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PECULIARITIES OF CALCULATION OF WATER BALANCE FOR THE EXISTING PERIOD IN GULISTAN CITY

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Abstract

This article describes the features of the calculation of water balance for the existing period in the city of Gulistan. The territory of the city of Gulistan for many years, even decades, is the subject to flooding with groundwater. In order to determine the causes of flooding, geological and hydrogeological studies were repeatedly carried out, and projects of reclamation measures were developed to lower the water table. Thus, the lithological structure and water-physical properties of soils on the territory of the city have been sufficiently studied. A number of ameliorative measures have been carried out, however, the reclamation state of lands on a large part of the city's land area continues to be unsatisfactory. For more than 50 years, the city has been submerged by groundwater, but constant and consistent observations of the dynamics of the groundwater and groundwater regime have not been carried out. In these cases, first of all, the system of horizontal drains should work effectively. Unfortunately, urban horizontal drain systems are not timely and systematically cleaned, so their efficiency is much lower. The possibilities of regulating the upgrading problems in the city of Gulistan are revealed. Recent years due to neglect, lack of the required power limit, morally and physically obsolete energy-intensive pumping and power supply equipment (transformers and cables), untimely cleaning of drainage systems, vertical drainage systems operate poorly or are practically not operated. The scientific novelty of the paper work is in the fact, that in the basis of the completed complex field studies and laboratory analyzes it is proved, that if the subterranean waters level drops to 2 m, there will be no underground outflow from the city's territory - there will be an inflow from the surrounding lands to almost the whole contour (as to "a large well"). The obtained research results can serve as a basis for differentiating the vertical drainage operation modes taking into account the hydro-geological conditions of the city.

Key words: the water balance, the total water balance, general water balances, articles of the water balance, calculating the total water balance.

Introduction

Over the past 10 years, in many cities and urban settlements, in certain areas or zones, groundwater levels rise, thereby creating negative consequences - flooding of territories.

In urban planning, the usual depth of laying basements or utilities is taken primarily up to 3 m from the surface of the earth [6]. A stable rise in the groundwater table above this mark creates additional difficulties both in the construction of engineering and housing facilities, and in laying underground utilities (heating mains, main water lines and sewers, power and communication cables and others)[10].

Therefore, a systematic study of the groundwater regime, the identification of possible flooding zones and the operational development of recommendations on water depletion in these zones is of paramount importance, both in the perspective urban planning, and in creating decent housing and social living conditions for the population, for the development of the engineering and communication infrastructure of the populated locality [1].

One of the cities of the republic, separate areas of which are the subject to flooding is the city of Gulistan.

Main part. The researches were conducted in 2016-2018 in the city of Gulistan, which is located in the northeastern part of the Mirzachul steppe. The natural boundaries of the city's territory are the K-3 channel from the south, the Dustlik main channel from the east and the northeast. The city of Gulistan is administratively the center of the Syrdarya region and the number of population currently more than 80 thousand people.

The main features of the climate (high air temperature, low rainfall and thereafter, the extraordinary dryness of the summer period) are determined by its location within the Asian continent.

The depth of subterranean waters in the city range from 0,5 to 2-3 m. The high position is observed on April, the low - on October. The amplitude of oscillation is 1,0 -1,5 m.

The subterranean waters are highly mineralized, their mineralization reaches 7-8 hl. Shallow leveling allows the subterranean waters reach the earth's surface through the capillary rise and spend a great deal on evaporation, and this factor is the cause of salinization of soils and ground.

Using observations on the piezometric network during the initial period of construction of drainage systems, it is possible to clarify the initial data on the conductivity and coefficients of filtration of aquifers and interlayers and to make appropriate corrections to the design [4]. Calculations on the forecast of the action of drainage are so complex that only when combined with field and laboratory studies can the desired effect be achieved.

The works of A.N.Kostyakov, S.F.Averyanov, M.M.Krylov, A.V.Lebedev, A.F.Slyadnev and many other scientists proposed a number of equations for the water balance of groundwater [2, 3, 11, 12].

