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Silting Dynamics of the South Mirzachul Canal in Sirdarya Region of Uzbekistan

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ABSTRACT: The article presents the study results of the South Mirzachul Canal siltation and its impact on the canal capacity. The process intensified due to the cross-regulator operation, i.e. the gate operation and upstream water level initiated an intensive silting process of the canal bed. The situation leads to decrease water supply to Jizzak region. The field studies were carried out in the canal section from PK624 to PK1035 to determine the water discharge, the hydraulic parameters, the flow rate and the canal efficiency. The amount of water supplied to the regions was determined at different values of the gate opening, taking into account siltation. The recommendations are developed to reduce the canal siltation process and increase its capacity.

I. INTRODUCTION

The hydraulic structures on canals play a crucial role in the regulation and management of water resources of irrigation systems. But in recent years, as a result of the construction of blocking hydraulic structures, there has been an increase in the process of siltation of canals as a result of the occurrence of backwater in front of the shields. However partitioning and water distribution facilities are necessary for the regulation of water resources for their intended purposes and an inevitable part of guaranteed water supply to the sectors of the economy [1, 2, 3, 4]. As a result of the impact of regulating hydraulic structures on the environment, one of the negative consequences is that sediments accumulation in the upstream of the structure, reducing its capacity. Sediment accumulation in the upper side of the structures strongly affects on the hydrological processes in earth canals [5, 6, 7, 8].

In Uzbekistan comprehensive measures are widely carried out to improve the irrigation systems efficiency by implementing measures aimed at reconstruction of irrigation systems using modern technologies [9, 10, 11, 12, 13]. The total length of the main irrigation systems in the country is 27800 km, inter-farm canals – 155000 km. More than 25 thousand hydraulic structures are located on the canals [14, 15]. In recent years over 1,500 km of the canal have been concrete lined and reconstructed in the country.

The study objective. In the research described sedimentation and its impact on the South Mirzachul Main Canal (SMMC) capacity commissioned in 1963. The canal provides water to 350 thousand hectares irrigated areas of Syrdarya and Jizzakh regions. The canal starts from the Main Hydro Complex at PK 0+00 and ends at PK 1027 and discharges into the Sanzar River on the southeastern border of the Mirzachul area. The part of the 109.3 km canal of the total 126.4 km length is in the semi-recess and half-embankment and the 17.1 km part is in the recess. The capacity of the canal is 300 m^3/s, width along the bottom b =18 m, up B = 68 m, depth h = 7 m, efficiency coefficient is 0.97.

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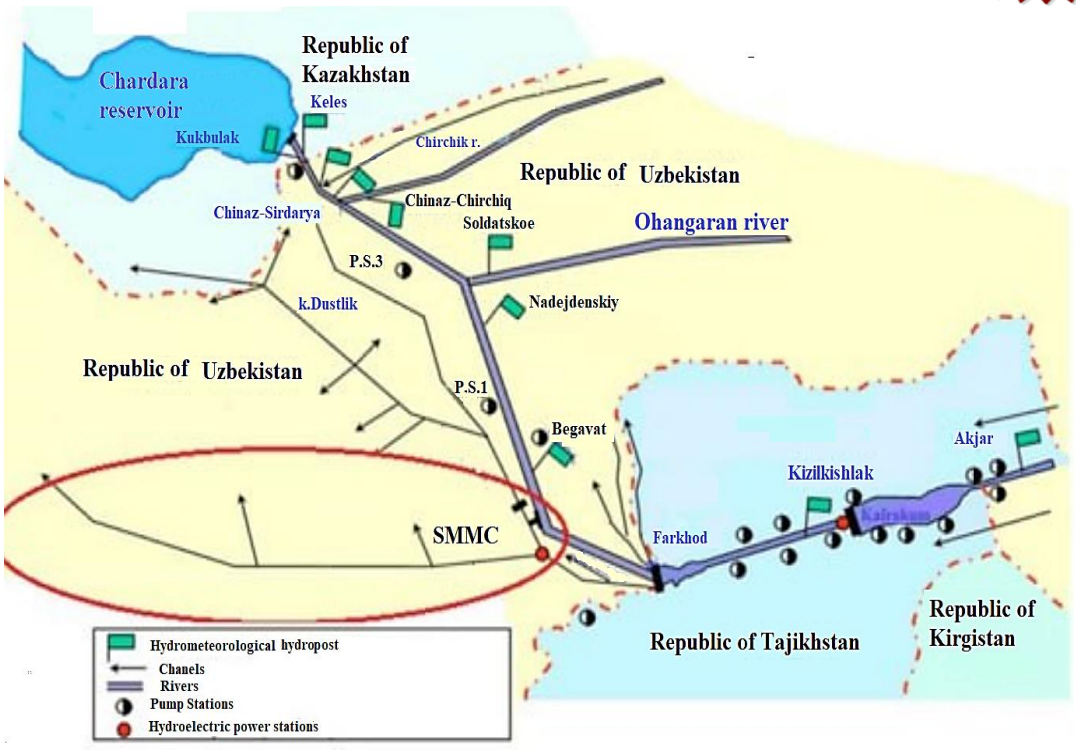

