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Identification of the Position of Subsurface Aquifers and the Distribution of Groundwater Level Depth in Oksibil District, Pegunungan Bintang Regency

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ABSTRACT

Keywords: Groundwater Resisivity, Aquifer Position, Depth Distribution, Pegunungan Bintang Regency

Groundwater is dynamic and influenced by natural factors, such as geology and geomorphology, which affect aquifer characteristics, groundwater movement, and surface morphology. This study aims to identify subsurface aquifer positions and the distribution of groundwater depth in Oksibil District, Pegunungan Bintang Regency. The research utilizes the resistivity geoelectric method with a Wenner configuration to determine lithology and aquifer characteristics. Measurements were conducted using the AIDU Golden Rod instrument, which analyzes natural electric fields. Results indicate the presence of pressurized aquifers at depths ranging from 125 to 300 meters with varying thicknesses of 20 to 85 meters. In contrast, free aquifers are primarily located at shallow depths (0–40 meters) in specific areas, such as Kabiding. The findings provide valuable insights into groundwater resource management and regional aquifer potential in Pegunungan Bintang Regency

Introduction

The distribution of the pipeline network in the center of Oksibil City has been served with 665 SR house connections (SR) in 2023. However, the fulfillment of the needs of Oksibil City has not been achieved due to the limited availability of water sources and difficult topographic areas. The alternative offered in this study is to increase the availability of water sources, namely the Okapnum River with the target of distributing the suburban pipeline network to the southern area of Oksibil City (Jalan Iwur) through the dabolding area. In terms of clean water needs, 20% = 2.70 ltr/s of the total clean water needs of Pegunungan Bintang Regency. The map of the clean water service plan in Oksibil City.

Groundwater potential identification is carried out using a tool in the form of, AIDU Golden Red (AGR) which is a special instrument for geophysical studies that provides a detailed vertical picture of rock and aquifer resistivity by measuring natural electric fields. This instrument measures natural electric fields passively with frequency domains (high to low frequencies in one measurement), high frequencies will produce resiliency data at shallow depths and low frequencies will generate resistivity data at deep enough to very deep depths.

The resistivity method is one of the geophysical methods used to determine the aquifer layer by utilizing the electrical properties of rocks. Groundwater under the surface interacts with the soil layer in the form of sand as a place for groundwater to be found (aquifer) (Putri et al., 2022). To find out the type of soil layer that groundwater passes through under the surface, measurements are carried out using the geoelectric method. The resistivity geoelectric method in this study uses a wenner configuration where this method is the main method used to find water content based on the parameters of different resistivity distributions.

Several studies have investigated groundwater availability using geophysical methods. For instance, Mandal et al. (2016) explored the role of land cover, geology, and rainfall in groundwater potential. Selvam et al. (2016) highlighted the significance of lithology and stratigraphy in groundwater movement. Similarly, Mekki and Laftouhi (2016) discussed how rock permeability and porosity influence groundwater storage. While these studies provide foundational insights, they focus on broader regional contexts or different geophysical conditions.

This research distinguishes itself by focusing on the specific hydrogeological conditions of Pegunungan Bintang Regency, particularly in Oksibil District. Unlike previous studies, this work combines advanced geoelectric methods with regional geological mapping to address the unique topographical and geological challenges of the area. The novelty lies in its detailed mapping of aquifer distribution using the AIDU Golden Rod instrument, which provides a more refined analysis of groundwater potential in this underexplored region. This approach not only enhances the understanding of groundwater resources but also contributes to sustainable water resource management in Oksibil City and similar remote areas.

The purpose of this study is to identify the Position of Subsurface Aquifers and the Distribution of Groundwater Level Depth in Oksibil District, Pegunungan Bintang Regency.

Research Methods

The location of this study is in Pegunungan Bintang Regency, Geoelectric measurement points are scattered in Oksibil District Geographically Oksibil District is located at 140o 17' 43.48" east longitude and 4o 31' 18.01" south latitude. namely to the north it borders Jayapura Regency and Keroom Regency, to the South it borders Boven Digoel Regency, to the West it borders Yahuimo Regency and to the East it borders Papua New Guinea Regency.

Survey of Identification of Subsurface Aquifer Position and Distribution of Groundwater Level Depth in Oksibil District, Pegunungan Bintang Regency for the construction of groundwater and raw water, including mapping the potential of groundwater in Pegunungan Bintang Regency and taking soil samples as well as testing physical parameters and soil shear strength.

