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Method of Increasing the Reliability of the Open Horizontal Drainage System For the Purpose of Managing the Melioration Regime of the Syrdarya Region

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ABSTRACT: The article provides materials for determining the patterns of failure of the collector-drainage network and the decrease in its performance during operation, using the method of mathematical statistics;decrease in the working depth of the collector-drainage network, with the extension of the operating time after mechanical cleaning, established by instrumental observations, along the sections fixed on the collector-drainage network of various orders, laid in different types of soil profiles.The influence of a decrease in the efficiency of the collector-drainage network on the land reclamation state, the required level of drainage was determined by the methods of general and partial water-salt balances.

KEY WORDS: open horizontal drainage, exploitation, reliability, melioration regime, water balance, Syrdarya region, collector.

I.INTRODUCTION

Maintaining in operational condition of reclamation systems and structures requires a lot of material, human, time and money costs. Maintaining the required operability of an open collector-drainage network is the main condition for ensuring land drainage, both in horizontal drainage systems and in the joint operation of horizontal and vertical drainage.

In modern conditions, in practice, in the current regulatory documents and scientific studies, repair and restoration work on open horizontal drainage systems is planned without linking with indicators of land reclamation conditions, actual reclamation regimes, indicators of the operational reliability of open drains, natural, economic and meteorological conditions.In the context of the economic reform, the importance of scientific substantiation of the timing of repair and restoration works and their volumes, taking into account: the impact of the operability of drains on the reclamation state of lands, is increasing; the requirement to maintain the level of drainage, which ensures the regulation of soil reclamation regimes within optimal limits; on the basis of establishing patterns of drain failures.

The purpose of this work is to study the patterns of failures of an open collector-drainage network, the effect of a decrease in their performance on the reclamation state of irrigated lands; development on their basis of a scientifically grounded methodology for calculating the terms and volumes of repair and restoration work of open drainage, taking into account the regulation of the reclamation regime of soils.

II. METHODOLOGY

Characteristic of the position of the center of scattering - the arithmetic mean of the variation series is determined according to the formula:

$$\bar{X} = \frac{X_1 + X_2 + X_3 + \cdots + X_n}{n} = \frac{1}{n}\sum_{i=1}^{n} X_i \quad (1)$$

where: n is the volume of the row.

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One of the important characteristics of the variation series, the mode, is the most probable value of a random variable.Mode is practically defined as the value of the average interval in which the frequency or frequency is greatest, on the frequency range its peak.

To characterize the empirical distribution of a random variable, definitions, only the arithmetic mean and mode are not enough, since two such distributions with the same means can have completely different forms.

The scattering characteristics are used to determine this property of a random variable. The characteristics of the scatter or spread of a random variable are as follows: spread of scatter (spread) – R; rms or standard deviation – σ; dispersion – $\sigma^2$and the coefficient of variation – V.

The span is determined by the formula:

$$R = X_{max} - X_{min} \tag{2}$$

The standard deviation is determined by the formula:

$$\sigma = \sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2} \tag{3}$$

Dispersion

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})^2 \tag{4}$$

The coefficient of variation characterizes the value of the standard deviation as a percentage of the arithmetic mean and therefore is convenient for comparing the empirical distribution by the value of their relative dispersion.

$$V = \frac{\sigma}{\bar{X}} \cdot 100\% \tag{5}$$

To significantly reduce the time of the statistical processing is used in practice sample observation. Selective observation should make it possible, without resorting to a continuous survey, to obtain the indicated generalizing indicators that would correctly reflect the characteristics of the entire general population.

The representativeness of the sample was assessed by the size of the average error of the sample mean equal to the square root of the variance of the feature, divided by the size of the sample:

$$\mu_x = \sqrt{\frac{\sigma^2}{n}} \tag{6}$$

For a visual representation of the probability distribution, polygons of the probability distribution were built, which have the form of broken lines. If you replace the polygonal line with a smooth curve that expresses the polyline under study as closely as possible, this curve is called a probability curve. It is important to know the relationship between the possible values of a random variable and their probabilities, which is called the theoretical law of distribution of a random variable.

