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Estimation of Groundwater Potential Using Geoelectric Methods in East Kupang Region, Kupang Regency, East Nusa Tenggara Province

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KEYWORDS

Geoelectric, Type Resistance, Aquifers, Schlumberger, Interpretation.

ABSTRACT

This study aims to analyze rock units containing aquifers in the study area using geoelectric measurements using the Schlumberger configuration method using the Resistivity Meter MC OHM 2115. Measurements were carried out as many as 12 measurement points and the length of each track was 150 m. The data processing of the measurement results was carried out using IP2WIN software followed by using Corel Draw X6 software. The results of the interpretation of 12 measurement points showed that there were 5 units of rock, namely 0 ≤ 2 Ohm m type resistance interpreted in the form of clay. The 2.5 ≤ 10 Ohm type of prisoner is interpreted as a napal. The 10.5 ≤ 20 Ohm type resistance is interpreted as napalan limestone, while the ≥ 20.5 Ohm m type resistance is interpreted as reef limestone. The aquifer in the study area is interpreted to be in layers of sand, gravel, gravel, and bolder. which is immediately terminated with an impermeable layer like clay. Based on the results of the interpretation, it was concluded that along the 12 measurement points there were only 11 aquifer points with varying depths, which could be optimized by making dug wells at points KT 01, KT 05, KT 11, KT 14 and KT 15, drilling work at points KT 02, KT 12, KT 21 and KT 22. But the location of KT 19 can be carried out well work at a depth of 7m – 20m and drilling work at a depth of 45m – 101. The KT 20 location can also be carried out well work at a depth of 8m-21m and drilling work at a depth of 44m – 102m.

1. INTRODUCTION

Groundwater is water that is found in the soil layer or rocks below the soil surface. Groundwater resources obtained from groundwater are generally directly used to meet daily clean water needs. Rainfall is the main source of groundwater in addition to other sources. The hydrological cycle plays an important role in tracing the origin of groundwater. Groundwater has a very important role, especially in maintaining the balance and availability of water raw materials for household and industrial purposes (EKARINI, 2021).

Water is a basic need for the people of NTT in various needs such as households or other public facilities. With the increasing pace of development in various fields, as well as the rate of growth and development of the population that continues to increase day by day, the carrying capacity in several locations is increasingly limited due to poor management of water catchment areas.

Kupang Regency is one of the regions in the province of NTT which consists of 24 sub-districts, one of which is East Kupang District.

East Kupang District is known as a food barn for Kupang Regency and Kupang City because it has the largest agricultural area ± 4096.2 Ha.

To find out the location of water sources and to be able to map the location of water sources and the potential of groundwater, it is necessary to conduct a survey to get a clear picture related to the location (coordinates), potential (discharge), and distribution of water in the East Kupang District area.

In the groundwater potential mapping survey activity, the data information needed both through primary and secondary data is in the form of drilled well data, dug well data, and discharge from each water source.

According to the background and problems above, a survey and mapping of groundwater potential in the East Kupang area, Kupang Regency is needed, which is expected to provide information to the surrounding community or agencies that will carry out drilling or excavation of the soil to get water can clearly know the areas with good potential.

This study aims to identify the types of rocks found in the research area, analyze the results of geoelectric measurements using the Schlumberger configuration resistivity method, and determine locations with groundwater potential based on the geophysical data obtained.

2. METHOD

This research was carried out in the East Kupang area, Kupang Regency, East Nusa Tenggara Province, with the research period lasting from October 1 to November 28, 2024.

