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Distribution of Free Groundwater Aquifers in Rumpin and Surrounding Areas, Bogor Regency, West Java

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Abstract— *The geology of the Tangerang area, including the Rumpin area, is mostly formed by Quaternary surface deposits (Alluvium, Pematang Pantai, Alluvium Fan and Banten Tufa) and a small part (southern) is Tertiary sedimentary rock (Genteng Formation and Serpong Formation). The boundary of the groundwater basin at the surface is estimated to be located along the Cisadane river, as well as at the boundary of tertiary rock outcrops (southern) that pass and impermeable to groundwater. The problem that arises is how the relationship between surface data (outcrop) and subsurface data (based on estimation of geoelectrical data) which is validated with drilling data becomes a model of the hydrogeological system in the research area. The purpose of this study was to determine the hydrogeological conditions and distribution characteristics of the aquifer, as well as to calculate the groundwater potential in the Rumpin area and its surroundings based on outcrop data, subsurface geological data and drill log data. Based on the research results, the lower boundary of the groundwater basin can be in the form of compact rock or very thick clay and is estimated to be more than 100 meters deep. The hydrogeological system of the Rumpin area and its surroundings is the result of geoelectrical data, then validated with surface outcrop data and drill logs, can be grouped into aquifers which include the Free Groundwater Aquifer Group, has a depth range of 0–15 and 15–45 meters with 1-2 aquifers thick ranged from 2-7 meters. The shallow/free groundwater level (0–10 m) data has a groundwater level ranging from 0 to -5 m (mts). The results of the geoelectrical analysis show that the distribution of the aquifer layer is uneven and there is an impression that the free groundwater aquifer can reach a depth of 3–20 meters (mts). The distribution of isoresistivity maps with resistivity at a depth of 3–20 meters has the potential for fresh groundwater.*

Keywords— *Rumpin, Aquifer, Geoelectric, Groundwater.*

I. INTRODUCTION

The Rumpin area has a very rapid development of its territory, it is planned to be developed into a new district capital. By becoming the capital of a new district, it will become a new growth center area that is strategically close to the national capital. In particular, studies on the Rumpin area have never been carried out. The results of the author's latest research (Nuryana, et al., 2020) regarding the estimation of subsurface structures in the middle of the Cisadane watershed. Groundwater is a renewable natural resource, even though it has gone through a long process of formation, tens or even thousands of years. If groundwater is damaged both in quantity and quality, then the recovery process also requires a long time with high costs and complicated technology. Even that does not guarantee a return to its original condition (Freeze and Cherry, 1979). The geological condition of the study area based on the Serang Sheet Geological Map (Rusmana et al, 1991) and the Jakarta Sheet Geological Map (Turkandi et al, 1992) the Tangerang area is part of the Jakarta Basin which is filled with Quaternary deposits which are located inconsistently above the bedrock in the form of sedimentary rock. Tertiary (Martodjojo, 1984). Quaternary deposits are formed by Plio-Pleistocene to Resen age rock units with lithology, in the form of: volcanic fan deposits resulting from volcanic eruptions in the south. Then during that period, processes also occurred including the erosion of existing rocks, formation of sedimentary river channels resulting from erosion/rain/floods, coastal developments, and sea deposition (Figure 1).

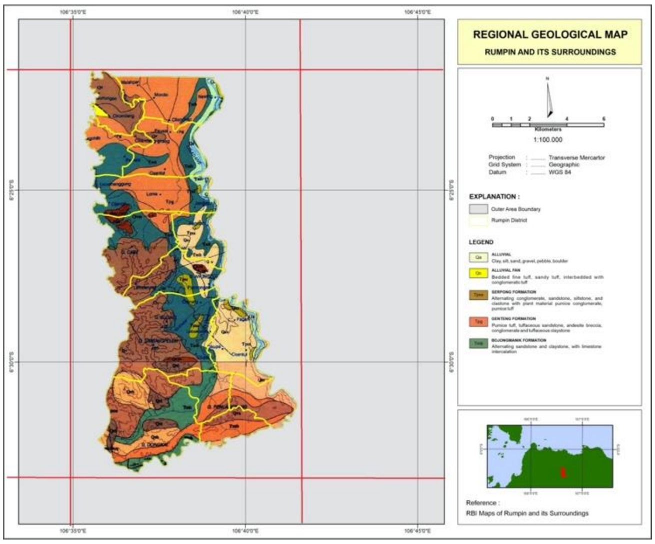

Fig. 1. Geological map of the Regional Geology of the Rumpin region and surroundings.

