Report on monitoring of the Amudarya river delta and the exposed bed of the Aral Sea within the framework of the CAWA Project - Dynamics of surface water and groundwater changes in the Amudarya river delta and the exposed bed of the Aral Sea June 2009 – May 2010

The Project is implemented jointly by SIC ICWC, German Geoscience Research Centre (GFZ) and GIDROINGEO Institute at the Uzbekistan's State Geological Committee in order to study dynamics of changes in surface (river and collector-drainage) water and shallow and deep ground water in the delta and Prearalie.

The objectives of work for 2009-2010 were to conduct monitoring of the Amudarya river delta (quantity and quality of surface water and groundwater) and the Aral Sea, including water (sea water level and salinity) and soil (salt composition), as well as monitoring of groundwater. This work is a follow-up of the three-year research undertaken within the framework of the GTZ Project "Stabilization and use of the dried bed of the Aral Sea in Central Asia", the results of which indicate to significant dynamics of landscapes during the progress of drying up of the sea and formation of a new earth.

This work involves studying both external and underground processes that take place on the land, sea, the exposed seabed, in Prearalie and identifying dynamics of deep and shallow groundwater.

Data for conducting the analysis of processes were collected in 2009 and 2010.

Level lowering in the Aral Sea has shifted the line of natural bio-resources use in this region from the area of the sea to the area of delta's wetlands.

The Prearalie's deltaic lakes existing mainly through the inflow from the Amudarya river have underwent a broad range of negative changes. The same time, with the completion of new large collectors, a new type of water bodies – the so called tail accumulators (sinks) for drainage water – occurred in Prearalie. Recent decade, an area of lakes was 70.2 km^2 in the normal year 1984, then in increased up to 120 km^2 in the humid year 1997 and decreased to 26.0 km^2 in the dry year 2000.

According to the proposed plan, monitoring of the Amudarya river delta was conducted:

- in three points (sections) of the Amudarya river (Takhiatash, Samanbai and Kyzyljar) to measure flow rate and salinity every three months;
- at the head of two canals (Glavmyaso and Porlytou) to measure flow rate and salinity every three months;
- at the tail of four main collectors (GLK, KC-1, KC-3 and KC-4) to measure flow rate and salinity;
- in 44 points, wells were drilled to measure groundwater levels and salinity every three months;
- including soil and water samples selected from western area of the sea and passed to Germany partners;
- and summarized and analyzed large amount of actual data for 1991-2009 on regime of groundwater in the Neogene-Quaternary and chalk deposits within the studies area.

At present, all water bodies existing within the Amudarya delta may be divided into two groups according to their water regime:

- the lakes fed by drainage water (Sudoche, Western Karateren, Akushpa, Eastern Karateren, a part of Djiltirbas Lake and others);

- the lakes fed by the Amudarya river water (lakes Mezdureche, Dautkul, Ribache, Muynak, Dumalak and others).

During many decades, such lakes as Karateren, Akchakul, Sudoche and Kokchiel have been used as receiver-evaporators for irrigation waste and drainage water discharged from irrigated lakes. In the nearest future, these lakes would be impossible to use for both fishery and reed harvest needed for cattle-breeding if fresh water supply is not rehabilitated.

The volumes of drainage water supply through main drains (collectors) situated in the left and right bank areas of the Amudarya river depend mainly on annual water availability and the amount of water delivered for irrigation within the command area of the Suenly and Kyzketkent canals.

According to the pattern of water supply and quality of water, the territory of the Amudarya delta may be divided into three zones:

1. The Left Bank Zone is the system of the Lenin canal and main drain GLK, Sudoche lake and Adjibai Bay. The main water bodies are lakes of the Sudoche wetland – Akushpa, Taily, Karateren, Big Sudoche and Begdulla-Aidyn and lakes of the Karadjar system – Mashankol, Hojakol, and Ilmenkol.
2. The Priamudaryinskaya zone of seashore lakes and delta lakes fed by the Amudarya river water and large irrigation canals. The main water bodies are the Mezdureche reservoir, Ribache and Muynak Bays and Makpalkol lake.
3. The Right Bank Zone is the system of the Kyzketken canal, main drains KC-1, KC-3, KC-4, and Karateren lake. The main water body is the Djiltyrbas Bay.

