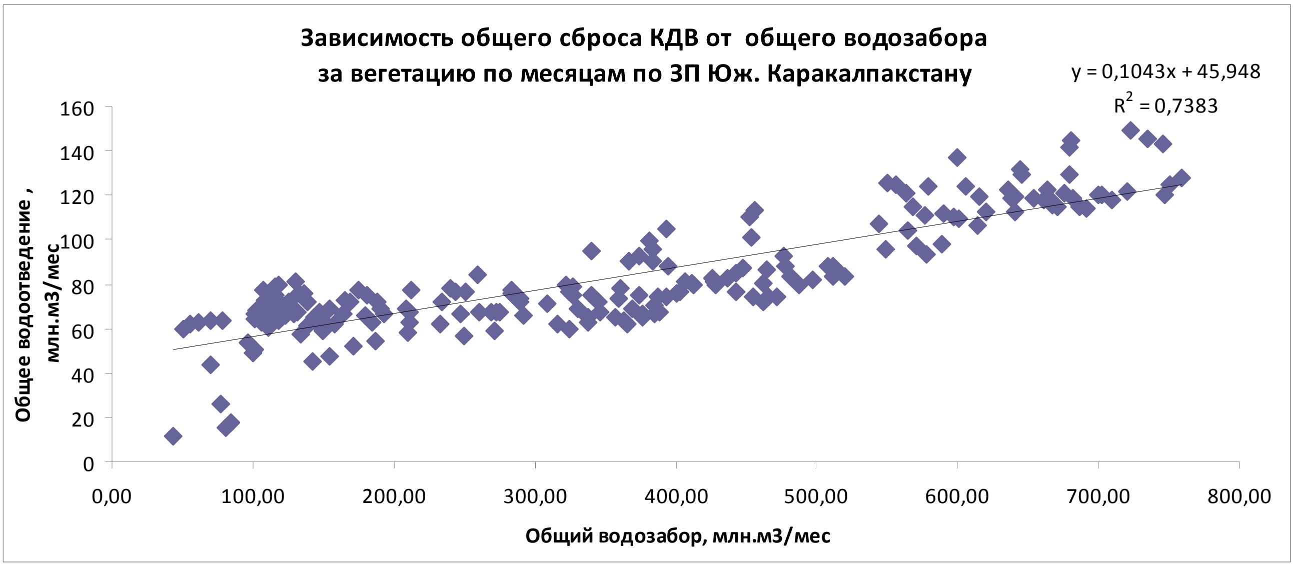

Fig.10. Relationship between the total CDW discharge and the total water intake in the growing season, by month, Southern Karakalpakstan PZ

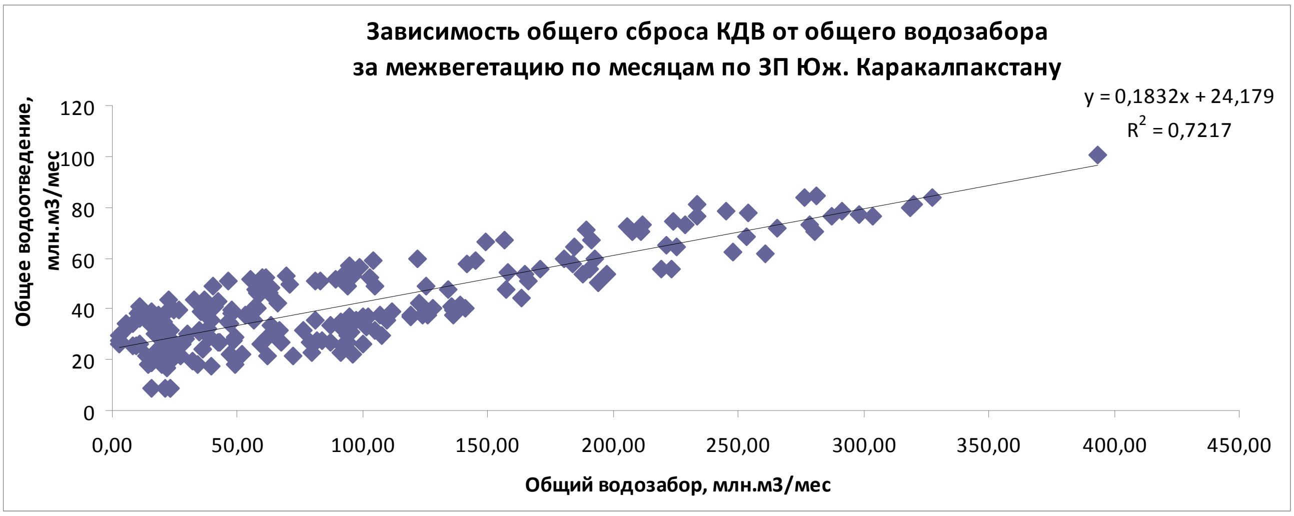

Fig.11. Relationship between the total CDW discharge and the total water intake in the non-growing season, by month, Southern Karakalpakstan PZ

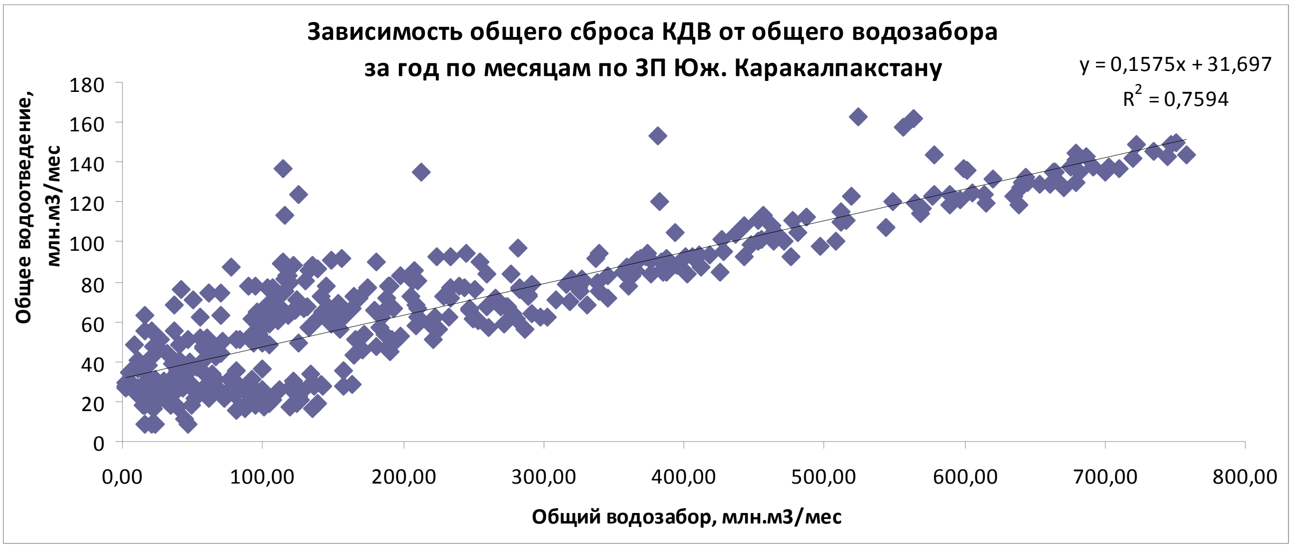

Fig.12. Relationship between the total CDW discharge and the total water intake in hydrologic year, by month, Northern Karakalpakstan PZ

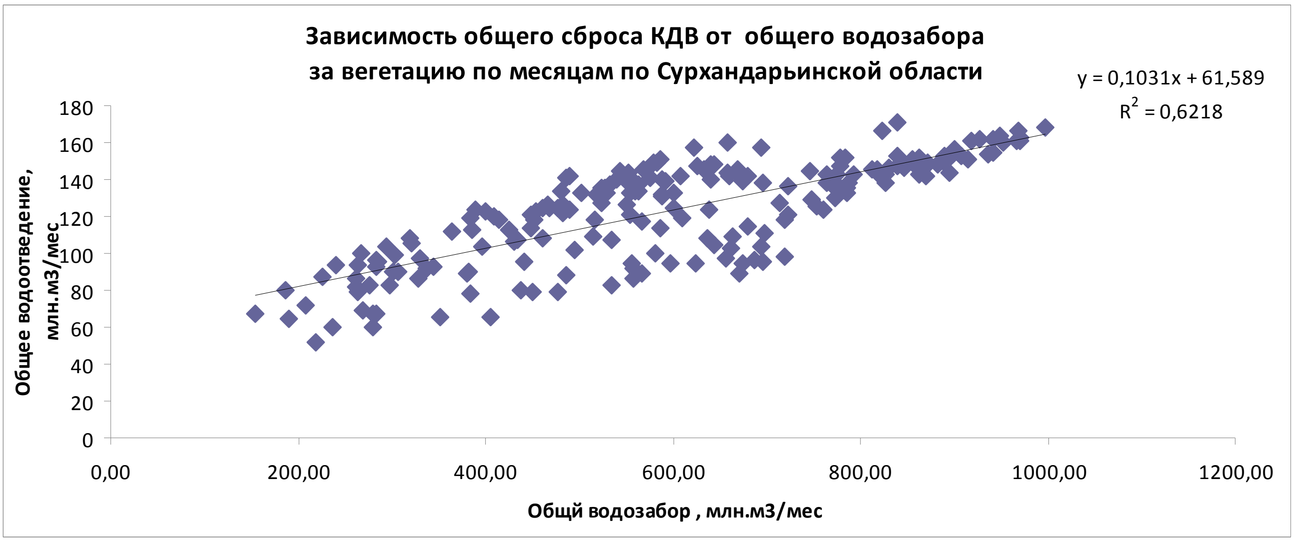

Fig.13. Relationship between the total CDW discharge and the total water intake in the growing season, by month, Surkhandarya province

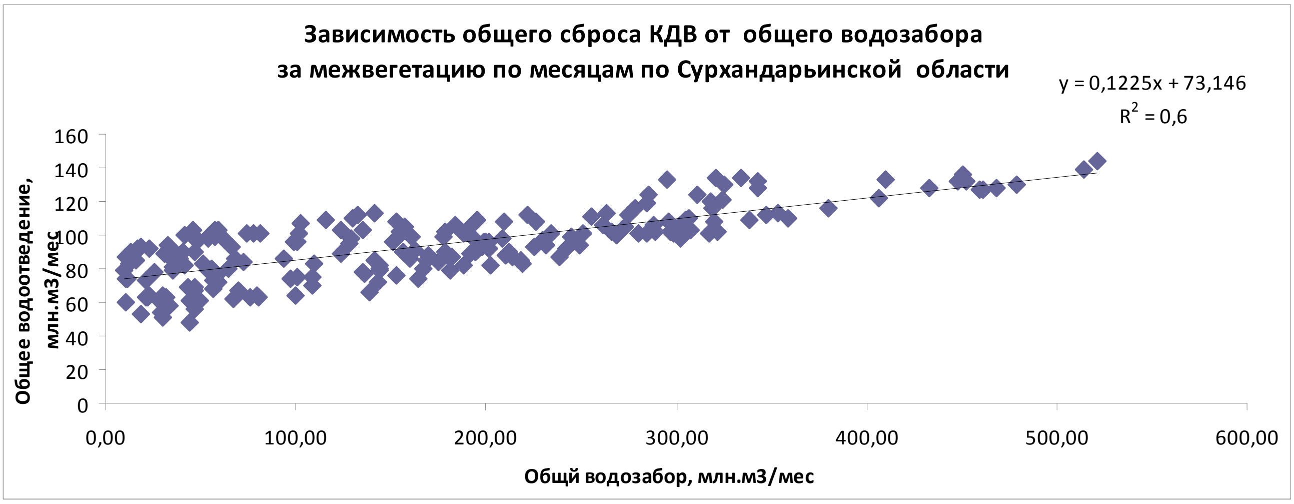

Fig.14. Relationship between the total CDW discharge and the total water intake in the non-growing season, by month, Surkhandarya province

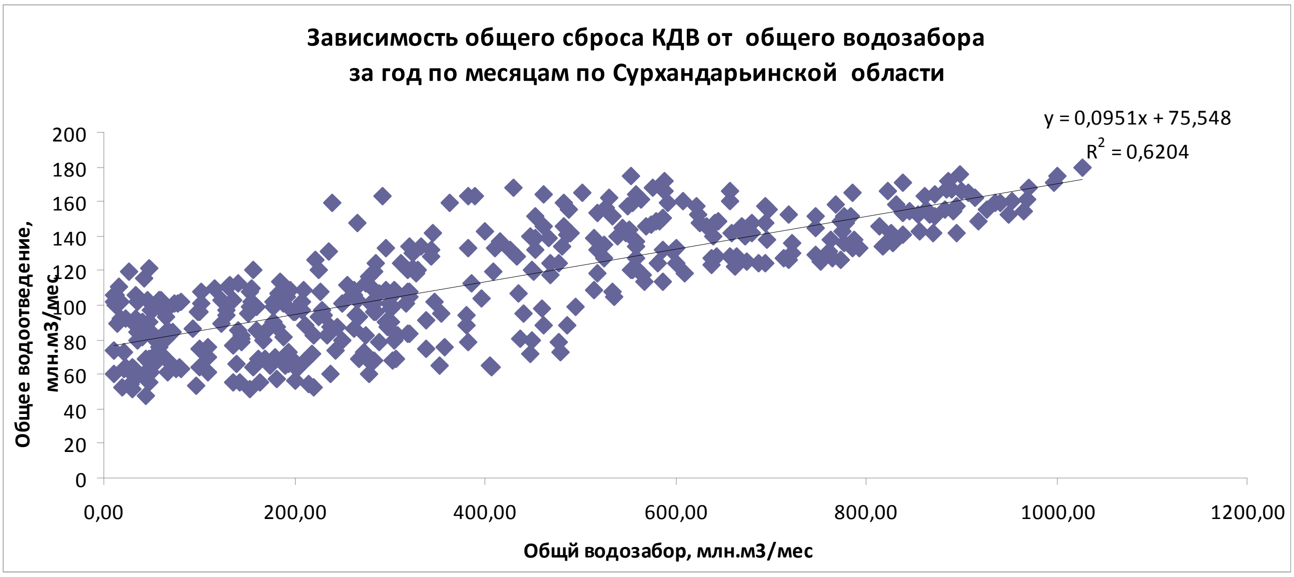

Fig.15. Relationship between the total CDW discharge and the total water intake in hydrologic year, by month, Surkhandarya province

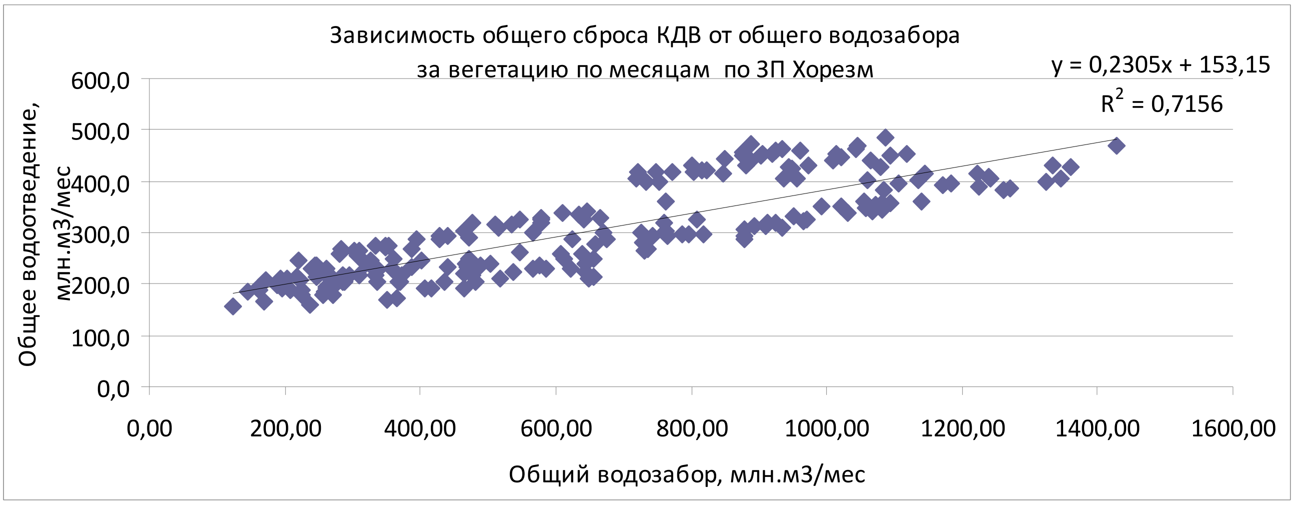

Fig.16. Relationship between the total CDW discharge and the total water intake in the growing season, by month, Khorezm PZ