In the area The research which is a watershed of the Cisadane River seen from the hydrological condition can be seen whether the aquifer system is continuously affected by water from the Cisadane River or not, because the aquifer is a lensis of alluvial embankment deposits (Efendi, et al., 1998) or due to other factors. The method used to determine the hydrogeological system of the research area is outcrop data, correlated with subsurface data from geoelectric results which will be validated with outcrop data or drill logs so that the hydrogeological system model in the study area will be known. Resistivity measurement is done by flowing current into the ground through two current electrodes and measuring the voltage difference generated at the two potential electrodes.

Thus, the subsurface resistivity can be estimated. Soil resistivity is related to various geological parameters, such as mineral and fluid content, porosity, degree of fracture, percentage of fracture filled with groundwater and degree of water saturation in rock (Rozaq et al., 2013) and the relationship between apparent resistivity and actual resistivity is very complex. . To determine the actual resistivity from below the ground surface, it is necessary to invert the apparent resistivity results using a computer program (Loke, 2000). Aquifers have two main properties, namely the capacity to store groundwater and the capacity to drain groundwater. This is greatly influenced by the nature of the geological diversity, namely the hydraulic properties and the volume of the reservoir. Based on these characteristics, aquifers can contain very large amounts of groundwater with a wide distribution of up to thousands of square kilometers or vice versa (Karmadi, 2019). The problem that arises is how is the relationship between surface data (outcrop) and subsurface data (based on geoelectrical data estimation).

II. RESEARCH METHODS

The method used for this research consists of 2 (two) namely primary data in the form of geoelectric data collection and supported by secondary data in the form of maps related to the area, in the form of drill log data and topographic data, and secondary data in the form of lithological data and geomorphological maps which will then be analyzed. correlate to the aquifer distribution. The description of geological conditions in the research area can be used as a reference to determine the characteristics of the aquifer layer in the research area supported by outcrop data from observations in the field and data collection from observations.

A. *Geoelectrical Methods*

Geoelectrical are used to determine variations in subsurface resistivity values and their lateral distribution. The value of this type of resistance describes a certain rock layer, so that an overview of the distribution of the rock layers below the surface will be obtained as well as an interpretation of the rock layer that functions as an aquifer. The resistivity method is used to see the subsurface conditions by studying the nature of the flow of electricity in the rock below the surface. earth (Souisa et al., 2018). The resistivity method is used for rock mineral surveys, soil movements (landslides), seawater intrusion, liquid or solid waste, geothermal, geological sites and so on (Cornforth, 2004), used for shallow exploration, around 300-500 m and the earth has a different layers have different resistivity values (Cornforth, 2004). The principle of this method is that an electric current is injected into the earth through two current electrodes and the potential difference that occurs is measured through two potential electrodes. In actual geoelectrical measurements the medium is not homogeneous with an arbitrary resistivity distribution. (Sapulete, et al, 2012), to calculate the apparent resistivity, a geometric factor number (K) is needed depending on the type of configuration, the distance AB/2 and MN/2, determine the depth, the distance between the AM and NB electrodes is increased to 2a and the measurement is repeated for n until the last electrode, then the distance between the AM and NB electrodes is increased to 3a, and so on. With the position of each electrode side by side with each other, the potential electrode distance (MN) is set as small as possible so that it is theoretically constant but when the distance AB is relatively large, the distance MN should not be greater than 1/5 of the distance AB (figure 2).

