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Professional paper

HYDROGEOLOGICAL PARAMETERS OF THE EXPLOITATION WELLS EB-1 AND EB-2 IN THE CENTRAL CITY AREA OF THE MUNICIPALITY OF SVETI NIKOLE

Milica Nikolovska[1], Blagica Doneva[2], Orce Spasovski[2]
[1]Author/s address, (the address of more authors from different institutions to be noted with superscript)
[2] Faculty of natural and technical sciences, Goce Delcev University, Stip
**Corresponding author: orce.spasovski@ugd.edu.mk*

Abstract

The knowledge of all water resources, today, is a basic prerequisite for the existence and further development of society. Over 80% of the water supply to the population and industry in the Republic of Macedonia is provided through the capture of underground water. Since for regional water supply systems it is necessary to invest enormous funds, mainly for the construction of surface reservoirs, solving the problem of water supply at the sub-regional, municipal or local level practically gains greater importance, among other things, due to rational conditions of the construction and maintenance of the systems.

In that sense, the municipality of Sveti Nikole is an example of a very high-quality approach to research for the needs of finding local potential conditions for public centralized water supply in individual settlements or parts of municipal territories, and thus rational and thoughtful investments for the future. In this paper, the potential opportunities for capturing economically viable amounts of underground water in Neogene sediments are highlighted, based on the results of the hydrogeological research.

Based on the specified parameters, the environment is characterized by a filtration coefficient EB – 1 - K = 5.00×10^{-5} m/s, EB – 2 - K = 1.7×10^{-5} m/s, coefficient of water permeability EB – 1 - T = 2.22×10^{-4} m^2/s = 23 m^2/day. EB – 2 - T = 7.5×10^{-4} m^2/s = 24 m^2/day and yield Qexp for EB-1 - 1.47 l/s, Qexp for EB – 2 = 1.07 l/s.

Key words: *groundwater, aquifers, water supply, permeability coefficient, hydrogeological characteristics, boundary type of wells.*

INTRODUCTION

In the region of Ovce Pole, the needs for water have always been greater than the water capacities. Population growth, greater food production needs, global climate changes and longer dry periods contribute to making these needs more pronounced. The city of Sveti Nikole has been facing the problem of insufficient amounts of quality drinking water for a long time. In the last few years, the population of the city has been using drinking water from natural sources in the town and the immediate surroundings, which are of questionable quality. The hydrogeological resources, i.e. underground cold water for drinking in the locality Divjak, are undoubtedly present, which can be claimed based on the previous investigative works. However, since the results of the research so far are insufficient, i.e. they are not in a form that it is possible to approach the construction of a water-related object, therefore it is necessary to continue with the started hydrogeological research and determine the correct possibilities for discovering and proving the water resources. According to the location of the terrain, the morphology, the geological structure, the representation of the types of wells, also, from the observation of the results of the hydrogeological investigations carried out so far for this area, it can be said that it is promising for the construction of new water capture exploitation facilities.

The researched area has been very little studied from a hydrogeological point of view. Data on the hydrogeological characteristics of the wider environment of the specified area can be found in the works of Georgievski et al. [1-3]. The first more specific data on the geological structure of this area were presented during the preparation of the Basic Geological Map for the sheet Veles. Gjuzelkovski [4] and Karajovanović et al. [5, 6] in their works present certain hydrogeological data for the wider environment of the area in question.

In more detail, from a hydrogeological point of view, the immediate surroundings of this area have been studied by Spasovski et al. [9]. The latest data on the hydrogeological characteristics of the subject area can be found in the works of Nikolova et al. [7], Spasovski [8], Spasovski et al. [10, 11].

MATERIALS AND METHODS

In order to understand the conditions and possibilities for the exploitation of groundwater in the Neogene sediments in the central city area of the Sveti Nikole area, the investigative works include field investigation and examination works and cabinet works. The field investigation and examination works are carried out in the following order: detailed hydrogeological mapping of the field and complete construction of two research and exploitation wells at a depth of 50 m, with a diameter of Ø250 mm, monitoring of the material during their drilling, registration of underground phenomena water and measurement of groundwater levels, purification of exploratory wells, testing of exploratory wells.

The detailed hydrogeological mapping of the terrain was performed by following the contact zones between Neogene sediments and parent rocks and by registering all water phenomena and objects. The exploration - exploitation wells were performed within the Neogene sediments, which enabled the determination of the lithological composition and hydrogeological characteristics of the well profile, the position of the groundwater level, the definition and discovery of aquifers at a depth greater than 50 m'. During the research, two exploratory - exploitation wells up to a depth of 50 meters were drilled, within which several aquifers were determined. The results obtained from these wells give hope that the selected locality is promising in terms of finding the necessary quantities of quality drinking water.

The laboratory work included: preparation of granulometric analyses of the extracted material during drilling from aquifers, preparation of abbreviated and complete physical - chemical analysis of the groundwater samples taken from the aquifers.

Cabinet work consists of processing all collected data from field and laboratory tests and their interpretation.

RESULTS AND DISCUSSION

Geological structure

Based on the previously performed surveys (Basic geological map – OGK sheet Stip and Basic geological map – OGK sheet Veles (fig. 1) and current research and tests, generally, the geological structure of the wider vicinity and the location of the exploitation wells EB - 1 and EB - 2 are represented by flysch sediments ($^3E_3$), deluvial sediments (d) and alluvial sediments (al).

