Table C.9 (2) Collector Discharge Rate (1976 to 1993)

Section : Kerki - Dargan Afa - Tuyamuyun unit : million m3/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	VERAGE
1976	3.74	5.65	7.22	7.27	6.70	6.47	7.06	7.67	6.54	2.98	2.22	1.71	5.44
1977	2.91	3.68	6.03	6.95	6.40	7.17	7.70	7.82	6.55	4.25	2.59	3.62	5.47
1978	4.14	6.18	8.10	7.78	7.83	8.42	9.39	8.39	6.78	5.52	3.47	2.44	6.54
1979	3.64	5.11	9.54	8.08	6.78	7.06	8.44	9.55	6.61	4.50	2.86	2.30	6.21
1980	4.04	4.24	6.76	9.12	7.02	7.90	8.65	7.62	6.21	3.75	2.26	2.50	5.84
1981	4.75	7.49	10.34	8.19	7.29	8.10	10.22	9.65	7.16	5.27	3.11	2.24	6.98
1982	5.42	7.93	10.11	10.83	7.55	8.57	8.85	8.92	8.33	6.48	4.16	2.38	7.46
1983	2.35	4.14	2.18	1.44	1.15	2.21	9.58	9.67	8.49	6.10	4.74	3.28	4.61
1984	2.30	2.49	7.09	5.26	6.33	8.90	10.20	10.18	8.93	7.03	5.40	2.59	6.39
1985	6.57	8.75	10.49	13.10	13.10	12.10	12.60	10.80	9.89	9.15	6.09	4.14	9.73
1986	5.92	9.87	8.42	7.75	8.61	7.54	9.34	9.06	7.46	5.94	3.85	2.43	7.18
1987	5.59	5.72	4.98	7.82	8.84	11.60	13.70	11.95	8.18	4.81	4.34	2.44	7.50
1988	5.70	5.65	5.10	7.97	8.98	11.80	13.37	12.15	8.35	4.92	4.45	2.50	7.58
1989	11.27	25.55	16.97	9.52	7.87	5.14	2.34	1.87	1.38	3.70	3.10	2.54	7.60
1990	4.15	9.84	12.27	9.52	8.36	7.12	6.50	6.37	6.07	5.52	4.85	3.90	7.04
1991	5.21	3.07	5.93	6.94	3.31	4.43	4.53	4.01	3.79	5.81	4.45	3.90	4.62
1992	5.48	3.15	5.73	7.53	3.03	4.64	4.56	3.96	3.19	4.21	3.88	3.43	4.40
1993	3.96	8.35	10.17	8.03	7.45	6.14	4.99	4.92	4.66				6.52
VERAGI	4.84	7.05	8.19	7.95	7.03	7.52	8.45	8.03	6.59	5.29	3.87	2.84	
Non-exceeding probability													
90%	5.8	9.9	11.1	9.9	8.9	11.7	13.1	11.8	8.6	6.7	5.1	3.9	
75%	5.5	7.9	10.1	8.9	8.2	8.5	10.0	9.7	8.0	5.9	4.5	3.4	
50%	4.2	5.1	7.1	7.9	7.4	7.4	8.8	8.7	7.2	5.3	3.9	2.5	

Table C.9 (3) Collector Discharge Rate (1976 to 1993)

Section : Tuyamuyun - Sumambay unit : million m3/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
1976													
1977													
1978													
1979													
1980													
1981													
1982													
1983													
1984			0.03	0.05	0.11	0.04	0.07	0.07					0.06
1985			0.07		0.03	0.03	0.03	0.06					0.04
1986													
1987													
1988													
1989										1.4	1.2	1.7	1.43
1990	0.7	2.0	3.2	3.3	2.3	1.9	2.5	2.8	1.5	1.1	0.9	0.9	1.93
1991	0.8	1.2	3.5	4.2	2.2	2.4	3.9	4.3	4.4	2.0	1.0	0.9	2.57
1992	0.8	1.7	2.7	3.2	2.7	2.9	4.2	4.0	3.5	2.5	1.7	1.4	2.61
1993	1.0	1.6	3.9	3.7	2.7	2.8	3.3	3.4	2.0				2.71
AVERAG	0.8	1.6	3.3	3.6	2.5	2.5	3.5	3.6	2.9	1.9	1.2	1.1	
Non-exceeding probability													
90%													
75%													
50%													

Table C.10 (1)Canal Flow Rate

Section : Termez - Kerki | unit : million m3/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
1976	25.4	32.2	37.4	26.0	30.7	44.4	56.4	52.3	37.6	24.1	24.1	17.9	34.0
1977	17.8	26.3	33.8	35.7	39.7	52.9	57.8	56.4	38.7	24.5	20.0	19.7	35.3
1978	30.1	34.7	47.7	39.8	37.5	46.4	62.4	60.0	38.9	26.6	21.3	21.6	38.9
1979	21.3	35.2	41.4	40.9	39.6	55.1	64.4	63.0	49.4	39.8	25.8	22.8	41.6
1980	25.1	29.9	43.2	41.6	44.4	63.0	67.6	63.3	47.2	36.4	25.8	25.8	42.8
1981	35.1	42.8	39.2	38.8	37.8	55.9	64.1	62.8	49.1	36.7	31.6	21.9	43.0
1982	39.7	36.8	55.1	40.6	61.7	72.3	64.5	67.2	53.2	52.7	30.4	17.8	49.3
1983	19.5	28.1	31.4	28.8	35.1	59.6	65.4	69.1	54.5	41.6	33.6	23.4	40.8
1984	25.5	39.8	51.1	49.3	52.8	60.1	70.4	70.9	47.8	42.1	40.5	26.4	48.1
1985	18.9	35.6	60.0	56.2	57.8	61.5	61.5	61.3	44.3	42.0	34.0	35.3	47.4
1986	40.9	46.9	27.5	35.7	34.4	40.9	62.7	61.4	40.0	37.7	38.9	41.9	42.4
1987	39.2	39.8	38.6	58.5	63.3	88.2	68.1	74.1	55.8	40.3	45.7	30.4	53.5
1988	39.1	40.6	35.4	51.5	55.7	78.5	61.7	62.4	53.5	41.6	44.3	35.2	50.0
1989	35.8	32.5	41.2	57.6	61.6	61.5	63.5	60.9	46.1	44.5	50.6	48.5	50.4
1990	34.3	31.9	34.2	46.3	58.4	68.3	68.1	67.0	46.9	40.5	45.0	44.2	48.8
1991	17.7	17.0	17.8	21.4	26.0	25.9	27.7	26.4	20.6	39.2	34.5	33.9	25.7
1992	12.6	13.4	14.4	21.8	24.5	22.5	21.1	27.0	23.8	28.4	33.8	35.3	23.2
1993	21.7	26.9	40.0	52.3	53.3	41.0	41.6	36.8	24.1				37.5
AVERAG	27.8	32.8	38.3	41.3	45.2	55.4	58.3	57.9	42.9	37.6	34.1	29.5	
Non-exceeding probability													
90%	39.9	43.6	56.1	57.8	62.0	80.4	68.6	71.5	54.8	47.0	47.2	45.5	
75%	37.5	39.8	45.5	51.9	58.1	65.7	66.5	67.1	51.3	41.9	43.4	35.3	
50%	25.5	34.7	39.2	40.9	44.4	55.1	63.5	62.4	46.9	40.1	33.9	28.4	

Table C.10 (2)Canal Flow Rate

Section : Kerki - Tuyamuyun unit : million m3/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
1976	17.4	19.7	16.8	8.6	11.0	33.6	43.4	37.1	20.4	7.2	0.2	0.2	18.0
1977	3.6	9.8	33.0	13.3	12.6	37.0	49.3	45.6	21.6	10.3	8.7	14.4	21.6
1978	22.7	24.5	21.2	15.3	18.2	42.4	51.2	46.9	26.6	6.8	0.6	3.5	23.3
1979	15.0	31.3	16.5	11.6	17.8	39.7	48.9	48.2	28.4	11.4			26.9
1980	18.2	24.7	30.5	22.1	25.4	46.0	58.2	57.9	29.1	15.9	5.2	2.1	27.9
1981	25.9	31.0	26.0	19.9	26.5	50.1	61.3	58.7	33.4	13.8	4.3	2.8	29.5
1982	38.8	31.8	39.9	31.6	43.7	81.5	61.2	63.2	37.5	19.9	4.0	4.2	38.1
1983	20.6	29.7	17.8	16.8	21.6	52.0	66.7	68.1	36.1	15.6	4.1	3.1	29.4
1984	23.6	27.4	42.4	32.0	37.8	59.6	74.2	71.3	33.2	15.6	4.9	3.0	35.4
1985	13.4	26.2	38.7	31.8	40.2	56.9	63.9	58.9	29.3	16.2	4.8	6.0	32.2
1986	33.3	31.9	19.1	20.4	21.4	34.5	58.5	54.1	27.6	14.1	4.7	6.4	27.2
1987	30.0	31.7	30.9	35.7	40.1	78.0	62.3	65.2	41.5	15.1	5.6	3.7	36.7
1988	31.0	32.6	27.3	31.0	36.0	66.2	63.5	56.8	37.4	15.5	5.4	4.8	34.0
1989	28.5	27.8	30.7	31.9	38.0	51.0	57.5	53.0	32.6	16.7	6.2	7.0	31.7
1990	27.2	32.2	27.8	26.7	39.6	59.5	63.1	58.3	36.0	15.4	5.5	5.3	33.1
1991	16.6	15.0	21.3	14.3	18.5	27.2	29.1	24.8	20.0	14.8	4.2	5.1	17.6
1992	9.7	18.5	10.5	13.7	18.2	20.7	21.9	27.0	17.8	10.9	4.1	6.1	14.9
1993	19.9	24.6	28.9	32.5	35.3	34.4	36.3	32.4	23.1				29.7
AVERAGE	22.0	26.1	26.6	22.7	27.9	48.4	53.9	51.5	29.5	13.8	4.5	4.9	
Non-exceeding probability													
90%	34.4	32.3	40.4	33.1	40.9	78.7	68.2	68.7	38.3	17.7	7.0	9.2	
75%	29.3	31.8	32.0	31.9	38.8	59.6	63.3	61.1	36.1	15.8	5.5	6.1	
50%	22.7	27.8	27.8	22.1	26.5	50.1	58.5	56.8	29.3	15.3	4.8	4.5	

TableC.10 (3)Canal Flow Rate

Section : Tuyamuyun - Sumambay　　　　unit : million m3/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
1976	31.5	8.8	31.3	42.5	80.2	99.4	127.0	131.3	25.2	34.9	30.3	21.2	55.3
1977	5.6	12.4	39.0	45.5	36.1	85.4	146.9	125.3	16.5	11.8	57.1	41.0	51.9
1978	24.6	21.8	42.3	38.3	59.5	107.3	153.2	155.3	51.4	3.1	45.4	48.6	62.6
1979	24.8	31.1	37.8	49.4	77.4	101.3	148.8	152.3	32.1	3.2	34.8	55.6	62.4
1980	26.0	27.2	44.6	47.3	82.9	108.1	154.8	138.1	15.9	10.3	43.5	51.3	62.5
1981	27.8	23.0	38.0	35.4	77.9	85.1	135.7	134.4	35.9	9.4	34.9	69.2	58.9
1982	22.2	24.8	45.5	20.4	55.8	97.2	64.5	108.5	27.0	0.7	29.8	36.5	44.4
1983	26.6	26.1	13.7	34.3	76.5	85.4	130.4	122.4	19.1	17.0	36.9	40.0	52.4
1984	20.4	8.5	30.5	27.9	63.7	97.9	148.9	146.4	32.7	5.2	15.3	15.6	51.1
1985	3.9	41.0	77.2	45.0	92.5	103.9	129.1	132.1	13.8		11.9	48.8	63.6
1986	53.4	20.7	33.7	39.7	48.7	62.4	131.9	112.4	23.8	20.0	42.0	68.8	54.8
1987	26.2	30.4	72.6	87.2	101.4	176.3	126.3	136.3	63.9	11.1	6.3	10.6	70.7
1988	39.0	32.4	60.0	45.9	100.7	117.0	215.3	139.4	35.6	55.6	14.8	30.7	73.9
1989	38.9	36.6	64.1	53.0	81.0	81.7	111.7	101.5	35.0	26.9	43.0	58.7	61.0
1990	34.4	65.8	67.0	54.1	133.8	126.8	137.0	112.5	63.4	41.5	20.1	10.7	72.3
1991	11.0	31.6	77.6	45.7	72.9	105.4	104.8	69.9	31.9	23.3	24.2	52.1	54.2
1992	9.3	24.5	20.9	36.8	81.0	55.1	75.3	95.6	29.1	39.4	41.0	86.8	49.6
1993	55.2	40.8	56.2	84.0	109.5	59.5	53.3	67.4	35.9				62.4
AVERAGE	26.7	28.2	47.3	46.2	79.5	97.5	127.5	121.2	32.7	19.6	31.3	43.9	
Non-exceeding probability													
90%	53.8	46.0	77.3	84.6	114.4	136.7	166.9	150.1	63.5	47.1	48.9	74.5	
75%	36.7	34.5	65.6	51.2	96.6	107.7	148.9	138.8	35.9	39.4	42.8	57.9	
50%	26.0	27.2	44.6	45.5	80.2	99.4	131.9	131.3	32.0	17.0	34.9	48.7	

RESEARCH REPORT

"HYDROGEOLOGICAL STATUS AND WATER QUALITY OF RUSLOVOYE (BED) AND KAPARAS RESERVOIRS"

SANIIRI

Tashkent - 1996

Introduction to This Research Report

This report was compiled by the Central Asian Scientific Research Institute for Irrigation & Land Reclamation (SANIIRI) under the guidance of the JICA Study Team to evaluate of a usability of the Kaparas reservoir as a drinking water source in Karakalpakstan and Khorezm. The evaluation results are shown in Chapter 5 of main report (Part 1).

CONTENTS

INTRODUCTION

Currently the Republic of Uzbekistan is suffering a heavy situation related to drinking water supply for the population. The problem is even much more acute with the population living in the downstream of Amudarya river where during last 10-12 years extremely negative consequences resulted from utilization of poor quality water have been observed.

The major reasons to deterioration of the natural water quality are mainly as outlined below: firstly, increase in water consumption volumes for irrigation purposes; and secondly, discharge of highly mineralized trapped and drained water into rivers, where the said water is highly contaminated with various substances of both organic and inorganic origin (the compounds of nitrogen, phosphorus, pesticides, phenols, etc.).

Similar to other Central Asian republics, the sources of drinking water in the Republic of Uzbekistan are surface waters of rivers and reservoirs, and also the fresh ground waters. However, the general water sources are in deficit in the Republic. For instance, only about 1 percent out of 68.996 river streams mapped in the Aral sea basin is located within the boundary lines of Uzbekistan, whereas the main part of those does not reach even to the major rivers of Syrdarya and Amudarya, i.e. being yet in piedmont zones the water is taken off by the multiple irrigation systems.

As the same time the stock of fresh ground water in major aquifers of the Republic is limited to about 48.802.000 m^3/day. The distribution of the stock is uneven, being quite limited on the major part of steppe, desert and flatland areas, or even inavailable at all.

Given the deficit of ground fresh water volumes in the Republic, recently the surface fresh water as a major source of drinking and useful water supply for the population has become growing in the importance.

Thus, for instance, one of the surface water sources known as Kaparas and Ruslovoye (Bed) water reservoirs included to the reservoir system TMHU (Tuayamuyun Hydro Unit) has been recommended by the Research-&-Industrial Association SANIIRI to be used for water supply of the population in the downstream of the Amudarya river.

In connection with the above described situation, a problem has been come to existence related to the comprehensive studies of hydroecological status and development of operation conditions aiming at the improvement of the drinking water quality from the abovenamed sources.

1. WATER MANAGEMENT ACTIVITY OF RUSLOVOYE (BED) AND KAPARAS RESERVOIRS AT THE CURRENT LEVEL

Hydrogeological, level and alluvial performance data for 1985 through 1993 period has been collected to analyze the current water management status of Ruslovoye (Bed) and Kaparas water reservoirs.

1.1. PHYSICO-GEOGRAPHICAL AND MORPHOMETRIC CHARACTERISTICS OF THE WATER RESERVOIRS

Ruslovoye (Bed) and Kaparas water reservoirs are included to the TMHU of water reservoirs. All those are located at a boundary line of mid- and downstream of the Amudarya river in Tuyamuyun ravine at the joint of administrative boundaries of Karakalpakistan, Khoresm Region of the Republic of Uzbekistan and Chardjou region of Turkmenistan.

The Amudarya river had been dammed in the section of hydrounit as far as in November, 1979, but before 1981 the river outflow was not controlled. Starting from 1981, first the Ruslovoye (Bed) and Kaparas interconnecting water reservoirs have been filled with water, followed by the Sultansadjar reservoir - in October, 1983, and Koshbulak - in June, 1985.

Morphometric specifications of TMHU are furnished in Table 1.1.

The initial Gross capacity of all water reservoirs was equal to 7.80 km^3, and the useful capacity was 5.27 km^3.

The Ruslovoye (Bed) reservoir is getting permanently silted up, with the result that its volume by now has been somehow reduced. Data on silting of this reservoir are summarized below.

Table 1.1

Tuyamuyun Hydro Unit (TMHU) Morphometric Characteristics

No.	Length, km	Width, max., ave. km	Depth at HBL, max., ave. km	Water table area at HBL, km^2	Shoal water (to 2m) area, km^2	Volume		Water levels, m		Water table area at DVL
						Total	Useful	HBL	DVL	
1	2	3	4	5	6	7	8	9	10	11
1.	Ruslovoye (Bed) Water Reservoir									
	102	11.0 / 4.0	20 / 7.7	303	93	2.34	2.07	130	120	87
2.	Kaparas Water Reservoir									
	15	9.0 / 4.0	36 / 13.7	70	6	0.96	0.55	130	120	43.5
3.	Sultandjar Water Reservoir									
	24	12 / 8.0	38 / 18.0	149	10	2.69	1.63	130	116	86
4.	Koshbulakskoye Water Reservoir									
	28	11.0 / 6.0	41 / 14.2	128	7	1.81	1.02	130	120	78.5

1.2. Hydrogeological Conditions of the Amudarya River

Mainly the Amudarya river is fed by the Pyandj River (%50 of the total outflow in the river at Kerki Hydro Section) and Vakhsh (%33), and to a smaller extent - from the rivers of Kaphirnigan and Surkhandarya.

The catchment area volume of the Amudarya river up to the TMHU section is 227.000 km^2. The source of feeding the river is ice and snows. Average volume of discharge for many years is 65.1 km^3, whereas at %90 of supply is equal to 55.6 km^3. Period of spring flood for many years is usually between April and September with the discharge volume of 50.0 km^3. Usually, the rise of outflow starts in March-April and reaches its peak value in June-July. Starting from August-September the outflows fall down and continue to decrease up to January-February. Starting from November the major feeding sources are the ground waters.

Analysis of outflows and turbidity of water has been carried out at Kerki section (1985-1989), Darganata and Tuyamuyun (1985-1993). Their monthly average values are summarized in Table II.1 and II.2.

During the years under consideration the Amudarya river discharge rate in the section of Kerki has been changed to 1.7 times. In 1988, noted for its low water level, it was 53.7 km^3. The highest outflows were observed in June-August. In low water level year the outflow did not exceed 2780 m^3/s, while in a year with the high water level the outflow reached 4240 m^3/s. Lowest outflows were observed in February-March and October-November. Those were ranging between 430 and 1040 m^3/s, i.e. summer outflows during the years under consideration were 4-7 times higher than during low water period.

As the result of water consumption in the mid-stream, the annual discharge in Darganat section has been reduced by 10-13 km^3, totaling to 18 km^3 in 1986, and 44 km^3 in 1988.

During a high water period of 1992 the discharge reached 54 km^3. Similar to Kerki section, the maximum outflows in the section of the river occurred in summer time, where the peak values of outflows were observed in 1988 (3580 m^3/s) and 1992 (3912 m^3/s), and minimum outflows were registered during autumn-winter season, when the outflows reduced down to 204-230 m^3/s in 1986-1987, and to 600 m^3/s - in 1992.

In the downstream of the river (section of Tuyamuyun) the annual discharge values, as the result of monitoring the outflow by Tuyamuyun Hydro Unit, have been ranging between 16.8 km^3 (in 1986) and 49.4 km^3 (in 1992), i.e. those values decreased by 1.2-4.6 km^3 as compared with Darganat section. The range of values was similar to Darganat section.

Larger water outflows (1410-2990 m^3/s) have been discharged to the tail race in the spring and summer, while in autumn and winter - smaller (70-440 m^3/s) outflows. In this section the summer outflows exceed the winter values by 7-20 times.

In the Kirki section, the river carried detritus ranging from 0.58 to 9.0 kg/m^3. The most turbid stream was observed in April-July, while the least turbid stream - in October-March.

In Darganata section, the amount of detritus reduced and ranged between 0.50-3.8 kg/m^3.

Practically clarified water has been fed into the downstream of the river, as the result of affluent of levels in the Ruslovoye (Bed) Reservoir and sedimentation of detritus. The water turbidity was registered at the value of 0.02-1.30 kg/m^3. The peak values of turbidity were registered during summer period, while the minimum values - during autumn and winter.

Thus, the discharge of the mid-stream of the river, between the upper section (Kerki) and lower (Tuyamuyun), reduced by 13 km^3 in 1988 which was peculiar for its high water level, while in 1986, which was lower watered, - by 14 km^3 per year. At the same time, the reduction of water turbidity in certain months was ranging between 2 to 200 times.

As per data collected by the R & D Institute "Sredazgiprovodkhlopok", currently the annual discharge of drainage water (DW) from the irrigated massifs in the mid-stream of Amudarya river (Kerki-Tuyamuyun sections) makes 3.5 km^3, that affects the quality of the river water.

It is worth to note that in the mid-stream of the Amudarya river one can find the largest massifs of the state-of-art irrigation, namely: Karshinskaya Steppe and Bukhara Oasis in the Republic of Uzbekistan, Chardjou region in Turkmenistan.

1.3. Operation Mode of Reservoirs

The "Rules of TMHU Operation" contain provisions of the operation process for Tuyamuyun Hydro Unit water reservoirs, which process, under normal conditions, envisages for:

- Safe operations of water head structures forming the water reservoir; as well as safety of the population and farming in the surrounding zone of the reservoir and the river flatland at the lower section;
- supply of consumers living in the downstream of Amudarya river with water.

Operation Schedule of water reservoirs has been developed with the view of the operations of Nurek water Reservoir.

The major principle of adjusting the Amudarya river discharge by TMHU water reservoirs to secure a stable development of water consuming sectors of the Amudarya region in its downstream as recommended by the "Rules...", is as follows:

- during the period of September to May, all basins of reservoirs are getting filled, in cycles with periods of some minor emptying. Whereas the first to fill are the Ruslovoye (Bed) reservoir and Kaparas; filling of the two other basins, i.e. Sultansandjar and Koshbulak becomes possible only when the first two basins - Ruslovoye (Bed) and Karapas- have been completely filled.

In the period between June to August all basins of the TMHU reservoirs are completely emptied in the following sequence: first - Ruslovoye (Bed) and Kaparas, and then - Sultandjar and Koshbulak.

