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Effective Methods of using of the Water Resources of Mountain Rivers with high turbidity

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Abstract**—***The article focuses on the solution methods of the problems arising from the rational use of the water resources of mountain rivers with high turbidity.Technical and operational indicators of water reservoirs constructed on mountain rivers characterised by high turbidity have been analysed and measures preventing stagnation of water reservoirs have been investigated.Issues related to the construction of a water reservoir outside the river bed and the prevention of stagnation of this water reservoir were investigated. The option of building a water receiving reservoir providing partial regulation and limpidity of the flow in the river valley was proposed. Hydraulic washing installation was proposed to remove sediments from the water reservoir equipped with the water tank. The working principle of washing installation with hydro-technical and hydraulic parameters are listed.*

Keywords**— *mountain rivers, water resources, sediment, hydraulic irradiation, water reservoirs,water grubbing dam, water receiver/tank, washing corridor,directional walls.***

I. INTRODUCTION

Recently, acceleration of joining of fertile soils located in the foothills zone to the sowing cycle has led to the extensive use of the water resources. As a rule, a water reservoir is being constructed in its scope to enable annual or perennial adjustment on the riverbed to use the water resources of the mountain rivers efficiently.The operational experience of the water reservoirs built in last 70 years in the world shows that reservoirs built on many mountain rivers lose their volumes while silting and become useless for exploitation.Sediments in the flow enter to the water management systems along with water during the withdrawal of water from such reservoirs. Sediments lead to the disruption of water management systems and complicate the process of exploitation. River sediments basically silt the water reservoir, decreases its useful volume, shortens the service life, complicates the exploitation of the water intake junction, reduces the submersible ability of channels by siltation.

Anti-siltation measures in water reservoirs are mainly carried out in passive form, i.e. after siltation of the reservoir by hydraulic washing or hydro mechanical methods. As the sediments in the water reservoir become solidified, the use of these methods is observed with great energy and water loss and is not considered economically viable.

II. CURRENT STATE OF THE PROBLEM AND FINDINGS OF THE RESEARCH

There are many water reservoirs that built in North America, Africa, including Central Asia, and Azerbaijan in the world, which have stopped their operations before the end of exploitation because of siltation.Water reservoirs in the United States are estimated to be silted 1.2 billion cubic meters a year, and this indication in China's Shanghai province is 80 million cubic meters.2 % of water reservoirs in Japan, and 1 % of in India and Portugal lose its volume annually due to siltation.[5]

The Khashm Roseires water reservoir in the Sudanese Republic has lost about 50-55 million cubic meters, or about 60% of the total volume, during the first decade. In the United States, the volume of Garrison, Saxe, Fort water reservoirs decreases by 30-45 million cubic meters per year as a result of intensive sedimentation.

There are many water reservoirs located on the mountain rivers flowing through the North Caucasus and Central Asia which silted up to 70-90% in 5-10 years.[5]

Pirsaatchay, Bolgarchay, Javanshir, Jeyranbatan, and Ayrichay are examples of water reservoirs exposed to the over siltation in the Republic of Azerbaijan. The Ayrichay water reservoir, which was commissioned in 1986 with a useful volume of 80 million m^3, was silted up to 80%. Pirsaatchay and Bolgarchay water reservoirs constructed in 1964-1965 generally stopped their activities.(photo 1). The main reason for rapid siltation of all these reservoirs is the high turbidity of rivers and the lack of preventive measures during the exploitation period. In the territory of the Republic of Azerbaijan, there are several mountain rivers with high turbidity, which is why they are not used effectively for their water resources. An example of these rivers is Sumgayitchay, Kazluchay, Turyanchay, Jeyrankezmez, Karachay, Girdimanchay, Goychay Gobuchay.

Girdimançay is relatively exuberant but very turbid among these rivers. Girdimanchay's water resources are currently used in very small quantities incoherently. The reason for this is that the water of the river is high turbid and often occurs destructive floods. The problem of constructing a reservoir on the river has been repeatedly tried and therefore no work has been done.

Fig.1: Pirsaatchay water reservoir built in 1964 with a total area of 16.9 million m^3(2017)

S.T. Altunin, N.F. Lapshenkov, G.I. Shamov, D.I.Mukhammedov, L.G. Gvelesiani, V.A. Skrillnikov, G.T. Macharadze, F.B. Bashirov and A.M. Mammadov conducted wide research in the rivers located in Central Asia and the South Caucasus related to the forecasting reports on the sedimentation of the water reservoirs and prevention from that [5,7,10].

V.A. Skrilnikov conducted extensive research on the dynamics of sedimentation and the deposition of sediments of the water reservoirs built on the territory of Central Asia. He proposed removing slimes that collapse in the valley usingslime washing equipment with hydromechanical method. It should be noted that this cleaning method is considered to be feasible for regions with low water resources.

G.T. Macharadze examined the reasons of the sedimentation of many water reservoirs built in the territory of the Republic ofGeorgia and proposed the following method for the cleaning of collapsing slimes. (Figure2)

Adjusting unit in the riverbed of the upper part of the water reservoir has been designed in the method proposed by G.T. Macharadze. Binding sluices regulated with the lifting crane attached to the unit to control the river flow. The working principle of the unit is as follows. Initially, binders 6 and 8, shown in Figure 2, are kept closed, the binder 7 is opened to pump water in that direction and the slime sediments are removed from the area by the bottom water discharger. In the next stage, the bottom discharge unit is closed and water is collected inside the valley washed by the channel 12. In this case, a certain amount of sediments in the upper parts are washed and removed from the area with the bottom discharge unit.Then, alternately, the other binders are opened and the sediments are washed in the same direction. The proposed method has the following disadvantages:

- the water reservoir should be completely discharged to wash the sediments, in this case, large quantities of water losses occur;
- the river flow cannot be controlled as the mechanism cannot be brought to the surface of sediment;
- because the river flow is not controlled, the established erosion valley is usually formed by passing the parts where the relatively small amounts of slimes deposited. This causes a small amount of slime washing;
- The flow of water discharged from the gateway at the entrance of the water reservoir enters into the initial erosion valley after a short distance and covers only a small part of the sedimentary area inside the water reservoir;

During washing process in the subsequent years, it is not possible to go beyond the erosion valley at the initial stage, and only a small part of the water reservoir can be cleaned from the slimes;

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Even though there is more turbidity is observed in the initial stage of washing time, in the ongoing process the amount of turbidity in the wash water is dramatically decreasing causing large quantities of water losses;

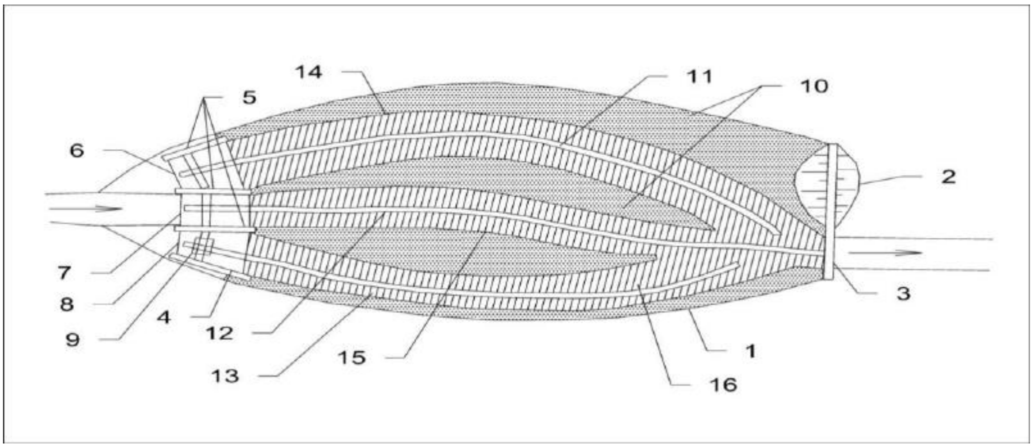

Fig.2: Hydraulically wiping the lions in water reservoirs.

