Conference Paper

Assessment and Calculation of Groundwater Reserves for Drinking Water Supply in Mountainous Areas of the Chechen Republic

Sh Sh Zaurbekov[1,2], L I Ozdoyeva[2], A A Shaipov[2], V A Gridin[3,4], R Z Dzharnagaliyev[2], A M Movlayeva[2], I V Sarkisyan[2], and Z I Gadayeva[2]

[1]Department of Geology, Complex Research Institute named after Kh.I. Ibragimov, Russian Academy of Sciences, Grozny, Russia
[2]Oil and Gas Institute, Grozny State Oil Technical University named after acad. M.D. Millionshchikov, Grozny, Russia
[3]Oil and Gas Institute, North Caucasus Federal University Oil and Gas Institute, Grozny, Russia
[4]Grozny State Oil Technical University named after acad. M.D. Millionshchikov, Grozny, Russia

Corresponding Author:
Sh Sh Zaurbekov
sher_57@mail.ru

Received: 25 October 2019
Accepted: 15 November 2019
Published: 25 November 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the AgroSMART 2019 Conference Committee.

Abstract

This article is devoted to the urgent problem of drinking water supply in the mountainous regions of the Chechen Republic. The results of the assessment and calculation of groundwater reserves are presented. The article gives a brief assessment of the hydrogeological conditions of the study area, especially the complex of alluvial lower-upper Pleistocene sediments of the overdeepened river valleys, represented by boulder-pebble and boulder-rubbly formations with sand and sand-loamy aggregates. For inventory assessment and choice of a methodology of the reserves calculation in the Research Methods section, the hydrogeological conditions for the formation of groundwater are schematized in all the four study areas (Khimoyskiy, Shatoyskiy, Itum-Kalinskiy, Vedenskiy). On the basis of experimental field hydrogeological works, the calculation hydrogeological parameters necessary for the calculation of the groundwater reserves are determined (the main hydrogeological parameters on the estimated areas are given in the article, in the table 1). In the Methods section, the detailed justification of the scheme of placement of project wells is given (further the wells are supposed to be used as a water intake). For all the four areas -- Khimoyskiy, Shatoyskiy, Itum-Kalinskiy and Vedenskiy the ``strip aquifer'' scheme is adopted as the calculation, limited by two parallel impermeable contours (the slopes of river valleys are composed of impermeable water-resistant bedrocks). In the Results section, all schemes, formulas and brief characteristics of each investigated area (the acreage, the necessary water demand, the type of project water intake) are given. For each area, an security assessment of the calculated reserves is given, which is confirmed by the balance method (all the calculations are given in the article). In conclusion of the article in table 03 the data on the reserves of fresh groundwater based on the results of prospecting-evaluation works of 01.06.2015 are given.

Keywords: groundwater areas, water intakes, groundwater reserves, river valleys of mountain rivers, hydrodynamic method of the reserves assessment, reserves supply.

1. Introduction

The problem of providing high-quality water to more than 65-thousand people living in the Khimoyskiy, Shatoyskiy, Itum-Kalinskiy and Vedenskiy regions of the mountain part of the Chechen Republic becomes more acute every year.

Historically, the water supply of mountainous areas was based on the use of the water springs and partly the rivers. The use of surface water for drinking purposes, which is polluted everywhere by sewage and other domestic and industrial wastewater, is now almost impossible.

Today, the deficit of drinking water for mountainous areas is more than 30 000 m^3/day. Payment of the existing deficit is possible by finding the sources of groundwater supply, as they have a number of undeniable environmental and economic advantages over the surface waters.

Currently, population growth has led to the enlargement of the residential areas, that is why the organization of centralized water supply is necessary.

An assessment of the groundwater resources for domestic and drinking use in the study areas has not previously been made, with the exception of the Itum-Kale area: there in 2012--2013 CJSC ``GIDEK'' searched and assessed the groundwater resources in the area of the projected water intake situated near a river channel for the needs of the Year-Round Ski Resort Veduchi object. The results of these works the Khacharoyakhksky deposit of fresh groundwater was explored and confined to the alluvial sediments of the valley of the Khacharoyakhk river, which belong to the upper uaqternary and modern divisions of the quaternary system.