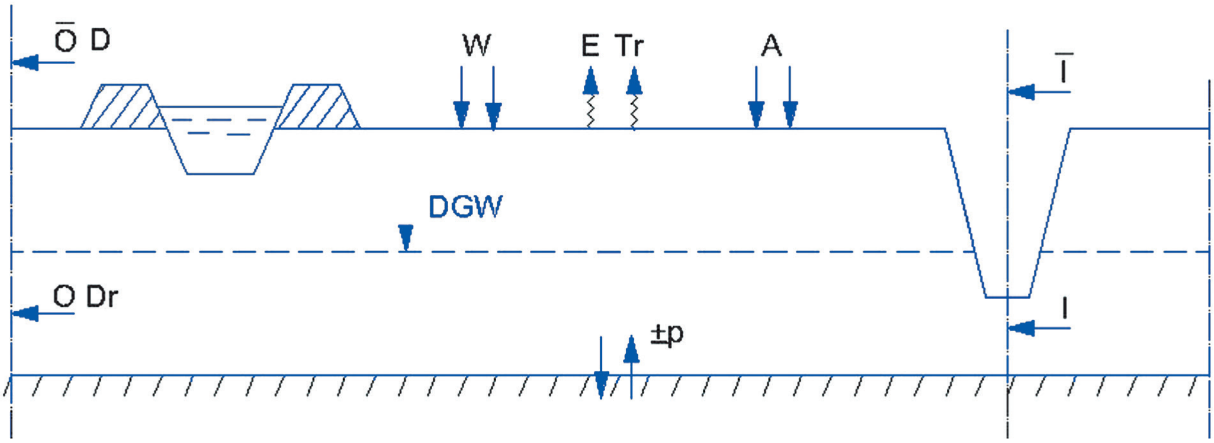


Fig.1. A general water balance

The reasons for the formation of flood zones within populated areas are different. The territories of individual cities and urban settlements located in the lowland areas due to weak natural outflow of groundwater are constantly subject to flooding. The natural watercourses and irrigated fields around these settlements gradually feed the groundwater horizon. In these cases, first of all, the system of horizontal drains should work effectively. Unfortunately, urban horizontal drain systems are not timely and systematically cleaned, so their efficiency is much lower [13].

Drawing up the water balance of the city's territory on the existing conditions provides an opportunity to determine the main causes of unsatisfactory land reclamation and the correlation of balance items, the definition of quantitative indicators and the nature of the interaction between water management and land reclamation factors [4, 7].

For the current period, general water balances are usually compiled for the correlation of water management and meliorative indicators. (Partial balances are mainly drawn up for project conditions).

In accordance with the normative documents (VSN-P-8-74 and VSN-33-2.2.03-86 "Reclamation systems and structures: design standards, drainage and land reclamation measures...") for existing and existing facilities, the compilation of a general water balance (fig.1)for the existing conditions it is recommended to perform the method of solving equation:

$$\Delta W = (\bar{I} - \bar{O}) + (I - O) + A - E - Tr + W + Fk - D \pm p - Dr \quad (1)$$

ΔW - change (total) of water reserves in the aeration zone and groundwater.

$\bar{I} - \bar{O}$ - the difference between the inflow and outflow of surface waters.

$I - O$ - inflow and outflow of ground (underground) waters along the calculated layer along the contours of the balance section.

A - atmospheric condensation.

E - evaporation from the water surface of reservoirs (fig.3).

Tr - evaporation and transpiration of soil moisture and groundwater by vegetation and crops (fig.3).

W - water intake for irrigation of crops and vegetation.

Fk - filtration losses from irrigation canals passing through the territory of the city or on its borders.

D - discharges of irrigation, rain and meltwater.

$\pm p$ - vertical interaction between the calculated layer of groundwater and the underlying strata through interlayers of weakly permeable rocks.

Dr - drainage runoff (vertical drainage, other water intake wells, collector-drainage network).

Research results. According to the city service of "Suv-Oqava", the water supply and sewage system in the city are in unsatisfactory condition and losses exceed 20% of the water intake, the water balance equation includes articles on water supply and sewerage.

Now the equation for calculating the total water balance(fig.2) will be as follows:

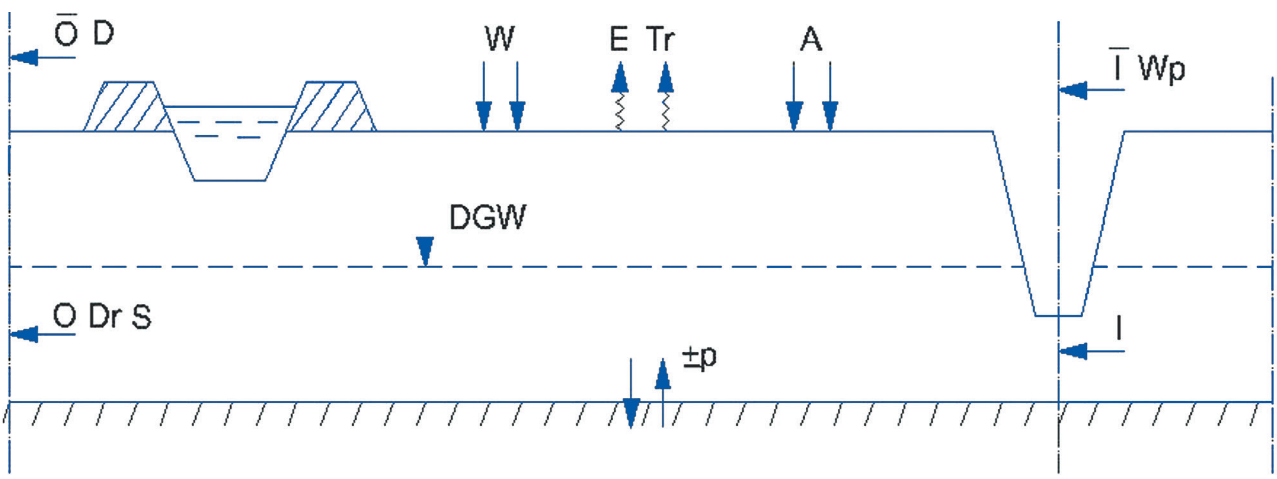


Fig.2. The total water balance of the territory of the city of Gulistan

$$\Delta W = (\bar{I} - \bar{O}) + (I - O) + A - E - Tr + W + Fk - D \pm Wp - S \pm p - Dr \quad (2)$$

Where the additional articles are:

Wp - drinking water supply.

S - the diversion of water through the sewerage system.

The initial data obtained for the compilation of the water balance of the territory of the city of Gulistan on the existing conditions are as follows:

- the area of the balance sheet in existing conditions - 2009,4 ha;
- population - 84,4 thousand people;
- irrigation area (irrigated area) - 899,1 ha; including: tree plantations - 369 ha, lawns and flower gardens - 267 ha, household plots - 263,1 ha;
- the area of the open surface of the earth, without vegetation is roughly assumed from the calculation (2009,4-899,1) x 0,1 = 111 ha;
- maps of the depths of groundwater (fig.4) in the city contours for March - May.

Other reasons for flooding the city with groundwater are: irrigation of urban crops and vegetation inappropriately large norms.

In the city in 2014, the water intake for irrigation was 13,97 mln. m^3, specific water supply was 13970: 899 = 15,5 thousand m^3 / ha in a year (against 10-11 for the Republic). It should be noted that when the irrigation norms of their calculated values are increased, the entire volume of excess is completely spent on the replenishment of groundwater resources.

Relatively large losses of water in the drinking water supply system are also one of the reasons for the flooding of the city's territory (30% of the volume of vertical drainage pumping). The annual volume of losses from the water supply and sanitation system is (13920-11600) =2320 thousand m^3/year.

Water losses from transit irrigation canals passing through the city make up 4305 thousand m^3/year. This also has a definite value in the formation of the groundwater regime.

With an insufficiently developed network of catchment-discharge channels in the city, atmospheric precipitation also contributes to a certain extent to the elevations of the ground water level.

One of the reasons for the flooding of the city of Gulistan should also include shortcomings in the operation of the vertical drainage system: frequent power outages; the lack of a normal record of pumped out water (no water meters), channels that drain water from wells are also in an unsatisfactory state - some of the water is lost to filtration.

The insecurity of the conditions of normal (without support) drainage of waste and drainage waters outside the city limits also

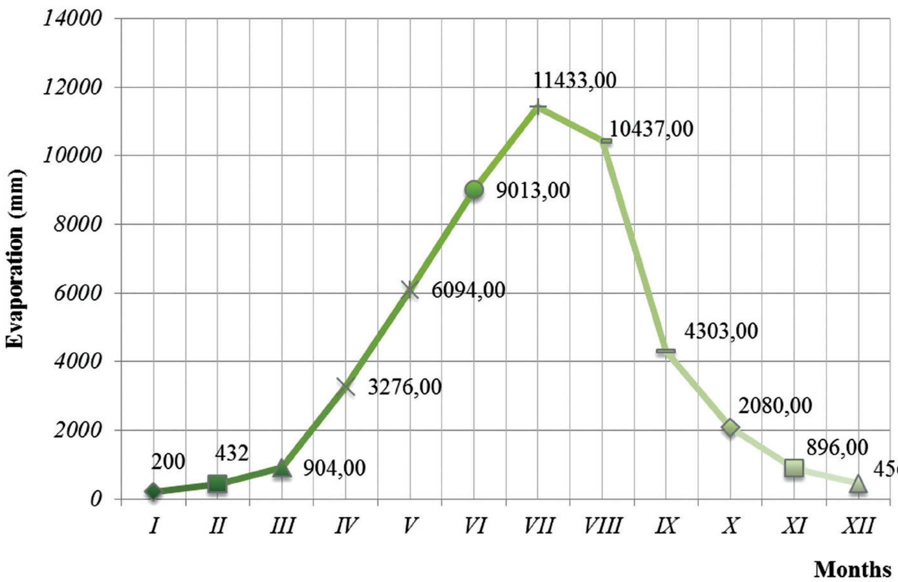


Fig.3. Monthly changes in evaporation and transpiration rate

For the current period, for the correlation of water management and meliorative indicators, as a rule, general water balances.