1-water reservoir, 2-dam, 3- bottom water pumper, 4-Sluice gate, 5-directional walls, 6,7,8-binders, 9-lifting crane for the control of binders, 10-slime sediments, 11,12,13-erosion valleys after cleaning, 14,15,16-the islands after the wash, respectively.

F.B.Bashirov conducted extensive research on washing of deposited slimes in Siyazan water reservoir with a volume of 6.6 m^3, designed to prevent sedimentation of the Samur Absheron Channel in the territory of the Republic of Azerbaijan, and proposed a method for intensifying the washing process.(Figure 3)

In the proposed method for washing Siyazan water decanter by F.B. Bashirov, the channels were laid along the coast of the basin in the direction of the dam. Special cuts and binding gates are placed on the channels to provide the washing water. Coastal channels are supplied with water through the gates 9, 11 and 14.Washing operations are carried out through the cuts on the channels and, in addition, washing operations are carried out by the release of water in sluices # 10 and 13. In this method, washing water is partially controlled, unlike the previous one. However, in this method, the water flows released for subsequent washings reaches to the erosion valley emerged from the previous wash, and parts that are not washed remain in the form of the island.

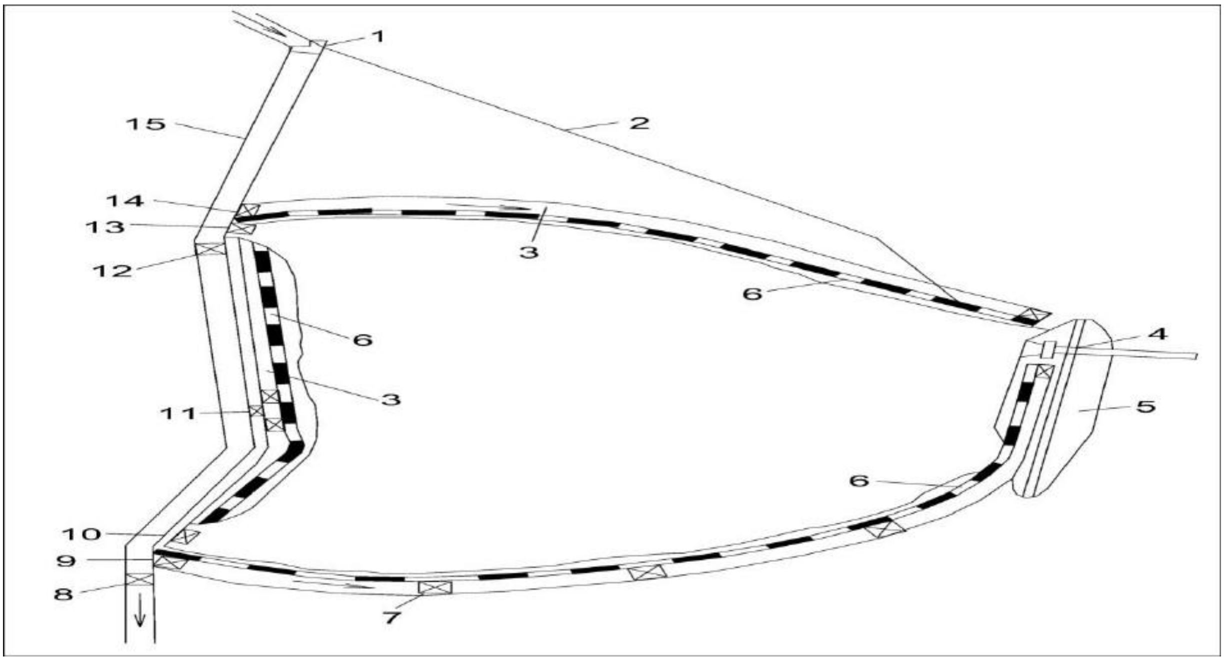

Fig.3: Basin of Siazan water reservoir and washing unit.

1. *Sluice, 2. leading channel, 3. washing channel, 4. water discharge device, 5.dam, 6.water discharge cuts on the washing channel; 7,8 və 12 binding gates, 9,10,11,13 və 14 control gates, 15 Samur Absheron channel.*

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A. Sh. Mammadov, in contrast to existing approaches, proposed a method for preventing siltation during the operation of water reservoirs. He proposed a new constructive solution to discharge the more turbid flows, floods and water that flow from the river to the water reservoir to lower canal pound without mixing in the water of the reservoirIn order to discharge more turbid waters to the lower canal pound without siltation in the water reservoir decanter equipment has been removed by means of a special pipe to the entrance of the water reservoir.The water discharge tower is provided with multi-stage washing gates, which ensures the discharge of more turbid flows from the river into the lower canal poundand allows to prevent siltation of the water reservoir. The proposed installation complexes are considered to be more favourable for the waterreservoirs which are not long but are deep (1-2 km).

It should be noted that existing methods and designs do not allow to solve the problems arising from the effective use of the waters of exuberant mountain rivers characterised by the high turbidity.

There are several shortcomings of existing methods:

1. There are not taken anti-siltation measures in the water reservoirs;
2. Larger water losses occur during hydraulic washing of sediments;
3. Ignore the volume of flood bringing in siltation reports;
4. Deterioration of the quality of water collected in the water reservoir due impact of the flood bringing;
5. Accidents occurring when floodwater enters rapidly into the water reservoir (occurrence of fluctuations in full water reservoir due to floods is dangerous as dam can collapse due to wash);

We developed a new reporting method to prevent such cases and to use more efficientwater resources of rivers with high turbidity. While developing a new method, it was preferred to use water resources of mountain rivers with high turbidity more efficiently and eliminate the major shortcomings of existing methods.