According to the graphic representation of the variation series, it is assumed that the empirical distribution of random variables is subordinated to some theoretical law of the distribution of random variables, according to the appropriate methods and criteria, the agreement of the empirical distribution with the proposed theoretical one is checked.

The influence of the failure rate and the overall performance of the collector-drainage network on the land reclamation state, the required level of drainage were determined by the methods of general and particular water-salt balances, according to the refined schemes of R.K.Ikramov.

1. General water-salt balances are compiled for the reclaimed gross area:

$$\Delta W = W_e - W_b = O_P + B + \Phi_{mc} + Bv_{/d} + B_{cdn} + \overline{\text{П}} + \underline{\text{П}} - \overline{\text{O}} - \underline{\text{O}} - ET_{\text{в}} - C - Д_G - Д_{vd} \pm P \tag{7}$$

$$\Delta \text{C} = \text{C}_{vd} + \text{C}_{\Phi} + \text{C}_{\text{вд}} + \text{CB}_{cdn} + \text{C}_{\overline{\text{П}}} + \text{C}_{\underline{\text{П}}} - \text{C}_3 - \text{C}_2 - \text{C}_{\text{C}} - \text{C}_{Ggw} - \text{C}_{G\text{в}} + \text{C}_{\text{P}} \tag{8}$$

2. The water-salt balances of the aeration zone of the reclaimed territory are compiled for the gross area of the balance contour according to the formulas:

$$\Delta W^a = W_b^a - W_e^a = O_P + O_w + Bv_{/d} + B_{cdn} + (1-\alpha)\Phi_{\text{вн}} - C_n - ET \pm g_I \tag{9}$$

$$\Delta \text{C}^a = C_b^a - C_e^a - C_{op} + Cv_{/d} + C_{Bcdn} + C_{(1-\alpha)\Phi_{\text{вн}}} - C_{C\text{п}} + C_{g_I} \tag{10}$$

3. The water-salt balances of the aeration zone of the irrigated field are compiled for the irrigated area:

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$$\Delta W^{a} = W_b^a - W_e^a = \frac{1}{\Psi}(O_P + O_w + Bv/_d + B_{cdn} + (1-\alpha)\Phi_{\text{вн}} - C_n - ET \pm g_I) \quad (11)$$

$$\Delta C^{a} = C_b^a - C_e^a = C_{op} + Cv/_d + C_{cdn} + C_{(1-\alpha)\Phi_{\text{вк}}} - C_{C\text{п}} \pm C_{g_I} \quad (12)$$

4. The water-salt balances of the surface layer of groundwater are compiled to predict the salinity of the surface layer of groundwater: the outflow of groundwater from the calculated surface layer (h_0) to the underlying ones can be determined by the formulas:

a) when the groundwater level rises

$$z = (\alpha\Phi_{\text{в}/\text{x}} \pm g_I)\left(1 - \frac{\Delta W_{gw}}{\alpha\Phi_{\text{в}/\text{x}} + \Phi_{mc} + \Phi_{\text{м}/\text{x}} \pm g_I}\right) \quad (13)$$

b) when the groundwater level drops

$$z = \alpha\Phi_{\text{в}/\text{x}} \pm g_I \quad (14)$$

c) when

$$\alpha\Phi_{\text{в}/\text{x}} < |-g_I| \qquad z = 0 \quad (15)$$

Saltbalance

$$C_b^{\text{ПВГ}} - C_e^{\text{ПВГ}} = C + \Phi_{\text{в}/\text{x}} \pm C_{g_I} \quad (16)$$

5. Water-salt balance of the root zone

$$\Delta W^{rz} = O_P + \frac{1}{\Psi}(O_P^{\text{H}} - C_{\Pi}) - ET_n \pm g_2 \quad (17)$$

$$\Delta C^{rz} = C_b^{rz} - C_e^{rz} = C_{op} - C_n \pm C_{g_2} \quad (18)$$

where: $W_b - W_e$ – moisture reserves at the beginning and end of the billing period are determined by the formula of A.I.Engulatov:

$\Delta W, \Delta C$– general changes in moisture and salt reserves within the balance loop;O_P – precipitation; B – water intake (according to operational hydrometry data); Φ_{mc} – filtration losses from main canals (according to operational hydrometry data);$Bv/_d$ – use for irrigation of water from vertical drainage;B_{cdn} – use for irrigation of water from the collector-drainage network; $\overline{\Pi}, \overline{O}$ – inflow, outflow of surface water to the balance area; $\underline{\Pi}, \underline{O}$ – inflow, outflow of groundwater into the balance area from the side; $ET_{\text{в}}$ – evatranspiration; C – total discharge of irrigation water; $Д_G$ – wedging out of groundwater into horizontal drainage; $Д_{vd}$ – pumping volume of vertical drainage wells; $\pm P$ – inflow, outflow of groundwater from below; $C_B, C_\Phi, C_{\text{вд}}, C_{cdn}$ – accordingly, the content of salts in the elements of the water balance, t/ha; $W_b^a, W_e^a, \Delta W^a, C_b^a, C_e^a, \Delta C^a$ – respectively, the initial and final drifts of moisture and salts in the aeration zone and their change during the billing period;

$$\Delta W^a = \Delta W - \Delta W_{gw};\ \Delta W_{gw} = Q(h_b - h_e) = Q\Delta h \quad (19)$$

where: ΔW_{gw} – change in groundwater reserves; Q – fluid loss or lack of saturation; O_w – water supply to an irrigated field, net:

$$O_w = B - \Pi_{M/X} - \Pi_{B/X};\ \Pi_{M/X} = B(1 - \eta_{M/X});\ \Pi_{B/X} = B(1 - \eta_{B/X}) \quad (20)$$

where: $\Pi_{M/X}, \Pi_{B/X}$ – respectively, losses from the inter-farm and intra-farm networks; $\eta_{M/X}, \eta_{B/X}$ – Efficiency of interfarm and intrafarm network; C_{Π} – discharge from the field of irrigation water; ET_n – evatranspiration from the irrigated area; g, C_g – water and salt exchange between the aeration zone and groundwater, according to the formula: α- 0,8 – the share of filtration from the on-farm network supplied to the groundwater supply; $\Psi = \frac{F_{\text{н}}}{F_{\text{в}}}$ – respectively, net area and gross balance contour; g_I, C_{g_I} – water and salt exchange between the aeration zone and groundwater; z – outflow of groundwater from the design surface layer to the underlying; g_2, C_{g_2} – water and salt exchange of the root zone with the underlying ones.

Determination of the elements of water-salt balances.

1. Evatranspiration calculation.

Evatranspiration during the non-growing season is determined by the Blaney and Criddle formula:

$$ET = 0{,}458 \cdot K_v \cdot P(17{,}8 + t^0) \quad (21)$$

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where: K_v – coefficient depending on the type of vegetation for the non-growing season can be taken $K_v = 0{,}2$; P – the proportion of the duration of daytime hours in a given month from the annual amount, % (for November – 6,52, January – 6,76, February – 6,73 and march – 8,33); t^0 – average monthly air temperature, ^{0}C.
Cotton evapotranspiration is determined by the formula of Kh.A.Amanov:

$$\mathrm{ET_X} = 11{,}64\beta\sqrt[4]{\frac{\sum t\cdot У\cdot n}{h_{cp}}} \qquad (22)$$

where: β – coefficient taking into account the water consumption of cotton in certain months and equal to: in April – 0,31, May – 0,57, June – 0,91, July – 1,54, August – 1,21, in September – 1,21, October – 0,57; $\sum t$ – the sum of the average daily air temperatures; У – yield of raw cotton, c/ha; n – number of days in a month; h_{av} – average monthly depth of groundwater, m.
Evapotranspiration from a complex hectare of the carrying area is calculated using the formula:

$$ET = ET_X\cdot K_{av};\ K_{av} = \frac{K_1\omega_1 + K_2\omega_2 + \dots + K_i\omega_i}{\sum\omega_i} \qquad (23)$$

where: K_{av} – weighted average coefficient of water consumption of crops; K_1, K_2, K_i – coefficient of water consumption of individual crops in relation to cotton; $\omega_1, \omega_2, \omega_i$ – respectively the area under these crops.
2. Determination of the total discharge of irrigation water.