With the help of the Federal State Budgetary Educational Institution of Higher Education, *Grozny State Oil Technical University* named after *acad. M.D. Millionshchikov*, in accordance with the agreement concluded with the Subsurface Management Department of the Chechen Republic, the search and evaluation works on drinking groundwater in the mountainous part of the Chechen Republic were carried out (Khimoyskiy, Shatoyskiy, Itum-Kalinskiy and Vedenskiy) [7].

Prospecting works, in the process of which a complex of hydrogeological, geophysical, laboratory, experimental filtration works were carried out, as well as regime observations of surface and underground waters were carried out. These works made it possible to identify the underground waters of alluvial sediments of the overdeepened valleys as the most promising ones.

In the process of prospecting and evaluation works the factors that determine the regularities of the reserves formation of drinking water were studied. The areas, promising for localization of the deposits (areas) for water supply of the region centers and nearby residential areas of the Vedenskiy (Vedeno), Sharoyskiy (Khimoy), Shatoyskiy (Shatoi) and Itum-Kalinskiy (Itum-Kale) areas, located in mountainous and high-mountainous parts of the Republic, and experiencing an acute shortage in drinking water were identified.

These works will sufficiently solve the issue of providing the population with water in the region centers that are the least provided with quality drinking water in the bad-studied mountainous part of the Republic, and to improve the sanitary and hygienic living conditions [7].

Stationary observations of the groundwater regime and experimental filtration work performed in all the four areas (Itum-Kale, Khimoy, Shatoi and Vedeno) allowed giving a preliminary assessment of the hydrogeological parameters of the alluvial upper-, medium-quaternary aquifer (specific flow rates, filtration coefficients, etc.) and to determine a possible performance of the water wells, to assess the quality of the groundwater alluvial aquifer.

According to the results of the specialized hydrogeological studies for ensuring the economic and drinking water supply of the Itum-Kale, Shatoi, Khimoy and Vedeno population, the areas that meet the requirements and opportunities for assessing the reserves of near-river aquifers in the overdeepened parts of the river valleys were identified.

The calculated value of the groundwater reserves in the estimated areas corresponds to the technical specifications and conditions of the license. Performed geological exploration works will solve the problem of drinking water supply in the Itum-Kale, Khimoy, Vedeno and Shatoi villages of the Itum-Kalinskiy, Sharoyskiy, Shatoyskiy and Vedenskiy mountainous areas of the Republic.

2. Research Problem

This article is devoted to the issue of searching for the sources of drinking water supply in the mountainous regions of the Chechen Republic. The article consistently explains the stages of solving this issue: the choice of research areas, based on the analysis of the performed works; the production of exploration; assessment and calculation of fresh groundwater reserves on the basis of experimental data on the hydrogeological parameters.

3. Research Questions

The study of the geological and hydrogeological mountain areas of the Chechen Republic (in the areas of the Itum-Kale, Khimoy, Vedeno and Shatoi villages) for selecting the sources of drinking water supply of the villages. The whole complex of geological and hydrogeological works performed in the study areas is described. The methods and techniques for assessment and calculation of fresh groundwater reserves for drinking water supply are selected and substantiated.

4. Objectives of the Study

On the basis of the specialized hydrogeological studies of the study areas, the objective of the study is to identify the promising aquifers suitable for drinking water supply, to assess the water reserves, to calculate them and to give recommendations for construction of the water intakes with a guarantee of 25 years. Each of the objectives is justified in this article in detail.

5. Research Methods

The hydrogeological conditions of formation of the reserves in the river valleys were schematized for substantiating the method of calculation of the reserves in the estimated areas of groundwater.

The estimated areas of groundwater by the typification of Borevsky B.V. and Yazvin L.S. belong to the subtype 1-B, that is, to the deposits in the river valleys of the mountain rivers [1--3].

The groundwater at all the areas of bowels are confined to the alluvial lower-upper Pleistocene sediments of the overdeepened river valleys, represented by boulder-pebble and boulder-rubbly formations with sand and sand-loamy aggregates in the area of high mountains and gravel-pebble sediments with sandy and sandy-clay aggregates in the area of foothills. The alluvial sediments are underlain by lower middle Jurassic (Itum-Kalinskiy area), upper Cretaceous (Khimoyskiy and Shatoyskiy areas) and Neogene (Vedenskiy area) sediments, which are represented by dark gray to black argillites, sandstones and limestones. They also make up the framing of the valleys outside the alluvium distribution zone.