In order to effectively use water resources of rivers with high turbidity and fight against the turbidity, A.Sh. Mammadov recommends the construction of water reservoirs outside the riverbed. Herecommends that the water is taken from the river by the intake facility and transferred to the water reservoir to be constructed outside the mold by focusing on the drainage device. It should be noted that the fight against lilies in high-lush rivers is not economically viable and more water and electricity (for opening and closing of doors) are used to hydraulically wash the collapsing lanes. [10]It is recommended to take the water from the river by means of the water intake facility and to transfer to the water reservoir to be constructed outside the riverbed by discharging into the drainage equipment. It should be noted that the fight against slimes in rivers with high turbidity is not economically viable and more water and electricity (for opening and closing of gates) are used to hydraulically wash the silted slimes. [10]

The newly developed method in comparison to mentioned one allows minimising water and energy losses. The small adjustable water regulator dam at the riverbed is directly used to clarify and take the water of the river with high turbidity. The water grubbing concrete dam water intake and slime washing corridors are included in this dam junction. The complex of hydro-technical installations consisting of these units allows relatively to regulate flow in the riverbed, to precipitate the main part of the slimes and subsequently to transfer them to the riverbedwashing by the hydraulic method. Thus, this process ensures the discharge of the limpid river water into the water reservoir to be built out-of-the-riverbed.

The proposed hydraulic equipment complex should be designed within the following parameters:

- a small water intake reservoir fulfils lake type water-purification function;
- The dead pool of the water intake reservoir is determined by the hydrological regime of the river in accordance with the volume of annual or quarterly bringing of the river;
- In the water intake reservoir, high turbid river water is mainly purified and then discharged into the out-of-the-riverbed water reservoir through the open channel or pipe;
- when the floods occur in the river and where the turbidity is high, the river flow is discharged directly into lower canal pound without being stored in the water intake reservoir
- The silted sediments in the water intake reservoir without full compaction (without the colmatage) are periodically washed by thehydraulic method and discharged intothe lower canal pound.

The proposed solution for eliminating the above-mentioned shortcomings is a comparative study of Girdimanchay located in the territory of the Republic of Azerbaijan, which is considered a sample for thehigh turbid river where the frequent floods are characteristic. A comparative analysis of the technical solution was conducted by comparison of existing and new methods.

III. BRIEF HYDROLOGY OF GIRDIMANCHAY

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Girdimanchay starts at 2900 m above the southern slope of the Babadag summit (3632 m) of the Greater Caucasus Mountain Range. After leaving the mountains, the river creates a large bringingcone in the Garamaryam Plateau and breaks into many branches. By breaking this plateau, the river flows into the Shirvan plain with six branches. In 1950-60s Girdimanchay and Agsuchay were merged and discharged into the Kur River through the Shirvan Plain via single artificial riverbed. The average width of the Girdimanchay basin is 812 km and the average elevation is 1212 m. There is 64 km2 forest area in the basin. The average river slope is 32.80 / 00 and the density of the river network is 0.48 km / km2. Girdimanchay is exuberant in thespring season and flooded in autumn due to water regime. There were four hydrometric stations in Girdimanchay. (Table 1)

According to the data of the Garanour Hydrometric Station of Girdimanchay, the average perennial water flow is 6.5 m^3/sec. Floodsaredangerous events occurring frequently in the river. Flood sources cover more than 50% of the basin. Flood accidents were observed in Girdimanchay on July 27, 1915, August 11, 1926, June 14, 1930, July 15, 1947, October 18,1951, June 22, 1953, July 7, 1963, May 24, 1975, May 16, 1982. According to the data of the Garanour Hydrometric Station of Girdimanchay, the largest water flow was 201 m3 / sec on July 15, 1988.

Table.1: Hydrological indicators according to the stations operated on Girdimanchay

Rivers	Stations	Water collection areain km^2s	Average annual flow m^3/sec	Operation Period
Girdimanchay	Bruydal	78,8	1,2	1960-1962
	Gandab	326	3,03	1949-1962
	Kulullu	453	2,6	1929-1940
	Garanour	352	6,5	1966-h/h

It is currently operational.

The main measurements on the dependent bringing in Girdimanchay were carried out in Garanour station (is located in the area where the water reservoir to be constructed)in 1966-1970s. Based on observations on the dependent bringing, the amount of annual flow was 2.0-3.5 million tons. (Table 2)[1,2,3,4]

Table.2: Prices of bringings flow on Girdimanchay(Garanour station), kg/sec

Observation Period	Average flow of bringing, kg/sec												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average annual
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1966	0,89	3,3	7,1	77	320	17	10	50	410	76	140	0,98	93
1967	0,37	0,35	13	440	530	77	9,6	0,43	110	110	61	1,2	110
1968	0,27	2,2	4,1	76	26	660	27	0,52	1,8	0,36	0,43	0,84	64
1969	0,1	0,26	23	310	180	25	190	15	17	5,5	0,95	3	64
1970	1,3	3,1	39	260	25	83	13	120	2,1	3,4	0,43	0,23	46
Average	0,59	1,8	17	233	216	172	50	37	108	39	41	1,2	75

1. **The option of constructing a water reservoir with traditional method on Girdimanchay.**The option of constructing a water reservoir at the absolute level of 830 meters on Girdimanchay was studiedin order to irrigate fertile soils at the foothills of the Shirvan zone. Based on hydrological data from Girdimanchay, the reports show that the complex of hydro-technical facilities made of the dam to be constructed on the river by thetraditional method will be within the following parameters.

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Hydro-technical calculations to find the volume of newly constructed water reservoir wereconducted according to the 75% guaranteed (Q = 4.69 m^3/sec) water flow of Girdimanchay. According to the 75% guaranteed water flow of Girdimanchay, the amount of water to be collected per year is 149,76 million cubic meters, and the annual volume of bringing is 1.5 million cubic meters (Table 3). The flood rate of the water discharge tower will be Q max = 350 m^3/sec.

The water reservoir to be constructed on the riverbed can be between 830 and 970 m of height. The water surface area of the water reservoir valley in the mentioned altitude ranges from 27109 m^2 to 2400000 m^2, and the capacity of the water reservoir valley at these elevations reaches 127843 million square meters.

Based on the water balance calculations the required useful amount of water reservoir is 49,493 million m^3Accumulative slime volume was estimated at 75.18 million m^3 during the 50-year service of Girdimanchay. Thus, the full volume of the reservoir will be as follows.

$$W_t = W_f + W_{dead} = 49{,}493 + 75{,}18 = 124{,}673 mln.m^3$$

Thus, in the option of constructing a reservoir in the Girdimanchay riverbed, the height of the earth dam will be 140 m. If the floods are taken into account, the dead pool of the reservoir will increase, causing the height of the dam to rise sharply. Finances are required up to 20% of the construction cost (20-30%) of the dam to discharge safely the water flow of 350 m^3/sec. To the lower canal pound.

Table.3: Average annual water flow and average perennial bringing volume in accordance with the 75% guaranteed water flow ofGirdimanchay

Indicators	**Months**												**Total annual mln.m^3**	**In 50 years mln.m^3**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**		
Turbidity kg/m^3	0,3	0,76	5,3	28,7	47,7	70,2	4,95	11,3	9,47	7,6	19,7	0,52		
Water flow m^3/sec	2,02	2,38	3,19	8,12	4,53	2,45	10,1	3,26	11,4	5,12	2,08	2,27	149,7	
Monthly discharge m^3/month	1014	2735	28302	377531	361720	278624	83692	61667	174892	65139	66381	1976	1,50	75,18

Apparently, 75.18 million cubic meters of the water reservoir is used for the collection of dead pool, and the construction of the dam at this height in the river valley with strong floods cannot be considered as economically and operationally expedient and is very risky. Given the seismicity of the area, the construction and special exploitation costs of the dam at this altitude require considerable funding.