$$\mathrm{C} = \mathrm{C_1} + \mathrm{C_2} + \mathrm{C_3} \qquad (24)$$

where: $\mathrm{C_1}$ – discharges and technical leaks from the inter-farm network, 1%; $\mathrm{C_2}$ – also from the on-farm collector and drainage network, 7%; $\mathrm{C_3}$ – discharges from fields are due to the efficiency of irrigation technique depending on the parameters of irrigation furrows, terrain slope, permeability and planning, in the Shuruzyak, Bayaut, Sardoba arrays, according to field studies, we take 16% of the water supply, for the floodplain array is determined by the hydrochemical method of A.I.Engulatov.
3. Calculation of groundwater wedging out into horizontal drainage.

$$Д_G = \frac{\pi\cdot К\cdot n\cdot l_s}{\ln\frac{10000}{l_s\cdot d} - 1}(h_d - h_{av}) \qquad (25)$$

where: К – filtration coefficient of soils, m/day; n – number of days in a month; l_s – specific length of the collector and drainage network, r.m./ha; d – drain diameter, for open drains $d = 0{,}5\cdot b + h$; h_d – drain depth, m; h_{av} – average monthly groundwater depth, m.
4. Calculation of the volume of pumping by vertical drainage.

$$Д_{в} = \frac{n\cdot Q_{av}\cdot t\cdot 86{,}4\cdot VDSE}{F} \qquad (26)$$

where: n – number of wells on the system; Q_{av} – average flow rate of one well, m^3/sec; t – well operation duration, days; F – reclaimed area, ha; VDSE – vertical drainage system efficiency.

$$VDSE = \frac{\mathrm{T}_a}{\mathrm{T}_c} \qquad (27)$$

where: T_a – actual operating time, moto/h;

$$\mathrm{T}_a = \frac{Э}{N} \qquad (28)$$

Э – actual consumption of electricity, kW;
N – pump power, kW/hour;
T_c – calendar time.
5. Determination of salt reserves in the aeration zone ($\mathrm{C}_{н}^{\alpha}$), in the surface of groundwater ($\mathrm{C}_{н}^{пвг}$), in the root zone ($\mathrm{C}_{н}^{rz}$).

$$\mathrm{C}_{н} = h\cdot\rho\cdot S\cdot 100\cdot\varphi \qquad (29)$$

where: h - for the aeration zone, the minimum GWL depth for the design period, for groundwater surface – 1,0 m, for the root zone – 0,8 m; S – salt content in soil in % of the weight of dry soil, respectively, in the aeration zone, groundwater surface, root zone; ρ – bulk mass of soil, t/m^3, for Syrdarya region 1,3-1,4; φ – the coefficient of conversion of water extracts to the initial calculated reserves of salts, according to P.S.Panin, for chloride soils – 1,17, chloride-sulfate and sulfate soils – 1,41.

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6. Determination of salt exchange in the aeration zone ($C_{Д}^{\alpha}$), groundwater surface (C_z) and root zone ($C_{g_2}^{кз}$).
When removing salts from the aeration zone (-g), groundwater surface (-z), root zone (-g$_2$) with infiltration waters:

$$C_g = C_H\left(1 - \frac{1}{\frac{K}{l^{\gamma}}}\right) \quad (30)$$

where:γ – salt leaching constant, the value of which for chloride soils – 1,5, chloride-sulfate and sulfate – 4,25; K – the frequency of water exchange, respectively, in the aeration zone, groundwater surface, root zone in fractions of a unit

$$K = \frac{g}{h \cdot m \cdot 10000} \quad (31)$$

where:g – descending currents of moisture from the aeration zone, groundwater surface, root zone;h - for aeration zone minimum groundwater depth, for surface – 1 m, for the root zone – 0,8 m; m – active porosity of soils, we take – 0,07.
When feeding the aeration zone (+g)

$$C_g = 0{,}001 \cdot g \cdot \mu_{г}^{пгв} \quad (32)$$

where:$\mu_{г}^{пгв}$ – average groundwater salinity for the calculation period, g/l (determined from the water-salt balances of the surface layer of groundwater).
When the root zone is replenished with upward currents of moisture from groundwater (-g$_2$)

$$C_{g_2} = 0{,}001 \cdot g_2 \cdot \mu_{вт} \quad (33)$$

where:$\mu_{вт}$ – ascending current mineralization, g/l.