According to a water exchange pattern, water bodies of Prearalie are divided into: flow-through water bodies – Mezdureche reservoir and Makpalkol lake; water bodies with low (periodical) flow-through – lakes Karateren, Big Sudoche, Begdulla-Aidyn, Mashankol, Hojakol and Ilmenkol, bays Ribache, Muinak, and Djiktyrbas; and closed drainage water sinks – lakes Akushpa and Tayli.

Description of observation points

A plan was drawn up for monitoring of the Amudarya river delta (quantity and quality of surface water and groundwater) and the Aral Sea, including water (sea water level and salinity) and soil (salt composition).

Object	Monitoring interval	Monitoring parameters	Monitoring points
Amudarya delta (soil)	Once a year	pH and salt composition	In 30 points
Amudarya delta (groudwater)	Every ten-days	Level and salt content	In 33 points
Amudarya (Takhiatash, Samanbai, Kyzyljar)	Every ten-days	Flow rate, temperature, salinity	In three points – flow rate
Canals – Glavmyaso, Porlytou and others flowing into delta	Every ten-days	Flow rate and salinity	In two points
Main drains GLK, KC-1, KC-3 and KC-4	Every ten-days	Flow rate and salinity	In four points
Aral Sea (data from Karakalpakstan's Hydromet – hydrometeorological service)	4 times a year (twice in 2009)	Water level	In western and eastern parts (if available, on western area)
	Twice a year (once in 2009)	pH, hydrochemistry	In western and eastern parts (if available, on western area)

Takhiatash point (Takhiatash waterworks) is located 2 km far from the city of Nukus. In this point water is distributed between Suenli canal and Kyzketken canal. The waterworks are equipped with hydrometers and flow rate is measured in the tail-water. As Delta Authority's staff reports, all meters in this point are outdated and need to be replaced by up-to-date ones.

Samanbay point. It is located within the city of Nukus and 6-7 km far from Takhiatash waterworks. Besides measuring of flow rate, samples are taken in this point to estimate river water salinity (once a month). Here outdated meters are also observed and need to be replaced.

Kzyldjar point is located approximately 100 km downstream of the Samanbay point. Recent decade, due to lack of financing, this section is almost not operated. Therefore, it is necessary to rehabilitate this section for measurement of water quantity and quality since the section is a key one; here water is distribute among the Mezdureche reservoir and the old channel of Kazakhdarya. There is no water measurement throughout the delta, and therefore inflow into the delta and its distribution is uncontrollable.

Along the Marinka, Muynak and Raushan canals, monitoring is conducted in outlets from the Mezdureche reservoir and the Suenli canal, respectively. The analysis shows that due to outdated meters, flow rates are not measured accurately.

The monitoring points at tails of the main drains are installed in form of hydrometric platforms to measure flow rate and take water samples for chemical analysis. However, in most cases, water accounting is made by eye and water samples are taken once a month.

Monitoring of groundwater level and salinity is conducted in three zones in the delta:

- central zone – the command area of the main channel of the Amudarya, along the Glavmyaso and Marinkinuzyal canals, in two sites – shirkat farm Aral (9 wells) and shirkat farm Muynak (16 wells);
- left bank zone – the command area of the Raushan canal, a site of shirkat farm Raushan (9 wells);
- right bank zone – the command area of the Kyzketken canal and along the Kazakhdarya channel (10 wells).

Based on the plan, monitoring of the Amudarya delta was conducted and gave the following results:

- in three points (sections) of the Amudarya river (Takhiatash, Samanbai and Kyzyljar) flow rate and salinity was measured every three months. The results are show in Tables 1-2 and in Figure 2;
- at the head of two canals (Glavmyaso and Porlytou) flow rate and salinity were measured monthly. The monitoring results are shown in Table 3;
- at the tail of four main collectors (GLK, KC-1, KC-3 and KC-4) flow rate and salinity were measured also and the results are shown in Tables 4-5;
- in 44 points, wells were drilled, and groundwater levels and salinity were measured every three months;
- soil profiles were cut directly near the wells, and 30 soil samples were taken in total. Figure 4 shows the expedition route and the sampling points.

