

# Investigation of resistivity for delineation aquifer layers and subsurface structures

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## Investigation of resistivity for delineation aquifer layers and subsurface structures

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**Abstract.** Delineation of aquifer layers and subsurface structures using investigation of resistivity was accomplished. The results of geoelectric resistivity investigations was described of the detailed subsurface structures conditions and clear aquifer layers. The resistivity geoelectric and well logging methods were used in this study because both of these methods give correct and efficient results, due to the strong correlation between the resistivity values of rock layers and the subsurface structure conditions. Result of investigations show research areas have potential aquifers with wide-spread. The potential of aquifers consists of surface aquifers and deep aquifers, with surface aquifers at a depth of 41 to 50 meters with resistivity values of 30.5-145 ohm-meters, and deep aquifers at depths between 140 to 170 meters with a resistivity of 14.7-46.8 ohm-meter. While the subsurface structure was dominated by clay, sandy clay, sand.

### 1. Introduction

One of the problems of the coastal communities is getting fresh water from the underground aquifer layer, because some aquifers are saltwater aquifers. Thus, a detailed description of the subsurface structure conditions was needed to find the layer of fresh water aquifer.

Geophysical methods are often used to find the potential zone of underground water [1], and one of the best techniques for geophysical methods in underground water exploration and subsurface structural conditions is geoelectric resistivity [2]. The geoelectric method shows optimal results in determining rock resistivity [3], and is an important method in underground water investigations because the method is simple, inexpensive, does not damage the environment, is capable of detecting subsurface rock layers [4], and there is a strong relationship between resistivity and rock layer water content [5].

However, the description of subsurface structures is a complex problem, cause of **irregular topography, surficial unconsolidated sediments in some areas** [6]. So this research combines the resistivity method and the well logging data to decide the underground water aquifer layer and describe the subsurface structure well and in detail. In particular, the purpose of this study is to delineation the underground water aquifer layer and its thickness, and describe the subsurface structure based on its constituent sedimentary layer.



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## 2. Location and geological setting

The research area is Sidoarjo District, East Java with a position of 112.5°-112.9° East Longitude and 7.3°-7.5° South Latitude (Figure 1). In general, the constituent rocks of Sidoarjo consist of passive tuffs, alluvium deposits, middle quarter volcanic rocks, and upper quarter volcanic rocks. Based on the geological map, the study area is composed of alluvial deposits consisting of sand, gravel, clusters, and clays (Qa), Quaternary volcanic deposits with wide distribution, and active volcanic deposits. The hydrogeological condition is a medium productive aquifer area with wide distribution [7].



Figure 1. Research area

## 3. Materials and Methods

The application of the geoelectric method consists of three important stages, namely the stages of data acquisition, processing and interpretation. Data acquisition is done using a Wenner configuration (Figure 4) with the distance between electrodes  $a$  the same, namely  $C1-P1 = P1-P2 = P2-C2$ .

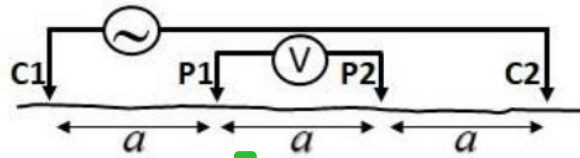


Figure 2. Wenner configuration

$C1$  and  $C2$  are current electrodes 1 and 2,  $P1$  and  $P2$  are potential electrodes 1 and 2. While the field acquisition design used is a 2-dimensional design (Figure 3).

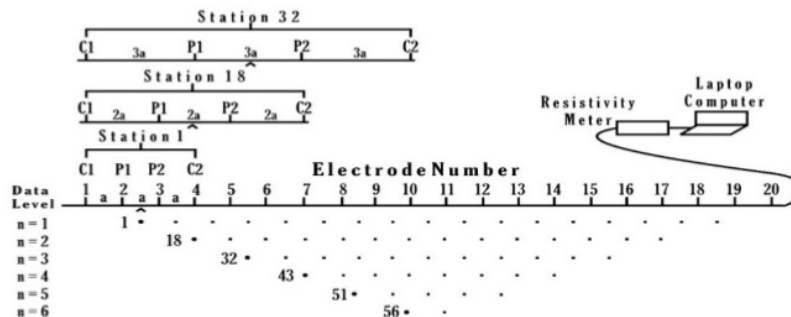


Figure 3. 2D survey design with Wenner configuration [8]

Data acquisition produces a potential difference value ( $\Delta V$ ) and the amount of current ( $I$ ), so that it can be calculated by the apparent type of resistance, with the equation:

$$\rho = k \frac{\Delta V}{I}$$

$k$  is a geometry factor, which is expressed by the equation:

$$k = 2\pi a$$

2D survey design with a Wenner configuration starts with the position of electrodes C1, P1, P2, C2 respectively in positions 1, 2, 3 and 4 for the first measurement. The second measurement, the position of the electrode C1, P1, P2, C2 are shifted sequentially in positions 2, 3, 4 and 5. The measurements are continued until the end of the landscape with fixed spaces.