According to drilling and geophysical studies, the power of water-bearing sediments varies from 10 to 50 m.

The groundwater flow of alluvial sediments is directed along the river valleys and is formed mainly due to the close hydraulic connection with surface waters. The aquifer is free-flow. The depth of the underground water mirror on the area during the low streamflow periods is from 0.83 m above the Earth's surface (VMS (Vibration and Monitoring System) 2, the Shatoi area) to 1.8--8.6 m below, in flood periods it almost reaches the level of the Earth's surface, thus, the maximum amplitude of the annual fluctuations of the level reaches 8--10 m. The stream slope corresponds to the slopes of the relief of the valley bottom, and, on average, is 0,012--0,036 m/m in the work areas. The width of the valley above and below the areas of the projected water intakes is 100--150 m. The selected areas are to extend the valley from the 460 m (the Khimoy area) to 600 m (the Shatoyskiy area), the length of it is 1.8--2.9 km [9].

The hydrogeological parameters necessary for the calculation of groundwater reserves are distributed for each area. The distribution of the calculated hydrogeological parameters was carried out based on the results of a complex of geological exploration works in the estimated areas, considering the works previously performed in the adjacent territories and in the areas of Mountain Dagestan [7--8]. The data obtained are presented in tables 1, 2.

The reserves were calculated for the necessary water demand of the Itum-Kale, Khimoy, Vedeno and Shatoi villages in the amount of 4.0 thousand m^3/day. The assessment of the groundwater reserves of the alluvial lower-upper Pleistocene aquifer in the overdeepened river valleys in the above-mentioned subsurface areas is carried out for the first time. The rivers and atmospheric condensation are the main sources of groundwater supply in all the four areas. The well operation mode is round-the-clock and continuous, the method of water extraction -- with the help of pumps, the water quality must meet the requirements of regulatory documents. (Sanitary Rules and Norms 2.1.4.1074--01.2001)

When choosing the location for the projected water intakes, the most favorable hydrogeological, ecological, sanitary, agrarian and other conditions were considered and studied in the process of searching and assessing the works. They allowed carrying out the water extraction continuously, during the design period (25 years), with an optimal (declared) capacity of the captive structures.

According to the complexity of the hydrogeological conditions, all areas are assigned to group 2, and the target aquifers are alluvial lower-upper Pleistocene sediments of the overdeepened valleys of the rivers Argun, Sharo-Argun, Khulkhulau.

For all the four areas -- Khimoyskiy, Shatoyskiy, Vvedenskiy and Itum-Kalinskiy -- the scheme "strip aquifer" is considered as a calculation model. It is bounded by two parallel

TABLE 1: Main Hydrogeological Parameters on the Evaluated Areas.

No.	№ VMS. Area	Static level Нст, m	Estimated Power of the Horizon m, m	Flow, l/s / m^3 day	Degradation of Level, S, m	specific capacity q, l/s/m	Radius of the Filter Working Part, r, m	Length of the Filter Working Part, l, m	Filter Setting Interval, m
1	1 Khimoyskiy	8.6	10	6.2 / 535.6	2.0	3.1	0.11	10	12.5--17.5 22--27
2	2 Shatoyskiy	+0.83	10	12.0 / 1036.8	2.03	5.9	0.11	10	11--21
3	4 Itum-Kalinskiy	1.8	9.5	16.0 / 1382.4	2.0	8.0	0.11	9.5	13.0--22.5

TABLE 2: Calculation of the Coefficients of Filtration (Water Transmissibility) According to the Experimental Unwatering from the Wells in the Estimated Areas.

No.	№ VMS. Area	Graphic Analytic Method, Temporary Tracking for Reducing and Recovering the Level, Ff, m/day		Calculated Value of Coefficients of Water Transmissibility and Filtration		Agreed Value of Ff for the Area, m/day
		Reducing	Recovering	Ff, m^2/day	Ff, m^2/day	
1	1 Khimoyskiy	21.6	21.1	310	32	21.1
2	2 Shatoyskiy	--	28.5	592.0	57.6	28.5
3	4 Itum-Kalinskiy	--	19.2	804.5	54.0	36.6

impermeable contours (slopes of river valleys are composed of impermeable bedrock -- argillites, clays, etc.), the consumption of them is zero (Q = 0). It is also known that the replenishment of the reserves occurs only during floods.