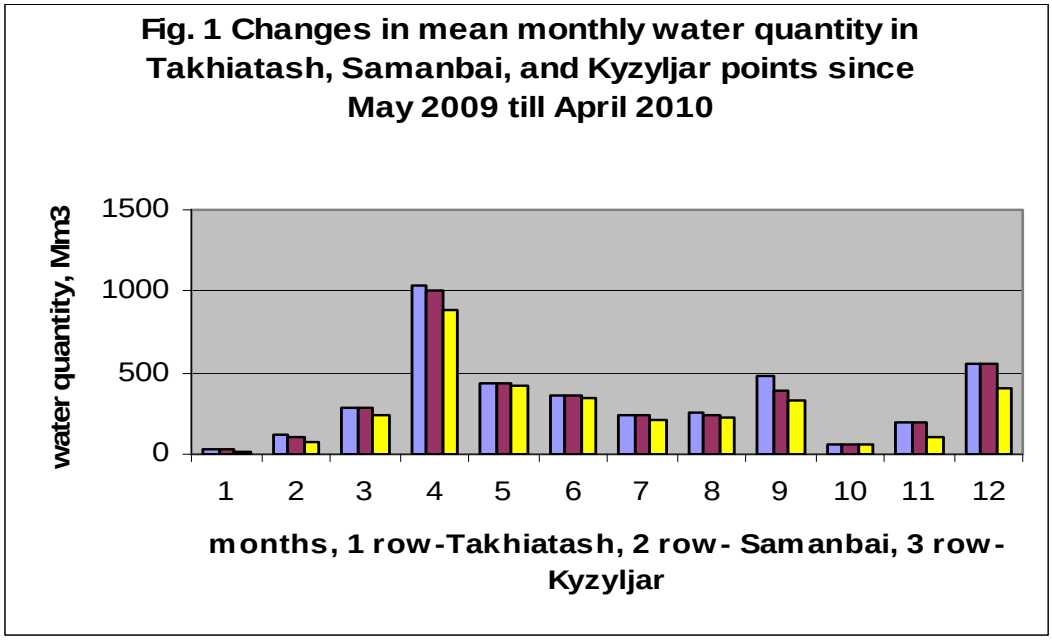
Inflow from the river into the delta

Monitoring of water inflow into the delta was conducted in Samanbai point. Table 1 shows actual quantity of inflow via Samanbai into the delta, while Figure 1 shows dynamics of mean monthly water quantity in Takhiatash, Samanbai, and Kyzyljar since May 2009 till April 2010.

Table 1

Actual quantity of inflow into the Amudarya delta (Mm^3)

Points (sections)	Years and months											
	2009								2010			
	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
Takhiatash	31,47	123,7	286,6	1037	438,05	362,88	243,65	251,6	479,8	63,67	192,54	558,6
Samanbai	28,12	105,5	280,4	1005	430,79	354,07	236,4	247,5	387,9	60,48	190,51	548,4
Kyzyljar	19,21	77,67	237,7	890	418,88	338,26	212,54	229,7	334,5	56,16	109,04	405,54



Water to the Left Bank system is supplied through the Suenly canal, while to the Right Bank system – through the Kyzketken canal. The water is distributed from the Takhiatash waterworks. Table 2 shows the total water withdrawals and discharge from the Suenli and Kyzketken canals over hydrological years.