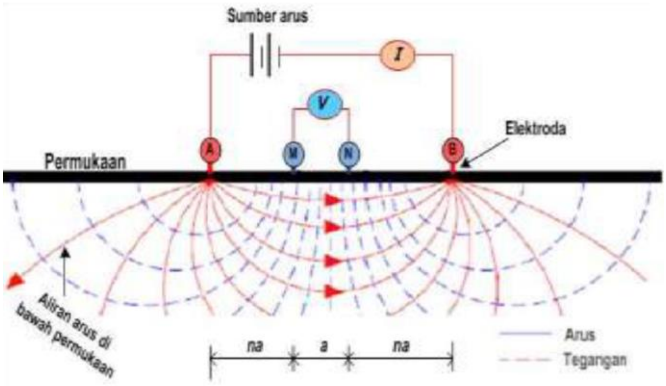

Fig. 2. Location of Electrode Position Wenner-Schlumberger configuration (Souisa et al, 2015 and 2016).

Electricity is injected into the earth through two current electrodes, while the potential difference will be measured through 2 (two) potential electrodes. The measurement results obtained variations in the value of the electrical resistivity in the layer below the measuring point. Illustration of equipotential lines that occur due to current injection shown at two opposite current points on the earth's surface can be seen in (Figure 3).

Using the Wenner configuration, shows the concept of electric propagation that applies to isotropic homogeneous media by measuring the potential difference between two points that occurs due to direct current flow through the subsurface (Figure 4).

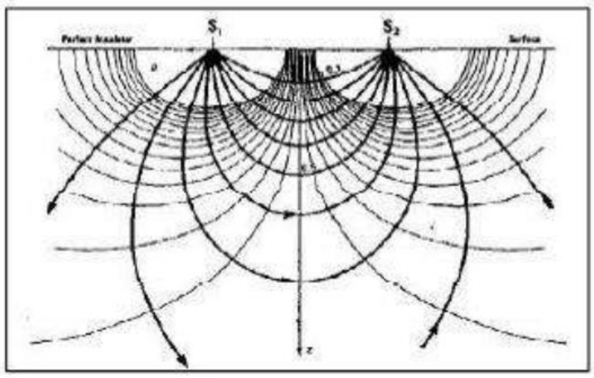

Fig. 3. Flow patterns and equipotential fields.

Each method has advantages and disadvantages. To find out the extent of the alignment (consistency) between the results of geoelectric measurements with the Wenner and dipole-dipole configurations, it is necessary to investigate in more detail using shallow drilling. By measuring the apparent resistivity below the ground surface using the Wenner and dipole-dipole configurations for the 2-D method and processing the apparent resistivity data below the ground surface to get the actual resistivity value using the software, it can interpret subsurface conditions (Railasha, 2015). Geoelectric method analysis which aims to determine the distribution of free or compressed groundwater aquifers in the Rumpin and surrounding areas, Bogor Regency. The resistivity geoelectric method is one method that is quite widely used in the world of exploration, especially groundwater exploration because the resistivity of rocks is very sensitive to water content where the earth is considered a resistor.

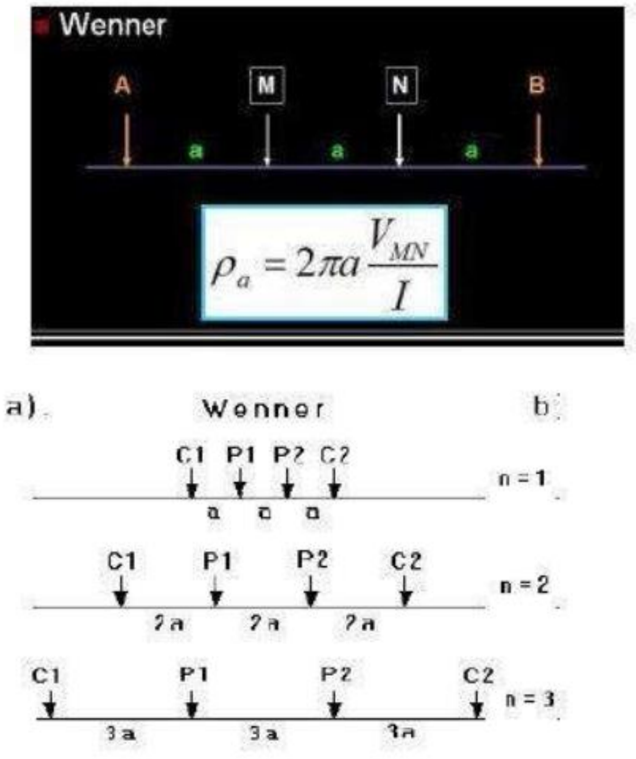

Fig. 4. Wenner configuration.

