GROUNDWATER EXPLORATION USING GEOPHYSICAL RESISTIVITY METHOD IN SIRUVADI VILLAGE, VILLUPURAM DISTRICT, TAMILNADU, INDIA

Abstract

Groundwater exploration in a section of Siruvadi Village, Tamil Nadu, utilized the VES method with Schlumberger electrode configuration, proving the efficacy of the Electrical Resistivity method in identifying subsurface structures. Interpretation of VES data revealed two, three, and four layers, with A and H type curves dominating, providing insights into layer number, thickness, and water-bearing capacity. Schlumberger-based VES identified water-bearing zones at 50m, 70m, 40m, 60m, 80m, and 73m depths, with the VES at 80m (VES POINT 5) suggested as a high-yielding well bore point. This comprehensive approach enhances our understanding of subsurface characteristics and informs groundwater resource management decisions in the region.

Keywords: Groundwater exploration, VES Schlumberger, Electrical resistivity, Subsurface structures, Water-bearing zones

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I. INTRODUCTION

1. **Geophysics:** The study of the physical characteristics of the Earth and the application of quantitative techniques to their analysis is the focus of the natural science field known as geophysics. Sometimes, only geological applications are meant when the term "geophysics" is used. The structure and makeup of the Earth gravitational and magnetic fields, its dynamics and how they manifest on the surface in plate tectonics, the internal creation of magmas, volcanism, and rock formation. The hydrological cycle, which includes snow and ice, fluid dynamics of the oceans and atmosphere, electricity and the ionosphere and magnetosphere, solar-terrestrial relations, and analogous problems with magnetism in relation to the Moon and other planets are all included in the modern geophysics. The effectiveness and utility of geophysical surveying have increased during the past few decades. (Raman et al., 2000).

2. **Geophysical Methods:** Geophysical methods in exploration are based on certain physical properties of earth materials. The properties are measured and their variation values are recorded. Gathered data are interpreted to determine the subsurface information. The most important rock properties are studied using the following methods. Gravity prospecting). Magnetic prospecting). Seismic prospecting). Electrical prospecting). Radiometric prospecting.

3. **Exploration of Groundwater:** Geophysical exploration is a method used in science to assess the Earth physical characteristics and investigate mineral deposits and other types of geologic structure. Oil was discovered using geophysical techniques in 1926, and the subsequent economic importance of finding petroleum and mineral resources hastened the advancement of other geophysical techniques and tools for study and development. Anomalies in the physical characteristics of the Earth crust are found using geophysical techniques. Geophysical techniques are most frequently used to measure the characteristics of the rocks, including density, magnetism and elasticity. Many people mistakenly believe that geophysical technologies are utilised to directly identify groundwater when applied to groundwater exploration. Other tools are also used in rather scientific approaches of groundwater investigation.

4. **Electrical Prospecting and Exploration Method:** Electrical resistivity techniques are based on the response of the earth to flow of electric current. The resistivity of a rock unit depends on its mineral composition and is influenced by the interstitial water content present in it. In field measurements, variety of electrode arrangements are employed. Electrical resistivity methods involves the measurement of surface potential caused by the passage of an electric current, which are allowed to flow on the ground from an artificial source. Further interpretation is based on the validity of Ohm's law for linear conductors R-Av/1, where Ris the resistance in Ohms, offered to the flow of current I and Av is the potential difference, in volts, across two end faces of the conducting material. The resistance of the medium is directly proportional to its length L and inversely proportional to its cross-sectional area so that $R \alpha L/A$ .The electrical resistivity or the specific resistance, P of the conducting medium, then isP= $(A/L) R = (\Delta v / I) A/L$ .Thus, the resistivity can be defined as the resistance offered by a material of unit dimensions and in the mkssystem and its unit is ohm-meter (Ω m).Theefforts of Conrad Schlumberger (1912 - 1914) are mainly responsible for the development of electrical resistivity method as an

effective tool in geophysical exploration of groundwater. In field measurement, current is introduced to the ground via two electrodes and the potential difference between another pair of electrodes is measured. The strength of current applied and their potential difference is measured, which is then used to calculate the resistivity of the ground. Taking into account that geometry of the electrode spread can also make a difference while interpreting.

5. **Electrode Configuration:** In field measurements, a various conventional electrode arrangements are employed, the difference being in the inner electrode distance and or geometry. The most commonly employed configurations are the Wenner, Schlumberger and dipole- dipole arrangements. In the Wenner electrode array, the four electrodes, equidistant with respect to each other,are kept along a straight line, the outer two being the current electrodes. The inner electrode distance is commonly denoted by the letter 'a'.