6. Findings

The calculation of the reserves is carried out by the hydrodynamic method according to the formula, which allows determining the decrease of the water level in the well during the low streamflow period, when the water intake will work on the drawdown of liquidity and the interception of a natural flow. For the mountain rivers of Chechnya, the low streamflow period lasts from December to February -- 3 months -- 90 days. [5]

Project water intakes should provide the necessary water demand for he residential areas, while the calculated decrease of the water level in wells should not exceed S (additory) -- 0.5--0.7 N.

The calculated decrease of the water level in wells, which are in the form of a longitudinal row in a narrow valley, is calculated by the following formula [1]:

$$S = H - \sqrt{H^2 - \frac{Q}{\pi K}(\ell n \frac{RK}{r_0} + \frac{2at}{R^2 K} - \frac{3}{4})}, \quad (1)$$

where H is the effective capacity of the aquifer, m

Q -- well flow rate, m3/day;

K -- filtration coefficient, m/day;

R0 -- radius of the capitalized well, m;

a -- the level of conductivity, m^2/day;

t -- duration of the low streamflow period, day.

This formula is derived on the assumption that each well will operate in a closed block. In other words, it is agreed that each well triggers natural reserves in the area bounded by lines passing through the middle of the distances between the wells and the impenetrable sides of the valley. In this calculation, the values of decreases for all blocks, except the Central one, are slightly overestimated.

The block area is reduced to an equal-sized circle, the radius of which is determined by the formula:

$$RK = \sqrt{\frac{\lambda \cdot L}{\pi}}, \quad (2)$$

where Rc is the radius of the block, m;

λ -- distance between the wells, m;

L -- width of the valley, m.

The calculation of the groundwater reserves is given below for each site separately.

6.1. The Khimoyskiy area of underground water

The area is located on the stretch of the mountain valley of the river Sharo-Argun, the average width of which is 460 m. The boundaries of the area are determined by the places of narrowing of the river valley. The western and eastern borders are on the border of the valley of the river Dzhurmut, composed of alluvial sediments and the primary Jurassic sediments.

The total size of the Khimoyskiy area is 2.8 km · 0.46 km = 1,29 km^2.

The projected water intake should provide the necessary water demand for the Khimoy village equal to 1100m^3/day, while the estimated decrease of the water level in the wells should not exceed S (additory) -- 0.5--0.7 N.

The type of the projected water intake is a linear longitudinal row of 3 wells (Fig. 1), located at the bottom of the valley, the length is 1600m with a distance of 800m between the wells.

The accepted flow rate of the water intake well will be: 1000 m^3/day:3 = 333,3 m^3/day.

The possibility of obtaining the projected flow rate is proved by the experimental works during the search and evaluation works.

In fact, the resulting production rate for VMS.1 is 535 m^3/day or 6.2 l/s.

Calculated Parameters:

- Ff -- 21.1 m/day (accepted according to the recovery schedule, table 2);
- H -- Effective Power -- 10.0 m;
- a -- 9,0·103 m^2/day;
- t -- 90 days (low streamflow period);
- r_0 -- 0,199;
- Q -- 333.3 m^3/day;
- λ -- 800 m;
- L -- 460 m
- S (additory) -- 0,7 N -- 7,0 m.

$$S = 10,0 - \sqrt{10,0^2 - \frac{333,3}{3,14 \cdot 21,1} \cdot (\ell n \frac{342}{0,199} + \frac{2 \cdot 9,0 \cdot 10^3 \cdot 90}{342^2} - \frac{3}{4}} = 4,3 \text{ m},$$

Which is less than S (additory) -- 7.0 m.