2. The option of the construction low-pressure water intake reservoir on Girdimanchay.

a) The construction of a water intake reservoir is intended for the aim of siltation of the river bringing between 830-845 meters on Girdimanchay and discharging to the lower canal pound by washing through the hydraulic method with the interruptions.

b) It is envisaged to construct a water reservoir with a height of 620-680 m on the right bank of Girdimanchay to collect partially limpid water to be taken from the river.

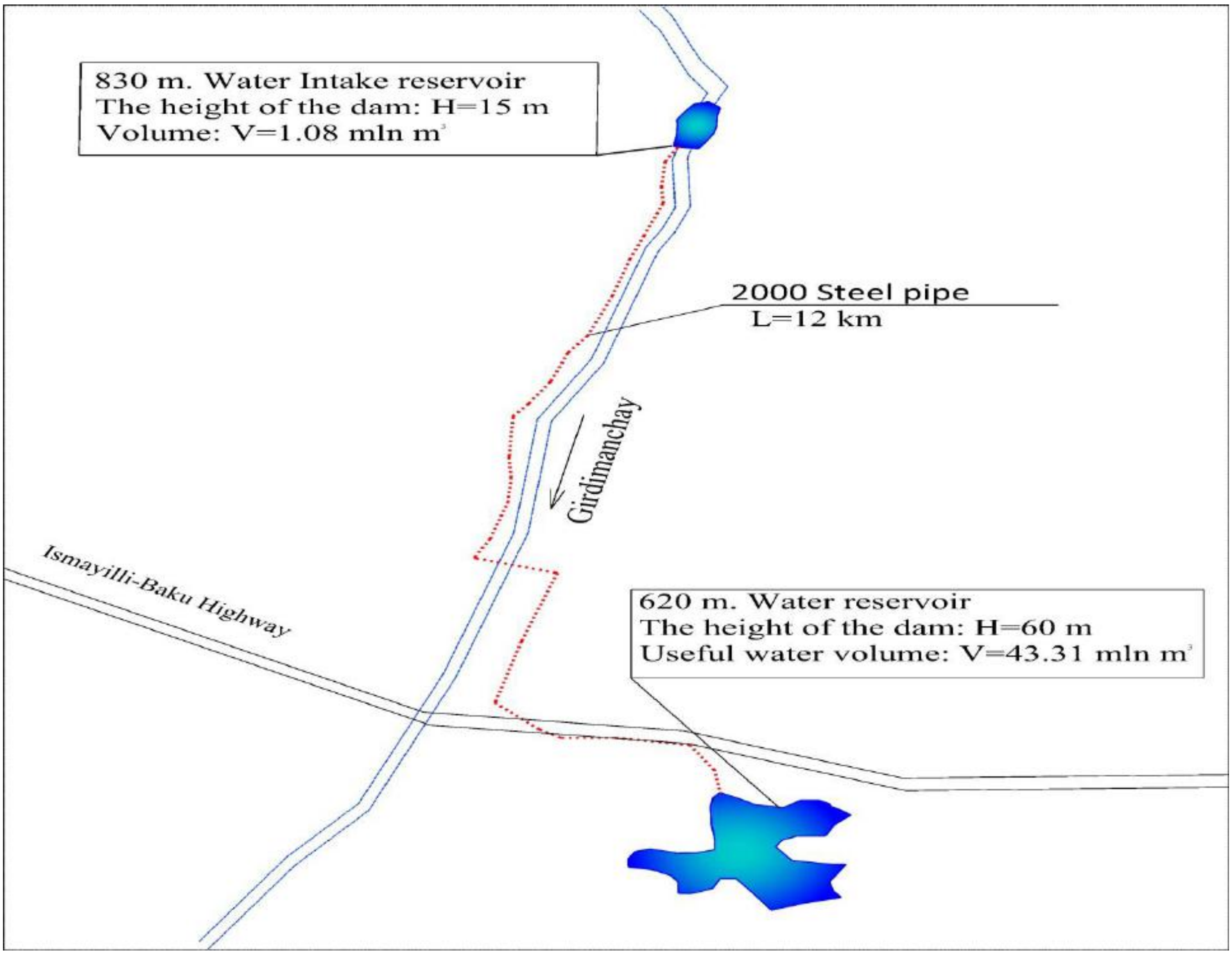
Main characteristic of water intake reservoir:The planned water intake reservoir can be constructed between the altitudes of 830-845 m on Girdimanchay.

The area of the water mirror at the level of 830 m and 845 meter in the river valley varies from 54217 m^2 to 115218 m^2, and the water volume limited to those elevations reaches 1,085 million cubic meters (Figure 4).

Water intake reservoir can be constructed from a gravel-sand and ground blend. The maximum height of the dam is 15 m and the total length is 220 m. The washing sluice, water grubbing dam and water intake sluice are installed in the body of the dam. The height of the dam is 12 m in the direction of its longitude. The soil dam of the water reservoir is made of the sediments of the riverbed, its pressed slope coefficient is m_1 = 3,0, downstream canal pound slope coefficient is m_2 = 2,5.

The volume of the water intake reservoir is determined by taking into account the hydraulic regime, which ensures complete displacement of the intended particles of river bringing. This volume may vary depending on the hydraulic gradient and volume of sediments to be precipitated here. The hydraulic calculations carried out at Girdimançay were carried out in accordance with the precipitation of the particles with a diameter of 0,5-0,001 mm.

The volume of water collected and partially to be limpid in the water intake reservoir will be discharged through the water intake gutter\sluice in the body of the dam and will be discharged into the water reservoirs outside the riverbed with a steel pipe of the total length L = 12000m and the diameter D2000.



Şəkil 4*. Placement plan of a water intake reservoir and a water reservoir outside riverbed on Girdimanchay.*

The volume of the water intake reservoir should be chosen so that a number of sediments which is not silted up there can create aminimum dead pool in the reservoir outside the riverbed. Otherwise, part of these sediments will lead to an increase in total volume of the water reservoir outside the riverbed and this will not be either technically or economically viable.

