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ESTIMATING GEOELECTRIC FOR THE CLEAN WATER NECESSITY PREDICTION (CASE STUDY: ABDUL RACHMAN SALEH AIRPORT MALANG)

Hirijanto[1*], Endro Yuwono[1], Annur Ma'ruf[1]
[1]Civil Engineering Department, National Institute of Technology Malang

*Corresponding Email: janto.hiri22@gmail.com

ABSTRACT: Abdul Rachman Saleh Airport of Malang plays a significant role in air transportation in Malang and its surroundings. The services provided at Malang Abdul Rachman Saleh Airport are expected to be the alternative solution to the high number of prospective passengers at Juanda Airport. However, it has an impact in the sense of the high public interest in utilizing Abdul Rachman Saleh Airport in Malang. Increasing airport service activities requires the fulfilment of supporting facilities and infrastructure, including raw water supply. Upon critical conditions such as sudden damage, it only relies on the PDAM Malang Regency water supply and in the long run, it is prone to water shortages. Therefore, it is required to have a pure water supply with raw water need analysis, raw water necessity estimation, and also the exploration for potential water resources that can be used as a clean water supply provider at Abdul Rachman Saleh Airport. The geoelectric method was used to explore the potential groundwater supply through a layer feature beneath the surface and the possibility of groundwater and minerals at a certain depth. Investigations related to topographic, physiographic, geomorphological, geological and hydrogeological conditions were carried out to analyze the potential for underground water around the Abdul Rachman Saleh airport area. Several location points were surveyed and measured to determine estimates of the availability of groundwater that were detected. The analysis results show there is potential for groundwater availability at three locations around the airport area which can be used as raw water reserves to meet the needs of clean water supply, which is predicted to reach 0.9 litres / second in 2036. As a natural water reserve, the need for clean water for Abdul Rachman Saleh Airport Malang services is predicted to be fulfilled.

Keywords: Groundwater Exploration, Geoelectric, Clean Water Service.

1. Introduction

Abdul Rachman Saleh Airport in Malang, as one of the air transportation terminals in East Java, plays a strategic role because the existence of Juanda Airport, which has the capacity to meet the needs of air transportation, is increasingly limited even though the airport has been expanded. Malang is considered the second-largest city after Surabaya, and Malang is a city of education and tourism are the ultimate reasons for the importance of Malang Abdul Rachman Saleh Airport. In addition, the characteristics of Malang as a support for other surrounding areas in the economic sector really need the fulfilment of air transportation modes for the mobility of the citizens.

Clean water is a basic need that cannot be replaced and abandoned, so water treatment and conservation efforts must be a concern for all clean water users so; that predictive analysis is necessary to meet the needs for clean water supply in the future [1]. Along with the increasingly dense transportation activities at Abdul Rachman Saleh Airport in Malang, the need for raw water to meet the airport's clean water services is also increasing; in fact, the existing clean water necessity still relies on bore wells as deep as 50 meters and water reservoirs with decreasing discharge. Limited locations under the authority of the Indonesian Air Force also make it difficult for operational and maintenance activities.

Meanwhile, the strategic location of Abdul Rachman Saleh Malang Airport as a new area provides sufficient space for the development of Malang's Abdul Rachman Saleh Airport area related to meeting the need for clean water for service in Malang's Abdul Rachman Saleh Airport area by utilizing the availability of groundwater. Groundwater is a water source that can be used if there are limited water sources on the ground or even if its availability cannot be found to meet human needs [2]. In addition, the use of groundwater to meet raw water needs for drinking and irrigation is more secure, especially during water shortages such as drought conditions [3].