Table 2

Total water withdrawal and discharge from the Suenli and Kyzketken canals through the delta's systems over hydrological years

Structure	Hydrological year							
Suenli and Kyzketken	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	1st quarter of 2010
Water quantity, Mm^3 (withdrawal)	3628	3255	3552	3186	1440	3196	35751.4	185.1
Water quantity, Mm^3 (discharge)	1403	1873	719	1414	1511	369	267.0	149.3

Water into the delta lakes, such as Muynak, Ribache, and Sudoche flows through the Muynak, Marinkin and Raushan canals, the Ustyurt and KKC main drains. Table 3 gives quantity of inflow by canal since July till December 2009 and since January till April 2010.

Table 3

Canal	Months									
	2009						2010			
	VII	VIII	IX	X	XI	XII	I	II	III	IV
Marinkin, Mm^3	12.7	85	97.5	-	-	-	-	-	-	46.66
Muynak, Mm^3	-	38.2	77.0	39.8	13.0	8.3	22.291	7.776	10.368	12.96
Raushan (Ustyurt and KKC), Mm^3	36.4	89.5	153.6	77.4	15.1	23.7	64.022	19.81	43.544	24.9

Inflow from collectors. Water into the delta flows from both the river and the main drains, such as KC-1, KC-3, KC-4 and Ustyurt (one should note that the Raushan canal carries water to Sudoche lake through the Ustyurt main drain). Table 4 gives data on water inflow from collectors into the delta since January till April 2010.

Table 4

Actual inflow into the delta from main drains

Main drain	Months									
	2009						2010			
	VII	VIII	IX	X	XI	XII	I	II	III	IV
KC-1	16.5	37.8	29.5	26.8	35.5	195.63	42.608	31.881	36.451	36.29
KC-3	10.5	13.7	26.2	9.9	2.3	76.45	20.474	7.335	16.33	22.3
KC-4	4.6	11.5	8.8	3.5	1.1	37.6	13.219	9.073	8.812	9.072
Raushan (Ustyurt and KKC)	26.7	52.8	52.7	35.0	14.8	23.7	63.96	19.2	43.574	24.9

Table 5 gives data on inflow from all the main drains since 2002 till 2009.

Table 5

Main drains	Year								
Drainage water (all main drains)	2002	2003	2004	2005	2006	2007	2008	2009	2010 Months I-IV
Water quantity, Mm^3	437	1061	1083	1156	1432	1117	663.5	991.1	406

The analysis of data on inflow into the delta from the Amudarya river shows that in 2009 the inflow, including drainage water, was about 3.7 billion m^3. Over the four months in 2010, the total water inflow, including drainage water, into the delta (Samanbay section) was about 1.59 (1.19 – river water, 0.406 – drainage water) billion m^3 (Tables 1 and 4). The planned water limit as approved at ICWC meeting for 2009 was 4.2 billion m^3. According to our estimations, 3.5 billion m^3 of water are needed to maintain the delta ecosystem stability. Thus, the quantity of water flown downstream of Samanbay point is enough to maintain the ecosystem stability in the delta and Prearalie in 2009 and 2010.

The results of monitoring over groundwater level and salt composition were obtained from 44 wells, including 27 of newly drilled wells around the periphery of Prearalie, from shirkat farm "Raushan" to shirkat farm "Kazakhdarya", including farms "Muynak" and "Aral". The groundwater level varies from the minimum of 2.5 m to 7.0 m. Figure 2 shows the average data on groundwater levels around the Amudarya delta.