$$\mu = \frac{S_{н}^{вт} \cdot \xi \cdot \rho \cdot 1000}{Q_a \cdot Q_{mh}} \quad (34)$$

where:ξ – conversion factor from the salt content in the soil to the mineralization of the soil solution. According to P.S.Panin for chloride soils – 0,82, chloride-sulfate and sulfate – 0,535; Q_a – actual soil moisture in% of the volume;Q_{mh} – maximum hygroscopic humidity in% of the volume,for medium soils 4-7%; $S_{н}^{вт}$ – salinity of soils in the zone of the upward current, %.
7. Determination of the salt content in the aeration zone, groundwater surface, root zone in% of the weight of dry soil at the end of the calculation period.

$$S_k = \frac{C}{h \cdot \rho \cdot \varphi \cdot 100} \quad (35)$$

To determine the change in the roughness coefficient (n) in the channel of the collector-drainage network after mechanical cleaning and depending on the dynamics of algae growth, hydrometric works were carried out at the existing gauging stations ,the flow rate of water (Q), the area of the free cross-section (w), the slope of the surface (i), and the water level (h) were measured.
"n" is determined depending on the hydraulic radius (R) and the Shezy coefficient (C) from the table compiled by G.V.Zheleznyakov.

$$C = \frac{Q}{w\sqrt{Ri}} \quad (36)$$

"R" can be taken equal toh_{av}

$$R = h_{av} = \frac{w}{b} \quad (37)$$

III. RESULTS

One of the main conditions for ensuring the required water-salt regime of soils is the reliable operation of the collector-drainage network.
Investigations of the regularity of the decrease in the operability of the collector-drainage network and their forecasting methods were carried out on the basis of the analysis of materials and contents of the maintenance services, design studies and literary sources, through systematization, generalization. Subject to analysis are materials on the frequency and volume of cleaning work on an open collector-drainage network. In this case, the methods of mathematical statistics and probability theory were used. The typification of soil profiles is carried out taking into account their lithological structure, mechanical composition and gypsum content in it.

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Full-scale and theoretical studies to establish the patterns of failures, the intensity of siltation of the collector-drainage network and factors that reduce their performance, were carried out for each selected type of soil-soil profiles. Considering that failures of an open collector-drainage network depend on many factors, all other things being equal, they can be considered as random values.

To establish the regularities of failures and the intensity of siltation of the collector-drainage network, statistical processing of data (random variables) on mechanical cleaning and siltation of drains is carried out. The empirical distribution of a random variable is presented either in tabular form or graphically. However, it is necessary to know the digital characterization of the distribution in a more concise, compact form. There are two types of mathematical statistics used for such characteristics:

- the position of the center of scattering. The scattering center is understood as the interval of values of a random variable in which it repeats with the highest frequency. In other words, it is some average value of a random variable around which it is more or less densely grouped;
- characteristic of dispersion (measure of oscillation) of a random variable. Scattering characterizes a somewhat scattered random variable near the center of the grouping. Both types of characteristics are called statistical measures.

IV. CONCLUSION AND FUTUREWORK

Creation of reliable systems, structures, equipment is the subject of consideration of the theory of reliability. The theory of reliability is based on probabilistic considerations. Since the external operating conditions and internal parameters of the system are random, failure is usually interpreted as a random event, and reliability - as a probabilistic characteristic of the system. For example, such factors that reduce the efficiency of the collector-drainage network - overgrowth with algae, discharge of irrigation water, erosion of slopes, operating mode of the water intake, slope, turbidity of water have a random character.

Therefore, the reliability of drainage systems can be correctly described and calculated using the methods of probability theory and the theory of random processes. The established patterns of failures of an open collector-drainage network, methods of calculation justification of the terms and volumes of cleaning an open horizontal drainage, can be used in the preparation of operation projects, planning the repair of existing ones, as well as in the design of new drainage systems to ensure their required reliability.

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