

**CAWa Scientific Report
for first half of 2010**

**Title: Development of methods for irrigation monitoring in Central Asia
(on the example of Fergana Valley)**

Executors:

**Kh.U. Umarov
Sh.M. Kenjabaev**

Supervisor:

V.A. Dukhovny

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I. INTRODUCTION

1.1 Analysis of dynamics of amelioration condition of irrigated lands and drainage systems in Fergana province

Fergana province is characterized by complex hydro-geological conditions (**fig.1**) causing development of negative ecological and ameliorative processes with irrigation (strengthening head of underground water, rise of level and mineralization of ground water and thereafter soil salinity). Climatic condition of intermountain depression is defined by its peculiar geographical location: locked by high mountain ranges from all sides and only with relatively narrow pass to Bekabad, which is open to the west of Syrdarya river course. Significant seasonal and daily fluctuation in temperature, fewer amounts of precipitation (100-200 mm per year), drought, frequent winds, high evaporation and solar radiation is typical for continental climate and impose to mesorelief situation. Average temperature in vegetation period (April-September) is 22-23 °C, evaporation 1100-1300 mm, moisture deficiency 790-980 mm. Froze-free period fluctuates within 200-215 days with the sum of effective temperature 2600-2640 °C.

In the geomorphologic relation the territory of the Fergana province is presented by the intermountain locked basin covered with alluvial deposits in the top thickness of the Syrdarya River's quarterly period, and periphery parts with alluvial-proluvial deposits of framing mountains. The height of quarterly deposits in the central zone of territory reaches 400-500 m, and in periphery parts of 25-50 m. In a lithological structure of quarterly deposits prevailed by overlay with sandy-loam soils, divided melkozems in the form of lenses. A relief in a plane part of the region is evenly, with a slope from 0.002 to 0.0005, and the foothill part has slope more than 0.002 – 0.05. The territory from the southeast to the northwest is crossed by the Syrdarya River which is a water intake of collector-drainage and waste waters.

Geomorphologic conditions have caused original hydro-geological conditions of the Central Fergana - formation of high pressured underground water with their inflow from framing mountains, and also shallow laid ground water. Here before development of drainage systems ground waters laid within 2.0 m, and their mineralization fluctuated from 3-5 to 10 g/l and more. Piesometric pressures are everywhere established at 0.2-0.95 m above ground water levels. Water in deep layers (> 20-50 m) is low mineralized with a maximum concentration up to 3 g/l. Thus underground water at the depth 180-200 m and deeper gives well-spring and their mineralization does not exceed 0.5-1.0 g/l. The volume of ground water inflow due to overflow from underlying pressured head water at permeable horizons of quarterly deposits in the Central Fergana ranges from 2-3 to 8-10 thousand m³/hectares which causes raise of ground water table and formation considerable natural drainage runoff.

According to conditions of natural draining capacity the territory of the Central Fergana is subdivided into 5 zones:

- intensive draining, located in a foothill part – the area of formation of ground water with deep laying its level;
- moderated draining, covering the territory above Big Fergana canal (BFC) in the western part of the region;
- weak draining – the territory between BFC and South Fergana canal (SFC);
- rather weak draining - the Central part of the territory located lower BFC;
- inflowing zone - an inundated zone of the Syrdarya river.

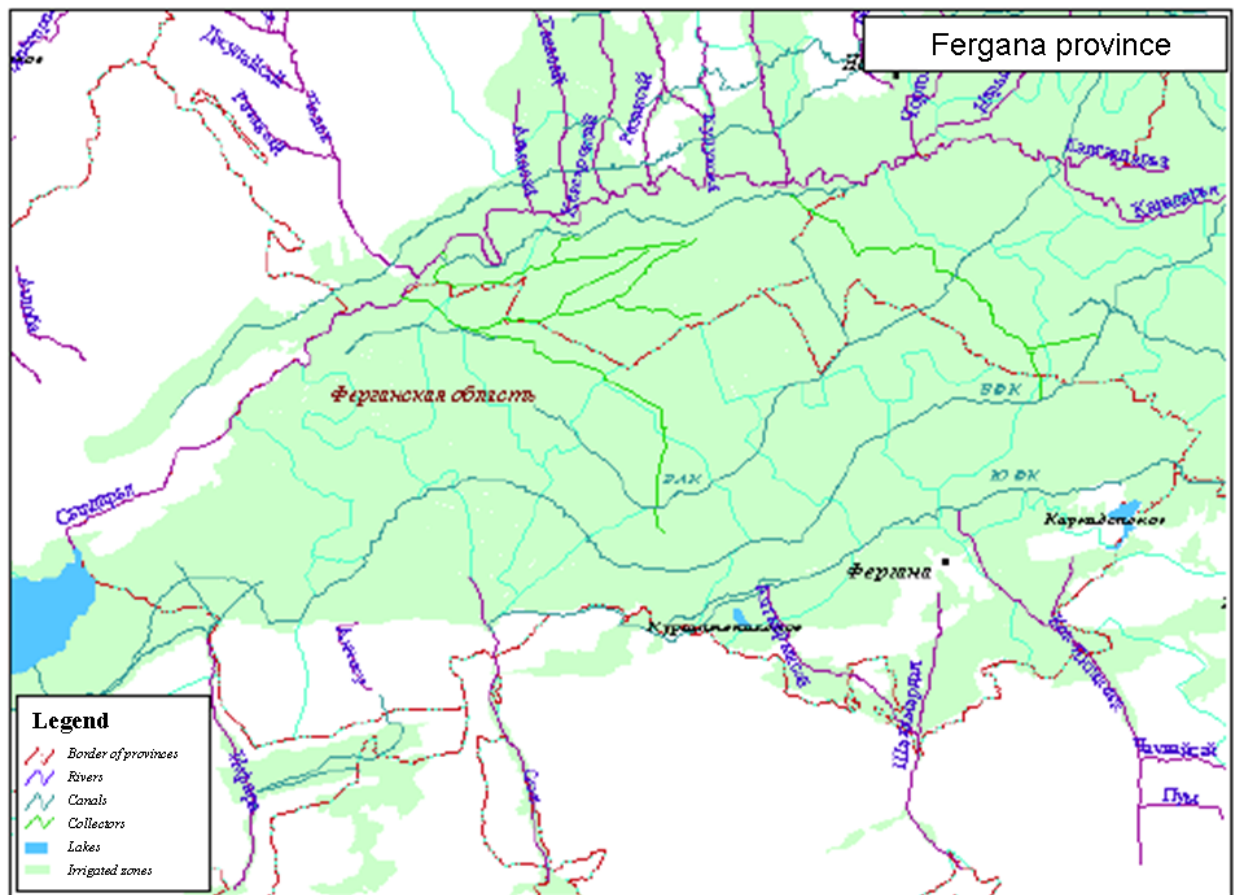


Figure 1 – Complex hydro-ameliorative systems in Fergana province

Soil-ameliorative features of the region are closely interlinked with geomorphologic and hydro-geologic factors. The territory in the foothill zone presented by shallow soils of light mechanical structure (sandy loam, light loam, etc.) underlying with fine coarse-fragmental grounds. In this area ground water is not participate in soil formation processes. Flat part of the territory occupies by meadow-sierozem and meadow soils formed with influence of ground water. The lands are presented by layered soils with various mechanical structures. Runoff-free zone is characterized by meadow and meadow-marshy soils in which ground water predominated in its formation. All over zones excluding intensive drained formed surface salinity and accumulation of salt stock in the top layer at 1.0-1.5 m due to shallow laying ground water and strengthened head of underground waters.

Thus Fergana province according to its climatic, geomorphologic and hydro-geologic and soil-ameliorative conditions related to quite complex region. Nevertheless, these conditions and presence of fertile soils in combination to water resources of the Syrdarya River and its numerous inflows have created a basis for occurrence and subsequent development of a world renowned Fergana oasis - one of the most ancient centers of an agricultural civilization in the planet (S.Vavilov, B.Andrianov). Here till XXth century it was irrigated more than 150 thousand hectares of lands, thus, basically, not demanding artificial drainages. In the middle of 20th century irrigated agriculture was about 250 thousand hectares. The irrigation is developed with attraction of new tracts, most of all in zones of moderate and weak drainage with construction of off-farm and rare on-farm collectors without primary regulating drains which have not allowed to prevent development of secondary salinization at shallow laying ground water.

An intensive development of new lands and reconstruction of old irrigation systems in Fergana province as like in the other regions of Uzbekistan started during 1956-1960. Irrigated lands

reached 286.7 thousand ha in 1970 and increased till 350 thousand ha in 1990, i.e. more than 64 thousand ha of lands are developed within 20 years. The new lands in the central part of the Fergana province, mainly between BFC and Syrdarya River and also steppes, located within natural drained territories were brought into development. The development of steppes strengthened delivery of grounds located in lower tracts which caused decline of ameliorative condition of lands (MCL). About 90-100 thousand ha from total irrigated lands do not required artificial drainage. The lands provided by drainage made 188 thousand ha in 1970 (65.7 % from total irrigated lands) and reached 261 thousand ha in 2000 (73.2 %).

Nowadays 15211.2 km collector-drainage network including 1334 km closed horizontal drainages and 1119 pcs. of vertical drainage wells are constructed and operated at these lands. The same time the number of operated vertical drainage wells is decreased up to 193 pcs. and length of closed horizontal drainage (CHD) reduced to 248.1 km in 2008 (**table-1**) due to high operation cost and aging of systems. The specific length indirectly defines the degree of providence an artificial drainage. Fergana province rather had relatively high specific length of drainage network (44.7-52.8 m/ha) in 1970-1975 and from 1975 it practically not changed. Such a system of horizontal and vertical drainages provided runoff of voluminous drainage water and salt. The total drainage runoff ranged from 2.6 to 3.5 billion m³ in 1980-2009 under water intake from 4.0 to 7.3 billion m³ (**fig.2**). In 2000 both water intake and total drainage runoff were declined. The share of drainage runoff from water intake changed from 44.1 to 67.5 % in Fergana province (**fig.3**) thus the parity is increased by reduction of water intake in last years. Due to increasing total volume of water intake and its mineralization (from 0.4 to 0.7 g/l) the salt inflow is changed from 2285.5 thousand ton in 1970 till 3600.2 thousand ton with specific value of 17.7 t/ha per year and 15.8 t/ha per year respectively. At the same time carrying out of salts from irrigated lands slightly exceeds of their inflow: specific inflow of salts with irrigation water changes within 8-10 t/ha per year, and specific carrying out of salts with a drainage runoff of 15-21.1 t/ha per year.