From a geological point of view, the terrain, as well as the wider region, is generally composed of the following lithological units:

Flysch ($^3E_3$) – This series occupies the largest area in the Paleogene basin, and has the greatest thickness, represented north and east of Sveti Nikole. The research area itself is located in these sediments at the border with the Quaternary sediments. The following lithological members participate in its composition: sandstones, conglomerates, slates, siltstones, marls and rare marl limestones. They are characterized by a gray to greenish color with sharp lower borders

Sandstones are gray in color, mostly plated to stratified in thick beds. They are fine-grained to coarse - grained with carbonate cement. They consist of quartz and mica, less of feldspar, quartzite and cherts. A rich fossil fauna can also be found in them

The clays are sandy and are most represented in the flysch series. They occur in the form of layers or banks between sandstones. They are gray to gray - green in color and composed of clay material of the illite type of clay, as well as quartz, feldspar, muscovite, garnet, tourmaline, etc.

Conglomerates occur in large layers or banks intercalated between other flysch sediments. They occurred as a result of a change in the depth of the basin and a greater inflow of coarse clastic material. Their composition includes limestones, sandstones, schists, less often marbles and quartzites, poorly to well processed, bound with sandy material.

Marls usually occur with calcarenites, siltstones and marly limestones. They usually occur in the upper parts of the series. They are gray in color and have a $CaCO_3$ content of about 35 %.

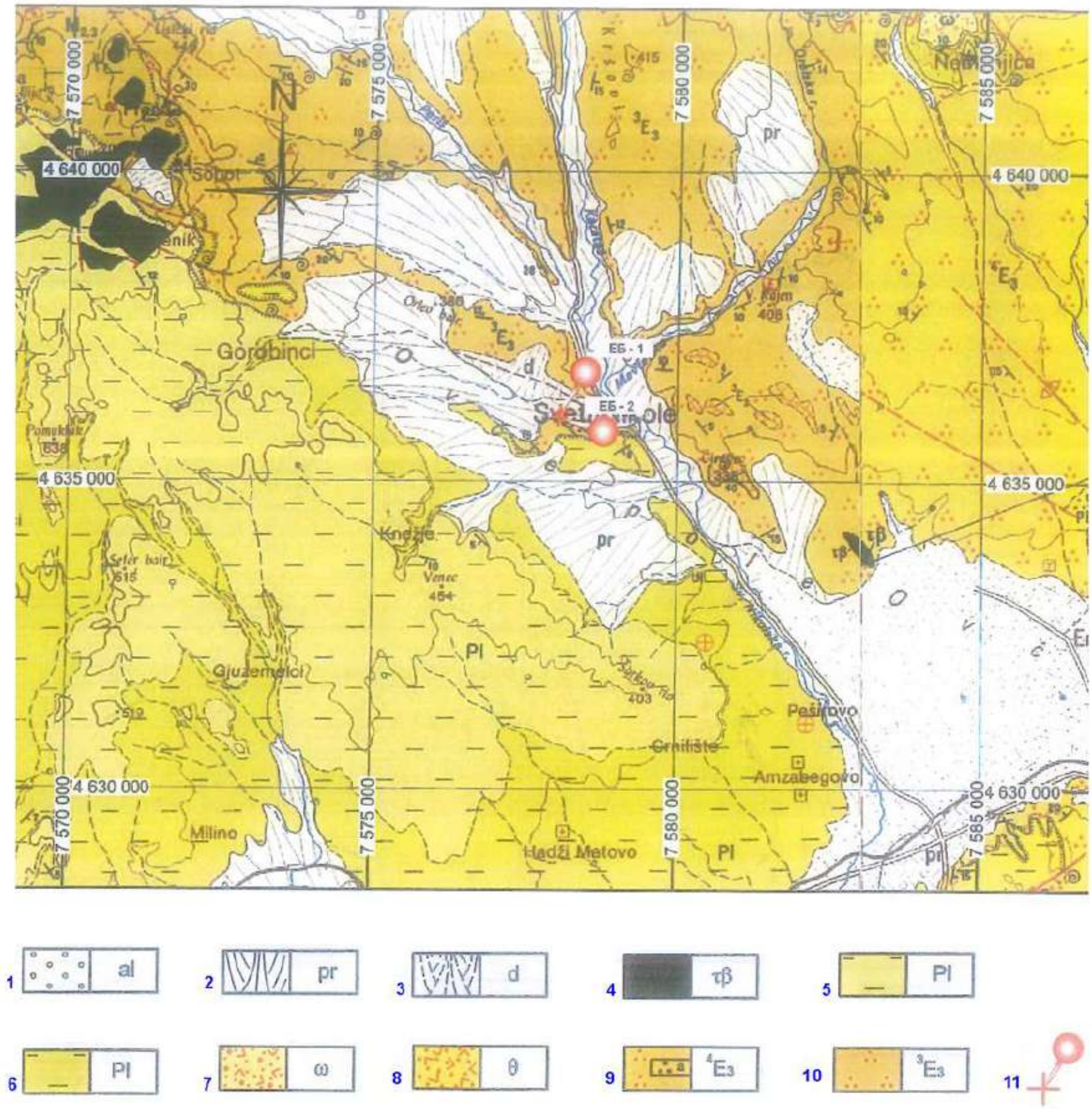

Figure 1. Geological map of the wider vicinity

1. alluvium, 2. proluvial material, 3. deluvial deposits, 4. young effusive rocks, 5. gravels and sands, 6. sands and clays, 7. andesitic breccias, 8. andesitic tuff, 9. upper flysch zone: clays and sandstones, marls, limestones and slates (a), 10. flysch: sandstones, slates and siltstones, 11. location of exploitation wells EB-1 and EB-2

Deluvial sediments (d) – Deluvial sediments are unevenly distributed on the terrain on the gentle slopes of some hills. They are represented by unprocessed pieces and larger blocks of soil with a sandy - clay mass between them.

