GEOPHYSICAL TEST REPORT

Alikhel Village

Tagab District / Kapisa Province

16 August 2023

Table of Contents

List of Figures

List of Tables

1) Background

Groundwater can be explored using different methods. The four major groundwater exploration methods are the aerial method, surface method, subsurface method and esoteric methods. Among these methods, esoteric method is not based on science, mostly based on traditional indicators. Each of the above listed groundwater exploration methods have different sub methods under them. Geophysical survey is therefore one of the sub-methods under the surface method of groundwater exploration. This method is very important for both groundwater resource mapping and water quality evaluations. Its application for groundwater exploration purposes has increased over the last few years due to the rapid advances in computer packages and associated numerical modeling solutions.

There are different types of surface geophysical survey methods. However, here the geomagnetic and geo-frequency methods are used. The instrument which is used for the test is Aqufinder 3D. It is a 3D water locater and uses geomagnetic field to locate the groundwater and geo-frequency to identify the depths of water bearing layers. It is a small size, lightweight and portable to carry device. In addition, the exploration depth can vary from 25m till 1200m below ground level. Overall, this device has transmitter and receiver antennas to measure the magnetic field and frequencies. Moreover, the detailed principle of working for this machine is provided in the (Geophysical Method) section.

2) Objective

The objective of this geophysical test is to estimate a proper location for the borehole for water supply in the target area of Alikhel Village in Tagab District of Kapisa Province . The specific objectives of the study can be summarized as following.

- To estimate a proper location for the borehole.
- Get information about the layers of soil in the area, in order to estimate a proper depth for the borehole.

3) Geophysical Method

In this geophysical test electromagnetic methods are used for ground water exploration. Electromagnetic (EM) methods detect the electrical properties of the subsurface by inducing EM energy within the subsurface and measuring the response of earth materials. Generally, EM geophysical instruments output a time-varying electric current into its transmitter coil, or loop. As the current travels in the transmitter loop, it generates a magnetic field that has the same frequency and phase as the current. This induced field propagates lines of force that penetrate the earth.

If a conductive body or conductive material exist in the vicinity of the instrument, an electromotive force (i.e., voltage) forms within it (i.e., Faraday's Law). Electrical current flow is then initiated within the subsurface conductors, and a secondary magnetic field is generated. The secondary field is detected by the receiver coil of the EM geophysical instrument, which compares this received energy to the transmitted energy and records the data. These data are then processed and interpreted to characterize the subsurface EM properties.

Subsurface EM energy is propagated due to the three electromagnetic properties of matter: electrical conductivity, dielectric permittivity, and magnetic susceptibility. Electrical conductivity and magnetic susceptibility govern the magnitude of the received EM signal and, therefore, are used to understand the electrical properties of subsurface materials.

The machine uses two methods to detect and identify the ground water. Firs it uses electromagnetic field method to identify the location of the ground water. Then it uses geo-frequency method to identify the depth of ground water. The geo-frequency method, is a passive source geophysical prospecting method that is based on the difference in electrical conductivity of underground rock-soil mass, and it uses the Earth's natural electromagnetic field as the working field source. By observing the horizontal variation of the electric field generated by the natural electromagnetic field at different frequencies, the difference in electrical conductivity of the rock-soil mass at different underground depths is analyzed to determine the location of the underground aquifer. The magneto telluric field can be approximately regarded as a plane electromagnetic wave incident perpendicular to Earth's surface, and its propagation characteristics in the medium are based on Maxwell's equations; by solving the equations, we can derive the relationship between the electromagnetic wave penetration depth (δ), homogeneous dielectric resistivity (ρ) and the frequency (f) of the measuring instrument, as shown in (Equation 1). Therefore, different frequencies can be selected to detect the formation information at different depths in a homogeneous formation medium.

$$\delta=503.5\sqrt{\frac{\rho}{f}}$$

Equation 1

In the actual detection process, the formation around the electrode is rarely homogeneous, and the measured resistivity (i.e., apparent resistivity, ρ_s) is affected by the comprehensive conditions within the range of the measuring electrode. According to Maxwell's equations, the apparent resistivity can be calculated by using (Equation 2); when the frequency is constant, the apparent resistivity is proportional to the square of the electric field intensity in the x direction (E_x). The electric field intensity in the x is measured by the machine. Finally, the machine gives apparent resistivity for different depths.

$$\rho_s = \frac{1}{\mu\omega}\,(E_x/H_y)^2$$

Equation 2

4) Project Site

The project site is a Village named Alikhel Village in Tagab District of Kapisa Province . The coordinates of the Village are provided in the following table. In addition, the geophysical test is done on 16 August 2023.