According to a dispatching Schedule, the adjustment of incoming Amudarya discharge flow is mainly maintained by Ruslovoye (Bed) and Kaparas basins. The Sultansandjar and Koshbulak basins, after having been fully filled by January, do not play any role in adjustment until July, and then, during the following two months - July and August, are completely emptied down to the level of DVL (Dead Volume Level).

The dynamics of water levels during 1985-1993 for both Ruslovoye (Bed) and Kaparas reservoirs is shown in Table 1.3.

During the first year of filling the volume of reservoirs reached 1.5 km^3 by December, 1991, and thereafter the filling volume of reservoirs has been increasing every year to reach 6.7 km^3 by October of 1987.

During the years of operations, the filling of Ruslovoye (Bed) and Kaparas reservoirs up to HBL level and close to that has been noted since 1983 and up to 1992.

In order to compensate the water deficit marked during low water level years (i.e. 1982, 1986, 1989), as well as in September of 1991-1993 and August 1993, the water reservoirs were allowed to be emptied to a level lower that the DVL level. The water levels during this period went down to routine values of 112-114 m in Ruslovoye (Bed) reservoir, in Kaparas - down to 113.3 m, Sultansandjar to 113.2 m; Koshbulak - 117.0 m.

The level conditions of TMHU reservoirs were characterized with accumulation of volumes during autumn and winter season, and emptied for the irrigation purposes during the period of spring seasonal soil flushing procedures prior to seeding, and during summer vegetation. During high water level years the summer emptying was insignificant.

In order to estimate the level conditions of the Ruslovoye (Bed) reservoir, the operating hydrometric office of TMHU carries out their observations in water gauging station at the dam. The performance of this reservoir between October, 1991, to August, 1993, is shown in Table 1.2.

Filling and emptying of Tuyamuyun Hydro Unit basins is effected through the Ruslovoye (Bed) reservoir. Since the Ruslovoye (Bed) basin is interconnected through a canal with the Kaparas, the water levels in those basins are practically equal.

This canal was dammed in August 1991 to construct an adjustment unit thereon. A permanent low water level was set in Kaparas, where its value was at 116.2 m that corresponded to the volume of 280 mln m^3. However, in April 1993 this level went again down reaching the level of 115.7 m, thus, the volume of water has been reduced to 250 mln m^3.

Upon the completion of construction of the adjustment unit in the mid-September 1993, water from the Ruslovoye (Bed) reservoir started to be fed again into Kaparas. The losses of the head at passing through the adjustment unit do not exceed 10-15 cm, thus allowing to assume the water levels in the both water reservoirs to be equal. As a result, by the end of September, the level in Kaparas reached 121.04 m, equal to volume of 390 mln m^3, as reported in observation data of the water gauge station at the Ruslovoye (Bed) reservoir. By the end of September, the level raised to 123.33 m, and volume - to 600 mln m^3. By the end of November, the level came up to the level of 126.7 m, with the volume reaching 790 mln m^3.

The alluvial conditions of the TMHU reservoirs are characterized by the fact that river detritus entering the Ruslovoye (Bed) basin (Darganata section) at the affluent of levels, is settled down to the tail race also, and clarified water is fed into reservoirs.

For the years of the Hydro Unit operation, the losses of useful capacity due to silting of the Ruslovoye (Bed) reservoir, as per data of field observations, reached 565 mln m^3 by the October, 1989, whereas by the end of 1993, as per preliminary estimations, this figure reached about 850 mln m^3.

More exact estimation of silted volume of the Ruslovoye (Bed) water reservoir currently requires to undertake some special field observations and computations.

Table 1.2.

THU RUSLOVOYE (BED) RESERVOIROPERATING PERFORMANCE
FROM OCTOBER 1991 TO AUGUST 1993
(F. - Filling; E - Emptying)

Operating mode	Operation Cycle			Level, *m*		Amplitude of fluctuations, *m*	Intensity of Modification, *cm/day*		
	Start	Fin.	Duration, days	At start	At Fin.		Avg.	Max.	Date
	date	date	days			m	cm/day	cm/day	Date
F	5-Oct-91	28-Dec-91	85	120.08	129.73	9.73	11.44	26	24-Dec-91
E	29-Dec-91	10-Jan-92	13	129.73	129.14	0.59	-4.54	11	9-Jan-92
F	11-Jan-92	17-Jan-92	7	129.14	129.62	0.48	6.85	13	14-Jan-92
E	18-Jan-92	29-Jan-92	12	129.62	129.23	0.39	-3.25	9	23-Jan-92
F	30-Jan-92	7-Feb-92	9	129.23	129.52	0.29	3.22	9	31-Jan-92
F	8-Feb-92	3-Apr-92	56	129.52	123.50	6.02	-10.20	30	15-Mar-92
E	4-Apr-92	9-Apr-92	6	123.50	124.11	0.61	10.16	23	6-Apr-92
F	10-Apr-92	14-Apr-92	5	124.11	123.80	0.31	-6.20	13	2-Apr-92
E	15-Apr-92	9-May-92	25	123.80	127.82	4.02	16.75	56	24-Apr-92
F	10-May-92	18-May-92	9	127.82	126.26	1.56	-17.33	35	15-May-92
F	19-May-92	27-May-92	9	126.26	128.77	2.51	27.89	49	24-May-92
E	28-May-92	9-Jun-92	13	123.77	126.40	2.37	-18.23	38	6-Jun-92
F	10-Jun-92	23-Jun-92	14	126.40	128.94	2.54	18.14	37	17-Jun-92
E	24-Jun-92	15-Jul-92	22	128.94	123.18	5.76	-26.18	56	13-Jul-92
F	16-Jul-92	6-Aug-92	22	123.18	128.22	5.04	22.91	49	23-Jul-92
F	7-Aug-92	2-Sep-92	27	128.22	118.55	9.67	-35.81	94	18-Aug-92
E	3-Sep-92	15-Sep-92	13	118.55	119.35	0.80	6.15	45	4-Sep-92
F	16-Sep-92	18-Sep-92	3	119.35	115.40	3.95	-131.66	180	17-Sep-92
E	19-Sep-92	22-Sep-92	4	115.40	119.48	4.08	-102.00	119	20-Sep-92
F	23-Sep-92	29-Sep-92	7	119.48	116.00	3.48	-49.71	155	27-Sep-92
F	1-Oct-92	31-Oct-92	31	116.63	126.60	9.87	32.80	204	4-Oct-92
E	17-Nov-92	28-Nov-92	12	126.42	125.62	0.86	-7.80	16	26-Nov-92
F	30-Nov-92	29-Jan-93	61	125.62	129.67	4.05	13.00	15	29-Dec-92
E	29-Jan-93	26-Feb-93	29	129.67	129.16	0.51	-1.80	10	21-Feb-93
E	26-Feb-93	13-Apr-93	47	129.16	122.63	6.53	-14.20	35	9-Apr-93
F	13-Apr-93	17-May-93	35	122.63	128.76	6.13	17.40	40	15-May-93
E	17-May-93	30-May-93	14	128.76	126.92	2.84	-21.80	66	26-May-93
F	30-May-93	6-Jun-93	8	125.92	127.73	1.81	26.00	53	2-Jun-93
F	6-Jun-93	16-Jun-93	11	127.73	129.91	2.82	-28.20	45	9-Jun-93

Operating mode	Operation Cycle			Level, *m*		Amplitude of fluctuations, *m*	Intensity of Modification, *cm/day*		
	Start	Fin.	Duration, days	At start	At Fin.		Avg.	Max.	Date
	date	date	days			m	cm/day	cm/day	Date
E	19-Jun-93	29-Jun-93	11	125.15	121.53	3.62	-36.20	72	26-Jun-93
F	29-Jun-93	4-Jul-93	6	121.53	123.21	1.68	33.60	45	3-Jul-93
E	5-Jul-93	15-Jul-93	11	123.21	122.55	0.66	-6.60	21	14-Jul-96
F	15-Jul-93	20-Jul-93	6	122.55	124.17	1.62	32.40	49	19-Jul-93
E	20-Jul-93	28-Jul-93	9	124.17	119.93	4.24	-53.00	75	22-Jul-96
F	28-Jul-93	1-Aug-93	5	119.93	122.51	2.58	64.50	106	30-Jul-93
E	1-Aug-93	2-Aug-93	2	122.51	116.71	5.80	-58.00	106	9-Aug-96
F	2-Aug-93	13-Aug-93	12	116.71	118.16	1.45	72.50	74	13-Aug-93
E	13-Aug-93	16-Aug-93	4	118.16	116.49	1.67	-52.30	102	16-Aug-93
F	16-Aug-93	19-Aug-93	4	116.49	118.00	1.51	50.30	74	18-Aug-93
E	19-Aug-93	23-Aug-93	5	118.00	115.94	2.60	-51.50	72	22-Aug-93

Table 1.3.

AVERAGE MONTHLY WATER LEVELS OF RUSLOVOYE (BED) WATER RESERVOIR AND KAPARAS RESERVOIR

(Unit : m)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Ruslovoye Reservoir													
1985	130.0	128.6	122.4	120.7	120.9	119.9	118.4	120.3	124.2	128.1	128.7	128.0	124.2
1986	125.1	124.9	124.9	123.0	119.1	117.5	120.4	116.4	115.5	120.9	124.3	127.2	121.6
1987	129.4	129.5	125.3	125.2	125.3	126.1	125.9	125.9	129.2	129.7	129.4	129.1	127.5
1988	128.8	129.0	127.7	127.7	127.7	121.5	126.7	128.1	129.3	129.5	129.5	129.5	127.9
1989	129.6	129.1	125.7	125.7	123.2	123.6	117.7	116.4	117.6	121.3	123.9	126.3	123.3
1990	128.3	127.1	120.0	120.0	123.3	125.6	125.5	119.7	124.2	128.2	129.5	129.6	125.1
1991	129.6	128.5	120.5	120.5	121.4	127.2	126.4	120.5	118.2	121.5	126.3	127.6	124.0
1992	129.4	128.9	124.3	124.3	127.3	127.6	125.1	124.6	118.4	123.8	126.2	126.7	125.5
1993	128.8	129.3	123.9	123.9	127.1	125.2	122.5	117.9	118.9	122.9			124.0
1994	128.8	129.2	121.9	121.9	123.7	125.3	125.8	120.7	124.7	124.4	126.4	127.3	125.0
Kaparas Reservoir													
1985	129.8	128.6	122.4	120.6	120.8	119.7	118.5	120.3	124.1	128.0	129.6	128.0	124.2
1986	125.0	124.8	124.8	123.0	119.3	117.8	120.3	116.7	116.0	120.9	124.3	127.2	121.7
1987	129.4	129.5	125.3	125.2	125.3	126.2	125.9	125.9	129.2	129.8	129.4	129.1	127.5
1988	128.8	129.0	127.7	127.7	127.7	127.6	126.7	128.1	129.2	129.5	129.5	129.5	128.4
1989	129.6	129.1	125.9	125.6	123.2	123.6	117.7	116.5	117.6	121.3	123.8	126.3	123.4
1990	128.2	127.1	118.9	119.9	123.3	125.6	125.5	119.7	124.1	128.2	129.5	129.6	125.0
1991	129.5	128.4	124.5	120.5	121.4	127.2	126.4	116.2	116.2	116.2	116.2	116.2	121.6
1992	116.0	116.0	116.0	116.0	116.0	116.0	116.0	116.0	116.0	116.0	116.0	116.0	116.0
1993	116.0	116.0	116.0	115.7	115.7	115.7	115.7	115.7	121.0	123.3	126.7		118.0

Notes:

1. Data on water levels has been furnished on the basis of onservations carried out by the operating hydrometric office of TMHU

2. 1994 - as of the end of the mont

3. Since 09.1993 the water levels by the end of month in Kaparas reservoir

2. RUSLOVOYE (BED) RESERVOIR WATER QUALITY EVALUATION

2.1. Research technique

This work has been performed on the basis of generalization and systematization of materials gained in the result of hydrochemical observations undertaken by Department of Hydrometeorological service of the republics of Uzbekistan and Turkmenistan in the Amudarya river (sections: Termez, Kerki, Darganata, Tuyamuyun) during the period of 1986-1991, as well as per data of field observations (Darganata, Lebap sections) and also Ruslovoye (Bed) and Kaparas water reservoirs, during the period of 1982-1993 by salt composition, and during 1987-1993 by the rated indices of the water quality to be used for domestic and drinking purposes.

The samples of water to estimate the mineralization and major ions were taken from the specified sections and observation points located throughout the water area of reservoirs, while sampling for analysis of all other indices was performed seasonally.

Hydrobiological, microbiological and radiological studies included the estimation of the following indices:

- percentage of phyto- and zooplankton, and benthos;
- total quantity of microorganisms;
- quantity of saprophytic group bacteria;
- quantity of *Escherichia coli* group bacteria
- gamma-radiation background;
- specific beta-activity.

The water quality estimation as to drinking and domestic purposes has been developed to meet the requirements of appropriate standard and regulative codes (i.e. GOST [USSR Standard] 2874-82 "Drinking Water", and SanPiN [Sanitary Rules and Codes] # 4630-88).

2.2. Hydrochemical Conditions

The Ruslovoye (Bed) Reservoir' hydrochemical conditions materially differ from same in river water. The Amudarya river water, being fed to the reservoir, gets mixed with water. With this effect the physico-chemical composition changes, where the extent of changes is usually inadequate at different sections and depth of water area.

The analysis of physico-chemical indices of water property (e.g. hydrogen index [pH], dissolved oxygen, odour, taste, color index and turbidity) showed the following:

Both in the Amudarya river (Lebap section) and in water reservoir, the medium of water used to change during studies from neutral to alkaline. The hydrogen index ranged between 7.00 to 8.30, averaging to 7.80. The dissolved oxygen content never decreased lower than 5.4 mg/l and reached 13.7 mg/l. As a rule, in benthonic deep layers the concentration of dissolved oxygen was lower by 10-15 percent as compared to surface ones. In general, during the whole period of field observations the content of dissolved oxygen in water of the reservoir was substantial enough for development of hydrobionths.

During the whole period of researches neither a specific odour, nor the taste of water was identified. The color index of water was estimated in degrees. Its intensity was mainly connected with the presence of humic acids. The GOST requirements allow the color index to be maximum 20 degrees. The index did not exceed three-four degrees in the reservoir.

Water turbidity index was estimated by measuring the content of suspended substances of both organic and inorganic origin. The water turbidity in the reservoir decreased gradually from the inlet section and further to the dam.

The highest turbidity was noted in Lebap section where it ranged from 0.4 to 3.7 g/l. The water flow rate sharply decreased at the inlet to the reservoir. Sedimentation of suspended particles is noted, and water becomes more transparent. In the main part of reservoir the water turbidity was maximum 2.0 g/l, whereas at the dam it got down to 0.02 g/l. Due to this, water fed into the tail race of the reservoir and to the Kaparas reservoir is much more transparent and clarified.

Similarly, the water salt composition in the reservoir is not homogeneous at different sections. Dynamics of mineralization and general hardness of water is shown in Tables 2.1 and 2.2.

For the period of observations, the mineralization of water at the inlet of the reservoir (Lebap section) was fixed within the limits of 0.5 to 1.6 g/l. Peak values of water mineralization were registered in autumn-winter season, and minimum values were noted during summer period. The water mineralization starts to decrease in April-May and continues up to August. Then a sum of ions is again growing (Fig. 2.1.)

Table 2.1.

Mineralization of Ruslovoye (Bed) Reservoir Water

(Unit:g/l)

No.	Section	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
						1990							
1.	Lebap	0.9	1.0	1.5	1.1	0.7	0.8	0.7	0.7	0.8	0.9	1.2	1.0
2.	At the dam	0.9	0.9	1.2	1.1	0.8	0.8	0.7	0.8	0.9	0.9	1.0	1.1
						1991							
1.	Lebap	0.9	1.2	1.6	1.2	0.7	1.0	0.7	0.8	0.9	1.0	1.0	1.0
2.	At the dam	1.0	1.0	1.4	1.1	0.8	0.7	0.8	0.8	0.9	1.0	1.0	1.1
						1992							
1.	Lebap	0.9	1.1	1.4	1.2	0.8	0.7	0.5	0.6	0.8	0.9	1.2	1.1
2.	At the dam	0.9	0.9	1.3	1.6	1.2	0.7	0.6	0.5	0.7	0.8	1.0	1.1
						1993							
1.	Lebap	1.2	1.3	1.6	1.6	1.3	0.7	0.8	0.8	0.8	0.9	1.1	-
2.	At the dam	1.2	1.2	1.3	1.6	1.2	0.7	0.8	0.8	0.9	0.9	1.0	-

Table 2.2.

Total Hardness of Ruslovoye (Bed) Reservoir Water

(Unit:meq/l)

No.	Section	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
						1990							
1.	Lebap	7.7	9.1	14.0	10.3	8.0	7.6	6.8	7.0	8.0	8.1	10.5	9.1
2.	At the dam	7.7	9.1	11.5	10.7	6.6	7.3	6.6	7.0	8.6	8.5	9.5	9.1
						1991							
1.	Lebap	8.0	10.5	13.8	9.5	6.7	5.2	5.6	7.0	7.2	8.4	8.4	8.4
2.	At the dam	8.4	8.4	9.8	8.5	7.4	5.9	6.0	7.4	7.2	8.3	8.4	8.4
						1992							
1.	Lebap	7.7	9.8	12.6	9.1	7.0	6.3	7.0	9.1	9.8	7.7	9.1	8.4
2.	At the dam	7.7	9.1	10.3	12.2	8.7	6.3	5.4	4.8	6.3	7.7	9.1	8.4
						1993							
1.	Lebap	10.5	11.2	11.2	11.9	7.0	5.6	7.0	6.3	7.0	-	-	-
2.	At the dam	9.1	10.5	11.5	13.5	6.8	6.2	7.4	6.7	7.4	-	8.0	-

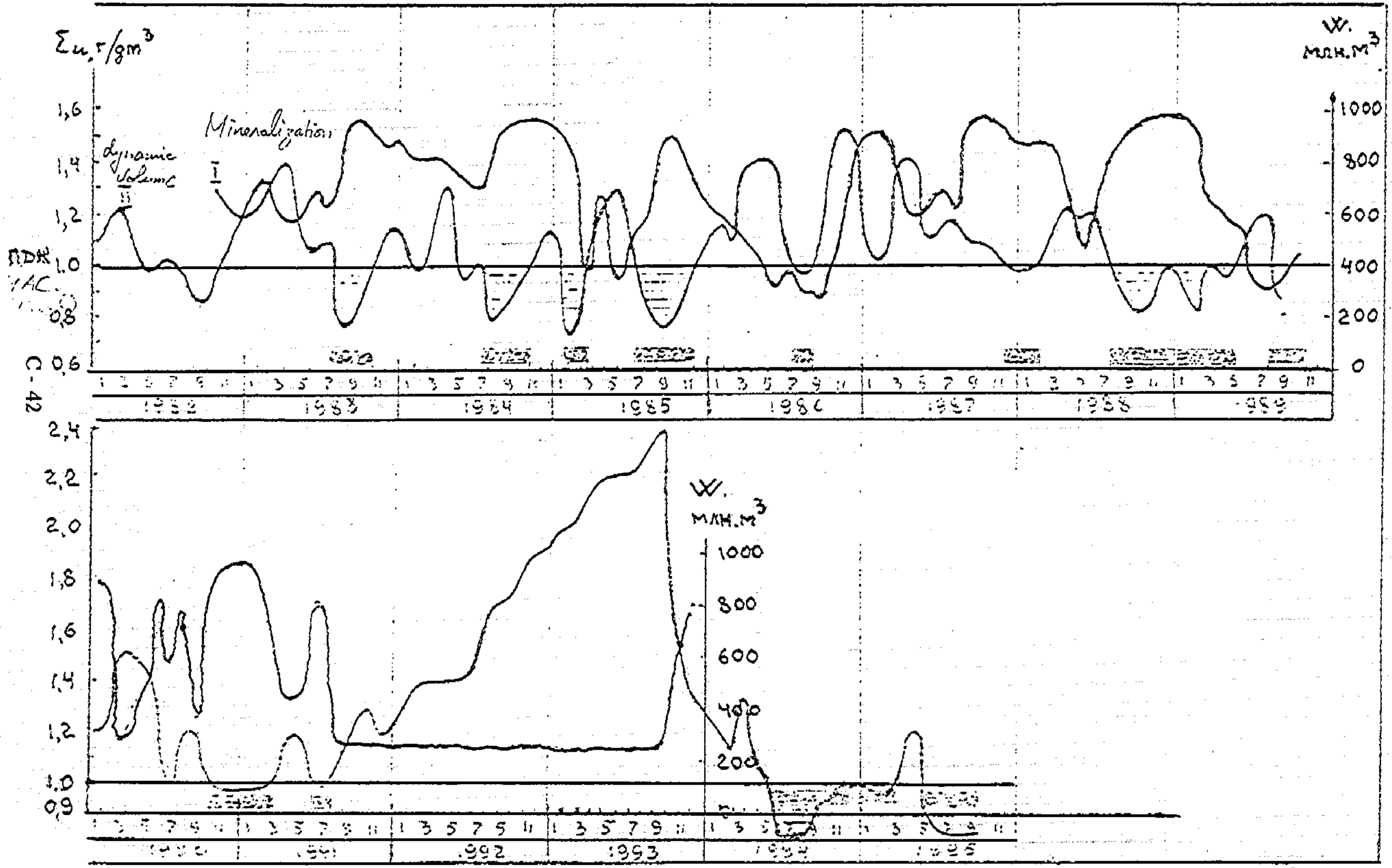

Рис. 2.1 Динамика объемов (II) и минерализации воды (I) Капарасского водохранилища

dynamic volume II and mineralization

Total water hardness in Lebap section was high enough (meq/l): in 1990 it was ranging from 6.8 to 14.0, in 1991 - from 5.6 to 13.8; in 1992 - from 6.3 to 12.6; and in 1993 - from 5.6 to 11.9.

Water mineralization at the reservoir dam, for the years of studies, was ranging from 0.5 to 1.6 g/l, while the total hardness - from 4.8 to 13.5 meq/l. The dynamics of such indices sometimes differs from same at the main part of the reservoir, where the main difference is in time of decrease and growth of major ions and sums thereof (Fig. 2.1.)

Synchronized dependence exists between water mineralization and major ions. The concentration of sulphate ions has a prevailing significance in the mineralization composition. Their number in the Ruslovoye (Bed) reservoir at different section ranged between 0.15 to 0.60 g/l.

The concentration of chloride ions is by 20-50% less than the sulphate ions. The same is true in respect to summarized ions of sodium and potassium. The concentration of hydrocarbonate ions ranged between 0.11 to 0.20 g/l.

The following biogenic elements were subject to analysis: nitrogen compounds, iron and silicon; whereas the organic substances have been estimated by the following indices: BOD_{tot} and COD (Table 2.3.).

The concentration of nitric compounds in the reservoir is not high. Nitrogen of ammonium was limited to 0-0.21 mg/l; nitrogen of nitrites - from 0 to 0.081 mg/l; nitrogen of nitrates - from 0.15 to 3.80 mg/l. The iron content was not higher that 0.12 mg/l; while that of silicon - 7.4 mg/l.