Main water carrying channels in the province are collectors namely “Achikkul” with discharge 53 m³/s, “P-3” – 21.2 m³/s, “Shimoliy” – 17.7 m³/s, “Naynova” – 11.8 m³/s, “Sokh-Isfara” – 12.5 m³/s, “K-4” – 8.8 m³/s, “Sary-Juga” – 3.8 m³/s.

Mineralization of collector-drainage water ranges between 2.0-3.7 g/l. All volume of drainage runoff diverted into Syrdarya River excluding applied water for irrigation, those volume is changed according to water year.

Table-1 The parameters of horizontal drainage network

Years	Irrigated lands, thousand ha	Drainage catchment area, thousand ha	Length of drainage, km				Specific length
			Total	Open horizontal drainage	Vertical drainage	Closed horizontal drainage	
1970	357.65	188.0	8413.2	8399.0	126	14.3	44.75
1980	329.45	237.38	12781.5	12733.3	556	48.2	53.84
1990	355.4	260.96	14443.1	13205.5	1088	1237.6	55.35
2000	356.8	260.96	14952.6	13845.6	1312	1107	57.30
2008	358.71	255.12	15211.2	13876.5	1119	1334.7	59.62

Water-salt balance of surface waters turning out into salt reduction with removal of salts about 5.2-11.3 t/ha per year from irrigated lands. Salt removal from aeration zone fluctuated within 3.56 to 2.03 t/ha in 1970 to 1990 respectively. Starting from 1990 aeration zone balance turned into accumulation of salts at the top soil due to inflow from down layers. During these years it

were formed positive water cycle between aeration zone and ground water with inflow 528-865 m³/ha per year and salt flux about 7.28-12 t/ha per year. Thus the tendency of growth saline lands and, especially by category of higher than moderate salinity confirms deterioration of technical condition of drainage systems. This deterioration is mainly caused by sharp decline of on-farm drainage system's workability and also reduction of vertical drainage systems pump volume till 2.0-2.5 times in last decade.

Off-farm network presented by open collectors with depth more than 5 m, bed's width more than 3 m and steepness of slope more than 2 m. On-farm network constituted from open drain with depth till 5 m and closed horizontal drainage (CHD). The construction of CHD conducted from ceramic pipe and spread by sand-filter. The drains as a drainage line applied polyethylene pipes in 1986 with diameter of 100 mm, wrapped by bonded fabric. The drain laying depth is 3 m, slope - 0.0015 -0.02.

Data about dynamics of drainage catchment area by various drainage types is given in **table 1** and in **table 2** given dynamics of technical condition of open drainage.

Table 2

Technical condition of horizontal drainage

Year	Of-farm collectors, km				On-farm collectors, km			
	Total	Satisfied	Not satisfied	Cleaned	Total	Satisfied	Not satisfied	Cleaned
1970	3076.3	1948.3	1128.0	827.9	5322.6	3548.4	1774.2	1619.8
1975	3117.7	2190.1	927.6	926.8	8149.2	4291.8	3857.4	3439.4
1980	3747.6	2376.8	1370.8	890.0	8842.7	5023.7	3819.0	3540.0
1985	3922.3	2891.2	1031.1	950.0	9022.4	5015.0	4007.4	3549.0
1990	3912.0	2643.8	1268.2	1123.0	8962.4	5141.6	3820.8	3488.0
1995	3862.8	2582.4	1280.5	1123.0	8623.7	5623.7	3000.0	1953.0
2000	3888.7	2462.8	1425.9	1292.0	9971.2	5686.2	4285.0	2763.8
2008	3892.8	2380.6	1512.2	1310	9986.1	5540.0	4446.1	2840.0

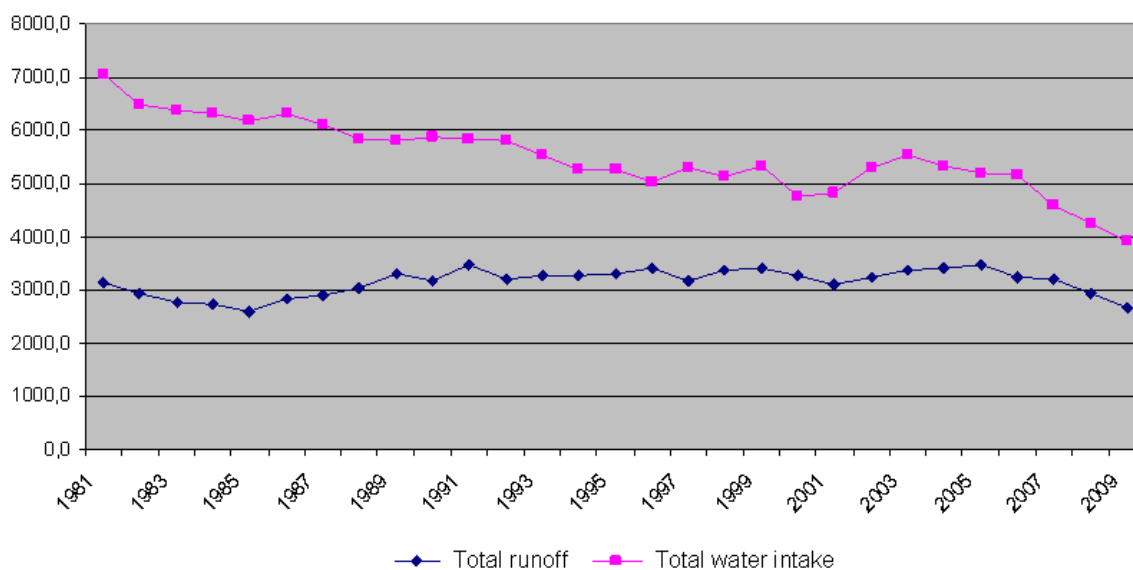


Figure 2 – Dynamics of water intake and drainage runoff in Fergana province

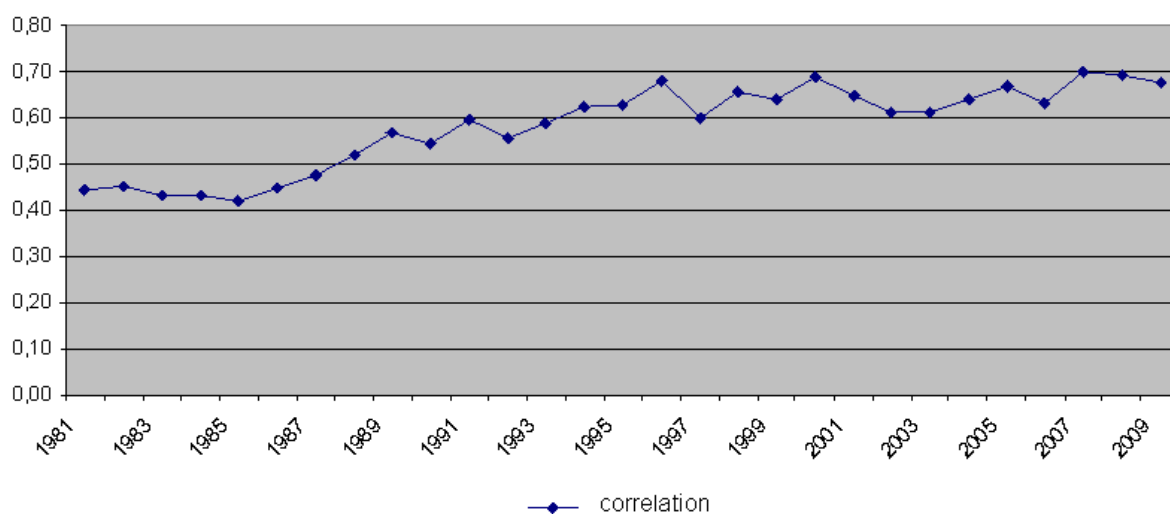


Figure 3 – Ratio of drainage runoff vs. water intake in Fergana province

The analysis on technical condition of off-farm drainage network showed that annual requirement to cleaning off-farm collectors are 33.0 %. Actual cleaning works performed on 85.0 % from required volume. This is a highest rate of performance of repairing in the republic. However, the volume of required on-farm network repair is 40.0 %. The cleaning volume is declined to 65 % which in turn brought reduction to readiness index till 0.83. As a whole it can be concluded that technical condition of open drainage network is satisfied in overall foreshortening.

An existing alarm calls that even average specific cleaning volume of off-farm collectors are 5.1 m³/ha i.e. practically equal to recommended but an actual specific volume of on-farm network is 1.6 times less than allowable value. Thus specific volume reduced with declining the length of cleaned collectors and drains as well. This resulted about fourth of on-farm network is in the unsatisfactory condition. Such a situation is explained with some factors. First, out-of-repair of earth machinery or aging: 127 excavators out of 216 manufactured before 1980. Second main reason is low paying ability of land users and insufficient support from outside.

Starting from 1990 (**tables 2 and 3**) occurred drastic deterioration of technical condition of drainages. Out of 4 only one drain rod machine (PDT-125) is remained in 1987. At failure rate of 7 % annually about 93 km of the closed drains are necessary to restore, and restored only 15 km. It has lead that nowadays 43 % both opened, and closed horizontal drainage is in a non-working condition in province.

Table 3

Data of technical condition and repair CHD

Year	Length, km	Failure		Repaired		Readiness rate
		Length, km	% from total length	Length, km	% from necessary volume	
1990	1185.2	108.3	9.1	62.0	57.2	0.94
1995	1332.4	323.4	24.2	28	8.6	0.78
2000	1332.4	620.0	46.5	15	2.4	0.55
2009	1334.7	580.0	43.4	22	3.8	0.57

Fergana province is one of zones as an intensive application of vertical drainage wells with captured area by one pump-shaft about 60-80 till 120-140 ha. Designed depth of well changed within 30-40 m and above, and moreover 10-25 m of this length is filter. Проектная глубина скважин варьирует в пределах 30-40 м и более, из которых длина фильтра составляет 10-25 м. Calculated debit of wells under this parameters are ranged within 30-60 l/s and more. Construction of vertical drainage wells in Fergana province is started in 1965 and prolonged till 1995.

The number of operated wells increased from 95 in 1970 to 1288 in 2000 under the process of development of drainage works. Accordingly drained area also increased from 9.6 thousand ha to 88.2 thousand ha. All wells (VDW) constructed using metallic pipes with diameter of 300-400 mm, depth from 40 to 50 m, rare 60 m. length of filter 10-25 m, drilling diameter 900-1000 mm. the wells have 3-5 to 10 l/s specific debit in 1 m lowering as aquifer in Fergana province is presented mainly by gravel-sand grounds and pebble stones.

Pumping volume from wells formed depending on debit, number of operated wells and their run time during a year expressed as systems efficiency factor (ratio of actual run time into calendar deadline extracting time for restoration works).