Table 1: Coordinates of the project site

	Northing	Easting
Alikhel Village	34.921748°	69.634973°

4.1 Hydrology:

The aerial imagery of the site is given in the following figure and the catchment is enclosed with the blue line in the figure. As can be observed from the figure, the catchment of the stream which passes in the area has a narrow shape. In addition, the area of the catchment is almost 2.5km^2. The catchment area is mainly formed of mountainous terrain and just near to the test site the topography is flat. In addition, as can be observed from (Figure 2: Land cover of the site), in most of the catchment area, there are areas of rangeland. Thus, this is an indicator for enough precipitation during the year for growing the grass. Although the catchment area is small but as can be observed from the following figure, but the precipitation in this area is high. So, it is expected that there will be water for the water supply in the targeted area.

Figure 1: Aerial imagery of the site.

4.2 Land Cover:

The land cover of the area is provided in the following figure. As can be observed from the figure, most of the area in the upstream is formed of grassland, which shows that there is enough precipitation in the area. In addition, in some areas of the catchment, there is bare soil. However, the target area of the test is located in an area which is irrigated and there are also some settlements in the area.

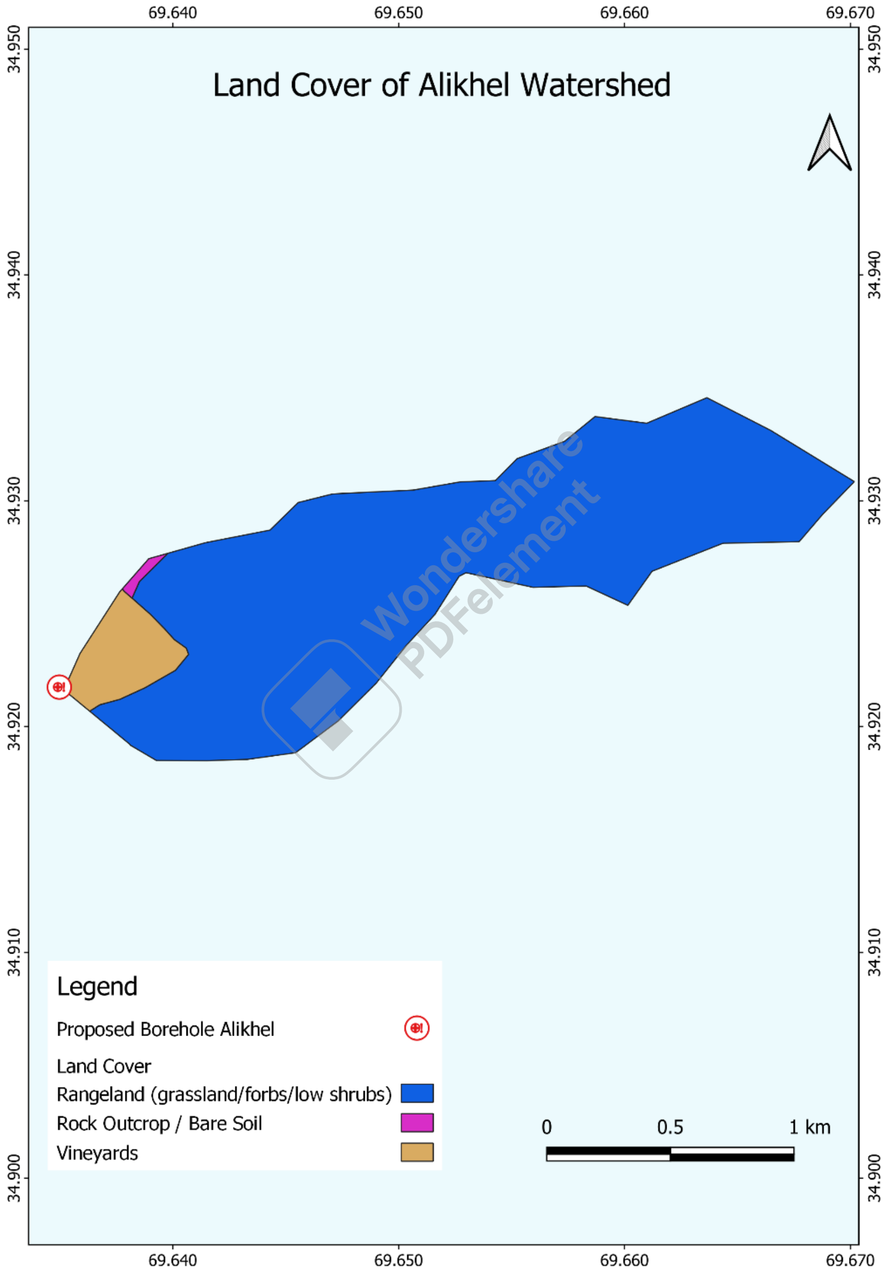


Figure 2: Land cover of the site

4.3 Geology:

The lithology of the catchment of the river which passes in the area and the areas around is presented in the following figure. As can be observed from the figure, in the catchment most of the lithology in the upstream is gneiss. The second most, there are siltstone and sandstone. However, the target area of the test is located in an area which has conglomerate and sandstone.