The content of organic substances was much greater in the reservoir water, both easily and hard oxidizing. The BOD_{tot} concentration ranged from 0.30 to 4.83 mg/l, that of COD - between 1.7 to 30.2 mg/l.

Among the pollutants such substances as phenols, oil products, specific surfactants and pesticides, and also heavy metals were subjected to analysis (Table 2.4).

The MAC excess has been applicable to phenols in the major part of all pollutants, where the concentration of phenols reached 0.007 mg/l. The quantity of specific surfactants did not exceed 0.07 mg/l, while in some periods those were not detected.

From time to time the following were identified: rogor, carbophose and buthyphose; no signs of chlororganic pesticides, like DDT or analogues and methaphos were noted.

Table 2.3.

Minimum and Maximum Concentration of Biogenic Elements and Indices of Organic Substances in Ruslovoye (Bed) Reservoir

(Unit:mg/l)

Year	$N\text{-}NH_4^+$	$N\text{-}NO_2^-$	$N\text{-}NO_3^-$	BOD_{tot}	COD	Fe	Si
Lebap Section							
1990	0.01 - 0.15	0.004 - 0.046	0.37 - 3.80	1.78 - 3.40	10.0 - 18.5	0 - 0.12	2.7 - 6.7
1991	0 - 0.11	0.007 - 0.017	0.15 - 0.48	1.62 - 4.65	5.7 - 14.9	0 - 0.24	4.2 - 7.4
At the dam							
1990	0.01 - 0.20	0 - 0.046	0.80 - 3.90	1.62 - 3.14	10.0 - 18.5	0 - 0.09	4.0 - 6.7
1991	0 - 0.16	0.001 - 0.072	0.15 - 0.25	1.85 - 2.90	6.1 - 14.8	0.03 - 0.10	5.2 - 6.5
1992	0.01 - 0.21	0 - 0.081	0.17 - 1.02	0.30 - 4.83	1.7 - 24.3	0 - 0.04	2.7 - 4.7
1993	0.01 - 0.05	0.006 - 0.033	0.30 - 1.25	1.50 - 4.51	14.0 - 30.2	0.01 - 0.03	-

Table 2.4.

Maximum Concentration of Specific Pollutants
in Ruslovoye (Bed) Reservoir

Year	Spec. Pollutants mg/l	Phenols mg/l	Pesticides, µg/l			Oil products mg/l	Heavy metals, µg/l							
			α-HCCP	γ-HCCP	Rogor		Cu (copper)	Zn (zinc)	Cr (Chromium)	Mo (Molibdenum)	Pb (led)	Ni (Nickel)	Al (Aluminium)	Hg (Mercury)
	(0.5)	(0.001)	(0.02)	(0.004)	(0.03)	(0.3)	(1.0)	(1.0)	(0.5)	(0.25)	(0.03)	(0.1)	(0.5)	(0.00005)
Lebap Section														
1990	0.000 0.600	0.000 0.006	0.000 0.040	0.000 0.034	0.000 33.600	0.010 0.020	0.000 12.500	0.000 13.600	0.000 1.600	- -	0.000 41.000	- -	- -	0.000 0.020
1991	0.000 0.040	0.000 0.007	0.004 0.062	0.000 0.020	0.000 0.000	0.005 0.150	0.000 8.000	5.000 12.000	0.000 0.000	0.000 31.000	0.000 27.000	- -	- -	0.000 0.320
At the dam														
1990	0.000 0.070	0.000 0.005	0.000 0.081	0.000 0.041	0.000 18.300	0.000 0.030	1.400 10.000	0.000 8.300	0.000 2.200	- -	0.007 12.000	- -	- -	- -
1991	0.000 0.030	0.000 0.003	0.000 0.024	0.000 0.012	0.000 0.000	0.005 0.040	0.000 26.000	2.000 8.400	0.000 0.000	6.000 21.000	0.000 0.000	8.000 15.000	5.000 27.000	0.000 0.300
1992	0.000 0.010	0.000 0.007	0.000 0.056	0.000 0.050	0.000 0.000	0.000 0.050	0.000 5.000	3.000 15.000	- -	- -	- -	- -	- -	- -
1993	0.010 0.030	0.001 0.004	0.000 0.026	0.000 0.020	0.000 0.000	0.006 0.050	1.000 4.000	0.000 3.000	0.000 0.000	- -	- -	- -	- -	0.000 0.000

Note: 1. No chlororganic pesticides or methathose were not detected.

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At the same time alfa- and gamma hexochlorcyclopenthanes have been systematically detected. However, their concentration was some ten-thousands fractions of mg/l.

The concentration of oil products was also minor and ranged between 0 and 0.15 mg/l.

Copper and zinc (up to 15 μg/l) made the major part of the heavy metals. Individual samples taken during 1990-91 showed that the reservoir water contained such heavy metals as chromium (up to 2.2 μg/l), molybdenum (up to 31 μg/l), led (up to 41 μg/l), nickel (up to 15 μg/l), aluminium (up to 27 μg/l) and mercury (up to 0.30 μg/l).

It is worth to note that observation of the content of biogenic elements, organic and pollutants in the Ruslovoye (Bed) water reservoir showed that this reservoir plays a role of natural settling basin, and due to the effect of various factors such as solar radiation, mixing of water masses, high concentration of dissolved oxygen, sedimentation of suspended particles, a rather active self-cleaning occurs there which facilitates the improvement of water quality.

Observation of the hydrochemical behaviour of the reservoir tail race showed that the essence of water quality indices here differs from the same in the reservoir section at the dam by some ±5-10%.

2.3. Hydrobiological and bacteriological conditions

The Ruslovoye (Bed) water reservoir was studied in the upper part and at-the-dam reach. Totally, 9 water samples were taken and 27 microbiological analyses were carried out, as well as 13 hydrobiological samples were analyzed (May, August, 1990, October, 1991).

The upper part of the reservoir was noted to have relatively high microbiological indices, namely: the total quantity of microorganisms reached 1.36-1.72 mln.cl/cm^3, the quantity of saprophite group of bacteria was ranging between 6.28-9.21 thous. cl/cm^3, *Escherichia coli* group bacteria (ECGB) - 13.5-20.0 cl/cm^3.

In the reservoir part near the dam, the water gets clearer due to sedimentation of suspended particles, and the quantity of microorganisms substantially decreases. Their total number in winter and autumn was ranging from 0.42 to 1.12 mln.cl/cm^3, the quantity of saprophite group of bacteria was ranging between 0.06-0.23 thous. cl/cm^3, and ECGB - 0.01-0.4 cl/cm^3.

Due to high water turbidity water vegetation is absent in the upper part of the reservoir. Phytocenosis is insigninficantly represented by periphython basically consisting of diatoma algae and other groups of phytoplancton are fully absent.

Zooplancton is represented by occasional forms of organisms carried to the river bed from the floodplain reservoirs. Mainly, these are cyclopes and diapthomia.

Sandy soils are practically liveless. The organisms of benthos can be met only at the banks with hard sandstones, hard clay and silted sands. Basically, they are algae of caddis flies which quantity did not exceed 30-40 pcs/m^3.

In the central part and at the dam of the reservoir the conditions for development of hydrobionths are more favorable. Here zooplancton is represented with 8 forms of microorganisms and reached the quantity of 2436 pcs/m^3 in spring and 152 pcs/m^3 in autumn. At the same time, when the reservoir is practically emptied and turbidity increases, zooplancton has been practically absent.

Therefore, the water quality analysis for micro- and hydrobiological indices allowed to make the following estimate. The upper part of the reservoir, during all seasons and for all of microbiological indices, the water is classified as moderately polluted, at the dam - as very clean in autumn and spring, and as moderately polluted - in summer, when the water level is sharply decreased.

2.4. Radiological situation

The estimation of radiological situation in the Ruslovoye (Bed) reservoir included the study of natural gamma-radiation background and specific betta-activity of bottom depositions.

Gamma-radiation background of the reservoir area was ranging between 10-15 mcr/hr, gamma-activity was about 12-15 mcr/hr, specific betta-activity of bottom depositions was about 6.2-6.4$\cdot 10^{-9}$ Curie/kg.

The results of analyses showed that all indices of radiological situation of the Ruslovoye (Bed) reservoir are lower to some magnitudes than the radiation permissible limits, therefore it shall be considered to be completely safe.

2.5. Water Quality Analysis at the Current Level

The analysis was made in order to determine seven indices of water quality in the Ruslovoye (Bed) reservoir which are referred to general sanitary LIH (Limiting Index of Hazardousness), 15 indices referred to organoleptic LIH, and 13 to 15 indices - to sanitary-toxicologic LIH. Thus, every sample of water was used to analyze the content of 35 to 38 indices of water quality.

The results showed that the major part of the water quality indices did not exceed the MAC for reservoirs of drinking and domestic water supply. These are: dissolved oxygen, zinc and pH related to general sanitary LIH; odour, taste, color index, methaphosis, carbophos, α-HCCP, rogor, iron and copper referred to organoleptic LIH, and all indices referred to sanitary-toxicological LIH.

The analysis of data collected showed that during different periods 8 indices of water quality were higher than the MAC requirements. Maximum mineralization excess by 1.5-1.6 times were noted during spring season, while during June to September, the water mineralization was lower than MAC going down to 0.5-0.7 values. The concentration of sulphate ions reached to and sometimes exceeded the MAC values in certain years in autumn and spring, going up to 1.2 value, while that of chloride ions - only in spring season. The rest of the year those values were ranging between 0.3 to 0.9.

During the whole year the water in the reservoir is substantially hard, with its total hardness (TH) being minimum 0.7 of the values allowed by MAC in summer time and maximum values (1.5-2.0) in spring season.

Concentration of phenols was rather high as well exceeding the MAC values by 7 values. However, in some months phenols were not detected, and in average, for the years of observations their excess over the MAC was ranging between 2.0 to 4.0 values.

In certain periods the excess over the MAC values was noted from a part of indices of organic substances: BOD_{tot} - up to 1.6 times and COD - by 2.0 times.

The water turbidity in the upper part of the reservoir as much higher than in the central part and at the dam. Therefore, the excess of the turbidity value over the MAC values reached to several hundreds and even thousands of values, while closer to the dam it went down to dozens and hundreds of values.

As a whole, it should be noted that the best water quality, from the viewpoint of chemical indices and bio-bacteriological situtation, was noted in the Ruslovoye (Bed) reservoir during June-July to August-September.

3. KARAKAS RESERVOIR WATER QUALITY EVALUATION

In order to arrange the Kaparas reservoir in the Karakas depression, as well as in other depressions to be further used to construct flooded water reservoirs of TMHU, the research works have been undertaken by the "Hydroproekt" R & D Institute to study the bottom situation of those depressions so that to estimate the depositions of salts therein.

Pursuant to surveys, rather substantial depositions of easily soluble salts have been identified to be present in bottoms of those depressions. Rather substantial areas coming up to the bottoms were formed with saline soils of various types and saline lakes consisting of the following formations:

⇒ stains of subcrust natural brine deep up to 0.10 m;

⇒ layer of novosadka [*salt deposited in a lake during one season*] up to 0.07 m of thickness;

⇒ thin interlayers of silt up to 0.04 of thickness;

⇒ loose salt-granatka [*sodium chloride*] mixed with dark grey silt (where silt content is about 5 to 25%) with a thickness ranging between 0.10 to 1.40 m;

⇒ deep-well dense crystallised salt, with a thickness of up to 12-13 m (Sultansandjar);

⇒ saline soil depositions ranging in thickness between 1.0-3.0 laying in-between the silt loan, which is upper layer and heavy loam with gypsum crystals below.

Bedrock is found below.

Easily soluble salts in deep-well deposits and novosadkas contained, mainly, 80 to 85% of hallite (NaCl) and about 6% of mirabilite ($Na_2SO_4 \cdot 10H_2O$), while in crusts of saline soils - up to 50% of hallite and thenardite (Na_2SO_4) - up to 20% as to absolutely dry substance.

3.1. Impact of salt deposits in the Kaparas basin on the salt composition of the reservoir.

The following were identified in the flooded basin of the Kaparas reservoir bed: deep-well salt on the area of 1.5 mln m^2, saline soils with the content of salts up to 20% on the area of 16.6 mln m^2, various salted lakes of the total area of 0.2 mln m^2, novosadkis of 0.1 m thickness and covering the area of 3.5 mln m^2.

Basing on the data collected by Hydroproekt for salt stock in TMHU depressions, we have estimated more precisely that the salt stock in the Kaparas basin which was found to be 8.7 mln tons (including the upper loose layer of deep-well depositions, novosadka, natural brine and salt in grounds of 2 m thickness).

Observations by Hydroproekt allowed to establish that there was a drainage of ground waters occurring in the basin of all depressions which was mainly due to the infiltration of the Amudarya river water. In the meantime it was noted that during spring and summer season the sources were with greater abundance of water, while in autumn their flow rate used to decrease. It was also established that the aggregate flow rate of sources in Kaparas was 1.65 l/sec ($5.2 \cdot 10^4$ m^3/year) with weighted average mineralization equalling to 9.1 kg/m^3. These sources brought in to the depression as much as 473 tons of salts annually.

In June of 1981 they started to fill in the Kaparas reservoir via a watercourse connecting the said reservoir with the Ruslovoye (Bed) water reservoir. Emptying was also effected through the same watercourse.

Observations for water mineralization dynamics carried out during the initial period of the Kaparas reservoir existence showed that 920.000 tons of salts were dissolved during the first round of filling, and leaching of salts in the bed was observed to be the most intensive during the first years of its operations, with the peak value reaching 25 thousand tons. During the last years (1988-1993) the intensity of salt leaching has been materially reduced, with the average rate of 8.000 tons per month. By the end of 1993 the stock of potentially soluble salts in the reservoir decreased by 30% according to the preliminary estimations. It should be noted that a part of soluble salt is filtered through the bottom and side walls of the reservoir basin.

The dynamics of volumes and water mineralization in the Kaparas water reservoir for the 12 year of its existence (1982-1993) is shown in Fig. 2.1

The whole period of the reservoir operation may be subdivided into three periods:

Ist - June, 1981 - August, 1991, - irrigation mode operation period;
IInd - August,1991-September, 1993, - period of isolation when the watercourse was dammed to construct a adjusting unit;
IIIrd - since September, 1993 and by now, - the rehabilitation period for water recirculation, when the construction was completed and water was fed again.

Prior to the Kaparas isolation period, the reservoir was filled six times up to the HBL [*Highest Back-up Level*] (130 m) or close to that: in 1983-1985, in 1987-88 and in 1990. During the years with low water the reservoir was emptied to the level of DVL [*Dead Volume Level*].

During the isolation period the volume of water in the reservoir was 280 mln m^3, while at the initial rehabilitation stage of water recirculation, i.e. from September to December 1993, the level in the water reservoir reached 126.7 by December, and the volume - up to 790 mln m^3.

Studies carried out during many years showed that the major factors influencing upon the dynamics of water mineralization in the Kaparas water reservoir were the operational performance of the reservoir itself (emptying, filling), mineralization and the composition of salts in the influx water coming from the Ruslovoye (Bed) water reservoir.

During the first year of operation, water mineralization in average for the reservoir was ranging between 0.7 to 1.55 g/l. Whereas, the sum of ions lower than 1.0 g/l was observed from July-August to September-October during the period of 1982 to 1988 (except for 1986-1987). Besides, in 1985 and 1989, the value of water mineralization lower than 1.0 g/l was detected during the winter season. Since 1989 and up to August, 1991, the sum of ions lower than 1.0 g/l was noted to take place from March to May and in August-September, 1989, while it never reduced to lower values during other periods, at certain periods reaching 1.2-1.5 g/l.

During the second period, i.e. the period of isolation, water mineralization has been gradually increasing, and by January, 1992, reached 1.3 g/l, by June - 1.4 g/l, by July - 1.5 g/l; by September - 1.7 g/l; by October - 1.8 g/l; and by December -1.9 g/l. In January, 1993, the sum of ions increased up to 2.0 g/l and continued to raise up to September when it reached 2,4 g/l.

Thus, during the isolation period mineralization of water increased to 2.2 times, accompanied by a certain metamorphozation of ionic-salt composition of water related with migration properties of individual ions and biochemical processes occurring in the reservoir.

The increase in water mineralization during the period between August, 1991, to May, 1993 was caused due to increase in the number of all the ions, excluding hydrocarbonate ions. Then, during the summer period of 1993 the process of ion-salt composition metamorphization was noted to become more and more stable. With the further growth of water mineralization, the quantitative ratio of ions was noted to start re-distributing. The quantity of Ca^{2+} ions decreased by 25% during the period from May to September, that of magnesium - by 37%, sulphates - by 10%. In the meantime, the quantity of sodium and chlorine increased by 43% and 27%, respectively, while the content of hydrocarbonate ions increased negligibly. The water chemical composition changed as well, where, being a sulphate-sodium type before the isolation period, by end thereof it became the chloride-sodium type.

During the isolation period in Kaparas (26 months), water mineralization increased by 1.3 g/l, i.e. the average monthly growth rate was 0.05 g/l. Calculations made for salt increments showed that during 26 months the total quantity of salts increased by 280.000 tons, wherefrom: 80.000 tons - due to evaporation and filtration of highly mineralised water from the side walls of the reservoir, and 200.000 tons - by means of salt leached from the reservoir bed.

During the third period, i.e. the period of water exchangeability rehabilitation, when water delivery from the Ruslovoye (Bed) reservoir was again restarted, water mineralization in Kaparas began to slow down, since the sum of ions in water delivered was about 0.7-0.8 g/l. Under such situation, the volume of water in Kaparas grew to more than 3 times by December, while the water mineralization decreased almost twice and was about 1.3 g/l (Table 3.1).

Change of mineralization values can be explained by the content of basic ions and, first of all, sulphate and chloride ions which are classified as "Drinking Water" pursuant to GOST.

During the first period of the water reservoir existence the concentration of sulphate ions was ranging between 0.32 and 0.49 g/l. During the isolation period their content increased reaching 0.84 g/l, then by December 1993 - reduced to 0.47 g/l. Same dynamics was noted in respect to chloride ions. Their concentration did not exceed 0.39 g/l during the first period, and then, during the isolation period it increased to 0.69 g/l. After filling the reservoir by December, 1993, it went down to 0.37 g/l.

The total water hardness was always high enough (6.3-10.7 meq/l), and reached 17.0 meq/l during the isolation period, and thereafter, by December, 1993, it dropped down to 11.9 meq/l.

Thus, disturbance of the Kaparas reservoir operation mode caused by suspension of water exchange with the Ruslovoye (Bed) reservoir during the period of August, 1991, to October, 1993, resulted in severe deterioration of the water quality in this reservoir as to its salt compositions. However, in 1994-95 the water mineralization dynamics was rehabilitated reaching the previous level (as before 1991).

Table 3.1

Average Multi-Year Dynamics of Mineralization , Sulphate, Chloride Ions and Total Hardness of Kaparas Reservoir

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mineralization, g/l												
1990	1.2	1.2	1.5	1.5	1.4	1.2	1.0	1.2	1.2	1.0	1.0	1.0
1991	1.0	1.0	1.0	1.2	1.2	1.0	1.0	1.1	1.2	1.3	1.2	1.2
1992	1.3	1.4	1.4	1.4	1.4	1.4	1.5	1.7	1.7	1.8	1.9	1.9
1993	2.0	2.0	2.1	2.2	2.2	2.2	2.2	2.3	2.4	1.9	1.4	1.3
Sulphate ions, g/l												
1990	0.40	0.46	0.49	0.48	0.45	0.40	0.35	0.45	0.48	0.36	0.38	0.37
1991	0.35	0.36	0.31	0.38	0.36	0.32	0.33	0.40	0.37	0.37	0.37	0.42
1992	0.39	0.41	0.40	0.44	0.44	0.46	0.51	0.53	0.55	0.59	0.62	0.65
1993	0.68	0.79	0.73	0.84	0.84	0.82	0.81	0.78	0.76	0.71	0.66	0.47*
Chloride ions, g/l												
1990	0.23	0.22	0.39	0.38	0.35	0.26	0.25	0.29	0.28	0.21	0.23	0.22
1991	0.21	0.25	0.26	0.27	0.21	0.20	0.22	0.26	0.29	0.34	0.31	0.32
1992	0.32	0.36	0.38	0.36	0.38	0.38	0.38	0.40	0.42	0.43	0.32	0.52
1993	0.52	0.52	0.53	0.54	0.55	0.55	0.57	0.60	0.69	0.52	0.50	0.37*
Total hardness, meq/l												
1990	8.2	8.4	12.0	11.2	9.2	8.8	7.6	9.2	8.6	9.0	7.8	6.9
1991	8.3	9.0	10.7	8.3	9.3	7.7	8.3	8.4	8.8	9.4	9.8	9.2
1992	8.4	9.1	9.3	9.4	9.9	10.0	10.1	10.3	10.8	12.5	14.7	14.6
1993	15.6	16.0	16.4	17.0	17.1	16.1	15.3	13.5	11.9	13.2	14.6	11.9*

Note: * - data of the late November - early December

3.2. Performance of Hydrochemical Indices and Water Quality Evaluation

The previous Chapter was devoted to description of results of studying the Kaparas reservoir water quality as to mineralization and basic ions - sulfate and chloride - contained in the composition of rated indicators, as well as to dynamics of the total water hardness. Table 3.2 presents the values for the calculations of A/MAC [*Average Annual/Maximum Permissible Concentration*] for the period of four years, namely, 1990-1993, showing changes of water quality during a year as to it salt compositions in respect to the requirements of GOST for drinking and domestic water.

As it has been already noted above, prior to 1990, the water mineralization in Kaparas did not exceed the MAC values during summer season, and during some years - even in spring season. Since 1990 to 1993, the sum of ions in average for the reservoir was ranging from 1.0 to 2.4 of the MAC values. After the filling of Kaparas started again, the mineralization MAC values began decreasing reaching 1.3 by December of 1993, and 0.8 g/l by July-August of 1994.

Estimations of A/MAC for the other indicators of water quality (about 35 to 37 indicators on each sample were analyzed) allowed to elaborate the following conclusion.

For all the years of observations in the Kaparas water reservoir, the MAC values were overrun over by eight indicators of water quality. Part of those is referred to the general sanitary LIH (mineralization, total hardness, BOD_{tot}, COD), while the other part - to organoleptic LIH (sulfate and chloride ions, phenols and turbidity). Neither of sanitary-toxicological indicators exceeded the MAC values (Rf. Tables 3.3; 3.4).

With the abovesaid in view, values of A/MAC of the eight indices noted, at least, once to exceed the MAC values are shown in the Table 2.3. As it is seen from this Table, the sulfate ions were noted to start exceeding the MAC values since July 1992 only, while the chloride ions - since March, 1992. The total water hardness during all the years was reaching to, or exceeding the MAC values, with the peak excess of 2.4 times at maximum. The MAC values of phenols have been also noted to exceed the rated values by 6 times maximum, excluding March and August, 1992, when those were not detected. The excess of MAC for organic substances, during certain periods, was to 1.6 times for BOD_{tot}, and for COD -2.4 times.

Clarified water incoming from the Ruslovoye (Bed) reservoir to Kaparas resulted in the fact that the turbidity in the basin did not have significant values. However, as per GOST requirements in respect to the turbidity, the water in Kaparas was still higher than the MAC values reaching 20-45 values in certain months (MAC rated value is 1.5 mg/l).