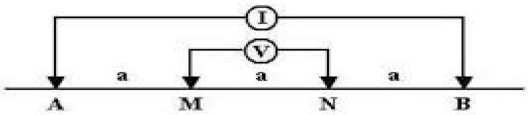


Figure 1: Wenner electrode configuration

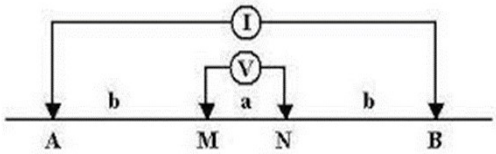


Figure 2: Schlumberger electrode configuration

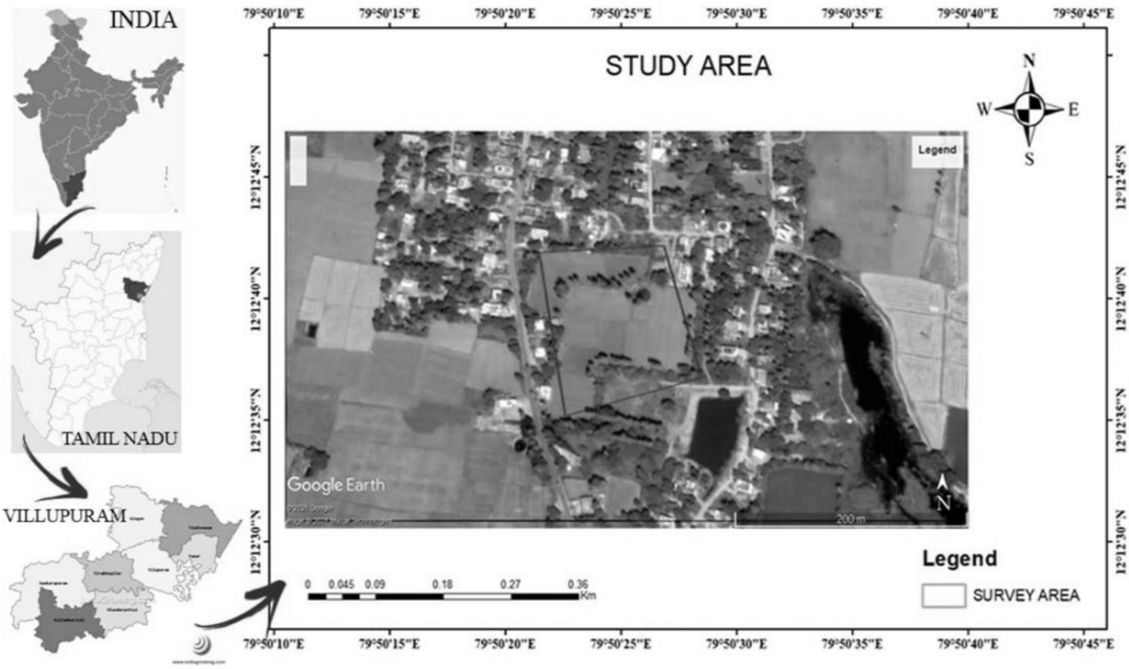
The Schlumberger electrode configuration is also a symmetrical array like wenner, but in this case the potential electrodes are kept close to each other and away from the current electrodes, with the distance between the potential electrodes (MN) being generally kept less than 0.2 AB

6. **Horizontal Profiling:** Apparent resistivity measurements are made along the chosen azimuth covering the entire area using a pre - determined electrode separation, the value of the separation dependent of the depth of interests. In practice, the whole electrode array is moved from one point of measurement to the next as a single unit. The distance between two locations were measured .Data variation occurs and it depends on the nature of the rock, type of the terrain and time etc.,

7. **Vertical Electrical Sounding:** Profiling gives an indication of any changes in the lateral direction, to obtain information of the subsurface in the vertical direction, a technique known as vertical electrical sounding (VES)is employed. This involves in making a series of measurements at a given point with several electrode separation. The electrode separations are expanded, around the point of measurement, from an initial small value to several hundred meters, depending on the depth of interests. This is because, in in general, larger the electrode separation, greater will be the depth of investigation is quite a complex one, and among other things is controlled by the relative thickness of individual layer, and the resistivity contrast present between them.The VES data is plotted as an apparent resistivity versus electrode separation curve, normally on a log - log scale. The general practice is to plot a as a function of a' in case of Wenner and AB/2 in the case of Schlumberger.