Systems efficiency factor in the territory of Fergana province in 1970-1990 time interval fluctuated within 0.46 (1985) to 0.76 (1980). During these years pumping volume reached 514.1 mln.m³ or 7588.2 m³/ha per year accordingly. The maximum pumped volume observed in 1990 when it reached 633.1 mln.m³ or 7800.2 m³/ha per year under systems efficiency rate of 0.51. Starting from 1990 it is observed decline of pumped volume and accordingly specific volume of water removal from irrigated lands which linked to decrease of numbers of operated wells and the value of systems efficiency. Pumped volume in 1995 and 2000 were 405 mln.m³ with operated wells 750 pcs. and systems efficiency at 0.39 and 390 mln.m³ (4.5 thousand m³/ha) with operated wells 1288 and systems efficiency 0.33 respectively.

The system provided high drainage rate of irrigated lands within 5,7-7.8 thousand m³/ha during satisfactory work in 1970-1990. In the districts such as Kuva, Tashlak, Bagdad and Besharyk where intensive development of vertical drainage wells are resulted negative water and salt balance of irrigated lands.

High degree of drainage in 1970-1990 created by VDS allowed regulating ground water table within 2.0-2.5 m during vegetation period causing favorable water-salt regime of irrigated lands thus high crop yields. Moreover satisfactory work of system with systems efficiency from 0.5 to 0.7 supported by high operation costs the value which ranged from 3336 to 5346 rubles per well. The specific costs for 1 ha were 30-50 rubles at the cost in 1984 where power costs averaged till 50 %. The operation level was worsened starting from 1996 due to increase of electricity power costs, imbalance between well parameters and pump-power equipments and lack of spares to them as well as intensive reduction of work ability of well itself.

Present day an operational cost of VDW for 1 ha not exceeds 6-7 USD. Due to worsening of the operation an efficiency of the system declined to 0.33 in 1995-2000 and now ranges 0.2-0.25.

Given analysis of ameliorative condition of systems in Fergana province seriously expressed in the fluctuation of ground water table and presence of saline lands.

Distribution of irrigated lands of the province by ground water levels are shown in **figure 4**, and dynamics of salinity of irrigated lands in the **table 4**. Obviously given data indicated that a more or less favorable condition of lands is kept in the province as a whole although moderate and highly saline lands are slowly increasing in some zones especially in downhill valleys and interadyr depressions. As well as lands with ground water table at 2 m is gradually increased due to somewhat decrease of lands with GWT within 3-5 m.

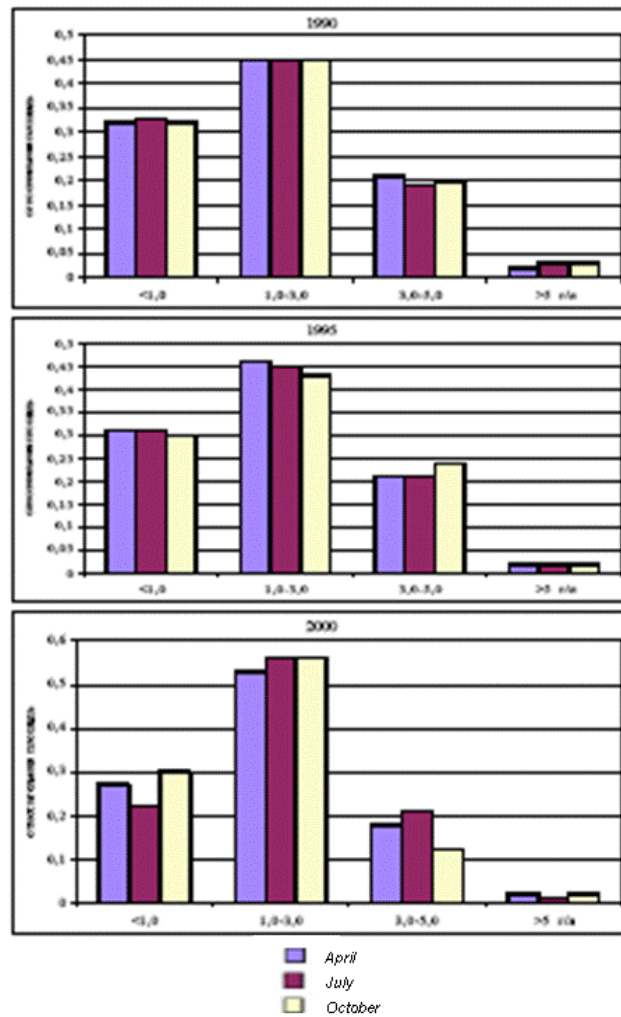


Figure 4 – Distribution of irrigated lands by GWT in Fergana province

Table 4

Dynamics of soil salinity in Fergana province

Year	non saline	weak	moderate	high	non saline	weak	moderate	high
	Thousand ha				Relative lands			
1980	219.70	73.50	23.80	12.80	0.71	0.24	0.08	0.04
1990	167.20	141.00	33.00	8.50	0.48	0.40	0.09	0.02
2000	170.10	90.40	75.30	21.00	0.48	0.25	0.21	0.06
2009	161.60	133.60	43.30	21.60	0.45	0.37	0.12	0.06

Recharge of aeration zone from ground water is a main factor of satisfaction of crop water use and determination of total balance of irrigated lands and aeration zone. Unfortunately all available methods to estimate capillary inleakage either too approximate or to much academical for practical implementation. It was found also in FAO guidance book (issues 24 and 56) and at many other research materials particularly in our jointly work with Lisbon Agrarian University on the theme “Irrigation management against drought in the Aral sea basin” under editors Prof. L.S. Pereira, Prof. V.A. Dukhovny and Dr. M.G. Khorst.

In view of the aforesaid the given project and recruited students' works such as study of interaction of drainage and irrigation and simultaneously refinement of ground water recharge calculations have a high profile in further detailed elaboration of having gaps in land reclamation knowledge.

II. Objectives

Principle tasks of the field investigation is definition of interrelation between irrigation and groundwater from point of minimization of total used water resources.

III. Methods and results

3.1 Description of the object of research, methodology and observation results

The research area is located in the irrigated lands of "Azizbek" farm in Ahunbabaev district, Fergana province, earlier belonged to the abandoned lands of the Central Fergana which have been developed in 60th of last the century. In 1958-60 a deep horizontal drainage had been constructed with a depth of 3.5 – 3.7 m, steadily working now more 45 years. The closed drains #1 and #2 with length of 1600 and 750 m respectively lay by asbestos-cement pipes with diameter of 150-200 mm with the reformed holes and strewed by gravel with coarse sands as a filter.

The distance between drains is 242 m which is near to mouth of spillway into open collector and at the above part on 249 m spills into open collector with a depth of 4.0-4.5 m where located mouth facility.

In the hydrological relation the drainage site is in a charge zone of underground waters. According to the study results of SANIIRI, underground inflow from the sides make 3.0-4.0 thousand m³/ha, therefore piezometric pressure of underground waters dated for more deeper water permeable layers (the depth is 100 m all over the year) is established on 20-70 cm above from GWT.

Except specified drains three plastic drains B-1, B-2 and B-3 with depth of 2.4 m are constructed on irrigated fields 1, 2, 3 and 4 with total area about 40 ha.

The cytological structure of a pilot is presented by overlaid deposit of grounds. The top thickness of covered melkozem differs by non-uniform-layered structure, dusty, presence of low permeable gypsum layers on depth of 0.7-1.2 m which slowing down the process of movement of moisture, and their average filtration rate changes from 0.2 to 2.0 m/days

GWT on irrigated lands fluctuated at 1.2-1.6 m (with total mineralization about 7-9 g/l) before construction of closed horizontal systems and non irrigated lands – 2.5-2.8 m (with mineralization of 20-22 g/l) which defined the intensity of salt accumulation in aeration zone.

In an initial condition salt content in a 1 m soil layer was 2.3-3.0 %, in some places ranged up to 5 % against dry soil weight and chloride – 0.03-0.08 %. The type of soil salinity and ground water is sulfate.

Closed drainage system is introduced into operation from second half of 1960. Mean annual water supply on irrigated lands from 1961 to 1975 changed within 13-15 thousand m³/ha and drainage constant was 0.22-0.36 l/s/ha against designed - 0.17 l/s/ha. A whole length of drainage lines operated in a pressured regime in this period. Overhang of ground water in a pipeline of drain fluctuated from 0.5 to 1.4 m increasing towards their mouth.

As a result of high performance capacity of constructed drains and following to required leaching regime of irrigation on the study plot it was reached a particular improvement of water-salt regime in the end of 1964-1965:

- Soils are desalinated up to 1.2-1.4 % against total salts in dry soil;
- Ground water mineralization was reduced till 3.5-5 g/l against initial conditions' 5.5-10 g/l

- Main crop- cotton yield increased up to 25-27 c/ha against initial -12-18 c/ha.

Water-salt balance was practically stabilized in the end of 70th with a certain range of change through period of year depending on water supply to the territory.

On the background of this drainage two irrigated plots are set up namely № 13 and № 15 with area of 10.2 and 8.92 ha respectively.

Field № 13 was cultivated by winter wheat and field № 15 - cotton. Both fields were equipped by observation wells in three lines on each inter drains which are made by polyethylene pipe with a diameter of 32 mm, length – 3.6 m, perforated from the depth of 1.2 m.

The following field observation is conducted: measurement of GWT, discharges of drains, all agro technical applications together with water supply and identification of irrigation norms as well as measurement of evaporation by evapometer. GWT measurements were conducted on each 10 days and more often during irrigation application aiming to define irregularity of irrigation and drainage interaction and interpretation of drainage module (**fig.5**).