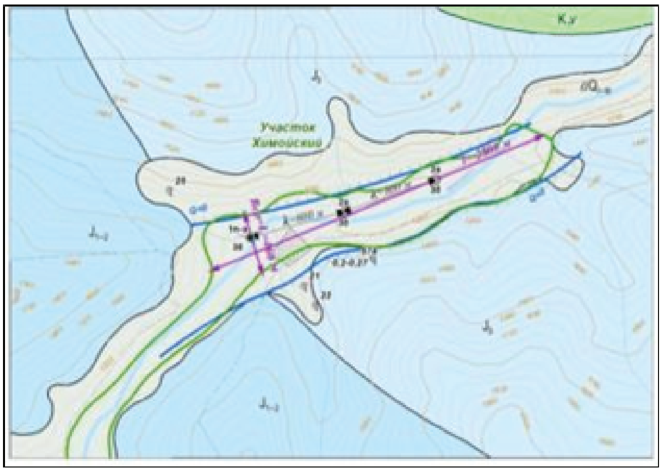

Figure 1: Scheme of the Reserves Calculation of the Khimoyskiy area.

It follows from the above stated calculation that with the row 1600 m long and with productivity of 333,3 m^3/day of the exploitation wells, the average distance between the wells is 800 m, the water intake capacity will be 1000 m^3/day and the reserves will be provided.

6.2. The Shatoyskiy area of underground water

The area is an extended section of the bottom of the mountain valley of the Argun river, the average width of which is 600 m. The boundaries of the area are determined by the places of narrowing of the Argun river valley. The western and eastern borders are on the border of the valley of the Dzhurmut river, composed of alluvial sediments and the underlying Cretaceous and Paleogene sediments.

The total siye of the Shatoyskiy area is 2.4 km · 0.6 km = 1,44 km^2.

The project water intake should provide the necessary water demand of the Shatoy village equal to 1000 m^3/day, while the estimated decrease of the water level in the wells should not exceed S (additory) -- 0.5--0.7 N.

The type of the projected water intake is a linear longitudinal row that is 1000 m long, consists of 3 wells (Fig. 2), located at a distance of 500 m from each other.

The accepted flow rate of the water intake well will be 333.3 m^3/day. The possibility of obtaining the projected flow rate is proved by the experimental works during the search and evaluation works.

In fact, the resulting production rate for VMS.2 is 1036 $м^3$/day or 12.0 l/s with lowering of 2.03 m.

Calculated Parameters:

- Ff -- 28.5 m/day (accepted according to the recovery schedule, table 2);
- H -- Effective Power -- 10.0 m;
- a -- $9{,}0 \cdot 10^3$ m^2/day;
- t -- 90 days (low streamflow period);
- r0 -- 0,199;
- Q -- 333.3 m^3/day;
- λ -- 500 m;
- L -- 600 m;
- S (additory) -- 0,7 N -- 7,0 m.

L = 2375--500 = 1875 м (the building area is excluded from the total length of the study area).

$$RK = \sqrt{\frac{500 \cdot 600}{3.14}} = 309 \text{ m}$$

$$S = 10,0 - \sqrt{10,0^2 - \frac{333,3}{3,14 \cdot 28,5} \cdot (\ell n \frac{309}{0,199} + \frac{2 \cdot 9,0 \cdot 10^3 \cdot 90}{309^2} - \frac{3}{4}} = 4,8 \text{ m}$$

which is less than S (additory) -- 7.0 m.

It follows from the above stated calculation that with the row 1000 m long and with the productivity of 333,3 m^3/day of the exploitation wells, the average distance between the wells is 500 m, the water intake capacity will be 1000 m^3/day and the reserves will be provided.

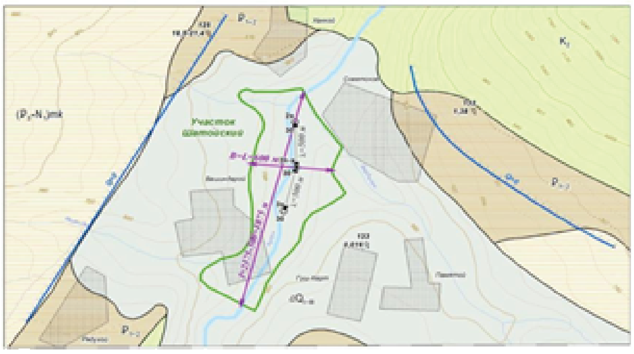

Figure 2: Scheme of the Reserves Calculation of the Shatoyskiy Area.

6.3. The Itum-Kalinskiy area of groundwater

The area is a narrow (up to 650 m) mountain river valley, the average width of which is 530 m. The boundaries of the area are defined by the places of narrowing of the Argun river valley. The western and wastern borders run along the border of the valley, composed of alluvial sediments and primary Cretaceous and Paleogene sediments.

