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The North Fergana Canal Monitoring Database

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ABSTRACT: In recent years, due to the depletion of water resources, the scientific researches are focused on water saving technologies, water accounting and in time delivery of required water volume to consumers is an urgent priority. A unified interactive database and balansing methodology has been developed aimed to improve water evaluation and distribution to the water intake networks of the North Fergana Main Canal. The article presents the results obtained by using the developed database and water distribution soft, taking into account water lost in the North Fergana Main Canal during delivery process and the canal's opeartion capacity.

KEYWORDS: irrigation canal, water discharge, flow rate, distribution, doppler profiler, database.

I. INTRODUCTION

Main part of the irrigation canals in Uzbekistan have been built 30-50 years old. The irrigation canals and hydraulic structures used to supply the requested amount of water to various economic sectors at specified times form a complex network. The gradual deterioration of canals and hydraulic structures during their operational period and fluctuations in water supply regimes over time contribute to increasing of water resource management process issues [1, 2, 5]. A systems-based approach for managing of water distribution in irrigation canals will improve the performance of all components. Therefore, the development and implementation of highly effective technologies for metering and monitoring water at water intake points is becoming important [7, 10]. In this case the canals' technical state, an improved water accounting and metering plays significant role in water planning and water delivery to users. The concept for the development of water management in the Republic of Uzbekistan for 2020–2030 is approved by the government with focus on the improving the water resources management system, introducing Smart Water facilities and similar digital technologies in the accounting of water use and water consumption.

Currently, researches on digitalization of the irrigation structures management aimed at improving of water distribution and monitoring, use of modern methods and devices in water management to increase the water accounting accuracy based on water flow measurements and to develop digitalized information systems [3, 4, 8].

The study objects. The North Fergana Main Canal (NFMC) has been put into operation in 1940. The total length of the canal is 167.8 km, of which 134.8 km runs through the Uzbekistan territory and 33.0 km is located in the Asht district of the Republic of Tajikistan. The water intake structure of the NFMC is located on the right bank of the Noryn River, 200 meters upstream from the Uchkurgan Hydroelectric Complex (Figure 1). The water intake structure consists of 6 spans of each 4 meters wide equipped with flat gates. Water level and discharge is regulated by the automatic functioned and controlled gates. The operation of these gates is managed from the Dispatch Control office.

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Figure 1. Water intake to the Northern Fergana Main Canal

NFMC oversees a total of 250 hydroposts, which provide daily data on water discharge. 168 hydroposts have been newly renovated, ensuring the accuracy of the water data. It was discovered that 32 hydroposts' water accounting is not satisfactory accurate, so they are need to be renovated. According to the established plan, the hydroposts 170,000 water data should provide throughout the year. The canal consists of 5 sections with the length: 1 section – 28.64 km, 2 section – 30.16 km, 3 section – 33.10 km, 4 section – 22.10 km, 5 section – 22.85 km. The NFMC water intake points and hydroposts by sections is presented in Table 1.

Table 1. The state of hydrometrical stations at the NFMC

Sections	Water intake points	Hydroposts	Q-ty of the hydroposts to be renovated
Section 1	55	51	6
Section 2	49	52	9
Section 3	54	56	4
Section 4	44	47	7
Section 5	43	44	6

1770 measurements were planned at the cross-sections where hydro posts were installed, of which 995 were actually completed in 2025 (Table 2).

Table 2. Information on the hydro posts' operation in the NFMC (as of 30.06.2025)

Total hydroposts	Renovated hydro posts	Data obtaining process			
		Hydro posts' data		Data by measurement	
		scheduled	actually	scheduled	actually
250 (339)	168	170208	84399	1770	995

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By developing an electronic linear schematic of the North Fergana Main Canal, it will be possible to monitor and control the planned water flow data in the water intake networks along the canal.

