Dynamic and kinematic conditions for designing water channels

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Abstract. Studies are conducted for design institutes in which the mating structures of pumping stations (PS) are designed. In the regional conditions of the Republic of Uzbekistan during the operation of the PS, of particular importance is the problem of protecting equipment from pumps and fins, as well as the stability of water supply facilities and the creation of favorable hydraulic conditions for supplying flow to the pumps. The main factors in the conditions of flow inlet are calculations related to suspended particles.

1. Introduction
Water supply to pumping stations, irrigation, energy purposes or reservoirs is allowed through accepted water channels. The canals from the river are constructed in favorable conditions - hydrological, topographic and geological. In water practice, the level of in-river water turbidity and the water intake channels in the water intake channels are maintained and the sludge pressure is maintained. The water intake channels are designed without water intake facilities, and water management units are regularly offered per channel. Water intake at the beginning of the canal is recovering in the event of an emergency flood. Complex hydrological conditions of water sources (sediment, sludge, etc.), the most common use of water from the river.

2. Methods
The operation of the head unit should be coordinated with the pump saturation operation. Supply channels are usually the shortest route from the water source to the pump station.

Basic conditions for use of water supply channels:
- construction of a water supply canal to reduce the length of the pressure pipes;
- good geological conditions, allowing the construction of the canal without special expenses to increase the water level in the source and control the filtration;
- Relative accuracy of water use in the canal, uninterrupted operation of the channel;
- clearing the channel from sedimentation and maintaining the pumping station's normal operating mode;
- water shelf endurance;
- relatively small variations in water levels at the source, which do not lead to economically unreasonable expenses for the construction of the canal and the pumping station;
3. Results and discussion
When rebuilding water intake structures in reservoirs it is necessary to consider the possibility of rebuilding the shoreline caused by changes and damages caused by waves, damage, destruction, etc. Therefore, the choice of location and protection of the channel head is important. The second and subsequent rising water comes from the pumping stations. Sometimes the length and depth of inlet channels can also be used for reasons for selecting a good base for the pumping station, especially for sludge dropping conditions.

The average speed of water in a canal must meet the following conditions

\[ v_1 < v < v_2, \]

here \( v_1 \) and \( v_2 \) – Speeds in the canal to check for water in the channel m/s 50 m\(^3\)/s The allowable water velocities in streams with a flow rate of not less than one shall be in accordance with SNiP (Table - 1.1; 1.2; 1.3).

Soil boundary washing rate, m / s, soil density \( p = 2650 \) kg / m\(^3\), working condition coefficient 1 and various flow depths.

| Extent of soil, mm | Flow depth, m |
|-------------------|---------------|
|                   | 0,5           | 1             | 3             | 5             |
| 0,05…0,25        | 0,52…0,37    | 0,55…0,39    | 0,6…0,41     | 0,62…0,45    |
| 0,25…1           | 0,37…0,51    | 0,39…0,55    | 0,41…0,62    | 0,45…0,65    |
| 1…2,5            | 0,51…0,69    | 0,55…0,75    | 0,62…0,86    | 0,65…0,90    |
| 2,5…5            | 0,69…0,87    | 0,75…0,96    | 0,86…1,10    | 0,90…1,17    |
| 5…10             | 0,87…1,10    | 0,96…1,23    | 1,10…1,42    | 1,17…1,51    |
| 10…15            | 1,10…1,26    | 1,23…1,42    | 1,42…1,65    | 1,51…1,76    |
| 15…25            | 1,26…1,46    | 1,42…1,65    | 1,65…1,93    | 1,76…2,12    |
| 25…40            | 1,46…1,68    | 1,65…1,93    | 1,93…2,32    | 2,12…2,50    |
| 40…100           | 1,68…2,15    | 1,93…2,54    | 2,32…3,14    | 2,50…3,46    |
| 100…200          | 2,15…2,47    | 2,54…3,03    | 3,14…3,92    | 3,46…4,31    |
| 200…300          | 2,47…2,90    | 3,03…3,32    | 3,92…4,40    | 4,31…4,94    |

Boundary washing rate, m / s, flow depth, soil type and viscosity.