II. STUDY AREA

The study area is from Siruvadi,Villupuram district, Tamil Nadu. This area lies between 12◦12’41.70″ and 12◦12’41.62″ North latitude and 79◦50’19.45″ and 79◦50’23.12″ east longitude. TheElevation of the area is 44 m (144 ft.) (MSL).Thestudy area comprises pink augen gneiss and pink migmatite with younger instructions of Tindivanam and Gingee Granites (2250 Ma) and basic dykes (Proterozoic)dominently. The Migmatite Complex forms the major country rock of the area covering more than sixty percent and extending towards east uptoVikravandi, South of Gingee.



III. GEOLOGY

Alkali complex of Proterozoic age, including the Charnockite Group, Migmatite Complex, Sathyamangalam Group, and Bhavani Group. The area contains the Charnockite Group of rocks, including charnockite, pyroxene granulite, and garnetiferous gabbro, west of Kallakurichi (in the district's southwest). The Migmatite complex is made up of Hornblende-biotite gneiss and is located west of Tirukoilur (the district's major area) and east of the charnockite terrain, or the kallakurichi area. Pink migmatite and augen gneiss with newer Tindivanam and Gingee granite intrusions (2250 Ma) and dykes (Proterozoic).The basic intrusive that travels equally through the migmatite and charnockite regions is composed of dolerite dykes. The marine fossiliferous Upper, Cretaceous, and Paleogene Formations, which are located in two distinct sub-basins and are divided by a thick layer of alluvial sediments deposited by the Gadilam and Pennaiyar Rivers, overlie the Archaean. The Palaeocene rocks that lie on top of the Upper Cretaceous Formations are separated into the Putturai Group's Karasur Formation and Manaveli Formation, which both contain siltstone and fine-grained argillaceous sandstone. The Karasur Formation is composed of fossiliferous limestone with calcareous shale. The Cuddalore Formation is part of the Tertiary strata and is made up of cobbly and pebbly sandstone, mottled sandstone, ferruginous sandstone with bands and lenses of clay, as well as lignite seams. Around Thiruvakkarai, this deposit has a significant amount of fossil wood that has been designated and preserved as a national fossil wood park.These are dominated by Quaternary fluvial, marine, and aeolian formations near the shore as well as river courses. Due to the numerous deformations the terrain has undergone, it exhibits a highly complicated structural makeup. There are many notable shear zones that have been identified, including the N-S shear shone east of Gingee town and the NNE-SSW to ENE-WSW shear zone, the most notable of which is the one running NNE-SSW near the eastern foot of the Kalrayan hills SW of Kallakurichi. The dense valley fill close to Villupuram creates the primary ground water discharge zone. Only a small portion of the Kallakurichi and Sankarapuram regions have lineaments, and certain pockets have productive fractures. Hard rocks along the crystalline sedimentary contact fault have sympathetic fractures, however they are typically dry fractures.. Red soil and forest soil make up the majority of the district's soil types. On the eastern side along the coast, alluvial soils are present. Black soils are only found in a few low-lying areas in the Vanur taluk.

IV. RAINFALLS AND CLIMATE

The district receives rainfall from the monsoon (June – September), northeast monsoon (October – December) and non-monsoon periods (January – May). The amount of precipitation is generally heavy during cyclones. The annual rainfall is 1119.8 mm (1901-1980) and the higher is towards coast. The area experience higher temperature during the summer months from March to May.

V. HYDROGEOLOGY

The western and eastern sides of the Villupuram district are both covered by sedimentary tracts and crystalline metamorphic complexes, respectively (Plate-II). Near the southern portion of the district, the silt thickness approaches 600 meters. While groundwater exists in phreatic, semi-confined circumstances in unconsolidated sedimentary rocks such as Vanur sandstone, Kadapperikuppam formation, and Turuvai limestone, it occurs in consolidated formations such as worn and fractured granites, gneisses, and charnockites. The majority of the Kallakurichi, Sankarapuram, and Tirukoilur taluks of the district are covered in rocky outcrops. The level of weathering and fracturing is quite unpredictable, and it determines how deep the abstraction structures go. Wells range in depth from 6.64 to 17 m bgl, and water levels are monitored.pre-monsoon (May 2006) ranged from 0.74 to 9.7 m bgl on shallow aquifer wells, while post-monsoon ranges from 0.7 to 4.45 m bgl (January 2007).