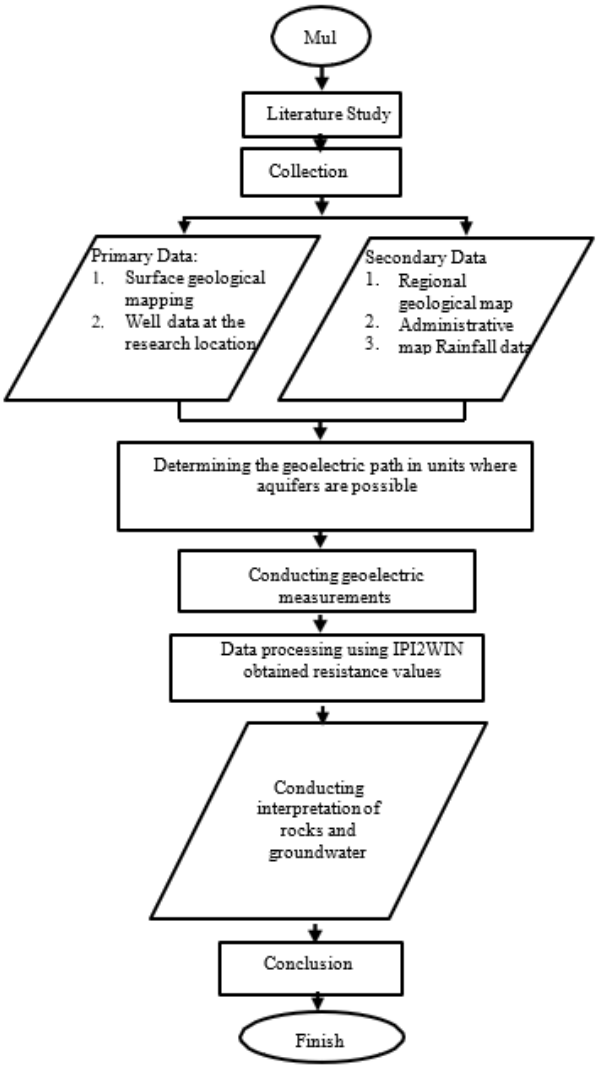

Figure 1. Research Flow

The results of geoelectric surveys and measurements in East Kupang District, Kupang Regency include in Manusak Village, Oefafi Village and Tanah Putih Village, After the management and interpretation of geological data, lithological and aquifer cross-sectional maps were obtained.

Based on the results of the interpretation, it is associated with the possibility of an aquifer, namely when viewed from the side of rocks in East Kupang District such as sand, gravel, crab, bolder, are rocks that have high enough porosity so that they can function well as a place for

groundwater infiltration because they are permeable and have high porosity, causing a great chance of finding aquifers along the research area. It is also suspected that this layer of permeable rock is also ended with an impermeable like clay.

Thus, based on the results of the interpretation, the author conjectured that along the research area, namely East Kupang District, aquifers can be found.

Geolistrik

The geoelectric method or known as type resistance measurement is a geophysical method that can be used in hydrogeological research. The basis of this geoelectric method is to conduct current into the earth through current electrodes and measure its potential on the earth's surface using potential electrodes .

This method is carried out by using a direct electric current injected through two current electrodes into the earth, then observing the potential formed through two potential electrodes located elsewhere (Telford et al., 1990). To determine the deep subsurface structure, the distance between the current electrode and the potential electrode is gradually increased. The larger the electrode spacing, the deeper the downward current penetration effect. The relationship between the resistance value of the rock type with the potential difference and the electric current injected into the soil is as follows:

$$\rho a = \frac{dV}{I} \times K$$

ρa = Apparent resistivity value (ΩM)
dV = The voltage generated from the current injection (V)
I = Injected current (A)
K = Geometric factors that depend on the span distance (AB/2)

$$= \pi \frac{AB^{\angle} - MN^{\angle}}{4MN}$$

Schlumberger Configuration Method The use of the Schlumberger method was first carried out by Conrad Schlumberger in 1912. The advantage of this configuration is the ability to detect the non-homogeneity of rock layers on the surface by comparing the apparent resistivity value when the potential electrode distance (MN/2) occurs and is very suitable for sounding measurements, namely the investigation of subsurface resistivity in the vertical direction, carried out by means of a fixed size point, the electrode distance of current and voltage is changed and among these four methods the Schlumberger method is the most efficient and It is easy to implement in the field and is suitable for measuring instruments such as the one used in this study, namely Mc OHM. 2115 with high accuracy and can display a voltage of at least 2 digits after a comma.

The working principle of the Schlumberger method is to conduct an electric current into the ground with a low frequency (0.1 - 1.0 Hz) through a pair of electrodes A and B, and then the potential difference is measured on a pair of potential electrodes M and N that are symmetrical to A and B.

List of Type Prisoner Values

Based on research that has been conducted previously by Telford et al. in 1976. Then there is further research conducted by M. H Loke in

2000 so that it classifies the resistance of several rocks into the following table:

Table 1. List of Type Prisoner Values

Material	Resistivity (Ω m)
Clay	0.1 - 50
Marls	2 - 50
Limestone	$20 - 4 \times 10^{2}$
Granite	$5 \times 10^{3} - 10^{4}$
Quartz	$10^{2} - 2 \times 10^{6}$
Sandstone	8 – 100

(Source: Directorate General of Water Resources, 2003)

3. RESULT AND DISCUSSION

Data Analysis

Interpretation of Rock Units

The results of geoelectric surveys and measurements in East Kupang District, Kupang Regency include in Manusak Village, Oefafi Village, and Tanah Putih Village. After the management and interpretation of geological data, a cross-sectional map of lithology and aquifers was obtained.

Based on the results of the interpretation, it is associated with the possibility of an aquifer, namely when viewed from the side of rocks in East Kupang District such as sand, gravel, crab, bolder, are rocks that have high enough porosity so that they can function well as a place for groundwater infiltration because they are permeable and have high porosity, causing a great chance of finding aquifers along the research area. It is also suspected that this layer of permeable rock is also ended with an impermeable like clay.

Thus, based on the results of the interpretation, the author conjectured that along the research area, namely East Kupang District, aquifers can be found. In the research area, the type of resistance that is suspected of containing aquifers is in the type of resistance that ranges from 20-200 Ohm m and the rocks are in the form of sand, gravel, kerakal, bolder. The aquifer in the study area is interpreted to be in layers of sand, gravel, gravel, and bolder. which is immediately terminated with an impermeable layer like clay. The type resistance in the study area is classified into several types of rocks, namely:

1. The value of 0 ≤ 9 Ohm m type resistance is grouped as a unit of clay formation.
2. The value of resistance of type 9 ≤ 15 Ohm m is grouped as a unit of sand clay formation
3. The value of resistance of type 15 ≤ 20 Ohm m is grouped as a unit of clay sand formation
4. The value of resistance of type 20 ≤ 200 Ohm m is grouped as a unit of sand, gravel, crab, bolder formation
5. The value of resistance of type 300 ≤ ~ Ohm m is grouped as a unit of clay formation.