The total sedimentation dynamics in the water intake reservoir were carried out according to the formula of Y.A.Ibadzadeh and Ch.C.Nuriev:[6]

$$\rho_{\text{вх}} = \frac{\rho_0}{\upsilon H/\ _0 + L_x} \cdot \frac{\upsilon H}{\ _0}$$

$\rho_{\text{вх}}$-turbidity of water discharging into the water intake sluice, kg/m^3;

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ρ_0- turbidity of water of the river discharging into the water intake sluice, kg/m^3;
L_x-the length of limpidity zone, m;
$\square_0$- average hydraulic irradiation of slimes, m/sec;
υ- average flow velocity, m/san;
H-the average depth to water, m;
The turbidity of the water at the entrance of the water purifying reservoir was taken from perennial observation data on Girdimanchay. The length of the limpidity is taken in accordance with the sedimentation distance of the slimes in the water intake reservoir.
The average hydraulic irradiation of the sediment is calculated by the following formula [6]:

$$\square_0 = \frac{0,5(\square_{max} - \square_{min})}{\ln(\square_{max}/\square_{min}) - 1}$$

$\square_{max}$ və $\square_{min}$- is the maximum and minimumhydraulic irradiation of the sediment particlesand depending on the size is taken from the special tables (Ibadzade, Yu.A., & Nuriyev, C.G., (1979), Отстойники речных водозаборов.[Sedimentation of river water intakes.]).[3]
By using the above formula, monthly siltedslime volumes are calculated for the cases of the height of 10, 15 and 20 m of the water reservoir, and the results are shown in Figure 7. If the height of the dam is H = 10 m, the volume of bringing to be precipitated will be 799282 m^3 per year, non-silted bringing volume is 704391 m^3, when the height of the dam is H = 15 m, the sedimentation volume is 1131145 m3, the non-silted volume is 372528 m^3, and when the height of the dam is equal to the H = 20 m, thesediment volume is 1295066 m^3 , the non-silted volume is 208607 m^3(Figure 5).

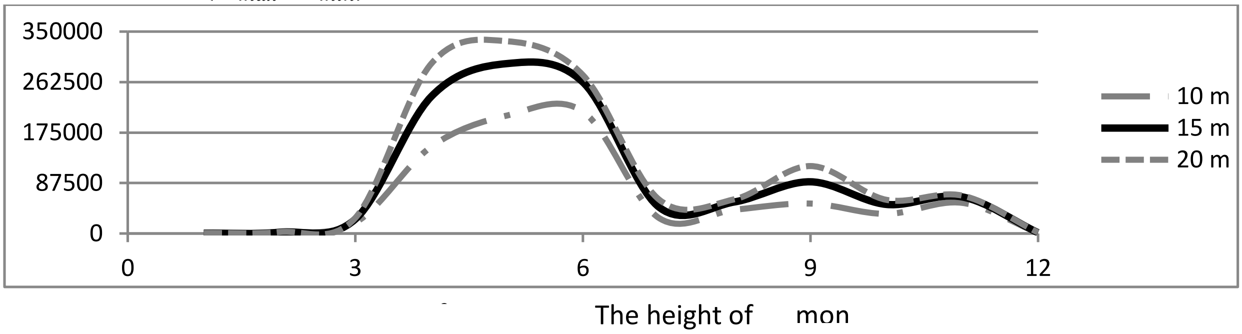

Fig.5: The monthly volume of precipitated slimes in water intake reservoirs depending on the height of the dam.

If the height of the dam is 10 m, the non-silted slime volume will be very large, which will significantly increase the dead pool of the out-of the-riverbed water reservoir. In the case of the height of the dam at a height of 20 m and above, the relative change in the size of the silted slimeat a height of 15 m is not economically viabledue to thelarge volume of the dam and the greater loss of water for the washing of silted sediments. Given the above, the 15 m height of the water intake reservoir was considered as a basis.
The diameter of a large amount of the not-silted slime is <0.001 mm which requires a long time to silted in the out-of-the-riverbed of the water reservoir. These particles are mainly observed in May and October, in thiscase,water intake will be intensive from the reservoir to be built out-of-the-riverbed. The dynamic movement of the water collected in the water reservoir outside of the riverbed does not create conditions for the sedimentation of these particles.
The sedimented slimes in the water reservoir should be periodically hydraulically washed and discharged into the lower canal pound. This periodicity should be performed taking into account the hydrological characteristics of the river, and the clean water accumulated in the water reservoir must be dumped before the spring floods and the sediments of the reservoir should be washed using spring flood water.

IV. WASHING OF THE SILTED SLIMES IN THE WATER RESERVOIR

It is recommended to use different methods and means to eliminate silted slimes in water reservoirs by existing literature materials. [5,7,9]Taking into consideration local conditions, the method of removing the silted slimesin the reservoir is selected. The hydraulic wash method is used mostly as one of the economically efficient methods for cleaning slime in water reservoirs. [5,7] In this method, the water reservoir is completely discharged to ensure the washing of the slimes and the river flow is directed toward the sediments in the reservoir valley to ensure the wash of the slimes. Numerous large-scale field studies have shown that at the beginning of the process, the wash is intensive and then it is weakening, which results in a large amount of water loss. [5,7]
As water flow in water reservoir cannot be controlled in case of the washing with this version it is possible to wash the slimes onlyalong with one stripe and washing water cannot be directed to the slimes in other areas. A new washing system has been proposed in order to eliminate all these shortages and use the washing water

more efficiently to direct and manage the river flow. The new facility will allow to intensify the washing of the slimes in the water intake reservoir and significantly reduce water losses.

In order to intensify the washing process by managing the river flow and to direct the water flow to the whole area of the sedimentation site, it is recommended to place flow-oriented concrete walls in an intensive sedimentary zone of the upper canal pound. In order to guide river flow through these directional walls, a system of shields has been installedat their entrance. These flat shields along the width of the river allow to fully close its width and is controlled by the bridge above the maximum water level that will be formed in the river. When the water from the water intake reservoir is taken, all shields are lifted upward and the river flows into the water reservoir valley bypassing all of the directional walls.

During the wash, the water reservoir is discharged and all other shields are lowered by keeping one of them above to ensure the flow of river intensively from one side. This hydraulic regime ensures the intensive wash of slimes over there and the water losses are minimal in this case. The sediments in other parts can be washed intensively by regulating the river flow.

Calculations made for the water intake reservoir to be constructed at the selected site at Girdimanchay valley allowed to determine the parameters of the washing installation. The length of the wash channels has been adjusted to the area to be washed. The first 500 m part of water intake reservoir is intended as a washing area. The washing channels are not considered in the area close to the dam of the water intake reservoir, i.e. in the first 100-150 m section. There will be precipitated slimes with smaller diameters. Part of these slimes will be washed away when the water reservoirs discharged and the rest will be washed away during the washing of the other parts. Washing channels are constructed at a distance of 200 meters starting from the 150 meters at a distance of the dam, and as large slime particles dominate in the rest of the 150 m section of the riverbedthere is no concrete channels are provided. The bottom sediments at the entrance of the water intake reservoir can be transported from the area to the construction site with special vehicles at the time of washing (Figure 6).