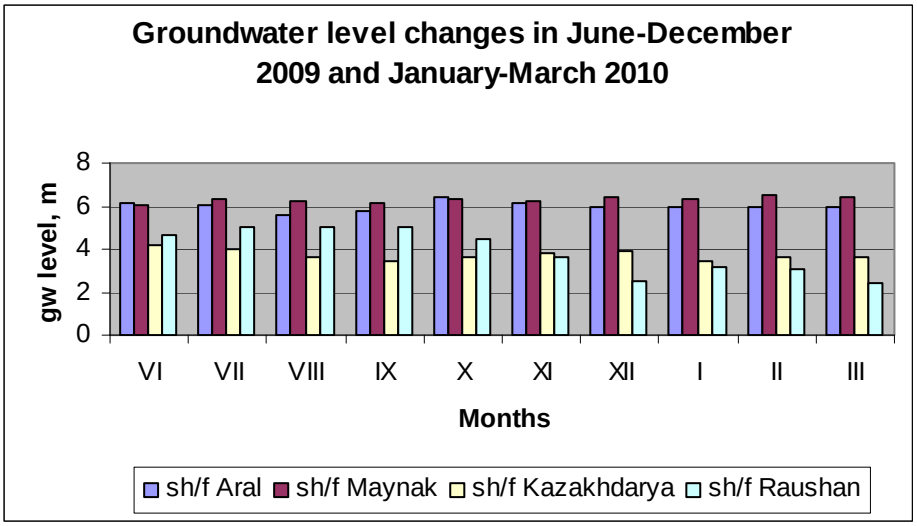


Fig.2 Groundwater level dynamics around the delta (average values)

Assessment of the state of delta through RS and the results of expedition

Two expeditions were undertaken to the selected objects. The first expedition was organized in May-June 2009, while the second one – in April-May 2010. The expedition in the end of May – beginning of June has found that such lakes as Sudoche, Ribache, Muynak, and Mezdureche did not almost have a water surface, although water availability had increased dramatically in the Amudarya river.

Given the minimum design water surface of water bodies in the delta of about 120 thousand ha, from the RS images, the actual water surface was 8280 thousand ha in June, 16230 thousand ha

in July, and 22794 ha at the beginning of August (Table 7) – as low as at the end of the dry period 2000-2001 in the delta.

However, data on filling of lakes that were received later (October and December 2009) show that water levels in some of lakes reached the design level (Table 6). Those are Zhiltyrbas, Ribache, and Mezdureche. Water levels in Muynak and Sudoche lakes exceed the design ones. A representative of the Amudarya Delta Authority reports that currently water keeps flowing into the lake systems of Prearalie from both the river and the main drains. Based on the results of examination in April-May 2010, actual levels in some lakes even exceeded their design levels (Sudoche: design level – 52.20, current level – 52.49; Zhiltyrbas: 52.00 – 52.10; Ribache: 52.00 – 52.11, respectively, etc. (Table 6)). This happened when after our expedition we have applied to the Government of Uzbekistan and have informed it about the catastrophic situation with the lake systems in the Amudarya delta. The Republican Government has reacted immediately and gave instructions to respective water institutions. Since then, during only two-three months, about 1.5-2.0 billion m^3 of water were supplied to the delta. The tables below show the results of NOAA image processing for wetland (lake systems) areas in hectares over September, October, and November 2009, as well as over April 2010. Thus, in November 2009, an area of wetlands was about 105 thousand ha, whereas in April 2010, it already reached 226.4 thousand ha, i.e. increased as much as more than twofold (Table 7, 8).

Table 6

Changes in water horizon in the lake systems in the Amudarya delta, January-April 2010

Lake	Sampling date	Water horizon level			
		January	February	March	April
Sudoche	1st ten-day	51.88	52.10	52.17	
	2nd ten-day	51.98	52.14	52.18	
	3rd ten-day	52.03	52.16	52.30	52.49
Zhiltyrbas	1st ten-day	51.95	51.94	51.90	52.11
	2nd ten-day	51.96	51.93	51.96	52.13
	3rd ten-day	51.96	51.92	52.06	52.13
Dautkul	1st ten-day	64.85	65.13	65.18	65.34
	2nd ten-day	65.01	65.15	65.20	65.33
	3rd ten-day	65.10	65.17	65.29	65.35
Mezdureche	1st ten-day	55.69	56.01	56.03	52.82
	2nd ten-day	55.75	56.02	55.99	55.74
	3rd ten-day	55.91	55.99	55.82	55.84
Ribache	1st ten-day	52.00	52.12	52.06	52.09
	2nd ten-day	52.09	52.12	52.03	52.11
	3rd ten-day	52.11	52.09	52.05	52.06
Muynak Bay	1st ten-day	50.00	50.52	50.98	51.52
	2nd ten-day	50.09	50.70	51.10	51.49
	3rd ten-day	50.30	50.86	51.33	51.52