Results of Geoelectric Measurement of Schlumberger Configuration Resistivity Method

Based on the geological map of the research area as a result of lithological interpretation and observation in the field, the placement of geoelectric measurement points was carried out. The placement is based on the discovery of outcrops, groundwater catchment areas, and around areas where there are dug wells and drilled wells. This is what

causing the determination of geoelectric measurement points cannot be carried out in all areas of East Kupang District, but only in areas that are strongly suspected of having the potential for the existence of aquaeries. This geoelectric measurement was carried out at 12 points around community dug wells, and also in

areas suspected of being groundwater catchment areas. The possibility of a layered aquifer is evidenced by the presence of wells dug around geoelectric tracks with varying depths. The data of dug wells and drilled wells are important to correlate the resistance values of the type and rocks observed in the drilled wells and the rocks at the groundwater level in the dug wells.

Based on the results of geoelectric measurements in the study area, it can be interpreted that aquifers exist along geoelectric measurement trajectories with varying depths. This is evidenced by the presence of community dug wells, and also based on the interpretation of type detention data with geoelectric measurements. Here are the results of his interpretation of the Geoelectric measurements:

1. KT 01 Measurement Point
   The measurement location is located in Kilodoki, Manusak Village, East Kupang District. This measuring point is at coordinates (S 10°05'34.20", E 123°51'51.69") with an elevation of 29 meters above sea level. The rock units found at this point are from the top soil, clay, gravel sand, clay. The aquifer is found between the sand and gravel units that are smashed with a layer of clay. The aquifer is at a depth of ± 21.157 m – 36, 457 m underground with a thickness of ± 15.3 m. At this location, it is recommended to make dug wells.

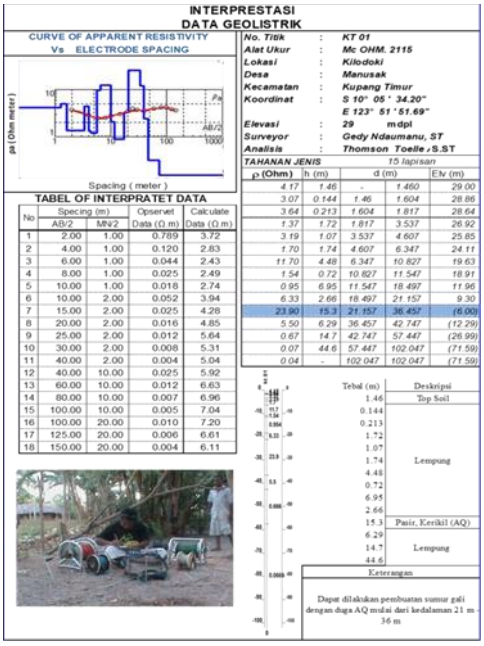

Figure 2. Interpretation of KT 01 Measurement Point (author, 2024)

2. KT 02 Measurement Point
   The measurement location is located in Kuledoki, Manusak Village, East Kupang District. This measuring point is at coordinates (S 10°05'53.1" , E 123°52'0.96") with an elevation of 30 meters above sea level. The rock units found at this point are from the top soil, sand, gravel, and clay units. The aquifer is found between the sand and gravel units that are smashed with a layer of clay. The aquifer is at a depth of ± 21,373 m – 42,793 m underground with a thickness of ± 21.42 m. At this location, drilling is recommended.

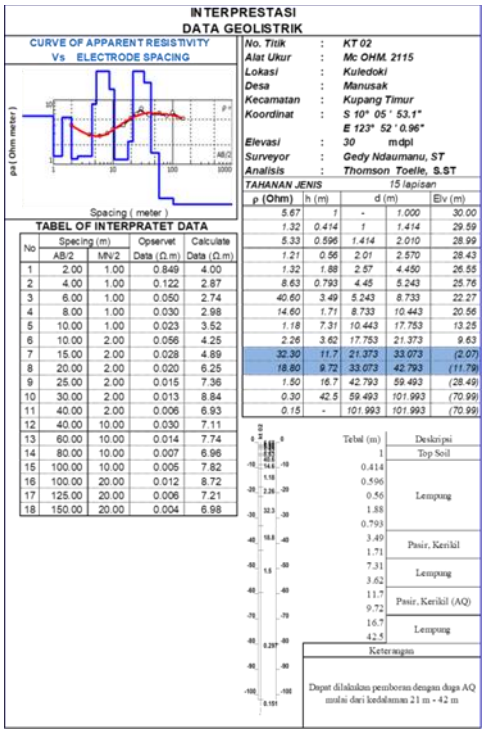

Figure 3. Interpretation of KT 02 Measurement Points (author, 2024)

3. KT 05 Measurement Point
   The measurement location is located in Kilodoki, Manusak Village, East Kupang District. This measuring point is at coordinates (S 10°05'47.1" , E 123°52'1.8") with an elevation of 31 meters above sea level. The rock units found at this point are from the top soil unit, clay, sand, gravel, clay. The aquifer is found between the sand and gravel units that are smashed with a layer of clay. The aquifer is at a depth of ± 9.09 m – 18, 930 m underground with a thickness of ± 9.84 m. At this location, it is recommended to make a dug well.