Thus, the analysis of dynamics of the water quality indicators studied which are referred to various LIH showed that during the period of field observations the Kaparas reservoir water did not have any specific odour or taste. Its colour index was not more than 3-4 points (the MAC rated value is 20 points). The dissolved oxygen concentration never decreased lower than 7.0 mg/l (whereas the minimum MAC value is 4.0 mg/l), and was quite favorable for vital activity of hydrobionths.

The water medium was ranging from weak-alkaline to alkaline: pH ranged between 7.2 to 8.3 whereas the rated value is between 6.5 and 8.5.

While comparing the content of water quality indicators in the Ruslovoye (Bed) reservoir, in its main part with that of the Kaparas reservoir, it becomes clear that due to self-cleaning property of the said reservoirs, the concentration of biogenic elements, organic substance and pesticides in the Kaparas reservoir reduces by 25-40%, or more, in average, and the turbidity - by 1.5-2 magnitudes.

The major hydrochemical indicators exceeding the MAC values during the summer period and needed to be purified are the total hardness, phenols, COD and turbidity.

Currently there are certain economically acceptable techniques of water purification to remove the abovesaid indicators. Thus, for instance, the water turbidity (suspended particles) may be cleaned by means of horizontal settlers. The total hardness can be reduced by means of chemical reagent method which is widely used. The method is to add the lime ($Ca(OH)_2$) in water. This admixture results in transforming both calcium and magnesium bicarbonates into hard soluble compounds (i.e. calcium carbonate and magnesium hydroxide) which are removed after settling and filtration.

It is worth to note that softening of water facilitate the reduction of mineralization down by 15-25%.

Phenols are removed by chlorinating in combination with ammonization. This method prevents the formation of chlorphenols, since the chlorine is first reacting with the ammonia with the resultant chloramines produced and thereafter the latter reacts with phenol. This method allows to reduce the content of phenols down to 6 MAC at the absence of chlorphenol odour.

Average /MAC Ratio of Kaparas Reservoir (Weighted Average for the Reservoir)

No.	Water Quality Index	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	1990												
1.	Σ_n(Mineralization)	1.2	1.2	1.5	1.5	1.4	1.2	1.0	1.2	1.2	1.0	1.0	1.0
2.	SO_4^{2-}	0.6	0.6	0.9	0.8	0.5	0.5	0.5	0.5	0.6	0.6	0.9	0.8
3.	Cl^-	0.5	0.5	0.6	0.4	0.3	0.3	0.3	0.3	0.5	0.5	0.7	0.6
4.	Total Hardness	1.1	1.3	2.0	1.5	1.1	1.1	1.0	1.0	1.1	1.1	1.4	1.3
5.	Phenols	-	-	4.0	3.0	4.0	1.0	1.0	1.0	-	-	-	-
6.	BOD_{tot}	-	-	0.4	-	0.5	-	0.4	0.4	-	-	-	-
7.	COD	-	-	1.0	1.1	1.1	1.1	0.8	0.8	-	-	-	-
8.	Turbidity	-	-	-	-	1.0	1.7	1.0	1.0	-	-	-	-
	1991												
1.	Σ_n(Mineralization)	1.0	1.0	1.0	1.2	1.2	1.0	1.0	1.1	1.2	1.3	1.2	1.2
2.	SO_4^{2-}	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.8	0.7	0.7	0.7	0.8
3.	Cl^-	0.6	0.7	0.7	0.8	0.8	0.6	0.6	0.7	0.8	1.0	0.9	0.9
4.	Total Hardness	1.2	1.3	1.5	1.2	1.3	1.1	1.2	1.2	1.2	1.3	1.4	1.3
5.	Phenols	-	-	-	3.0	-	2.0	-	-	2.0	2.0	-	-
6.	BOD_{tot}	-	-	-	0.9	-	1.1	-	-	0.8	-	-	-
7.	COD	-	-	-	1.0	-	1.1	-	-	0.8	1.4	-	-
8.	Turbidity	-	-	-	45.0	-	37.0	-	-	21.0	16.0	-	-

Table 3.2 *Contd*

No.	Water Quality Index	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	1992												
1.	Σ_n(Mineralization)	1.3	1.4	1.4	1.4	1.4	1.4	1.5	1.7	1.7	1.8	1.9	1.9
2.	SO_4^{2-}	0.8	0.8	0.8	0.9	0.9	0.9	1.1	1.1	1.2	1.2	1.2	1.3
3.	Cl^-	0.9	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	0.9	1.5
4.	Total Hardness	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.8	2.1	2.1
5.	Phenols	-	-	0	4.0	1.0	-	6.0	0	1.0	-	-	-
6.	BOD_{tot}	-	-	1.2	0.9	0.2	-	0.3	0.5	0.3	-	-	-
7.	COD	-	-	1.7	2.4	1.6	-	1.3	1.3	1.8	-	-	-
8.	Turbidity	-	-	4.8	13	15	-	25	3	4	-	-	-
	1993												
1.	Σ_n(Mineralization)	2.0	2.0	2.1	2.2	2.2	2.2	2.2	2.3	2.4	1.9	1.4	1.3
2.	SO_4^{2-}	1.4	1.4	1.5	1.7	1.7	1.6	1.6	1.6	1.5	1.4	1.3	0.9
3.	Cl^-	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.7	1.9	1.5	1.4	1.0
4.	Total Hardness	2.2	2.3	2.3	2.4	2.4	2.3	2.2	1.9	1.7	1.9	2.1	1.7
5.	Phenols	-	-	-	1.0	-	-	3	-	-	-	-	-
6.	BOD_{tot}	-	-	-	1.2	-	-	1.6	-	1.1	-	-	-
7.	COD	-	-	-	1.3	-	-	1.0	-	1.4	-	-	-

Maximum Concentration of Biogenic Elements
and Organic Substance Indicators
in Kaparas Reservoir Water

(Unit:mg/l)

Year	$N\text{-}NH_4^+$	$N\text{-}NO_2^-$	$N\text{-}NO_3^-$	BOD_{tot}	COD	Fe	Si
1990	0.010	0.005	0.110	0.660	12.600	0.010	2.400
	0.080	0.023	1.420	1.450	17.200	0.040	5.300
1991	0.000	0.002	0.160	1.560	6.300	0.000	2.300
	0.050	0.090	0.430	3.900	21.200	0.100	5.800
1992	0.010	0.000	0.020	0.720	3.500	0.010	2.600
	0.150	0.050	0.520	4.000	39.500	0.030	5.800
1993	0.020	0.003	0.000	2.200	11.600	0.010	-
	0.370	0.028	0.970	5.720	26.300	0.120	-
MAC for above indicators							
	2.0	1.0	10.0	3.0	15.0	0.3	10.0

Table 3.4

Maximum Concentration of Specific Pollutants in Kaparas Reservoir

Year	Spec. Pollutants mg/l	Phenols mg/l	Pesticides, µg/l			Oil products mg/l	Heavy metals, µg/l							
			α-HCCP	γ-HCCP	Rogor		Cu (copper)	Zn (zinc)	Cr (Chromium)	Mo (Molibdenum)	Pb (led)	Ni (Nickel)	Al (Aluminium)	Hg (Mercury)
	(0.5)	(0.001)	(0.02)	(0.004)	(0.03)	(0.3)	(1.0)	(1.0)	(0.5)	(0.25)	(0.03)	(0.1)	(0.5)	(0.00005)
1990	0.000	0.001	0.000	0.000	0.000	0.010	2.000	1.000	0.000	-	2.000	-	-	0.000
	0.110	0.001	0.060	0.030	0.015	0.030	8.000	15.000	0.400	-	15.000	-	-	0.020
1991	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.020	0.006	0.038	0.024	0.000	0.060	15.000	8.000	6.000	12.000	0.000	26.000	3.600	0.360
1992	0.000	0.000	0.003	0.000	0.000	0.000	0.000	3.000	0.000	0.000	3.000	1.000	-	0.000
	0.020	0.004	0.045	0.700	0.000	0.040	5.000	9.000	0.000	0.000	6.000	1.000		0.000
1993	0.010	0.000	0.000	0.000	0.000	0.000	5.000	1.000	-	-	1.000	0.000	-	0.000
	0.040	0.004	0.006	0.004	0.000	0.220	14.000	3.000	-	-	5.000	2.000	-	0.200
MAC for the above indicators														
	0.500	0.001	20.000	4.000	30.000	0.300	1.000.000	1.000.000	50.000	250.000	30.000	100.000	500.000	0.500

Note: numerator - minimal, denominator - maximal for reservoir

Organic substances (BOD & COD) included to the composition of suspended substances are removed by means of coagulants (Fe_2O_4) and flocculants (polyacrilamide) with the subsequent filtration. As a summary, let us note that issues related to the preparation of water by methods of reducing the concentrations of certain hydrochemical indicators of the water quality require for a special consideration that have not been planned to in this report. At the same time, such technical and operational measures shall be envisaged that allowed to keep the water mineralization at the level of 1.0 g/l per yearly cycle.

3.3 Biological and Bacteriological Conditions and Radiological Situation of Reservoir

The Kaparas reservoir water quality performance by its micro-'and hydrobiological indicators is given on the basis of three field trips occurred in May, August and October of 1990-1991. Studies were carried out for three sections: at the upper part (Section 1), middle part (Section 2) and the lower end of the reservoir (Section 3). Sampling of water in each of the sections was performed from three levels - surface, middle part, and at the bottom. Totally 27 samples were taken and 81 microbiological analyses were completed.

The hydrobiological studies were carried out both in the above sections and for the entire area of the reservoir. Totally, 18 qualitative and 9 quantitative samples of plankton were taken and analysed.

Microbiological studies included: the determination of the total quantity of micro-organisms (direct counting), quantity of saprophyte group bacteria (method of serial culture at peptone agar-agar mixture [PAM]) and *Escherichia coli* group bacteria (membrane method).

Hydrobiological studies included qualitative and quantitative estimation of phyto- and zooplanctone.

The results of microbiological studies showed that the total quantity of microorganisms in the reservoir water reached its peak values of 0.7-0.99 mln.cl/cm^3 in summer time and minimum - in autumn: 0.16-0.44 mln.cl/cm^3. In the meantime, the quantity of microorganisms has been decreasing from the upper part to the lower part of the reservoir. Distribution of microorganisms along the vertical section of the water thickness was practically homogeneous on the entire aquifer of the reservoir.

Quantity of saprophyte bacteria was ranging: in spring time it was about 0.01 to 0.09 thous.cl/cm^3, in summer time - 0.18-0.89 thous.cl/cm^3 and in autumn - 0.01-0.04 thous.cl/cm^3. In summer period the saprophytes become more numerous when the thermal mode gets more favorable for development of this very group of bacteria. However, in general, the total quantity of saprophyte bacteria is not too high in the reservoir water. The explanation is in the fact that the concentration of organic substance was not very high, and such a situation seems to prevent their intensive culture development.

The quantity of *Escherichia coli* group bacteria was insignificant throughout all of the seasons in the entire water area of the reservoir reaching some 0.001-0.3 cl/cm3, the fact testifying to the absence of any fecal pollution sources in this region.

The zooplancton of the reservoir is mainly represented with 8 major forms of organisms. Both quantitywise and qualitywise, it becomes richest in autumn (2.3-25.2 thousand pcs/m^3), and less rich in spring - 0.068-10.9 thousand pcs/m^3.

The quantity of organisms was increasing while getting closer to the central stretch of water where it reached its peak values. Copepoda crayfishes were the dominating group of organisms throughout the whole year where in spring their quantity was 87-91% of the total quantity, in summer it decreased to 54-64%, and in autumn is raised up again to 74-91%.

Higher aqueous vegetation is practically absent. The phytocenosis is represented by agglomerates of blue-green algae forming bright green films at the bottom of shallow water part of the reservoir nearby the banks. The phytoplankton is mainly formed with diatoma algae, namely, diatoma, cerarium, asterionella and others. The total quantity of phytoplankton reached 29-94 thous. cl/l in spring season, in summer it was about 173-560 thous. cl/l, and in autumn - 132-316 thous. cl/l.

During the summer period of 1991, when the Kaparas reservoir was under isolation, the total quantity of micro-organisms was lower than during the same period of 1990, thus proving that the micro-flora was delivered from the Ruslovoye (Bed) Reservoir. At the same time zooplankton of the Kaparas water reservoir is much richer than that of the Ruslovoye (Bed) reservoir (Rf. Table 3.5).

Table 3.5

Micro- and Hydrobiological Characteristics of Kaparas Reservoir
(as to Average Data)

No.	Season	Section	1990						1991					
			1	2	3	4	5	6	1	2	3	4	5	6
1.	Spring	I	1.10	0.15	0.6	7,230	2.20	2.25	0.93	0.068	0.30	68	1.84	1.75
		II	0.79	0.08	0.2	9,020	1.96	1.75	0.84	0.023	0.01	10,468	1.89	1.75
		III	0.66	0.06	0.2	6,340	1.99	1.75	0.74	0.018	0.01	10,913	1.73	1.75
2.	Summer	I	1.60	0.27	0.07	1,870	1.88	2.00	0.75	0.36	0.03	1,995	1.78	1.75
		II	0.73	0.53	0.07	1,980	1.67	1.75	0.65	0.23	0.03	2,285	1.75	1.75
		II	1.29	0.78	0.07	705	1.84	2.00	0.53	0.19	0.01	2,020	1.79	1.75
3.	Autumn	I	0.37	0.09	0.01	7,050	1.57	1.50	0.36	0.03	0.003	2,346	1.78	1.50
		II	0.23	0.03	0.01	23,700	1.72	1.50	0.22	0.02	0.003	25,173	1.72	1.50
		III	0.27	0.08	0.01	19,850	1.65	1.50	0.36	0.02	0.004	10,423	1.86	1.50

LEGEND:

1 - total quantity of micro-organisms, mln/pcs/m^3
2 - quantity of saprophytes, thous. cl/cm^3
3 - quantity of ECGB, cl/cm^3
4 - quantity of plankton organisms, pcs/m^3
5 - saprobility index
6 - water quality gradation

Water quality evaluation was carried out in accordance with GOST 17.13.07-82, supplemented with data on ECGB (*Escherichia coli* group bacteria) as assumed from water classification developed by the Institute of Hydroblology of the Ukrainian Academy of Science. The water quality grade was estimated as per GOST 2761-84. The saprobility index calculation was performed using the technique of Pantlette and Bukk.

The water quality evaluation results showed that by microbiological indicators the reservoir water might be defined as very clean in spring and autumn, and in summer time - as very clean with signs of minor microbial pollution facilitating the transition to the gradation of clean (saprobility index - 1.3).

As a whole, from the viewpoint of microbiological and hydrobiological indicators the reservoir water may be classified as follows: in spring and summer seasons - as clean (saprobility index - up to 1.75), while in the autumn - as interim, being between very clean and clean (saprobility index is up to 1.5), so that considering the Kaparas water reservoirs as the source of centralized water supply, it shall be referred to as the first grade reservoir by the water quality indicators.

It should be noted that the water quality in this reservoir during the autonomous period of 1991 was even higher from the viewpoint of micro- and hydrobilogical indicators than that in 1990. This fact proves that the Kaparas reservoir is peculiar with the process of natural self-cleaning, with the result that the quality of water incoming from the Ruslovoye (Bed) water reservoir becomes higher.

The radiation situation of the Kaparas reservoir was investigated through studying the gamma-radiation background and specific beta-activity of the bottom depositions.

The gamma-radiation background was studied by a technique of route survey using a SRP-68-01 device. The gamma-radiation levels were measured directly against the soil surface and at the height of 100 cm. The measurement of specific beta-activity was performed with RKB-4-1 device in a led protective case. The own background of the device was 3-5 pulses/sec, measurement time of the device was 2100 sec.

Prior to measuring the soil samples were subject to drying, grinding and screening through a 0.8 mm mesh sieve. The specific weight of a specimen was 300 g. The device sensivity at calculation of the samples activity was assumed to be equal to $6.6\cdot 10^{-2}$ Bk/kg, or $2.4\cdot 10^{9}$ Curie/kg..

The radiation situation of the area is identified by intensity of both natural and technogenic radiation. The natural radiation background is formed by adding up space emission to the surface radiation. The intensity of space emission depends upon the solar activity, geographic location of the region and increases with the value of the sea level. Average soil-surface radiation background is assumed to be $4.5\cdot 10^{-2}$ μGr/hr (4.5 mCr/hr). Major contribution to this dosage of radiation is provided by gamma-emitting nuclides of uranium-radium and thorium range, as well as ^{40}K.

The level of radiation background is the factor determining the level of radioactive danger. The governing document to regulate the levels of impact on the people is known as "Limits of radioactive safety" (NRB [*Radioactive Safety Noms*] 76/87) in pursuance to which the dosage ultimate level, ignoring dosages obtained in medical institutions and natural background, is the value equal to 50 mZ/hr (0.5 rem/yr.), which is approximately 60 mCurie/hr (Maximum allowable) of gamma-radiation. As far as specific beta-activity is concerned, according to the "Principle Sanitary Rules of Handling Radioactive Substances and other sources of ionizing emissions" (OSP-72/87) which is the basic normative document in the field, solid substances are considered to be radioactive if the pollution level exceeds 50 β-particles/min$\cdot$ cm^2, with the capacity of gamma-radiation at a close contact with surface being more than 0.3 μrem/hr, or 315 mCurie/hr. (AAC).

The results of studies showed that gamma-radiation background in the reservoir area was ranging between the limits of 8 to 15 mCurie/hr and was about 0.03-0.09 of MA, whereas gamma-radiation of soil was 12-15 mCurie/hr that makes up 0.04-0.05 of AAC; specific beta-activity of bottom depositions was ranging between 0.56-0.63 β-particles/min· cm², or 0.002 of AAC.

As one can see from the data collected, the radioactive background level in the area of the reservoir was found to be by 2-3 magnitudes lower than the allowable values, and, thus, no radiological danger is anticipated here.

3.4. Evaluation of Conditions and Possibilities of Eutrophication and "Blossoming" of Water in Kaparas Reservoir

The previous chapters were devoted to considering the issues connected with the water quality dynamics by chemical, micro-biological and hydrobiological indicators. This Chapter is mainly focused to the issue related with the possibility of eutrophication and blossoming of Kaparas reservoir water which materially affect the hydroecological status of reservoirs and, therefore, deteriorate its quality for drinking and domestic water consumption.

The eutrophication of natural reservoirs, that should be understood as the process of their natural aging, is a consequence of enrichment of reservoirs with nutriments (biogenic substances), and, first of all, with phosphorus and nitrogen compounds. Eutrophication manifests itself in enhanced development of plankton and benthos (especially, phytoplankton which cause water and phytobenthos to "blossom"), and also in changed water quality as to ita physico-chemical properties, in silted soils, change of ichtyofauna and in gradual over growth and marshing of reservoirs.

Natural eutrophication of reservoirs is a rather slow process, but at the same time the anthropogenic factors do promote substantial intensification of this process.

Water eutrophication level, along with its bio-bacteriological indicators is the characteristic to the water quality. There are four grades of biological water quality:

1. Oligosaprobe - uncontaminated;
2. β-mesosaprobe - slightly contaminated;
3. α- mesosaprobe - moderately contaminated;
4. Polysaprobe - highly contaminated.

Depending upon the content of biogenic elements and organic substances, there are three gradations of eutrophication level:

No.	Gradation	NH_4^+ mg*N*/l	NO_3^- mg*N*/l	PO_3^- mg*P*/l	PO mg*O*/l	COD mg*O*/l	BOD_5 mgO_2/l
I	Oligotrophic	0.1	0.2	0.03	3	10	1.5
II	Mesotrophic	0.8	0.3	0.07	8	30	5.0
III	Euthrophic	3.0	0.4	0.15	12	70	8.0

In order to determine the eutrophication level in Kaparas reservoir, average value for the reservoir is given hereinbelow in respect to the content of biogenic and organic substances detected in water of this reservoir during spring-summer (S-S) and Autumn-Winter (A-W) periods of 1990-93.

Indicators	NH_4^+ mgN/l		NO_3^- mgN/l		PO_3^- mgP/l		BOD_5 mgO_2/l		COD mgO/l	
	S-S	A-W	S-S	A-W	S-S	A-W	S-S	A-W	S-S	A-W
Concentration	0.08	0.05	0.35	0.30	0.02	0.01	1.46	1.33	20.6	19.1
Eutrophication level	I	I	II	II	I	I	I	I	II	II

As seen from the results obtained, the Kaparas reservoir water is mainly referred to oligotrophic gradation, and only by the nitrogen of nitrates and COD - to mesatrophic, i.e. this reservoir is not rich with the content of biogenic and easily oxidising organic substances, although the concentration of hard oxidising substances is somewhat excessive.

It should be noted that the eutrophication of reservoirs is the main reason for "blossoming" of water which shall be recognised as one of the major factors of biological pollution of the reservoir.

The following major abiotic conditions will promote the development of water 'blossoming":

⇒ water temperature: minimum 17-19°C and maximum 30-33 °C, with the optimum being 20-25 °C;
⇒ water flow rate - less than 0.2 m/sec;
⇒ permanganate oxidization - at least, 20 mg O/l;
⇒ ammonia nitrogen concentration - 3.0-4.0 mg/l, minimum;
⇒ mineral phosphorus concentration - 0.25-0.40 mg P/l, minimum
⇒ water pH - within the limits of 7.8-8.5;
⇒ transparency - high.

Field multi-year studies of abiotic factors in Kaparas reservoir have proved that there are no optimal conditions for water "blossoming" in this reservoir, because these conditions are favourable only by temperature indicators, water flow, pH and transparency, while such significant indicators as permanganate oxidization, ammonia nitrogen content and phosphorus content are by, at least, a magnitude smaller than required to cause the water "blossoming". Thus, for instance, the permanganate oxidization does not exceed 2.0 mgO/l; ammonia nitrogen - 0.1 mg/l; phosphorus - 0.05 mg/l.

As it has been already noted above, the phytoplankton of water reservoir is mainly represented by diatoma algae, while green, periphotonic, golden and blue-green algae are substantially less significant.

Thus, the total quantitative development of algae in water reservoir, especially, the blue-green ones, which cause the blossoming of water, both during the first years of this reservoir operation, and during the period of isolation, is so negligible that it is not adequate even to define the signs of such phenomena ("weak blossoming' happens at their biomass equal to 5-10 g/m^3, while in the water reservoir it never exceeded 0.2 g/m^3). Therefore, the water "blossoming", as the factor of biological pollution, may be neglected. Besides, there is no sense in awaiting any deterioration of biological quality of water, neither in Kaparas, nor in Ruslovoye (Bed) reservoirs, due to the prospective plans on a complex of measures and arrangements directed towards the improvement of environmental situation in the basin of the Aral Sea.

4. RECOMMENDED MEASURES ON KAPARAS WATER QUALITY IMPROVEMENT

Improvement of water quality in Kaparas reservoir will be greatly facilitated through a number of recommended measures, some of which should be implemented soonest, while the others - in the nearest future.

First of all, the filling of Kaparas should be effected in the period when the quality of water in the Ruslovoye (Bed) reservoir is the best.

Field observations for the Ruslovoye reservoir water quality during 1989-1993 carried out by ourselves, as well as analysis of data presented by the Department of Pollution Monitoring under Main Hydrometereological Station of the Republic of Uzbekistan collected during 1981-1993 showed that the optimal period to fill in the Kaparas water reservoir is the end of June-early September.