Proluvial sediments (pr) – Proluvial sediments are widespread in the immediate vicinity of Sveti Nikole. The thickness of this material is variable, but on separate profiles it is up to over 30 meters. The composition of this material includes semi-processed pieces from the surrounding hills, mixed with sand and a very large percentage of clay substance. These sediments are significant for the micro location of the exploitation wells, which are at the border of proluvial sediments and flysch sediments. The water-bearing part of them is composed of proluvial sediments.

Hydrogeological characteristics

Based on the geological structure and the structural type of porosity within the represented rock masses, the following types of wells are distinguished:

- Compact type of wells with intergranular porosity (medium water permeability);
- Complex type of wells with intergranular porosity
- Compact type of wells with intergranular porosity (conditionally waterless parts of the terrain).

At the very location of the area in question, lithological formations with intergranular porosity are represented, in which a compact type of well has developed within the proluvial and deluvial sediments, which are mostly of medium permeability and water-bearing capacity.

Pliocene sediments also have a significant presence in the wider environment of the research area. These sediments, in places, are covered with Quaternary unbound proluvial materials (pr) and deluvial deposits (d).

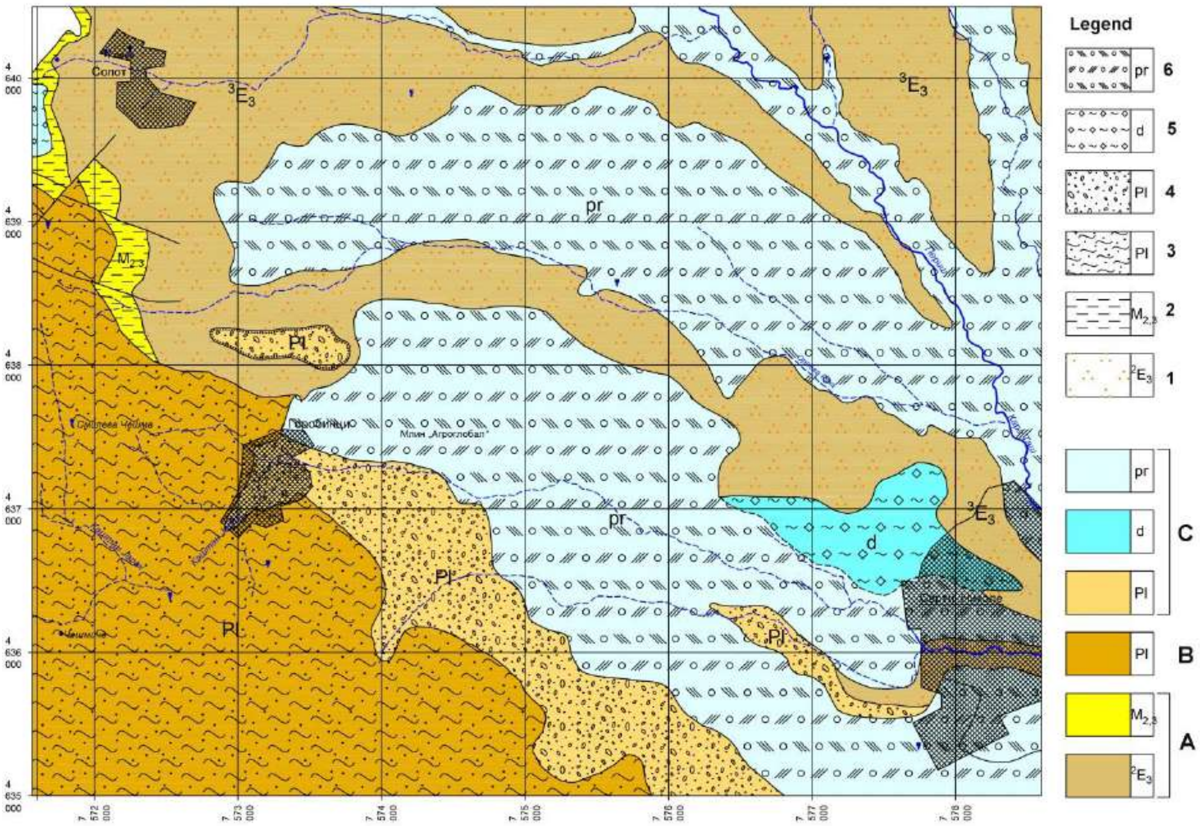

Figure 2. Hydrogeological map of the wider vicinity

1. flysch: sandstones, claystones and siltstones; 2. conglomerates, sands, clays and marls; 3. Sands and clays; 4. gravels and sands; 5. diluvium; 6. proluvium; A – conditionally waterless rocks (hydrogeological insulators); B – rocks with a complex type of wells (hydrogeological reservoirs); C – rocks with a compact type of wells with intergranular porosity (poorly to moderately permeable).

Wells with intergranular porosity - This type of well, within the wider vicinity of the investigation terrain, has a large spread in plan, but with a short spread in profile. It was developed within the Quaternary (alluvial, deluvial and proluvial) sediments, which were formed in the post-lake phase of sedimentation as a product of the exogenous factors. It is composed of medium grained to coarse grained sands and silty to clayey sands. The thickness of these sediments is quite variable, but it is not very big. The filtration properties of this type of wells are quite good and, according to them, it is a good water-bearing environment, but with a small thickness. The underground waters of this type of well are mainly of a free level and mostly follow the configuration of the terrain. The different levels of groundwater are the result of different locations and configuration of the terrain. The groundwater recharge of these wells is due to the inflow of groundwater from the edge of the field, i.e., from other environments that are at a hypsometrically higher level and from atmospheric precipitation. Drainage of underground water from this well is by means of dug and drilled wells and primitive boreholes. This type of well can be said to be a well-permeable collector with a small thickness and as such is not interesting from a hydrogeological point of view for water supply to larger consumers.