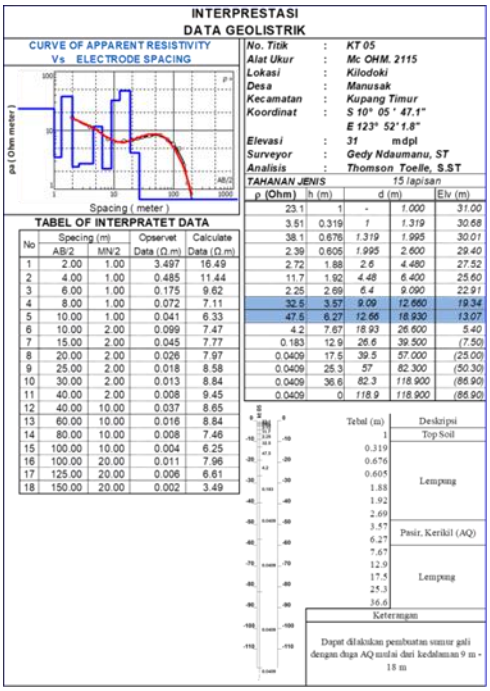

Figure 4. Interpretation of KT 05 Measurement Points (author, 2024)

4. KT 08 Measurement Point
   The measurement location is located in Kuledoki, Manusak Village, East Kupang District. This measuring point is at coordinates (S 10°05'57.8" , E 123°51'59.3") with an elevation of 29 meters above sea level. The rock units found at this point are from the top soil unit, clay, sand clay, clay. It is suspected that it does not contain aqiver so that drilling or digging wells is not recommended at this location.

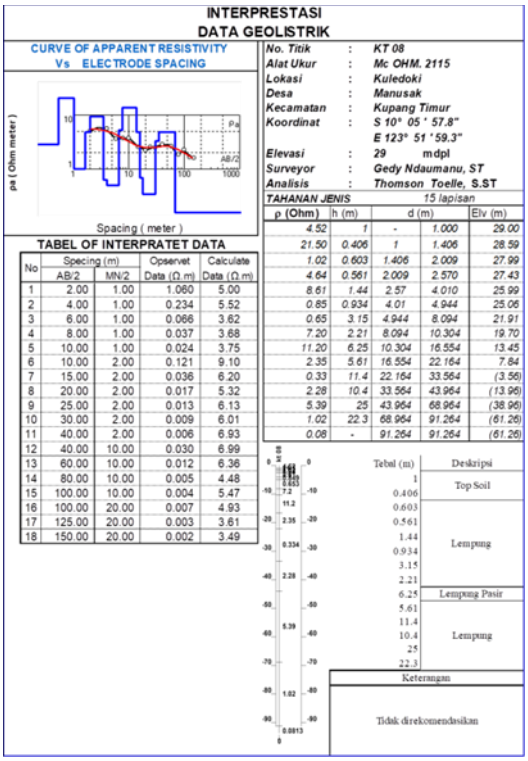

Figure 5. Interpretation of KT 08 Measurement Points (author, 2024)

5. KT 11 Measurement Point
   The measurement location is located in Nefomalo, Oefafi Village, District. East Kupang. This measuring point is at coordinates (S 10°08'06.3", E 123°48'08.9") with an elevation of 30 meters above sea level. The rock units found at this point are from the top soil unit, clay, bolder, clay, sand, gravel, clay. The aquifer is found between the sand and gravel units that are smashed with a layer of clay. The aquifer is at a depth of ± 7 m – 17 m underground with a thickness of ± 10 m. At this location, it is recommended to make a dug well.

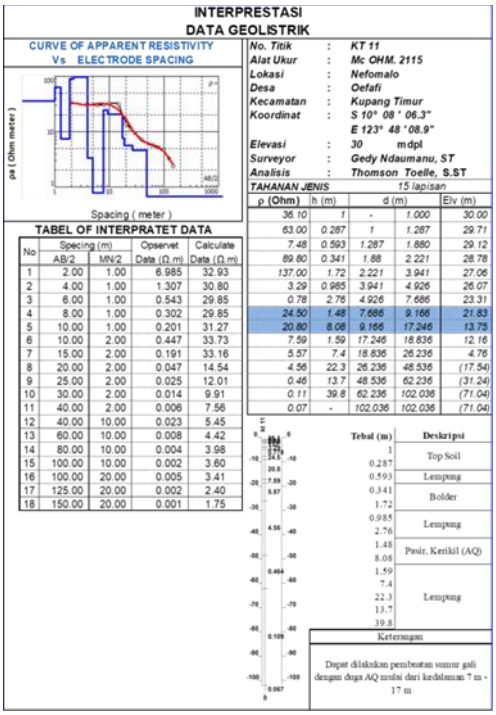

Figure 6. Interpretation of KT 11 Measurement Points (author, 2024)