Groundwater potential mapping is carried out using an aid in the form of *an AIDU Golden Rod (AGR)* which is a special instrument for geophysical studies that provides a detailed picture of the vertical resistivity of rocks and aquifers by measuring natural electric fields. This instrument measures natural electric fields passively with frequency domains (high to low frequencies in one measurement), high frequencies will produce reciprocity data at shallow depths and low frequencies will produce resistivity data at deep enough depths. The reciprocity value is used to analyze the type of lithology below the surface, which is then used as a basis for determining the existence of a spring source (aquifer).

For soil sampling in the reservoir location plan using *the Test pit* method, soil sampling is carried out by digging a hole with a size of 1x1x1 m^3. At each point of the test hole, a soil sample is taken using a tube *(Undsitrubed sample)* which is then taken to the laboratory to be tested to obtain the amount of physical properties and shear strength of the soil.

Results and Discussion

1. Pegunungan Bintang Regency

Based on the results of the Geoelectric Testing Research of Pegunungan Bintang Regency, especially Oksibil, composed of types of marine clastic rocks, most of which are fine-grained including dolomitan limestone, a little black rijang of pyrite nodules, siltstone, limestone quartz sandstone, a little napal, and a little, causing this type of material to have the ability to store and drain water high. has a shallow groundwater surface depth, and has a thick soil thickness as a good infiltration medium. Partly tufaan calcilunite, mostly composed of red clastic with red mudstone and some green ones, felsparan interspersed sandstone, glaukonitan quartz sandstone, and a little volcanic clastic sandstone and tufa at a depth of 1 – 5 km. Paleozoic rocks are inseparable, slab rocks, sandshale, arcostal sandstone and napalan limestone, basalt and volcanic breccia with some intendrobic limestone or basically and low-grade malahan in the northern part of the path.

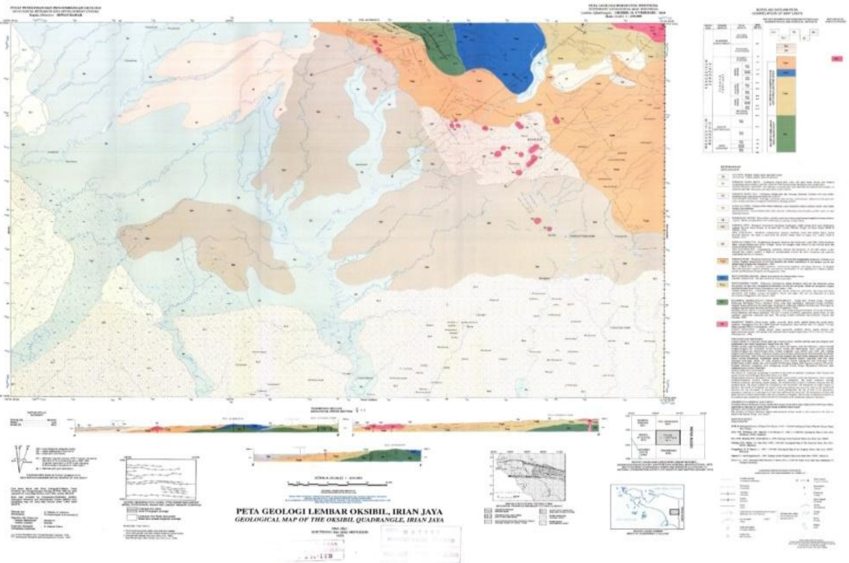


Figure 1. Geological Map of Pegunungan Bintang Regency

2. Availability of Groundwater

The presence of groundwater in an aquifer is influenced by various factors. A potential groundwater zone is a location where there is a potential source of groundwater in it. The identification of groundwater potential zones depends on a variety of factors. Some of the factors that are important in determining groundwater potential are land cover, soil type, geology, drainage density, rainfall, and slope (Mandal, et al., 2016). Geological formations play an important role in the formation of land. The type of rock in an area has a significant effect on the availability of groundwater (Selvam, et al., 2016). The ability of water to flow from the surface to the ground is influenced by the type of rock in an area (Das & Pal, 2019; Hasilatagama et al., 2023; Mekki & Laftouhi, 2016). The type of rock affects the water-holding capacity of an aquifer and the presence of groundwater (Duan, et al., 2016). Each type of rock has different porosity and permeability values Important aspects included in the groundwater study are geological conditions (lithology, stratigraphy, and structure), Differences in lithology will affect the availability of groundwater. Rock units or geology in general will show the characteristics of groundwater.