Complex type of wells – This type of well, within the investigation area and in general in the Ovce Pole valley, has a significant spread, especially from the aspect of water supply. It is developed within the middle and upper Pliocene sediments (sands and gravels) with significant thickness. The existence of this type of wells has been confirmed with the exploratory and exploitation drillings in the Divjak locality. Water - bearing collectors within the complex type of wells occur at several levels. What is characteristic for this type of well is expressed stratification, while water - bearing environments occur in the form of layers, dirt bands and lenses. The top and bottom of the aquifers of this type of wells are covered with Pliocene clays.

Groundwater in the complex type of wells is characterized by a phreatic or a free level. Groundwater recharge of this type of well is from the atmospheric precipitation that takes place in two ways, direct recharge along the open parts of the terrain, and recharge along the contact zones. Also, there is groundwater recharging through the inflow of groundwater from the fissure type of wells located at a hypsometrically higher level and inflows of groundwater from deeper aquifers. The drainage of underground water is through groundwater seepage along the open parts of the terrain, seepage using springs and boreholes. The groundwater regime of this type of well is dependent on the amount of atmospheric precipitation, groundwater inflow from environments with fissure porosity, and groundwater inflows from deeper aquifers.

Conditionally waterless terrains - This type of well, within the research area, also has a significant distribution and is formed mostly in flysch and clayey formations. Usually, there is no or there are very small amounts of water draining through this type of well. From the point of view of water supply, it is practically not interesting.

Hydrogeological parameters

The hydrogeological characteristics of the represented type of well and its hydrogeological function, as well as the assumed direction and velocity of groundwater movement, represent the basis for defining the dynamics of groundwater for a certain area.

Namely, the researched terrain represents an environment within which a dense and complex type of wells with a free level of underground water has been developed and for which the laws for non-stationary movement of underground water apply.

To define the predicted exploitation capacity and determine the hydrodynamic and hydrogeological parameters of the environment, i.e., investigated area, two operational wells EB-1 and EB-2 were drilled, and a test extraction was carried out, i.e., testing of the exploitation wells. A test extraction of the wells was carried out to determine the yield capacities (Q_1 and Q_2) which would be reference points in the process of testing the exploitation wells.

In order to define the possible exploitation capacity and determine the hydrodynamic and hydrogeological parameters of the environment, i.e. of the researched area, two exploitation wells EB-1 and EB-2 (figure 3) were drilled and a test extraction was carried out, i.e., testing of the operational wells. Test extraction of the wells was carried out in order to determine the yield capacities (Q1 and Q2) which would be reference points in the process of testing operational wells.

The testing of exploitation wells EB-1 and EB-2 was carried out with the so-called step test with two hydrodynamic (reference) levels of groundwater lowering with a duration of 12 hours per one hydrodynamic level or capacity, or a total of 24 hours for the entire testing for one well, with continuous monitoring of the functional dependence [Yield - Q , Reduction - S, time - t or Q = f (t), S = f (t), Q = f (S)].

The testing of the wells EB-1 and EB-2 was performed with an Italian-made Calpeda submersible pump.

Based on the previously described parameters and the results of testing the exploitation wells EB-1 and EB-2, it was determined that Q_{exp} = 2.54l/s.

The results of the testing are given in Table 1.

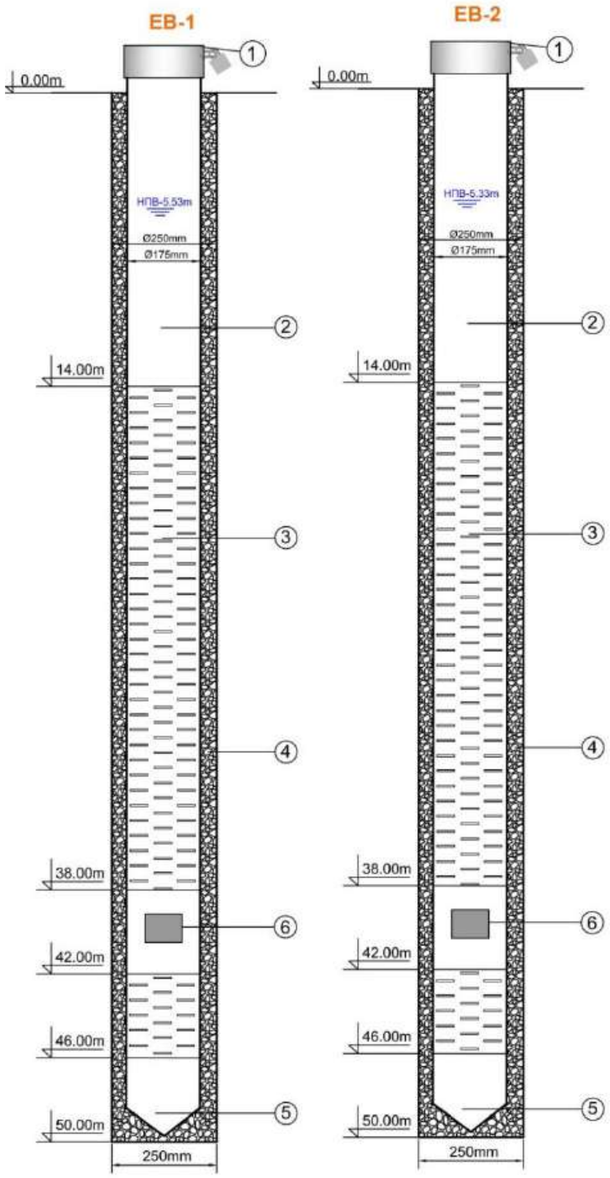

Figure 3. Schematic construction of exploitation wells EB-1 and EB-2
1. metal lid with padlock, 2. full PVC well pipe Ø175 mm, 3. perforated PVC well pipe Ø175 mm, 10 bars, with horizontal slits, 4. filter granulate (4-8mm), 5. precipitator, 6. full PVC well pipe Ø175 mm, 10 bars (space for submersible pump).