During the filling of Kaparas, water to supply the population in the downstream of Amudarya shall be provided from the Ruslovoye (Bed) reservoir, and during the period of September to June - from Kaparas.

Secondly, in order to ensure proper control over the water quality in Ruslovoye (Bed) and Kaparas water reservoirs, a resident supervising bureau shall be established which would be responsible to carry out systematic monitoring for the water quality parameters in those reservoirs and control during the Kaparas filling period. Such a bureau shall work in co-ordination with the operation service group maintaining proper functioning of TMHU water reservoirs and with water treatment plant.

Third, water protective and sanitary zones shall be arranged within the region where the reservoirs are located in.

Prior importance in sanitary and water protection zonation shall be paid to reservoirs and facilities connected with drinking water supply in the downstream of Amudarya. These facilities include:

- → water supply source - Kaparas filling water reservoir;
- → Ruslovoye (Bed) reservoir carrying the river water to Kaparas;
- → water intake facilities and pumping station at Kaparas water reservoir;
- → main water intake stations at the left and right banks of the Amudarya river in the tail race of Tuyamuyun HydroUnit;
- → pipelines connecting the pumping station at Kaparas with the main upstream water intake units.

We have made certain efforts to designate sanitary and water protective zones on the basis of standard and methodological materials.

Sanitary protection zones (SPZ) in the territory and water area of both Kaparas and Ruslovoye reservoirs should be arranged in two stripes: first - of strict mode; second - restriction mode. The both two stripes have been mapped starting from waterline at the Normal Backup level (NBL).

The first SPZ stripe. The most important object for sanitary protection is the water intake unit at Kaparas. The first SPZ stripe at the water intake facility shall cover the water area at the distance of 100 m from the NBL spreading in all directions. The stripe boundary line in the water area shall be marked with warning signs and beacons.

Applicably to the territory of pumping stations at the Kaparas reservoir in the TMHU tail race, the first SPZ stripe boundary line coincides with fencing of sites with structures and has been designated to be located with the following distances:

→ 30 m minimum from the walls of reservoirs with filtered (drinking) water, filters (excepting the head filters), contact clarifiers with the open water surface;

→ 15 m minimum from the walls of other facilities and from the bodies of water head towers.

The first stripe territory is to be delineated, fenced and landscaped with greenery, whereas the fencing shall be installed as per subclause 14.4. of SNiP [*Construction Codes & Rules*]-2.04.02-84 (dead-end -2.5 m; dead-end with barbed wire - 2.0 m).

The second SPZ stripe shall also cover the water area and territory of reservoirs,

This zone shall include the total water area of the Kaparas reservoir as being the water area of water supply source.

The Ruslovoye (bed) reservoir is a water flow feeding the Kaparas.

The second stripe zone of the Ruslovoye (Bed) reservoir shall be inclusive of the water area at a distance of 5 km from the water inlet section entering the Kaparas.

Bank boundaries in the Ruslovoye and Kaparas reservoirs shall be provided at a distance of 500 m from the NBL waterline, that will be also corresponding to the width of water protection zones (WZ).

Bank SPZs (WZs) shall cover the Kaparas reservoir banks along the entire perimeter of water area at NBL.

The upper border of SPZ (WZ) at the Kaparas reservoir inflow including the Ruslovoye (Bed) reservoir and a part of the Amudarya river was calculated with the lag time in view.

The following data was used for calculations:

→ low water year, 95% of supply (1986);

→ minimal level at which the Kaparas reservoir may be filled - 118-123 m;

→ minimal monthly average consumption rate during the filling at minimal level - 300 m^3/sec;

→ river flow rate in emptied reservoir, averaged by width and length of bed in the head race - 0.61 m/sec;

→ lag time - 3 days.

The calculation was made using the following formulae:

$$Z = 3 \cdot t_c \cdot V_{av} = 3 \cdot 86400 \cdot 0.61 = 158 \text{ km};$$

where: Z is a rated consumption lag time;

t_c - is a total of seconds per 24 hours;

$V_{av.}$ - is the average estimated river flow rate.

Thus, the calculation showed that the upper border of SPZ (WZ) should extend to the section of Darganata settlement. This distance corresponds to lag time to reach the Kaparas reservoir with rated consumption of 300 m^3/sec within 3 days.

The second SPZ (WZ) stripe lower border in the TMHU tail race shall be placed at a distance of 1.2-1.5 km far from the dam at the main water pipeline stations' section.

It should be noted that the width of sanitary protection stripe of water supply pipelines (d > 1000 mm) laid from the pumping station at the Kaparas reservoir up to the main water pipeline stations in the tail race of TMHU shall be designated in accordance with the standard requirements and be at the following distance from the end water pipelines:

→ if laid down in dry soils - not less than 20 m;

→ in wet soils - not less than 50 m.

Water pipelines at the left bank and in the tail race partially cross through the cultivated areas, therefore, certain steps shall be made to arrange the protective stripes along the pipelines, in accordance with sanitary and water protection requirements as per SNiPs mentioned above.

Fourth, in order to improve the water quality in both Ruslovoye and Kaparas water storage reservoirs, no sewage and drainage water (SDW) shall be discharged into the Amudarya river during the period of filling the Kaparas reservoir (i.e. June-September). This will facilitate the decrease of concentrations of the major part of pollutants by 20-50%.

Therefore, from this point of view, the construction of the Right-Side Bank mainline collector should be treated as one of the first priorities in water protection arrangements to be implemented in the basin of the Amudarya river. Same is true in respect to the arrangements undertaken to diverse the SDW in the left bank of the Amudarya river mid-stream.

Fifth, implementation of preventive measures connected with a thorough flushing of Kaparas and possibility of filling it with somewhat lower levels of the Ruslovoye reservoir will urge to study a project to construct the second open type water intake unit nearby the dam # 3. However, the expediency of this project may be defined after 5-7 years of the Kaparas reservoir operation with a single water adjusting unit.

5. PRELIMINARY PROGNOSIS OF THE KAPARAS RESERVOIR WATER QUALITY WITH THE VIEW OF WATER MANAGEMENT ARRANGEMENTS AS IMPLEMENTED AND RECOMMENDED

The prognosis of the Kaparas reservoir water quality has been carried out on the basis of "Methodological Recommendations"

The prognosis of the water quality components' concentration was estimated using the following balance equation:

$$M_k = \frac{(M_i \cdot V_i + M_n \cdot V_n - M_c \cdot V_c) + S_{gen.}}{V_i + V_n - V_c}$$

where: M - water quality index concentration
V - water volume
i, n, c - respectively: initial value in the reservoir, of - influx; - discharge;
$S_{gen.}$ - content of salts delivered from the reservoir bed, due to evaporation (difference between precipitation and evaporation) and water drainage through the reservoir side walls.

In order to evaluate the water quality, major indicators have been selected which may result either in changes, or in deterioration of the reservoir water qualitative composition.

The analysis of retrospective, current and prospective conditions of water quality formation in the Kaparas reservoir allowed to determine the composition of such indicators:

1) General sanitary LIH: mineralization, total hardness, BOD_{tot}, COD.
2) Organoleptic LIH: sulphates, chlorides, phenols, α-HCCP, copper.
3) Sanitary toxicological LIH: Specific surfactants, nitrogen of nitrates, nitrogen of nitrites, ammonium nitrogen, 3-valent chromium; 6-valent chromium, led, mercury, γ-HCCP.

Water quality prognosis has been performed for the worst hydrological conditions - low water years of 90-95% supply, as based on the data of field observations.

5.1. Water Quality Prognosis by Salt Composition

According to GOST 2874-82 "Drinking Water", the following salt composition indicators are subject to rating: mineralization, sulphates, chlorides and total hardness.

As it was noted above, the Kaparas water reservoir was isolated from the Ruslovoye (feeding source) reservoir starting from August, 1993 and by September, 1993. During this period the reservoir was emptied up to the dead volume, i.e. 280 mln.m^3.

During the above period we were performing certain observations to detect any changes of the water quality indicators. Those observations allowed, particularly, to evaluate the increment of salts during the isolation period.

Taking into consideration that Kaparas would be filled up, mainly, during two months (July-August), while the remaining ten months would be isolated from the influx, basing on field observations we have evaluated the value of increments of salts during 10 months which is assumed as a basis of the prognosis computations. This value was 0.33 g/l, i.e. in August 1991 water mineralization was 1.10 g/l, whereas in 10 months thereafter, i.e. in June, 1992, this figure raised up to 1.43 g/l (Table 5.1). This increment of salts included the amount of leached salts from the reservoir bed, salts which had been brought in together with the drained water from the side walls of the reservoir and also due to evaporation from the reservoir surface (S_{tot}).

Computations showed that S_{tot} for the 10 months reached the figure of 92.4 thous.tons, i.e. monthly average increment of salts for the said period would be equal to 9.24 thous.tons. At V_f = 280 mln.m³, the S_{tot} value will make:

$$S_{tot} = 280 \cdot 0.33 = 92.4 \text{ thous.tn/10 months}$$

Whereas, from the total quantity of salts the sulphate ions make 30%, chloride ions - 35%, sodium and potassium - 27%, and 8 % is the total hardness.

Table 5.1

Averages of Mineralization and Major Ions
in the Kaparas Reservoir Water in August, 1991, and June, 1992

(Unit:g/l)

Year, Month	Qnty of averaged samples	Ca^{2+}	Mg^{2+}	$NA^{+}+K^{+}$	HCO_3^-	SO_4^{2-}	Cl^-	Minerali-zation
1	2	3	4	5	6	7	8	9
1991, VIII	31	0.11	0.04	0.20	0.15	0.34	0.26	1.10
1992, VI	15	0.13	0.05	0.30	0.11	0.45	0.39	1.43

As seen from the data above, water mineralization in Kaparas raised by 30% during 10 months, while the increase of chlorides was 50%, that of sulphate - 32%, magnesium ions - 25%, calcium 18%. In the meantime, the concentration of hydrocarbonates reduced by 27%.

Therefore, basing on the materials available, we have assumed the following initial data for our computations:

→ water mineralization in Kaparas as on the date of filling started (M_H) - 1.0 g/l (Table 5.2);
→ water volume (V_H) - 280 mln.m³;
→ mineralization mean for the filling period (M_n) - 0.75 g/l;
→ total influx volume as to NBL of Kaparas (V_n) - 680 mln.m³.

Whereas, the concentration of other salt composition indicators in the influx as averaged for the filling period was the following:

→ sulphate ions - 0.27 g/l;
→ chloride ions - 0.20 g/l;
→ total hardness - 6.5 meq/l.

In the meantime, before filling, the concentration of the same indicators in Kaparas was as below:

→ sulphate ions - 0.33 g/l;
→ chloride ions - 0.22 g/l;
→ total hardness - 9.0 meq/l.

Table 5.2

Mineralization and Major Ions
in the Kaparas Reservoir Water in June, 1991

(Unit:g/l)

Section, Vertical	Depths, *meters*	Ca^{2+}	Mg^{2+}	$NA^{+}+K^{+}$	HCO_3^-	SO_4^{2-}	Cl^-	Aggregate of ions
S.1, v.1	Surface	0.10	0.06	0.14	0.13	0.28	0.19	0.90
	bottom (15)	0.11	0.06	0.17	0.14	0.40	0.23	1.11
S.1, v.2	surface	0.07	0.05	0.16	0.13	0.33	0.20	0.94
	5.0	0.08	0.06	0.13	0.13	0.32	0.20	0.92
	10.0	0.06	0.07	0.14	0.13	0.31	0.21	0.92
	15.0	0.07	0.08	0.16	0.15	0.39	0.21	1.06
	bottom 19.4	0.10	0.06	0.18	0.14	0.39	0.23	1.10
S.1, v.3	surface	0.08	0.04	0.21	0.13	0.38	0.21	1.05
	bottom 6.0	0.08	0.08	0.16	0.13	0.39	0.21	1.05
S.2, v.4	surface	0.08	0.06	0.17	0.16	0.33	0.21	1.01
	bottom 16.3	0.12	0.07	0.13	0.16	0.33	0.23	1.04
S.2, v.5	surface	0.11	0.04	0.14	0.14	0.33	0.20	0.96
	5.0	0.10	0.03	0.18	0.13	0.34	0.21	0.99
	10.0	0.10	0.05	0.15	0.15	0.29	0.23	0.97
	15.0	0.13	0.04	0.12	0.15	0.28	0.23	0.95
	bottom 26.3	0.07	0.06	0.20	0.19	0.30	0.25	1.07
S.2, v.6	surface	0.09	0.07	0.10	0.14	0.26	0.23	0.89
	bottom 15.0	0.10	0.04	0.19	0.15	0.32	0.23	1.03
S.3, v.7	surface	0.07	0.06	0.23	0.13	0.31	0.23	1.03
	bottom 26.7	0.08	0.06	0.22	0.16	0.37	0.27	1.16
S.3, v.8	surface	0.11	0.04	0.17	0.16	0.30	0.25	1.03
	5.0	0.10	0.04	0.15	0.15	0.30	0.20	0.94
	10.0	0.08	0.06	0.17	0.15	0.33	0.23	1.02
	15.0	0.07	0.05	0.19	0.16	0.31	0.21	0.99
	bottom 29.0	0.08	0.07	0.22	0.14	0.37	0.30	1.18
S.3, v.9	surface	0.11	0.04	0.15	0.13	0.32	0.21	0.96
	bottom 13.3	0.12	0.04	0.15	0.16	0.31	0.23	1.01
S.4, v.10	surface	0.08	0.07	0.14	0.13	0.33	0.21	0.96
	bottom 10.0	0.06	0.07	0.17	0.14	0.34	0.21	0.99
S.4, v.11	surface	0.06	0.07	0.16	0.13	0.34	0.20	0.96
	10.0	0.08	0.06	0.14	0.13	0.31	0.21	0.93
	bottom 12.7	0.06	0.06	0.19	0.13	0.33	0.23	1.00
S.4, v.12	surface	0.09	0.08	0.10	0.15	0.30	0.21	0.93
	bottom 10.0	0.07	0.05	0.18	0.15	0.30	0.23	0.98
Average for reservoir: out of 34 samples		0.09	0.06	0.16	0.14	0.33	0.22	1.00

Results of prognostic computations by the salt composition indicators, given the monthly uniform discharge rate (V_c) equal to 68 mln.m^3 are summarised in Tables 5.3 and 5.4. below.

Table 5.3

Prognostic Values of Water Mineralization in Kaparas
(as of the end of each month)

Month	kg/m^3		mln.m^3		kg/m^3	mln.m^3	'000 tons	mg/l
	M_j	I_n	V_f	V_n	M_d	V_d	S	M_k
1	2	3	4	5	6	7	8	9
VIII	1.0	0.75	280	680	0	0	9.24	0.83
IX	0.83	-	892	-	0.83	68	9.24	0.84
X	0.84	-	824	-	0.84	68	9.24	0.85
XI	0.85	-	756	-	0.85	86	9.24	0.86
XII	0.86		688	-	0.86	68	9.24	0.87
I	0.87	-	620	-	0.87	68	9.24	0.88
II	0.88	-	552	-	0.88	68	9.24	0.89
III	0.89	-	484	-	0.89	68	9.24	0.90
IV	0.90	-	416	-	0.90	68	9.24	0.92
V	0.92	-	348	-	0.92	68	9.24	0.94
V	0.94	-	280	-	0.94	68	9.24	0.97

Table 5.4

Results of Prognostic Computations of Water Quality by the Kaparas Reservoir Salt Composition
in Low Water Years as to the Level of Year 2005

(Unit:mg/l)

Index	VIII	IX	X	XI	XII	I	II	III	IV	V	VI
Σ_n	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.92	0.94	0.97
SO_4^{2-}	0.29	0.29	0.29	0.29	0.29	0.29	0.30	0.30	0.31	0.32	0.33
Cl^-	0.21	0.21	0.21	0.21	0.21	0.22	0.23	0.24	0.25	0.26	0.27
T.H., *meq/l*	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4

Σ_n - *mineralization*

As seen from Table 5.4, water mineralization, sulphate and chloride ions will not exceed the MAC rates, while the total hardness, after Kaparas is filled, is expected to be within the MAC limits, but, however, will be then gradually growing to reach 1.3 value of MAC for the 10 months.

The Ministry of Health shall study and address the issue on the total hardness MAC rates, since the GOST 2874-82 allows for this indicator to be at 10 meq/l. In this case, it is anticipated that the total hardness of the Kaparas reservoir water would be within the standard limits .

5.2. Water Quality Prognosis by Biogenic Elements, Organic and Other Polluting Substances

Initial data needed to make prognosis on biogenic elements, organic and other polluting substances are shown in Table 5.5

Average for the reservoir values of water quality indicators' concentration are provided for the Kaparas water reservoir which were registered in July, 1991, prior to isolating thereof from the Ruslovoye (Bed) reservoir.
Maximum averaged concentrations during low water years are shown for the Ruslovoye (Bed) reservoir, registered in July-August at the dam as the influx water of Kaparas.
From among the water quality indicators presented for the prognosis, the major part is non-conservative, i.e. subject to the self-cleaning process in the reservoirs.

Table 5.6. provides the results of the prognostic computations with the self-cleaning process ignored. In the meantime, it is worth to note that according to our observations during many years, the self-cleaning process in Kaparas facilitates the decrease of concentrations of various substances by 20-25% in average, and even more as compared to the initial one. Self-cleaning is caused by intra-reservoir physico-chemical and bio-bacteriological processes (i.e. absorption, sedimentation, feeding of micro-organisms: reductases and consummates, as well as phytoorganisms, and others).

As seen from Table 5.6, the water quality prospective estimate has been given on the basis of C/MAC calculations made in accordance with the GOST 2874-82 and SanP&N 4630-88. Individual indicators as to SanP&N have somewhat "stricter" MACs. And, even if those are assumed as the basis, it is clear that during the period by the year 2005, under the worst hydrological conditions assumed for prognosis reasons, only three indicators can be expected to excess the MAC rates, where two of those are referred to general sanitary LIH, namely - BOD_{tot} and COD, and the one referred to organoleptic LIH is the phenols. All other indicators of water quality, including sanitary toxicological ones, will not exceed the standards for drinking and domestic water consumption.

Thus, summarising the results of studies in respect to the Kaparas reservoir water quality prognosis challenging by the year 2005 for the worst conditions that might occur in the low water years, is should be stressed that in the long-term plan, among the hydrochemical indicators under analysis (up to 36) referred to various LIH only the following five indicators would probably exceed the MAC values rated for drinking and domestic water consumption:

→ turbidity - up to 25 values;
→ total hardness - up to 1.3
→ BOD_{tot} - up to 1.03;
→ COD - up to 1.15;
→ phenols - up to 3.0.

All other indicators will be ranging within the allowed rated limits.

Table 5.5

Maximal Concentration of Water Quality Indicators in Russlovoye (Bed) and Kaparas Reservoirs during the Filling Period

(Unit:mg/l)

No.	Indicators	Ruslovoye (Bed) Reservoir	Kaparas Reservoir
1	2	3	4
1	BOD_{tot}	3.0	3.4
2	COD	17.5	16.3
3	Zinc	0.02	0.001
4	Phenols	0.003	0.002
5	Oil Products	0.01	0.03
6	α-HCCP	$0.002 \cdot 10^{-3}$	0
7	Copper	0.01	0.002
8	Specific surfactants	0.01	0.01
9	Ammonium nitrogen	0.006	0.010
10	Nitrogen of nitrites	0.005	0.015
11	Nitrogen of nitrates	0.20	0.30
12	6-valent chromium	0.001	0.003
13	3-valent chromium	0.0005	0
14	Led	0.0002	0
15	Mercury	0.0001	0.0003
16	γ- HCCP	$0.04 \cdot 10^{-3}$	0

Prognostic Maximal Concentrations of the Major Indicators
of the Kaparas reservoir Water Quality within 10-month Periods
(between the beginning of filling at V= 960 mln.m^3 and emptying up to V=280 mln.m^3)

No.	Water Quality Indicators and Hazard Grade of Substances		MAC as to GOST 2874-82	MAC as to SanR&N 4630-88	Prognostic concentration, mg/l	C/MAC	
						As to GOST	As to SanP&N
1	2		3	4	5	6	7
	I. General Sanitary LIH						
1	BOD_{tot}	-	3.0	3.0	3.1	1.03	1.03
2	COD	-	15.0	15.0	17.2	1.15	1.5
3	Zinc	(3)	5.0	1.0	0.002	0.0004	0.002
	II. Organoleptic LIH						
1	Phenols	(4)	0.001	0.001	0.003	3.0	3.0
2	Oil Products	(4)	0.3	0.3	0.02	0.07	0.07
3	α-HCCP	(4)	0.02	0.02	$0.0015 \cdot 10^{-3}$	$0.075 \cdot 10^{-3}$	$0.075 \cdot 10^{-3}$
4	Copper	(3)	1.0	1.0	0.008	0.008	0.008
	III. Sanitary-Toxicological LIH						
1	Sp.Surfactants	(3-4)	0.5	0.5	0.01	0.02	0.02
2	Ammonium nitrogen	(3)	2.0	2.0	0.007	0.004	0.004
3	Nitrogen of nitrites	(2)	1.10	1.0	0.008	0.008	0.008
4	Nitrogen of nitrates	(3)	10.0	10.0	0.23	0.023	0.023
5	6-valent chromium	(3)	0.1	0.05	0.0015	0.0015	0.03
6	3-valent chromium	(3)	0.5	0.5	0.0003	0.0006	0.0006
7	Led	(2)	0.1	0.03	0.0001	0.001	0.003
8	Mercury	(1)	0.005	0.0005	0.00015	0.03	0.3
9	γ- HCCP	(1)	-	0.004	$0.03 \cdot 10^{-3}$	-	0.008

Note: Danger Class of Substances is given in brackets:
1 - extremely dangerous; 2- highly dangerous; 3- dangerous;
4- moderately dangerous;
C/MAC - ratio of prognostic concentration (C) of water quality indicators to maximum allowed concentration (MAC)

CONCLUSION

The following principle conclusions may be formulated from the results of studies implemented:

1. One of the most acute problems in the Amudarya river basin is currently the problem of drinking water quality.

2. This problem can be addressed by a complex method counting for the availability of a limited number of water sources with good quality indicators. Namely: by means of expanding the construction of desalination plants; construction of supplementary wells to pump out ground water of good quality and exploring the surface water sources and providing enough facilities to accumulate and keep the water with a good quality.

3. This report considers one of the options to detect and use sources of public water supply in the Amudarya river basin downstream. It is the Kaparas and Ruslovoye (Bed) reservoirs. With this in view, analysis was performed for the results of field observations by hydrological, hydrochemical, bio-bacteriological conditions and radiological situation during the period of 1986-1993, using the materials available from Glavgidromet (Main HydrometeoStation) and the Department for operation of TMHU reservoirs.

4. The Amudarya river, being a tributory of the Ruslovoye (Bed) water reservoir receives waste water discharged from industrial enteprises, utilities and recirculated collecting and drainage water from the irrigated lands. That is why, the river water, starting from Termez section and up to TMHU, shows the presence of certain indicators exceeding the MAC values for drinking and domestic water supply. These are, first of all: total hardness, indicators of organic substance (BOD_{tot}, COD), phenols, and in Darganata section - these also include mineralization and sulphate ions.