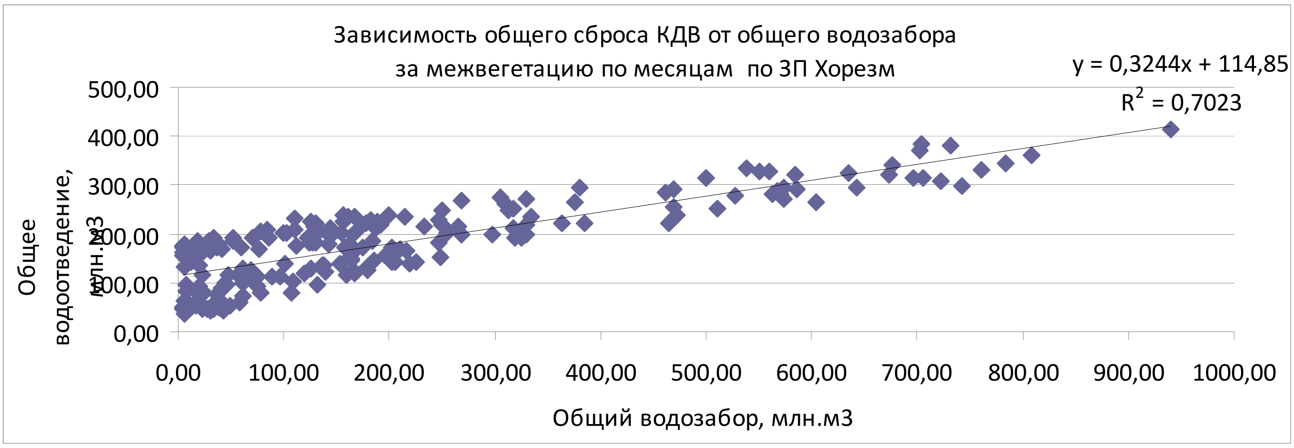

Fig.17. Relationship between the total CDW discharge and the total water intake in the non-growing season, by month, Khorezm PZ

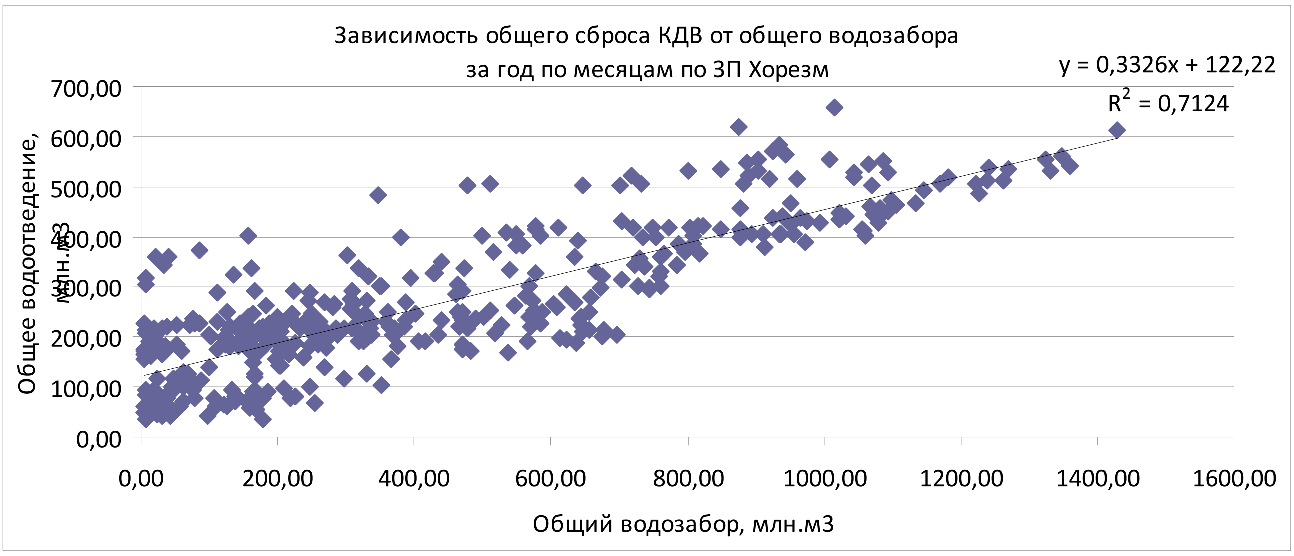

Fig.18. Relationship between the total CDW discharge and the total water intake in hydrologic year, by month, Khorezm PZ

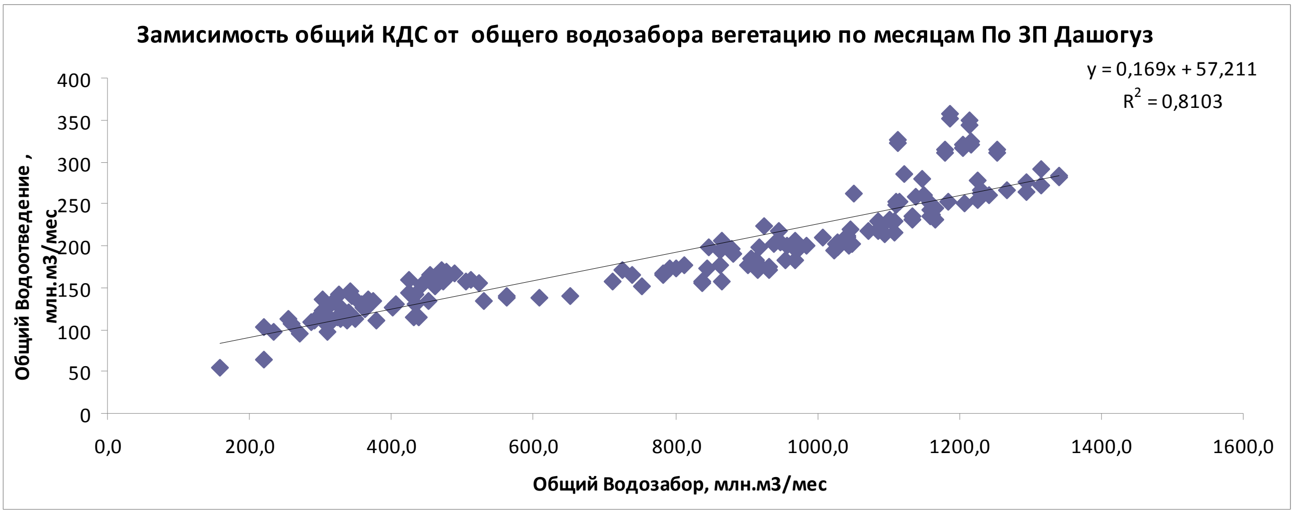

Fig.19. Relationship between the total CDW discharge and the total water intake in the growing season, by month, Dashoguz PZ

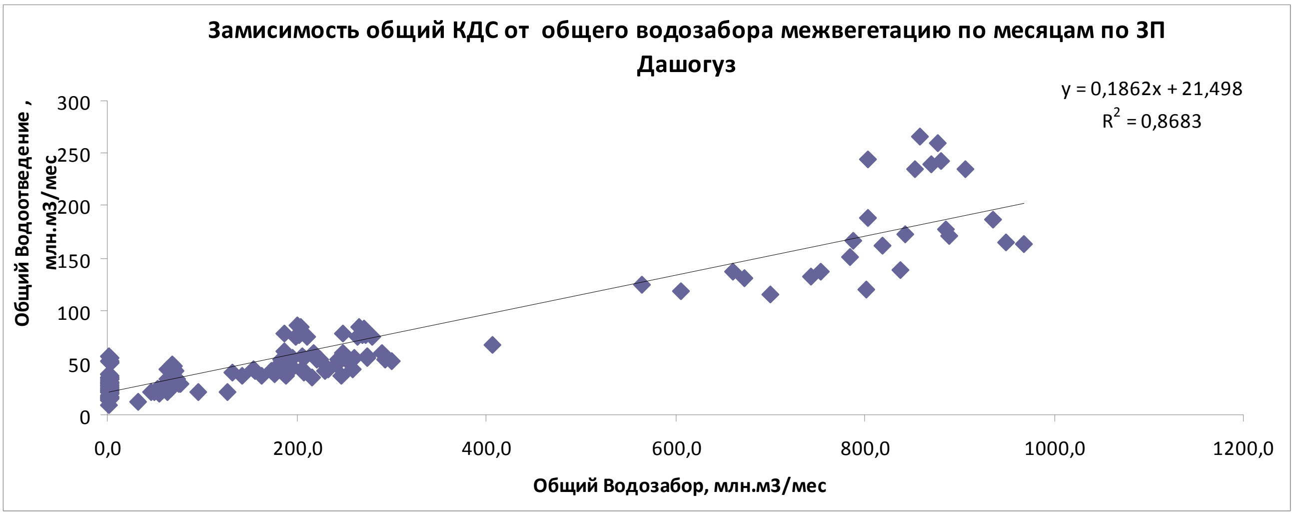

Fig.20. Relationship between the total CDW discharge and the total water intake in the non-growing season, by month, Dashoguz PZ

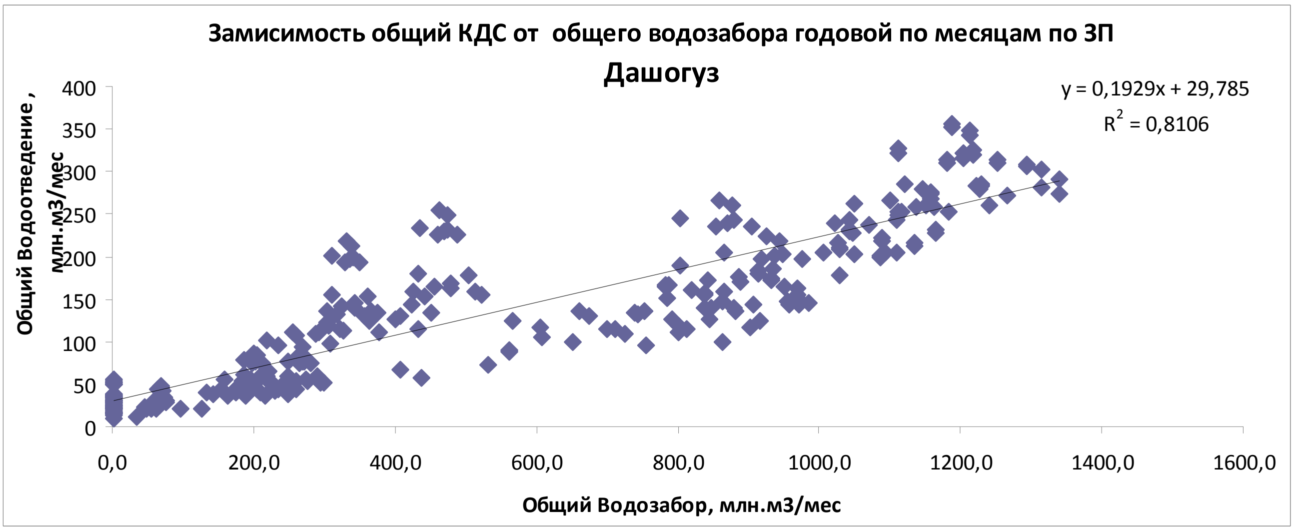

Fig.21. Relationship between the total CDW discharge and the total water intake in hydrologic year, by month, Dashoguz PZ

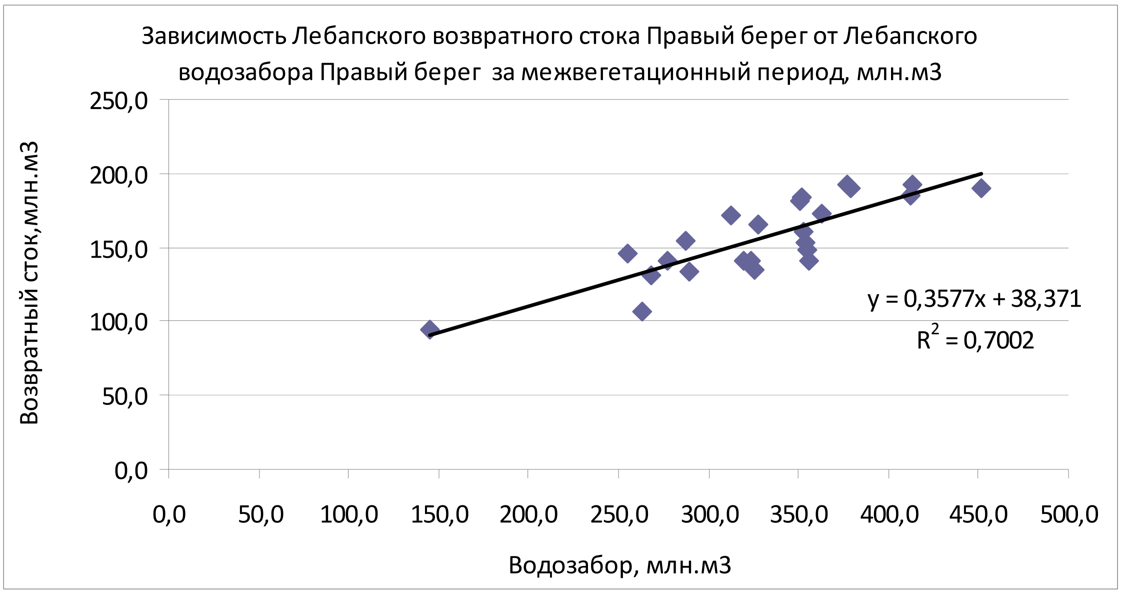

Fig.22. Relationship between the Lebap return flow, right bank, and the Lebap water intake, right bank, in the non-growing season, mcm

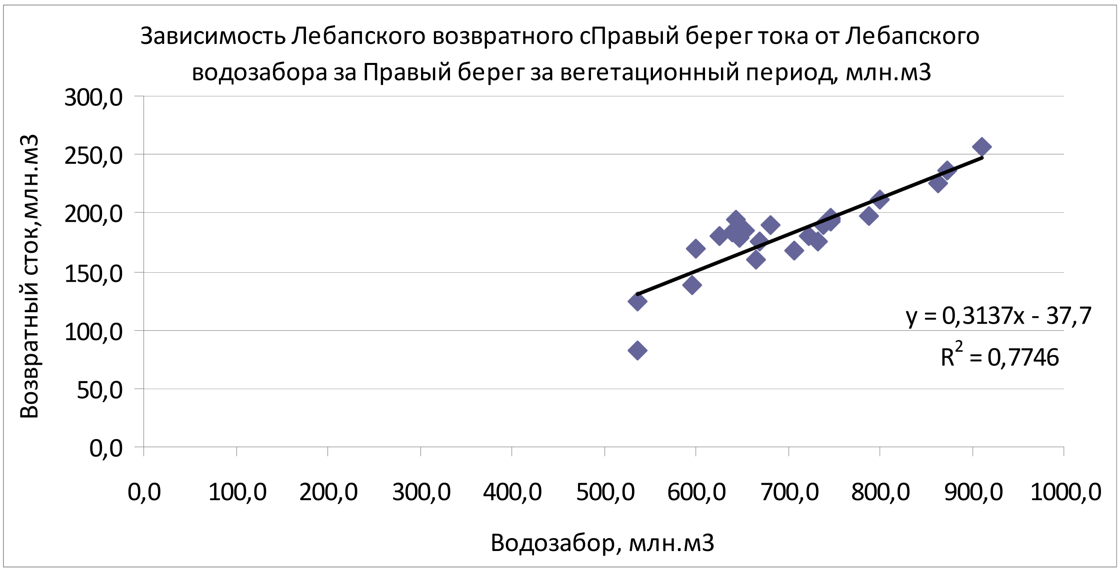

Fig.23. Relationship between the Lebap return flow, right bank, and the Lebap water intake, right bank, in the growing season, mcm