The total size of the Itum-Kalinskiy area is 4.2 km·0.53 km = 2,2 km^2.

The projected water intake should provide the necessary water demand for the Itum-Kale village equal to 1000 m^3/day, while the estimated decrease of the water level in the wells should not exceed S (additory) -- 0.5--0.7 N.

The type of the projected water intake is a linear longitudinal row of 3 wells (Figure 3), located at the bottom of the valley that is 1000m long, with a distance of 500 m between the wells.

Figure 3: Scheme of the Reserves Calculation of the Itum-Kalinskiy Area.

The accepted flow rate of the water intake well will be 333.3 m^3/day. The possibility of obtaining the projected flow rate is proved by the experimental works during the search and evaluation works.

In fact, the resulting production rate for VMS.4 significantly exceeds the projected one, it is 1382,4 m^3/d or 16.0 l/s at a decrease of 2.0 m.

Calculated Parameters:

- Ff -- 36,6 m/day (the average value of the parameter calculated in different ways is accepted, table 2);
- H -- Effective Power -- 9.5 m;
- a -- $9{,}0{\cdot}10^3$ m^2/day;
- t -- 90 days (low streamflow period);
- r_0 -- 0,199;
- Q -- 333.3 m^3/day;
- λ -- 500 m;
- L -- 530 m;
- S (additory) -- 0,7 N -- 6,6 m.

L = 4250--1330 = 2920 m (the building area is excluded from the total length of the study area).

$$RK = \sqrt{\frac{500 \cdot 530}{3.14}} = 290,5 \text{ m}$$

$$S = 9,5 - \sqrt{9,5^2 - \frac{333,3}{3,14 \cdot 36,6} \cdot (\ell n\frac{290,5}{0,199} + \frac{2 \cdot 9,0 \cdot 10^3 \cdot 90}{290,5^2} - \frac{3}{4}} = 4,3 \text{ m},$$

which is less than S (additory) -- 6.6 m.

It follows from the above stated calculation that with the row 1000m long and with the productivity of 333,3 m^3/day of the exploitation wells, the average distance between the wells is 500 m, the water intake capacity will be 1000m^3/day and the reserves will be provided.

6.4. The Vedenskiy area of groundwater

Geomorphologically the area represents a broad (up to 650 m), confluent valley of the Khulkhulau and Akhkichu rivers, the average width of which is 2.25 km. In fact, it is an alluvial cone formed at the entrance of the mountain rivers to the foothill plain.

Powerful continental sediments of foothill inclined plains are natural collectors of huge reserves of the ground and artesian waters.

The reserves are formed by the absorption of the surface water streams, as well as the infiltration of atmospheric condensation. In the zone of free water exchange, waters usually have low mineralization.

The significant unit costs of natural flows and the presence of the areas of intensive discharge by spring flowing or evaporation determines the structure of the reserves formation due mainly to natural resources. The performance of the intake in general is quite high.

The boundaries of the Vedenskiy area in the south are determined by the places of narrowing of river valleys. The south-western and north-eastern borders run along the borders of the valleys that are formed by Paleogene and Neogene sediments. The north-western border is drawn conditionally. The total size of the Vedenskiy area, minus the building area, is 45.0 km^2.

Taking into account the absence of data for testing of water-containing alluvial sediments in the area, the assessment of the reserves was carried out by the method of hydrogeological analogies, which is used for assessing the reserves in low categories (C2). The neighboring areas with similar geological and hydrogeological conditions -- Shatoyskiy and Khimoyskiy are taken as the analogues. It is suggested that the estimated area with the same conditions will be approximately equal to the values of flow and level decreases.

The projected water intake should provide the necessary water demand for the Vedeno village equal to 1000 m^3/day, while the estimated decrease of the water level in the wells should not exceed S (additory) -- 0.5--0.7 N.

The type of the projected water intake is a linear longitudinal row that is 2000 m and consists of 3 wells, located within 1000 m from each other.

The accepted flow rate of the water intake well will be 333,3 m^3/day. The possibility of obtaining the projected flow rate is proved by the experimental works during the prospecting and evaluation works on areas- analogues, where the flow rates of 535-- 1000 m^3/day were obtained during the testing of the prospecting and evaluation wells.