5. Both Ruslovoye and Kaparas reservoirs are operated in the irrigation mode that effects the dynamics of the water qualitative composition.

6. Out of 35-38 indicators referred to general sanitary, organoleptic and sanitary toxicological limiting indicators of hazard which were analysed in the Ruslovoye reservoir, only 8 of those exceed the MAC values. In the meantime, the maximal exceeding values have been detected during spring and autumn-winter seasons, whereas in the period from June to September the water in this very reservoir has the best qualitative indicators. Water mineralization, sulphate and chloride ions are usually by 30-50% lower than the MAC values.

7. As for bio-bacteriological situation, the best water quality is also observed in the Ruslovoye reservoir during the summer season, from June-July to August-September.

8. The Kaparas depression was started to be filled from June 1981 through the watercourse connecting this reservoir with the Ruslovoye water reservoir. This depression, prior to filling thereof, contained the salt amounting to 8.7 mln.tons. By the end of 1993, the stock of potentially soluble salt reduced by 30%, as to the preliminary estimation. During the last years, the leaching of salts was about 8.000 tons per month.

9. The whole period of the reservoir operation may be subdivided into three periods:

Ist	-	June, 1981 - August, 1991, - irrigation mode operation period;
IInd	-	August,1991-September, 1993, - period of isoltaion when the watercourse was dammed to construct a adjusting unit;
IIIrd	-	since September, 1993 and by now, - the rehabilitation period for water recirculation, when the construction was completed and water was fed again.

Those periods were characterised with the peculiar water quality indicators, especially, by the salt composition.

10. During the first year of the Kaparas reservoir existence, the lowest water mineralization was observed between June-August and September-October, getting lower than 1.0 g/l.
During the second period, when the water volume was 280 mln m3 and there was no water exchange, water mineralization was gradually increasing and by the end of the period it reached 2.4 g/l. In the meantime, for the 26 months of the reservoir isolation period, the total amount of salt increment became equal to 280.000 tons wherefrom 80.000 tons were due to evaporation and filtration of salt water from the reservoir side walls, and 200.000 tons - through leaching of salts from the bed. In average, the water mineralization was monthly increasing by 0.05 g/l during this period.

During the third period, when water from the Ruslovoye (Bed) reservoir again started to be fed, water mineralization started to decrease, and by December, 1993, it dropped down to 1.3 g/l, and by July-August, 1994, - it reached 0.8 g/l.

11. During all years of observations in the Kaparas water reservoir, out of 35-37 indicators analysed only eight indicators showed the excess of MAC values. Part of those is referred to the general sanitary LIH (mineralization, total hardness, BOD_{tot}, COD), while the other part to organoleptic LIH (sulphate and chloride ions, phenols and turbidity). Neither of sanitary toxicological LIH exceeds the MAC values.

Prior to the period of isolation, the best quality of water was observed during June to August. During this period, the water mineralization, sulphate and chloride ions did not exceed the MAC values, while the major indicators which needed to be clarified were the total hardness, phenols, COD and turbidity.

12. The results the Kaparas water quality estimation by bio-bacteriological characteristics showed that as by microbiological and hydrobiological indicators, the water could be referred to as a very clean grade during the spring and autumn season, while in summer time it should be referred to as a very clean grade transitional to clean, and so, as a source of centralised water supply, the Kaparas water reservoir shall be referred to the first grade as for the water quality indicators.

13. Results of radiation situation on the Kaparas water reservoir (gamma-radiation background, specific beta-activity of bottom depositions) showed that the level of radioactive background is by 2-3 magnitudes lower than allowable (NRB 76/87 and OSP-72/87) limits, so the situation does not represent any radiological danger.

14. Many years of field studies aimed at evaluating the probability of water "blossoming" in the Kaparas reservoir allowed to establish that there were no optimal conditions connected with abiotic factors that might cause any water "blossoming' effect. Total quantitative development of algae in the reservoir, especially, blue-green ones which cause water to blossom, is so negligible, both in the period of isolation and during the first years of this reservoir' existence, that it is not adequate even to detect any signs of the phenomena.

15. Stock-taking of water management facilities in the Kaparas water reservoir showed that currently the construction of water adjustment unit has been completed, thus allowing to adjust the filling and emptying of the reservoir. A water intake station is also under construction currently. A water pipeline has been planned to be constructed from the pumping water intake station and up to treatment plant facilities (totally 4 pipelines, 11 km long each), with the passage across the Amudarya river.

Currently, there are treatments plants under operation which consist of settlers and sand filters, with partial use of activated coal.

The R & D Institute "Uzkommuninjproekt" is designing a project of treatment plants where activated coal will be used.

16. The concept of improving the Kaparas reservoir water quality includes the following arrangements:

→ partial or complete termination of any collector and drainage water discharge in the mid-stream of the Amudarya river;

→ adjustment of the water quality while filling the reservoir (July-September);

→ establishing a system of water quality monitoring and information distribution using automated hard- and software;

→ arranging water protection and sanitary zones around the reservoirs and hydrotechnical structures.

17. Preliminary prognosis of the Kaparas reservoir water quality has been performed on the basis of field observations of the water quality of this reservoir during the period of isolation thereof from the Ruslovoye (Bed) reservoir (1991-1992).

Computations showed that before the year 2005, under the recommended mode of filling and emptying, the MAC values should be expected to be overrun by the following indicators: turbidity (by 25 times, max.), BOD_{tot} to a smaller extent (by 1.03, max.), COD (by 1.15 times, max.), phenols (by 3.0 times, max.) and total hardness (by 1.3 times, max.) All other indicators will be ranging within the specified limits.

WATER MANAGEMENT UNITS AT RUSLOVOYE AND KAPARAS RESERVOIR

The Kaparas water reservoir is one of water management units included to Tuyamuyun HydroUnit (TMHU).

The total system of TMHU facilities is a complicated system with more than 20 major hydroengineering units which are subdivided into two groups:

1. River hydro-unit with Ruslovoye reservoir.
2. A complex of facilities at flooded reservoirs of Kaparas, Sultansandjar and Koshbulak.

The first group includes the following facilities:

1. Hydropower station building with assembling site.

2. Tuyamuyun Hydropower Station operating under irrigation mode with six turbines of 150.000 thous. kWt capacity.

3. Concrete water discharge dam, which has 8 spans with bottom holes (12x6 m) and water discharge hole (12x12 m) to discharge wastes and sludge. The total dam length is 141 m, width is 41 m. The water discharge hole threshold level is 118.0 m.

4. The left side bank water intake facility of two-stage type with six openings (5x5 m) with the threshold level at 114 m. The water intake unit is provided with the bottom flushing galleries which serve to prevent the bottom detritus in front of the unit, and to participate in maintaining the passage of flood water and levelling of linear flows in the Hydro Unit tail race.

5. The left side bank conjunction consisting of the upper and lower conjugating walls and stream-directing pier.

6. The right side bank water intake two-stage type unit with three water intake holes (5X5m), with a threshold level of 115.0 and three flushing galleries, with the cross-sections of 2.5x5.0 at the inlet, with a threshold level of 110.0 m.

7. The right side bank conjunction consisting of same structures as the left side.

8. Fore apron, apron, downstream apron of major concrete structures.

9. Soil dam

10. The right side bank dams ## 1 & 2.

11. A left side bank dam overlapping the slot for the railroad.

12. The left side bank dams ## 3, 4, 5, 6, 7,8.

13. The left side bank main canal (*LMBC*) with the throughput capacity of 500 m^3/sec.

14. Inverted siphon and regulating watergate (SRG) at the left side bank canal. SRG apron consists of 4 rows of reinforced concrete plates with the total length of 52 m. Along the apron end row there are reinforced concrete supports for pipeline passage for domestic and drinking water supply of the Druzhba town through LBMC.

15. The left side bank settler is located between the lower conjugating walls and inverted siphon, regulating watergate on the LMBC. Settler with mechanic cleaning of detritus. Its length without transitions is 560m, width at the bottom - 108 m, design level of the settler bottom - 110.0 m, level of dams' ridge - 119.5 m.

The second group includes the following facilities:

1. Filling and emptying water intake facility of Sultansandjar water reservoir. Water intake facility is a water discharge dam with 4 bottom openings sized 5x5 m, with the threshold level of 117.0 m. The water intake upper part level exceeds the NBL by 4 meters, i.e. 134.0 m

3. Water intake of clarified water from Sultasandjar water reservoir. The plant is located at the initial part of Sultansandjar dam and is designed to supply the clarified water from the Sultansandjar water reservoir in the LMBC. Water intake consists of four sections of outlet doorway with the total length of 87.0 m, a board section of 42.5 m length and 2 sections of the apron' supporting walls. The water intake threshold level is 112.0 m, throughput capacity is 500 m^3/sec.

4. Filling and Emptying Canal of Koshbulak water reservoir. Total length is 24 km with the maximal throughput flow rate of 100 m^3/sec.

5. Sultansandjar dam and dam #9. Located at the western bank of the depression. Total length is about 20 km.

In 1993, a construction of water adjusting unit was completed at the Kaparas water reservoir with the throughput capacity of 200 m3/sec allowing at present to adjust filling and emptying this reservoir.

Two pumping stations are planned to be constructed which will be used for water intake from Kaparas, to be further fed through the water pipeline to treatment facilities.

The first water intake station is currently under construction. The second station is planned to be constructed after the year 2010.

The water pipeline from the pumping station up to treatment plants is planned to be constructed with four pipelines consisting of 1400 mm diameter pipes. Every line will be 11 km long. This water pipeline will be crossing through the Amudarya river.

At present water treatment plants are constructed and operated which consist of settlers and sand filters partially using the activated coal. The R & D Institute "Uzkommuninjproekt" is now dealing with designing a project of water treatment plant with activated coal used as a filtering agent.

HYDROCHEMICAL TESTING METHODS

Chemical composition of water was investigated under field conditions during expeditions and also in laboratories.

In the first case, the researches were carried out to measure the water temperature, transparency, pH-value, oxidisation, alkalinity and content of dissolved gases. The concentration of other chemical components in water was determined in a laboratory. Water sampling was performed by means of Molchanov bathometer following the instruction outlined in the "Manual..."

1. Surface water layers temperature was measured by a spring-type mercury thermometer with 0.1°C intervals, while in subsurface deep layers - with tilting thermometer.

2. Transparency was estimated using a Sekki disc.

3. pH-values were determined by electrometric method:
   - under field conditions: pH-meter # 5123 (mfd. in Poland)
   - in laboratory: universal ionmeter EV-74.

4. Oxidisation was estimated using the following two methods: permanganate and bichromatic.

4.1. The permanganate method (A Kubel method) is based on oxidation of easily oxidising organic substances present in water, by 0.01 H with $KMnO_4$ in sulphuric acid medium at boiling.

4.2. A bichromate method (chemical absorption of oxygen) is based on oxidising all organic substances present in water with strong oxidising agents, namely, $K_2Cr_2O_7$ and H_2SO_4 added as a catalyst. The excess of $K_2Cr_2O_7$ is then subject to titration with a solution of $(NH_4)_2SO_4 \cdot Fe_2SO_4 \cdot 6 \cdot H_2O)$-ferric ammonium sulphates.

5. The suspended particles were determined by filtering of 0.5-1.0 litre of water through an ash-free filter with subsequent drying at 105°C. The weight difference characterised the quantity of those particles in a certain volume of water.

6. Water colour index was determined on a simulated platinum-cobalt scale (standard solution of potassium hexochlorplatinate and cobalt chloride).

Determination of dissolved oxygen was performed by oxymeter (Tlenomiezz # 5221, mfd. in Poland)

7. Biochemical oxygen demand (BOD) was determined by incubation of water sample within 5 days at 20°C, while BOD_{tot} was determined within 20 days. The BOD result was estimated by a difference in the content of oxygen before and after the incubation.

8. Free carbon dioxide content was determined by volumetric method which is based on titration of dissolved carbon dioxide by alkaline solution in presence of phenolphthalein.

9. Determination of total alkalinity was performed by direct titration of water tested with hydrochloric acid solution in presence of methyl red (and methyl orange) indicator with subsequent blowing through of CO_2-free air.

The method principle is in transition of HCO_3^- ions containing in water tested into H_2CO_3 while adding hydrochloric acid. Simultaneously CO_3^{2-} ions, if any present in water, are transformed into CO_2.

10. Calcium and magnesium ions were determined by titrometric method (with Trilon B - disubstituted sodium bicarbonate of ethylenediaminetetraacetic acid).

11. SO_4^{2-} (sulphate) ions - by weighing method using $BaCl_2$.

12. Hydrocarbonates (HCO_3^-) and carbonates (CO_3^{2-}) - by reverse titration (adding the hydrochloric acid -HCl and titration of the excess of the acid with borax solution - $Na_2B_4O_7$)..

13. Chlorine ions (Cl^-) - by argentometric method using silver nitrate - $AgNO_3$.

14. Sodium and potassium ions (Na^++K^+) - by computation, by a difference between the sum of meq/l of anions and cations analytically found. Empirical coefficient (25) was used to recalculate *meq* into *mg*. For individual samples - on flaming photometer ARNO-4.

15. Water mineralization was estimated as a sum of major ions - anions and cations.

16. Biogenic elements (all compounds of nitrogen, phosphates, silicon, iron) were determined by photometric method using a KFK-3 photometer.

17. Fluorine (F) was determined calorimetrically, using zirconalizarine, and also by potentiometric method using an ion-selective electrode.

18. Oil products - by lamellar chromatography.

19. Phenols (volatile) - by spectrophotometric method (SF-16) using dimethylaminoantipyrine.

20. Pesticides (chlor- and phosphororganic) - by gas chromatographic method using a "Gasochrom-3700" device;

21. Heavy metals - by spectrographic method using a ISP-28, 30 type spectrograph, and also by atomic absorption method using a spectrophotometer.

Table of Water Quality Data Analyzed by Uzbeki Side

Sampling Point : Surkhandarya - Termez
Indicator :Mineralization (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	1,150	1,160	1,070	-	-	-	-	-	-	1,090	1,070	1,050	1,160	1,100	1,050
1975	1,150	1,120	1,020	1,040	929	-	-	-	-	1,060	935	978	1,150	1,029	929
1976	1,130	1,200	1,160	1,200	910	710	1,050	940	990	1,280	1,070	1,060	1,280	1,071	710
1977	-	1,350	-	1,230	1,320	-	-	-	-	1,160	1,200	-	1,350	1,268	1,160
1978	-	1,480	1,410	1,040	670	-	-	-	1,450	1,140	920	1,180	1,480	1,197	670
1979	-	860	-	-	-	1,040	1,380	-	583	1,170	-	-	1,380	1,069	583
1980	-	1,180	-	790	648	1,200	-	-	-	-	1,240	-	1,240	1,050	648
1981	-	1,209	-	1,289	696	1,038	-	1,313	1,395	1,191	1,073	1,231	1,395	1,183	696
1982	-	1,210	1,126	1,289	1,214	1,249	-	1,211	1,322	1,416	1,200	1,303	1,416	1,269	1,126
1983	-	1,318	1,272	-	1,348	1,208	-	1,158	1,201	1,388	1,353	1,285	1,388	1,292	1,158
1984	-	1,296	724	1,113	1,129	1,354	-	1,173	1,116	-	-	1,275	1,354	1,170	724
1985	-	1,211	1,135	-	1,290	1,256	-	902	1,131	-	-	1,419	1,419	1,220	902
1986	1,270	1,311	1,316	1,182	1,274	1,069	1,493	1,290	1,210	1,177	1,177	1,129	1,493	1,260	1,069
1987	1,199	1,210	1,173	1,244	734	413	1,141	1,148	1,369	1,134	1,234	1,165	1,369	1,111	413
1988	1,145	1,168	675	1,059	926	972	977	-	1,381	1,403	1,314	1,549	1,549	1,179	675
1989	1,061	1,183	1,438	1,091	1,079	1,171	1,491	1,918	1,307	1,137	-	-	1,918	1,373	1,079
1990	1,099	1,179	1,116	1,090	722	544	1,105	1,047	1,127	1,123	1,152	1,261	1,261	1,061	544
1991	1,276	1,235	1,160	1,147	1,075	1,077	1,110	1,115	885	844	883	1,200	1,276	1,084	844
1992	1,297	1,175	692	845	517	519	461	756	1,034	956	987	1,095	1,297	861	461
1993	1,234	1,135	959	1,017	984	450	-	-	1,407	1,422	1,249	-	1,422	1,116	450
1994	1,044	735	668	766	1,084	1,236	1,080	-	1,164	1,255	1,315	1,347	1,347	1,091	668
Max.	1,297	1,480	1,438	1,289	1,348	1,354	1,493	1,918	1,450	1,422	1,353	1,549	1,918	1,373	1,160
Ave.	1,171	1,187	1,066	1,084	976	971	1,129	1,164	1,181	1,186	1,140	1,220	1,378	1,145	789
Min.	1,044	735	668	766	517	413	461	756	583	844	883	978	1,150	861	413
No of Smpl	12	21	17	17	19	17	10	12	17	18	17	16	21	21	21

Sampling Point : Surkhandarya - Termez
Indicator : Total Hardness (meq/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	13.8	13.2	12.3	12.3	11.2	12.7	-	-	-	14.5	13.2	14.8	14.8	13.2	11.2
1975	15.8	13.3	11.4	13.2	12.8	-	-	-	-	15.1	13.5	14.0	15.8	13.6	11.4
1976	12.4	14.2	-	15.8	10.9	8.9	-	13.8	14.1	-	14.1	5.5	15.8	12.6	5.5
1977	-	13.2	-	11.5	13.9	-	-	-	-	13.9	14.2	-	14.2	13.5	11.5
1978	-	14.0	12.3	12.7	7.8	9.8	-	-	13.7	12.8	9.5	13.4	14.0	12.0	7.8
1979	-	12.5	-	-	-	11.4	10.1	-	13.8	14.4	-	-	14.4	12.8	10.1
1980	-	13.6	-	8.9	8.2	8.1	-	-	-	-	12.4	-	13.6	10.8	8.1
1981	-	13.8	-	14.3	7.4	11.1	-	13.8	15.0	13.7	14.0	13.7	15.0	13.2	7.4
1982	-	13.1	14.3	11.6	13.3	14.0	-	12.7	14.9	16.0	13.4	13.9	16.0	13.9	11.6
1983	-	12.3	12.2	-	13.5	13.8	-	13.9	13.7	14.9	14.2	-	14.9	13.7	12.2
1984	-	14.6	6.3	13.7	13.0	14.6	-	13.9	15.2	-	-	15.4	15.4	13.6	6.3
1985	-	12.7	12.6	-	14.3	13.7	-	8.5	15.4	-	-	15.2	15.4	13.5	8.5
1986	13.7	14.1	14.2	13.8	13.4	12.9	14.8	13.2	13.4	14.3	14.3	12.6	14.8	13.8	12.6
1987	14.9	16.6	15.5	16.8	11.4	5.3	16.0	-	18.4	15.2	15.2	14.8	18.4	14.9	5.3
1988	15.2	15.8	9.1	13.4	7.3	12.0	12.2	-	18.6	19.2	17.9	21.5	21.5	15.3	7.3
1989	14.3	17.0	19.6	13.6	13.9	15.3	19.6	19.8	17.3	15.0	-	-	19.8	17.1	13.6
1990	14.9	13.9	12.5	13.3	8.9	7.3	14.4	14.2	14.9	13.8	15.1	16.4	16.4	13.4	7.3
1991	16.7	14.9	15.2	14.9	5.6	14.5	13.6	13.6	15.0	13.5	12.9	14.6	16.7	13.8	5.6
1992	16.0	14.5	9.0	10.2	6.1	6.0	5.2	8.7	11.5	10.6	11.0	11.9	16.0	10.1	5.2
1993	13.7	12.3	11.0	10.9	11.1	4.5	-	-	12.1	13.1	12.8	-	13.7	11.3	4.5
1994	11.2	7.8	6.9	7.6	9.1	11.6	10.9	-	13.5	14.5	11.8	11.6	14.5	10.9	6.9
Max.	16.7	17.0	19.6	16.8	14.3	15.3	19.6	19.8	18.6	19.2	17.9	21.5	21.5	17.1	13.6
Ave.	14.4	13.7	12.2	12.7	10.7	10.9	13.0	13.3	14.7	14.4	13.5	14.0	15.8	13.2	8.6
Min.	11.2	7.8	6.3	7.6	5.6	4.5	5.2	8.5	11.5	10.6	9.5	5.5	13.6	10.1	4.5
No of Smpl	12	21	16	18	20	19	9	11	17	17	17	15	21	21	21

Sampling Point : Surkhandarya - Termez
Indicator : BOD5 (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	-	-	-	-	-			
1975	-	-	-	-	-	-	-	-	-	-	-	-			
1976	2.0	0.8	-	0.7	0.5	-	-	0.2	1.2	-	0.7	-	2.0	0.9	0.2
1977	-	0.8	-	0.2	0.5	-	-	-	-	0.4	0.3	-	0.8	0.5	0.2
1978	-	0.9	1.1	1.0	2.0	2.0	-	-	0.8	0.6	0.5	-	2.0	1.2	0.5
1979	-	1.2	-	-	-	1.1	1.7	-	8.1	0.8	-	-	8.1	3.5	0.8
1980	-	-	-	0.7	1.8	2.2	-	-	-	-	-	-	2.2	1.7	0.7
1981	-	1.0	-	0.9	0.9	1.1	-	1.8	-	-	0.2	0.8	1.8	1.1	0.2
1982	-	2.0	1.5	-	0.2	1.0	-	2.3	0.4	0.1	0.8	0.9	2.3	1.2	0.1
1983	-	-	0.7	-	0.8	1.3	-	1.1	2.1	0.6	0.5	-	2.1	1.2	0.5
1984	-	0.7	-	-	0.2	0.4	-	0.6	0.7	-	-	0.5	0.7	0.5	0.2
1985	1.9	1.0	0.9	-	0.8	0.5	-	1.8	1.1	-	-	1.0	1.9	1.1	0.5
1986	0.8	2.4	1.7	0.8	0.5	0.2	1.5	3.0	0.9	0.4	1.1	0.4	3.0	1.3	0.2
1987	-	2.0	0.5	0.6	1.2	1.4	0.6	2.6	0.1	-	0.2	-	2.6	1.2	0.1
1988	1.9	2.5	1.5	-	2.7	0.5	1.1	-	1.2	1.8	-	0.3	2.7	1.6	0.3
1989	1.0	4.0	1.9	1.3	-	1.2	2.1	0.4	1.0	0.9	-	-	4.0	1.9	0.4
1990	0.1	0.6	0.6	0.5	3.4	0.8	1.0	2.1	0.5	0.4	0.2	1.2	3.4	1.2	0.2
1991	2.5	2.3	0.9	1.9	0.4	3.2	1.4	2.0	0.9	1.2	1.3	1.7	3.2	1.7	0.4
1992	0.1	1.9	0.4	0.3	1.4	2.0	3.2	2.8	0.4	3.2	0.6	0.6	3.2	1.7	0.3
1993	1.6	2.5	0.4	1.5	-	1.2	-	-	0.5	1.8	1.8	-	2.5	1.5	0.4
1994	1.3	1.0	0.5	1.8	1.6	0.8	0.8	-	1.3	0.3	0.4	1.1	1.8	1.0	0.3
Max.	2.5	4.0	1.9	1.9	3.4	3.2	3.2	3.0	8.1	3.2	1.8	1.7	8.1	3.5	0.8
Ave.	1.3	1.6	1.0	0.9	1.2	1.2	1.5	1.7	1.3	1.0	0.7	0.9	2.6	1.4	0.3
Min.	0.1	0.6	0.4	0.2	0.2	0.2	0.6	0.2	0.1	0.1	0.2	0.3	0.7	0.5	0.1
No of Smpl	10	17	13	13	16	17	9	12	16	13	13	10	19	19	19