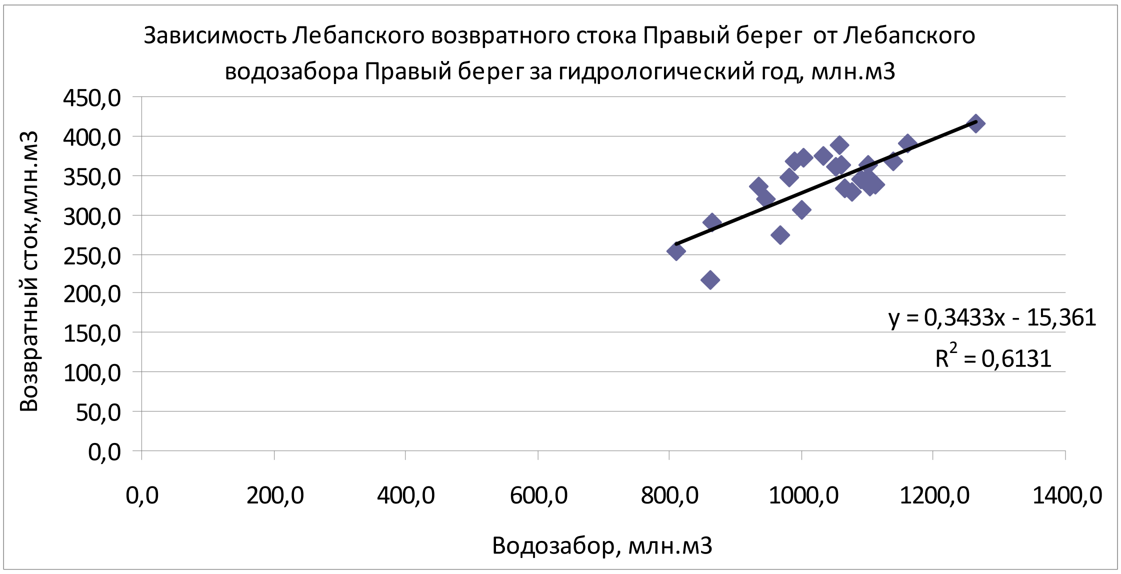

Fig.24. Relationship between the Lebap return flow, right bank, and the Lebap water intake, right bank, in hydrologic year, mcm

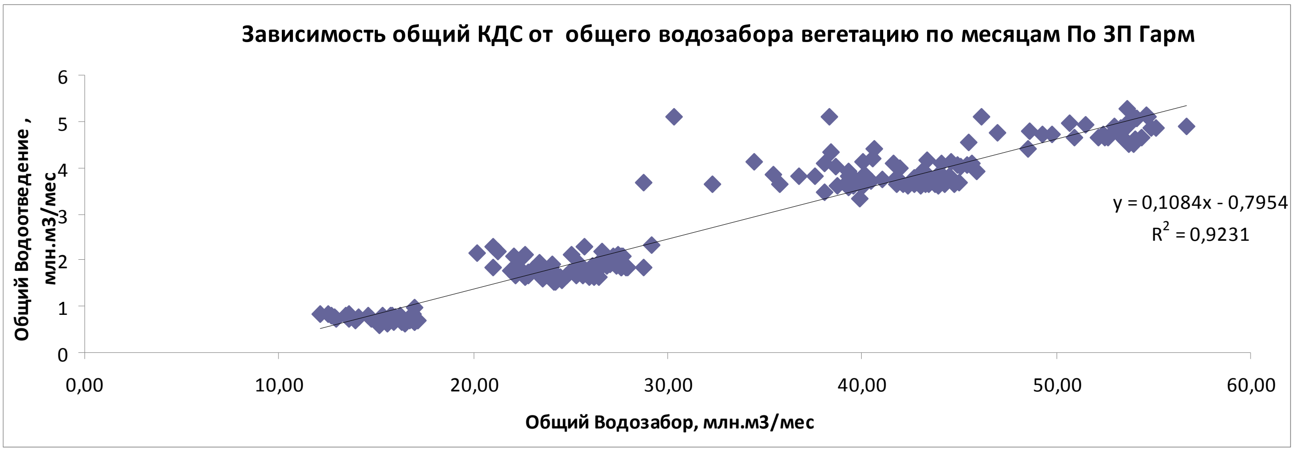

Fig.25.Relationship between the total CDW and the water intake in the growing season, by month, Garm PZ

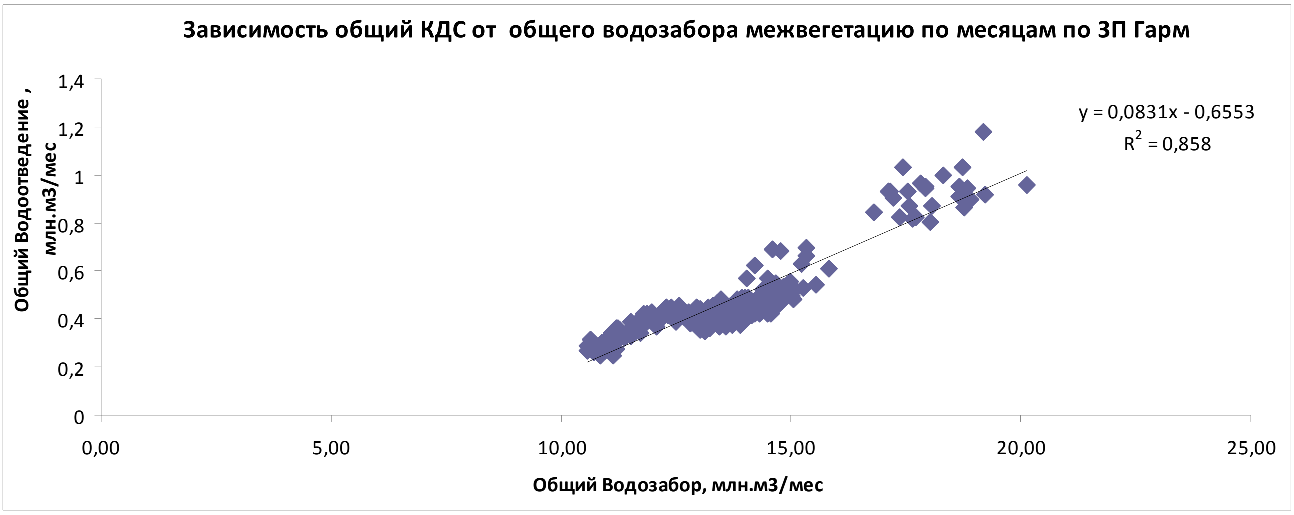

Fig.26. Relationship between the total CDW and the water intake in the non-growing season, by month, Garm PZ

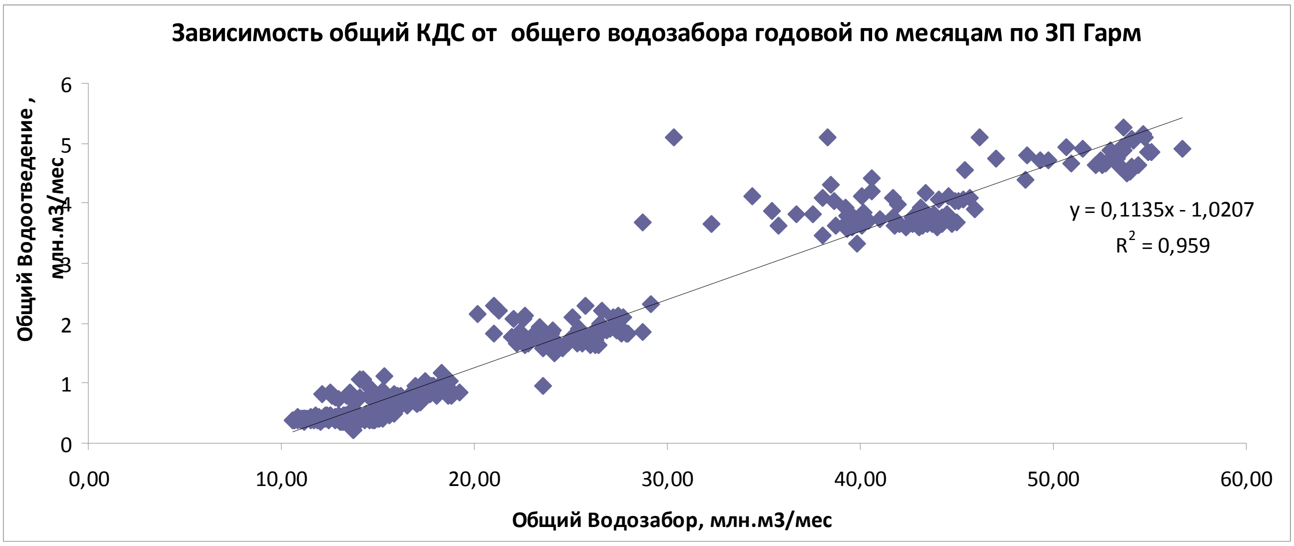

Fig.27. Relationship between the total CDW and the water intake in hydrologic year, by month, Garm PZ

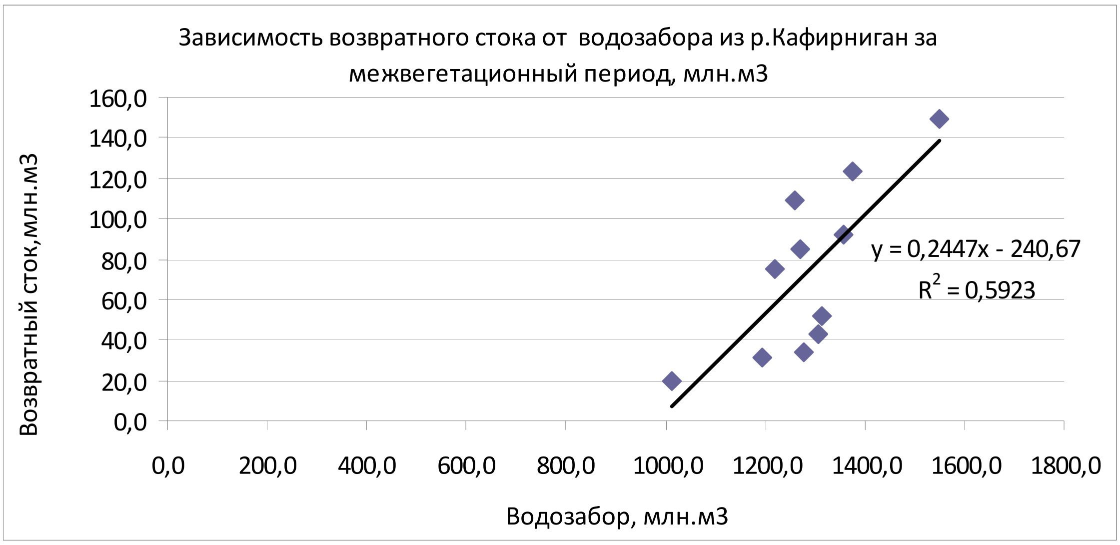

Fig.28. Relationship between the return flow and the water intake from the Kafirnigan in the non-growing season, mcm

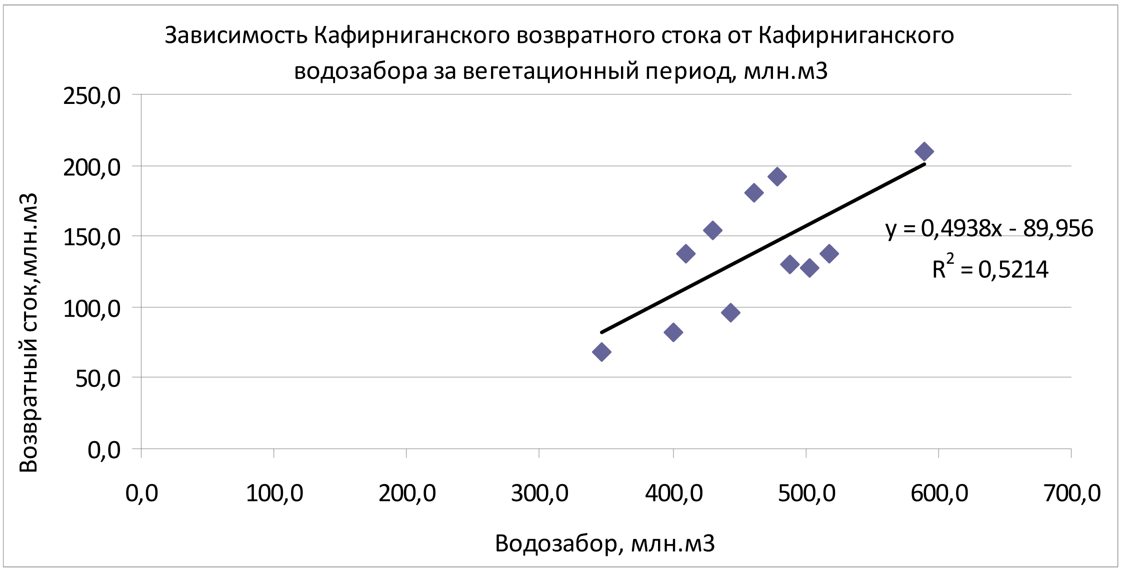

Fig.29. Relationship between the return flow and the water intake from the Kafirnigan in the growing season, mcm

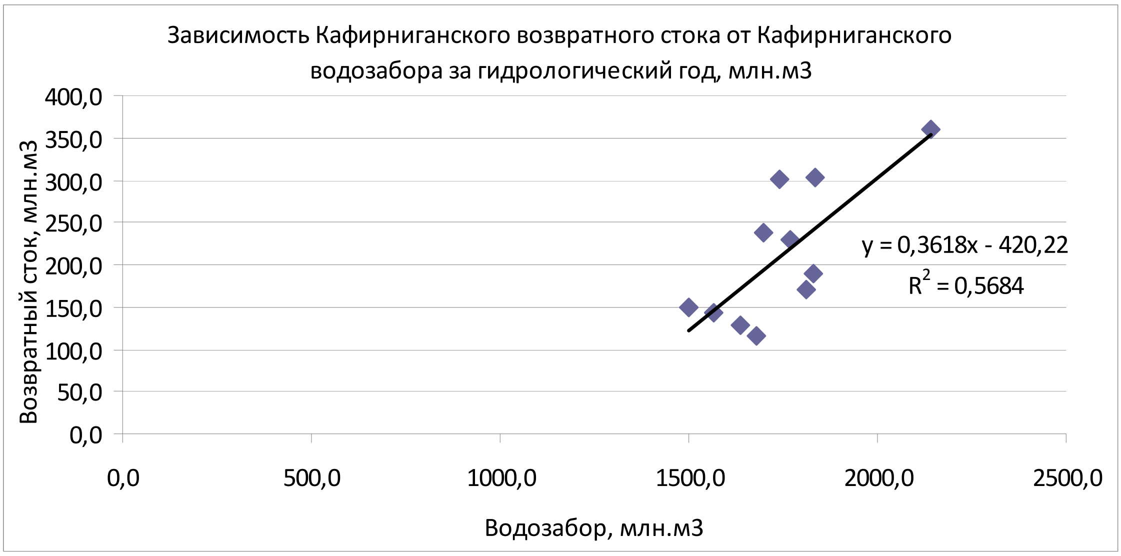

Fig.30. Relationship between the return flow and the water intake from the Kafirnigan in hydrologic year, mcm

Relationship between the CDW discharge and the water intake from the Amudarya River

River section	Growing season	Non-growing season	Hydrologic year
Upper reaches			
Republic of Tajikistan			
Vakhsh	y=0.3545x+342.14	y=1.0922x-865.79	y=0.2912x+1299.9
	R2= 0.637	R2= 0.5298	R2= 0.1817
Pyandj	y=0.2148x-115.86	y=0.0959x+5.8719	y=0.216x-130.52
	R2= 0.7969	R2= 0.6518	R2= 0.7352
Kafirnigan	y=0.4938x-89.956	y=0.2447x-240.27	y=0.3618x-420.22
	R2= 0.5214	R2= 0.5923	R2= 0.5684
Republic of Uzbekistan			
Surkhandarya	y=2.6946x+91.281	y=0.2826x+72.489	y=1.8242x-141.83
	R2= 0.6496	R2= 0.7433	R2= 0.6602
Middle reaches			
Republic of Uzbekistan			
South Karshi	y=1.5301x+121.26	y=2.3548x+7.5074	y=1.9176x+62.208
	R2= 0.7461	R2= 0.7414	R2= 0.7683
Parsankul	y=0.1928x-88.474	y=0.3431x+78.902	y=0.2633x-100.94
	R2= 0.8025	R2= 0.8182	R2= 0.7682
Turkmenistan			
Lebap, total	y=0.426x-430.98	y=0.4869x+60.623	y=0.4737x-486.87
	R2= 0.827	R2= 0.6055	R2= 0.7494
Lebap, left bank	y=0.4681x-401.34	y=0.6423x-67.135	y=0.5309x-503.55
	R2= 0.7735	R2= 0.7164	R2= 0.7432
Lebap, right bank	y=0.3137x-37.7	y=0.3577x+38.371	y=0.3433x-15.361
	R2= 0.7746	R2= 0.7002	R2= 0.6131