Table 1. Results of testing of exploitation wells EB-1 and EB-2

Well	Static groundwater Level – GWL (m)	Test pumping				
		Q (l/s)	GWL(m)	S (m)	q(l/s/m)	t (h)
EB - 1	5.53	1.00	10.38	4.85	0.2061	18
		1.10	11.30	5.77	0.1908	18
		1.25	12.75	7.22	0.1731	18
EB - 2	5.33	0.60	9.31	3.98	0.1507	18
		1.25	20.82	15.49	0.0806	18
		1.55	37.16	31.83	0.0486	18

Analyzing the results obtained from the tests and the performed graphical and analytical calculations and the constructed diagrams of the dependence of the yield as a function of the decreasing Q = f(s), which have a curvilinear shape (figures 4, 6), it can be concluded that it is a compact type of wells with free groundwater level. The diagrams of the specific yield depending on the reduction q = f(s) which also have a curvilinear shape (figures 5, 7) confirmed this finding, i.e., with a higher pumping capacity, a lower value of the specific yield is obtained.

A more detailed view of the dynamic levels of the exploitation wells is given in Table 2.

Table 2. Maximum allowed reduction in exploitation wells

Well	Well depth (m)	GWL	Well	2/3 H+GWL (m)
EB-1	50.00	5.53	44.47	35.17
EB-2	50.00	5.33	44.67	35.11

Taking into account the hydrogeological characteristics of the terrain, the depth and construction of the wells, as well as the parameters obtained from the testing of the wells, we can conclude the following: since it is a compact type of wells with a free level and the maximum allowable lowering of the underground water level for this type of water wells is S_{max} = 2/3 H+GWL, where GWL is groundwater level and H is the height of the water column in the wells. In this case, for the well EB-1 it is H = 44.47 m, for the well EB-2 it is H = 44.67 m, for their operation in terms of preventing unwanted consequences such as suffusion and even damage to the well structure, as well as their smooth operation in dry period conditions - hydrological minimum transferred to the Qf(s) diagram, it follows that for EB-1 S_{max} = 35.17 m with operational level Sexp = 16.54 m, for EB-2 S_{max} = 35.11 m with operational level S_{exp} = 16.20 m.

Hydrogeological parameters for exploitation wells EB-1 and EB-2 are given in Table 3

Table 3. Hydrogeological parameters for exploitation wells EB-1 and EB-2

Hydrogeological parameters	EB-1	EB-2
Well depth	50.00 m	50.00 m
Groundwater level (GWL)	5.53 m	5.33 m
Height of water column H	44.47m	44.67m
Maximal (Q_{max}) capacity (maximum yield)	2.10 l/s	1.53 l/s
Exploitation (Q_{exp}) capacity (exploitation yield)	1.47 l/s	1.07 l/s
Maximal (S_{max}) allowed lowering	35.17 m	35.11 m
Exploitation (S_{exp}) lowering	16.54 m	16.20 m

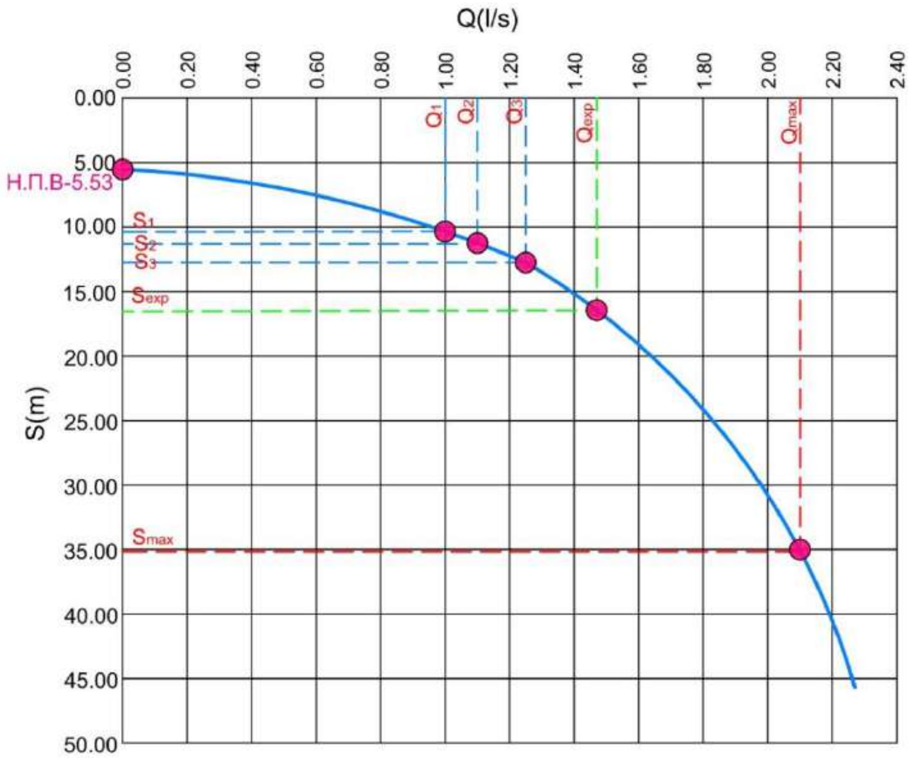

Figure 4. Diagram of dependence of yield depending on Qf(s) lowering for exploitation well EB-1