Based on the existing conditions, an analysis of the need for clean water for services in Malang Abdul Rachman Saleh airport was carried out by conducting geoelectric estimation at the location around the airport based on the prediction of needs and the existing conditions of service fulfilment. Several methods are used to analyze the need for clean water use, and a combination of using the geoelectric resistivity method is applied to model subsurface geological conditions [4, 5, 6]. Groundwater exploration activities through geological and hydrogeological investigations with geoelectric estimation is a geophysical method wherein subsurface rock unit arrangement data is presented through the rock's electrical properties to identify conditions below the earth's surface. If there is an electric current with a single source flowing below the surface of the earth, the direction of the flow of electric current is to spread in all directions in a half-spherical space, as shown in Figures 1 [1, 7, 8, 9].

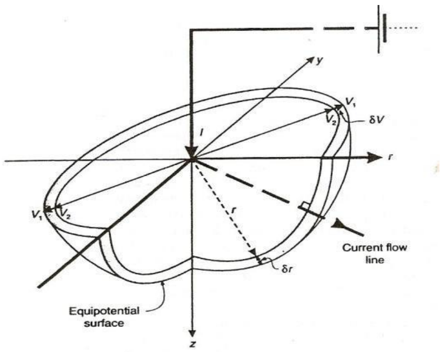

Figure 1. Electrical Characteristics of Rocks in Groundwater Observation

Data generated from geoelectric measurements in resistivity can be used for several needs, including geology, mining, archaeology and hydrology. This method can be used to detect rock layers up to a depth of 500 meters. Geoelectric estimation has several advantages, including an easy measurement process, the ability of the data obtained to be used as predictions, the relatively inexpensive equipment required, the short time allotment, and the fewer field personnel requirements that make this method more effective and economical [10].

The results of geoelectric measurements are plotted in a graphical form where abscissa (x) is the detected depth, and the ordinate (y) is the apparent resistivity (ρa). The processing stage is carried out to obtain the actual resistivity value (ρ). According to Suyono and Roy E. Hunt, the rock resistivity value is based on the rock material that can be used as a reference in analysis and interpretation, as shown in Tables 1 and 2.

Table 1. Rock Resistivity Cost, according to Suyono

Material	Resistivity Cost (Ohm meter)
Surface water	80-200
Groundwater	30-100
Silt-loam	10-200
Sand	100-600
Sand and Gravel	100-1000
Mud Stone	20-200
Sandstone	50-500
Conglomerate	100-500
Tufa	20-200
Andesite group	100-2000
Granite Group	1000-10000
Chert group, slate	200-2000

Table 2. Rock Resistivity Cost, according to Roy E. Hunt

Material	Resistivity Cost (Ohm meter)
Lempungan Land	1,5-3,0
Lanauan Clay	3,0-15
Tanah Lanau Pasiran	15-150
Moist bedrock	150-300
Kelanauan Pebble Sand	300
Non -Obsolete Base Rock	2400
Dry Pebble Sand	2400
There is Fresh Water	20-60
Salt Water	20-200
Chert group, slate	0,18-0,24

Survey trajectory points that can represent the research location are selected. The subsurface resistivity value obtained at each measurement point is correlated to obtain the subsurface (electro stratigraphic) section. Figure 2 is an example of the results of geoelectric data processing using the Schlumberger configuration, while Figure 3 illustrates an example of the result of interpreting the resistivity value.

This geoelectric estimation is simultaneously used to determine the required groundwater reserves based on an analysis of clean water needs. The need for clean water is grouped into two parts, namely domestic and non-domestic needs.

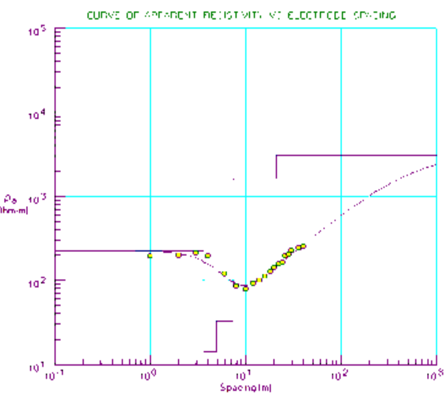

Figure 2. Example of Geoelectric Data Processing with Schlumberger Configurations