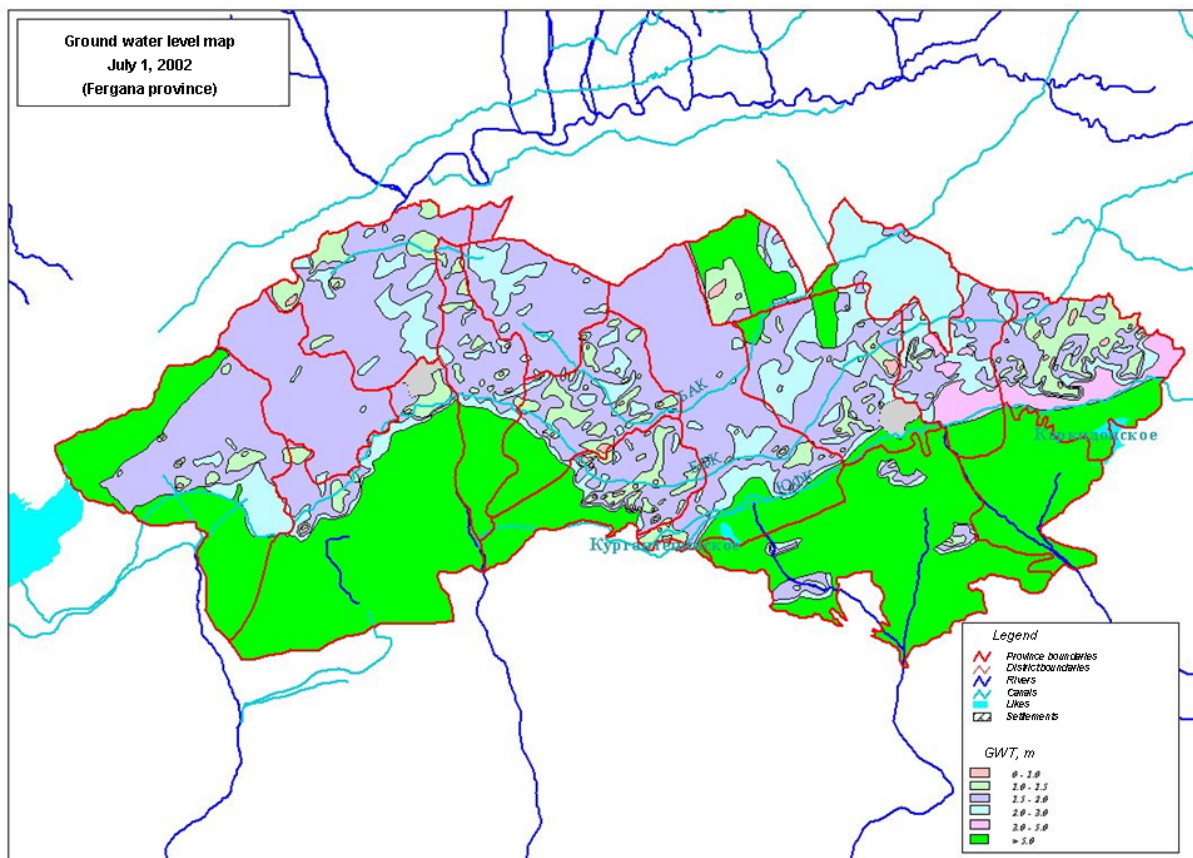


Figure 5 – GWT map of Fergana province

Soil moisture measurements were conducted by German specialists and their results of comparison with dynamics of GWT would be given in an annual report.

Investigation results

The results of GWT measurements on the field #13 is given in the next **table 5** where sown winter wheat for 2009-2010 cropping year.

Table 5

GWT on the field #13 (in m from soil surface)

Measurement date	Wells No.									Note
	1	2	3	4	5	6	7	8	9	
10.09.2009	2.92	2.68	2.81	2.85	2.71	2.80	2.78	2.64	2.72	Before irrigation
20.09.2009	1.02	0.60	2.23	1.11	1.46	2.51	0.96	1.26	2.60	
03.10.2009	1.59	1.27	0.96	1.58	1.19	1.08	1.61	0.87	1.13	
11.10.2009	1.86	1.61	1.60	1.82	1.53	1.60	1.84	1.28	1.54	
20.10.2009	2.11	1.76	1.79	1.98	1.71	1.75	1.89	1.63	1.81	
01.11.2009	2.32	1.79	1.91	2.24	1.80	1.90	2.01	1.74	1.97	
03.11.2009	0.93	1.81	2.03	0.89	1.86	1.92	0.74	1.78	2.01	
08.11.2009	1.21	0.80	0.40	0.34	0.72	1.24	1.30	0.91	1.31	
13.11.2009	1.51	1.38	1.82	1.68	1.50	1.58	1.67	1.31	1.20	
18.11.2009	1.87	1.56	2.07	1.83	1.61	1.82	1.68	1.70	2.14	

Winter wheat in the field #13 was sown in September 14-15, 2009. GWT (10/09/09) before sowing the wheat were almost uniform within 2.64-2.85 m from soil surface.

At the same time GWT in the territory of drain #1 fluctuated from 2.78 to 2.85 m from soil surface and in the middle of the field (observation wells 2, 5, 8) – 2.64-2.71 m and near to drain #2 – 2.7-2.8 m (observation wells 3, 6, 9).

After the beginning of the rechargeable irrigation of wheat from September 18 to 23, the GWT began gradually rising; the water-charging irrigation rate was 1260 m³/ha; at that, on early days, GWT was rising at the places where irrigation was being performed (near to the drain # 1).

By September 20, GWT in the well # 1 was 1.02 m; in the well # 2 – 0.6 m; well # 4 – 1.11 m. At the middle of the field, in the well # 5, the depth was 1.46 m; well # 7 – 0.96 m; and well # 8 – 1.26 m from the ground surface. At the place where irrigation was not performed yet (wells 3, 6, and 9), the GWT was within the range of 2.23 to 2.6 m.

After finishing the rechargeable irrigation by October 3, GWT lowered in the well # 1 down to 1.59 m; well # 4 – 1.58 m; and well # 7 – 1.61 m; GWT at the middle of field in the well # 2 was 1.27 m (wells 2, 5, and 8); well # 5 – 1.19 m; well # 8 – 0.87 m from the soil surface.

Similar GWT decline is observed in the wells 3, 6, and 9 near to the drain # 2.

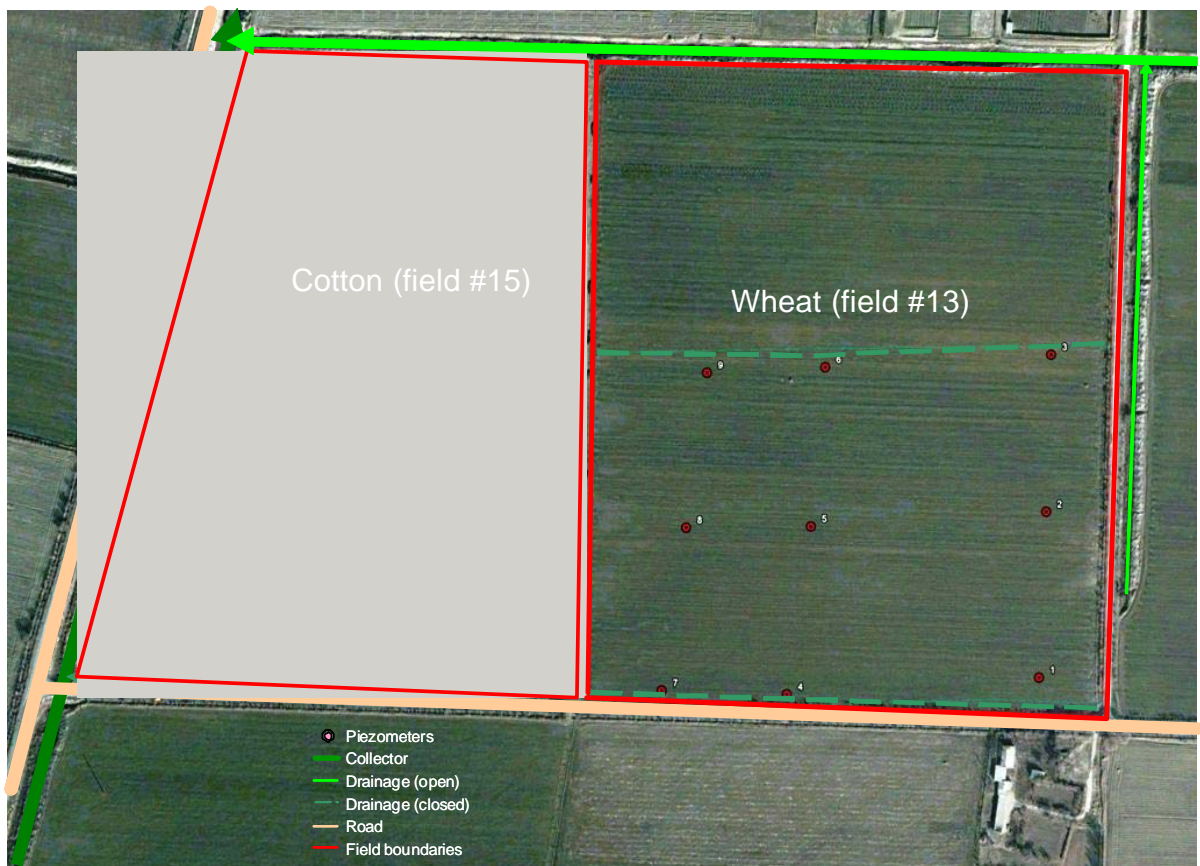
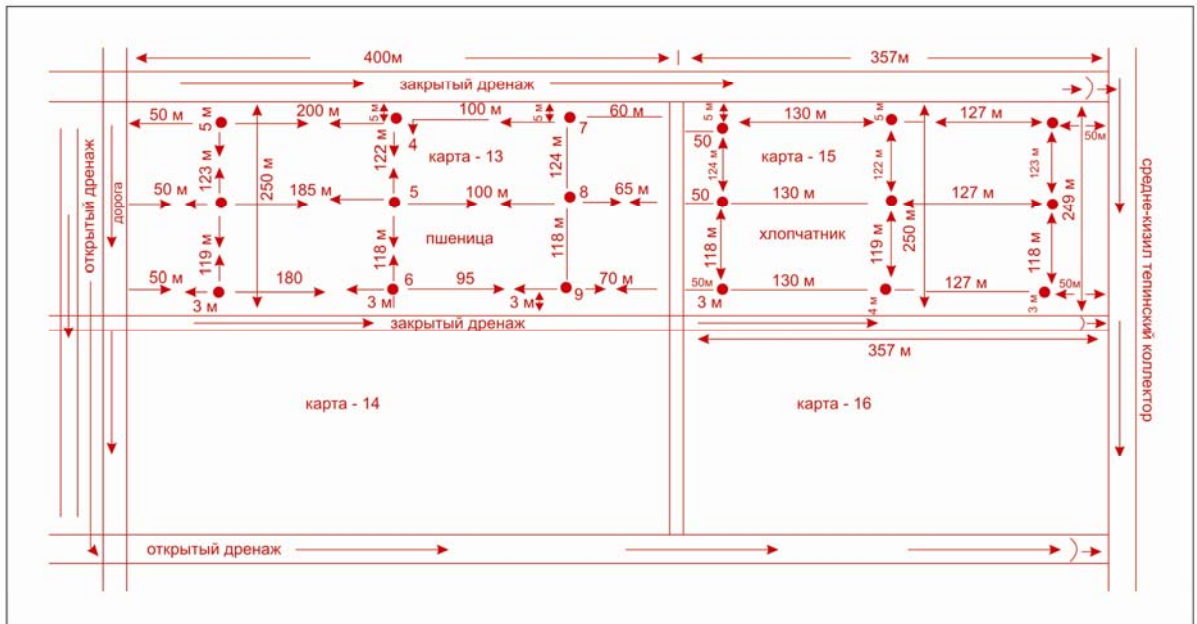


Figure 6 – Field layout showing the location of investigation wells, closed drains and collectors

GWT fall on all the fields is uniform, and by November 1, 2009, it was falling more down at the places near to the drains in the wells 1, 4, and 7; and in the middle of field, it is somewhat less falling. This is evident from the data in **table 6**.