The distribution of groundwater availability in Pegunungan Bintang Regency based on Figure 2, is divided into various conditions such as in the northern part of Pegunungan Bintang Regency is an area with moderate water availability and some northern and western areas are areas with high water availability conditions while the eastern and southern parts of Pegunungan Bintang Regency are areas with high water availability conditions. With the distribution of the majority of rocks in the Bintang Mountains Regency, especially Oksibil, composed of types of marine clastic rocks, most of them are fine-grained including dolomitan limestone, a little black rijang of pyrite nodules, siltstone, limestone quartz sandstone, a little napal, lonely The availability of groundwater in this area is abundant throughout the year. Areas with high groundwater potential are areas that are very prone to water.

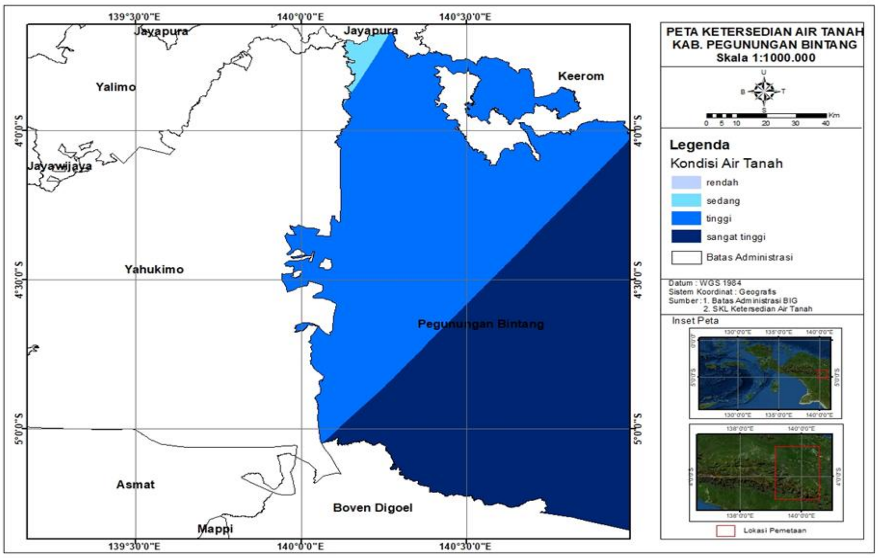


Figure 2. Water Availability Map of Pegunungan Bintang Regency

3. Geoelectric Testing Sites

Based on the resistance data obtained from the results of geoelectric tests, it is possible to predict the type of material below the ground surface. The stratigraphy of the soil layer at the geoelectric point collection site can be seen in Table 1. Geoelectric data collection was carried out in Oksibil District, Pegunungan Bintang Regency. In this study, Geoelectric testing was carried out at 10 test location points spread across the Oksibil district, Pegunungan Bintang Regency.

Figure 3. Layout of Geoelectric Measurement Locations in Pegunungan Bintang Regency

Table 1. Geoelectric Testing Locations in Pengungga Bintang Regency

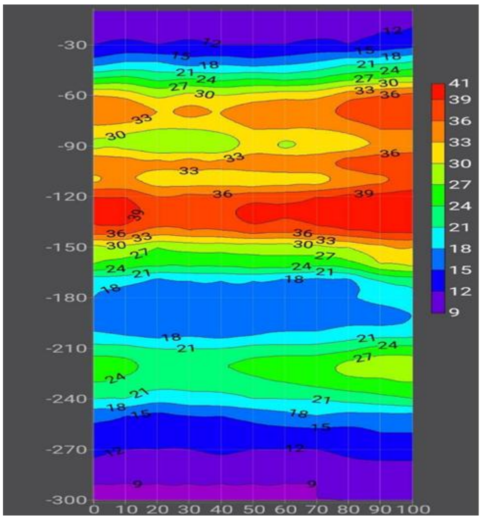
NO	LOCATION	KOORDINAT				
		B1		B2		ELEVATION
1	Arinkop	4º 55' 54.978"	140º 38' 3.541"	4º 55' 54.978"	140º 38' 3.541"	1312 m
2	Oksibil Airport	4º 54' 26.356"	140º 37' 51.64"	4º 54' 26.363"	140º 38' 3.589"	1321 m
3	Dabolding Office	4º 54' 33.423"	140º 36' 53.58"	4º 54' 33.423"	140º 36' 53.58"	1364 m
4	Kabiding	4º 53' 57.252"	140º 37' 13.634"	4º 53' 57.252"	140º 37' 13.634"	1340 m
5	Oksibil Regent Office	4º 53' 31.794"	140º 38' 29.756"	4º 53' 31.794"	140º 38' 29.756"	1446 m
6	Oksibil Health Center	4º 54' 25.255"	140º 38' 1.966"	4º 54' 25.255"	140º 38' 1.966"	1322 m
7	Oksibil Hospital	4º 54' 7.041"	140º 35' 54.273"	4º 54' 7.041"	140º 35' 54.273"	1336 m
8	Behind the petrol station	4º 54' 46.885"	140º 38' 13.027"	4º 54' 46.885"	140º 38' 13.027"	1296 m
9	Terminal Pasar Baru	4º 55' 11.434"	140º 38' 0.739"	4º 55' 11.434"	140º 38' 0.739"	1348 m
10	YAPIMAKOT	4º 53' 43.909"	140º 35' 38.832"	4º 53' 43.909"	140º 35' 38.832"	