Table 7

Areas of water surface in the Amudarya river delta, ha
(Landsat images processing data)

№	Water body	Date		
		8.04.2000	***14.06.2001***	***4.08.2002***
1.	Sudoche	41897.73	9570.04	6497.2
2.	Mezdureche	10050.42	592.79	18375.21
3.	Ribache	5317.64	2019.68	5513.1
4.	Muynak	8623.34	1292.23	5163.2
5.	Zhiltyrbas	29357.73	5277.33	27620.5
6.	Dumalak	4576.89	927.23	6784.9
7.	Mashan Karadjar	16835.18	726.27	2813.9
	Total	116658.9	20405.57	72768.01

Preliminary assessment of water surface areas in the Amudarya river delta, ha
(NOAA images processing data)

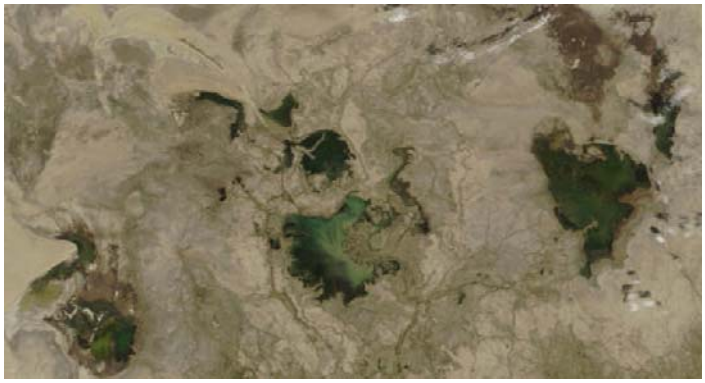
№	Water body	***2009***		
		June	***July***	***August***
1.	Sudoche	863.47	1172.54	2575.38
2.	Mezdureche	534.73	5581.92	6147.65
3.	Ribache	1207.36	1472.63	1965.32
4.	Muynak	134.47	147.21	163.24
5.	Zhiltyrbas	3982.87	4324.57	5095.36
6.	Makpalkol	231.42	641.86	2020.78
7.	Dumalak	441.95	1137.42	1203.16
8.	Mashan Karadjar	884.55	1753.69	3623.43
	Total	8280.82	16231.84	22794.32

Table 8

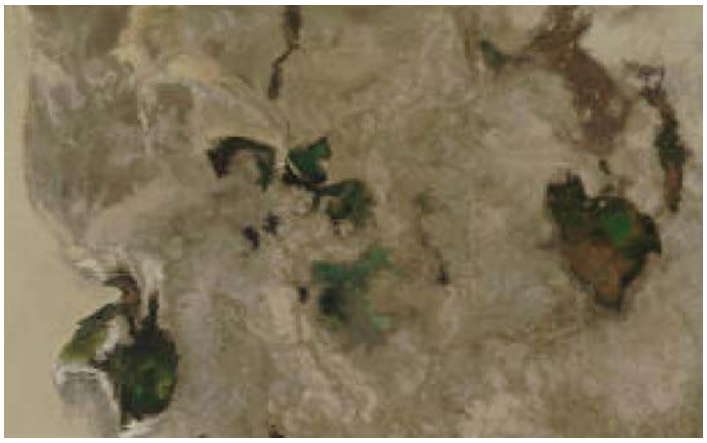
Area of wetlands, ha
(NOAA images processing data)