The autumn of 2009 was clear with less amount of rainfall. The second irrigation of the wheat on the field # 13 was applied on November from 3 to 9 thorough furrows which is located near to

the drain # 1 (wells 1, 4, and 7) and irrigation is gradually advanced into the middle of field (wells 2, 5, 8); and by November 8, irrigation reached to the end of field # 13, or up to drain # 2. Therefore, GWT on the whole field had sharply risen by November 8. This is seen from the data acquired (through the changes) in the well # 3 – 0.4 m; well # 4 – 0.34 m (that place was flooded); well # 5 – 0.72 m from the soil surface.

The second irrigation rate was 1087 m³/ha. The acquired measurement of data show that GWT on the field, due to efficient operation of the drains ## 1 and 2, was coming down by November 18, 2009. GWT on the whole field is within 1.56 to 2.14 m from the soil surface. At that, the lowest level is observed near to the drains; and in the middle of filed, it is somewhat higher. In winter of 2009 and spring of 2010, during the following spans were performed irrigations at the site: February 16-18 – at a rate of 1030 m³/ha; April 7-10 –722.4 m³/ha; April 29 to May 1 - 842.1 m³/ha; and May 22-25 – 593 m³/ha.

During the vegetation period, additional fertilizing was carried out as follows: by ammonium nitrate of 500 kg/ha (165 kg/ha of nitrate at the beginning) and 200 kg/ha of superphosphate (38 kg/ha at the beginning).

Appropriate GWT changes during the wheat vegetation period are given in Table 6.

Table 6

GWT observed by wells in “Lazizbek” farm, Akhunbabaev district (wheat field #13, growing period 2009-2010)

Date of measurement	# of wells								
	1	2	3	4	5	6	7	8	9
10.09.2009	2.92	2.68	2.81	2.85	2.71	2.8	2.78	2.64	2.72
20.09.2009	1.02	0.6	2.23	1.11	1.46	2.51	0.96	1.26	2.6
03.10.2009	1.59	1.27	0.96	1.58	1.19	1.08	1.61	0.87	1.13
11.10.2009	1.86	1.61	1.6	1.82	1.53	1.6	1.84	1.28	1.54
20.10.2009	2.11	1.76	1.79	1.98	1.71	1.75	1.89	1.63	1.81
01.11.2009	2.32	1.79	1.91	2.24	1.8	1.9	2.01	1.74	1.97
03.11.2009	0.93	1.81	2.03	0.89	1.86	1.92	0.74	1.78	2.01
18.11.2009	1.87	1.56	2.07	1.83	1.61	1.82	1.68	1.80	2.14
25.11.2009	1.89	1.59	2.08	2.19	1.99	1.97	2.09	1.99	2.66
01.12.2009	1.98	1.81	2.14	2.23	2.11	2.16	2.18	2.17	2.68
05.12.2009	2.13	2.04	2.29	2.39	2.34	2.41	2.48	2.39	2.87
15.12.2009	2.40	2.31	2.76	2.83	2.36	2.79	2.73	2.80	2.96
20.12.2009	2.70	2.65	2.78	2.78	2.59	2.80	2.86	2.86	3.02
30.12.2009	2.24	2.10	2.31	2.62	2.21	2.42	2.49	2.56	2.73
11.01.2010	2.28	2.22	2.39	2.13	2.20	2.40	2.14	2.32	2.41
16.01.2010	2.32	2.37	2.38	2.37	2.32	2.47	2.27	2.32	2.47
20.01.2010	2.37	2.27	2.37	2.37	2.27	2.49	2.32	2.41	2.49
26.01.2010	2.52	2.60	2.55	2.47	2.47	2.67	2.52	2.42	2.61
30.01.2010	2.63	2.72	2.74	2.67	2.59	2.72	2.52	2.52	2.73
05.02.2010	2.77	2.82	2.68	2.72	2.65	2.74	2.67	2.57	2.76
10.02.2010	2.50	2.40	2.55	2.50	2.40	2.54	2.40	2.51	2.59
15.02.2010	2.55	2.36	2.50	2.57	2.50	2.55	2.45	2.53	2.56
21.02.2010	2.60	2.60	2.75	2.65	2.60	2.70	2.60	2.55	2.66
25.02.2010	2.65	2.60	2.65	2.66	2.60	2.70	2.65	2.60	2.66
02.03.2010	2.65	2.70	2.70	2.65	2.65	2.80	2.65	2.70	2.68

07.03.2010	2.70	2.71	2.75	2.70	2.70	2.83	2.70	2.70	2.76
12.03.2010	2.65	2.66	2.70	2.60	2.60	2.80	2.65	2.60	2.75
17.03.2010	2.50	2.45	2.50	2.40	2.50	2.60	2.45	2.35	2.54
25.03.2010	2.40	2.35	2.55	2.45	2.25	2.50	2.40	2.37	2.52
30.03.2010	2.31	2.40	2.51	2.46	2.41	2.47	2.38	2.36	2.46
05.04.2010	2.36	2.31	2.50	2.50	2.35	2.45	2.37	2.40	2.39
10.04.2010	1.19	1.08	1.11	1.21	1.06	1.05	1.15	1.02	0.92
17.04.2010	1.90	1.80	1.89	1.91	1.73	1.85	1.87	1.76	1.86
23.04.2010	1.86	1.84	1.87	1.83	1.71	1.83	1.91	1.82	1.85
27.04.2010	0.66	1.90	1.93	0.87	1.80	1.89	1.88	1.76	1.90
30.04.2010	0.71	0.83	1.74	0.61	1.05	1.76	0.73	1.41	1.82
06.05.2010	1.55	1.43	1.68	1.58	1.39	1.62	1.69	1.61	1.7
12.05.2010	1.9	1.6	1.72	1.86	1.61	1.72	1.67	1.75	1.81
16.05.2010	1.92	1.78	1.8	1.91	1.74	1.8	1.69	1.74	1.83
20.05.2010	1.91	1.78	1.83	1.92	1.76	1.84	1.7	1.77	1.86

It is significant that due to dry winter, irrigation of 1030 m³/ha was completely used for the charging the aeration zone moisture and did not affect the GWT at all.

In spring, much less irrigation rate of 711 m³/ha caused GWT rise by 1.2 m almost uniformly in all inter-drains; but GWT falling rate at the margin sites that are remote from the collector were rather lower: by 20 cm right after the irrigation. Later, it became smooth. Hence, one should take into account during irrigation within 1000 m³/ha, the spreading intensity is sufficient to keep uniformity of the drainage and irrigation interaction at good degree of drainage.

Water level dynamics in piezometers (table 6) shows that at a depth of 1.5-1.8 m, certain pressure head remains within 20 cm at no irrigation, but with the main canals being filled. At the irrigation, the pressure immediately increases up to 75 cm, and then gradually decreases (figs. 7, 8), and with no irrigation and no water, it disappears in the canals. The pressure appears again with filling systems and especially under influence of irrigation.

Water flow measurement in the drains shows that under the conditions of low pressure supply, the drainage flow dynamics change slightly (figure 9), but it lowers up to two times after the wheat irrigation is stopped.