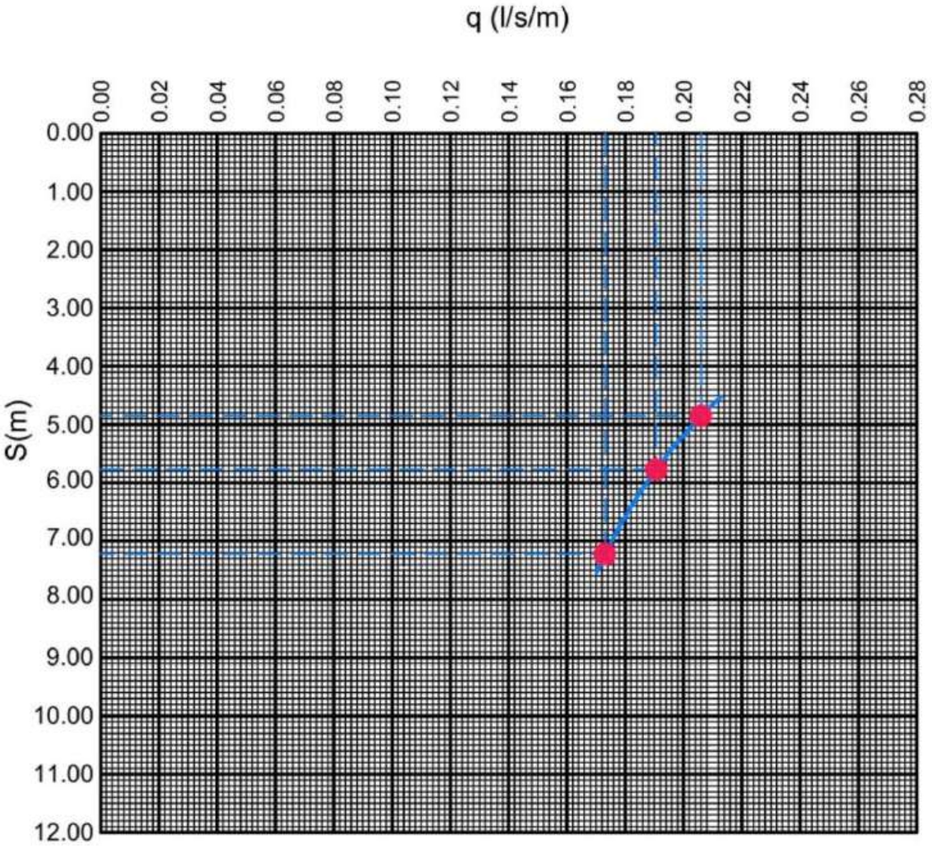

Figure 5. Diagram of specific yield q = f(S) for exploitation well EB-1

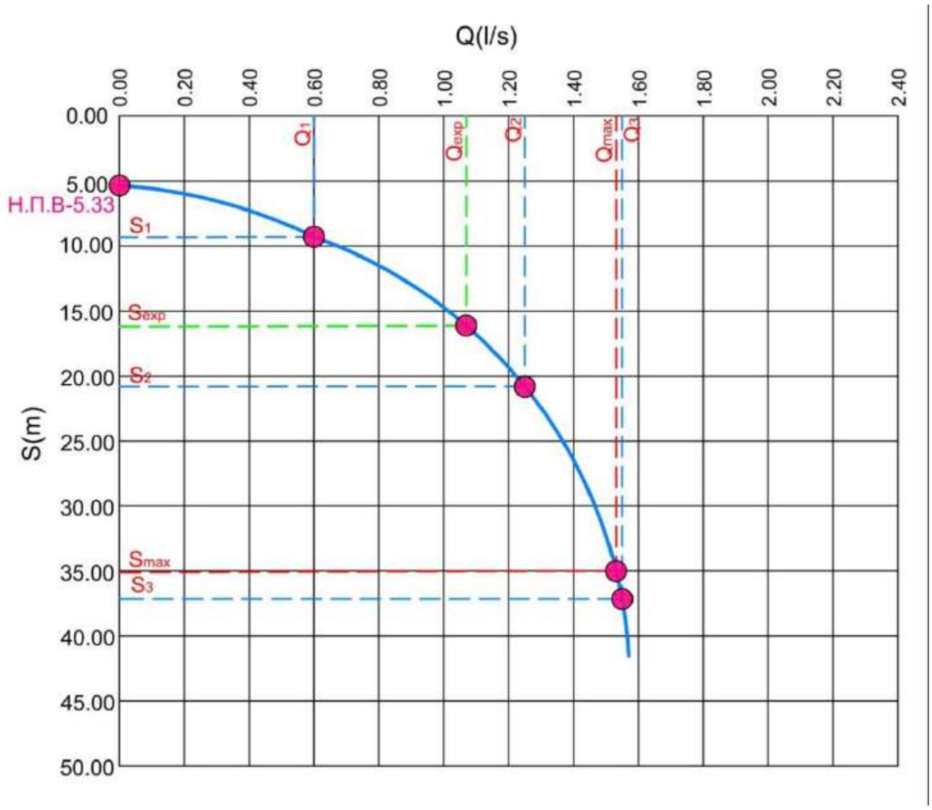

Figure 6. Diagram of dependence of yield depending on Qf(s) lowering for exploitation well EB-2