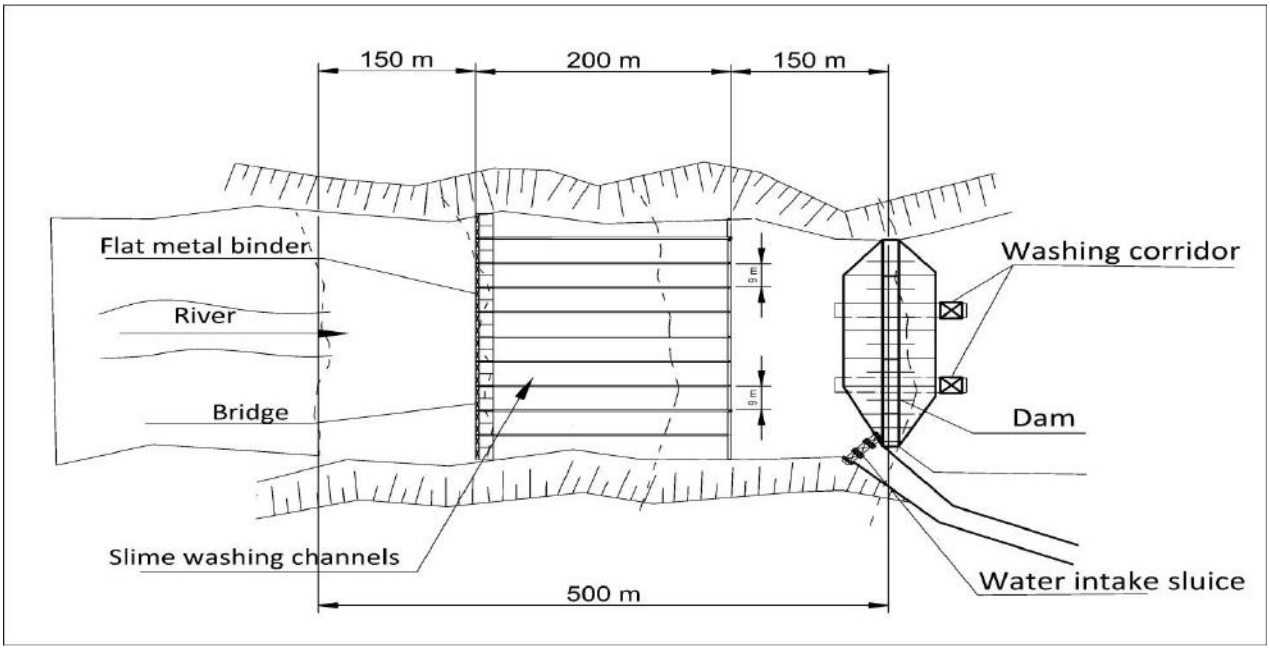

Fig.6: Layout scheme of slime washing channels in the water intake reservoir.

In order to control the water supply to the slime drainage channels, special flat metal binders are placed on their entrance thresholds. It is always kept in an open position, i.e. above the maximum water level, in order to prevent the slime assembly in front of flat metal binders.All of them are closed only during the wash, and open one-by-one to wash intensively the slimes between the directional walls. In the period of excessive water flow several binders can be kept open in several channels simultaneously to intensify the washing process. A bridge designed for the regulation of flat metal binder (Figure 7)

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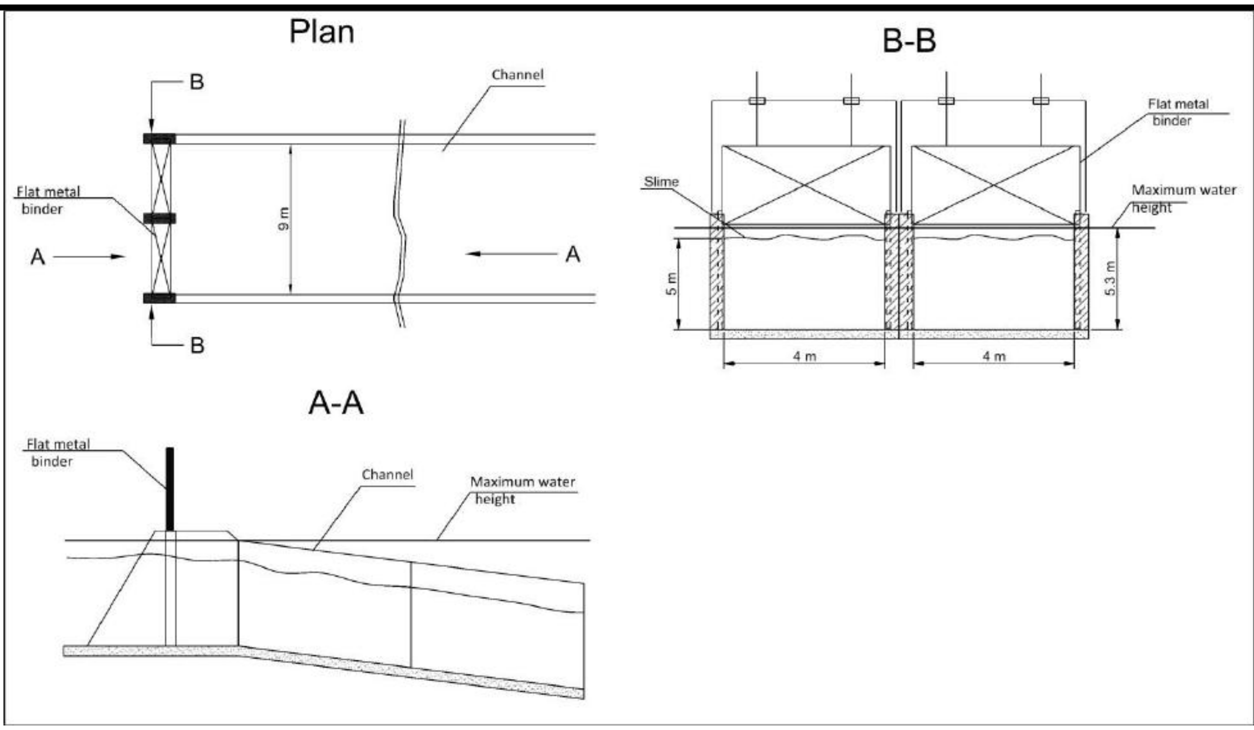

Fig.7: The layout scheme of flat metal binders on the channels located in the water intake reservoir.

The proposed washing installationto wash the silted slimesintensively and with minimum use of the water in the water intake reservoir to discharge into the lower canal pound should be designed depending on the height of the dam, the distance of the sediment particles and the thickness of the precipitatedslime layer. The sediments in the upper canal pound of the dam can be washed several times a year considering hydrological regime of the river in case of need.The washing should be conducted using the spring and autumn floods.

The value of turbidity to be arising during the washing in the wash canals was calculated by the formula proposed by B.K.Shkundini for the washing of thesettling.[8]

$$\rho_{tr} = g\frac{(\vartheta_{\text{пр}} - 0{,}35)^3}{h_{\text{пр}}^2}$$

ρ_{tr}-slime transportation capacity of the flow, kg/m^3;

$\upsilon_{\text{пр}}$-washing speed, m/sec;

$h_{\text{пр}}$-the height of the water in the chamber during the washing, m;

The hydraulic parameters of the washing channels are calculated according to the maximum turbidity to be arising during washing. Based on The above-mentioned expression the value of the turbidity to be arising as a result of washing the channels with the rectangular cut of width from the bottom 7 m, 9 m and 11 m in width, from the bottom was calculated and the results are shown in (*Figure 8).*

As it is seen from the calculations, the turbidity caused by washing in all the channels increased to a certain amount of water flow and then started to decline. The maximum density of the turbidity is 139.04 kg/m^3 for the channel with 7.0 m width at the bottom, and the water flow rate is 26.96 m^3/m^3. When the width is 9 m the maximum turbidity is 155.83 kg/m^3, water flow rate is 51.58 m^3/m^3 and in case of the 11 m, the maximal turbidity amount is 169.33 kg/m^3 with 64.67 m^3/sec water flow rate. However, because of the lack of water flows in the examined river, it is not possible to wash a number of slimes in the indicated amount.