If a balance sheet is drawn up for an average year, the total change in the water reserve (ΔW) must be zero;

If the balance is drawn up for a particular year, then the change in stocks as a result of the year should correspond to the actual observed changes in groundwater levels.

The main revenue item of the balance sheet is the amount of filtration losses of water from the canal "Dustlik".

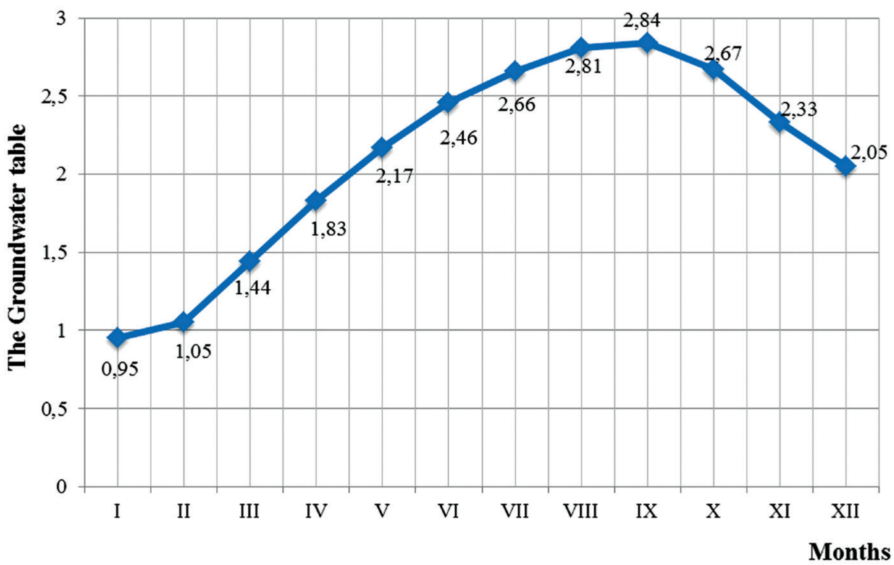
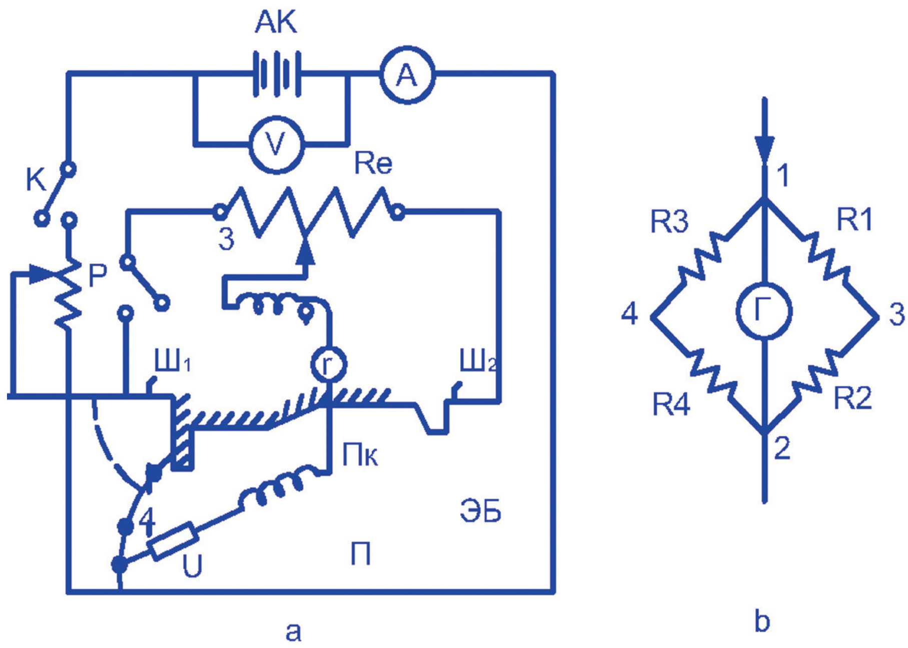


Fig.4. The average monthly schedule for the change in the Groundwater table for 2014 on bush № 44 well № 2

significantly affects the meliorative condition of the lands of the city of Gulistan (even no accounting for the costs and runoff of collectors was conducted).