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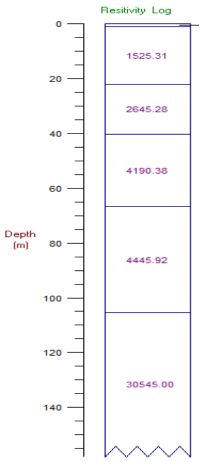

Depth (Meter)		Thickness (Meter)	Resitivity (Ohm.M)	Litology	Annotation
0	0.57	0.57	32	Soil Coverage	
0.57	3.79	32.73	4	Clay material	
3.79	11.9		5.7		
11.9	32.4		6.9		
32.4	33.3		0.2		
33.3	99.3	66	2458	Lava	
99.3	118.2	21.7	61.6	Sand	Aquifer
118.2	121		196.4		
121	150	29	1015	Breccia	

Figure 3 Example of Rock Resistivity Interpretation Result

The need for clean water is grouped into domestic and non-domestic. Domestic needs are water needs used for household purposes and public taps. Meanwhile, non-domestic needs are water needs for social facilities, places of worship, schools, hospitals, airports, dormitories, and commercial needs such as industry, hotels, trade, and public services [11]. The number of clean water needs is determined based on the city category and the number of inhabitants, as listed in Table 3 [12].

Table 3 Amount of Provision for Clean Water Need

City Category		Number of Inhabitants	Water Needs (lt/org/hr)
I	**(Metropolitan)**	> 1.000.000	190
II	**(Big)**	500.000 – 1.000.000	170
III	**(Medium)**	100.000 – 500.000	150
IV	**(Small)**	20.000 – 100.000	130
V	**(Village)**	10.000 – 20.000	100
VI	**(Small Village)**	3.000 – 10.000	60

Source: [12]

2. Method

Prediction analysis of clean water reserves at Abdul Rachman Saleh Airport Malang was carried out with several stages of research activities based on primary and secondary data tracing results. The stages in the prediction analysis of the fulfilment of the need for clean water services at Abdul Rachman Saleh Airport included:

1. *Analisis Data Analysis of Topography, Physiology, Geomorphology, Geology and Hydrogeology*

   Topographical data provides an overview of the height and lowness of an area as well as the height difference between the Abdul Rachman Saleh airport location in Malang to the surrounding area. Physiographic studies, with the help of aerial photograph interpretation, map the soil based on its classification, use, and properties. Geomorphological conditions can show the history of the formation of an area and can be used as a reference base for the development of the area. Geological data can provide an overview of the rock structures that comprise the topmost layer of the earth's crust. Hydrogeological analysis can describe the potentials of groundwater based on soil water basins and rock properties to water. Topography, physiography, geomorphology, geology and hydrogeology were obtained from published reference map data. This information was needed to assess available groundwater reserves near Malang Abdul Rachman Saleh Airport.
2. *Analysis of clean water need in Abdul Rachman Saleh Airport Malang*

   Fulfilling the need for clean water for service activities in the airport area was carried out by analyzing the number of passengers operating airlines, a predicting an increase in the flow of air transportation at Malang Abdul Rachman Saleh Airport. Data was collected by interviewing the airport authority manager of Abdul Rachman Saleh Malang.
3. *Analysis of Potential Groundwater*

   Using reference data and surveys in the previous stage was continued using the geophysical method with geoelectric estimation measurements to determine the presence of aquifers as one way to determine the presence of existing groundwater potential. Geoelectric measurements were carried out at several location points directly in the field so that an alternative potential for underground water could be obtained to meet the needs of clean water services at Abdul Rachman Saleh Airport in Malang. Furthermore, the data from geoelectric measurements were processed using geoelectric software and plotted in graphical form for later use in determining the resistivity value and adjusted for the resistivity value of the aquifer in the study area and the position of the value.
4. *Modelling of Geoelectric Analysis Result and Recommendation*

   The final result of geoelectric data processing was 3-dimensional modelling of geological structures and recommendations that could be provided following the analysis of the fulfilment of raw water services for clean water in the Abdul Rachman Saleh Airport Malang area.