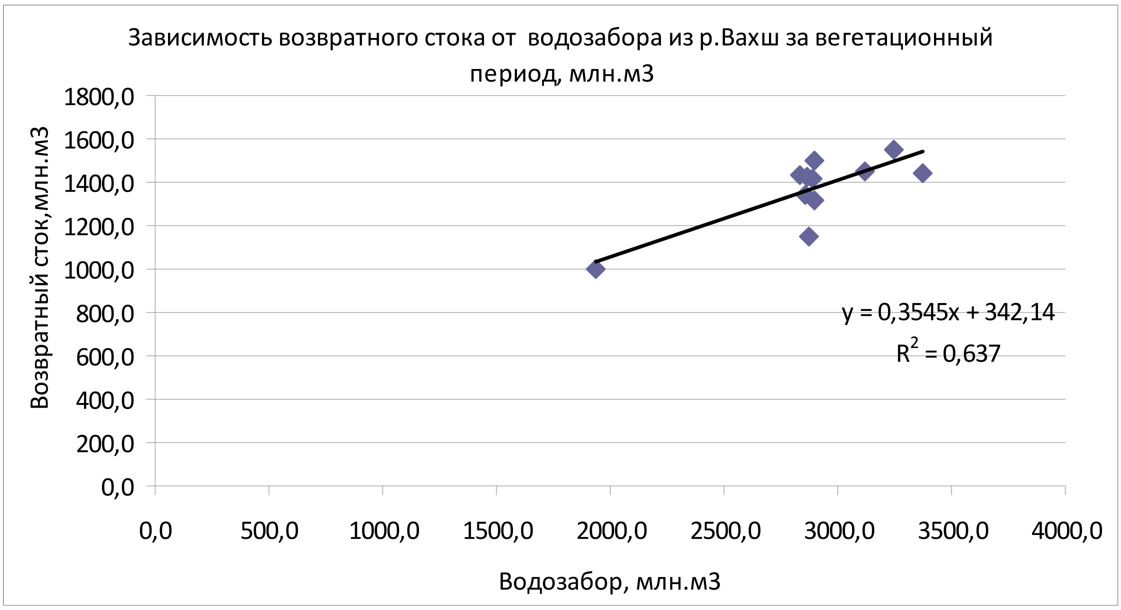

Fig.31. Relationship between the return flow and the water intake from the Vakhsh River in the growing season, mcm

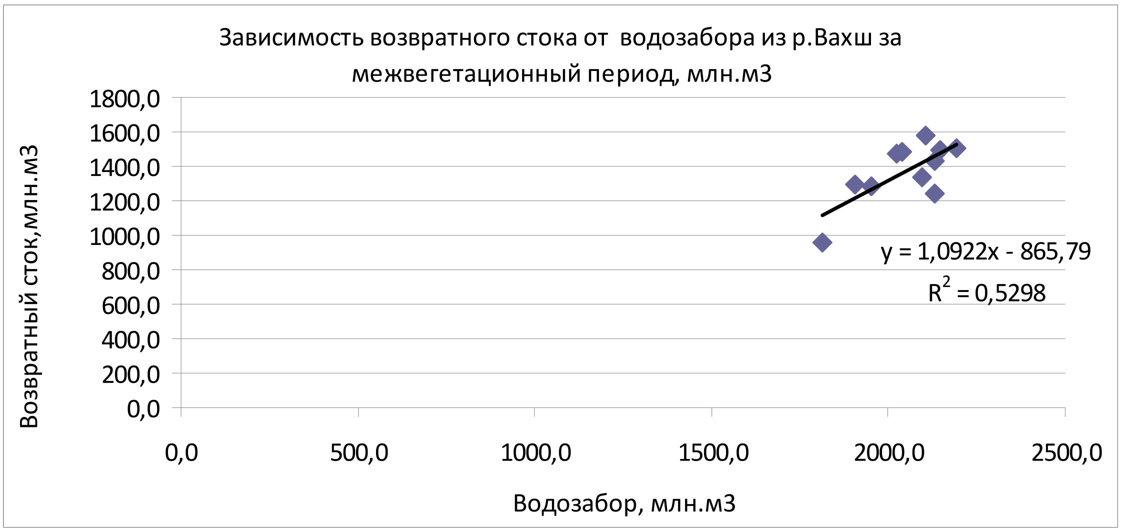

Fig.32. Relationship between the return flow and the water intake from the Vakhsh River in the non-growing season, mcm

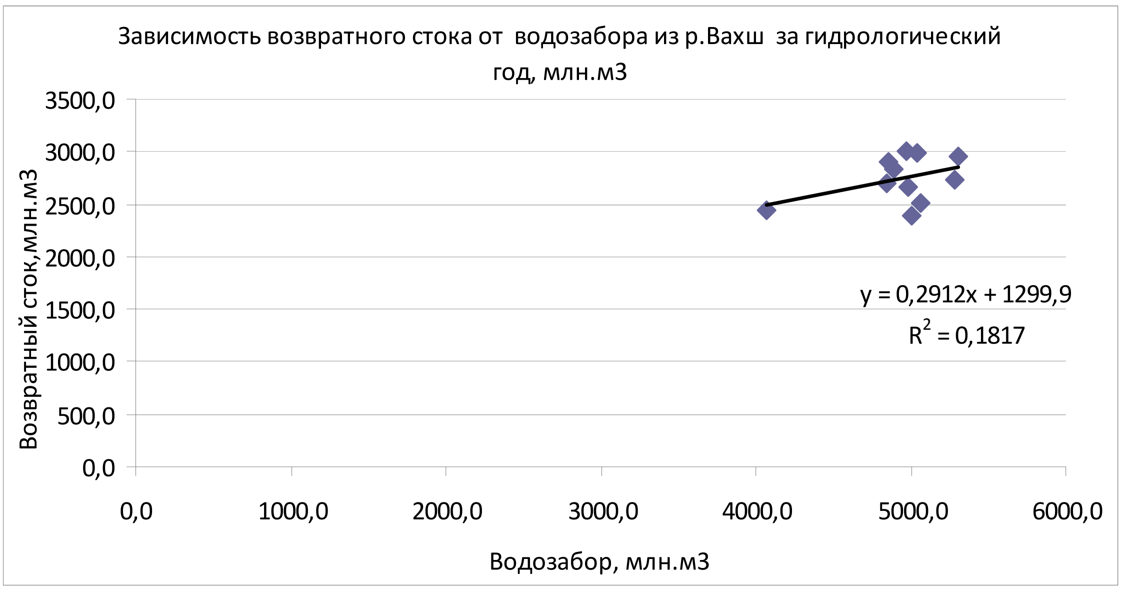

Fig.33. Relationship between the return flow and the water intake from the Vakhsh River in hydrologic year, mcm

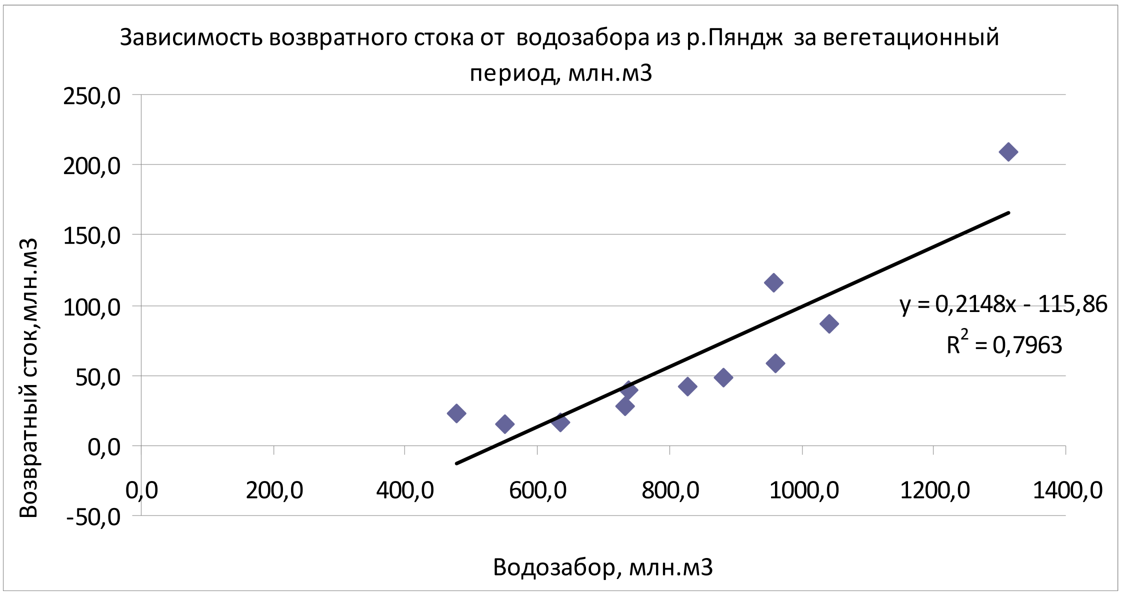

Fig.34. Relationship between the return flow and the water intake from the Pyandj River in the growing season, mcm

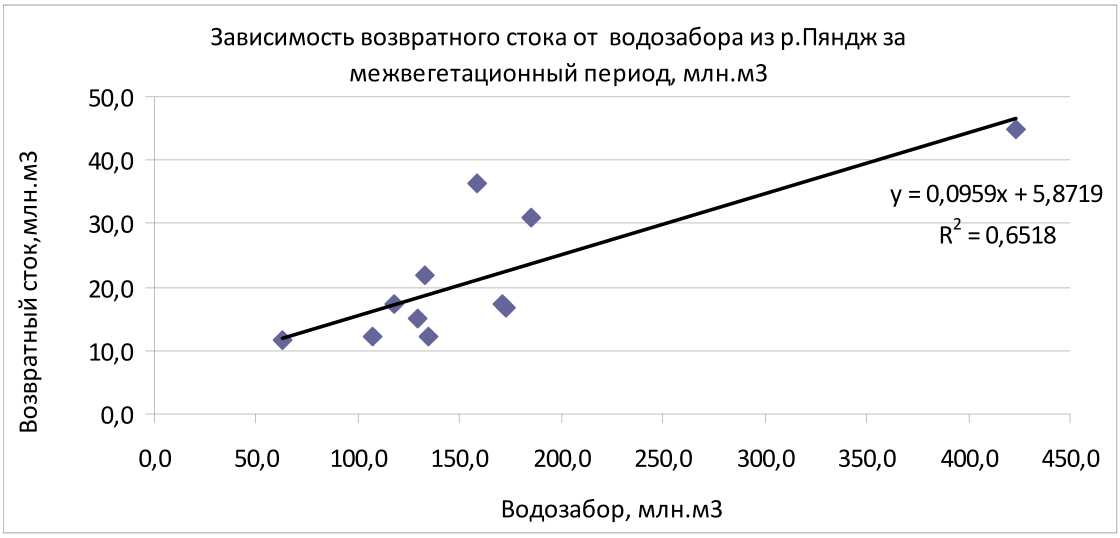

Fig.35. Relationship between the return flow and the water intake from the Pyandj River in the non-growing season, mcm

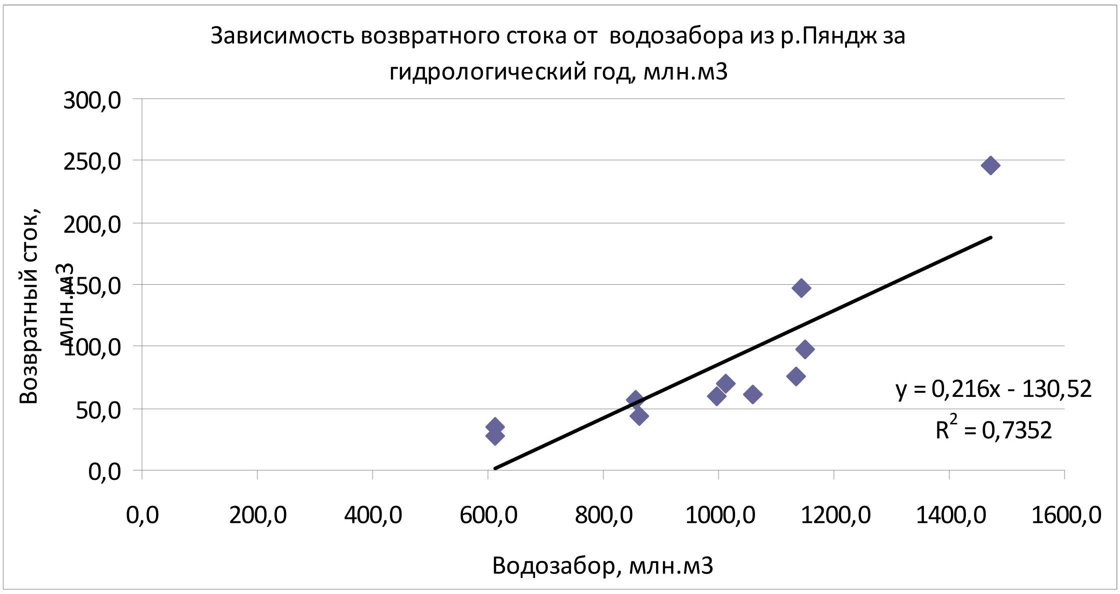

Fig.36. Relationship between the return flow and the water intake from the Pyandj River in hydrologic year, mcm

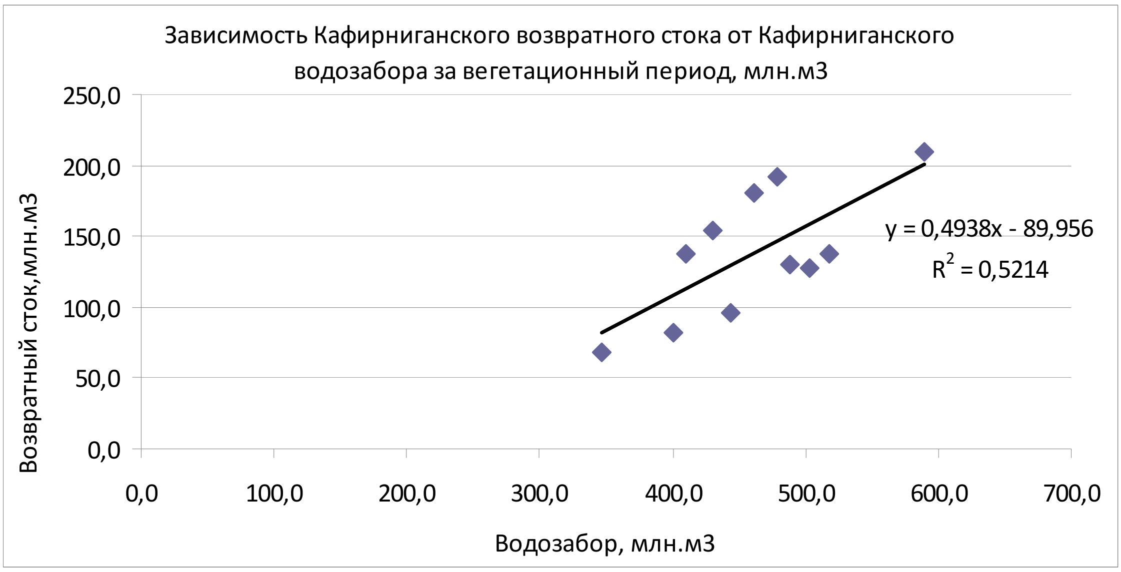

Fig.37. Relationship between the Kafirnigan return flow and the Kafirnigan water intake in the growing season, mcm

Fig.38. Relationship between the Kafirnigan return flow and the Kafirnigan water intake in the non- growing season, mcm