III. RESEARCH

The morphology of the Rumpin area and its surroundings is divided into 3 (three) units, namely in Figure 5:

- *Fan Alluvium*

Plains Wavy plains, the slope is less than 5%, the valleys reach 30%, the elevation ranges from 20-50 meters above sea level. lithology of tuffaceous sandstone, pumice tuff, lava breccia, weathered to silt clay and silt clay, extending from north to south. Between the hills, sometimes separated by narrow valleys, relatively flat is an area of inundation during the rainy season. The morphological unit is controlled by the rock units that compose it in the form of a quarter volcanic product.

- *Morphology of the Volcanic*

Plain Wavy plains, the slope of which is less than 5%, the valley reaches 30%. Elevation ranges from 20-50 meters above sea level. The lithology of tuffaceous sandstone, lahar and sandstone deposits. Spread from the north of the investigation area, extending from the north-west. Showing a relatively flat terrain, this morphology is also controlled by the results of the quarter volcano.

- *Morphology of River Alluvial*

Plain Wavy plains, slopes are generally less than 5%, river valleys are 30%, elevation 10-20 meters above sea level, located in the middle with an area of 30% of the study area. Rivers and streams leading south-north parallel patterned, local dendritic pattern. Lithology in the form of sedimentary deposits in the form of silty clay, tuff and tuffaceous sandstone. The distribution is on K. Cisadane, the distribution is according to the pattern of the river flow.The altitude ranges from 10 - 30 m, the slope is less than 0.5% and the terrain is relatively flat.

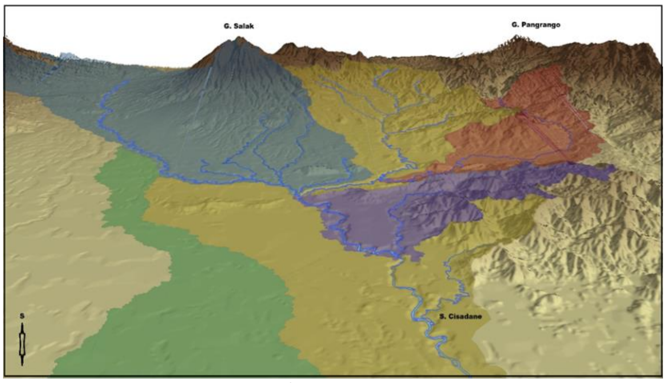

Fig. 5. Morphology of Rumpin and surrounding areas.

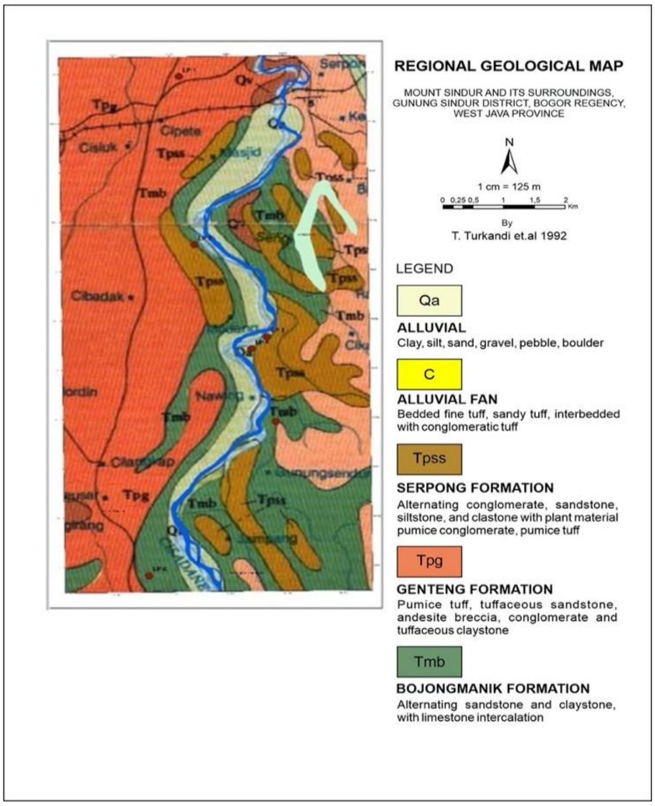

Fig. 6. Research Geology (Turkandi, 1992).