VI. EQUIPMENTS AND ACCESSORIES

Basically there are two types of equipment for carrying out electrical resistivity investigation using direct current or low frequency alternating current. The direct current has the disadvantage of being affected by naturally existing current (e.g. S.P.). Measurement with AC equipment are influenced by "skin effect". Used of non-polarizing electrodes solves the problem created by natural potential and cell-effect associated with direct current .A simple non-polarizing electrodecan be designed by taking a porous earthen pot, filling it with copper sulphate solution, in which a copper electrode is kept immersed.

VII. FIELD PROCEDURE

Resistivity sounding also known as vertical electrical sounding(VES) has been used in this study. This method is most commonly used for groundwaterinvestigations and will be discussed in detail. A series of measurement of resistivity were made by increasing the electrode spacing in successive steps about a final point, depending on the depth of interest. This is because, in general, larger the electrode separation greater will be the depth of investigation. The variation of apparent resistivity with current electrode separation thus obtained would give the variation in the electrical characters of the formation with depth.In the study area 12 vertical electrical sounding were carried out in the field using schlumberger electrode arrangement with maximum current electrode separation of AB/2 - 100m. The locations of these VES are shown in fig.The 'p.' values obtained for various AB/2 separation after this exercise are given in table. The field VES curves are discontinuous in nature, the discontinuity is caused by the shifting of potential electrodes during the sounding. Data on another 10 sounding were collected for the area from other workers (Ballukraya PN. 1994).

VIII. INTERPRETATION OF THE FIELD DATA

Interpretation of the electrical resistivity data in terms of subsurface geology and hydrogeology forms the most important part for groundwater explanation. The resistivity pattern and the anomalies if any form the key part of the exercise (Ruwaih and Ali, 1986).Interpretation of VES data is both qualitative and quantitative. The type of VES curve obtained indicates the qualitative nature of subsurface that may be expected in an area. And the main aim of interpretation of resistivity data is to determine the thickness and resistivity of different horizons. This method is a faster way of solving and VES curves, makes use of two-layer theoretical curves. Two auxiliary charts are needed. H type for A and H type VES curves and Q-type for Q and K-type VES curves. Using this method three or more layers solved, since the method involves solving the curve in sections of two layers at a time.The procedure of the interpretation can be given as-the first part of the curve (two layers) is matched with cither ascending or descending two layer theoretical curves and the origin of the type curved is marked on the field curve sheet. The co-ordinates of the origin of the master curves as read as on the field curve will give the value of p, and h, (resistivity and thickness of the first layer). The theoretical curve also gives the ratio p/pi, from which pa can be calculated. This origin is superimposed on the origin of the appropriate APC, with the axes of the two parallels to each other. The trace of the curve for the same resistivity ratio of the APC is now marked on the field curve sheet. Then, the next part of the field curve is matched with the appropriate two-layer curve, ensuring in the process that the origin of the two-layer curve lies on the previous APC curved. Once a match is found the origin of the type curve is marked as second origin and the resistivity ratio is noted. If there is one more layer the process is continued, till the entire field curve is completed. Next, the first origin is superimposed on the appropriate APC and the value of the line passing through the second origin is noted, which gives the high ratio, Thus the second layer thickness (h;) is obtained. The resistivity of the third layer is calculated by reading the value of the second resistivity ratio noted. In this way any number of layers present can be solved by repeating the same procedure.

The data obtained from the study area are thus interpreted and the layer parameters are found out. Out of the 12 soundings, 7curves are of A-type (pi>pp); 4 curves are of H-type (PPP2<) and one of K-type. And one sounding is of two layer, 6 of three layer and 5 of four layer. The results of interpretation thus obtained were further verified and corrected with computer simulation using RESIST-87 software package (Vander velphen, 1988).The results of VES interpretation are given in table -IIb.

IX. RESULT AND DISCUSSION ANALYSIS WITH "IPI2 WIN"

The interpreted resistivity and thickness of different layers are shown in Fig.2 to Fig 7.Solid line represents the interpreted data and solid line with circles represents the observed data.The curve types obtained in the study area where 6 VES sounding was carried out include 1H type curves (p1 > p2 <p3), 5 A type (p1 <p2 < p3), respectively (Table.2). IPI 2WIN output shows good match with concept of three-layers and few cases it matches perfectly. Obtained layer are listed below