3. Result and Discussion

3.1 Malang Abdul Rachman Saleh Airport Area

The Abdul Rachman Saleh airport area in Malang is located in Malang district, part of the Malang Raya area, to be exact, in Pakis Village, Malang district. The Location description is in Figure 4.

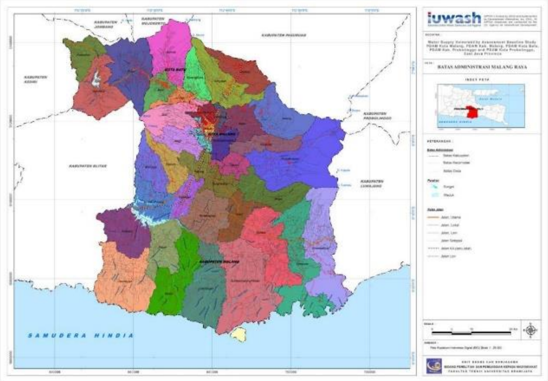

Figure 4 The Map of the Malang Raya Region

3.2 Topography, Physiography, Geomorpho logy, Geology, and Hydrogeology Analysis

Topographical map of Malang regency as in Figure 5. Topographically, almost the entire district of Malang consists of highlands and karst hills, which are a series of southern mountains. There are 18 large rivers located in the Malang district. The existing topographical conditions indicate potential large forestry, which constituted a sufficient groundwater storage source.

Figure 5 The Map of Malang Raya Region Topography

Meanwhile, the geomorphological map of the Malang Regency, as shown in Figure 6, gives an overview of the formation of the area. Thus, it is concluded that the condition in question allows airport area development.

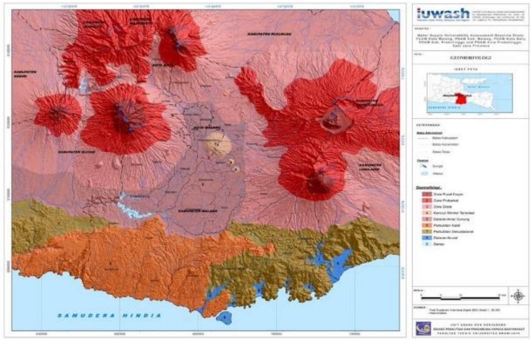

Figure 6 The Geomorphological Map of the Malang Raya Region

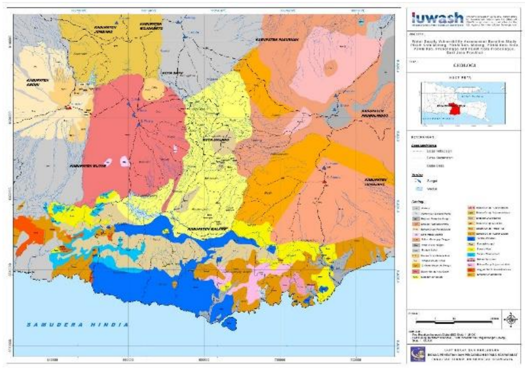

Figure 7 Geological Map of Malang Raya Region

The rocks found in Malang Regency are very diverse as this area is geologically located at the junction of three volcanic complexes, and some of them exist at the southern mountain route. The rocks encountered are sedimentary, intrusive igneous rocks, lava, and pyroclastic rocks resulting from the eruption of the surrounding mountains (Figure 7).

The potential for groundwater in an area is determined by rainfall, geology/rocks that can store and drain water (aquifers), and morphology. Malang district has two groundwater basins (CAT), namely the Brantas CAT, the cross-regency CAT, and the Sumberbening CAT. According to morphology, Malang Regency has potentially abundant groundwater because this area is an inter-mountain basin. The recharge area has high rainfall with constituent rocks that potentially become a good aquifer. Meanwhile, based on the characteristics of the rock, the aquifer character of Malang Regency can be divided into several units, as listed in Tables 4, 7, and 8.