Geological Map Sheet Serang (Rusmana, et al., 1982) in general, it is formed from sedimentary and volcanic rocks of Middle Miocene-Pleistocene age, as well as surface deposits whose deposition process is still ongoing today. Tertiary rocks exposed on the surface can only be found in the southern part of Tangerang Regency, namely in the Balaraja to Serpong areas, in the form of claystone layers of the Tile Formation. The Quaternary deposits that cover the rocks are volcanic rocks originating from Gede-Pangrango Mountain and Salak Mountain (Figure 6).

A. Groundwater Potential

Underground water or groundwater is all water contained in the water-containing layer (aquifer) below the ground surface, including springs that occur naturally above the ground surface.formation groundwater is rainwater which partially seeps into the ground in the recharge area and is partially stored in the aquifer and partly comes out naturally in the discharge area. Groundwater is separated into 2 (two), namely: groundwater (uncompressed) and groundwater (Figure 7).

- Free (uncompressed) groundwater is groundwater contained in an aquifer which is limited at the bottom by an impermeable layer while the top is not covered by an impermeable layer. water but by a phreatic face that is at right pressure 1 (one) atmosphere.
- Depressed groundwater is groundwater found in aquifers which are bounded by an impermeable layer at the top and bottom.

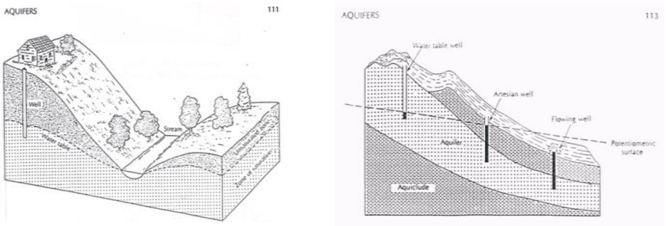

Fig. 7. Unstressed groundwater and groundwater (Fetter, 1994).

B. Groundwater System

Based on the Distribution Map of the Groundwater Basin, a Typological Distribution Map of the Aquifer System can be made which produces six (6) typologies, namely:

- Alluvial Deposits (Qa and Qbr).
- Young Volcanoes (Qav, Qpvb and Qpv).
- Old Volcanoes (Qv, Qvb, Qvl, Qvst and Qva).
- Coarse Sedimentary Rocks (Tpss, Tpg, Tmrs).
- Fine Sedimentary Rocks (Tmbs, Tmbls & Tmbc).
- Igneous Rocks (Tma & Tba).

The distribution towards the inside (subsurface) is generally a gradual boundary or commonly called the boundary of the facies change of one deposit with another. In general, Tangerang Regency has four (4) typologies of aquifer systems, namely:

- Alluvial deposits (Qa and Qbr).
- Young Volcanoes (Qav, Qpvb and Qpv).
- Old Volcanoes (Qv, Qvb, Qvl, Qvst and Qva).
- Coarse Sedimentary Rocks (Tpss, Tpg and Tmrs).

Meanwhile, in the southern part of the Tangerang Regency area, it is very possible to obtain a Typology of Fine Sedimentary Rock Aquifer System (Tmbs, Tmbl and Tmbc).

C. Measurement Data Geoelectrical the Rumpin Area

Measurements in the Rumpin area were carried out on the side of the road near El-Farm, due to the limited area, the maximum stretch of geoelectric cable that could be used was 140 meters, with an electrode distance of 3 meters. The results of data acquisition are used to calculate the apparent resistivity value (Res2dinv). The next step is processed using software to get the actual resistivity value. Obtaining a cross-sectional model of the true resistivity (true resistivity). The results of this modeling are shown in that which shows the cross section of the resistivity anomaly image (Figure 8).