(Source: Calculation Results, 2024)

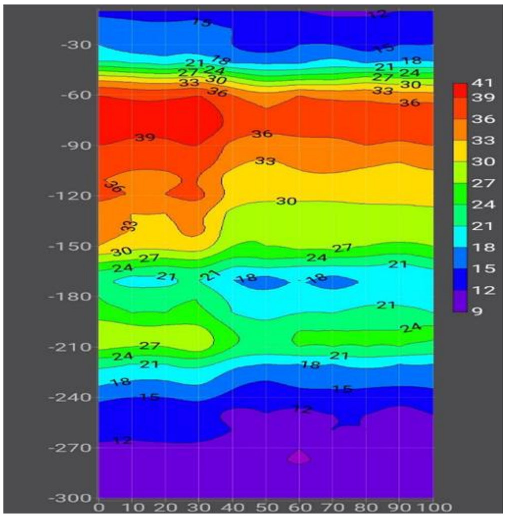
4. Interpretation of Geoelectric Test Results

The interpretation of this data analysis is carried out from several field analysis data in a geoelectric cross-section. The results of this interpretation are presented in the form of a cross-section of type resistance, and a geoelectric interpretation of type resistance, as well as a map of the slip plane analysis of the subsurface lithological arrangement at the measurement site. Data interpretation is carried out to determine the lithology of rocks on the attached trajectory as follows:

a. Oksibil Airport



a. B1 Span Pieces



b. B2 Spanning Pieces

Figure 4. (a) Stretch Chunk B1 (b) Stretch Chunk B2 Oksibil Airport

The results of the Geoelectric test at Oksibil Airport, it was found that in the B1 Stretch the depth of the aquifer is 250 - 300 m deep, while in the B2 Stretch at a depth of 225 - 300 m below the surface with a resistivity value of 9 - 18 ohmm, the lithology that constitutes this aquifer is sandstone. The existence of deep aquifers has quite a large volume, with a thickness of 50 – 75 m below the surface.

Table 2 Interpretation of Stretch B1 Oksibil Airport

NO	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	WARNA LAPISAN PADA DIAGRAM
1	Lapisan Atas	0-55 m	Breksi rekahan rendah hingga sedang	
2	Lapisan - 01	55-160 m	Lempung kelanauan	
3	Lapisan - 02	160-210 m	Lanau Pasiran	
4	Lapisan - 03	210-250 m	Breksi rekahan rendah hingga sedang	
5	Lapisan - 04	250-300 m	Breksi rekahan sedang - tinggi	

Table 3 Interpretation of Aobil Airport B2 Stretch

NO	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	WARNA LAPISAN PADA DIAGRAM
1	Lapisan Atas	55-130 m	Breksi rekahan rendah hingga sedang	
2	Lapisan - 01	130-220 m	Lempung kelanauan	
3	Lapisan - 02	220-300 m	Lanau Pasiran	
4	Lapisan - 03	225-300 m	Breksi rekahan sedang - tinggi	

(Source: Calculation Results, 2024)