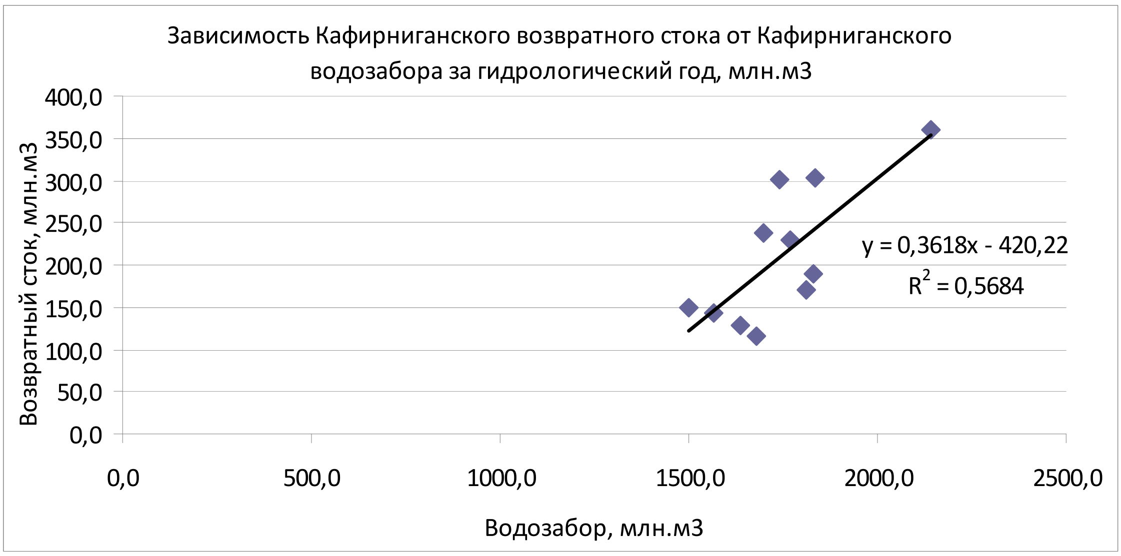

Fig.39. Relationship between the Kafirnigan return flow and the Kafirnigan water intake in hydrologic year, mcm

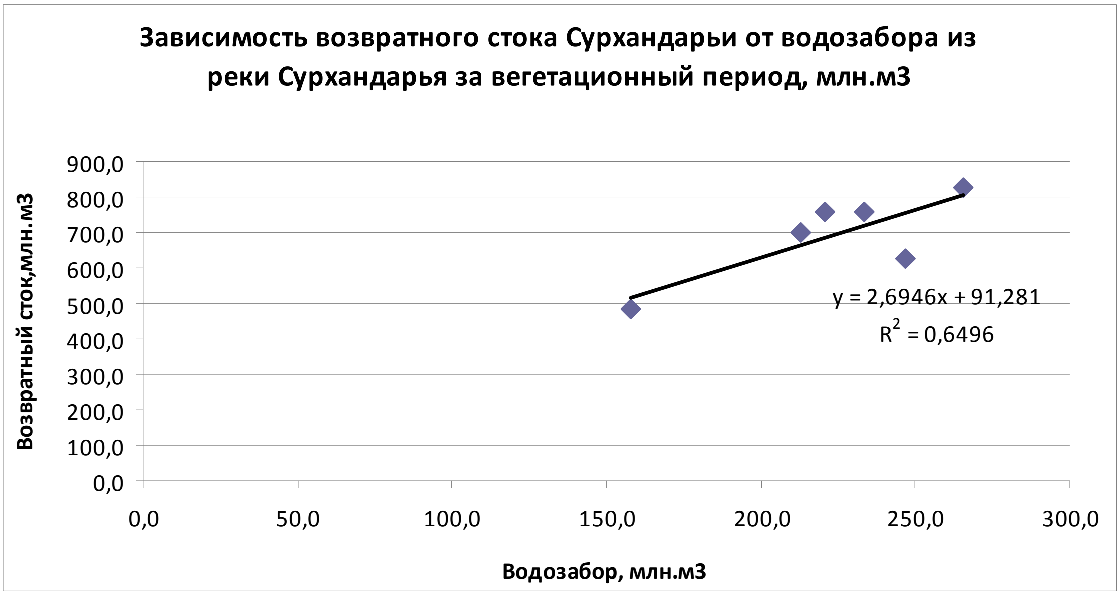

Fig.40. Relationship between the Surkhandarya return flow and the Surkhandarya water intake in the growing season, mcm

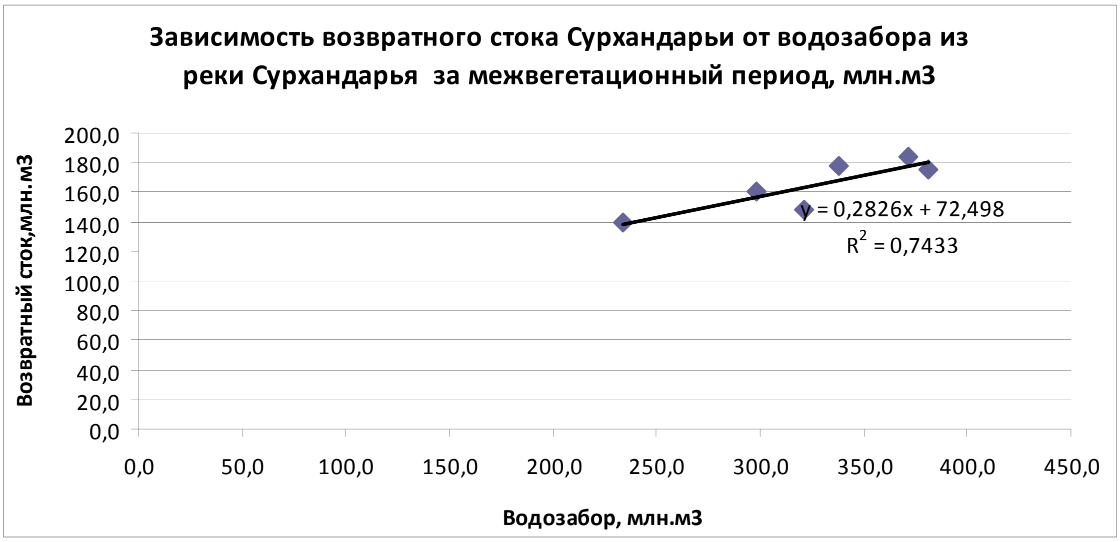

Fig.41. Relationship between the Surkhandarya return flow and the Surkhandarya water intake in the non-growing season, mcm

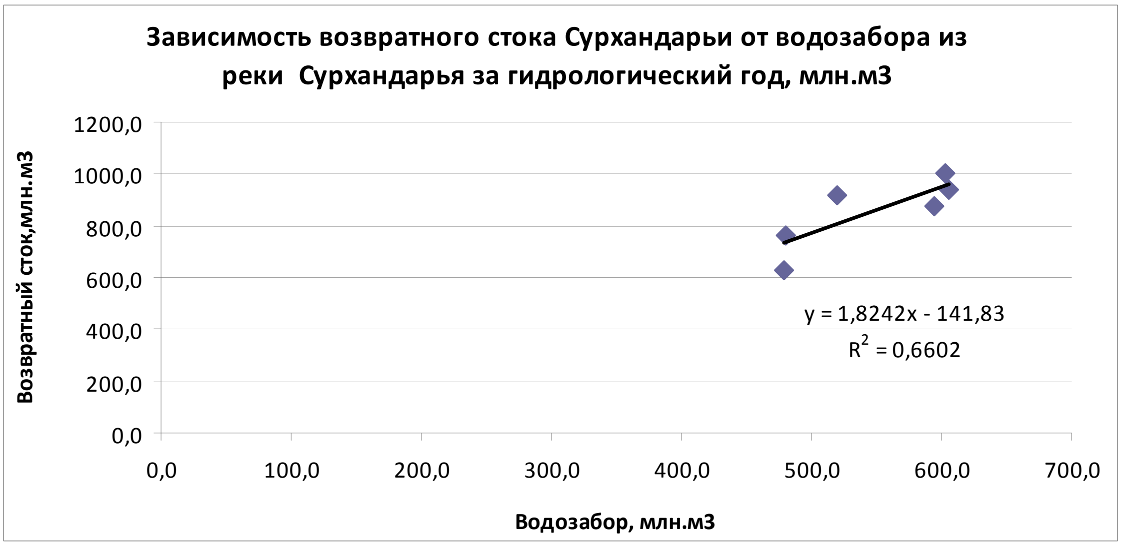

Fig.42. Relationship between the Surkhandarya return flow and the Surkhandarya water intake in hydrologic year, mcm

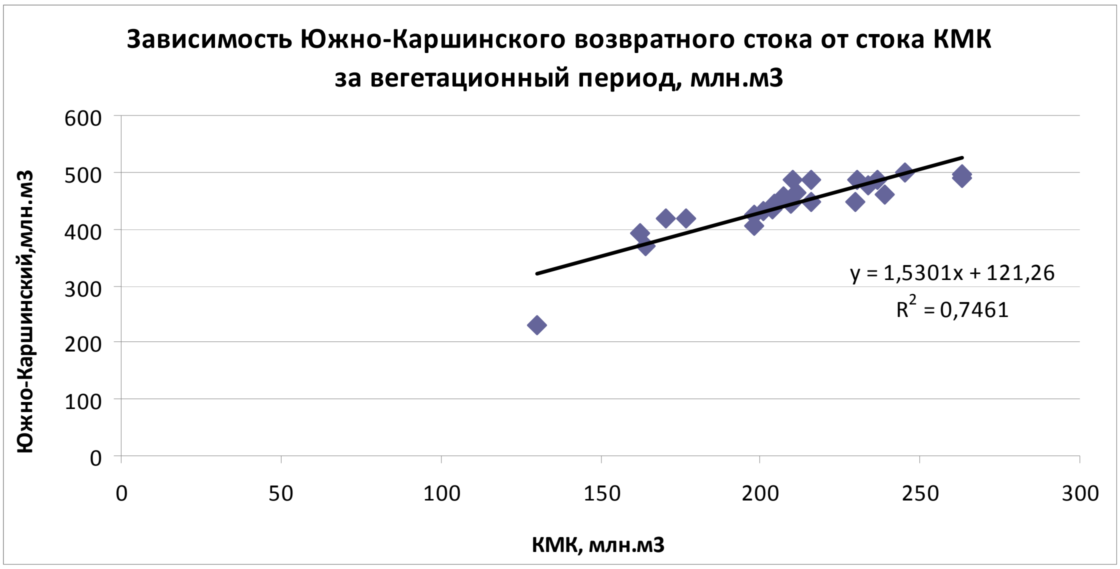

Fig.43. Relationship between the South Karshi return flow and the KMC flow in the growing season, mcm

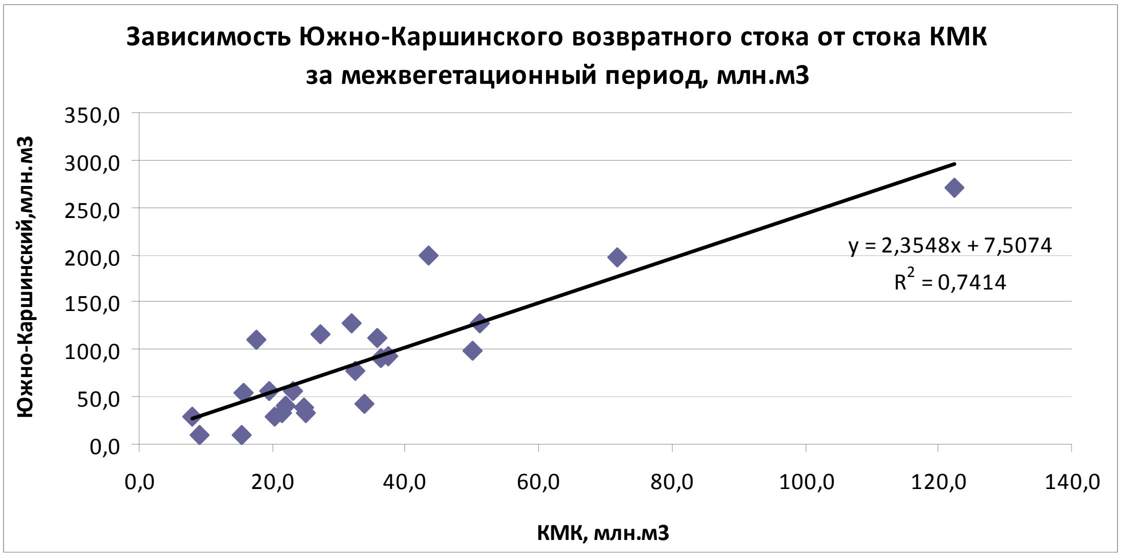

Fig.44. Relationship between the South Karshi return flow and the KMC flow in the non-growing season, mcm

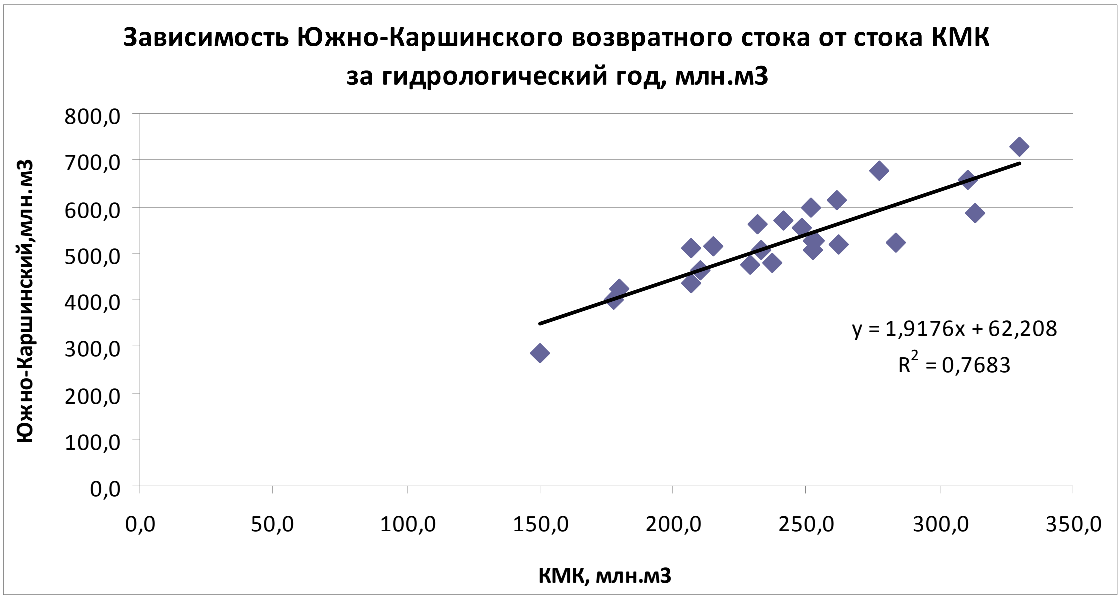

Fig.45. Relationship between the South Karshi return flow and the KMC flow in hydrologic year, mcm

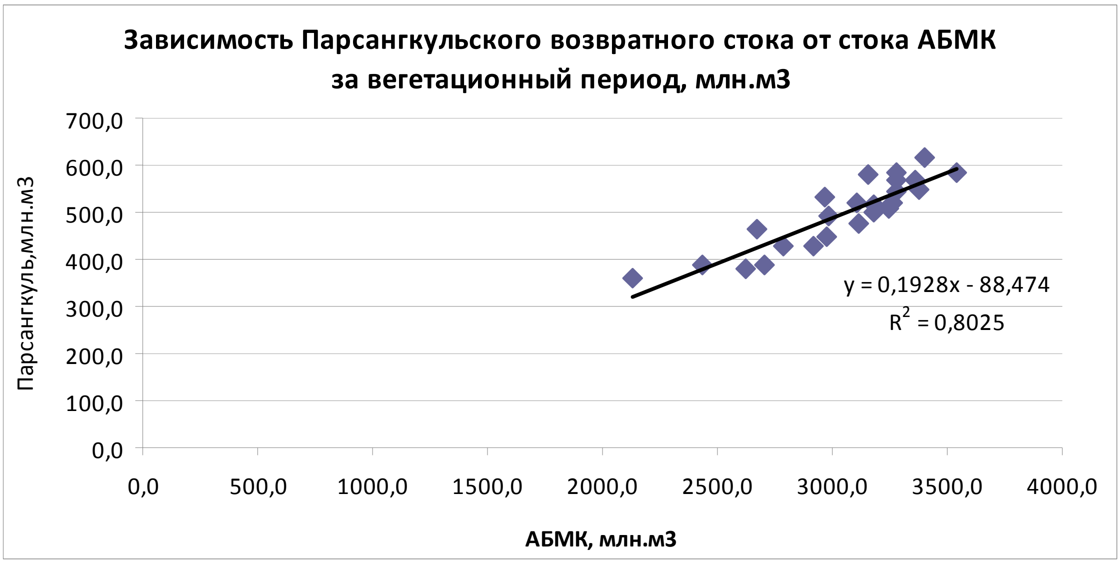

Fig.46 Relationship between the Parsangul return flow and the ABMC flow in the growing season, mcm