№	Water body	2009			2010	
		September	October	November	April	June
1.	Sudoche	12648.24	32733.24	31365.50	63364.26	57719.78
2.	Mezdureche	19908.48	14794.54	10677.52	19548.23	29100.30
3.	Ribache	2065.75	15724.73	16841.11	9014.13	5642.84
4.	Muynak	2133.51	6606.02	5355.89	5125.59	9483.95
5.	Zhiltyrbas (limited by dam)	27473.0	29615.43	30180.17	41059.73	39551.59
6.	Zhiltyrbas (more to the right of the Left channel)	-	-	-	89653.79 – 41.060	82474.72
7	Former Adjibay Bay	-	-	-	7563.21	8475.62
8.	Dumalak	2700.66	2746.61	2882.24	5068.52	15329.55
9.	Adjibay 2*				6306.59	7723.54
10.	Makpalkol	7235.98	7710.05	4930.84	10328.17	10632.28
11.	Mashan Karadjar	1005.16	3116.32	2630.16	6434.11	7495.05
12.	Weltand southward of Muynak	-	-	-	3989.95	5765.70
13.	Wetlands north-westward of Muynak					1865.48
14.	Wetlands in the head of Kazakhdarya river					2066.65
15.	Kokdarya channel					8737.65
16.	Togyzarkan channel					3539.62
17.	Zakirkol lake					2872.87
	Total	75170.78	113046.94	104863.43	226396.55	298477.19

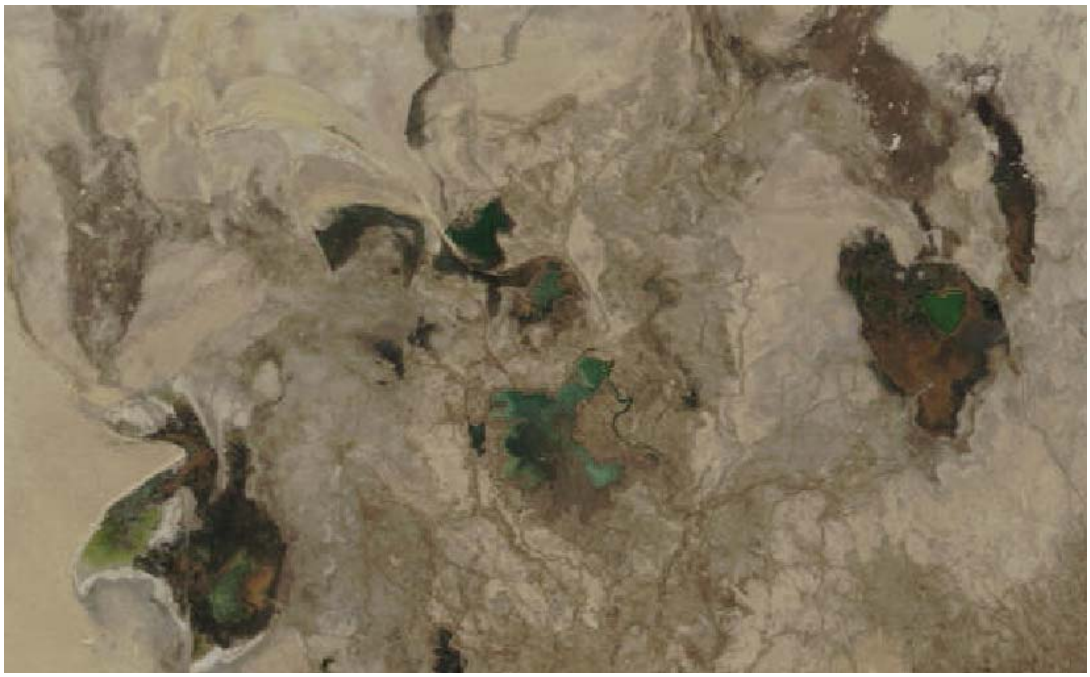
September



October



November



Wetland southward of Muynak

The Aral Sea

Eastern Sea ≈ 67551.40 ha

(This is what can be considered as the water surface, level ≈ 26.3. Perhaps, this area is larger, the next image will show.)

