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Improving Methods of Increasing Reliability without Dam Water Intake

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Abstract. The paper presents the results of field and experimental research in the damless water intake of the KMCh in the Amu Darya River. Under the conditions of the Amu Darya, with a large volume of irrigated water and intensive wandering of the river flow on a wide floodplain, the provision of a guaranteed damless water intake requires the implementation of channel control works to detach the pioneer ditch and systematically clean it from entering during the period of operation. The article improves the method of increasing the reliability of the damless water intake and the calculations of the route and the boundaries of the pioneer ditch, depending on the river flow. It also provides hydraulic schemes for improving the condition of a damless water intake and recommendations for the rational use and placement of a fleet of dredgers when laying a ditch route and cleaning it.

INTRODUCTION

As you know, with damless water intake, the main task is to take the volume of water of the required quality required by the consumer. When water intake is provided, the hydrodynamic characteristics of the flow change. This change, in turn, affects the morphometry of the river bed. The main characteristics of the Amu Darya are longitudinal and transverse profiles, planned outlines, redistribution of flow depths. In engineering practice, special attention is paid to the issues of determining the intensity and direction of channel processes in river beds and canals of the head structure and the development of methods for their calculation. In this direction, ensuring a guaranteed volume of water withdrawal with a minimum amount of the volume of bottom and suspended sediments at a damless water withdrawal is considered one of the important tasks [1-5].

The Amu Darya is characterized by a very unstable channel in plan and high intensity of erosion of the banks. The main reasons for the active reshaping of the Amu Darya channel are the presence of relatively large slopes, easy erosion of the soils that make up the bed, large fluctuations in flow rates and water levels in the intra-annual section [6-9].

The width of the modern floodplain valley at the water intake at the studied section of the ABMCh is up to 7-8 km. The river's floodplain is asymmetric, located mainly on the left bank. The valley's gentle, slightly rugged slopes do not have a clearly defined edge and imperceptibly merge with the adjacent terrain. At the water intake site, the edge of the slopes is clearly pronounced. The slopes here are mostly steep and steep, up to 10-20 m high. The floodplain is flooded during high floods. The river bed is moderately meandering but mostly highly ramified; there are many islands in the river bed. The river bed is extremely volatile. The river banks are mostly steep or steep during the period of the passage and, in particular, the recession; the floods are subject to intense destruction [10-16].

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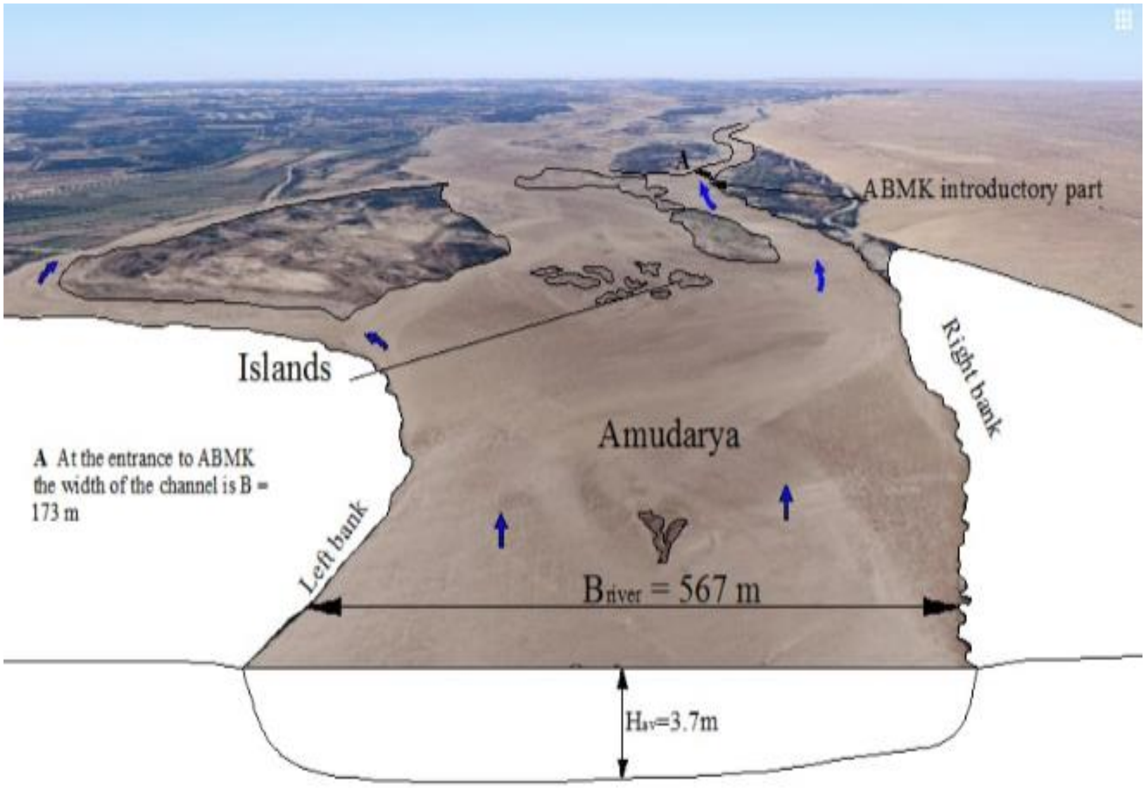