Table 4 The Character of Aquifer of Malang District

No	Type of Aquifer	Stream Media	Trans missifity Aquifer	Shallow Upper Surface	Well Debit
1	mall Productive Aquifer	Interstices-Porosity	Very low	Very deep	-
2	Moderate productive local aquifer	Interstices and Intergranular porosity	Very Diverse	Deep	-
3	Moderate productive Aquifer with vast distribution	Interstices and Intergra nular porosity	Very Diverse	Deep	< 5 Litre/ second
4	Productive Aquifer with high vast distribution	Interstices and Intergra nular porosity	Very Diverse	Very Diverse	> 5 Litre/ second
5	Productive Aquifer with vast distribution	Intergra nular porosity	Moderate	Shallow	> 5 Litre/ second
6	Moderate productive Aquifer with vast distribution	Intergra nular porosity	Moderate	Diverse	< 5 Litre/ second
7	Moderate Productive Local Aquifer	Intergra nular porosity	Low	Shallow	< 5 Litre /second
8	Moderate productive Aquifer	Inters tices-Fracture	Very Diverse	Deep	Various
9	Daerah airtanah langka	Inters tices-Porosity	Very low	Very Deep	-

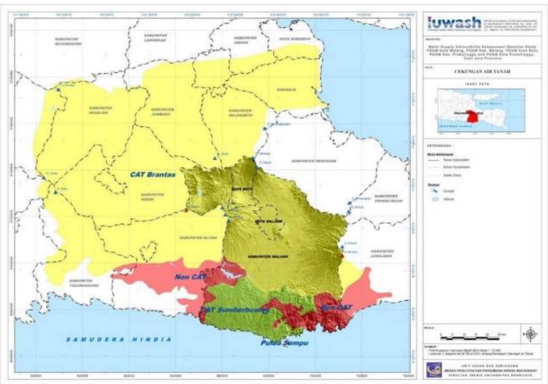

Figure 7 The map of the Groundwater basin of Malang District

3.3 The Analysis of Clean Water Necessity at Abdul Rachman Saleh Airport Malang

The number of passengers at Abdul Rachman Saleh Airport in Malang tends to increase yearly. The number of airlines operating includes Garuda Indonesia (2 flights from Malang - Jakarta), Sriwijaya Air (2 flights from Malang - Jakarta), Batik Air (1 flight from Malang - Jakarta), City Link (1 flight from Malang to Jakarta), Wings Air (1 flight from Malang - Denpasar), Wings Air (1 flight from Malang - Yogyakarta), Wings Air (1 flight from Malang - Bandung).

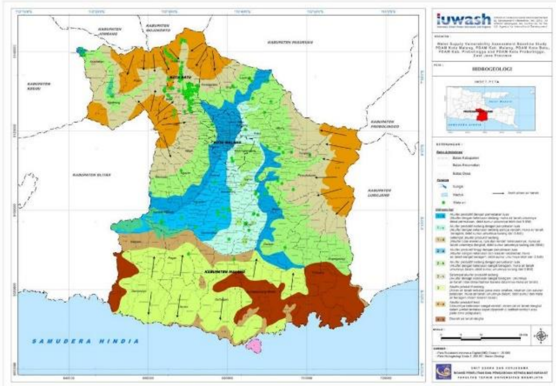

Figure 8 The Hydrogeological map of Malang District

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The passenger volume density on a monthly, daily, and hourly basis at Abdul Rachman Saleh Airport in Malang was analyzed using data on the number of passengers in 2017, which showed that there were as many as 288,000 people with an assumption of a 5% increase per year based on the interviews with airport authorities (Table 5). This data was used to analyze the need for clean water until the predicted year of 2036, as shown in Table 6.