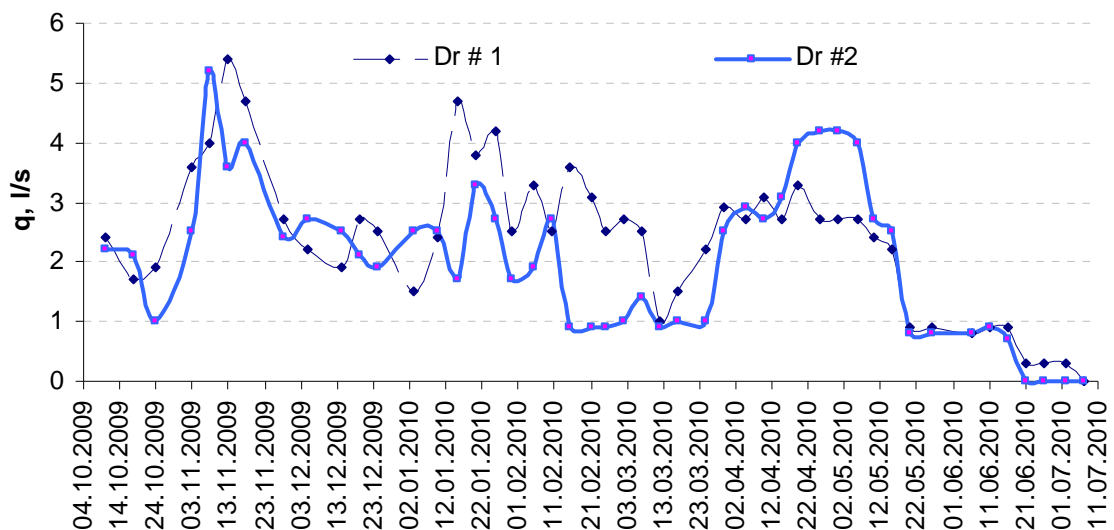
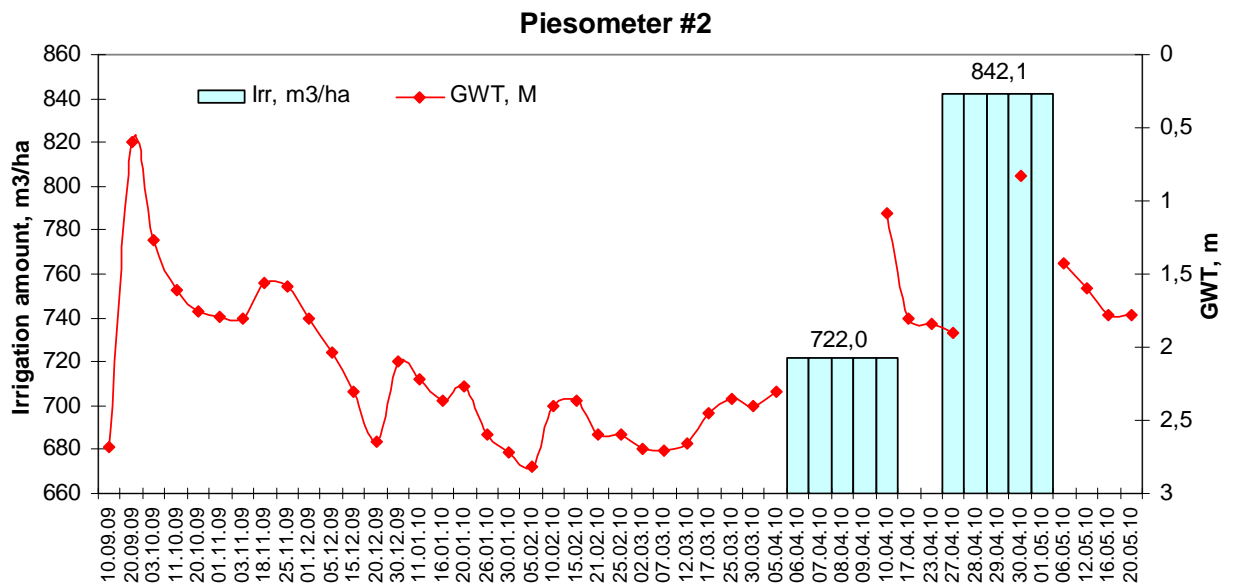
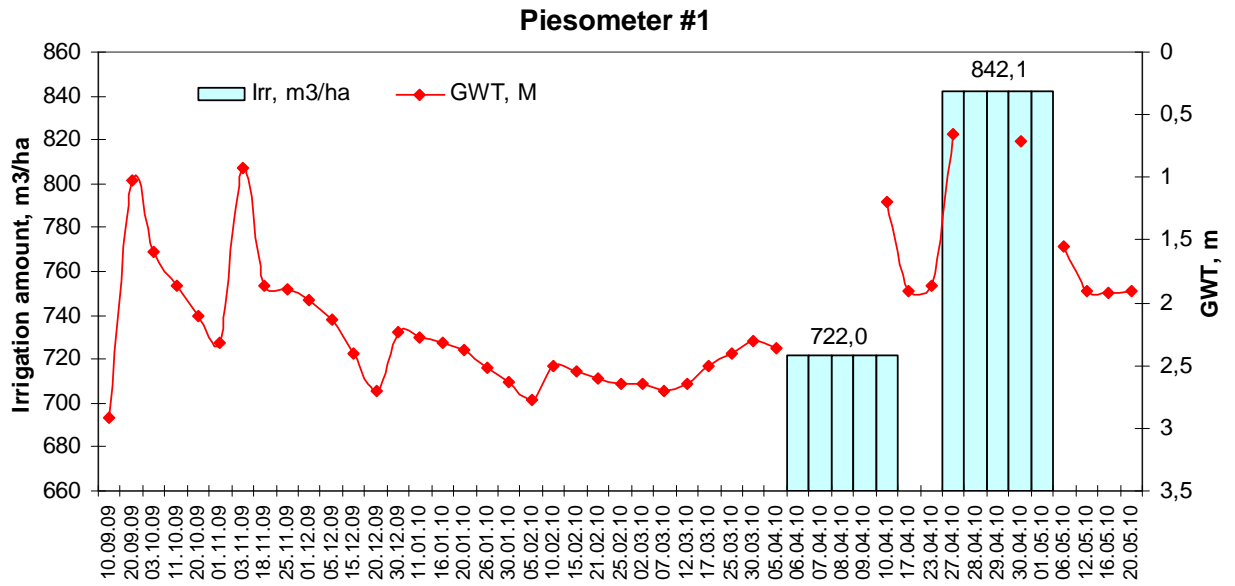
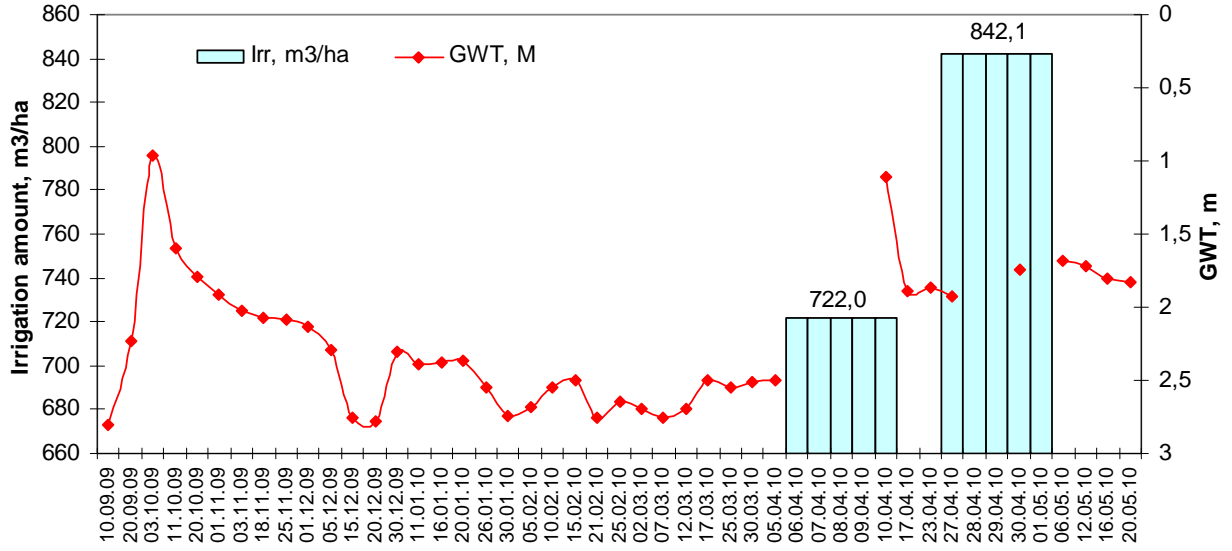


Figure 9 - Drainage flow dynamics (closed drains # 1 and 2)

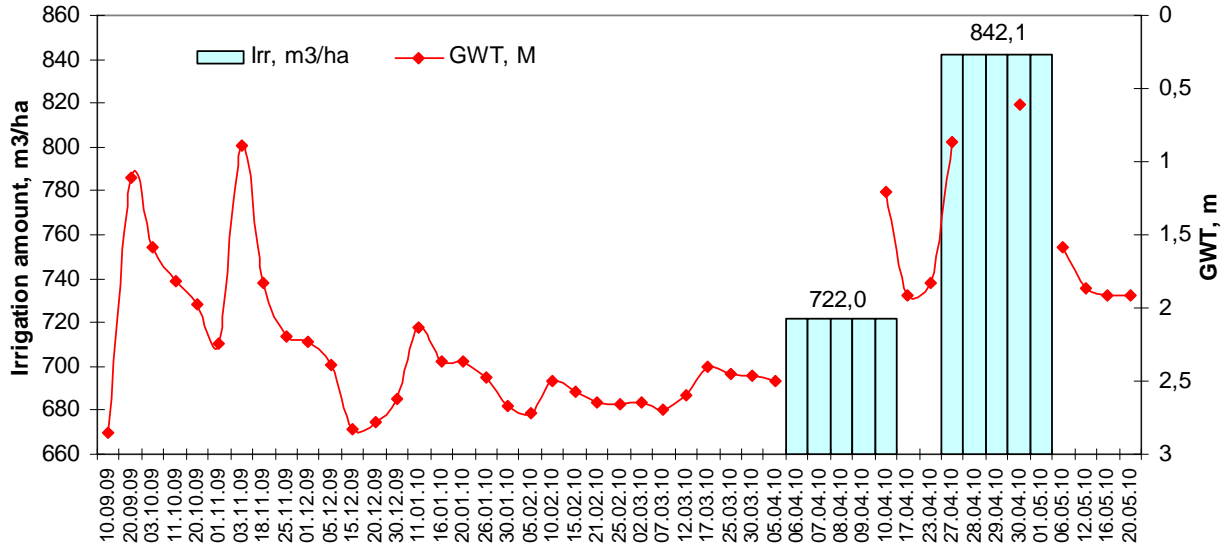
The land reclamation condition on both fields is good. Salt accumulation is absent as well as flooding, as evident.