FIGURE 1. A section of the Amu Darya river in the area of a damless water intake in the Amu-Bukhara machine channel

During water intake from the Amu Darya River to the ABMCH, difficulties arise due to the rapid siltation and sedimentation of the head section of the canal. Depending on the water content of the year, a flow with a turbidity of up to 5 kg / m3 enters the inlet part of the canal annually. The annual volumes of sediments ranged from 8 to 12 million tons. The main stream of the Amu Darya River in the area of the ABMCh water intake wanders over a wide floodplain. As a result of field studies 2006-2020 and the materials of previous years of studying the channel transformations of the main channel of the river near the damless water intake, the optimal operation mode of the head of the water intake at low river levels during the dry season and in dry years was revealed [16-20].

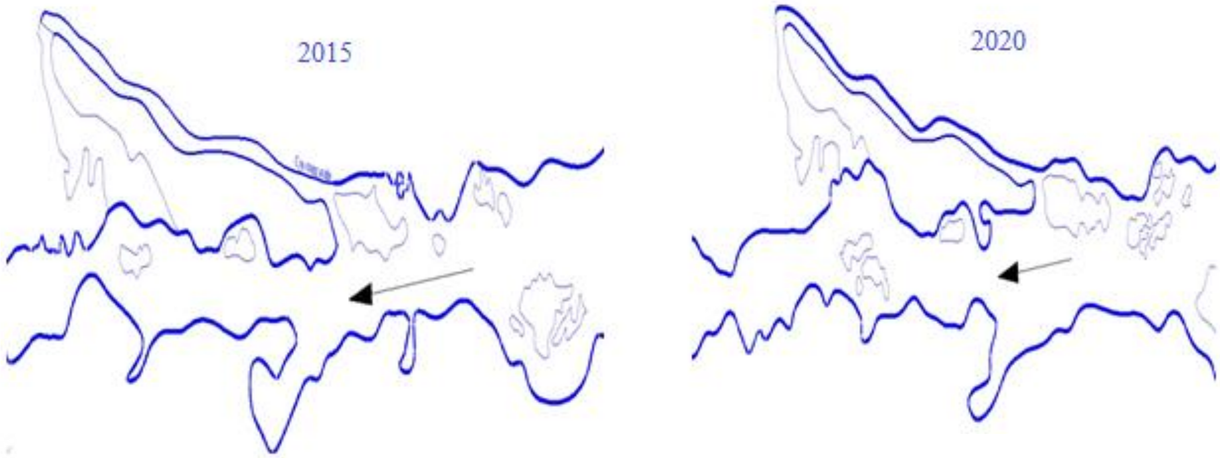
METHODS

Study of the results of field and experimental studies on the section of the Amu Darya river in the area of the damless water intake in the Amu-Bukhara machine channel, assessment of the state of the river bed. The Amu Darya in the area of water intake and increasing the reliability of the damless water intake is the research method of this work.

RESULTS AND DISCUSSION

Under the conditions of the Amu Darya, with a large volume of irrigated water and intensive wandering of the river flow on a wide floodplain, the provision of a guaranteed damless water intake requires the implementation of channel control works to detach the pioneer ditch and systematically clean it from entering during the operation period [1-2].

The optimal route and boundaries of the location of the pioneer digging hole are assigned depending on the location of the main stream of the river relative to the point of the damless water intake. When the main stream moves away from this point to the opposite bank of the river, the volume of channel control work increases while approaching it decreases. The timely organization of the production of channel-adjusting works for the separation of the pioneer digging and its systematic cleaning makes it possible to ensure guaranteed water intake during the period of low water levels in the river with the intensive wandering of the flow Fig. 2.



10.08.2015. 3.09.2020.