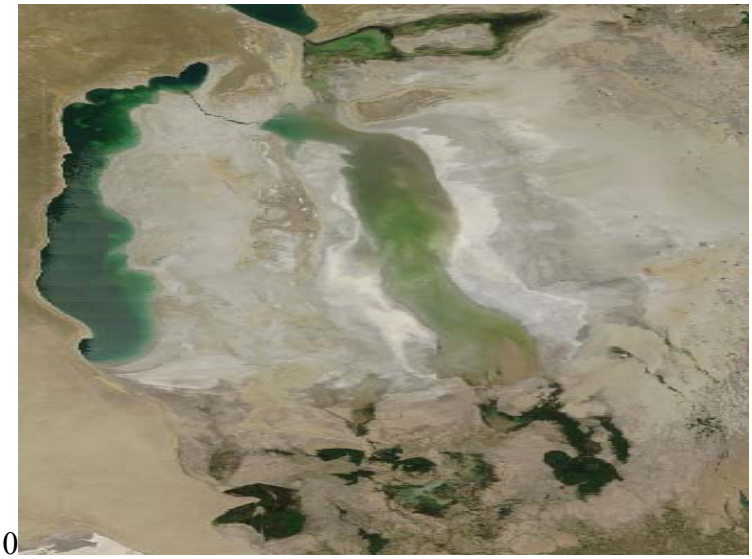
Western Sea ≈ 405688.90 ha (level ≈ 28.2)

The estimations showed that in the dry period of 2007-2008, inflow to the delta was 1.59 billion m^3, and the lake systems' area decreased from 120 thousand ha to 6-7 thousand ha. Here, there is no balance as such, i.e. the negative part of water balance exceeds the positive one by 1.5 billion m^3. The water quantity required for the delta's nature is not met by 2.0 billion m^3. In the humid years 2009-2010, inflow to the delta amounted to 5.1 billion m^3, and this allowed increasing the lake system areas to 81 thousand ha, i.e. inflow in water balance is higher than evaporation by 1.7 billion m^3. In this case, the water quantity required by the nature is exceeded by 1.7 billion m^3, and we think it expedient to supply this excess of water to the Western part of the Aral Sea.

The GIS experts from SIC ICWC have prepared new information on wetland areas in the Amudarya delta on the basis of satellite images. According to their data, currently the area of wetlands has increased to 300 thousand ha, i.e. large quantities of water are discharged from the river into the delta. The data on inflow to the delta will be ready by July 10, therefore we will not be able to calculate a delta's water balance for this period. This will be done in a report at the end of 2010.

Zakirkol lake, June 2010. Wetland at the head of the Kazakhdarya river

April 2010



June 2010

Estimation of water balance in the Amudarya river delta

Using the available data on water resources and wetland areas in the Amudarya delta, we have made calculations of water balance for two options:

- dry period - 2007-2008
- humid period – 2009–2010.

The components of water balance of the Amudarya delta (Mm^3) for the hydrological year 2009-2010 are as follows:

Based on image data, the delta area is 226.4 thousand ha for this hydrological year.

Evaporation in the delta, including flowage, was taken maximally as 15000 m^3 per hectare.

Water balance:

- river water inflow – 3875. 05 Mm^3
- drainage water inflow – 1029. 575 Mm^3
- rainfall – 226.4 Mm^3
- groundwater inflow – 0.315 Mm^3

Total: the sum of inflow is 5131.34 Mm^3

Evaporation (total) - 3396 Mm^3

Outflow towards the sea – 36.266 Mm^3

Total: the sum of losses is 3432.266 Mm^3

The exceeding of inflow over evaporation (balance) is **+ 1699. 074 Mm^3**

The components of water balance of the Amudarya delta (Mm^3) for the hydrological year 2007-2008 are as follows:

Based on image data, the delta area is 187.4 thousand ha for this hydrological year.

Evaporation in the delta, including flowage, was taken maximally as 15000 m^3 per hectare.

Water balance:

- river water inflow – 676.1 Mm^3
- drainage water inflow – 663.5 Mm^3
- rainfall – 202.4 Mm^3
- groundwater inflow – 0.315 Mm^3

Total: the sum of inflow is 1542.315 Mm^3

Evaporation (total) – 2810.3 Mm^3

Outflow towards the sea – 36.266 Mm^3

Total: the sum of losses is 2846.57 Mm^3

The exceeding of evaporation over inflow (balance) is **– 1539.47 Mm^3**