6. KT 12 Measurement Point
   The measurement location is located in Nefomalo, Oefafi Village, East Kupang District. This measuring point. located at coordinates (S 10°08 '01.5" , E 123°48'09.2") with an elevation of 32 meters above sea level. The rock units found at this point are from the top soil unit, (sand, gravel, gravel, bolder), clay, sandy clay, clay, (sand, gravel), clay. The aquifer is found between the sand and gravel units that are smashed with a layer of clay. The aquifer is at a depth of ± 66 m – 102 m underground with a thickness of ± 36 m. At this location, drilling work is recommended.

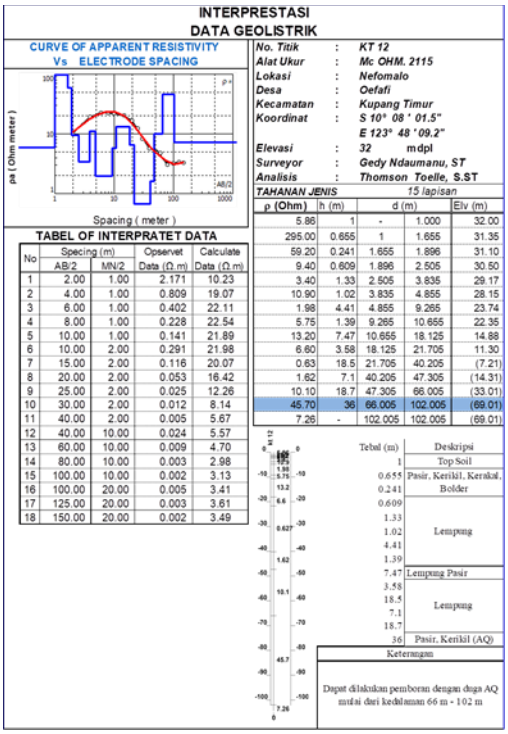

Figure 7. Interpretation of KT 12 Measurement Points (author, 2024)

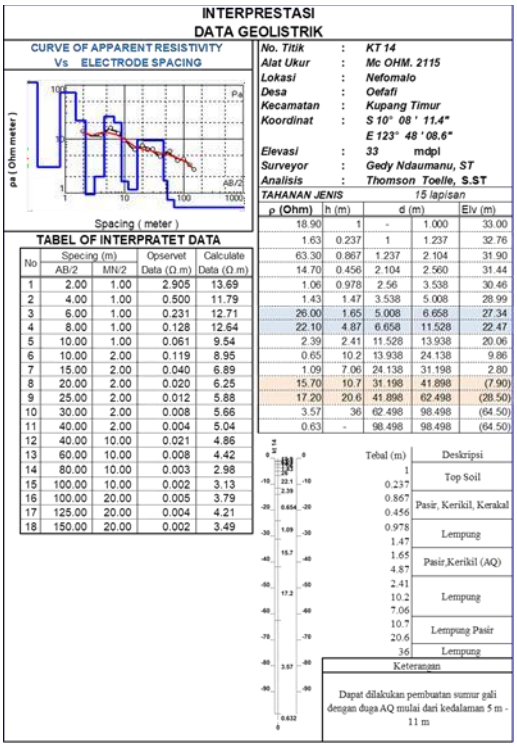

Figure 8. Interpretation of KT 14 Measurement Points (author, 2024)

7. KT 14 Measurement Point
   The measurement location is located in Nefomalo, Oefafi Village, East Kupang District. This measuring point is at coordinates (S 10°08'11.4" , E 123°48'08.6") with an elevation of 33 meters above sea level. The rock units found at this point are from the top soil unit, (sand, gravel, gravel), clay, (sand, gravel), clay, sandy clay, clay. The aquifer is found between the sand and gravel units that are smashed with a layer of clay. The aquifer is at a depth of ± 5 m – 11 m underground with a thickness of ± 6 m. At this location, it is recommended to make a dug well.

8. KT 15 Measurement Point
   The measurement location is located in Adol Sine, Oefafi Village, East Kupang District. This measuring point is at coordinates (S 10°07 '54.45" , E 123°48'10.91") with an elevation of 27 meters above sea level. The rock units found at this point are from the top soil unit, clay, sandy clay, (sand, gravel), clay. The aquifer is found between the sand and gravel units that are smashed with a layer of clay. The aquifer is at a depth of ±10 m – 22 m underground with a thickness of ± 12 m. At this location, it is recommended to make a dug well.