Kabiding

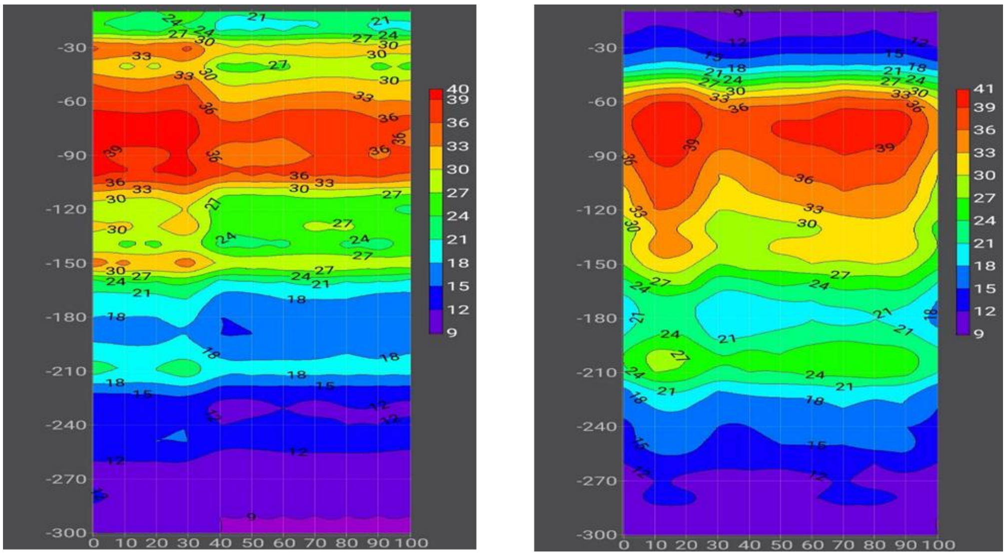


Figure 5 (a) Stretch Slice B1 (b) Stretch Slice B2 Kabiding
(Source: Aidu Prospecting Software)

The acquisition of geoelectric testing at the Kabiding site yielded subsurface data as shown in Figure 5. It shows that at the Kabiding location there is no deep aquifer on the surface of either stretch 1 or stretch 2.

In stretch 1 there is no free aquifer, while in stretch 2 there is a free aquifer spread along the stretch with a depth of 0 – 35 m below the surface. It has a resistivity value of 0 – 15 ohms. Aquifers are freely affected by surface water infiltration such as rainwater and river water.

Table 4. Interpretation of Kabiding's B1 Stretch

NO	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	WARNA LAPISAN PADA DIAGRAM
1	Lapisan Atas	0 - 40 m	Endapan Alluvial kerikil, pasir dan selipan lanau lempung	
2	Lapisan - 01	40-110 m	Lempung kelanauan	
3	Lapisan - 02	110-165 m	Lanau Pasiran	
4	Lapisan - 03	165-220 m	Breksi rekahan bercampur pasir	
5	Lapisan - 04	220-300 m	Breksi rekahan rendah hingga sedang	

Table 5. Interpretation of Kabiding's B2 Stretch

NO	URUTAN LAPISAN	KEDALAMAN	PERKIRAAN JENIS MATERIAL	WARNA LAPISAN PADA DIAGRAM
1	Lapisan Atas	0-40 m	Breksi rekahan sedang - tinggi	
2	Lapisan - 01	40-55 m	Endapan Alluvial kerikil, pasir dan selipan lanau lempung	
3	Lapisan - 02	55-150 m	Lempung kelanauan	
4	Lapisan - 03	150-220 m	Lanau Pasiran	
4	Lapisan - 04	220-300 m	Breksi rekahan rendah hingga sedang	

(Source: Calculation Results, 2024).

Table 6. Recap of Aquifer Position in Pegunungan Bintang Regency

NO	LOCATION	KOORDINAT					FREE AQUIFER		DEPRESSED AQUIFER	
		B1		B2		ELV	B1	B2	B1	B2
1	Arinkop	4° 55' 54.98"	140° 38' 3.541"	4° 55' 54.98"	140° 38' 3.541"	1312 m	-	-	230 - 300 m	230 - 300 m
2	Oksibil Airport	4° 54' 26.36"	140° 37' 51.64"	4th 54' 26.4"	140° 38' 3.589"	1321 m	-	-	250 - 300 m	225 - 300 m
3	Dabolding Office	4° 54' 33.42"	140° 36' 53.58"	4° 54' 33.42"	140° 36' 53.58"	1364 m	-	-	230 - 300 m	165 - 270 m
4	Kabiding	4° 53' 57.25"	140° 37' 13.63"	4° 53' 57.25"	140° 37' 13.63"	1340 m	-	0 - 40 m	-	-
5	Oksibil Regent Office	4° 53' 31.79"	140° 38' 29.75"	4° 53' 31.79"	140° 38' 29.76"	1446 m	-	-	220 - 300 m	220 - 300 m
6	Oksibil Health Center	4° 54' 25.25"	140° 38' 1.966"	4° 54' 25.26"	140° 38' 1.966"	1322 m	-	-	125 - 165 m	210 - 300 m
7	Oksibil Hospital	4° 54' 7.041"	140° 35' 54.27"	4° 54' 7.041"	140° 35' 54.27"	1336 m	195 - 240 m	165- 195 m	240 - 300 m	240 - 300 m
8	Behind the Gas Station	4° 54' 46.88"	140° 38' 13.02"	4° 54' 46.89"	140° 38' 13.03"	1296 m	-	-	215 - 300 m	215 - 300 m
9	Terminal Pasar Baru	4° 55' 11.43"	140° 38' 0.739"	4° 55' 11.43"	140° 38' 0.739"	1348 m	-	-	220 - 300 m	215 - 300 m
10	YAPIMAKOT	4° 53' 43.91"	140° 35' 38.83"	4° 53' 43.91"	140° 35' 38.83"	1377 m	-	-	220 - 300 m	220 - 300 m