Sampling Point : Surkhandarya - Termez
Indicator : Cr^{6+} (ug/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	-	-	-	-	-			
1975	-	-	-	-	-	-	-	-	-	-	-	-			
1976	-	-	-	-	-	-	-	-	-	-	-	-			
1977	-	-	-	-	-	-	-	-	-	-	-	-			
1978	-	-	-	-	-	-	-	-	-	-	-	-			
1979	-	-	-	-	-	-	-	-	-	-	-	-			
1980	-	-	-	-	-	-	-	-	-	-	-	-			
1981	-	-	-	-	-	-	-	-	-	-	-	-			
1982	-	-	-	-	-	-	-	-	-	-	-	-			
1983	-	-	-	-	-	-	-	-	-	-	-	-			
1984	-	-	-	-	-	-	-	-	-	-	-	-			
1985	-	-	-	-	-	-	-	-	-	-	-	-			
1986	-	-	-	-	-	-	-	-	-	-	-	-			
1987	-	-	-	-	-	-	-	-	-	-	-	-			
1988	1.0	0.0	1.0	1.2	0.0	0.8	0.6	-	0.6	3.1	1.3	1.3	3.1	1.2	0.0
1989	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0
1990	2.8	1.0	5.0	1.3	0.6	3.9	-	1.3	0.8	0.3	1.6	1.3	5.0	2.0	0.3
1991	2.1	1.0	2.2	0.3	2.3	0.0	2.1	2.7	0.7	1.5	1.2	0.7	2.7	1.5	0.0
1992	1.2	3.9	1.5	2.1	0.4	1.2	1.5	0.0	1.5	1.5	3.0	2.1	3.9	1.9	0.0
1993	4.5	2.1	1.2	0.7	1.2	1.5	-	-	1.2	1.5	2.1	-	4.5	1.8	0.7
1994	2.4	2.1	1.0	0.7	1.5	-	-	-	1.2	2.0	-	-	2.4	1.6	0.7
Max.	4.5	3.9	5.0	2.1	2.3	3.9	2.1	2.7	1.5	3.1	3.0	2.1	5.0	2.0	0.7
Ave.	2.3	1.7	2.0	1.1	1.0	1.5	1.4	1.3	1.0	1.7	1.8	1.4	3.1	1.4	0.2
Min.	1.0	0.0	1.0	0.3	0.0	0.0	0.6	0.0	0.6	0.3	1.2	0.7	0.0	0.0	0.0
No of Smpl	6	6	6	6	6	5	3	3	6	6	5	4	7	7	7

Sampling Point : Amndarya river - Termez
Indicator : Mineralization (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974															
1975															
1976	-	922	1,323	1,363	713	576	650	636	551	702	741	746	1,363	857	551
1977	773	687	760	681	727	558	328	454	369	725	639	626	773	611	328
1978	638	807	694	649	433	457	452	456	505	515	566	556	807	575	433
1979	-	1,356	698	-	-	586	377	391	500	746	729	-	1,356	749	377
1980	-	786	726	737	543	416	396	384	413	-	808	-	808	602	384
1981	671	860	809	730	559	482	399	601	583	634	688	711	860	660	399
1982	764	822	805	827	592	626	507	501	649	645	685	834	834	694	501
1983	848	749	807	1,051	531	479	389	409	378	329	679	648	1,051	625	329
1984	752	818	666	657	461	412	377	368	372	461	681	578	818	556	368
1985	794	687	614	608	552	448	474	356	594	594	620	639	794	582	356
1986	646	726	721	681	701	514	377	428	458	479	474	528	726	568	377
1987	621	625	675	563	566	364	304	416	365	545	-	576	675	516	304
1988	644	669	568	563	511	392	335	321	539	669	663	620	669	543	321
1989	724	703	864	701	728	487	437	452	492	-	-	-	864	636	437
1990	978	849	891	840	526	433	339	368	507	615	703	668	978	643	339
1991	520	590	-	900	880	960	750	700	410	990	910	740	990	802	410
1992	681	735	687	814	544	572	445	453	461	527	887	962	962	671	445
1993	-	-	889	1,288	849	842	597	701	786	960	890	-	1,288	909	597
1994	-	-	919	1,133	962	749	618	494	628	-	-	-	1,133	830	494
Max.	978	1,356	1,323	1,363	962	960	750	701	786	990	910	962	1,363	909	597
Ave.	718	788	784	821	632	545	450	468	503	634	710	674	934	665	408
Min.	520	590	568	563	433	364	304	321	365	329	474	528	669	516	304
No of Smpl	14	17	18	18	18	19	19	19	19	16	16	14	19	19	19

Sampling Point : Amndarya river - Termez
Indicator : Total Hardness

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974															
1975															
1976	-	9.3	7.8	8.0	6.4	5.5	5.2	4.9	4.2	5.7	6.9	6.6	9.3	6.7	4.2
1977	6.6	7.4	6.4	5.9	5.9	5.4	3.1	3.8	3.9	5.4	6.4	5.8	7.4	5.6	3.1
1978	5.9	6.7	5.6	5.6	4.8	4.5	3.2	4.4	4.7	4.7	5.8	5.5	6.7	5.2	3.2
1979	-	6.5	6.2	-	-	4.9	3.7	3.5	4.6	5.4	6.3	-	6.5	5.3	3.5
1980	-	7.3	6.7	5.9	4.5	3.6	3.5	3.5	3.9	-	5.4	-	7.3	5.2	3.5
1981	5.7	6.6	6.2	5.4	4.8	4.4	3.4	5.4	4.3	5.3	6.2	6.0	6.6	5.4	3.4
1982	6.3	6.8	6.6	6.4	4.9	4.2	3.9	3.5	4.5	6.9	4.9	6.1	6.9	5.5	3.5
1983	5.8	5.5	6.2	6.5	4.6	4.6	4.1	3.7	3.7	5.2	6.4	6.1	6.5	5.3	3.7
1984	6.9	7.0	5.9	6.0	4.6	4.3	3.9	3.2	3.8	4.7	6.5	5.1	7.0	5.2	3.2
1985	5.8	7.1	5.6	5.6	5.6	3.9	4.9	3.3	5.3	5.6	7.3	5.9	7.3	5.6	3.3
1986	6.2	5.4	5.6	5.9	5.7	7.1	3.8	4.5	4.2	5.2	5.4	5.0	7.1	5.4	3.8
1987	6.0	6.6	7.6	7.2	7.7	4.6	3.9	5.8	4.9	7.5	-	7.2	7.7	6.4	3.9
1988	8.2	8.7	7.0	6.2	6.5	4.9	4.2	4.1	7.3	9.8	7.9	8.2	9.8	7.1	4.1
1989	9.1	8.8	10.7	9.4	9.6	6.4	5.8	4.6	5.7	-	-	-	10.7	8.0	4.6
1990	13.1	10.4	11.4	10.9	6.6	5.4	4.9	4.6	5.1	7.1	8.0	7.8	13.1	7.9	4.6
1991	8.8	9.2	-	7.9	5.7	5.7	4.7	4.4	7.1	7.0	6.2	8.0	9.2	6.8	4.4
1992	8.2	8.8	8.9	8.6	6.3	6.5	4.8	5.1	4.4	5.2	9.0	10.0	10.0	7.3	4.4
1993	-	-	9.2	12.6	9.2	9.3	6.9	7.1	9.7	9.9	10.4	-	12.6	9.7	6.9
1994	-	-	0.5	11.1	8.0	6.9	5.1	5.0	5.8	-	-	-	11.1	6.7	0.5
Max.	13.1	10.4	11.4	12.6	9.6	9.3	6.9	7.1	9.7	9.9	10.4	10.0	13.1	9.7	6.9
Ave.	7.3	7.5	6.9	7.5	6.2	5.4	4.4	4.4	5.1	6.3	6.8	6.7	8.6	6.3	3.8
Min.	5.7	5.4	0.5	5.4	4.5	3.6	3.1	3.2	3.7	4.7	4.9	5.0	6.5	5.2	0.5
No of Smpl	14	17	18	18	18	19	19	19	19	16	16	14	19	19	19

Sampling Point : Amndarya river - Termez
Indicator : BOD5 (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1,974.0															
1,975.0															
1,976.0	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0
1,977.0	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0
1,978.0	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0
1,979.0	-	1.6	1.3	-	-	5.2	-	1.1	1.5	1.3	1.6	-	5.2	2.4	1.1
1,980.0	-	-	1.5	0.6	2.1	0.5	0.4	1.0	-	-	-	-	2.1	1.2	0.4
1,981.0	1.0	1.0	2.1	1.2	5.2	0.7	-	1.7	1.3	2.1	-	1.5	5.2	2.2	0.7
1,982.0	1.2	2.1	0.6	0.9	2.2	0.9	1.6	1.2	0.3	3.1	1.0	1.2	3.1	1.5	0.3
1,983.0	0.5	-	1.1	0.7	1.8	-	1.8	1.2	2.5	1.2	1.1	0.9	2.5	1.5	0.7
1,984.0	9.8	1.0	0.4	-	0.2	2.1	1.2	1.6	1.2	0.5	1.4	0.7	9.8	1.8	0.2
1,985.0	1.0	2.2	0.9	0.3	0.3	0.1	1.3	0.8	0.5	0.6	0.2	0.9	2.2	0.9	0.1
1,986.0	2.5	2.7	2.4	2.5	1.2	0.4	1.2	-	2.0	2.0	1.6	1.8	2.7	1.9	0.4
1,987.0	1.9	1.5	0.5	0.2	0.5	0.5	1.0	1.9	0.1	1.4	-	-	1.9	1.0	0.1
1,988.0	0.5	1.6	3.1	0.8	-	1.7	2.9	1.9	0.1	0.3	-	-	3.1	1.7	0.1
1,989.0	1.8	0.5	1.1	0.8	0.7	3.8	1.5	0.7	0.4	-	-	-	3.8	1.5	0.4
1,990.0	1.7	0.9	1.6	0.7	4.2	0.6	0.6	0.5	0.8	0.3	0.5	0.3	4.2	1.3	0.3
1,991.0	2.0	0.9	-	1.6	3.9	2.9	0.9	2.0	1.7	1.6	-	0.1	3.9	2.0	0.1
1,992.0	1.3	0.5	0.1	0.5	1.7	0.4	0.6	1.4	0.4	0.9	1.5	0.5	1.7	0.9	0.1
1,993.0		-	2.7	1.8	2.6	0.8	0.7	-	-	-	0.9	-	2.7	1.7	0.7
1,994.0	-	-	-	1.4	1.0	2.8	4.0	3.0	2.3	-	-	-	4.0	2.6	1.0
Max.	9.8	2.7	3.1	2.5	5.2	5.2	4.0	3.0	2.5	3.1	1.6	1.8	9.8	2.6	1.1
Ave.	2.1	1.4	1.4	1.0	2.0	1.6	1.4	1.4	1.1	1.3	1.1	0.9	3.1	1.4	0.4
Min.	0.5	0.5	0.1	0.2	0.2	0.1	0.4	0.5	0.1	0.3	0.2	0.1	0.0	0.0	0.0
No of Smpl	12	12	14	14	14	15	14	14	14	12	9	9	19	19	19

Sampling Point : Amndarya river - Termez
Indicator : Cr^{6+} (ug/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974															
1975															
1976	-	-	-	-	-	-	-	-	-	-	-	-			
1977	-	-	-	-	-	-	-	-	-	-	-	-			
1978	-	-	-	-	-	-	-	-	-	-	-	-			
1979	-	-	-	-	-	-	-	-	-	-	-	-			
1980	-	-	-	-	-	-	-	-	-	-	-	-			
1981	-	-	-	-	-	-	-	-	-	-	-	-			
1982	-	-	-	-	-	-	-	-	-	-	-	-			
1983	-	-	-	-	-	-	-	-	-	-	-	-			
1984	-	-	-	-	-	-	-	-	-	-	-	-			
1985	-	-	-	-	-	-	-	-	-	-	-	-			
1986	-	-	-	-	-	-	-	-	-	-	-	-			
1987	4.8	3.7	0.0	0.0	1.8	1.8	0.0	0.0	0.0	3.7	-	6.5	6.5	2.2	0.0
1988	1.0	8.8	2.9	0.3	0.3	0.6	2.3	1.0	0.3	2.1	1.8	1.3	8.8	2.5	0.3
1989	1.8	0.5	1.1	0.8	0.7	3.8	1.5	0.7	0.4	-	-	-	3.8	1.5	0.4
1990	1.7	0.9	1.6	0.7	4.2	0.6	0.6	0.5	0.8	0.3	0.5	0.3	4.2	1.3	0.3
1991	3.4	1.3	-	0.3	1.0	1.8	1.3	2.1	1.0	2.1	0.7	-	3.4	1.5	0.3
1992		3.6		3.9	3.3	1.8	5.1	-	1.5	3.3	1.8	3.6	5.1	3.3	1.5
1993		-	-	-	-	-	-	-	-	-	-	-			
1994		-	-	-	-	-	-	-	-	-	-	-			
Max.	4.8	8.8	2.9	3.9	4.2	3.8	5.1	2.1	1.5	3.7	1.8	6.5	8.8	3.3	1.5
Ave.	2.5	3.1	1.4	1.0	1.9	1.7	1.8	0.9	0.7	2.3	1.2	2.9	5.3	2.0	0.5
Min.	1.0	0.5	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.3	0.5	0.3	3.4	1.3	0.0
No of Smpl	5	6	4	6	6	6	6	5	6	5	4	4	6	6	6

Sampling Point : Amudarya - Tuyamuyun gorge (8Km downstream the dam)
Indicator : Mineralization (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	1,530	-	1,137	922	688	-	-	-	-	-	1,530	1,161	688
1975	-	-	1,330	1,120	678	713	442	462	664	672	864	859	1,330	830	442
1976	907	1,062	1,519	1,605	899	565	665	575	616	859	910	876	1,605	980	565
1977	-	-	1,205	1,143	1,127	-	551	572	-	713	758	1,054	1,205	925	551
1978	-	-	1,618	832	744	561	867	462	660	771	852	-	1,618	899	462
1979	-	-	1,312	1,116	794	761	552	556	-	1,008	925	-	1,312	926	552
1980	-	-	-	1,420	938	871	565	617	761	1,274	1,006	-	1,420	986	565
1981	1,162	1,373	1,470	1,249	920	662	543	734	-	578	-	-	1,470	1,000	543
1982	984	1,030	1,284	1,639	1,166	943	837	692	-	1,469	1,418	-	1,639	1,212	692
1983	1,122	1,158	1,482	2,147	1,393	727	1,042	701	-	803	1,039	-	2,147	1,264	701
1984	-	-	1,318	1,151	1,109	805	552	555	501	-	1,079	-	1,318	932	504
1985	-	-	1,076	1,402	1,330	1,048	791	946	769	-	867	-	1,402	1,070	769
1986	-	-	1,236	1,569	1,505	1,129	609	622	685	-	1,079	-	1,569	1,111	609
1987	-	-	1,231	1,028	862	601	605	574	666	743	738	-	1,231	828	574
1988	-	-	1,117	1,127	748	873	801	708	698	815	987	-	1,127	900	698
1989	-	-	1,185	1,247	1,344	1,030	1,010	845	697	1,409	1,206	-	1,409	1,138	697
1990	-	-	1,323	1,100	839	688	533	526	723	690	795	-	1,323	854	526
1991	-	-	889	1,288	849	842	597	701	786	960	890	-	1,288	909	597
1992	-	-	919	1,133	962	749	618	494	628	-	-	-	1,133	830	494
1993	-	-	1,159	-	895	674	-	805	980	-	1,127	-	1,159	971	674
1994	-	-	1,331	-	943	773	633	627	700	-	-	-	1,331	905	627
Max.	1,162	1,373	1,618	2,147	1,505	1,129	1,042	946	980	1,469	1,418	1,054	2,147	1,264	769
Ave.	1,044	1,156	1,277	1,295	1,009	797	675	639	702	912	973	930	1,408	982	597
Min.	907	1,030	889	832	678	561	442	462	504	578	738	859	1,127	828	442
No of Smpl	4	4	20	18	21	20	20	20	15	14	17	3	21	21	21

Sampling Point : Amudarya - Tuyamuyun gorge (8Km downstream the dam)
Indicator : Total Hardness (meq/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	10.8	-	9.7	11.8	5.3	-	-	-	-	-	11.8	9.9	5.3
1975	-	-	13.7	11.0	6.2	6.1	4.0	5.9	5.5	5.5	8.0	7.3	13.7	7.9	4.0
1976	8.2	10.8	14.2	12.4	7.3	6.4	6.4	5.0	5.3	7.0	6.9	7.9	14.2	8.7	5.0
1977	-	-	9.6	8.7	9.5	-	4.5	5.6	-	6.2	6.6	7.0	9.6	7.5	4.5
1978	-	-	11.6	6.0	6.2	5.2	7.1	4.4	5.7	6.2	-	-	11.6	7.1	4.4
1979	-	-	10.9	10.2	6.8	6.2	4.2	5.4	-	7.9	8.0	-	10.9	7.8	4.2
1980	-	-	-	10.3	7.2	6.4	4.7	5.3	6.5	9.3	-	8.5	10.3	7.6	4.7
1981	-	-	7.9	10.5	9.9	7.2	4.5	4.9	4.7	-	8.5	-	10.5	7.6	4.5
1982	8.2	8.2	10.1	11.7	7.6	6.1	6.6	5.5	-	10.9	10.1	-	11.7	8.9	5.5
1983	7.7	8.8	10.0	14.6	11.5	6.7	8.4	6.6	-	6.3	8.1	-	14.6	9.6	6.3
1984	-	-	7.9	10.5	9.9	7.2	4.5	4.9	4.7	-	8.5	-	10.5	7.6	4.5
1985	-	-	8.5	11.6	9.7	7.2	5.9	6.6	6.6	-	8.5	-	11.6	8.5	5.9
1986	-	-	9.9	12.9	11.6	7.9	4.8	5.3	6.1	-	11.5	-	12.9	9.2	4.8
1987	-	-	13.3	11.5	11.2	7.5	6.8	5.9	7.9	9.1	8.7	-	13.3	9.5	5.9
1988	-	-	11.2	12.7	5.9	3.7	10.3	8.6	8.9	11.1	11.4	-	12.7	9.7	3.7
1989	-	-	14.2	15.3	11.2	11.1	11.0	6.8	9.1	-	-	-	15.3	11.8	6.8
1990	-	-	12.8	10.7	8.2	8.2	6.6	4.8	8.1	8.3	9.0	-	12.8	9.0	4.8
1991	-	-	9.2	12.6	9.2	9.3	6.9	7.1	9.7	9.9	10.4	-	12.6	9.7	6.9
1992	-	-	0.5	11.1	8.0	6.9	5.1	5.0	5.8	-	-	-	11.1	6.7	0.5
1993	-	-	9.3	-	6.5	5.9	-	6.8	7.5	-	9.5	-	9.5	7.9	5.9
1994	-	-	10.4	-	6.5	5.9	4.8	4.9	6.9	-	-	-	10.4	7.1	4.8
Max.	8.2	10.8	14.2	15.3	11.6	11.8	11.0	8.6	9.7	11.1	11.5	8.5	15.3	11.8	6.9
Ave.	8.0	9.3	10.3	11.4	8.6	7.1	6.1	5.8	6.8	8.1	8.9	7.7	12.0	8.5	4.9
Min.	7.7	8.2	0.5	6.0	5.9	3.7	4.0	4.4	4.7	5.5	6.6	7.0	9.5	6.7	0.5
No of Smpl	3	3	20	18	21	20	20	20	16	12	15	4	21	21	21

Sampling Point : Amudarya - Tuyamuyun gorge (8Km downstream the dam)
Indicator : BOD5 (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	-	-	-	-	-			
1975	-	-	-	-	-	-	-	-	-	-	-	-			
1976	-	-	-	-	-	-	-	-	-	-	-	-			
1977	-	-	-	-	-	-	-	-	-	-	-	-			
1978	-	-	-	-	-	-	-	-	-	-	-	-			
1979	-	-	0.4	0.3	0.3	0.6	0.3	0.4	-	0.8	2.9	-	2.9	1.0	0.3
1980	-	-	-	0.7	-	2.5	2.4	1.3	3.9	-	-	1.4	3.9	2.3	0.7
1981	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0
1982	-	1.2	1.4	3.0	4.2	3.9	0.3	6.0	-	0.4	1.9	-	6.0	2.8	0.3
1983	0.7	1.9	1.9	2.8	5.5	2.3	2.1	6.9	-	1.4	1.8	-	6.9	3.4	1.4
1984	-	-	6.2	2.9	2.6	1.5	1.9	5.2	2.5	-	1.4	-	6.2	3.4	1.4
1985	-	-	2.3	9.2	1.8	-	1.6	4.1	4.8	-	1.3	-	9.2	4.3	1.3
1986	-	-	-	2.3	-	0.9	1.8	1.8	1.8	-	-	-	2.3	1.8	0.9
1987	-	-	1.7	1.3	0.9	1.1	0.3	1.3	-	2.5	1.1	-	2.5	1.4	0.3
1988	-	-	-	1.9	3.2	2.5	1.5	1.5	0.6	0.9	0.1	-	3.2	1.7	0.1
1989	-	-	3.3	3.4	3.9	-	3.4	1.6	-	-	-	-	3.9	3.3	1.6
1990	-	-	3.3	1.8	2.2	0.1	2.5	0.7	2.4	1.6	0.9	-	3.3	1.9	0.1
1991	-	-	2.7	1.8	2.6	0.8	0.7	-	-	-	0.9	-	2.7	1.7	0.7
1992	-	-	-	1.4	1.0	2.8	4.0	3.0	2.3	-	-	-	4.0	2.6	1.0
1993	-	-	0.6	-	1.1	2.9	-	1.1	1.6	-	1.0	-	2.9	1.6	0.6
1994	-	-	1.2	-	0.7	0.7	0.6	1.4	0.4	-	-	-	1.4	0.9	0.4
Max.	0.7	1.9	6.2	9.2	5.5	3.9	4.0	6.9	4.8	2.5	2.9	1.4	9.2	4.3	1.6
Ave.	0.7	1.6	2.3	2.5	2.3	1.7	1.7	2.6	2.3	1.3	1.3	1.4	3.8	2.1	0.7
Min.	0.7	1.2	0.4	0.3	0.3	0.1	0.3	0.4	0.4	0.4	0.1	1.4	0.0	0.0	0.0
No of Smpl	1	2	11	13	13	13	14	14	9	6	10	1	16	16	16