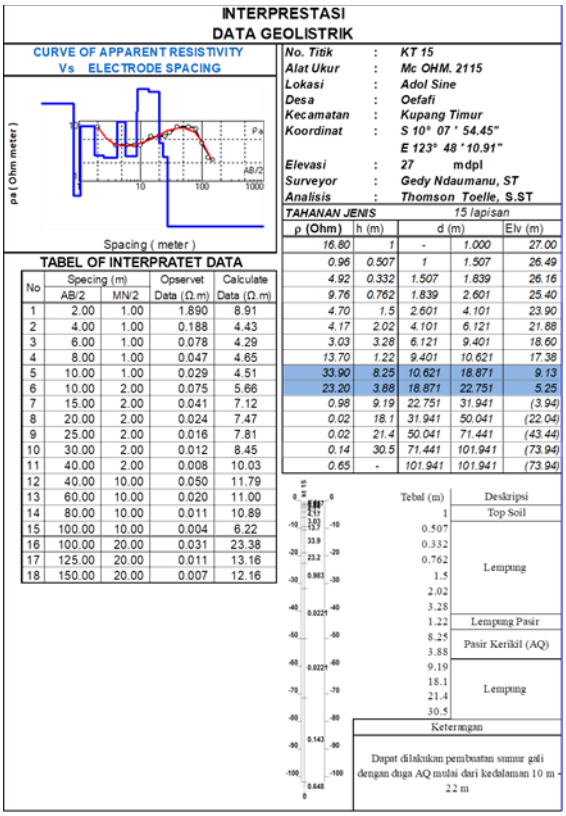

Figure 9. Interpretation of KT 15 Measurement Points (author, 2024)

9. KT 19 Measurement Point

The measurement location is located in Hamlet V, Tanah Putih Village, East Kupang District. This measuring point is at coordinates (S 10°08'4.78", E 123°45'17.66") with an elevation of 78 meters above sea level. The rock units found at this point are from the top soil unit, clay, (sand, gravel, gravel, bolder), (sand, gravel, gravel, clay), gravel sand, clay. At this location there are 2 layers of aqiver, namely the first aquifer is found between the sand units of ragrace gravel that are covered with a layer of clay, found at a depth of ± 7 m to 20 m, on this aqiver is recommended for the construction of dug wells with an aqiver thickness of ±13 meters. For the second aquifer, there are between sand and gravel units at a depth of ±45 m to 101 m, with an aqiver thickness of ±56 m, on this aqiver it is recommended to drill.

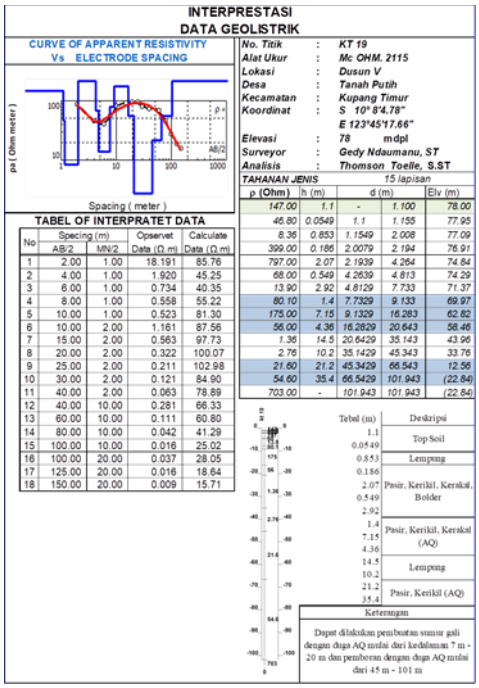

Figure 10. Interpretation of the Measurement Point KT 19 (author, 2024)

10. KT 20 Measurement Point

The measurement location is located in Hamlet V, Tanah Putih Village, East Kupang District. This measuring point is at coordinates (S 10°08'5.71", E 123°45'11.82") with an elevation of 78 meters above sea level. The rock units found at this point are from the top soil unit, clay, (sand, gravel, gravel, bolder), (sand, gravel, gravel, clay), clay, gravel sand, clay. At this location there are 2 layers of aqiver, namely the first aquifer is found between the sand units of gravel that are crushed with a layer of clay, found at a depth of ± 8 m to 21 m, on this aqiver is recommended for the construction of dug wells with an aqiver thickness of ±13 meters. For the second aquifer, there are between sand and gravel units at a depth of ±44 m to 102 m, with an aqiver of ±58 m, in this aqiver it is recommended to be drilled.