II. METHODOLOGY

A database and linear diagram of the canal has been developed. The results obtained regarding the canal's efficiency coefficient were submitted to the NFMC Operating Unit. Field studies were conducted on the section of the North Fergana Main Canal from PK2+00 to PK1035 to determine the water discharge and the canal's efficiency coefficient. Visual observations were carried out to assess the canal's water intake networks state. Measurements of water flow in the canal were carried out in the following order. The coordinates of geodetic points and markers are established with the specific points using the "BASE RTK" device and a GPS antenna, and corrections are made to the Baltic system. The coordinates of the start and end of the measurement points (stem) are entered into the manipulator. At the next step the "ONLINE" mode is switched to "BASE RTK" and "ROVER" are set. In the "DRAFT" mode, the indicators are measured and subsequently taken into account. The device is calibrated and the optimal speed of the boat is determined. The data is recorded on the ROVER, transferred to the tablet database and reviewed. The obtained data is processed using the "HD-MAX" program.

III. RESULTS AND ANALYSIS

The NFMC database includes a needs analysis and the design of a relational schema with key tables, such as inter-farm canals, hydraulic structures, water users, and water distribution indicators. The database management system is integrated with geographic information systems. This includes requirements analysis, infrastructure accounting, water distribution planning, state monitoring and reporting. The developed database has a logical data structure, uses a relational model that organizes data into tables with defined relationships to prevent redundancy, and it is managed by Microsoft SQL. Testing included checking data entry and relationship validity. Water distribution, i.e., records of actual water consumption and supply, consists of user ID and cannel ID, start - end dates and water volume. Monitoring indicators consist of data from sensors or hydrometric stations, canal ID, date and time, flow rate and water level. Relationships between tables allow for efficient data management and the generation of comprehensive reports on the state of the irrigation network and water use. A graphical representation of a canal route with key elements showing their purpose, including the main channel, subchannels, spillways, locks, aqueducts and other hydraulic devices necessary for water delivery (Figure 1).

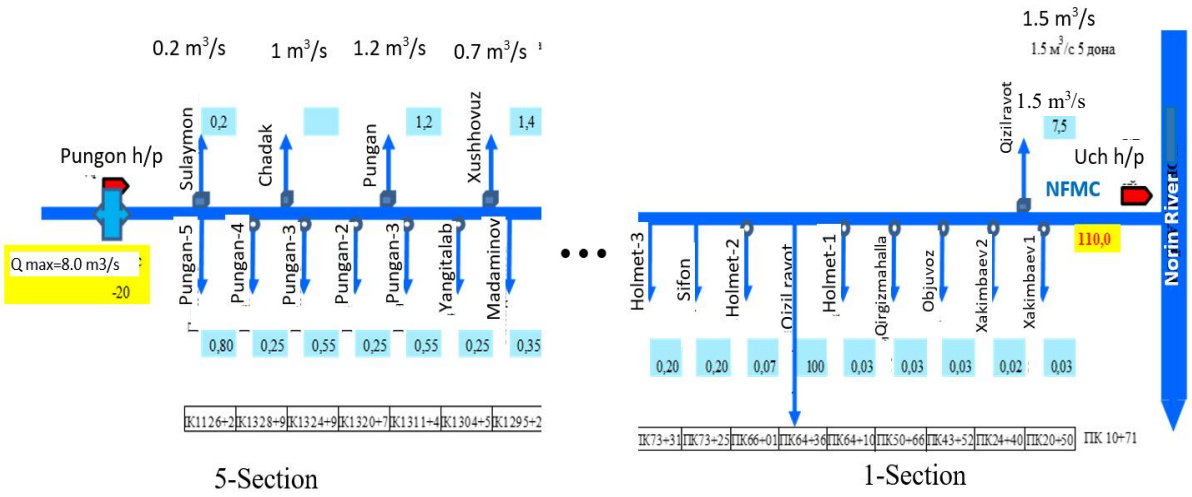

Figure 2. Part of the linear diagram of the North Fergana Main Canal

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To determine the accuracy of the NFMC operational data, field studies were conducted on all five sections of the canal and measurements of water discharge and flow velocity were carried out on August, 2024 (Table 3). In the first section of Northern Fergana Main Canal at the Uychi district Suvchilaruyi hydropost the flow rate was measured as Q_{high}=60.89 m^3/s at the PC 65+00 and Q_{low}=48.60 m^3/s at the PC 276+20. The distance between these points is 21.12 km, with 55 water intake points along the chennel. Based on the measurement results, the efficiency coefficient was determined to be K=0.91.