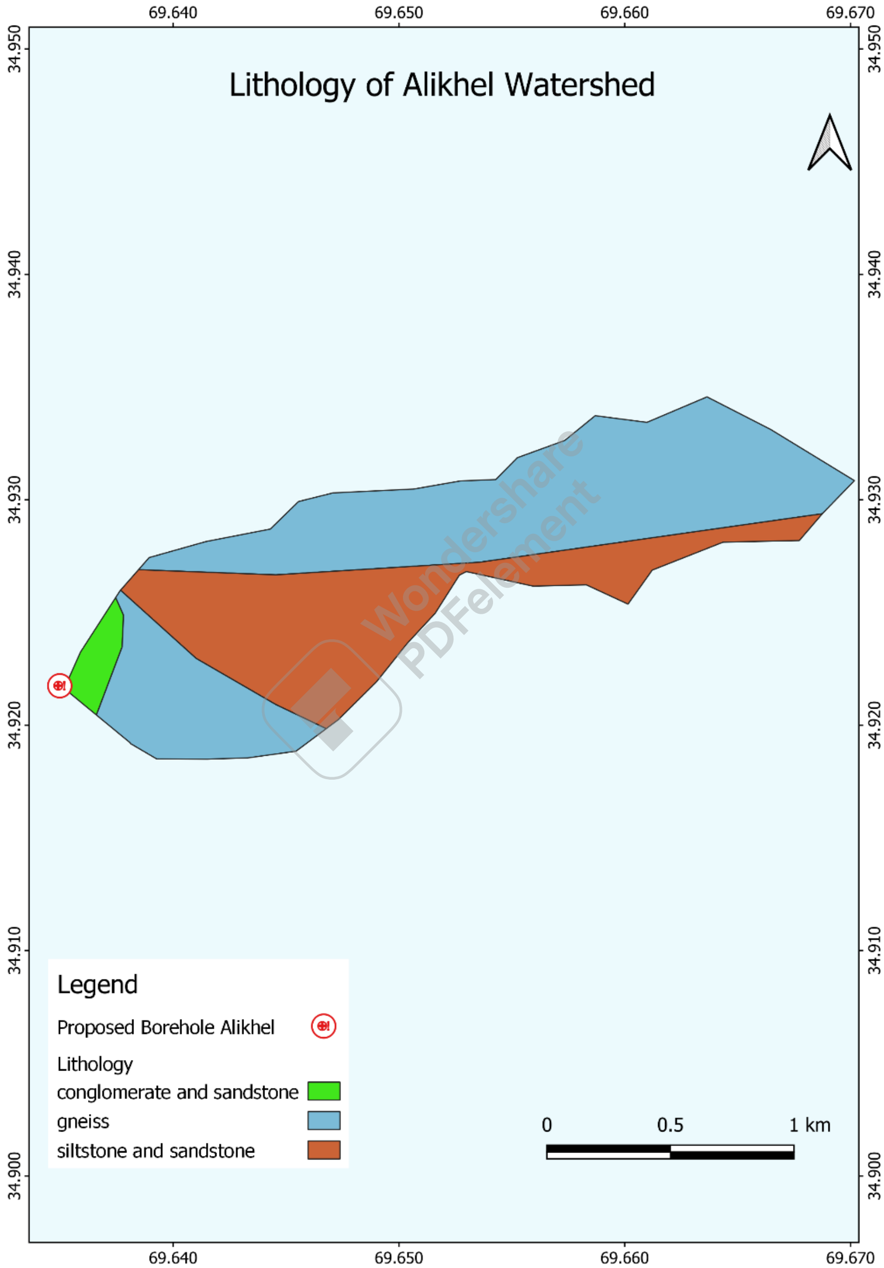


Figure 3: Geology of the site

4.4 Geophysical test location

The location of the geophysical test is shown in the following figure by the yellow pin.

Figure 4: Location of geophysical test

As was observed from the aerial imagery in (Figure 1: Aerial imagery of the site.), the catchment of the stream which passes in the area is (almost 2.5km^2). So, it has less capacity to attract water during rainy season and then supply it later as ground water during dry seasons. The test area is located in a flat area, as displayed in the above figure. A photo of during the test is displayed in the following figure.

Figure 5: Picture of the test site

5) Results

The result of the geophysical test is presented in the following figures. First, the location for borehole with potential water probability is searched using electromagnetic survey. Then the identified location is further searched for properties of the soil layers using electro-frequency survey. In the graphs; the numbers in the bottom show the distance from the tested point. In addition, the distance between these points is 1m. So, the overall