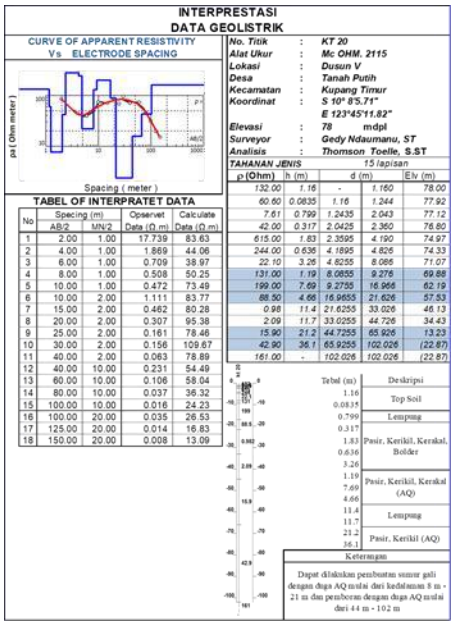

Figure 11. Interpretation of KT 20 Measurement Points (author, 2024)

11. KT 21 Measurement Point

The measurement location is located in Housing, Tanah Putih Village, East Kupang District. This measuring point is at coordinates (S 10°08'6.21", E 123°45'5.42") with an elevation of 69 meters above sea level. The rock units found at this point are from the top soil unit, clay, (sand, gravel, gravel, bolder), clay, (sand, gravel, gravel), clay. The aquifer is found between the sand units of crusty gravel that are enchanted with a layer of clay. The aquifer is at a depth of ± 14 m – 45 m underground with a thickness of ± 31 m. At this location, it is recommended that drilling work be carried out.

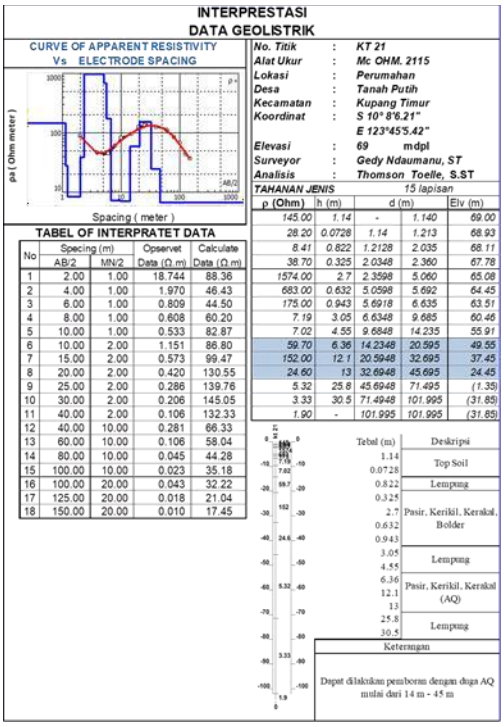

Figure 12. Interpretation of KT 21 Measurement Points (author, 2024)

12. KT 22 Measurement Point

The measurement location is located in Housing, Tanah Putih Village, East Kupang District. This measuring point is at coordinates (S 10°08'3.83", E 123°44'57.90") with an elevation of 69 meters above sea level. The rock units found at this point are from the top soil unit, clay, sand, (sand, gravel, bolder), (gravel sand), clay, (sand, gravel, gravel), clay. The aquifer is found between the sand units of crusty gravel that are enchanted with a layer of clay. The aquifer is at a depth of ± 17 m – 50.6 m underground with a thickness of ± 33.6 m. At this location, it is recommended that drilling work be carried out.

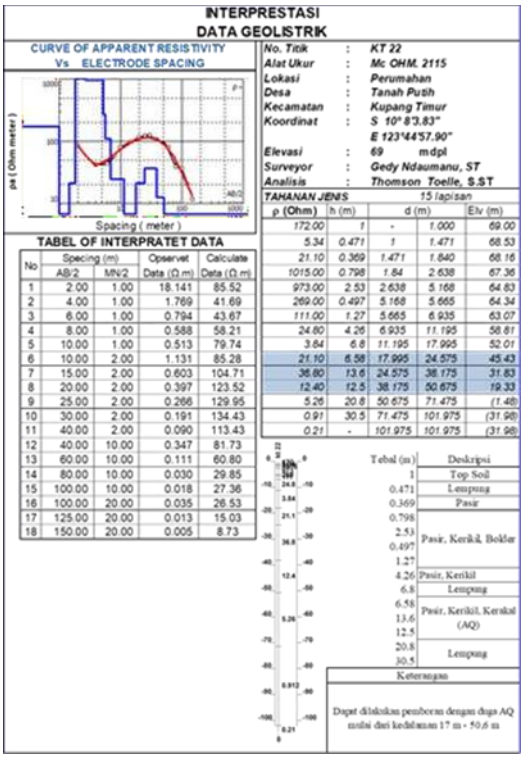

Figure 13. Interpretation of KT 22 Measurement Points (author, 2024)

Correlation Pieces of Interpretation Results

The following is a piece of geological cross-section correlation as a result of interpretation from resistivity data and field observations.