Tabel 5 Passenger Volume Density in Abdul Rachman Saleh Airport Malang

No.	Time	Passenger Volume Density (Person)
1.	Per day	800
2.	Per month	24.000
3.	Per year	288.000

Source: Data Analysis

Table 6 Clean Water Necessity in Abdul Rachman Saleh Airport Malang

Year	Number of Usages	Leakage and PMK	Faktor Hari Maksimum Maxmum Daily factor
	(l/day)	(l/day)	1,1
2017	31672.50	38007.00	41807.70
2018	32655.00	39186.00	43104.60
2019	33648.00	40377.60	44415.36
2020	35402.03	42482.43	46730.67
2021	36417.63	43701.15	48071.27
2022	37445.38	44934.46	49427.90
2023	38485.90	46183.08	50801.39
2024	40289.82	48347.79	53182.56
2025	41357.81	49629.38	54592.31
2026	42440.58	50928.69	56021.56
2027	43538.86	52246.63	57471.29
2028	45403.43	54484.11	59932.52
2029	46535.10	55842.12	61426.33
2030	47684.73	57221.67	62943.84
2031	48853.21	58623.86	64486.24
2032	50791.50	60949.80	67044.78
2033	52000.57	62400.69	68640.76
2034	53231.48	63877.77	70265.55
2035	54485.30	65382.36	71920.60
2036	56513.19	67815.83	74597.41

Source: Data Analysis

Table 6 shows that in 2036, the predicted need for clean water for service activities at Abdul Rachman Saleh Airport in Malang is 74,600 litres/day or 74.6 m^3 / day. If there are 86,400 seconds per day, then the need for a clean water supply for airport service operations is 0.9 litres/second.

3.4 The Potential Groundwater Analysis at Abdul Rachman Saleh Airport area in Malang

The results of morphological tracing showed that the potential for surface water in the Abdul Rachman Saleh airport area in Malang was relatively small. This is because the rivers in this area were intermittent or only water after the rainy season, so the reliable water reserve was the potential for underground water. Geoelectric measurements traced the potential for groundwater at several locations to obtain aquifers' presence. Some of the measured locations are listed in Table 7 and Figure 9.

Table 7 Location Coordinate of Geoelectric Measurement

Location	Code	X	Y
Area of Abdul Rachman Saleh Airport Malang	ABS-1	688474	9122247
	ABS-2	688489	9122251
	ABS-3	688477	9122331
	ABS-4	688721	9121953
	ABS-8	688644	9121984
	ABS-6	686893	9122343
	ABS-7	686688	9121957
	ABS-8	687004	9121903
	ABS-9	686943	9121698
	ABS-11	687676	9122028
	TA (Taman Arya)	687379	9122236

Source: Field Measurement data

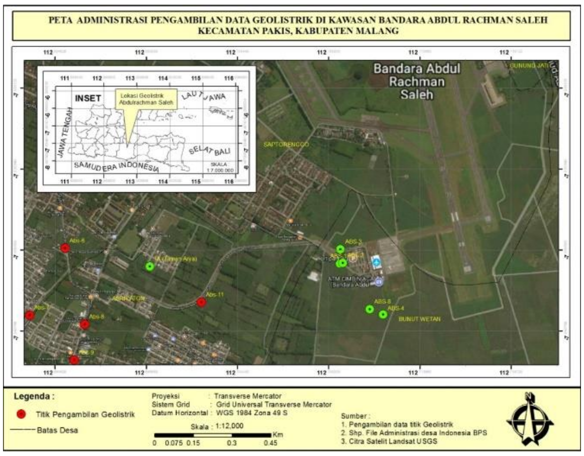

Figure 9 Location of the Geoelectric Measurement

Geoelectric measurements in the Abdul Rachman Saleh airport area in Malang were carried out at a location that allowed electrode cables to be stretched. The length of the cable drawn was 300 m to the left and 300 m to the right, with 5 m spacing of 50 m, 10 to 200 m spacing and 20 m to 300 m spacing. The selection of the location point was also based on the ease of accessibility, the morphological shape with a slope of less than 2 °, facilitating the implementation of measurements.