Sampling Point : Amudarya - Tuyamuyun gorge (8Km downstream the dam)
Indicator : Cr^{6+} (ug/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	-	-	-	-	-			
1975	-	-	-	-	-	-	-	-	-	-	-	-			
1976	-	-	-	-	-	-	-	-	-	-	-	-			
1977	-	-	-	-	-	-	-	-	-	-	-	-			
1978	-	-	-	-	-	-	-	-	-	-	-	-			
1979	-	-	-	-	-	-	-	-	-	-	-	-			
1980	-	-	-	-	-	-	-	-	-	-	-	-			
1981	-	-	-	-	-	-	-	-	-	-	-	-			
1982	-	-	-	-	-	-	-	-	-	-	-	-			
1983	-	-	-	-	-	-	-	-	-	-	-	-			
1984	-	-	-	-	-	-	-	-	-	-	-	-			
1985	-	-	-	-	-	-	-	-	-	-	-	-			
1986	-	-	-	-	-	-	-	-	-	-	-	-			
1987	-	-	-	-	-	-	-	-	-	-	-	-			
1988	-	-	-	-	-	-	-	-	-	-	-	-			
1989	-	-	0.0	7.6	-	6.0	-	-	-	-	-	-	7.6	5.3	0.0
1990	-	-	3.3	1.8	2.2	0.1	2.5	0.7	2.4	1.6	0.9	-	3.3	1.9	0.1
1991	-	-	2.7	1.8	2.6	0.8	0.7	-	-	-	0.9	-	2.7	1.7	0.7
1992	-	-	-	-	-	-	-	-	-	-	-	-			
1993	-	-	5.0	-	-	-	-	-	-	-	-	-	5.0	5.0	5.0
1994	-	-	0.7	-	1.2	0.0	1.0	0.0	0.0	-	-	-	1.2	0.6	0.0
Max.	0.0	0.0	5.0	7.6	2.6	6.0	2.5	0.7	2.4	1.6	0.9	0.0	7.6	5.3	5.0
Ave.	-	-	2.3	3.7	2.0	1.7	1.4	0.4	1.2	1.6	0.9	-	4.0	2.9	1.2
Min.	0.0	0.0	0.0	1.8	1.2	0.0	0.7	0.0	0.0	1.6	0.9	0.0	1.2	0.6	0.0
No of Smpl	0	0	5	3	3	4	3	2	2	1	2	0	5	5	5

Sampling Point : Amndary - Nukus (12Km downstream from Nukus - Sumanbay)
Indicator: Mineralization (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	480	600	726	-	799	799	681	480
1975	-	795	518	726	654	557	483	528	748	-	-	793	795	660	483
1976	-	-	-	-	-	-	731	669	615	799	801	1,276	1,276	881	615
1977	1,237	1,089	906	870	1,438	951	564	526	547	737	821	1,534	1,534	960	526
1978	1,181	1,288	1,350	1,266	766	605	660	526	623	711	824	756	1,350	894	526
1979	822	990	1,108	1,214	925	861	576	617	779	1,185	1,080	1,146	1,214	975	576
1980	998	1,397	1,236	1,546	1,364	742	617	607	811	959	2,111	1,148	2,111	1,221	607
1981	899	1,706	2,170	1,588	944	724	691	724	808	1,187	1,167	1,249	2,170	1,261	691
1982	1,218	1,091	1,463	2,009	1,653	1,152	910	889	805	1,187	1,508	-	2,009	1,334	805
1983	1,836	1,342	1,112	1,326	1,514	1,024	1,065	789	1,568	911	953	1,252	1,836	1,224	789
1984	1,483	-	1,345	1,113	1,310	975	638	-	622	640	-	1,057	1,483	1,020	622
1985	1,187	1,117	1,033	1,510	1,044	1,280	772	738	802	973	1,171	1,243	1,510	1,099	738
1986	1,300	1,582	1,340	2,312	1,691	1,764	1,176	760	1,092	1,339	1,210	1,177	2,312	1,480	760
1987	932	930	1,019	1,186	1,212	757	743	800	676	717	866	930	1,212	921	676
1988	1,027	1,290	953	1,286	928	837	447	596	736	897	1,021	1,037	1,290	943	447
1989	795	1,134	1,113	1,409	1,254	1,326	810	400	838	257	1,199	1,090	1,409	1,020	257
1990	1,065	1,025	1,110	1,206	1,539	573	618	610	1,006	804	846	963	1,539	987	573
1991	878	727	810	-	941	955	648	688	630	856	862	877	955	814	630
1992	925	924	1,037	1,296	1,312	802	669	526	679	845	931	966	1,312	942	526
1993	969	1,068	1,224	2,011	1,639	714	641	660	1,021	846	1,091	-	2,011	1,175	641
1994	1,732	1,102	1,111	1,540	1,629	966	713	690	794	1,111	1,275	1,119	1,732	1,149	690
Max.	1,836	1,706	2,170	2,312	1,691	1,764	1,176	889	1,568	1,339	2,111	1,534	2,312	1,480	805
Ave.	1,138	1,144	1,156	1,412	1,250	924	709	641	800	884	1,097	1,074	1,517	1,030	603
Min.	795	727	518	726	654	557	447	400	547	257	801	756	795	660	257
No of Smpl	18	18	19	18	19	19	20	20	21	20	18	19	21	21	21

Sampling Point : Amndary - Nukus (12Km downstream from Nukus - Sumanbay)
Indicator : Total Harrdness (meq/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	5.3	6.5	9.2	-	9.9	9.9	8.2	5.3
1975	-	7.0	4.9	6.6	6.7	5.6	4.1	5.2	-	-	-	-	7.0	5.9	4.1
1976	-	-	-	-	-	-	-	-	4.5	6.5	8.3	8.4	8.4	7.2	4.5
1977	9.6	8.5	6.7	-	-	7.2	5.0	4.6	5.0	6.4	6.8	-	9.6	6.6	4.6
1978	8.5	-	-	10.2	6.8	5.6	5.6	4.5	6.6	6.6	7.2	6.9	10.2	7.0	4.5
1979	7.4	9.4	10.0	10.6	6.8	6.9	5.0	5.2	6.4	7.8	8.5	7.7	10.6	7.9	5.0
1980	7.8	11.4	-	18.9	6.8	5.8	-	5.4	6.9	6.9	8.8	9.3	18.9	9.9	5.4
1981	9.7	12.9	16.8	11.2	7.5	5.7	5.8	5.9	6.1	9.2	9.9	9.2	16.8	9.8	5.7
1982	8.5	9.4	11.2	13.7	10.4	8.9	6.3	5.4	5.1	8.9	10.7	-	13.7	9.4	5.1
1983	14.4	10.3	8.7	10.9	12.7	8.6	9.3	5.9	13.9	7.3	8.8	10.4	14.4	10.1	5.9
1984	11.1	-	9.9	-	10.9	7.8	5.9	-	5.1	5.7	-	9.5	11.1	8.2	5.1
1985	9.9	10.1	8.8	11.7	10.9	9.8	6.8	5.7	7.7	7.2	8.8	10.2	11.7	9.1	5.7
1986	10.1	11.3	12.9	22.6	17.7	14.4	9.2	5.9	7.8	10.3	12.7	11.5	22.6	13.2	5.9
1987	9.4	10.9	13.0	14.7	15.3	9.3	9.4	10.8	8.4	8.9	9.7	12.1	15.3	11.5	8.4
1988	13.0	14.6	11.8	12.4	9.5	9.5	4.8	7.4	9.7	10.4	12.2	12.0	14.6	10.7	4.8
1989	10.4	14.9	14.4	15.6	16.5	14.4	8.7	27.9	10.3	21.5	-	-	27.9	17.2	8.7
1990	13.5	13.8	14.5	16.1	18.2	6.8	7.1	7.5	12.8	8.7	10.7	11.8	18.2	12.2	6.8
1991	10.2	8.1	9.9	9.7	-	11.6	11.8	8.1	8.5	11.4	10.2	9.4	11.8	10.0	8.1
1992	9.8	12.0	12.3	14.2	9.6	6.8	5.6	4.8	5.9	6.9	8.0	8.0	14.2	9.0	4.8
1993	9.0	9.0	10.1	13.8	12.6	6.1	5.5	5.3	8.3	8.8	8.9	-	13.8	9.3	5.3
1994	10.2	8.7	9.4	10.5	12.1	7.3	5.5	6.0	6.1	7.7	10.5	7.8	12.1	8.6	5.5
Max.	14.4	14.9	16.8	22.6	18.2	14.4	11.8	27.9	13.9	21.5	12.7	12.1	27.9	17.2	8.7
Ave.	10.1	10.7	10.9	13.1	11.2	8.3	6.7	7.2	7.6	8.8	9.5	9.6	13.9	9.6	5.7
Min.	7.4	7.0	4.9	6.6	6.7	5.6	4.1	4.5	4.5	5.7	6.8	6.9	7.0	5.9	4.1
No of Smpl	18	17	17	17	17	19	18	19	20	20	17	16	21	21	21

Sampling Point : Amndary - Nukus (12Km downstream from Nukus - Sumanbay)
Indicator : BOD5 (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	1.2	1.2	0.8	-	0.6	1.2	1.0	0.6
1975	-	-	-	-	-	-	-	0.5	-	-	-	-	0.5	0.5	0.5
1976	-	-	-	-	-	-	-	-	0.3	0.4	1.0	0.4	1.0	0.6	0.3
1977	0.5	1.0	3.3	-	-	2.6	2.6	5.7	-	-	0.0	-	5.7	3.0	0.0
1978	-	-	-	2.1	2.0	1.3	0.1	0.2	1.1	0.2	-	0.2	2.1	1.0	0.1
1979	-	1.2	0.9	1.4	1.1	1.1	-	1.3	-	-	0.4	1.9	1.9	1.2	0.4
1980	0.4	0.4	-	2.0	2.2	5.1	-	1.6	2.6	3.6	-	1.0	5.1	2.6	1.0
1981	1.9	1.1	1.8	3.6	3.4	2.9	3.9	2.3	2.8	2.3	1.6	2.4	3.9	2.7	1.6
1982	1.6	1.6	1.2	1.1	1.0	0.3	0.7	0.3	0.1	1.5	2.1	-	2.1	1.1	0.1
1983	1.9	1.7	1.6	0.9	1.8	-	2.4	2.2	1.5	2.2	1.3	0.4	2.4	1.7	0.4
1984	0.9	-	0.5	2.7	0.8	0.6	1.7	0.7	-	0.6	-	-	2.7	1.3	0.5
1985	-	1.3	0.8	1.4	5.6	1.7	0.9	0.9	0.7	0.7	0.8	0.2	5.6	1.7	0.2
1986	-	0.2	0.6	0.6	0.7	0.1	1.6	1.7	0.3	0.4	0.7	0.9	1.7	0.8	0.1
1987	0.6	1.7	0.9	1.3	-	0.8	1.1	0.5	0.2	0.5	-	-	1.7	1.0	0.2
1988	-	0.1	0.4	-	0.8	0.0	0.7	1.0	0.1	0.2	0.5	-	1.0	0.5	0.0
1989	0.2	0.2	0.5	0.3	0.1	0.3	0.9	0.3	0.5	-	-	-	0.9	0.4	0.1
1990	1.7	1.3	1.1	1.8	-	0.6	-	1.2	0.7	1.1	1.6	0.5	1.8	1.2	0.5
1991	-	-	0.7	0.6	1.4	0.9	0.9	0.2	0.5	-	0.2	0.2	1.4	0.7	0.2
1992	0.5	4.5	2.4	0.5	0.5	0.4	0.9	0.4	0.6	1.6	0.3	1.2	4.5	1.5	0.3
1993	0.7	0.6	0.8	0.4	0.4	0.7	0.5	0.4	0.7	0.8	0.4	-	0.8	0.6	0.4
1994	0.9	1.2	1.2	0.6	1.5	0.8	1.4	0.9	0.8	1.5	1.2	1.1	1.5	1.1	0.6
Max.	1.9	4.5	3.3	3.6	5.6	5.1	3.9	5.7	2.8	3.6	2.1	2.4	5.7	3.0	1.6
Ave.	1.0	1.2	1.2	1.3	1.6	1.2	1.4	1.2	0.9	1.2	0.9	0.8	2.4	1.2	0.4
Min.	0.2	0.1	0.4	0.3	0.1	0.0	0.1	0.2	0.1	0.2	0.0	0.2	0.5	0.4	0.0
No of Smpl	12	15	16	16	15	17	15	20	17	16	14	13	21	21	21

Sampling Point : Amndary - Nukus (12Km downstream from Nukus - Sumanbay)
Indicator : Cr^{6+} (ug/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	-	-	-	-	-			
1975	-	-	-	-	-	-	-	-	-	-	-	-			
1976	-	-	-	-	-	-	-	-	-	-	-	-			
1977	-	-	-	-	-	-	-	-	-	-	-	-			
1978	-	-	-	-	-	-	-	-	-	-	-	-			
1979	-	-	-	-	-	-	-	-	-	-	-	-			
1980	-	-	-	-	-	-	-	-	-	-	-	-			
1981	-	-	-	-	-	-	-	-	-	-	-	-			
1982	-	-	-	-	-	-	-	-	-	-	-	-			
1983	-	-	-	-	-	-	-	-	-	-	-	-			
1984	-	-	-	-	-	-	-	-	-	-	-	-			
1985	-	-	-	-	-	-	-	-	-	-	-	-			
1986	-	-	-	-	-	-	-	-	-	-	-	-			
1987	4.4	3.0	4.0	1.1	0.0	0.0	0.0	2.1	3.0	1.8	4.0	9.7	9.7	3.2	0.0
1988	0.6	1.6	1.6	0.6	0.6	0.3	1.2	0.0	0.6	1.0	0.5	0.0	1.6	0.8	0.0
1989	-	1.0	0.6	0.8	0.0	0.8	1.8	0.6	0.0	-	-	-	1.8	0.8	0.0
1990	2.1	1.6	2.1	0.8	4.1	0.0	0.6	0.3	0.0	0.0	0.8	0.8	4.1	1.3	0.0
1991	1.3	1.3	1.3	0.8	1.3	0.7	1.0	1.0	1.8	1.2	0.4	0.0	1.8	1.1	0.0
1992	1.0	2.4	1.2	1.0	0.7	7.5	5.4	0.9	4.8	1.2	1.2	2.4	7.5	3.0	0.7
1993	1.8	4.2	1.2	1.5	0.7	1.8	1.2	1.2	1.8	1.0	1.5	-	4.2	1.8	0.7
1994	0.4	0.4	0.4	1.0	1.5	1.0	1.3	1.2	0.5	-	-	-	1.5	1.0	0.4
Max.	4.4	4.2	4.0	1.5	4.1	7.5	5.4	2.1	4.8	1.8	4.0	9.7	9.7	3.2	0.7
Ave.	1.7	1.9	1.6	1.0	1.1	1.5	1.6	0.9	1.6	1.0	1.4	2.6	4.0	1.6	0.2
Min.	0.4	0.4	0.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.5	0.8	0.0
No of Smpl	7	8	8	8	8	8	8	8	8	6	6	5	8	8	8

Sumpling Point : Amudarya - Kijzildjar
Indicator : Total Hardness (meq/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	8.3	6.6	-	10.9	7.1	7.2	-	-	-	8.4	-	10.9	8.5	6.6
1975	-	6.6	6.6	5.3	8.0	4.7	6.5	6.6	-	-	-	-	8.0	6.5	4.7
1976	-	6.6	9.8	9.2	-	-	-	5.3	-	-	-	-	9.8	8.1	5.3
1977	-	-	6.8	-	8.4	-	6.6	4.3	-	5.8	6.8	8.4	8.4	6.9	4.3
1978	8.6	11.8	9.3	9.6	-	6.0	5.8	-	5.1	5.9	7.2	-	11.8	8.1	5.1
1979	-	-	8.8	15.8	-	7.0	5.9	-	5.1	8.2	8.1	-	15.8	9.3	5.1
1980	-	-	8.3	9.1	-	7.8	5.2	5.5	6.8	8.9	9.4	-	9.4	7.8	5.2
1981	-	13.4	14.5	17.0	-	5.9	11.8	5.7	6.7	7.9	9.4	-	17.0	10.9	5.7
1982	-	11.5	10.5	12.8	-	9.4	13.9	-	6.5	11.4	12.2	-	13.9	11.3	6.5
1983	-	10.2	27.5	15.9	-	12.2	12.1	-	7.9	7.0	7.7	-	27.5	14.2	7.0
1984	-	12.5	9.6	10.3	-	8.7	5.1	-	5.5	5.6	8.2	-	12.5	8.7	5.1
1985	-	9.8	7.8	11.8	-	12.3	7.9	9.0	-	7.2	8.9	-	12.3	9.7	7.2
1986	-	9.9	13.2	14.1	-	12.9	16.5	9.5	-	10.0	10.9	-	16.5	12.6	9.5
1987	-	11.7	13.1	19.4	-	11.9	6.0	9.7	-	5.7	8.7	-	19.4	11.7	5.7
1988	-	11.9	10.6	14.9	-	7.7	9.2	-	9.2	12.4	11.8	-	14.9	11.4	7.7
1989	-	13.4	13.1	16.0	-	18.6	13.5	12.8	-	-	-	-	18.6	15.1	12.8
1990	-	10.1	10.6	19.3	-	6.5	6.7	6.7	-	7.4	8.0	-	19.3	10.5	6.5
1991	-	8.3	8.7	12.8	-	8.7	3.8	7.5	-	8.6	8.4	-	12.8	8.8	3.8
1992	-	11.2	9.8	12.0	-	6.9	5.6	-	6.1	6.9	7.9	-	12.0	8.7	5.6
1993	-	8.4	10.1	12.6	-	6.8	5.9	-	8.1	9.0	8.6	-	12.6	9.1	5.9
1994	-	8.6	8.7	9.8	-	7.3	5.7	-	-	7.9	8.8	-	9.8	8.3	5.7
Max.	8.6	13.4	27.5	19.4	10.9	18.6	16.5	12.8	9.2	12.4	12.2	8.4	27.5	15.1	12.8
Ave.	8.6	10.2	10.7	13.0	9.1	8.9	8.0	7.5	6.7	8.0	8.9	8.4	14.0	9.8	6.2
Min.	8.6	6.6	6.6	5.3	8.0	4.7	3.8	4.3	5.1	5.6	6.8	8.4	8.0	6.5	3.8
No of Smpl	1	18	21	19	3	19	20	11	10	17	18	1	21	21	21

Sumpling Point : Amudarya - Kijzildjar
Indicator : BOD5 (mg/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	-	-	-	-	-			
1975	-	-	-	-	-	-	-	-	-	-	-	-			
1976	-	-	-	-	-	-	-	-	-	-	-	-			
1977	-	-	-	-	-	-	-	-	-	-	-	-			
1978	-	-	-	-	-	-	-	-	-	-	-	-			
1979	-	-	-	-	-	-	-	-	-	1.4	-	0.5	1.4	1.1	0.5
1980	-	-	-	-	-	0.4	0.1	0.8	-	0.2	0.1	-	0.8	0.4	0.1
1981	-	-	0.9	0.2	-	0.5	1.0	-	-	0.5	0.8	-	1.0	0.7	0.2
1982	-	-	-	-	-	0.5	-	-	-	0.4	0.5	-	0.5	0.5	0.4
1983	-	0.3	0.5	0.6	-	0.5	-	-	-	-	-	-	0.6	0.5	0.5
1984	-	-	-	-	-	-	-	-	-	-	-	-			
1985	-	1.2	0.4	1.7	-	-	0.4	-	-	0.4	0.7	-	1.7	0.9	0.4
1986	-	0.4	1.4	0.2	-	0.8	-	-	-	-	0.5	-	1.4	0.8	0.2
1987	-	0.4	0.4	1.1	-	0.1	1.9	0.8	-	0.6	0.5	-	1.9	0.9	0.1
1988	-	3.0	0.8	-	-	-	1.5	-	0.1	0.4	6.6	-	6.6	2.7	0.1
1989	-	0.6	3.8	4.3	-	3.9	3.3	3.4	-	-	-	-	4.3	3.4	3.3
1990	-	0.4	1.0	0.8	-	1.5	1.4	3.5	-	0.9	4.6	-	4.6	2.1	0.8
1991	-	3.8	3.4	4.5	-	0.6	3.8	1.0	-	1.2	1.2	-	4.5	2.7	0.6
1992	-	3.4	1.0	0.6	-	0.9	1.1	-	1.3	1.7	3.9	-	3.9	2.0	0.6
1993	-	3.3	0.9	1.6	-	1.0	0.6	-	0.8	0.7	0.8	-	3.3	1.4	0.6
1994	-	0.4	0.7	1.3	-	1.6	1.1	-	-	0.9	1.9	-	1.9	1.2	0.7
Max.	0.0	3.8	3.8	4.5	0.0	3.9	3.8	3.5	1.3	1.7	6.6	0.5	6.6	3.4	3.3
Ave.	-	1.6	1.3	1.5	-	1.0	1.5	1.9	0.7	0.8	1.8	0.5	2.6	1.4	0.6
Min.	0.0	0.3	0.4	0.2	0.0	0.1	0.1	0.8	0.1	0.2	0.1	0.5	0.5	0.4	0.1
No of Smpl	0	11	12	11	0	12	11	5	3	12	12	1	15	15	15

Sumpling Point : Amudarya - Kijzildjar
Indicator : Cr^{6+} (ug/l)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Ave.	Min.
1974	-	-	-	-	-	-	-	-	-	-	-	-			
1975	-	-	-	-	-	-	-	-	-	-	-	-			
1976	-	-	-	-	-	-	-	-	-	-	-	-			
1977	-	-	-	-	-	-	-	-	-	-	-	-			
1978	-	-	-	-	-	-	-	-	-	-	-	-			
1979	-	-	-	-	-	-	-	-	-	-	-	-			
1980	-	-	-	-	-	-	-	-	-	-	-	-			
1981	-	-	-	-	-	-	-	-	-	-	-	-			
1982	-	-	-	-	-	-	-	-	-	-	-	-			
1983	-	-	-	-	-	-	-	-	-	-	-	-			
1984	-	-	-	-	-	-	-	-	-	-	-	-			
1985	-	-	-	-	-	-	-	-	-	-	-	-			
1986	-	-	-	-	-	-	-	-	-	-	-	-			
1987	-	-	-	-	-	-	-	-	-	-	-	-			
1988	-	-	-	-	-	-	-	-	-	-	-	-			
1989	-	-	-	-	-	-	-	-	-	-	-	-			
1990	-	-	-	-	-	-	-	-	-	-	-	-			
1991	-	-	-	-	-	-	-	-	-	-	-	-			
1992	-	-	-	-	-	-	-	-	-	-	-	-			
1993	-	-	-	-	-	-	-	-	-	-	-	-			
1994	-	0.4	0.7	1.2	-	3.0	0.8	-	-	0.0	0.0	-	3.0	1.1	0.0
Max.	0.0	0.4	0.7	1.2	0.0	3.0	0.8	0.0	0.0	0.0	0.0	0.0	3.0	1.1	0.0
Ave.	-	0.4	0.7	1.2	-	3.0	0.8	-	-	0.0	0.0	-	3.0	1.1	0.0
Min.	0.0	0.4	0.7	1.2	0.0	3.0	0.8	0.0	0.0	0.0	0.0	0.0	3.0	1.1	0.0
No of Smpl	0	1	1	1	0	1	1	0	0	1	1	0	1	1	1