Figure 1. The South Mirzachul Main Canal

The canal route passes mainly in the high groundwater standing zone (1.5-3.0 m) from the ground surface. The groundwater interaction and water filtration at different sections of the canal during the vegetation and non-vegetation periods is different. In this regard, the canal partially feeds groundwater, partially drains itself. According to the project, the filtration losses in the canal average 65 l/s per running meter. This made it possible to give up on the expensive concrete lining of the canal and construct of 103.5 km in the earth bed. The last 22.9 km of the canal is concrete lined. The efficiency of the canal at a flow rate of 300 m^3/s is 0.97 according to the design document developed by the design institute UZGIP.

The cross profile of the earth part of the canal has polygonal form and only at the end it has the trapezoidal section. The special feature of the canal reflects on that, it is designed and operates in the backwater mode necessary for discharging to the water intakes at minimum flow rates.

The canal technical metrics are as following: PK145-PK400 water flow rate is 260-230 m^3/s, water depth - 6.8-6.6 m, longitudinal slope is 0.0005, water velocity is 0.98 m/s; PK923-PK1035 respectively, water flow rate is Q= 42-37 m^3/s, depth is 3.67 m, slope is 0.0001, average velocity is V=0.90 m/s. At the PK 395+73 section the Jizzak Pump Station feeding canal DM-1 has been built with a flow rate of 164.9 m^3/s. The canal's efficiency analysis showed that for the consideration period 27.02.2022 - 23.01.2024 the canal efficiency ranged from 0.85 to 0.88. The data for the period as of January 23, 2024 are as follows: 5.5 m^3/s water was taken from the SMMC to the Bayevut District, 9.9 m^3/s to the Khavas, 12.6 m^3/s to the Sardoba, 3.7 m^3/s to the Pakhtakor, and 10.4 m^3/s of water was taken to the Zafarobod Districts. At the same time at the PK145+00 picket of SMMC the water flow was Q=191.2 m^3/s.

II. METHODOLOGY

The field studies were carried out in the canal section from PK624 to PK1035 to determine the water discharge, the hydraulic parameters, the flow rate and the canal efficiency. Measurements have been conducted on every cross-regulation structure at the upper and lower sides of the gates and compared with the design data. At each of the 4 cross regulation structures water flow measurements were carried out depending on the gate opening and the difference in the upstream water level and downstream, then the water balance has been calculated. The measures have been taken at different water discharge and according open levels of the gates. The measurement analysis shows that the canal indicators significantly differ from the design values.

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III. RESULTS AND ANALYSIS

At the canal water balance calculation, taking into account water abstraction, the following results: water intake to the Sardoba reservoir Q=80 m^3/s, to the Jizzakh pumping station Q=25 m^3/s, to the JR-18 canal Q=12 m^3/s, and water efficiency coefficient is equal to 0.88, what means that the actual canal efficiency is lower than the design by 0.07-0.09. In the canal section from PK 624 to PK 923 the water velocity is 0.70 m/s but according to the design 0.79 m/s; in the section from PK 923 to PK 1035 the velocity is 0.60 m/s against the project of 0.81 m/s, i.e. the real water velocity is less than the design one by 0.9-0.21 m/s.

The SMMC canal depths have been measured in 2020 and 2024 to study the sedimentation dynamics. At the PK 145+00 measured water depth was 4.6 m, at the PK 746 - 3.4 m, at the PK 923 - 2.6 m. The results showed, that silt layer at the PK 400 is 1.6 m, at the PK 624 is 1.5 m, at the PK 923 is 1.0 m and at the PK 1089 is 0.9 m (Fig.2).