Calculated Parameters:

- Ff -- 21,0 m/day (The parameter value on the basis of the Khimoyskiy area-analogue);
- H -- Effective Power -- 11.6 m (accepted according to the geophysical data);
- a -- 9,0·10^3 m^2/day;
- t -- 90 days (low streamflow period);
- r_0 -- 0,199;
- Q -- 333.3 m^3/day;
- λ -- 1000 m;
- L -- 550 m (the width of the Khulkhulau river valley with the exception of building areas is accepted);
- S (additory) -- 0,7 N -- 8,1 m.

L = 2700 -- 400 = 2300 meters (building areas are excluded from the total length of the study area).

$$RK = \sqrt{\frac{1000 \cdot 550}{3.14}} = 418,5 \text{ m}$$

$$S = 11,6 - \sqrt{11,6^2 - \frac{333,3}{3,14 \cdot 21,0} \cdot (\ell n \frac{418,5}{0,199} + \frac{2 \cdot 9,0 \cdot 10^3 \cdot 90}{418,5^2} - \frac{3}{4}} = 3,3 \text{ m},$$

which is less than S (additory) -- 8.1 m.

It follows from the above stated calculation that with the row 2000 m long, with the productivity of 333.3 m^3/day of the exploitation wells is and with the average distance of 500 m between the wells, the water intake capacity will be 1000 m^3/day and the reserves will be provided.

At this stage, considering the staging of the hydrogeological works and the accepted group 2 of complexity of the hydrogeological conditions of the area, the estimated reserves should be classified as C2.

6.5. Assessment of Security Calculated Reserves

The security of the calculated reserves at all areas is also confirmed by the balance method.

The reserves are assessed by the balance method on the basis of:

$$\Theta = \Theta_{\Sigma} + \frac{Ve}{t}, \quad (3)$$

where Qe is the natural resources, m^3/day are determined by the flow rate of groundwater in the range of the projected water intake;

Ve is the natural reserves that are characterized by the mass of the gravitational water in the reservoir.

$$Qe = KH \cdot B \cdot J, \quad (4)$$

where K is the filtration coefficient, m/day;

H -- Average Capacity of the Aquifer, m;

B -- Width of the Flow Front in the Alignment of the Projected Water Intake, m;

J -- Hydraulic Slope;

In the process of exploitation of the alluvial aquifer, a drawdown of the natural resources will take place (0.7 power of the reservoir).

$$Ve = \frac{B \cdot H \cdot \ell \cdot \mu}{9125} \quad (5)$$

where B -- the Width of the Groundwater Flow, m; -- the Length of the Groundwater Flow, m;

H -- the Average Power of the Aquifer, m (0.7 is accepted);

μ -- Water Yield Coefficient;

t -- the Time for Which the Operational Reserves are Calculated (25 years ≈ 9125 days)

It should be noted that the determination of natural reserves depends on the accuracy of the determination of the water yield. Yield determination of species is difficult. The value of the yield for all areas is accepted to be 0.2 at the stage of the search and evaluation works at the minimum experimental work and monitoring observations, and also without carrying out the laboratory research on determination of granulometric composition and yield.

The reserves of the areas calculated by the balance method will be:

The Khimoyskiy area

Qe = 21,1·10,0·0,023·460 = 2232 m^3/day;

= 198 m^3/day;

Qe = 2232 + 198 = 2430 m^3/day.

The Shatoyskiy area

Qe = 28,5·10,0·0,012·600 = 2052 m^3/day;

= 246 $м^3$/day;

Qe = 2052 + 246 = 2298 m^3/day.

The Itum-Kalinskiy area

Qe = 36,6·9,5·0,012·530 = 2211 m^3/day;

= 322 m^3/day;

Qe = 2211 + 322 = 2533 m^3/day.

The Vedenskiy area

Qe = 21,0·11,6·0,036·550 = 4823 m^3/day;

= 224,5 m^3/day;

Qe = 4823 + 224.5 = 5047 m^3/day.

Thus, according to the results of the calculations, the groundwater reserves of the Khimoyskiy, Shatoyskiy, Itum-Kalinskiy and Vedenskiy areas submitted for approval with the planned volume of production in the amount of 1000 m^3/day on each of them are fully provided with natural resources.