The results of the recap of geoelectric measurements, lithological analysis and resistivity values, show that only the Kabiding research site has a free aquifer with a thickness ranging from 0 to 40 m calculated from the ground surface. Meanwhile, in other locations such as Arinkop, Oksibil Airport, Dabolding Office, Oksibil Regent Office, Oksibil Health Center, Behind Gas Stations, Pasar Baru Terminal, and Yapimakot there are no free aquifers. This shows that the availability of surface groundwater in Pegunungan Bintang Regency is not high enough except in the Hospital area where there is no surface aquifer.

As for the pressurized aquifer, it can be found at a depth varying between 125 – 270 m from the ground level with the thickness of the aquifer layer between 20 -85 m, with the deepest aquifer location found at the location of Arinkop, Oksibil Airport, Oksibil Regent Office, Oksibil Hospital, Behind the Gas Station, Pasar Baru Terminal and Yapimakot with a depressed aquifer depth of 215 - 250 m, Meanwhile, in other research locations, the depth of the depressed aquifer is in the range of 125 – 165 m from the ground surface.

Aquifer Depth Distribution Map

The approximate position of the aquifer, its depth and distribution can be identified based on the resistance data from the geoelectric test. The method is carried out by combining several data from the results of geolysis testing so as to produce a cut of the longitudinal direction of the underground section from the location being reviewed. The longitudinal cut is made and adjusted to the direction of taking geoelectric data (B1 and B2) in accordance with the data from the geoelectric test in the previous discussion, which can be seen in the layout and longitudinal cut of the geoelectric. The distribution of groundwater level depth was carried out using groundwater depth data for each test point (data analysis results) and using *the Inverse Distance Weighted (IDW) method* with the help of the ArcGis assistance program.

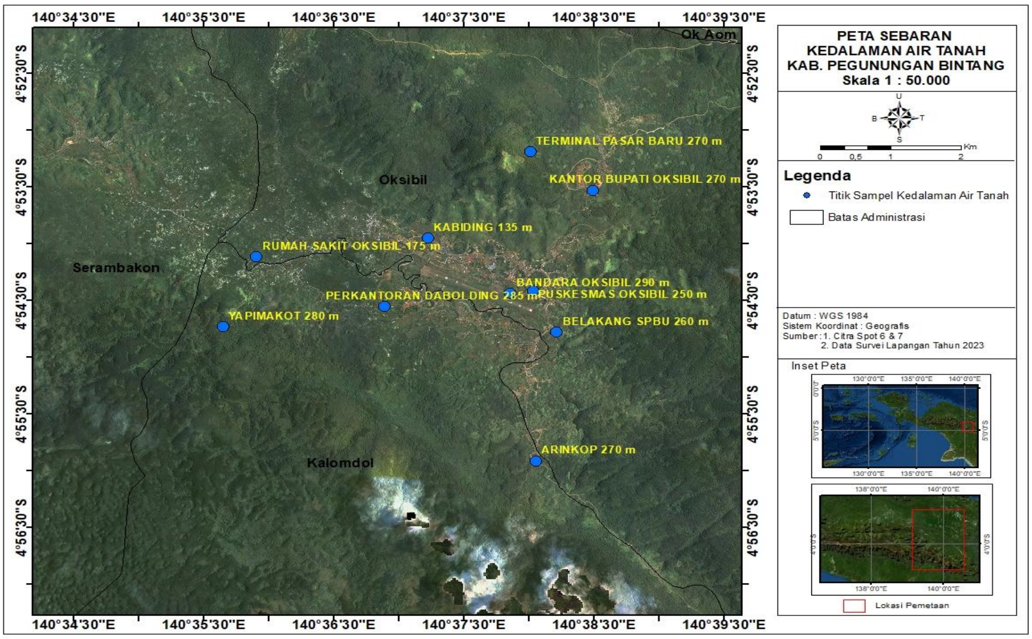


Figure 6. Map of the Depth of Aquifer Observation Point of Pegunungan Bintang Regency