length of each profile is 6m and its direction is from south to north. Moreover, the numbers on the left of the figure shows the depth, which can vary according to the needs. On the other hand, the numbers on the right show the apparent resistivity of soil in ohm-meter. In these graphs, the areas which are blue and have lower values are representative of the areas which have higher probability of water. As the water is conductive of electricity, so the areas which have more water will cause less resistivity. On the other hand, the areas which are red have higher resistivity and as a result, less probability of water.

5.1 Test Profile

5.1.1 Profile 1

The result of the geophysical test is presented in the following figure.

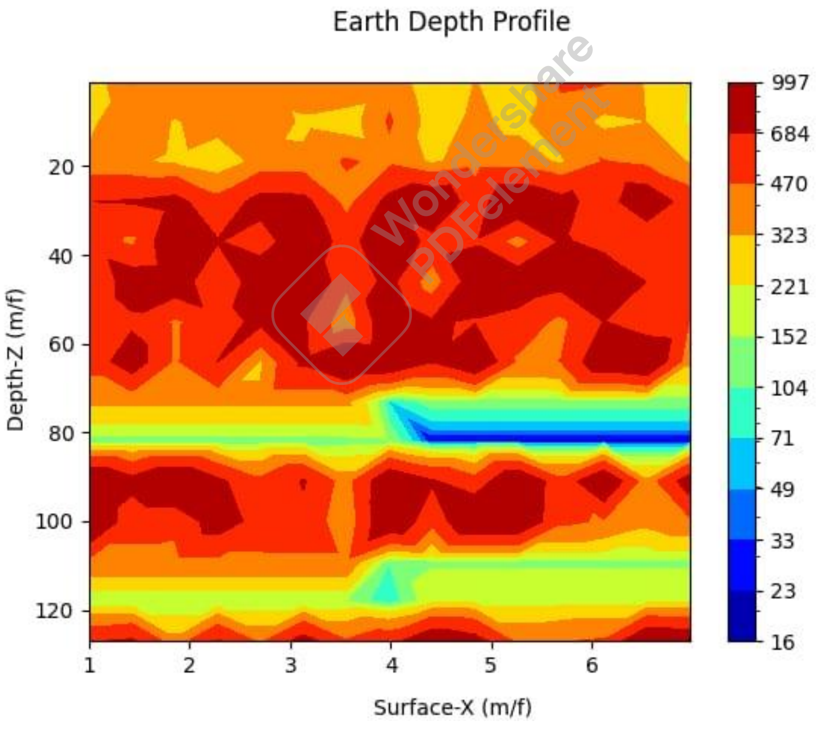


Figure 6: Profile of test one

The test is done on the identified point and is shown with the yellow pin in (Figure 4: Location of geophysical test). As can be observed from the figure, the total length of this profile is 6m and the depth is 100m. In addition, it can be observed from the graph that the aquifers are located at point 4 at the depth of 60m below ground level.