Measurements were carried out at the Yarkatai hydropost PC276+20 at Q_{high}=48.30 m^3/s and at the Aktash hydropost PK577+75 at Q_{low}=37.70 m^3/s. The distance between the PCs was 30.10 km. There are 53 water intake points on the plot and based on the measurement results, it was identified that the efficiency is K=0.94. In the 3- Section of the canal, the following measurements were recorded: at the Oqtosh hydropost PC577+75 Q_{high}=38.00 m^3/s; at the Janjal hydropost PC683+79 Q_{low}=28.60 m^3/s; at the Gordiy hydropost PC802+80, Q_{low}=23.30 m^3/s; and at the To'da hydropost PC907+56 Q_{low}=26.50 m^3/s. The section distance is 33.0 km and contains 57 water intake points. Based on the measurement results the efficiency coefficient was determined to be K=0.93. Measurement of the canal's water discharge has been conducted in 4-Section and 5-Section located at the Tajikistan border hydropost. In 4-Section the Toda hydropost has been operated at PC907+56 with Q_{high}=30.83 m^3/s and PC1007+00 with Q_{low}=21.25 m^3/s. The distance is 9.44 km, with 26 water intake points. Based on the measurement results, it was found that the canal efficiency is K=0.89.

Table 3. Natural measurement data

The canal sections	Districts	Hydropost	Pickets	Distance, km	Results	
					Water discharge m^3/s	Efficiency coefficient
1-Section	Uychi District	Suvchilaruyi	PK 65+00	21.12	60.89	**0.91**
			PK 276+00		48.60	
2-Section	Namangan City	Yorkatay	PK 276+20	30.10	48.30	**0.94**
	Namangan District	Oqtosh	PK577+75		37.10	
3-Section	Turakurgan-Chust District	Oqtosh	PK577+75	33	38.0	**0.93**
		Janjal	PK 683+79		28.60	
		Gordi	PK 802+80		23.30	
		Tuda	PK 907+56		26.50	
4-Section	Pop District	Tuda	PK 907+56	9.4	30.83	**0.89**
		Filol	PK 1007+00		21.25	
		Filol	PK 1007+00	12.34	20.16	**0.90**
		Yangiyer	PK 1130+44		16.51	
5-Section	Pop District	Yangiyer	PK 1130+4	21.4	13.40	**0.67**
		Chegara	PK1348+50		3.10	

On May 2025 2-st round of field measures have been implemented. At the Filol hydropost the discharge was Q_{high}=20.16 m^3/s and Q_{low}=16.51 m^3/s at the Yangiyer hydropost at the PC1130+44. The distance between PCs was 12.34 km, and there are 25 water intake points located. According to the measurement results, the efficiency was K=0.9. At the 5-Section of the canal, the measurements were carried out at the Yangiyer hydropost with Q_{high}=13.40 m^3/s and at the boundary PC1348+50 Q_{low}=3.10 m3/s. The distance between the hydroposts is 21.40 km, there are 52 water intake points. Based on the measurement results, it was identified that the canal efficiency at this section was K=0.67.

The research conducted on clarification the canal efficiency coefficient of the North Fergana Main Canal and its results are presented in Figures 2 and 3.