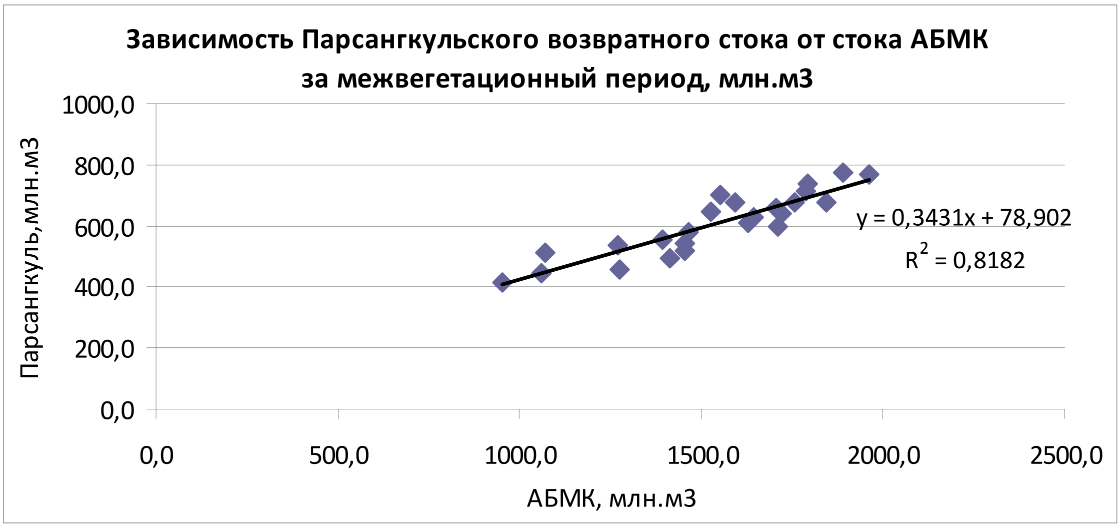

Fig.47 Relationship between the Parsangul return flow and the ABMC flow in the non-growing season, mcm

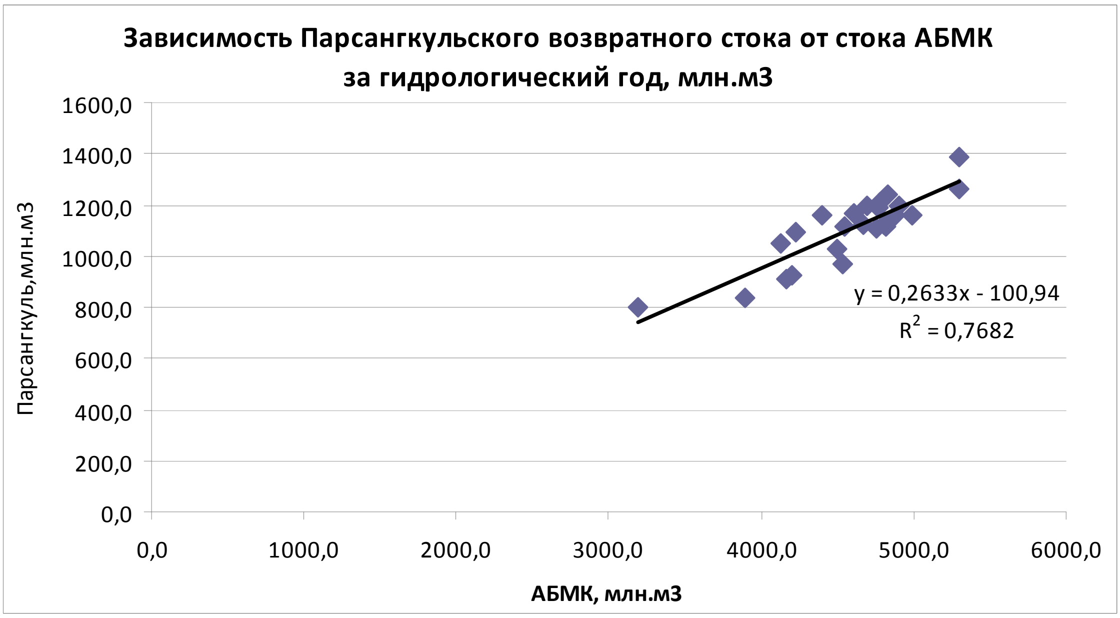

Fig.48 Relationship between the Parsangul return flow and the ABMC flow in hydrologic year, mcm

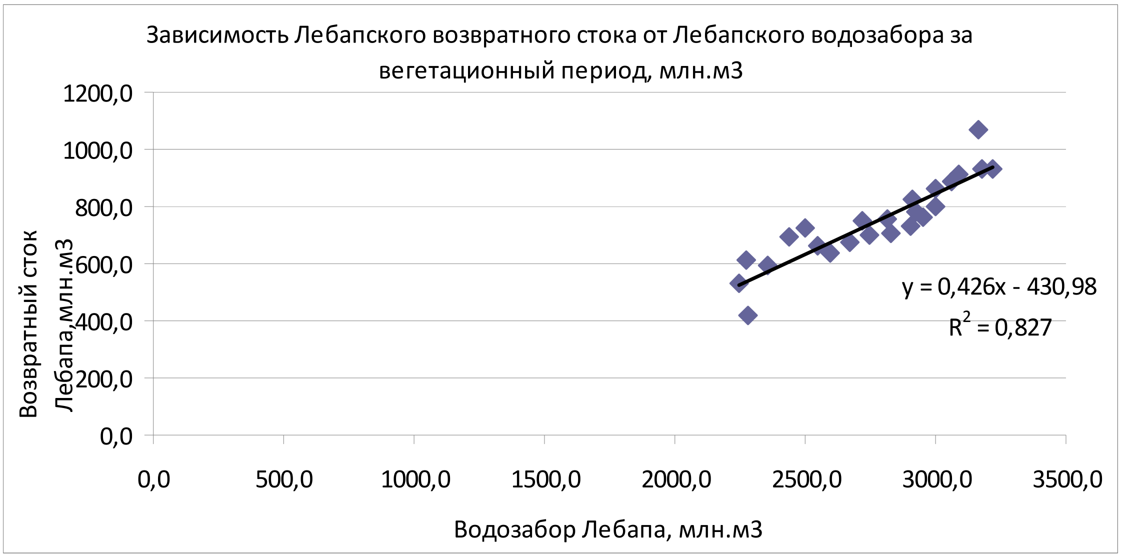

Fig.49 Relationship between the Lebap return flow and the Lebap water intake in the growing season, mcm

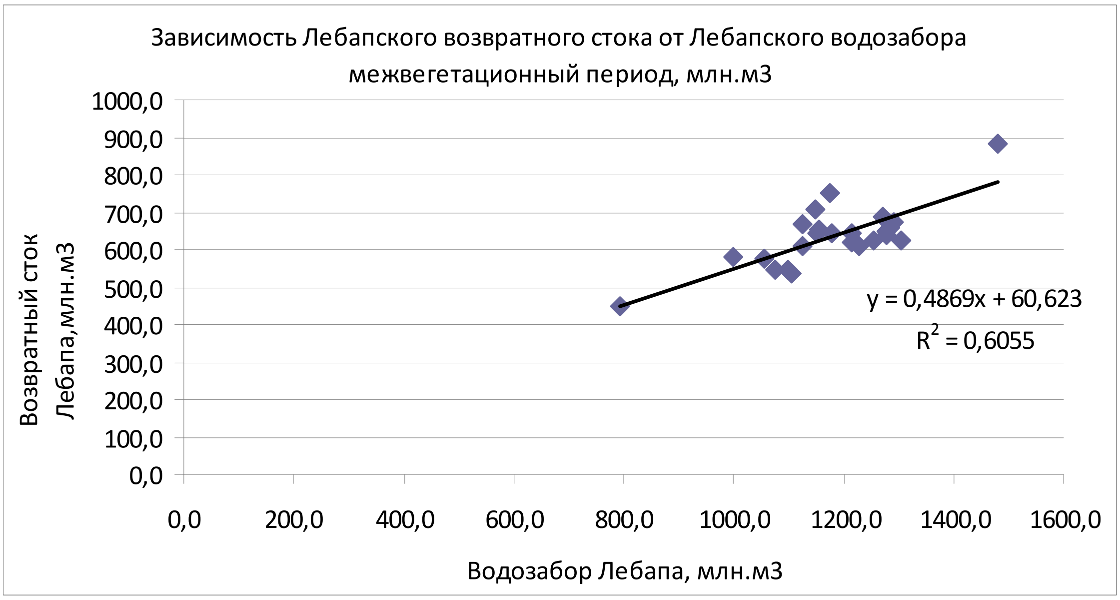

Fig.50 Relationship between the Lebap return flow and the Lebap water intake in the non-growing season, mcm

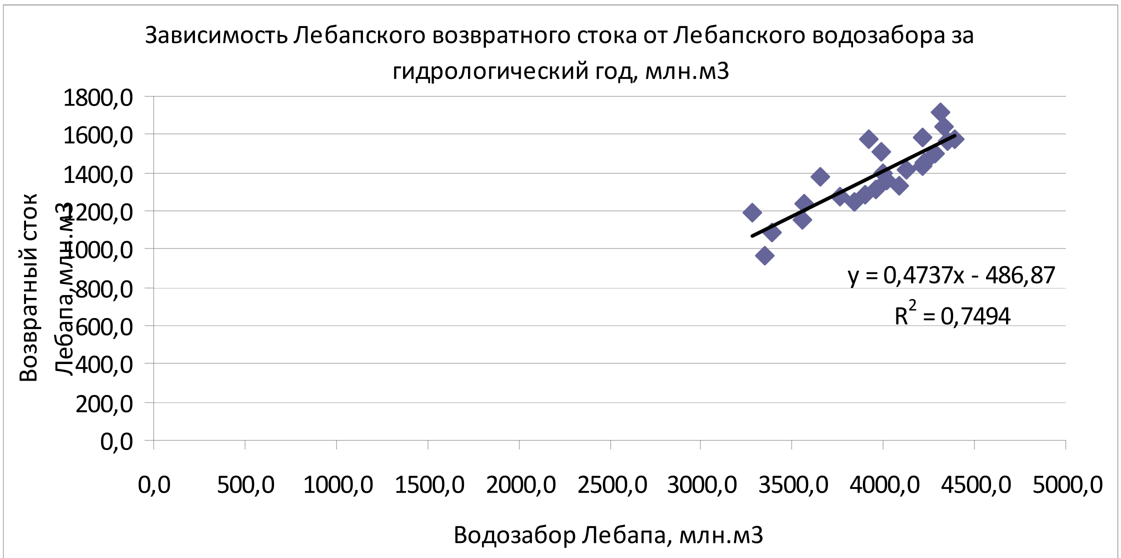

Fig.51 Relationship between the Lebap return flow and the Lebap water intake in hydrologic year, mcm

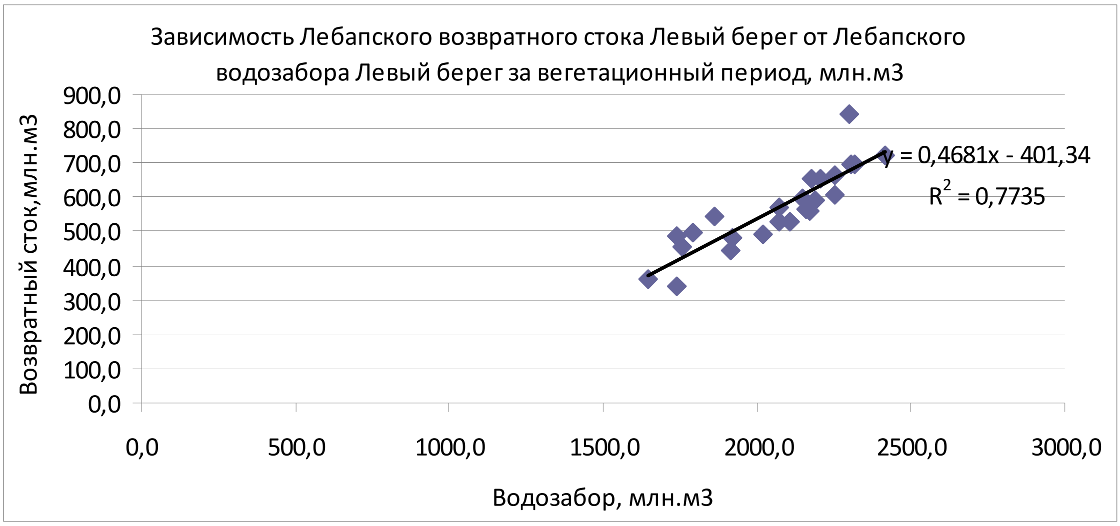

Fig.52 Relationship between the Lebap return flow, left bank, and the Lebap water intake, left bank, in the growing season, mcm

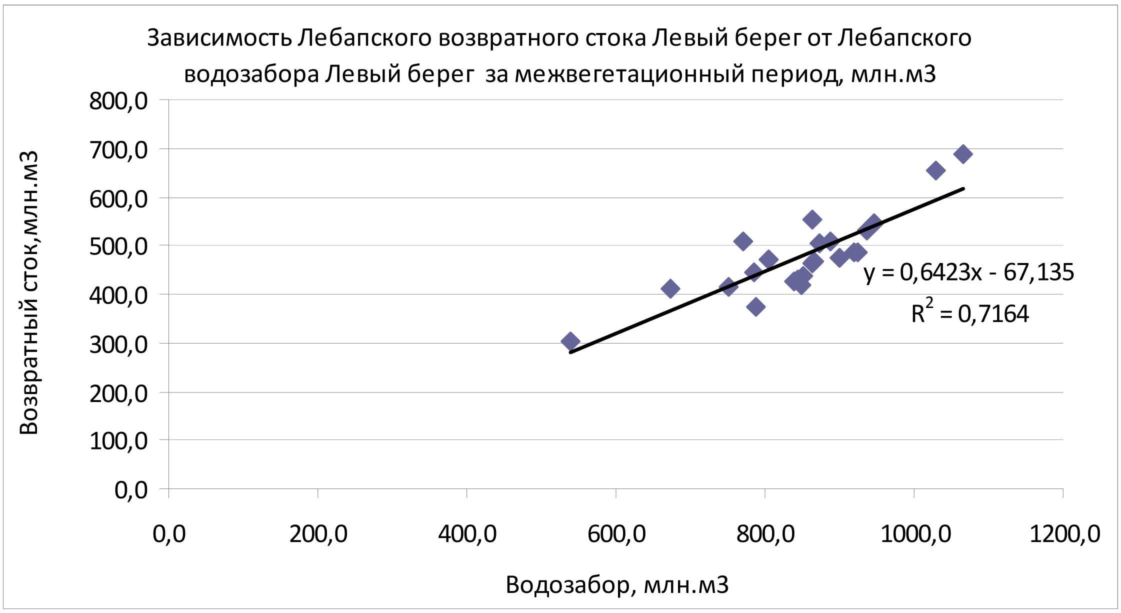

Fig.53 Relationship between the Lebap return flow, left bank, and the Lebap water intake, left bank, in the non-growing season, mcm

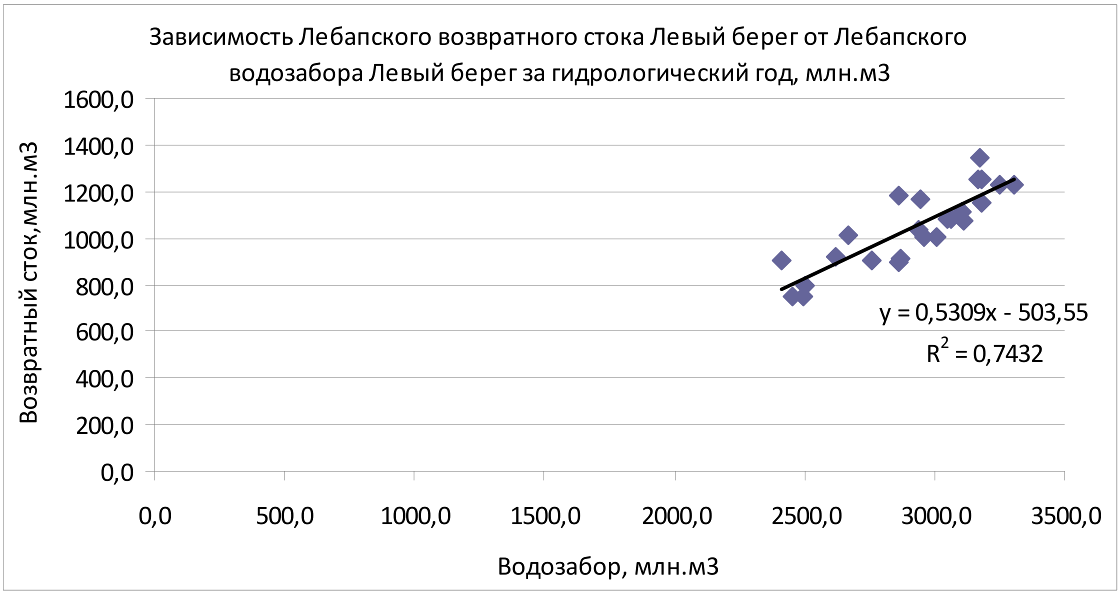

Fig.54 Relationship between the Lebap return flow, left bank, and the Lebap water intake, left bank, in hydrologic year, mcm