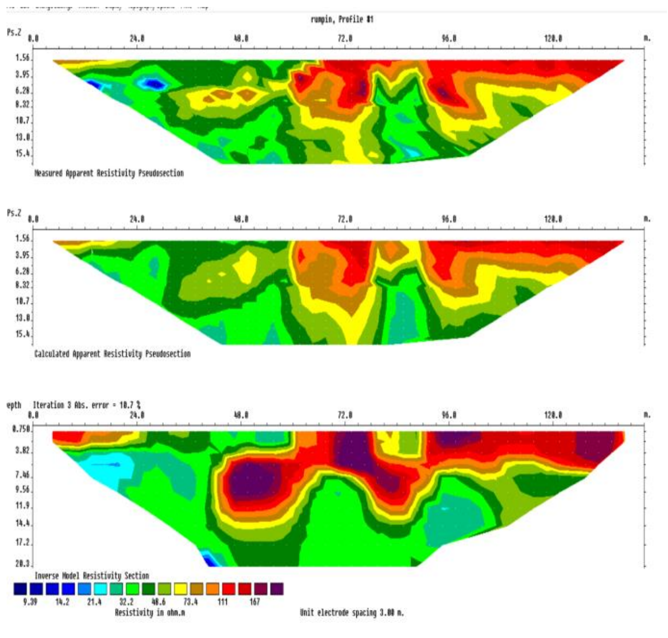

Fig. 8. 2-D Resistivity Section of Rumpin Area.

TABLE I. Interpretation of Geoelectrical Measurement Results

S. No.	Interpretation of Geoelectrical Measurement Results			
	ρ (Ω m)	Thickness/h (m)	Depth/d (m)	Lithological Estimate
1	266	0.667	0.667	Soil
2	39.7	4.86	5.52	Clay sand
3	4.34	11.2	16.7	Sand
4	59.4	15.8	32.5	Clay
5	0.0844	-	-	Clay sand

IV. DISCUSSION

Rumpin area with morphological condition Wavy plain, slope generally less than 5%, except the river valley reaches 30%, elevation 10-20 meters above sea level, is located in the middle with an area of 30% in the study area. Rivers and streams leading south-north parallel and local patterns with dendritic patterns. Lithology in the form of sedimentary deposits in the form of silty clay, tuff and tuffaceous sandstone. The distribution is on K. Cisadane, the distribution according to the pattern of river flow. With the outcrop data, the area has layered soil lithology, sandy tuff, clay tuff and gray clay (Figure 9).

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Fig. 9. Outcrop in the Rumpin area.

The groundwater system in the Rumpin area uses drill log data, which has a cross section on the west - east part of the south, in the west part of the drill log data A-18 there is claystone lithology alternating with limestone which is estimated to be part of the Bojongmanik Formation exposed in the area around Rumpin which is of Tertiary age which is not continuous to the east which is interpreted as a fault structure. In drill log B-15, the top to bottom are composed of tuffaceous clay, breccia tuff, sandstone and intercalated claystone of Tertiary age and not continuous to the east. In drill log B8, it is composed of conglomerate sand, sandstone and claystone (Figure 10).

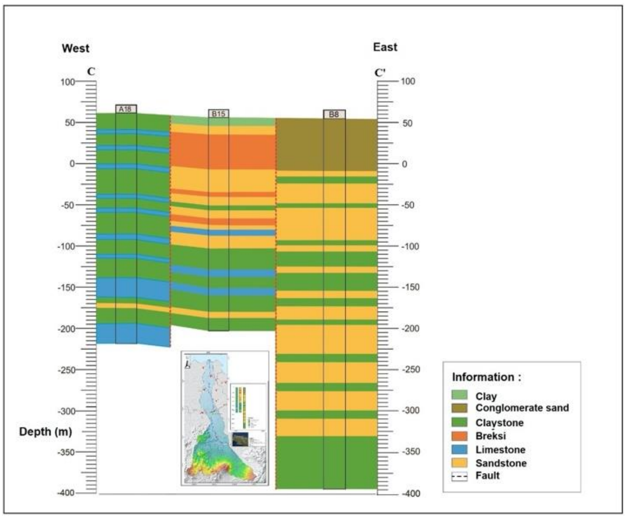

Fig. 10. The lithological cross-section in the west-east direction in the Rumpin area.