| C, \( 10^5 \) Pa | Flow depth, m |
|------------------|---------------|
|                  | 0,5           | 1,0           | 3,0           | 5,0           |
| 0,005…0,02      | 0,39…0,52    | 0,43…0,57    | 0,49…0,65    | 0,52…0,69    |
| 0,02…0,05       | 0,52…0,71    | 0,57…0,77    | 0,65…0,89    | 0,69…0,98    |
| 0,05…0,1        | 0,71…0,96    | 0,77…1,04    | 0,89…1,20    | 0,98…1,27    |
| 0,1…0,15        | 0,96…1,13    | 1,04…1,23    | 1,20…1,41    | 1,27…1,49    |
| 0,15…0,2        | 1,13…1,28    | 1,23…1,40    | 1,41…1,60    | 1,49…1,69    |
| 0,2…0,25        | 1,28…1,42    | 1,40…1,55    | 1,60…1,78    | 1,69…1,88    |
| 0,25…0,4        | 1,42…1,79    | 1,55…1,96    | 1,78…2,25    | 1,88…2,38    |
| 0,4…0,6         | 1,79…2,16    | 1,96…2,38    | 2,25…2,72    | 2,38…2,83    |
Boundary washing rate, m / s, cast concrete, precast concrete asphalt concrete, concrete grades and flow depth.

Table 3.

| Concrete grade durability | Flow depth, m |
|---------------------------|--------------|
|                           | 0.5 | 1.0 | 3.0 | 5.0 |
| B5                        | 11.2 | 12.4 | 14.3 | 15.2 |
| B7.5                      | 12.5 | 13.8 | 16.0 | 17.0 |
| B10.5                     | 14.0 | 15.6 | 18.0 | 19.1 |
| B15                       | 15.6 | 17.3 | 20.0 | 21.1 |
| B25                       | 19.2 | 21.2 | 24.6 | 26.1 |

The table below shows the boundary washing rate, m / s, hydraulic radius R = 1… 2 m.

Table 4

| The soil of the channel mouth | Speed of boundary washing |
|-------------------------------|---------------------------|
| Medium sandy soil             | 0.45…0.6                 |
| Medium and small sands        | 0.6…0.75                 |
| Large sand                    | 0.75…0.9                 |
| Minor                         | 0.9…1.1                  |
| Medium wavy                   | 1.1…1.3                  |
| Large scale                   | 1.3…1.4                  |
| It is small                   | 1.4…1.8                  |
| Moderately rocky              | 1.8…2.2                  |
| Large rocky                   | 0.7…0.9                  |

R > 2m water velocity \((R/2)^{0.125}\) times. The cross-sectional surface of the channels is assumed to be trapeze, if it does not meet geological conditions. Polygonal channel can only be used when the side and bottom of the channel are laid on low-density soils.

The minimum curve radius in mammals is \(r = 11v^2\sqrt{\omega} + 12\), \(1\)

where \(v\) is the average flow rate in the channel, m / s; \(\omega\) - cross-sectional surface, m^2.

\(R \geq 5\) B for the radius definition (B - the width of the channel at the water level).

The channel is projected based on static calculations, taking into account the hydrodynamic pressure of the water in the channel when the depth is more than 5 m. The slope of the channel sidewall walls is dug to a depth of 5m and the water level is not less than 0.5m.

The table shows the slope coefficients for soil type and water consumption in Table 1.5.

Channel channel slope coefficient "m".

Table 5.

| Type of soil                          | Water consumption, m 3 / s |
|---------------------------------------|---------------------------|
|                                       | 10 more than | 10+2 | 2+0.5 | 0.5 less |
| Rock, sandy gravel                    | 1.25          | 1.0   | 1.0   | 1.0      |
| Clay, heavy and medium loamy soil     | 1.5           | 1.25  | 1.2   | 1.0      |
| Light loamy soil, sandy soil          | 1.75          | 1.5   | 5     | 1.25     |
| Sand                                  | 2.25          | 2.0   | 1.5   | 1.5      |

Width of canal bottom 0.8; 1.0 m; It is calculated at intervals of 0.5 m to 5 m and over 1 m - 1 m.
The minimum channel width depends on the method of drilling: manually drilling is not less than 0.4 m, and mechanization is set at least 1.5 m. The bottom and the bottom of the channel sidewall are characterized by berm. Their width is calculated by the composition and method of construction and placed at a height of at least 1 m. The berths are used every 5m and the slope is more than 7m (according to Table 1.6).