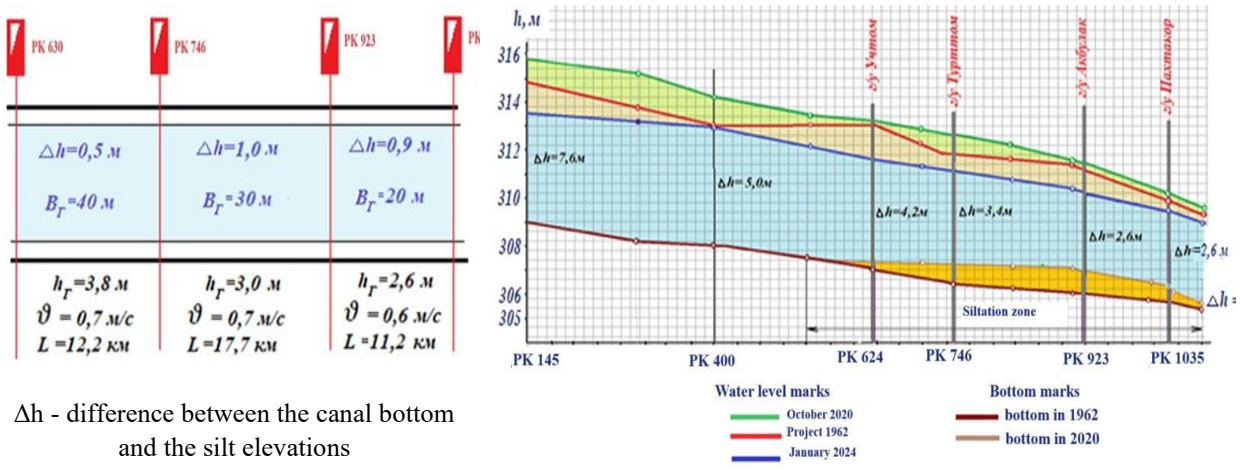

Figure 2. Dynamics of changes in the water horizons of the SMMC

In the canal section from the PK624 to PK1035 the canal bottom level increase due to the siltation. The Fig. 3 shows the change in the bottom design level - Δh: in the section between PK624 and PK746 this value is 0.5 m; in the section from PK746 to PK923 – 1.0 m and in the section from PK923 to PK1035 – 0.9 m.

Based on the analysis of the measured data in 2024 on February 15, calculations were made to determine the flow rate at PK624 and the water flow rate $Q=f(h_{sh}, z)$ graphics developed (Fig. 3.)

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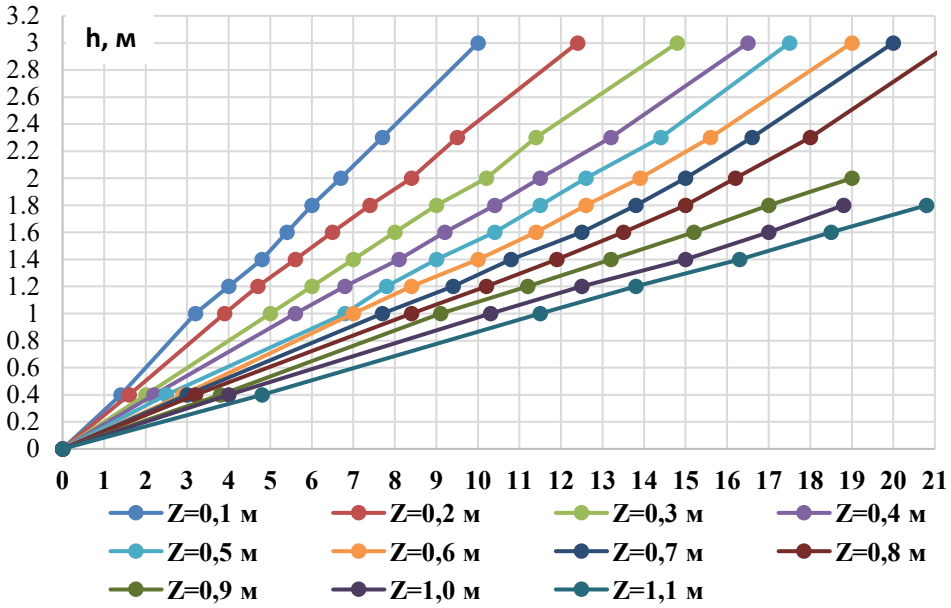

Figure 3. Water flow depending on the gate opening value and difference in water levels of the upper and lower sides

The calculations showed significant shortcomings in accounting of water discharge consumed. According to the hydraulic calculation of the flow through the structures gate openings at PK 624, it was found out that every cross-regulator water loss is 0.7-1.0 m^3/s.

Due to the loss of the canal capacity in the section from the PK 624 to PK 923 (Syrdarya region) water supply decrease to W=444,000 m^3 per year. In section from the PK 923 to PK 1035 (Jizzakh region), the shortage of water is W=523,600 m^3. In total, the water shortage per year through the SMMC is 967,000 m^3 due to the canal bed siltation.

IV. CONCLUSION

Based on the study results the following recommendations are proposed to mitigate the negative consequences of the channel siltation: organize regular monitoring of changes in the canal hydraulic parameters and periodically carry out removing the deposited sediments; fix corrections when determining the water flow through structures taking into account the changed bottom levels due to siltation; install modern water-metering equipment at hydro posts, based on the surveying the bottom morphology using ultrasound.

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