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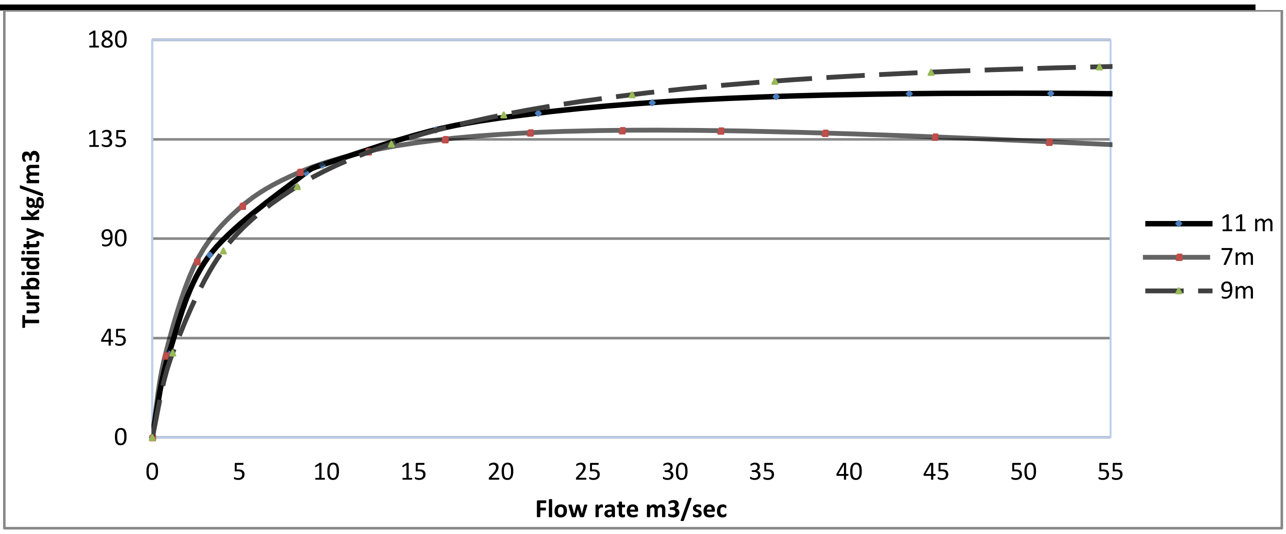

Fig.8: The change in the turbidity depending on the water flow during the washing in the channels with the bottom width of 7 m, 9 m,and 11 m.

The maximum turbidity during the wash period For Girdimanchay is possible within the water flows in the period of the floods. Since the average monthly water flow in the exuberant period of Girdimanchay is between 8-11 m^3/sec, the maximum turbidity that can occur during the wash can be adjusted to this range. As seen from Figure 8, the flow of the channelwith 7 m width at the bottom is 8.48 m^3/sec with the turbidity of 120.13 kg/m^3. In case the bottom width of the channel is 9 mwith the flow of 8.62 m^3/sec the turbidity is 120 kg/second the bottom width of the channel is 11 m with the flow of 8.32 m^3/sec the turbidity is 113,62 kg/m^3. As can be seen from the above-mentioned water flow, slime discharge ability of the channel with the 11 m bottom width is less than other channels, and turbidity in the channels with a width of 7 m and 9 m is very close to each other. However, if the channel with the 7 m bottom width is accepted, the number of channels to be installed in the riverbed will be relatively high and this can not be considered economically viable. For this purpose, a channel with a bottom width of 9 m was considered as the most viable channel during washing.

Table 4 presents the estimated amount of water required for washing the slimes in the water intake reservoirs with channels with a bottom width of 9m in the exuberant months and results.

Hydraulic calculations 10, 11, 12 shows that April water exuberant of the spring is more useful to wash the total volume of the silted slimes in the 1st, 2nd, 3rd, 4th months and autumn exuberant is more effective to wash the total volume of the silted slimes in the 7th, 8th and 9th months. In May, calculations on the volume of silted slime volume were carried out for the same month. In the 6th month, where the turbidity is the highest, it is planned to discharge the flow of water from the river without storing into the lower canal pound. Thus, it will have a positive impact on the flora and fauna as well as hydrogeological conditions of the river.

According to the calculations, the amount of water used to wash 262338 m^3 total slime volume in the 6th month is 7.34 million cubic meters and the monthly flow of the river is 6.35 million cubic meters per year. As you can see, the amount of water used for washing is relatively high from the monthly flow of the river and this can not be considered effective. Taking this into account, the precipitation of the slimes in the 6th month in the water intake reservoir was not considered appropriate.

As can be seen in Table 2, the time spent for the year is 30 days, and the amount of water required for the 6th month is 24,06 million m^3.

The number of wash channels has been adjusted to the width of the riverbed. The average width of the valley where the water intake reservoir located is about 90 m. As the bottom width of washing channels are about 9 m, 10 washing channels will be installed in the riverbed.

Table.4: Washing flow of sediments in water intake reservoir (with channel)

Indicators	Months											
	10	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Water flow, m^3/sec	5,12	2,08	2,27	2,02	2,38	3,19	8,12	4,53	2,45	10,1	3,26	11,4	
Slimevolume to be washed, (m^3/sec)	50749	63780	1880	958	2586	25407	237502	294534	262338	46420	55092	89899	
							382862	294534				485945	
Turbidity in the river during the cleaning, (ρ_0 kg/m^3)	7,6	19,7	0,52	0,3	0,76	5,3	28,7	47,7	70,2	4,95	11,3	9,47	
Washing capacity of the channel, ($\rho_1$kg/m^3)							120	120				120	
The amount of silt washed,(m^3/san)							0,463	0,205				0,788	
The time spent for washing, (day)							5,9	16,6				7,14	30
Water used for washing, (mln.m^3)							4,16	6,52	6,35			7,03	24,06

The height of the wash channels has been adjusted to the size of the silted slimes. As the slime cleaning in the water intake reservoir is carried out in accordance with the flow regime of the river,the thickness of the silted slime here is determined in accordance with the silted amounts. According to the calculations, the volume of the first wash cycle is 382862 m^3, the second cycle of washingis 29,4534 m^3 and the volume of the third wash cycle is 191411 m^3. However, as the volume of silted slimes during the wash month is included, the thickness of the slime layer could not be determined according to this amount. The thickness of the slime layer was determined according to the maximum silted slime volume at the time of the wash cycle.