For canals with or without casing, the upper part of the dam and the height of the creek shall be cm.

| The water consumption in the channel is m³ / s | Channel No coverage | Channel Covered |
|---------------------------------------------|---------------------|-----------------|
| 1 gacha                                     | 20                  | 15              |
| 1...10                                      | 30                  | 20              |
| 10...30                                     | 40                  | 30              |
| 30...50                                     | 50                  | 35              |
| 50...100                                    | 60                  | 40              |

The upper part of the channel shall be set not less than 1.5m, subject to the above conditions. Calculation of water level in the canal must also take into account the adverse effects of turning on and off one or more pumps at the station. Where the water consumption of a channel exceeds 100 m³ / s and where the wind speed is above 50 m / s, the height of the channel walls is determined by the following formula

\[ h_{\text{an}} = h_H + \Delta h + a, \]  \hspace{1cm} (2)

where \( h_H \) is the wind wave height, m; \( \Delta h \) - wind speed of water, m; \( a \) - Reserve, less than 0.1 m. The upper walls of the structures are considered to be 10 cm at 10 m³ / h, and 25 cm more than 10m³ / h. Supply channels are built to withstand the same and variable flow profiles.

Channel-specific coefficients "n" coefficients are assumed depending on the channel state:

| Technical condition of the channel | N               |
|-----------------------------------|-----------------|
| I. Non-coated channels            |                 |
| When \( Q> 25 \) m³s              |                 |
| 1) Sand and soils                 | 0,02            |
| 2) Gravel - for rocky soils        | 0,0225          |
| When \( Q = 25...1 \) m³s         |                 |
| 1) Sand and soils                 | 0,0225          |
| 2) Gravel - for rocky soils        | 0,0250          |
| II. Covered channels              |                 |
| Smooth concrete                   | 0,012-0,014     |
| Gelatin Concrete                  | 0,015-0,017     |
| Asphalt bitumen                   | 0,017-0,030     |
| Stony stone lying on the bed      | 0,020-0,025     |

The hydraulic flow of the machine canal is calculated as the maximum water consumption in relation to \( Q_{\text{max}} \), and the accelerated water consumption is to convert \( Q_{j\text{ad}} = 1.2 \cdot Q_{\text{max}} \). In addition, the channel is checked for washing and sinking. Based on the given soil type and \( Q_{j\text{ad}} \) expenditure, the following values are accepted:
Formula for water consumption at the irrigation pump station.

\[ Q = \omega C \sqrt{Ri} \]  

(3)

where \( \omega \) is channel cross-sectional surface, \( m^2 \); \( C \) - Sheze coefficient, \( m^{0.5} / s \); \( P \) is the hydraulic radius, \( m \); \( i \) - hydraulic bending. For channels with hydraulic radius \( R \leq 5 \text{m} \), the Shemi coefficient is usually determined by the following formula

\[ a:C = (1/n)R^y, \]  

(4)

\[ y = 2.5\sqrt{n} - 0.13 - 0.75\sqrt{R} (\sqrt{n} - 0.1) \]

where \( n \) is the unique coefficient. The Shemi coefficient for practical calculations can be obtained from the hydraulic reference.

\[ C = (1/n)R^{1/6}. \]  

(5)

For channels with hydraulic radius \( R > 5 \text{ m} \), the Chezy coefficient is determined by the channels operating under the same conditions.

The water supply channel slope must be low. At the same time, the water must reach the pump station even at the bottom of the canal at any water source. The canal is checked for non-washing. The formula given below shows the volume of channel discharge,

\[ g/l m^3 \rho = 700(v/w)^{3/2} \sqrt{R} \text{ при } 2 < w < 8 \text{mm/s}; \]  

(6)

\[ \rho = 350v\sqrt{Riv/w} \text{ при } 0.4 < w < 2 \text{mm/s}; \]  

(7)

where \( v \) is the rate of water in the channel, \( m/s \); \( w \) - average particle size, \( \text{mm/s} \); \( P \) is the hydraulic radius of the channel, \( m \); \( i \) - the bottom corner of the channel.

Channel non-washing check, \( m/s \),

\[ v_3 = 0.3R^{-0.25}. \]  

(8)

In the canals, water velocities exceeding \( 2 \text{ m/s} \) are formed by abrasive sediments with a small particle diameter of more than \( 0.25 \text{ mm} \). In this case the channel is exposed to its own erosion and the channels are concreted to prevent this.