5.2 Soil layers of proposed point

In order to gain more information about the proposed point, the data of this point is processed further. So, the values of apparent resistivity of the first profile for point 4 are provided in the following figure.

As can be observed from the graph, the resistivity of soil layers till 60m below ground level is high then it starts to drop.

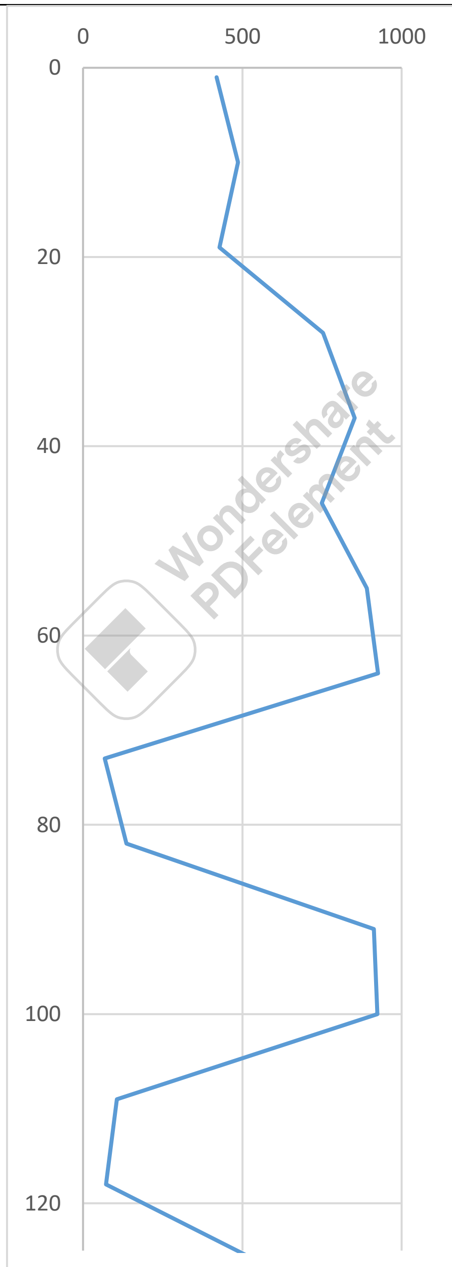
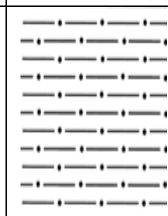
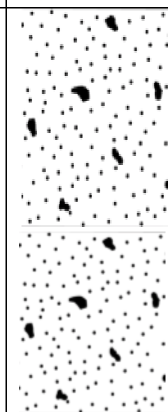
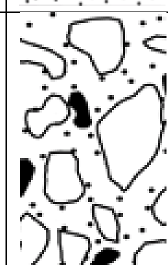
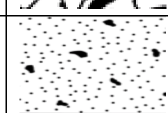
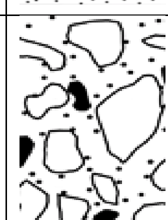
Strata Description	Depth (m)	Apparent Resistivity (ohm-m)	Thickness (m)	Symbolic Log
				
Clayey sand	0 to 20		20	
Conglomerate	20 to 60		40	
Gravel and Sand	60 to 90		30	
Conglomerate	90 to 100		10	
Gravel and Sand	100 to 125		25	

Figure 7: Stratigraphy of the proposed borehole point

Based on the graphs, further processing of the data for the proposed borehole point and site observations, the expected water level is almost 60m below ground level. So, the water is expected to start from around 60m and continue till almost 120m with a discontinuity at around 90m below ground level.

6) Conclusion

From the analysis of the test result, point 4 should be selected for the borehole. As the catchment area is small, but the total precipitation in this area is high. So, there will be water for water supply in this area. In addition, from the lithology and site observations, the area is flat and the strata is formed from sediments like conglomerate and sandstone. The expected ground water table is around 60m below ground level and will continue till around 120m below ground level. So, a total borehole depth of 120m will be enough for the water supply in the area.