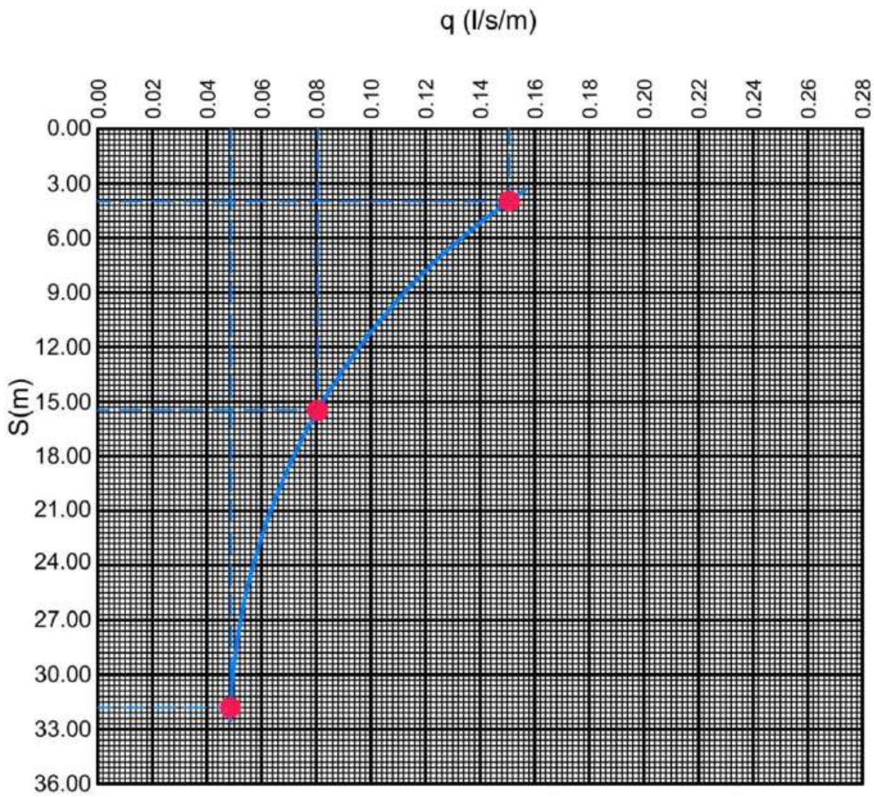

Figure 7. Diagram of specific yield q = f(S) for exploitation well EB-2

Filtration characteristics

The parameters that define the filtration characteristics of the medium are calculated for conditions of unsteady flows in a compact type of wells with a free level of groundwater [8].

Filtration coefficient – This coefficient is calculated according to the Dupuit equation for the case of a perfect well in which draining a compact type of well with a free groundwater level.

$$\boldsymbol{K = 0.732\, Q\, \frac{\log\frac{R}{r_0}}{S(2H-S)}} \text{ (m/s)}$$

where: Q – is the yield of borehole during pumping (m^3/s); S - lowering of the water level (m); r_0 - radius of the filter section (m); H - height of the water column (m); R - radius of depression (m).

The obtained values for the filtration coefficient are shown in Table 4.

Table 4. Filtration coefficient for wells EB-1 and EB-2

Well	Q	S	H	R	r	Kf	
	(m^3/s)	(m)	(m)	(m)	(m)	(m/s)	m/day
EB - 1	0.0025	7.22	44.47	100	0.0800	$5{,}00x10^{-5}$	4.3
EB - 2	0.00155	31.22	44.67	100	0.0800	1.7×10^{-6}	1.5

Coefficient of water permeability (transmissibility)

$$T = K \text{ x } M \ (m^2/s)$$

where: K – is the filtration coefficient (m/s); H = M - height of the water column (m); T - coefficient of water permeability (m^2/s).

The following values were used in the calculation for EB-1: K = 5,00 x 10^{-5} m/s, H = M = 44,47 m.

The calculated value for the coefficient of water permeability (transmission) for EB-1 is: **T = 2,22 x 10^{-3} m^2/s.**

The following values were used in the calculation for EB-3: K = 1,70 x 10^{-5} m/s, H = M = 44,67 m.

The calculated value for the coefficient of water permeability (transmission) for EB-2 is:: **T = 7,5 x 10^{-5} m^2/s.**

Determined parameters (filtration coefficient and coefficient of water permeability) indicate that it is an environment with moderately permeable rock masses.

Radius of depression R [m] **-** The radius of influence, i.e., the radius of the depression curve at the level of underground water at yield for the III pumping capacity of the wells, is calculated according to the following formulas:

According to Kusakin: $R = 575 \times S\sqrt{H} \times \sqrt{K}$ [m]

According to Zichard: $R = 3000 \times S \times \sqrt{K}$ [m]

where the input parameters are: R – radius of depression [m]; S – depression in the well [m]; K – filtration coefficient [m/s]; H – thickness of aquifer [m]; T – pumping time [s].

The obtained values for radius of depression according to formulas of Kusakin and Zichard are shown in Table 4.

Table 5. Calculation of radius of depression according to formulas of Kusakin and Zichard

Well	S [m]	K [m/s]	H [m]	T [s]	R (after Kusakin) [m]	R (after Zichard) [m]
EB-1	7.22	$5{,}00x10^{-5}$	15	129 600	114	153
EB-2	31.83	$1{,}7x10^{-6}$	15		92	124

Groundwater reserves

Groundwater reserves in the research area can be: statical, dynamic and exploitational.

Statical reserves - The calculation of static reserves is carried out as a volume of well with a certain degree of specific.

Based on the knowledge from the drilled wells, as well as the knowledge from all the existing documentation for the research area, the thickness of the aquifer within the compact well is adopted at about H = 50 m, and a conditionally taken feeding surface of the well of about 0,5 km^2, with a certain specific yield (μ=0.1-0.2). The specific yield is accepted as μ=0.15, according to the former data from the drilling of the exploration – exploitational boreholes, and from the literature.

Estimated statical reserves are presented in Table 6.

Table 6. Estimated static groundwater reserves for the adopted schematic HG model

Well surface F [m^2]	Well thickness H (m)	Well volume V [m^3]	Specific yield μ	Statical reserves of groundwater Q [m^3]
$0{,}5 \times 10^6$	15	$7{,}5 \times 10^6$	0.15	$1{,}125 \times 10^6$
TOTAL STATIC RESERVES				$1{,}125 \times 10^6$

Dynamic reserves - Dynamic reserves of groundwater represent the flow of groundwater through a certain transverse profile perpendicular to the groundwater flow.