The Rumpin area has more than four (4) aquifer layers with a thickness range of 5 to 15 meters (geoelectric data, outcrops and drill logs). There are three (3) groups of aquifers, namely 0 – 14 meters, 14 – 90 meters (Figure 11).

- 0 – 14 meters; The aquifer layer can come from weathering of Alluvial Deposits (Qa) which generally have a fresh groundwater taste.
- 14 – 90 meters; the aquifer layer is only one (1) piece with a thickness of 6-7 meters from Young Volcanic Deposits/Coarse Sedimentary Rocks (?) which taste groundwater fresh.

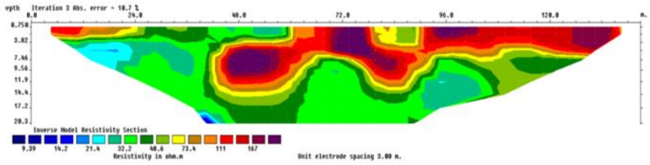

Fig. 11. Geoelectric 2-D cross-section.

Details from the results of calculations and data processing, in general, from each datum point on the resistivity cross-section, the resistivity value is in the range of 5.0 – 127.0 m. This resistivity value is divided into three resistivity zones as follows:

- Low resistivity zone with resistivity value < 24.8.0 ..m is assumed to be soil, clay and sandy loam, loose, moist brown to brown-orange in color. The material is loose / weathered and quite porous so that it can pass water at a low level.
- The intermediate resistivity zone with a resistivity value of 24.8–60.0 m is assumed to be sand, fine to coarse-grained loamy sand, clay and gravel. These rocks are found in varying depths and thicknesses. This material is generally loose / weathered, quite porous / hollow, and can pass water at a high level.
- The high resistivity zone with resistivity values > 60.0 m is assumed to be sandy claystone with fine to medium grain and compact and hard claystone. These rocks are found in varying depths and thicknesses.material is compact, generally acts as bedrock overburden which is found in almost all Aquifer survey areas.

Aquifer as one of the hydrogeological conditions and the size of groundwater recharge in the study area based on conductivity and transmissivity as well as the lithology of the constituent in the form of young volcanic rock. and old volcanic, where the rock is generally a good aquifer. The Rumpin area generally has groundwater and is a Free Groundwater System (0 – 30 meters) and has a groundwater level ranging from –2.5 to –20 meters (from the local ground surface/mts). The cone of groundwater subsidence ("Cone Depression") is developing in the south-east area of Tangerang Regency, namely around Ciputat, Pondok Aren, Curug subdistricts to Balaraja Subdistrict which is located in the west and Rumpin. And groundwater in Tangerang and surrounding areas has a groundwater ranging from -5 to 10 meters (mts), no groundwater subsidence was found, there are discharges located in the villages of Jelupang–Parigi Lama and Jombang. The physical condition of groundwater is generally fresh, pH 4.5 - 7.5 with electrical conductivity of 22 - 567 S and is used for drinking/eating and toileting for the local community.

V. CONCLUSION

- From the results of the geoelectric method, the intermediate resistivity zone with a resistivity value of 24.8 – 60.0 m is assumed to be sand, fine to coarse-grained claies sand, clay and gravel. These rocks are found in varying depths and thicknesses. This material is generally loose / weathered and quite porous / hollow so that it can pass high levels of water, or it can be called a good aquifer.

- Rumpin area is a free groundwater system (0 – 30 meters) depth groundwater table ranging from -2.5 to –20 meters (from local ground level/mts). The cone of groundwater subsidence ("Cone Depression") is developing in the south-east region of Tangerang Regency, namely around the Ciputat, Pondok Aren, Curug and Balaraja sub-districts which are located in the west and Rumpin area

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