7. Conclusion

As a result of the search and evaluation works, the groundwater reserves in the amount of 4,0 m^3/day were identified and assessed. The availability of the estimated reserves in all areas is confirmed by the balance method calculations (natural resources of the subrustal flow and capacitive reserves of the alluvial aquifer) and are the estimated balance, calculated for 25-year of exploitation.

Considering the staging of the hydrogeological works and adopted group 2 of complexity of the hydrogeological conditions, the assessed reserves of the Khimoyskiy, Shatoyskiy and Itum-Kalinskiy areas should be attributed to C1 category, and the reserves of the Vedenskiy area are calculated by the method of the hydrogeological analogy and belong to class C2.

Table 03 shows the reserves of fresh groundwater presented for approval according to the results of the search and evaluation works for drinking groundwater for water supply of the Itum-Kale, Khimoy, Shatoy and Vedeno villages of 01.06.2015.

According to the degree of knowledge, the Khimoyskiy, Shatoyskiy and Itum-Kalinskiy areas should be allocated to the proved areas, and the Vedenskiy area -- to the estimated ones.

The increase of the reserves on the areas should be carried out in the future only according to the monitoring of the exploitation of the groundwater intakes, which should be organized in all operational areas.

Table 3: Reserves of Fresh Groundwater According to the Results of the Search and Evaluation Works of 01.06.2015.

№	Name of the Area	Water Demand, Thousand of m^3/day	Water Consumer	Aquifer	Groundwater Reserves by Categories, thousand of m^3/day	
					C_1	C_2
1	Khimoyskiy	1.0	Khimoy village	Neopleistocene Alluvial Aquifer	1.0	--
2	Shatoyskiy	1.0	Shatoy village		1.0	--
3	Itum-Kalinskiy	1.0	Itum-Kale village		1.0	--
4	Vedenskiy	1.0	Vedeno village		--	1.0
	Total:	*4.0*			*3.0*	*1.0*

References

[1] Bindeman, N.N., Yazvin, L.S. (2012). *Estimation of Operational Groundwater Reserves*. Moscow: Nedra.

[2] Borevskiy, B.V., Samsonov, B.G., Yazvin, L.S. (1979). *Methods for Determining Parameters of Aquifers Based on Pumping Data.* Moscow: Nedra.

[3] Borevskiy, B.V., Khachiyan, T.P., Yazvin, A.L. et al. (2012). *Map of the Resource Potential of Fresh Groundwater in Russia. Masshtab 1:5 000 000*. Moscow: ZAO ``GIDEK''.

[4] Gordeyeva, G.V. *Hydrogeological Additional Exploration of Areas of 1: 200000 Scale within the Chechen Republic of the K-38-III, IV, V, X, XI sheets (GGDP-200 -- Revision Assessment Work).* The report of FGUGP «Sevkavgeologiya» on the work carried out in 1999--2001.

[5] Zaytseva, N.G., Sinichkna, L.I. (2000). The Report on the Topic ``*Assessment of the Provision of the Population of the Chechen Republic with Groundwater Resources for Drinking Water Supply*'', Stage II.

[6] Lyapichev, V.V. (1990). *On the Regime and Balance of Groundwater CHIASSR* (Report no. 26737).

[7] Ozdoyeva, L.I. et al. *Report on the Results of Exploration and Assessment of Drinking Groundwater for Providing Water to the Regional centers of the Mountainous Part of the Chechen Republic (Itum-Kale, Khimoy, Shatoy and Vedeno)*. State contract number 1-GK 21.05.13. Upravleniyem po nedropol'zovaniyu po Chechenskoy Respublike. FGBOU GGNTU, 2015.

[8] Uspenskiy, Y.N., Chuksin, V.V., Kolesova, O.G., Soboleva, T.V. (2007). Report on the Results of the Project ``*Assessment of the Current State of Proven Groundwater Reserves for the Groznyy, Argun and Gudermes cities*''. Zheleznovodsk: OAO ``Kavkazgidrogeologiya''.

[9] *Sanitary Rules and Norms* 2.1.4.1074-01. (2001). Drinking Water. Hygienic Requirements for Water Quality of Centralized Drinking Water Supply Systems. Quality Control. Hygienic Requirements for Ensuring the Safety of Hot Water Systems.

[10] *Hydrogeology of the USSR*. Book 3. *Groundwater Resources for their Utilization*. (1977). Moskow: Nedra.