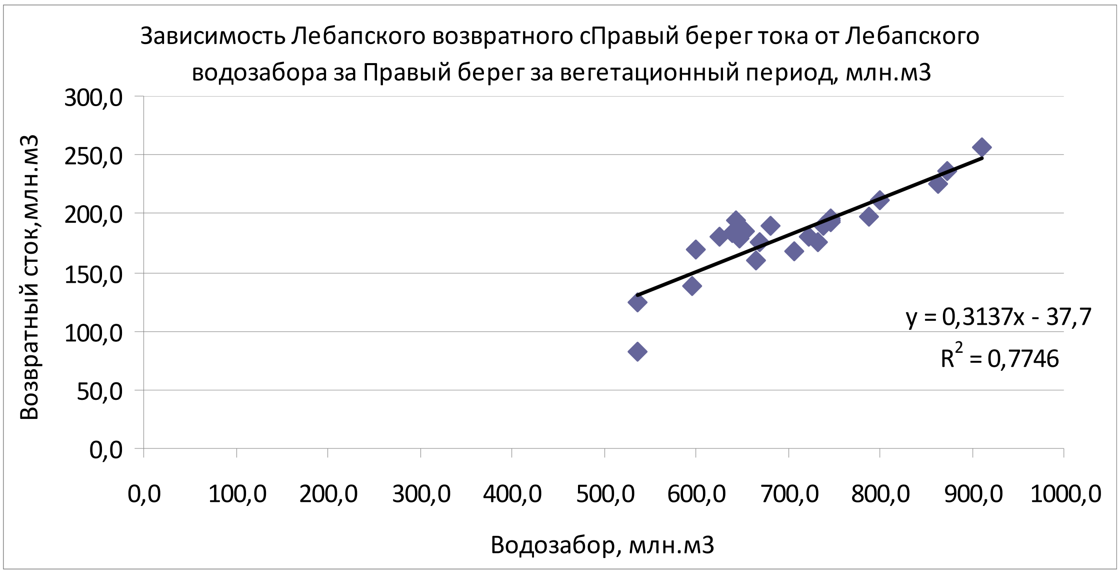

Fig.55 Relationship between the Lebap return flow, right bank, and the Lebap water intake, right bank, in the growing season, mcm

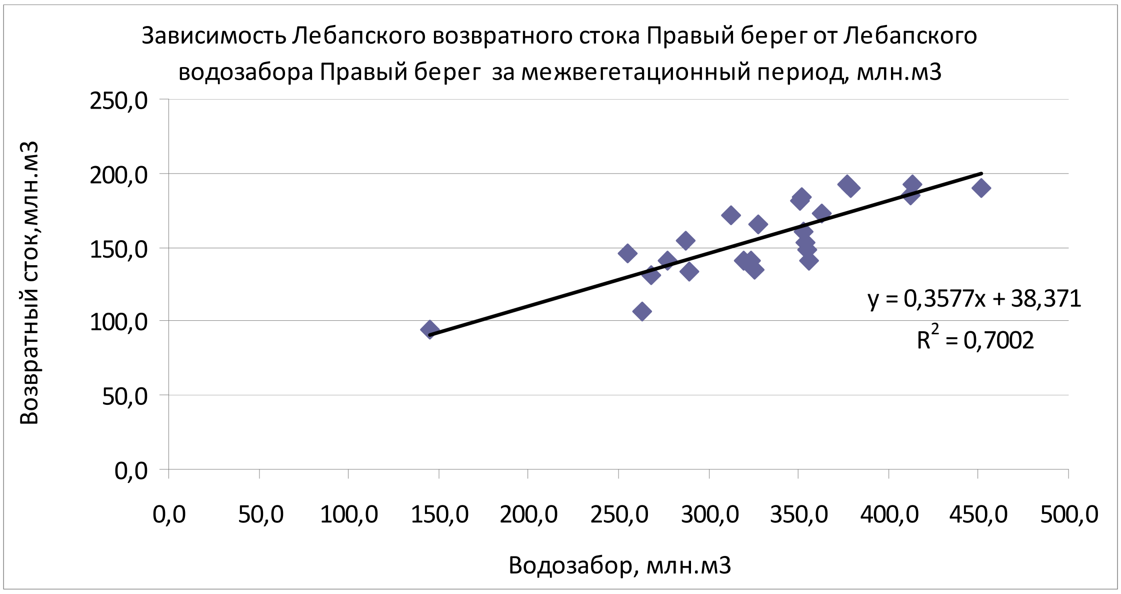

Fig.56 Relationship between the Lebap return flow, right bank, and the Lebap water intake, right bank, in the non-growing season, mcm

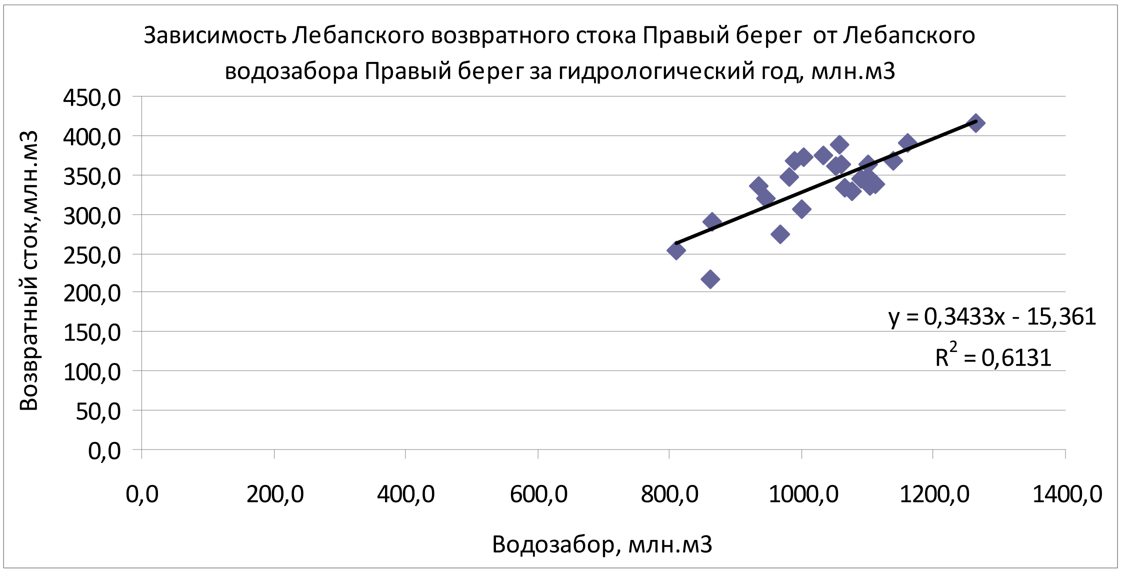

Fig.57 Relationship between the Lebap return flow, right bank, and the Lebap water intake, right bank, in hydrologic year, mcm

Water losses
in
Amudarya River sections

Summary table of channel balance discrepancies in the Amudarya River sections in the growing season

1. Kelif-Darganata section		2. Darganata-Tuyamuyun section		3. Tuyamuyun-Kipchak section		4. Kipchak-Samanbay section		Kelif-Samanbay section	
mcm	%	mcm	%	mcm	%	mcm	%	mcm	%
292.5	0.5	-6,030.2	-12.7	-6,890.8	-17.8	-90.1	-0.3	-12,718.7	-20.4
204.3	0.3	-3,011.5	-6.7	-4,302.3	-10.8	352.8	1.3	-6,756.7	-11.3
-774.8	-1.4	-6,918.9	-16.8	-3,311.0	-10.8	-1,394.9	-6.4	-12,399.6	-21.7
-3,791.1	-7.0	-1,613.0	-4.3	-3,653.9	-11.9	-1,336.8	-5.5	-10,394.9	-19.1
1,206.3	2.3	-2,970.4	-7.8	-5,046.7	-17.1	-2,523.5	-11.7	-9,334.3	-18.1
379.0	0.8	-5,263.9	-14.8	-2,865.3	-10.8	-4,526.1	-22.0	-12,276.4	-24.7
-4,884.0	-10.0	-1,944.7	-6.4	-3,559.7	-17.2	-892.3	-6.2	-11,280.8	-23.1
-523.2	-1.1	-4,293.3	-12.2	-2,564.2	-8.9	-1,315.4	-6.2	-8,696.1	-17.6
386.7	0.8	-5,805.1	-17.1	-3,295.5	-17.8	-1,838.4	-15.0	-10,552.3	-22.2
-3,538.3	-7.5	-2,072.3	-10.8	-2,614.0	-14.6	-1,372.6	-11.2	-9,597.2	-25.3
-2,351.1	-5.3	-1,721.2	-6.5	-2,905.3	-12.3	-781.4	-5.4	-7,759.0	-17.6
1,889.5	4.3	-6,429.3	-20.4	-4,448.0	-21.2	-1,116.5	-9.0	-10,104.3	-22.7
-261.2	-0.6	-7,084.4	-25.1	-3,612.0	-20.8	-1,138.3	-11.5	-12,095.9	-28.0
-3,753.5	-9.1	-1,661.5	-6.6	-2,723.0	-17.7	-1,414.8	-14.1	-9,552.8	-23.2
-6,761.3	-14.6	-1,143.8	-4.5	-2,762.8	-14.1	48.0	0.4	-10,619.9	-28.0
91.1	0.2	-2,885.3	-11.4	-1,967.1	-10.6	-3,229.0	-23.6	-7,990.3	-20.1
-1,925.2	-5.0	-4,363.4	-19.0	-2,696.8	-19.5	-782.0	-9.6	-9,767.4	-25.2
225.1	0.6	-2,630.6	-11.7	-2,554.0	-17.3	-1,936.2	-20.4	-6,895.6	-18.6
-3,484.4	-9.4	-2,804.1	-13.6	-2,381.3	-19.0	-1,181.4	-15.7	-9,851.1	-26.5
-923.8	-2.6	-5,167.4	-25.0	-3,650.8	-27.9	-141.0	-2.2	-9,883.0	-27.7
-421.6	-1.2	-4,381.2	-19.8	-2,200.3	-17.0	-1,694.9	-20.2	-8,698.1	-24.0
-2,626.7	-7.3	-2,072.3	-10.8	-2,637.5	-21.2	-1,000.4	-14.1	-8,336.9	-23.0
-5,629.2	-16.4	1,88.4	9.0	-1,912.7	-17.0	-1,181.7	-16.3	-7,335.1	-21.4
-5,041.5	-17.7	-3,293.2	-28.6	-1,903.4	-28.1	-817.7	-30.0	-11,055.8	-38.7
-4,192.7	-15.1	-2,850.0	-23.6	-1,340.3	-19.2	-488.2	-11.4	-8,871.2	-31.9
-7,110.5	-24.6	-2,779.0	-26.2	-2,142.7	-35.0	-825.7	-30.0	-12,857.8	-44.5
-247.0	-1.1	-1,290.0	-12.8	-2,313.1	-34.1	-504.0	-16.1	-4,354.2	-19.3

Maximum	1,206	**2**	-1,613	**-4**	-2,865	**-11**	353	**1**	-6,757	**-11**
Average	-1,053	**-2**	-3,965	**-10**	-4,233	**-14**	-1,487	**-7**	-10,737	**-20**
Minimum	-4,884	**-10**	-6,919	**-17**	-6,891	**-18**	-4,526	**-22**	-12,719	**-25**

Maximum	387	**1**	-2,072	**-11**	-2,564	**-9**	-1,315	**-6**	-8,696	**-18**
Average	-1,225	**-3**	-4,057	**-13**	-2,825	**-14**	-1,509	**-11**	-9,615	**-22**
Minimum	-3,538	**-8**	-5,805	**-17**	-3,296	**-18**	-1,838	**-15**	-10,552	**-25**

Maximum	1,890	**4**	-1,721	**-7**	-2,905	**-12**	-781	**-5**	-7,759	**-18**
Average	-241	**-1**	-5,078	**-17**	-3,655	**-18**	-1,012	**-9**	-9,986	**-23**
Minimum	-2,351	**-5**	-7,084	**-25**	-4,448	**-21**	-1,138	**-11**	-12,096	**-28**

Maximum	225	**1**	-1,144	**-5**	-1,967	**-11**	48	**0**	-6,896	**-19**
Average	-2,601	**-6**	-2,581	**-11**	-2,514	**-16**	-1,416	**-14**	-9,113	**-24**
Minimum	-6,761	**-15**	-4,363	**-19**	-2,763	**-20**	-3,229	**-24**	-10,620	**-28**

Maximum	-247	**-1**	1,388	**9**	-1,340	**-17**	-141	**-2**	-4,354	**-19**
Average	-3,274	**-11**	-2,556	**-17**	-2,263	**-25**	-832	**-18**	-8,924	**-29**
Minimum	-7,110	**-25**	-5,167	**-29**	-3,651	**-35**	-1,695	**-30**	-12,858	**-45**

Maximum	1,890	**4.3**	1,388	**9.0**	-1,340	**-8.9**	353	**1.3**	-4,354	**-11.3**
Average	-1,984	**-5.4**	-3,374	**-13.6**	-3,046	**-18.1**	-1,227	**-12.3**	-9,631	**-23.9**
Minimum	-7,110	**-24.6**	-7,084	**-28.6**	-6,891	**-35.0**	-4,526	**-30.0**	-12,858	**-44.5**

Summary table of channel balance discrepancy in the Amudarya River in the non-growing season

1.Kelif-Darganata section		2. Darganata-Tuyamuyun section		3. Tuyamuyun-Kipchak section		4. Kipchak-Samanbay section		5. Kelif-Samanbay section	
mcm	%	mcm	%	mcm	%	mcm	%	mcm	%
-7,14.4	-3.4	-586.0	-4.3	-1,152.0	-10.6	-1,380.2	-16.7	-3,832.6	-18.2
-4.6	0.0	-837.5	-6.2	-1,380.2	-13.3	-754.6	-9.9	-2,976.9	-15.2
-528.0	-2.6	-2,488.2	-20.1	-740.9	-9.4	-863.9	-14.0	-4,621.0	-22.7
505.2	2.5	-783.8	-6.0	-1,272.2	-10.8	-400.7	-4.6	-1,951.5	-9.7
-3,838.9	-18.4	-2,502.8	-24.7	-1,022.5	-13.9	-409.1	-7.7	-7,773.3	-37.3
-1,121.4	-5.6	-3,076.4	-28.0	-733.9	-11.2	-653.4	-13.5	-5,585.2	-27.9
-399.6	-2.1	-709.1	-5.8	547.8	7.4	-2,711.2	-39.6	-3,272.1	-17.0
-702.0	-3.6	-733.1	-6.2	-1,130.0	-12.5	-1,454.8	-21.3	-4,020.0	-20.4
-894.3	-4.7	559.1	5.3	-1,514.8	-13.4	-2,157.3	-28.4	-4,007.3	-21.0
656.5	3.4	-1,179.2	-9.5	-1,470.9	-13.5	-359.2	-4.4	-2,352.8	-12.2
1,091.6	5.8	-2,116.8	-17.5	-723.6	-8.2	-1,356.2	-19.0	-3,104.9	-16.4
-949.0	-5.8	-2,209.5	-25.6	-687.8	-10.8	-802.6	-17.1	-4,648.9	-28.4
-1,641.0	-8.2	-1,462.7	-13.5	1,161.0	18.0	-2,311.5	-35.6	-4,254.2	-21.4
-1,818.0	-10.4	-1,452.3	-17.1	-529.0	-7.2	-858.5	-14.5	-4,657.9	-26.7
-1,309.2	-7.3	-1,494.2	-15.0	-1,021.8	-17.9	-1,010.4	-25.6	-4,835.6	-27.1
-25.7	-0.2	-389.8	-5.4	-753.2	-11.6	-516.2	-15.1	-1,684.9	-11.1
1,058.2	6.2	-2,158.1	-19.9	-408.0	-6.8	-937.7	-20.5	-2,445.6	-14.3
-718.0	-4.2	-2,108.6	-22.4	-1,031.2	-15.6	-806.5	-18.1	-4,664.3	-27.6
2,753.4	17.0	-2,229.4	-18.6	-1,301.7	-22.2	-398.9	-11.7	-1,176.6	-7.3
-1,455.5	-9.2	-2,139.0	-28.3	-340.2	-5.8	-378.1	-7.9	-4,312.6	-27.4
-1,565.6	-8.8	-1,667.0	-18.1	-1,412.5	-25.4	-781.7	-23.9	-5,426.9	-30.4
-1,585.0	-10.9	-1,183.4	-17.3	-1,143.3	-29.6	-986.4	-45.0	-4,898.0	-33.8
-872.9	-6.0	-434.7	-6.3	-673.9	-15.2	-675.9	-22.6	-2,657.5	-18.1
-55.0	-0.4	-1,263.2	-17.3	-286.4	-6.1	-797.3	-21.8	-2,401.9	-16.6
650.8	4.8	-604.9	-7.7	-1,521.6	-26.8	-975.4	-28.3	-2,451.1	-18.0
-384.5	-3.1	-1,078.3	-19.6	-1,316.2	-38.0	-636.9	-38.4	-3,415.9	-27.8
-983.6	-8.9	-345.4	-7.6	-880.2	-28.7	-328.0	-21.0	-2,537.2	-22.9