FIGURE 2. Situational diagram of the damless water intake of ABMCh

Especially great difficulties arise in the design of head structures with a damless water intake from the Amu Darya, the channel of which, due to the large slopes of the bottom, high flow rates and easy erosion of bottom sediments (represented by fine sandy weak soils), is subject to extremely complex intense planned and deep deformations. To solve this problem, it is recommended to use physical - experimental modeling, which can give a specific forecast of channel deformations in the area of the damless water intake to the head structure. It should be noted that although experimental modeling requires a lot of material costs and a lot of research time, it gives rather acceptable than numerical research. Therefore, we made experimental studies of the structures and the adjacent section of the river channel where the damless water intake is carried out at the ABMCh [11, 12].

Experimental studies were carried out at different depths, in a flow with a moving resistance in the form of sand particles of different fractional composition, with a smooth bottom drawn with special square cells considering the boundary conditions. The results of the experiments were averaged over the average values of the longitudinal component of the velocity, the results of the standard deviations of the longitudinal, vertical and transverse components of the velocity, represented by the graphs of the distribution over depth.

In our scheme, trenches along the length of the canal were installed at an angle of 30-45 °. According to the experimental study, the ditch route should be planned based on the location of its head on a straight-line section of the river with an outlet angle of no more than 300 Fig. 3.

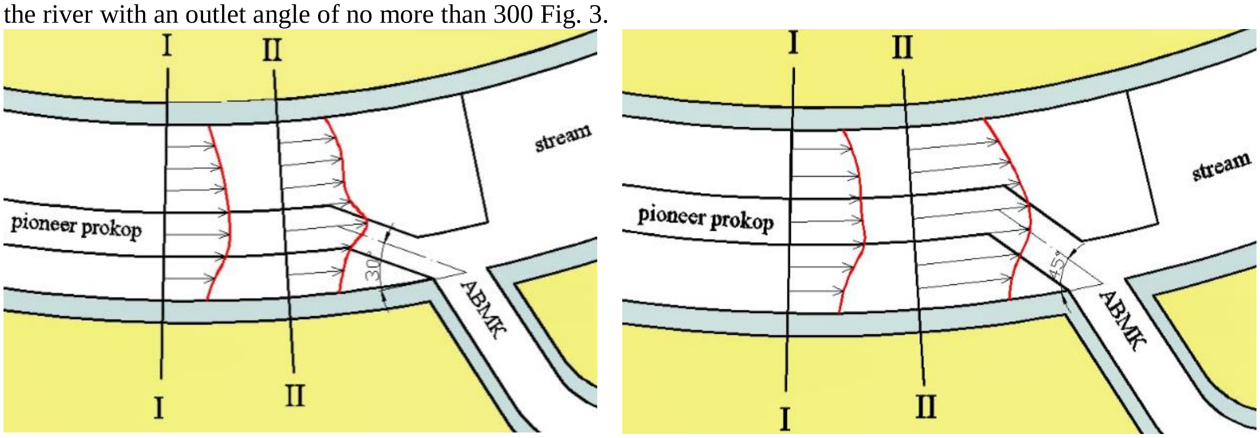


FIGURE 3. Experimental research on the development of a hole

Experimental studies show that the digging must be done during the low-water period, that is, during the period of the least dependence of the channel by traction. The length, width and depth of the pioneer ditch should be assigned depending on the planned location of the river channels relative to the point of the damless water intake, the alluvial regime of the river and the technical parameters of the dredgers.

The length of the pioneer dug should be determined based on the planned location of the ducts relative to the water intake point. The excavation depth is set from the silting conditions (Fig. 4).

To determine the effective amount of sediment, when, following their hydraulic size, they settle to the bottom for a length l, the following formula is recommended

$$q_l = q_n \frac{l\bar{u}}{h\vartheta} \quad (1)$$

where q_n is total suspended load, kg; ϑ is average speed of water flow, m/s; l is slot length, m; $\bar{u}$ is hydraulic particle size, m / s; h is water depth before excavation