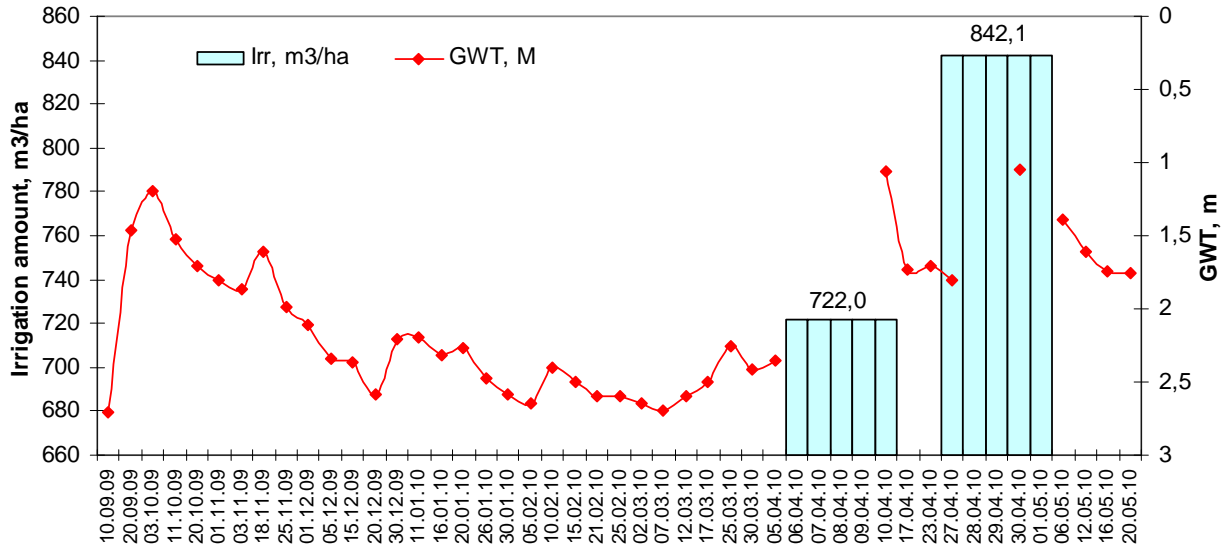
Piesometer #3



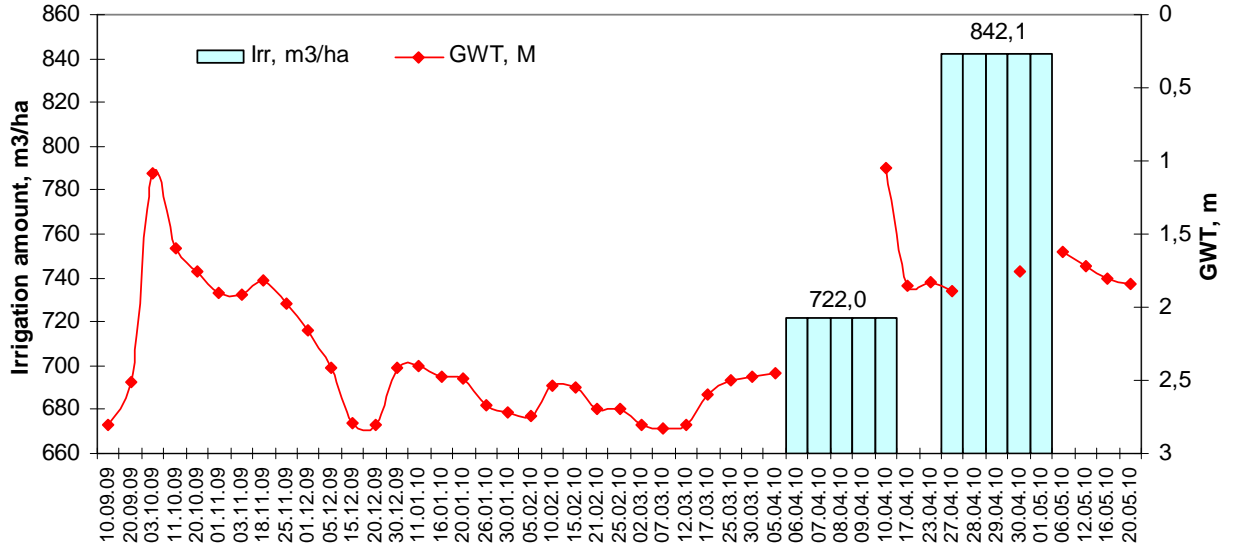
Piesometer #4



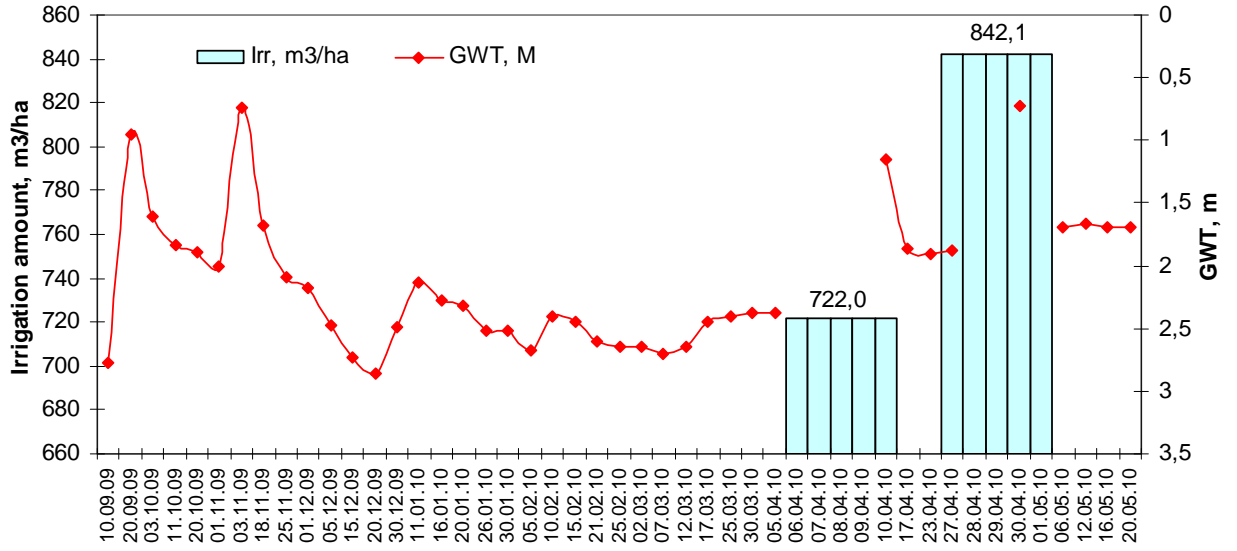
Piesometer #5



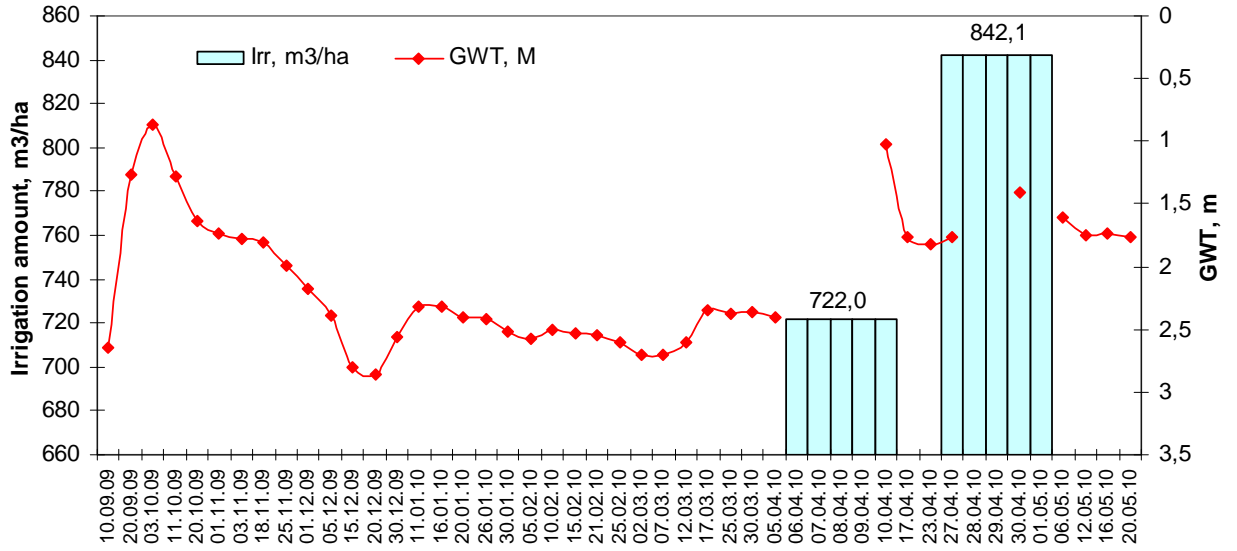
Piesometer #6



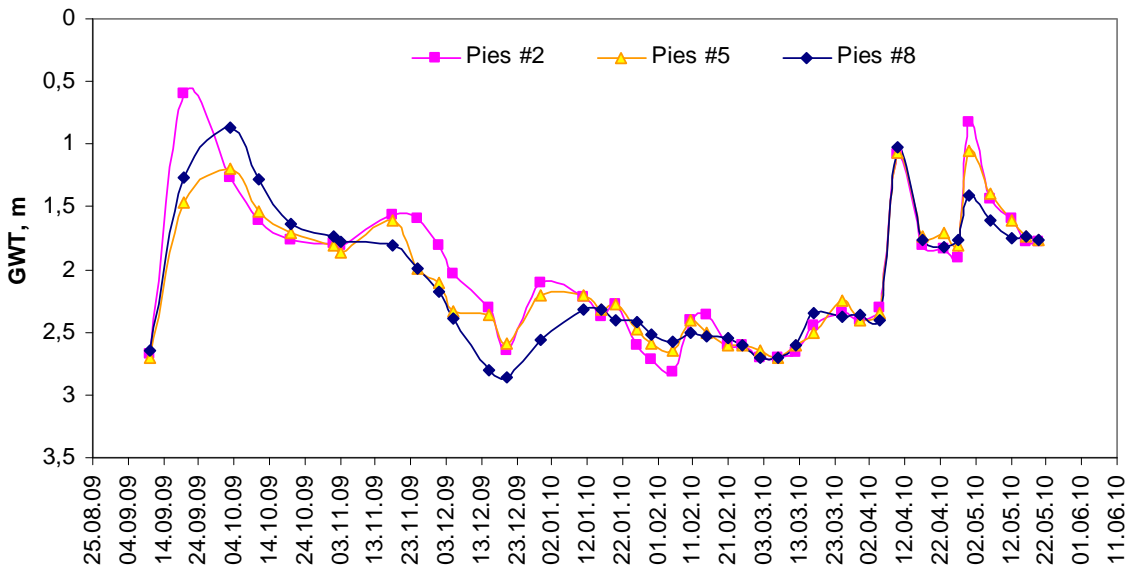
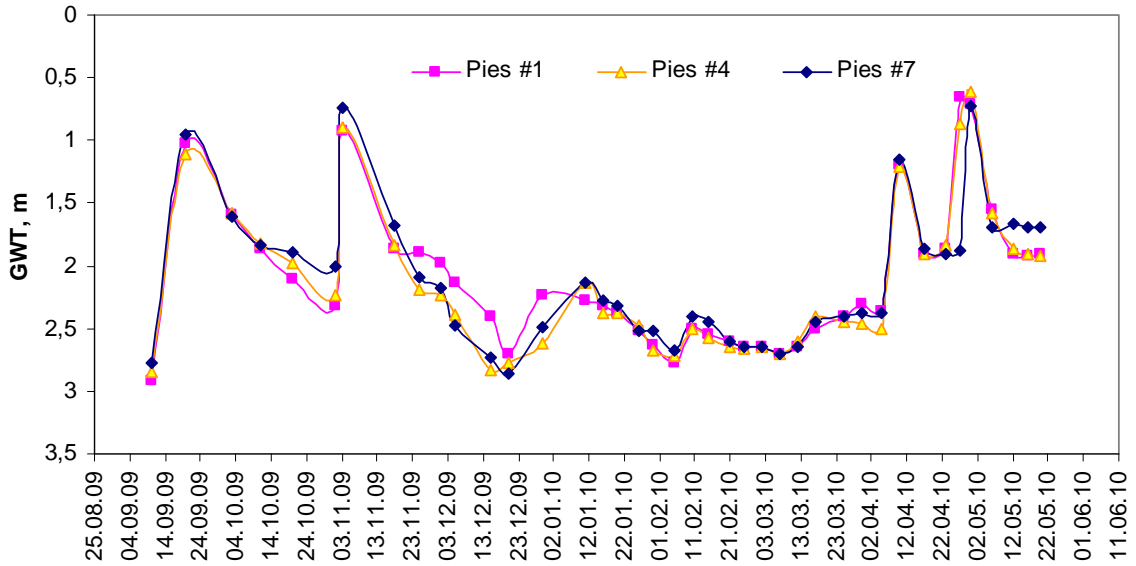
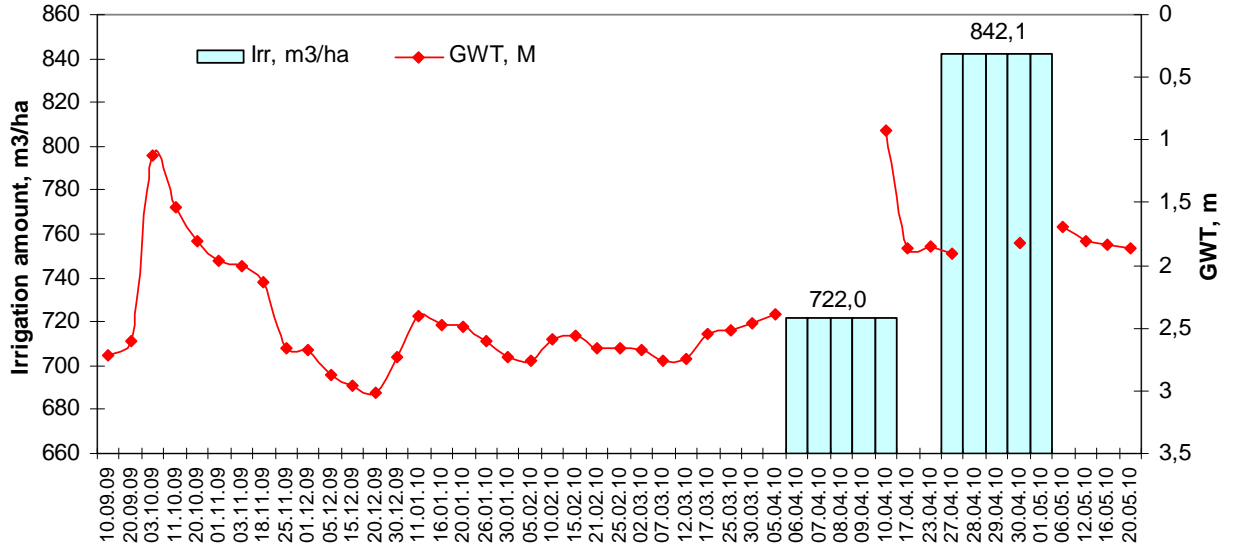
Piesometer #7