Processing and analysis of resistivity data using the RES2DINV program. This program uses inversion of quasi-Newton is based on an analytical calculation of Jacobian matrix for a homogeneous halfspace for the first iteration [9]

#### 4. Results and Discussion

Delineation of aquifer layers and subsurface structures was carried out by 2D model interpretation, and well-logging data interpretation. The RES2DINV program is used to process resistivity data into a 2D model, thus producing clear and detailed descriptions of subsurface structures [10].

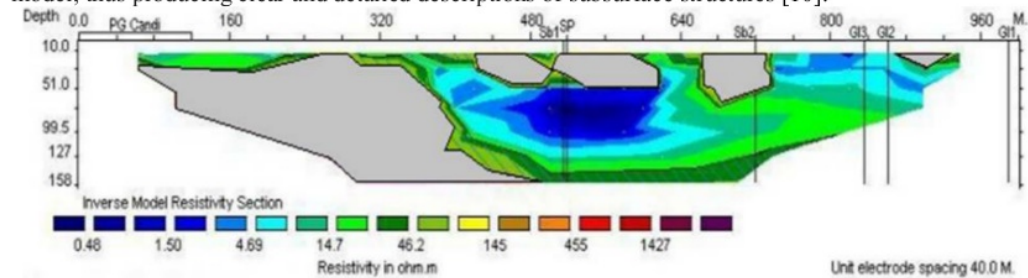


Figure 4. 2D model for aquifer layers

2D model for aquifer layers (Figure 4), illustrates the large distribution of resistivity, thickness, and depth of the aquifer layers indicated by green color with a resistivity around 14.7-46.8 ohm-meters. The resistivity range of the aquifer layer is almost the same as the resistivity range described in previous studies [2], [11], [1]. Aquifer layers are at measurement points 60 to 260, points 290 to 420, points 460 to 510, points 600 to 660, points 700 to 760. They are shallow aquifers with resistivity values of around 30.5-46.2 ohm-meters and depths of about 10 to 30 meters from ground level. Whereas deep aquifers have resistivity values of around 14.7 to 46.8 ohm-meters at the measurement point 370 to 880 with a depth of about 140-170. meters from the surface.

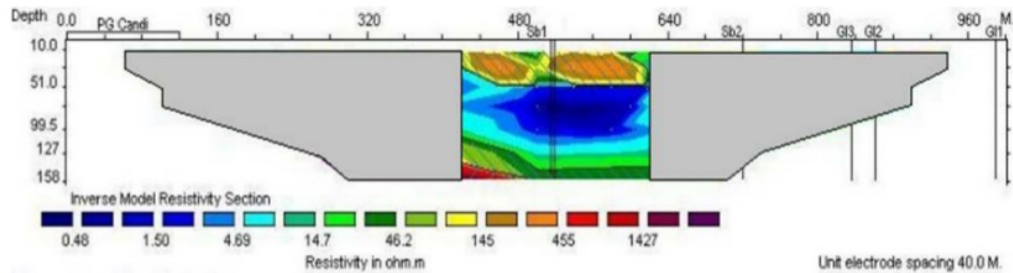


Figure 5. 2D model for subsurface structure at point 420 to 620

2D models for the conditions of subsurface structures (Figure 5), especially at point 420 to 620 show that the subsurface layer can be divided into 2 layers. The first layer at a depth of 0-40 meters, is a layer of sandstone and sand with resistivity values of 95.6-145 ohm-meters. The second layer with a depth of 40-170 meters, is a layer of clay and sand. But the second layer can be divided into several layers. In detail, the subsurface characteristics based on the 2D model for subsurface characteristic at point 420 to 620 is shown in **Table 1**.

**Table 1.** Subsurface structure at point point 420 to 620

Depth (m)	Resistivity (ohm-meter)	Rock layer
0-40	95,6-145	Sand stone, sand
40-50	30,5-46,2	Clay, sand (shallow aquifer)
50-110	0,48-3,1	Clay, sand
110-140	4,69-9,7	Clay, sand
140-170	14,7-46,8	Clay, sand (deep aquifer)

The 2D pseudo section model shows that aquifer potential is widespread and evenly distributed in the study area. The aquifer potential was indicated by the subsurface in the form of clay and sand. This result agrees with the hydrogeological map of the study area, which shows that the study area is a medium productive aquifer area with wide distribution. This also agrees with other studies, that the clay and sand material layers are rocks that makeup aquifers [12].

The results of well-logging (**Table 2**) show that the subsurface layer was divided into clay layers, sandy clay, sand (0-40 meters deep); inserts of clay, inserts of sand (41-50 meters depth); inserts of clay, sand (50-133 meters deep); and deep aquifers (133-168 meters deep).

**Table 2.** Subsurface characteristics based on well logging

Depth (m)	Rock layer
0-40	Clay, sandy clay, sand
41-50	Clay inserts, sand inserts
50-133	Clay inserts, sand
133-168	Deep aquifer

By comparison of the results investigation of resistivity and well-logging data, the subsurface structure consists of layers of sandy clay, sand, clay inserts, and sand inserts. While the potential of shallow aquifer layers is at a depth of about 41-50 meters and deep aquifers at a depth of 140-170 meters with wide-spread

## 5. Conclusion

The research area is an area that has a potential of shallow aquifers (about 41-50 meters deep) and deep aquifers (depth of about 140-170 meters), with a subsurface structure generally consisting of clay layers, sandy clay, sand, clay inserts, and inserts sand.

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