According to the results of the well testing, the dynamical reserves of underground water from the well amount to:

$$Q_{din} = 2.54 \text{ l/s} = 0{,}00254 \text{ m}^3\text{/s} = 219{,}456 \text{ m}^3\text{/day} = 0.08010 \times 10^6 \text{ m}^3\text{/year}.$$

The calculation of the dynamic reserves of underground water is given in Table 7.

Table 7. Calculation of dynamic underground water reserves

Well	Recommended exploitational yield Qex. [l/s]	Dynamic reserves Qdin.	
		[m^3/s]	$\times 10^6$ [m^3/year]
EB-1	1.47	0.00147	0.08010
EB-2	1,07	0,00107	

Exploitational reserves - Exploitational reserves actually represent a sum of the dynamic and the part of the static reserves that can be used without the danger of overdrawing the well, maintaining the process of renewability of the reserves for an exploitation period of 25 years, with a degree of utilization of n = 30 %, amount to:

$$Q_{exp.} = 2.54 \text{ l/s} = 0{,}00254 \text{ m}^3\text{/s} = 219{,}456 \text{ m}^3\text{/day} = 0.08010 \times 10^6 \text{ m}^3\text{/year}$$

Oscillations of the groundwater level in this well are seasonal and closely related to rainfall.

CONCLUSION

According to the results obtained from the testing of the exploitation well EB-1 and the calculation of its hydrodynamic parameters, it follows that the filtration coefficient for the compacted type of well with a free level is within the limits of $K = 5.00 \times 10^{-5}$ m/s, the water permeability of $T = 2.22 \times 10^{-3}$ m^2/s.

According to the results obtained from the testing of the exploitation well EB-2 and the calculation of its hydrodynamic parameters, it follows that the filtration coefficient for the compacted type of well with a free level is within the limits of $K = 1.70 \times 10^{-6}$ m/s, the water permeability of $T = 7.50 \times 10^{-5}$ m^2/s.

Based on the results obtained from the testing of the exploitation well EB-1, graphical and analytical calculations were performed, which determined the hydrogeological parameters of the represented water well, as well as the maximum capacity $Q_{max} = 2.10$ l/s and exploitation capacity of the well EB-1 $Q_{exp} = 1.47$ l/s, the dynamic levels S_1, S_2 and S_3 at Q_1, Q_2 and Q_3 are also determined, as well as the maximum lowering of the groundwater level in the well $S_{max} = 35.17$ m and the operational lowering $S_{exp} = 16.54$ m.

Based on the results obtained from the testing of the exploitation well EB-2, graphical and analytical calculations were performed, which determined the hydrogeological parameters of the represented water well, as well as the maximum capacity $Q_{max} = 1.53$ l/s and exploitation capacity of the well EB-2 $Q_{exp} = 1.07$ l/s, the dynamic levels S_1, S_2 and S_3 at Q_1, Q_2 and Q_3 are also determined, as well as the maximum lowering of the groundwater level in the well $S_{max} = 35.11$ m and the operational lowering $S_{exp} = 16.20$m.

We recommend exploitation wells EB-1 and EB-2 to be exploited with $Q_{exp} = 1.00$ -1.47 l/s with a submersible pump type: Lowara, Grundfos, Oddese, Caprari, Calpeda, etc. with characteristics for pump capacity N = 1.5 kw, Ø 98 mm and $H_{man} = 60$ m, which with its lower part should be lowered to a depth of 38 - 42 m. These parameters refer to the mouth of the well constructions.

REFERENCES

1. Georgievski, S., at all., (2015) Report on the construction of two exploitation wells EB-1 and EB-2 for water supply in the village of Krusica - Sveti Nikole Municipality
2. Georgievski, S., et al., (2015) Report on the performance of three exploitation wells EB-1, EB-2 and EB-3 for water supply in the village of Orel - Municipality of Sveti Nikole
3. Georgievski, S., et al., (2020) Report on the construction of two exploitation wells EB-1 and EB-2 for heat pumps for kindergarten Rahilka Goneva – Sveti Nikole
4. Gjuzelkovski, D., Kotevski, G., (1977) Hydrogeological map of R. Macedonia, M 1:200 000
5. Karajovanovic, M., Hadži-Mitrova, S., Arangelovik, R., (1975) Basic Geological Map 1:100,000, sheet Veles, Geological Institute Skopje, 1966-1975
6. Karajovanovic, M., Hadji-Mitrova, S., (1982) Interpreter of the Basic geological map 1:100 000 for the Sheet Veles, Federal Geological Survey Belgrade
7. Nikolova, P. M., et al. (2024) Hydrogeological research to ensure the necessary amounts of underground water for the water supply of Agroglobal Trade D.O.O. Skopje, branch office 1 Koki Lux Sveti Nikole. PODEX-POVEX 2024, Struga
8. Spasovski, O., (2008) The underground waters of the Divjak locality as an alternative for the water supply of Sveti Nikole. First congress of geologists of the Republic of Macedonia, Ohrid. Proceedings
9. Spasovski, O., et al. (2008) Project for detailed hydrogeological research of the Divjak locality for the water supply of the city of Sveti Nikole. GEOENGINEERING – M DOOEL Skopje. Professional fund of the Municipality of Sveti Nikole
10. Spasovski, O., et al. (2016) Hydrogeological research to ensure the necessary amounts of underground water for the water supply of Krusica village, Sveti Nikole municipality. PODEX - POVEX, Strumica
11. Spasovski, O., et al. (2023) Hydrogeological report with calculation of underground water reserves from exploitation wells EB-1 and EB-2 for water supply of Agroglobal Trade D.O.O. Skopje, branch 1 Koki Lux, Sveti Nikole