The measurement results showed that the aquifer in the Abdul Rachman Saleh airport area in Malang was found in breccia rock with fractures, forming porosity in the rock at a certain depth (Table 8). These porosities were used by underground water, which was called aquifers.

Tabel 8 Aquifer Depth Recapitulation of Abdul Rachman Saleh Airport Area

No	Geoelectric Points	Depth (meter)
1	ABS-1	100.3-149
2	ABS-2	54-71
3	ABS-4	17.3-48 89-200
4	ABS-8	12.7-105
5	ABS-6	89-129
6	ABS-7	48-121
7	ABS-8	65-170
8	ABS-9	111-157
9	TA	80-87

3.5 Modeling Geoelectric Analysis Result

The results of the geoelectric analysis were modelled in three dimensions in the form of cross-sections between measurement points. Modelling of geoelectric measurement points along with the results of geological descriptions found at the research location, as shown in Figure 10.

Breccia rock in the Abdul Rachman Saleh airport area in Malang was thought to be a water storage medium. Cross-sectional geological modelling provided an overview showing that there were impermeable rocks (lava-andesite rocks) on the west (outside the airport) and the east (inside the airport), which functions as a separator of the western and eastern aquifers. The breccia in the area was porous due to the influence of lava flow. Therefore, the heat effect on the lava rock resulted in poor cementation between breccia and lava and caused porosity.

4. Conclusion

Based on the analysis of the condition of the area according to topography, physiography, geomorphology, geology, and hydrogeology, the potential for underground water can be obtained, which then can be used as a raw water source for clean water services in the Abdul Rachman Saleh airport area of Malang.

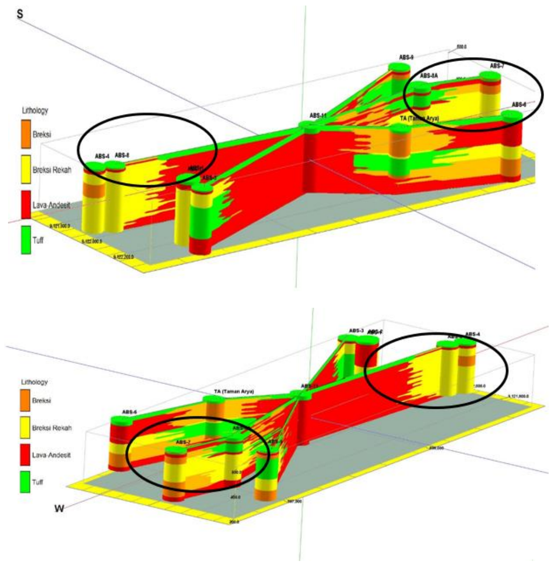

Figure 10 Modelling Geoelectric Analysis Result and Geological Description

The results of this search are an initial indication for further analysis in the form of geoelectric estimation at several measurement points in the area around the airport to ensure the position of the aquifer, which is a significant spot of the potential for underground water where the results of the potential aquifer location are found at point ABS-1, ABS-2. and ABS-4 from the nine measured locations. This also shows that not all locations provide the expected aquifer yields.

The potential for obtaining underground water is then used as a reserve to meet raw water needs for clean water services at Abdul Rachman Saleh Airport in Malang, with all the supporting facilities are analyzed for predicted daily water needs until 2036.

For further research, it is necessary to complete data on water needs and fulfilment of raw water using the pumping test method on the boreholes around Abdul Rachman Saleh Airport in Malang as a comparison of the analysis result of the study of the economic aspect of the fulfilment of clean water needs. In addition, it is also necessary to consider the fulfilment of raw water using the potential water surface and expanding the reservoir at a particular time as an alternative combination of meeting the needs for clean water, considering that the potential water surface water in the rainy season is quite reasonable according to the results of topographic, physiographic, geomorphological, geological and hydrogeological studies in the area around Abdul Rachman Saleh Airport Malang.

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