The presented, so-called preliminary water balances, in fact are not balances, but a list of income and expense items, without their linking. The word "balance" is equality. The amount of receipts should equal the amount of expenditure (at the end of the year). In the presented preliminary balances, the amount of income articles exceeds the expenditure ones by several times. It turns out that for a year in the city groundwater levels should rise above the surface of the earth.

Laboratory studies were carried out by the method of EGDA, where the filter losses from the channels were determined, and the need for the construction of cut-off drains along the channels Dustlik and K-3 was identified. The results of calculating the total water balance in the existing conditions on the territory of the city of Gulistan are shown in Table 1. The solution of problems by the method of EGDA is carried out on an electrical model, it is called the EHD device (figure 5).



a- circuit and electrical circuits; b- scheme stability Whiston.

Figure 5. Schematic diagram of the EGDA integrator

Water balance on existing conditions is only the initial and analytical stage of work. To determine the nature and extent of reclamation measures, a number of additional surveys and studies should be performed and balances should be drawn up for the design conditions. At the same time, there is not one balance across the

Table 1

The total water balance of the territory of the city of Gulistan in the existing borders for 2014 , thousand m³

Balance sheet items	Months												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Revenue articles													
Atmospheric condensation	853	705	1348	1758	261	32	-	-	22	585	1169	400	7133
Water intake for irrigation	-	-	-	-	2259	3240	3428	2865	2180	-	-	-	13972
Filtering losses from the canal "Dustlik"	1928	1742	1928	1867	1928	1867	1928	1928	1867	1928	1867	1928	22706
Filtering losses from the transit channels of BISA	702	57	175	393	468	407	552	397	309	192		330	363
Water supply	1182	1070	1182	1144	1182	1144	1182	1182	1144	1182	1144	1182	13920
Underground tributary	608	549	608	588	608	588	608	608	588	608	588	608	7157
Overflow of groundwater from the lower aquifers	29	27	29	28	20	28	29	29	28	29	28	29	342
Total	5302	4150	5270	5778	6726	7306	7727	7009	6116	4524	5126	4510	69395
Expenditure articles													
Evaporation and Transpiration	62	133	278	1018	1854	2740	3443	3185	1311	641	277	141	15083
Outflow of water through reservoirs outside the city limits	3909	3941	3012	3188	4062	4100	3761	3800	3318	2371	2619	2381	40462

including: vertical drainage	132	209	198	373	222	126	93	70	37	65	87	795	2407
Sewerage	985	889	985	954	985	954	985	985	954	985	954	985	11600
underground outflow	204	184	204	197	204	197	204	204	197	204	197	204	2400
Total	5292	5356	4677	5730	7327	8117	8486	8244	5817	4266	4134	4506	71952
Balance control													
Average levels of groundwater occurrence in 2014 according to observation data, m	0,95	1,05	1,44	1,83	2,17	2,46	2,66	2,81	2,84	2,67	2,05	1,6	
Actual changes in GW levels, m	-0,1	-0,39	-0,39	-0,34	-0,29	-0,2	-0,15	-0,03	+0,17	+0,62	+0,45	+0,65	
Actual changes in groundwater resources, thous. m^3	-201	-784	-784	-683	-583	-402	-301	-60	+342	+1246	+904	+1306	$\sum \pm W = 0$
Change in inventory of GW on balance sheet, thous. m^3	+10	-997	+743	+421	-370	-685	-846	-1165	+358	+323	+1079	+799	$\sum \pm W = 0$

city, but to divide the territory of the city into several balance loops (by terrain relief, lithological structure and location of local groundwater recharge sources).

The reasons for the formation of flood zones within populated areas are different. The territories of individual cities and urban settlements located in the lowland areas due to weak natural outflow of groundwater are constantly subject to flooding. The natural watercourses and irrigated fields around these settlements gradually feed the groundwater horizon. In these cases, first of all, the system of horizontal drains should work effectively. Unfortunately, urban horizontal drain systems are not timely and systematically cleaned, so their efficiency is much lower.

The possibilities of regulating the upgrading problems in the city of Gulistan are revealed [5, 8, 9, 14]. In order of optimization the situation, it is necessary to increase the planting of trees throughout the city, to put in order the city irrigation, the water supply and sewerage, the water catchment and discharge network. The optimal preventive measures are theoretically substantiated.

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