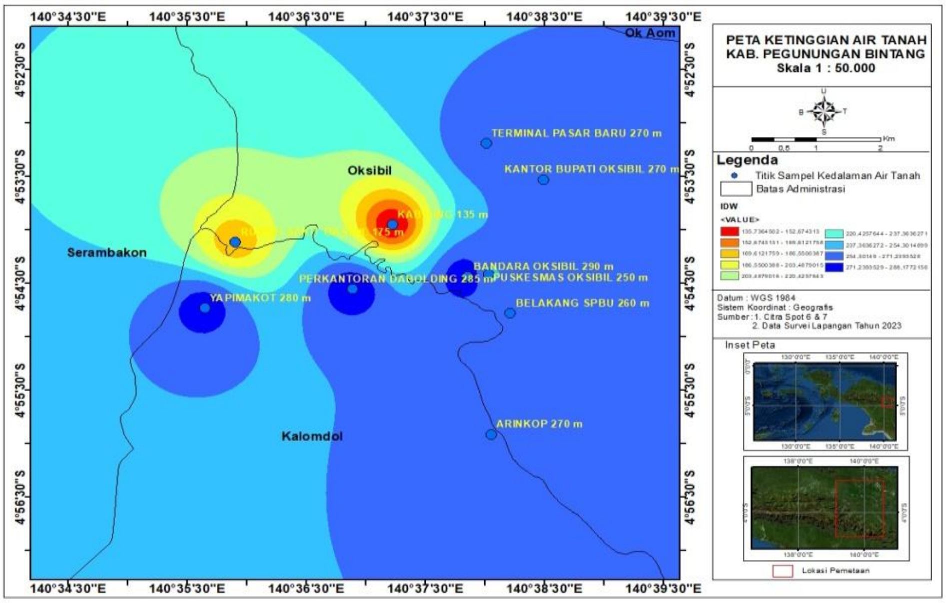


Figure 7. Map of the Distribution of Groundwater Depth in Pegunungan Bintang Regency

5. Geoelectric Longitudinal Layout and Pieces

The stratigraphic depiction of the subsurface soil layer in the longitudinal direction aims to obtain an overview of the location, depth and distribution of the aquifer from each review area (Kabaputen Capital District). From the results of the depiction, it can be seen that the type of soil layer on the surface, the waterproof zone/layer which is the layer before the aquifer, the depth of the aquifer, the slope and the location of the aquifer along the longitudinal cut plane.

In general, for the eight districts that have been geoelectric surveys, the position of the aquifer is at a depth of more than 150 m below the ground level, even for some districts

the position of the aquifer can be identified at a depth of 200 m below the ground level, such as Pegunungan Bintang Regency while for some districts such as Jayawijaya, Tolikara and Central Mamberamo Regencies there is surface groundwater with a depth of less than 50 m (detailed data can be seen in the data groundwater potential in each district and drill point recommendations).
For the next time, the depth and position of the aquifer can be seen in figure 8 longitudinal pieces of geoelectric test results in Pegunungan Bintang Regency.