1. Cross-Section Geoelectric Measurement Points KT 19 – KT 20 – KT 21 – KT 22.

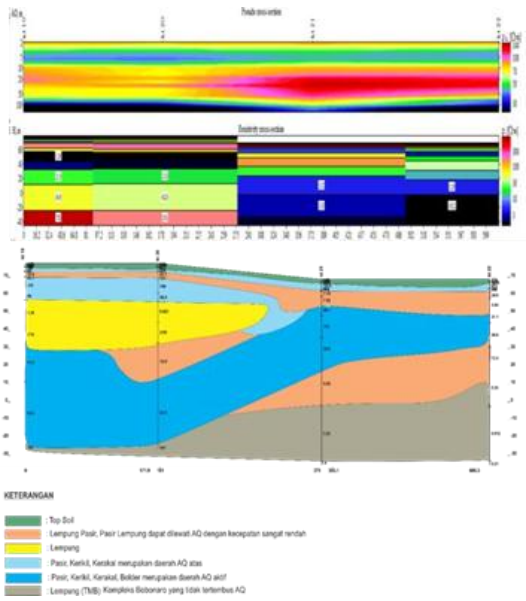

Figure 14. Correlation Pieces of Geoelectric Point Cross-section KT 19 – KT 20 – KT 21 – KT 22 (author, 2024)

In the cross-sectional correlation cut shown in figure 14. It can be seen that the results of the interpretation of the type resistance value state that the four measurement points have relatively the same rock layers, which consist of sand, gravel, crab, bolder and clay rock units. In this piece, all points are suspected to have active AQ.

2. Cross-Section Geoelectric Measurement Points KT 12 – KT 11 – KT 14 – KT 15

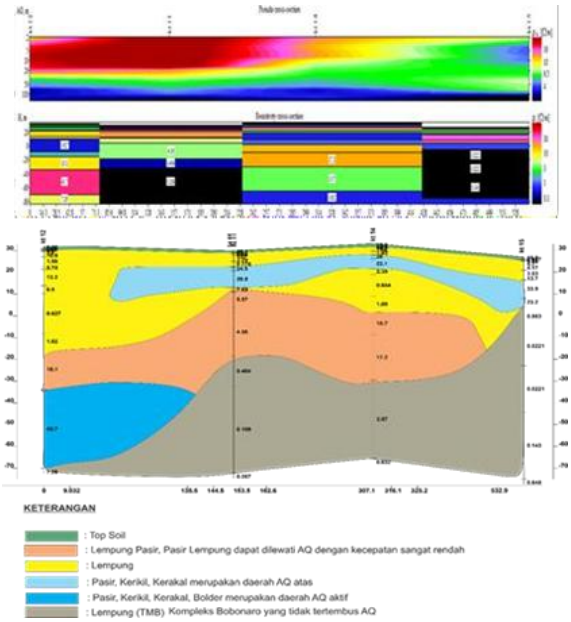

Figure 15. Correlation Pieces of Geoelectric Point Cross-section KT 12 – KT 11 – KT 14 – KT 15 (author, 2024)

In the cross-sectional correlation cut shown in figure 15. It can be seen that the results of the interpretation of the type resistance value state that the four measurement points have relatively the same rock layers, which consist of sand, gravel, crab, bolder and clay rock units. At KT 12 point only those that have an active AQ.

3. Cross-Section Geoelectric Measurement Points KT 19 – KT 20 – KT 21 – KT 22

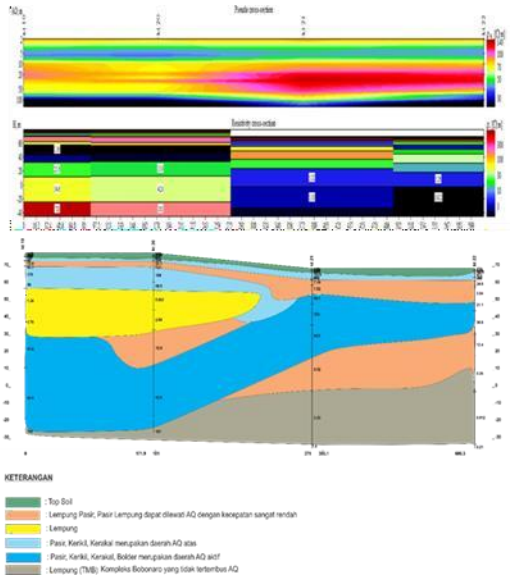

Figure 16. Correlation Pieces of Geoelectric Point Cross-section KT 19 – KT 20 – KT 21 – KT 22 (author, 2024)

In the cross-sectional correlation cut shown in figure 16. It can be seen that the results of the interpretation of the type resistance value state that the four measurement points have relatively the same rock layers, which consist of sand, gravel, crab, bolder and clay rock units. In this piece, all points are suspected to have active AQ.

4. CONCLUSION

The results showed that the rocks in the study area consisted of sand, gravel, gravel, and boulder with a type resistance value ranging from 20-200 Ohm.m, which indicates the potential for an aquifer. The results of the Schlumberger configuration resistivity method geoelectric measurements at several points showed the presence of aquifer layers at various depths, with variations in thickness and different rock characteristics in each location. Some points such as KT 01, KT 05, KT 11, KT 14, and KT 15 have the potential for well excavation, while points KT 02, KT 12, KT 21, and KT 22 are more suitable for drilling. The KT 19 and KT 20 points have potential for both dug and drilled wells. Based on these findings, it is recommended that the research be followed up with drilling activities to optimize the potential of existing groundwater. In addition, further research with different geoelectric configurations can be carried out to obtain more accurate results. Additional measurements in other villages in the East Kupang District area are also needed to obtain a more comprehensive mapping of the potential for groundwater in the area.

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