As can be seen, the amount of the silted sediments till the time of the first wash cycle, i.e. in the 1st, 2nd, 3rd, 10th, 11th and 12th months is 14,3360 m^3. The removal of thesilted sediments during the second wash period, i.e. during the 5th month is possible anytime, that is, it is not correct to determine the height of the washing channels corresponding to the thickness of the siltedsediment. The amount of the precipitated slime during the 7th and 8th months, that is, until the beginning of the third washing is 101512 m^3. The height of the sidewall of the channel is equal to the thickness of the silted slime layer formed during the first wash cycle. Thus the amount of the silted sediments in the first wash cycle is more than other cycles.

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The volume of silted slimesin 10th, 11th, 12th, 1st, 2nd, and 3rd monthsduring the first wash cycle in the water intake reservoir is given in Table 5.

As can be seen in Table 3, the maximum displacement volume at distances during the first wash period occurred at the distance from the entrance of the water reservoir at a distance of 150 to 220 meters, i.e. at a height of 70 meters. The volume of precipitated slimes in this part is 3,1181 m^3. Considering that the width of the riverbed is 90 m, the thickness of the slime layer to be formed here will be approximately 31181/70/90 = 4.95 m. According to the calculations, the maximum turbidity in the wash water happens in the 0.35 m depth of the flow. According to the above-mentioned, the height of the channel will be 4.95 + 0.35 = 5.3 m.

Table.5: The amount of precipitated slimebased on the distances during the first wash cycle

Distance, m	**The amount of precipitated slime on months (m^3)**						**Total Volume of silted slimes, m^3**	**Thickness of precipitated slime layer,m**
	January	**February**	**March**	**October**	**November**	**December**		
50	82	223	1757	2580	6118	168	10928	2,43
100	147	401	3294	5074	10756	300	19971	4,44
150	155	420	3636	5951	10958	312	21431	4,76
220	215	580	5496	10058	14410	423	**31181**	**4.95**
290	154	415	4347	9001	9790	297	24004	3,81
360	101	270	3136	7388	6030	190	17115	2,72
430	63	169	2186	5878	3574	117	11988	1,90
500	41	108	1556	4819	2144	73	8740	1,39

As can be seen in Table 3, the maximum displacement volume at distances during the first wash period occurred at the distance from the entrance of the water reservoir at a distance of 150 to 220 meters, i.e. at a height of 70 meters. The volume of precipitated slimes in this part is 3,1181 m^3. Considering that the width of the riverbed is 90 m, the thickness of the slime layer to be formed here will be approximately 31181/70/90 = 4.95 m. According to the calculations, the maximum turbidity in the wash water happens in the 0.35 m depth of the flow. According to the above-mentioned, the height of the channel will be 4.95 + 0.35 = 5.3 m.

Main characteristics of the water reservoir outside riverbed designed on the right bank of Girdimanchay:

The anticipated out-of-the-riverbed water reservoir is being built between 620 and 680 m on the right bank of Girdimanchay. According to the calculations, the useful volume of the reservoir is 43,312 million cubic meters. Part of the small slime particles that do not silt in the water reservoir will lay in the floodwater reservoir, which will increase the full volume of thewater reservoir. At the altitudes of 620 m and 680 m level of the water reservoir valley area of the valley, mirrors vary from 61498 m^2 to 2390000 m^2, and the water volume limited to those heights reaches 53.837 m^3. Thus, the height of the dam will be 60 m. in the in case of the construction of a water reservoir.

Technical indicators of the water reservoir constructed on Girdimanchay by traditional method and water intake reservoir and reservoir constructed outside of the riverbed proposed by the new method are given in Table 6.

If we compare current market prices, the construction cost of new installations will be 1,199 billion AZN or 85% lower than the conventional method of construction of the dam with a height of 140 m. Taking into account operational costs and the arising technical risks it is not recommended to build high-altitude dams in the riverbed of mountain rivers with high turbidity.

It is expedient to use the newly developed methodology for efficient use of water resources of such rivers. It should be noted that the water reservoirs constructed directly in the river valleys have a serious ecological impact on the environment. The river's hydrological regime that formed over the years is damaged, and this causes the collapse of the fauna-flora of the river valley. The trees and bushes in the river valley are destroyed by

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thirst, the hydrogeological conditions of the river valley are damaged, and the level of underground waters is reduced. As a rule, the ecological flows from the dams built on the river are not allowed, for example Sirab, Arpachay, Aghstafachay, Khanbulanchay, Ayrichay, Akhincachay and other water reservoirs built in the territory of the Republic.

Table.6: Technical indications of water reservoirs

Name of Reservoir	Location level, m	The height of the dam, m	Full volume of water reservoir mln.m^3	Effective volume of water reservoir mln.m^3	The value of water reservoir, mln.doll
Girdimanchay(in riverbed)	830-970	140	124,673	49,443	295.0
Girdimanchay (outside of riverbed)	620-680	60	53,312	43.310	67.5
Water Intake Reservoir (in the riverbed)	830-845	15	1,085	1,085	3.5

In the proposed new method the flow of the river is discharged fully into the river during the wash of the silted slimes in the water intake reservoir. This will allow to partially protect the ecological system surrounding riverbed in the downstream of the river and maintain hydrogeological conditions under the water.

V. FINDINGS

1. The article examines the methods of the effective use of water resources of mountain rivers with high turbidity. For this purpose, the Girdiman River, which is located in the territory of the Republic of Azerbaijan, has been selected as a sample and a comparative analysis of the technical and economic parameters of the construction of reservoirs by the traditional and the proposed new method was carried out by conducting hydrological reports.
2. The reports revealed that the dead pool of the water reservoir built on Girdimanchay by traditional method is 75 million cubic meters, and the total volume is 124,673 million cubic meters. The height of the dam of the water reservoir will be 140 m. The construction of the dam in the area being observed with frequent large-scale floods and high seismicity is dangerous in terms of exploitation.
3. In the proposed new method, it is proposed to silt Girdimanchay's bringing flows directly on the river bed and to build a water intake water reservoir outside of the riverbed to collect partially limpid water. In the water intake reservoir, where the height of the dam is 10 m, 15 m, 20 m, the volume of precipitated slimes and the amount of water required for the washing of the slimes in this volume was calculated and compared. 15 m height of the dam of water intake reservoir was accepted economically viable.
4. The design of the new washing installation has been developed with the aim of discharge of silted sediments in the water intake reservoir to the lower canal pound with the use of less water. The method of sedimentation dynamics of the slimes in the water intake-water reservoir and the report method of hydraulic wash mode has been developed.
5. It is recommended to construct a water reservoir for collecting partially limpid water in the river bed and the hydro-technical parameters of this reservoir (useful volume - 43,312 million m^3, theheight of the dam 60 m)were calculated.
6. According to the calculations, the value(with current market prices) of the water reservoir constructed on Girdimanchay is 295.0 million dollars, and the construction cost of the proposed hydro-technical facility is 71.0 million dollars. As we can see, the value of the huge water reservoir built on Girdimanchay is much higher than the value of the hydro-technicalfacility complex created by the proposed new method.

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