Different coatings are used to reduce water absorption in the canal and extend service life. These types of cover are recommended:

- Prevent significant reduction of water flow by covering parts of the canals with concrete and reinforced concrete slabs;
- Coating with asphalt and bituminous materials, as well as monolithic concrete and reinforced concrete slabs to prevent filtration;
- By cement and plaster insertion into the soil - filling gaps (usually for rocky areas).

Monolithic coating (concrete, asphalt) is carefully prepared in pre-prepared soil. Cover, 10 cm thick. In concrete and reinforced concrete ducts, coated materials are used to prevent filtration. In the coating of monolithic coatings, the use of hydraulic concrete of a grade not less than B12.5. The thickness of the monolithic coating is not less than \( a = 1 \text{ cm} \). If \( a = 8 \ldots 10 \text{ cm} \), the depth of the water in the channel is \( h <1; a = 12 \ldots 15 \text{ cm} \) is \( h > 2 \text{ m} \). For channels with flow rates greater than \( 50m^3/s \), the monolithic thickness is calculated by taking into account all the loads.

Water intake facilities in transit channels are located directly on the edge of the canal. Generally, they include a water intake canal, a self-propelled water pump, and water pumped from the pumps. These water intake structures are usually installed for small to medium-sized satellites (Figure 1).0,1...0,2 m^3/s The pumping structure may be the simplest type with the location of the suction pipes.
on the slope of the channel. The distance between the hoses of the hydraulic tubes takes at least \((3 \ldots 4) \, D_{vx}\). From the minimum entry level, the drop must be not less than \(0.6 \ldots 0.8 \, m / s\) on the request pipeline and \(1.5D_{vx}\) at a speed of not more than \(1 \, m\) in transit channel, but not less than \(0.5m, \, m / s\).

It is necessary to provide shelters to keep the waste in the pipeline. It is recommended that the velocity at the inlet of the tube be lower than the supply line in order to reduce the flow of the various pipes to the pipe. It is recommended to reverse the accumulated leakage in reverse flow.

If the water consumption of the pump is more than \(0.2 \, m^3 / s\), individual water intake chambers will be installed (see Figure 1).

The most severe mode is the lack of water at the pumping stations, which results in the failure of all pumps. In this case, the amount of space within the channel will increase. At the bottom of the channel, a sediment is formed (see 1. b). To do this, water must be brought to the canal. It is recommended that the direction of water intake along the canal is up to \(1.2 \, m / s\) in the maintenance canal. Water intake may vary depending on the high water consumption.

![Image](image.png)

**Figure 1.** Water pumping facility on the side of the pumping station

- a - b - 1 - Water intake chamber; 2 - scoop; 3 - trunk channel; 4 -

With such a regulation of water intake, there is a flow approach in the cells, which results in the formation of pits. They usually have a dumping grid, with grids at a depth of no less than 1.3 but no less than 1. In this case, the size of the inlet chambers and the location of the drain pipes in the water intake channels are in the canals.

Reduction of water intake structures in water intake \(Q_{HC} / Q_o \geq (0.1 \ldots 0.15)\) (Supply of \(Q_{HC}\) pump station, \(m^3 / h\); \(m^3 / s\)); It is advisable to leave the opposite side of the receiver in the channel (see 3.6, a). Design width of a channel,

\[
m_b \geq (0.25 \ldots 0.3)b_e,
\]

Where \(b_e = b + mh; b - Width of the supply channel, m; m - slope of channel walls; h - water depth in the channel, m.

4. Conclusions

- Studies conducted at the RIIWP with the participation of the authors showed that the obtained ratios allow not only the use of scientifically-based methods for calculating the well-known interfacing structures of the National Assembly (tank chambers, water inlets, outlets), but also an analysis of the calculation schemes of the dynamic and kinematic flow conditions, which allow us to establish the nature of the influence of flow parameters and soil particles of bottom and suspended sediments on the process of their layouts.
- For the natural watercourses of the conjugate structures of the PS, the hydrostatic loading for
particles $d > 0.03$ mm turned out to be small compared to the force of gravity acting on the particle and may not be taken into account in the calculations of soil resistance to erosion. The data obtained show that the maximum recorded speeds during removal from bottom sediments are on average 1.5 times higher than the average value of the rate during siltation.

- Recommendations for the selection of rational designs and operating modes of mating structures allow us to make technical and economic comparisons of the options at the design stage of pumping stations and take them into account during operation.

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