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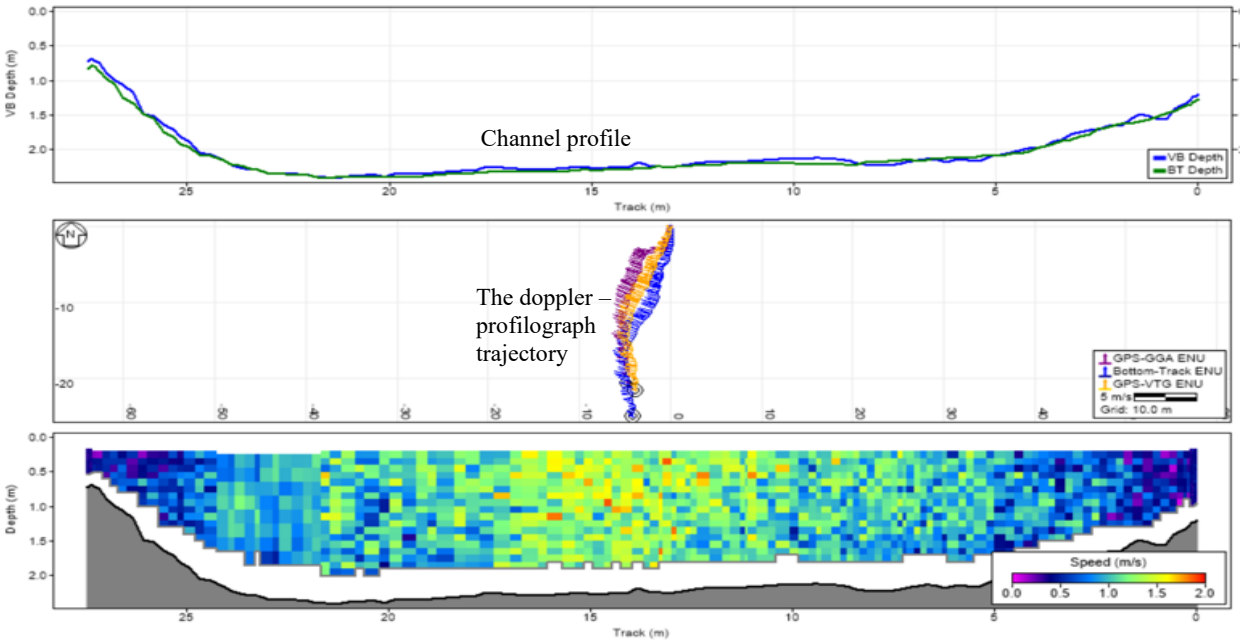

Figure 3. Measurement work using a Doppler profiler

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge						%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	MBTotal	Measured
1	R	8:02:45 PM	0:00:58	20.4	5.94	5.48	6.484	5.786	0.102	0.548	0.03	0.03	0.66	1.94	0.51	3.168	--	61.2
			Mean	20.4	5.94	5.48	6.484	5.786	0.102	0.548	0.03	0.03	0.66	1.94	0.51	3.168	0.000	61.2
			Std Dev	0.0	0.00	0.00	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.0
			COV	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Exposure Time: 0:00:58

Tr1=20240525200246r.rivr;

Comments

Tr1=20240525200246r.rivr - 108;

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge						%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	MBTotal	Measured
1	L	10:29:58 AM	0:01:38	17.6	11.92	10.73	12.429	15.762	0.122	0.828	0.18	0.21	2.09	8.61	1.95	13.050	--	66.0
2	R	10:31:41 AM	0:01:31	17.3	12.22	10.84	12.545	15.937	0.134	0.863	0.17	0.25	2.20	9.08	2.06	13.758	--	66.0
			Mean	17.5	12.07	10.79	12.487	15.850	0.128	0.846	0.18	0.23	2.14	8.85	2.01	13.404	0.000	66.0
			Std Dev	0.2	0.15	0.06	0.058	0.087	0.006	0.018	0.01	0.02	0.05	0.24	0.05	0.354	0.000	0.0
			COV	0.0	0.013	0.005	0.005	0.006	0.050	0.021	0.047	0.071	0.026	0.027	0.027	0.026	0.000	0.000

Exposure Time: 0:03:09

Tr1=20240526102958r.rivr; Tr2=20240526103142r.rivr;

Comments

Tr1=20240526102958r.rivr - Reka 114; Tr2=20240526103142r.rivr - Reka 114;

Figure 4. Doppler profile measurement results

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IV. CONCLUSION

The North Fergana Main Canal database aims to implement water monitoring using a digital system and create a unified information system for water resources. Data analysis shows that during the long-term operation of the canal, the amount of water loss has increased. The total amount of water loss due to evaporation, filtration, and during operation has increased to 25-30%. Losses due to operational deficiencies are significant. Determining water losses in canals is based on the hydraulic elements of the canal and the canal efficiency coefficient. Based on the water loss data it is recommended to improve the canal structures. It was found that water loss and canal efficiency decreased significantly mainly in the 5-Section. There is a need to repair and reconstruct as well update the technical state of this section of the NFMC.

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