Piesometer #8



Piesometer #9



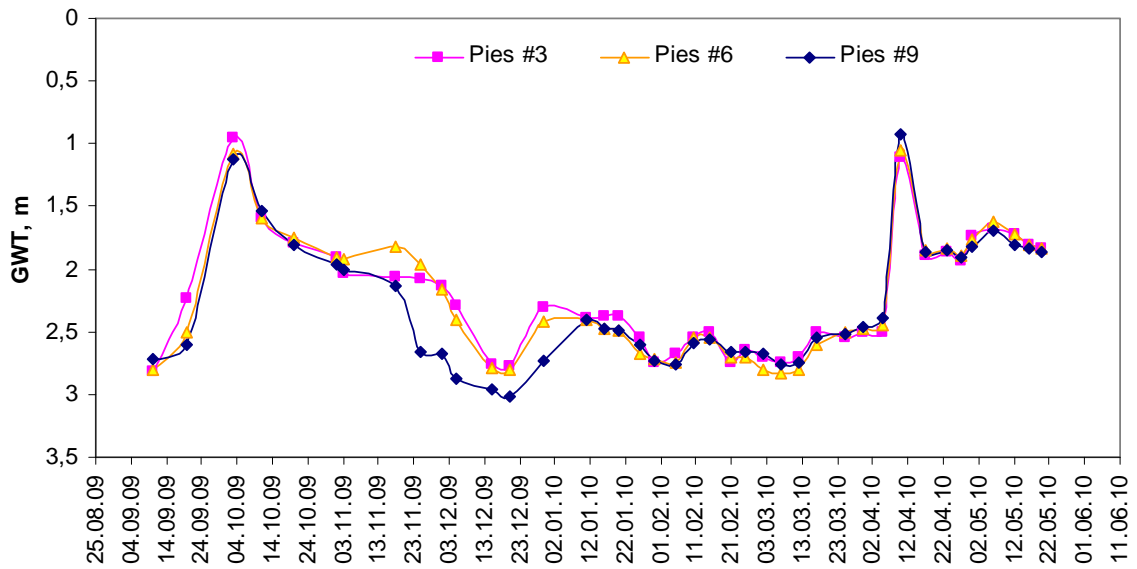
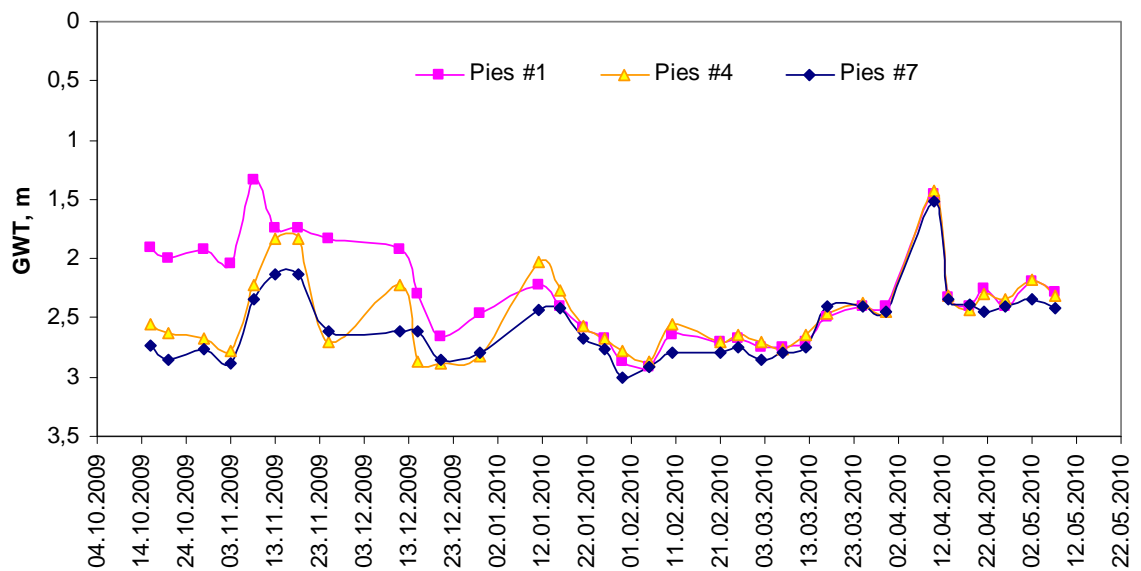


Figure 7 - GWT fluctuation at plot # 13 (wheat field)



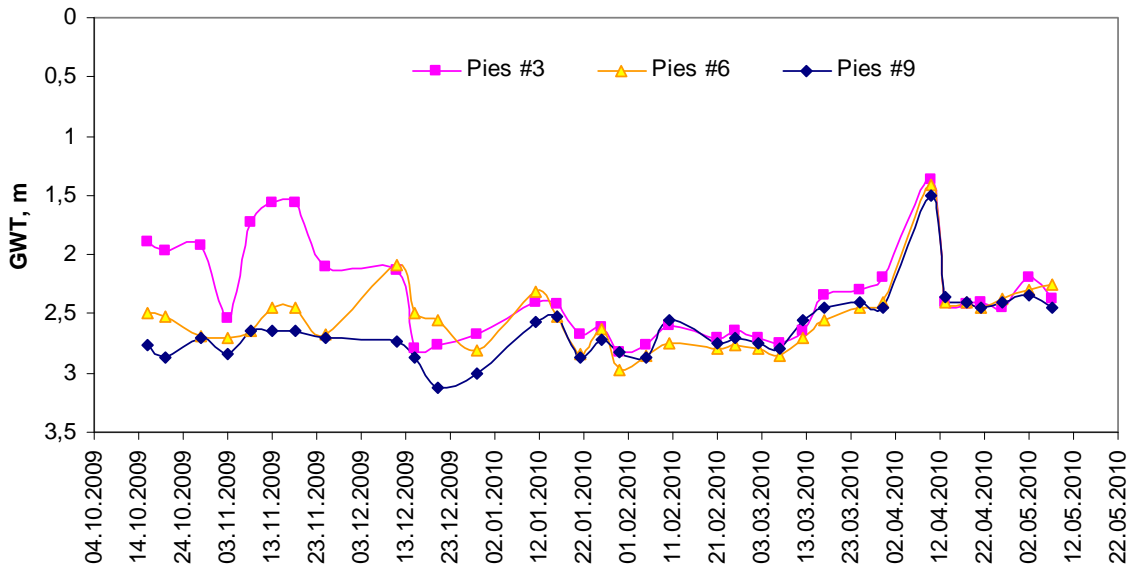
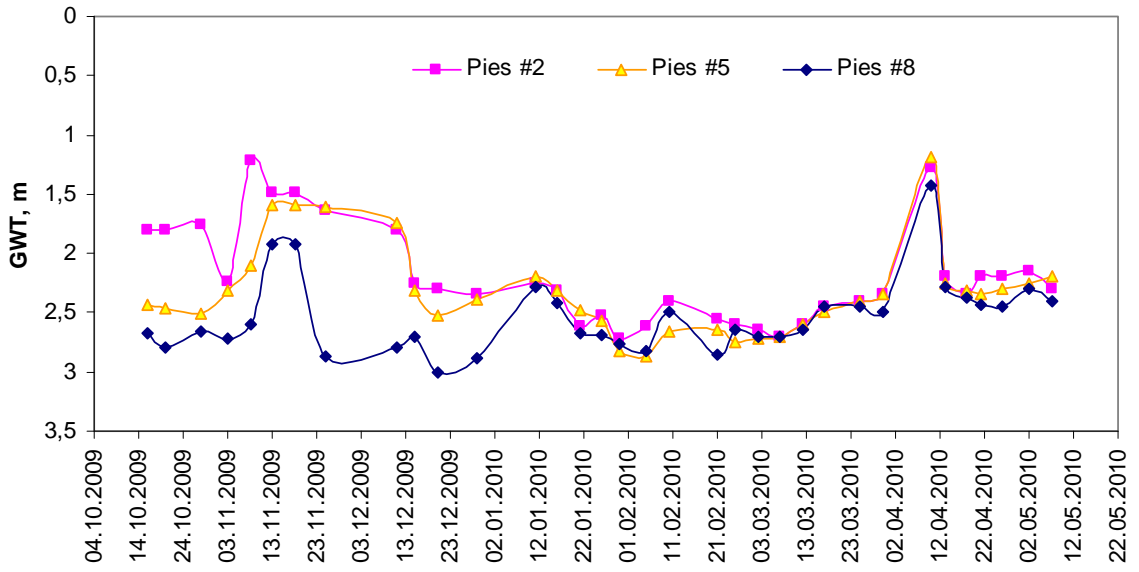


Figure 7 b – Fluctuation of GWT at plot # 15 (cotton field)