Maximum	505	**2.5**	-586	**-4.3**	548	**7.4**	-401	**-4.6**	-1,951	**-9.7**
Average	-872	**-4.2**	-1,569	**-13.6**	-822	**-8.8**	-1,025	**-15.1**	-4,288	**-21.1**
Minimum	-3,839	**-18.4**	-3,076	**-28.0**	-1,380	**-13.9**	-2,711	**-39.6**	-7,773	**-37.3**

Maximum	1,092	**5.8**	559	**5.3**	-724	**-8.2**	-359	**-4.4**	-2,353	**-12.2**
Average	38	**0.2**	-867	**-7.0**	-1,210	**-11.9**	-1,332	**-18.3**	-3,371	**-17.5**
Minimum	-894	**-4.7**	-2,117	**-17.5**	-1,515	**-13.5**	-2,157	**-28.4**	-4,020	**-21.0**

Maximum	-949	**-5.8**	-1,452	**-13.5**	1,161	**18.0**	-803	**-14.5**	-4,254	**-21.4**
Average	-1,429	**-8.0**	-1,655	**-17.8**	-269	**-4.5**	-1,246	**-23.2**	-4,599	**-25.9**
Minimum	-1,818	**-10.4**	-2,209	**-25.6**	-1,022	**-17.9**	-2,311	**-35.6**	-4,836	**-28.4**

Maximum	2,753	**17.0**	-390	**-5.4**	-408	**-6.8**	-399	**-11.7**	-1,177	**-7.3**
Average	767	**4.7**	-1,721	**-16.6**	-874	**-14.0**	-665	**-16.3**	-2,493	**-15.1**
Minimum	-718	**-4.2**	-2,229	**-22.4**	-1,302	**-22.2**	-938	**-20.5**	-4,664	**-27.6**

Maximum	651	**4.8**	-345	**-6.3**	-286	**-5.8**	-328	**-7.9**	-2,402	**-16.6**
Average	-781	**-5.3**	-1,089	**-15.3**	-947	**-22.0**	-695	**-26.1**	-3,513	**-24.4**
Minimum	-1,585	**-10.9**	-2,139	**-28.3**	-1,522	**-38.0**	-986	**-45.0**	-5,427	**-33.8**

Maximum	2,753	**17**	559	**5**	1,161	**18**	-328	**-4**	-1,177	**-7**
Average	-550	**-3**	-1,358	**-14**	-842	**-13**	-952	**-20**	-3,702	**-21**
Minimum	-3,839	**-18**	-3,076	**-28**	-1,522	**-38**	-2,711	**-45**	-7,773	**-37**

Summary table of channel balance discrepancy for the Amudarya River for hydrologic years

1.Kelif-Darganata section		2. Darganata-Tuyamuyun section		3. Tuyamuyun-Kipchak section		4. Kipchak-Samanbay section		5. Kelif-Samanbay section	
mcm	%	mcm	%	mcm	%	mcm	%	mcm	%
709.4	0.9	-3,795.3	-6.5	-5,574.8	-10.8	-48.1	-0.1	-8,708.8	-10.9
3,045.6	3.9	-8,259.5	-13.8	-8,192.3	-18.4	-489.1	-1.6	-13,895.3	-17.7
-779.5	-1.0	-7,756.4	-14.2	-4,691.4	-11.5	-2,149.4	-7.3	-15,376.7	-20.0
-4,509.1	-6.3	-3,721.7	-7.9	-4,685.1	-12.6	-2,143.3	-7.5	-15,059.1	-21.1
806.7	1.1	-3,679.5	-7.3	-4,498.9	-12.2	-5,234.7	-18.5	-12,606.4	-17.8
-1,237.8	-1.8	-4,879.2	-10.0	-3,716.3	-9.3	-2,695.4	-9.1	-12,528.8	-17.8
-1,439.1	-2.1	-6,716.2	-15.2	-3,394.4	-10.0	-5,384.7	-20.3	-16,934.3	-25.2
-6,187.5	-9.3	-3,423.8	-8.5	-4,569.6	-17.3	-1,900.9	-10.4	-16,081.8	-24.2
-3,245.6	-5.1	-1,162.2	-3.1	-4,420.5	-12.7	-2,938.8	-13.4	-11,767.1	-18.7
-963.2	-1.5	-7,817.5	-19.5	-4,742.0	-18.0	-2,593.2	-15.5	-16,115.8	-25.7
-5,104.0	-7.9	-6,058.6	-15.5	-4,026.4	-17.1	-2,154.3	-13.9	-17,343.4	-26.7
2,944.9	4.8	-8,595.5	-20.3	-4,853.3	-18.0	-2,054.6	-12.1	-12,558.5	-20.4
2.3	0.0	-6,883.5	-17.5	-4,611.7	-21.0	-2,475.3	-17.8	-13,968.2	-23.3
-1,268.7	-2.2	-5,542.7	-15.6	-4,167.8	-16.9	-1,141.2	-7.0	-12,120.4	-20.9
-1,550.0	-2.6	-4,348.0	-12.0	-806.1	-3.2	-5,540.4	-27.4	-12,244.6	-20.5
-6,787.3	-11.1	-1,533.6	-4.7	-3,516.1	-13.5	-468.2	-3.1	-12,305.2	-20.1
1,316.7	2.4	-4,747.3	-13.7	-3,277.5	-13.9	-3,292.4	-19.8	-10,000.5	-17.9
-2,045.2	-3.7	-8,243.8	-26.0	-4,384.7	-22.3	-794.5	-7.1	-15,468.2	-27.8
-3,573.8	-6.8	-4,263.3	-15.3	-3,321.7	-17.7	-1,797.2	-15.3	-12,955.9	-24.7
-9,468.1	-17.2	-1,114.4	-4.4	-2,935.1	-15.8	-1,590.8	-12.7	-15,108.4	-27.4
-4,737.2	-9.1	-2,006.9	-6.8	-3,603.2	-19.5	-1,742.7	-15.1	-12,090.0	-23.1
-4,357.3	-8.4	-3,238.8	-11.8	-3,055.2	-18.0	-1,857.3	-17.6	-12,508.6	-24.1
-476.7	-0.9	-5,644.4	-19.2	-2,486.8	-14.1	-2,492.2	-20.7	-11,100.0	-21.9
-5,569.5	-11.4	-5,781.4	-24.2	-2,644.3	-18.0	-1,681.6	-17.6	-15,676.9	-32.1
-5,648.1	-13.0	-4,989.0	-25.4	-1,680.5	-13.1	-866.3	-9.5	-13,183.9	-30.3
-6,709.2	-16.2	-3,962.3	-22.7	-3,286.0	-32.9	-1,812.0	-36.7	-15,769.5	-38.1
403.8	1.1	-1,894.9	-10.6	-3,834.7	-30.7	-1,479.5	-22.5	-6,805.3	-18.8

Maximum	3,046	**3.9**	-3,680	**-6.5**	-3,394	**-9.3**	-48	**-0.1**	-8,709	**-10.9**
Average	-486	**-0.8**	-5,544	**-10.7**	-4,965	**-12.1**	-2,592	**-9.2**	-13,587	**-18.6**
Minimum	-4,509	**-6.3**	-8,260	**-15.2**	-8,192	**-18.4**	-5,385	**-20.3**	-16,934	**-25.2**

Maximum	-963	**-1.5**	-1,162	**-3.1**	-4,420	**-12.7**	-1,901	**-10.4**	-11,767	**-18.7**
Average	-3,465	**-5.3**	-4,134	**-10.4**	-4,577	**-16.0**	-2,478	**-13.1**	-14,655	**-22.8**
Minimum	-5,104	**-7.9**	-8,595	**-20.3**	-4,853	**-21.0**	-2,475	**-17.8**	-17,343	**-26.7**

Maximum	2,945	**4.8**	-6,059	**-15.5**	-4,026	**-17.1**	-2,055	**-12.1**	-12,558	**-20.4**
Average	-719	**-1.0**	-7,179	**-17.8**	-4,497	**-18.7**	-2,228	**-14.6**	-14,623	**-23.5**
Minimum	-5,104	**-7.9**	-8,595	**-20.3**	-4,853	**-21.0**	-2,475	**-17.8**	-17,343	**-26.7**

Maximum	1,317	**2.4**	-1,534	**-4.7**	-806	**-3.2**	-468	**-3.1**	-10,001	**-17.9**
Average	-2,318	**-4.0**	-4,780	**-14.6**	-3,246	**-14.6**	-2,172	**-13.3**	-12,516	**-22.0**
Minimum	-6,787	**-11.1**	-8,244	**-26.0**	-4,385	**-22.3**	-5,540	**-27.4**	-15,468	**-27.8**

Maximum	404	**1.1**	-1,114	**-4.4**	-1,680	**-13.1**	-866	**-9.5**	-6,805	**-18.8**
Average	-4,570	**-9.4**	-3,579	**-15.6**	-2,941	**-20.3**	-1,690	**-19.0**	-12,780	**-27.0**
Minimum	-9,468	**-17.2**	-5,781	**-25.4**	-3,835	**-32.9**	-2,492	**-36.7**	-15,770	**-38.1**

Maximum	3,046	**4.8**	-1,114	**-3.1**	-806	**-3.2**	-48	**-0.1**	-6,805	**-10.9**
Average	-2,460	**-4.6**	-4,817	**-13.8**	-3,888	**-16.2**	-2,178	**-14.1**	-13,344	**-22.9**
Minimum	-9,468	**-17.2**	-8,595	**-26.0**	-8,192	**-32.9**	-5,540	**-36.7**	-17,343	**-38.1**

Analysis of channel losses within balancing sites of the Amudarya River for various flow conditions and growing and non-growing seasons over the last 27 years (1989-90 – 2015-16)

The average long-term channel losses within balancing sites of the Amudarya River are shown in Table below for growing and non-growing seasons and for hydrological year in general:

Table 1 %%

№	Water availability	Balancing sites	Non-growing season	Growing season	Hydrological year
1	Average long-term	Kelif -Darganata	-3.1	-5.4	-4.6
		Darganata – Tuyamuyun	-14.2	-13.6	-13.8
		Tuyamuyun - Kipchak	-13.3	-18.1	-16.2
		Kipchak – Samanbay	-20.2	-12.3	-14.1
		Kelif - Samanbay	-21.4	-23.9	-22.9

Conclusion

Having analyzed the above data on channel losses in Amudarya River sites from Kelif gauging station to Samanbay gauging station, the following conclusions can be made **(**see ***Summary Table of channel balance discrepancies in reaches of the Amudarya River over hydrological years, non-growing and growing seasons*****):**

First balancing site regarding channel losses is Kelif-Darganata.

The average long-term value of balance discrepancy over 27 years of observations for a hydrological year is -4.6%, including -3.1% in non-growing season and -5.4% in growing season; the minimum value of discrepancy for a hydrological year is – 4.6%, including -3.1% in non-growing season and -4.3% in growing season. The maximum value of discrepancy over 27 year was -17.2% in 2012-13, -18.4 % in non-growing season and – 24.6% in growing season during serious drought in 2001.

It should be noted that given the hydrological conditions of the river site and some inaccuracies in TurkmenHydromet's data, as well as the fact that water accounting at Kelif river section upstream of intake to Garagumdarya is made by estimation on the basis of measurements at lower gauging stations and there is an effect of water withdrawal by Turkmenistan and Uzbekistan, reliability of information on channel losses is not strong. Therefore, the above mentioned should be taken into account in setting the norms for channel losses.

Second balancing site regarding channel losses is Darganata–Tuyamuyun.

The average long-term value of balance discrepancy over 27 years of observations for a hydrological year is – 13.8%, including -14.2% in non-growing season and -13.6% in growing season; the minimum value of balance discrepancy for a hydrological year is – 3.1%. During non-growing season, the lowest channel losses were observed in 1990-1991 (-5.3%) and in 1992-1993 (-4.3%). The maximum value of balance discrepancy over 27 year was -26.0% in 1996-1997, -28.3% in non-growing season and -28.6% in growing season during serious drought in 2000. Within this site, channel losses directly depend on water availability in the Amudarya basin.

Third balancing site regarding channel losses is Tuyamuyun - Kipchak.

The average long-term value of balance discrepancy over 27 years of observations for a hydrological year is -16.2%, including -13.3% in non-growing season and -18.1% in growing season; the minimum value of balance discrepancy for a hydrological year is -3.2%. During non-growing season, the lowest channel losses were observed in 2006/2007 (- 6.1%). The maximum value of balance discrepancy over 27 year was -32.9% in the hydrological year 2000/2001, -38.0 % in non-growing season 2001/2002, and – 35.5% in growing season during serious drought in 2001.

The main causes of the negative effect on channel losses within this river site include some inaccuracies in UzbekHydromet's data for Tuyamuyun and Kipchak gauging stations and the impact of water withdrawals by Khorezm and Karakalpakstan (more than hundred pumping station are located along this site).

Fourth balancing site regarding channel losses is Kipchak-Samanbay.

The average long-term value of balance discrepancy over 27 years of observations for a hydrological year is -14.1%, including -20.2% in non-growing season and -12.3% in growing season; the minimum value of balance discrepancy for a hydrological year is – 0.1%. The lowest channel losses were -4.4% in non-growing season and -1.3% in growing season. The maximum value of balance discrepancy over 27 year was -36.7% in the hydrological year 2000-2001, including -45.0% in non-growing season and -30.0% in growing season during serous drought.

The main causes of the negative effect on channel losses within this river site include some inaccuracies in UzbekHydromet's data for Kipchak and Samanbay gauging stations and the impact of water withdrawals by Turkmenistan and Karakalpakstan.

Site – **Kelif-Samanbay**

The average long-term value of balance discrepancy over 27 years of observations for a hydrological year is -22.9%, including -21.4% in non-growing season and -23.9% in growing season; the minimum value of balance discrepancy for a hydrological year is -10.9%. The lowest channel losses were -7.3% in non-growing season and -11.3% in growing season. The maximum value of balance discrepancy over 27 year was -38.1% in the hydrological year 2000-2001, -37.3% in the non-growing season of 2012-2013, and -44.5% in the growing season 2001 during serious drought.

Conclusion

1. In fact, channel losses varied widely in river sites over 27 years of observation.
2. Particular problems related to water accounting are not observed in high-water years.
3. However, both water accounting and water distribution along all river reaches are strained during low-water years. This reaches its peak during serious droughts.
4. The report "Estimation of channel losses in middle and lower reaches of the Amudarya River" completed jointly by Turkmenistan NWG (A.Ovezov), NWG Uzbekistan (R.Srajitdinov), and RRG (O.Lysenko, A.Sorokin) under leadership of the Head of BWO Amudarya Yu.Khudaiberganov in December 2007 provides preliminary recommendations for setting norms of channel losses by river reach. Those recommendations were disseminated among all members of the Interstate Commission for Water Coordination (ICWC). With certain adjustments, the recommendations could be used as a base.