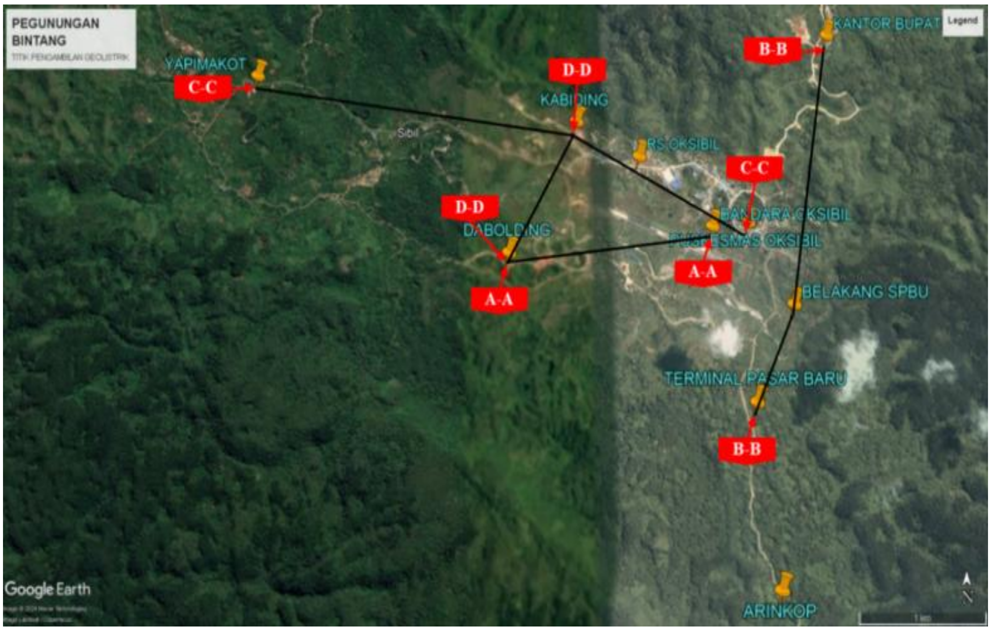


Figure 8. Layout of Long Section Geoelectric in Pegunungan Bintang Regency

From the results of the depiction, it can be seen that the type of soil layer on the surface, the waterproof zone/layer which is the layer before the aquifer, the depth of the aquifer, the slope and the location of the aquifer along the longitudinal cut plane. In general, the position of the aquifer in the Bintang Mountains district is at a depth of more than 200 m below the ground level.

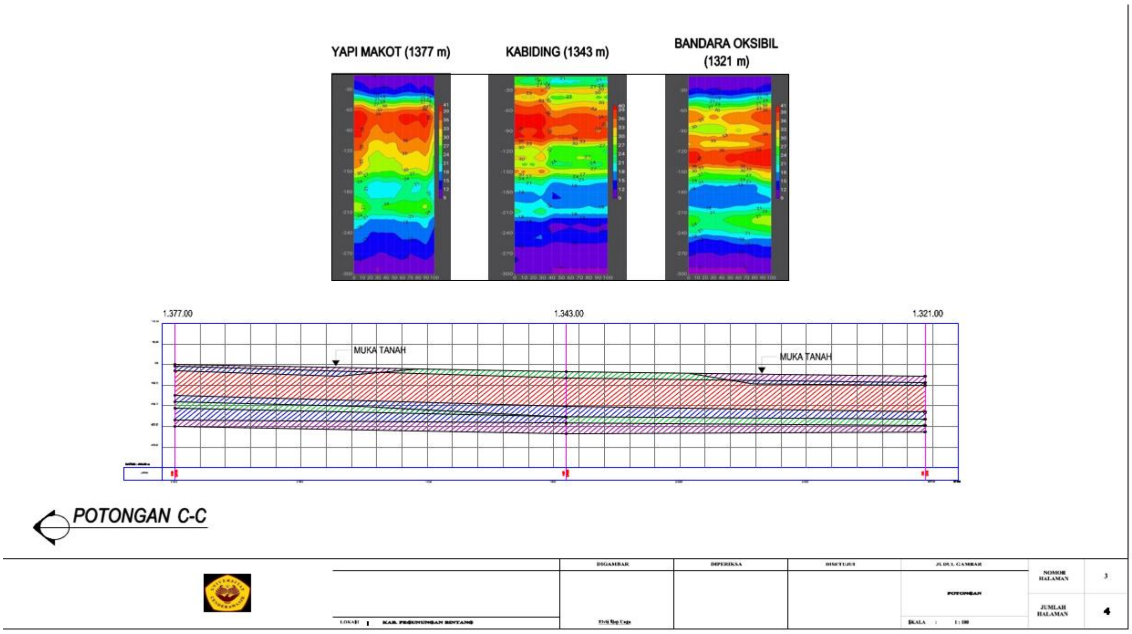


Figure 9. Longitudinal Cut of Geoelectric in Pegunungan Bintang Regency

Conclusion

This study conducted in Pegunungan Bintang Regency, specifically in Oksibil District, reveals significant insights into groundwater potential. The research identified that only the Kabiding location contains a free aquifer, with a thickness ranging from 0 to 40 meters below ground level. Other locations, such as Arinkop, Oksibil Airport, Dabolding Office, and Oksibil Regent Office, lack free aquifers but possess pressurized aquifers at depths varying between 125 and 300 meters. The thickness of these pressurized aquifers ranges from 20 to 85 meters.

The research highlights the challenging conditions for surface water availability in most parts of Pegunungan Bintang Regency. However, the findings offer valuable contributions to groundwater resource management by providing detailed mapping of aquifer locations and depths. The utilization of advanced geophysical methods, such as the AIDU Golden Rod instrument, underscores the potential for precise subsurface exploration. This study establishes a foundation for future research and practical applications aimed at optimizing groundwater use and addressing water scarcity challenges in remote and topographically complex regions.

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