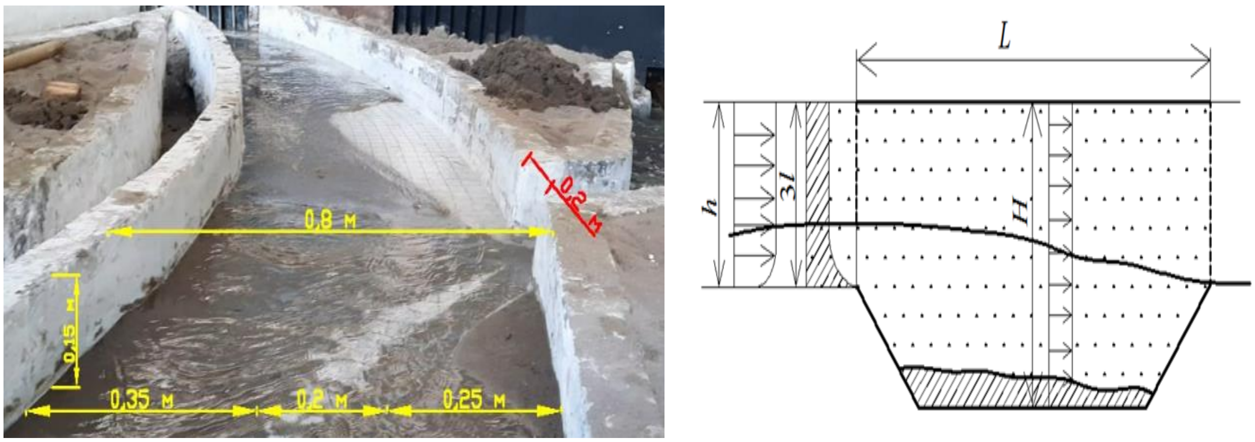


FIGURE 4. Diagram of the digging depth from the silting conditions

The total amount of sediment is determined by the formula

$$q_n = B \cdot H \cdot \vartheta \cdot \rho \cdot t \quad (2)$$

where B is the slot width, m; ρ is the average sediment concentration, kg/m3; t is the time, s; H is the water depth after development, m;

The amount of sediment deposited in the cut can be determined by the formula

$$q_o = kq_c \left(1 - \frac{\vartheta_p^2}{\vartheta_g^2}\right) \quad (3)$$

где k is a coefficient that takes into account a part of the effective amount of sediment involved in siltation;ϑ_g ,ϑ_p are the flow rates in the bottom hole and in the channel, m/s.

From the equation of continuity of flows

$$\vartheta_p \cdot h = \vartheta_g \cdot H \quad (4)$$

We have

$$\frac{\vartheta_g}{\vartheta_p} = \frac{h}{H} \quad (5)$$

Hence, substituting (1) into (3), taking into account (5), we obtain

$$q_o = kq \frac{l\bar{u}}{h\vartheta} \cdot \frac{H^2 - h^2}{H^2} \quad (6)$$

Taking into account (2), equation (6) is reduced to the form

$$q_o = kq\bar{u}Blt\left(\frac{H}{h} - \frac{h}{H}\right) \quad (7)$$

Denoting $kq\bar{u}Blt = A_t$, we obtain

$$q_o = A_t\left(\frac{H}{h} - \frac{h}{H}\right) \quad (8)$$

With the same value of A_t, the value $f\left(\frac{H}{h} - \frac{h}{H}\right)$ is determined by the hyperbola (Fig. 4). The value of k in equation (6) was obtained by Indian researchers during work on deepening the bottom of canals in the river of ports of India and is equal to 0.29. Formula (8) can be used when choosing the depth (H) of development, especially in places with a normal supply of sand fractions.

Establishing the development depth from the condition of a given throughput determines the width of the hole and the average flow rate

$$B = \frac{Q}{H\vartheta} = \frac{nQ}{H^{\frac{5}{3}}\sqrt{i}} \quad (9)$$

$$\vartheta = \frac{H^{\frac{2}{3}}\sqrt{i}}{n} \quad (10)$$

where Q is the water consumption in the hole; n is the channel roughness coefficient; i is the slope of the bottom or water surface of the water in the trench.

CONCLUSIONS

Based on the discussion of the results of observation of the dynamics of the river bed morphometry and the hydraulic parameters of the water flow of the damless water intake of the ABMCH, the following conclusions can be drawn:

1. In the recommended method, the rational use and placement of a fleet of dredgers when laying a ditch route and cleaning it is achieved by considering the intensity of the course of the channel process in the river and the introduction of dredging by entrained sediments. Thus, research has established that coastal deformations occur more intensively in the riverbed than deep ones.

2. The water discharge in the area of the damless water intake during the year varies in a wide range and has a sharply variable character;

3. The relationship between the morphometric parameters of the channel and the hydraulic parameters of the flow in the area of the damless water intake in the ABMCH is unstable;

4. The depth of the flow changes intensively in a wide range;

5. To prevent negative phenomena, it becomes necessary to conduct experimental and numerical studies aimed at regulating the direction of the flow and the nature of planned deformation in the area of the damless water intake.

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