Layer 1	Dry Sand
Layer 2	Medium Sand
Layer 3	Massive Charnockite

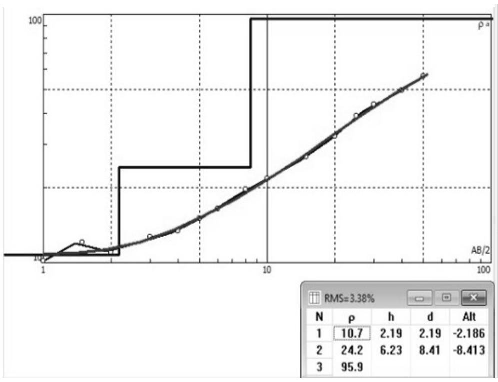


Figure 2: VES Curve at Location 1

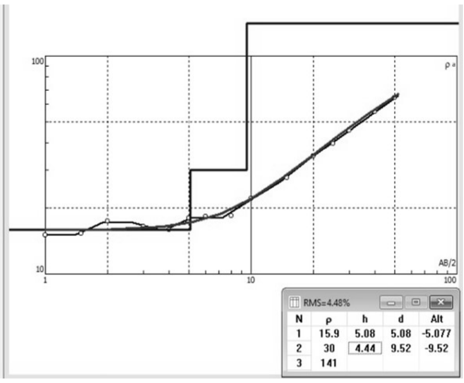


Figure 3: VES Curve at Location 2

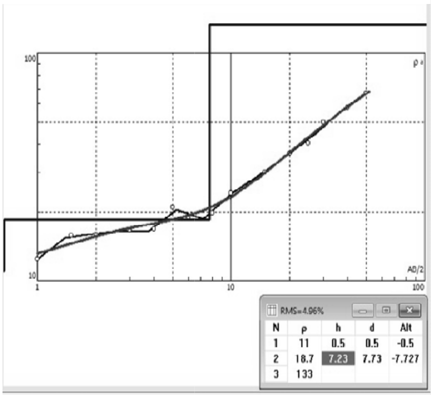


Figure 4: VES Curve at Location 3

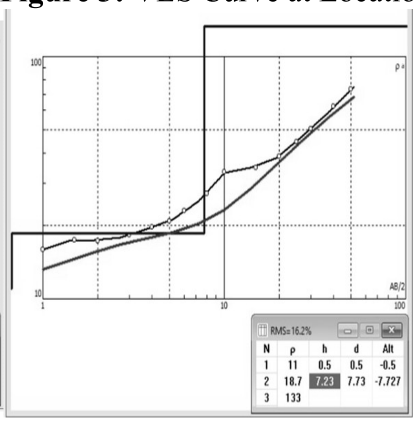


Figure 5: VES Curve at Location 4

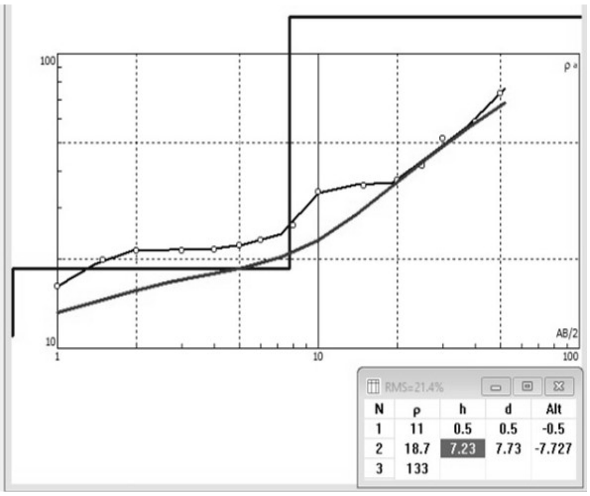


Figure 6: VES Curve at Location 5

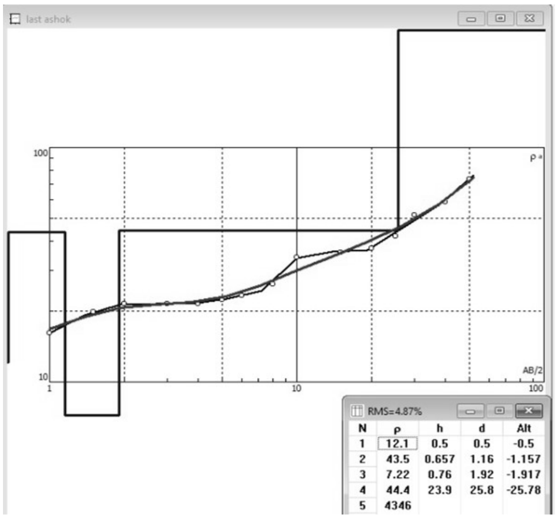
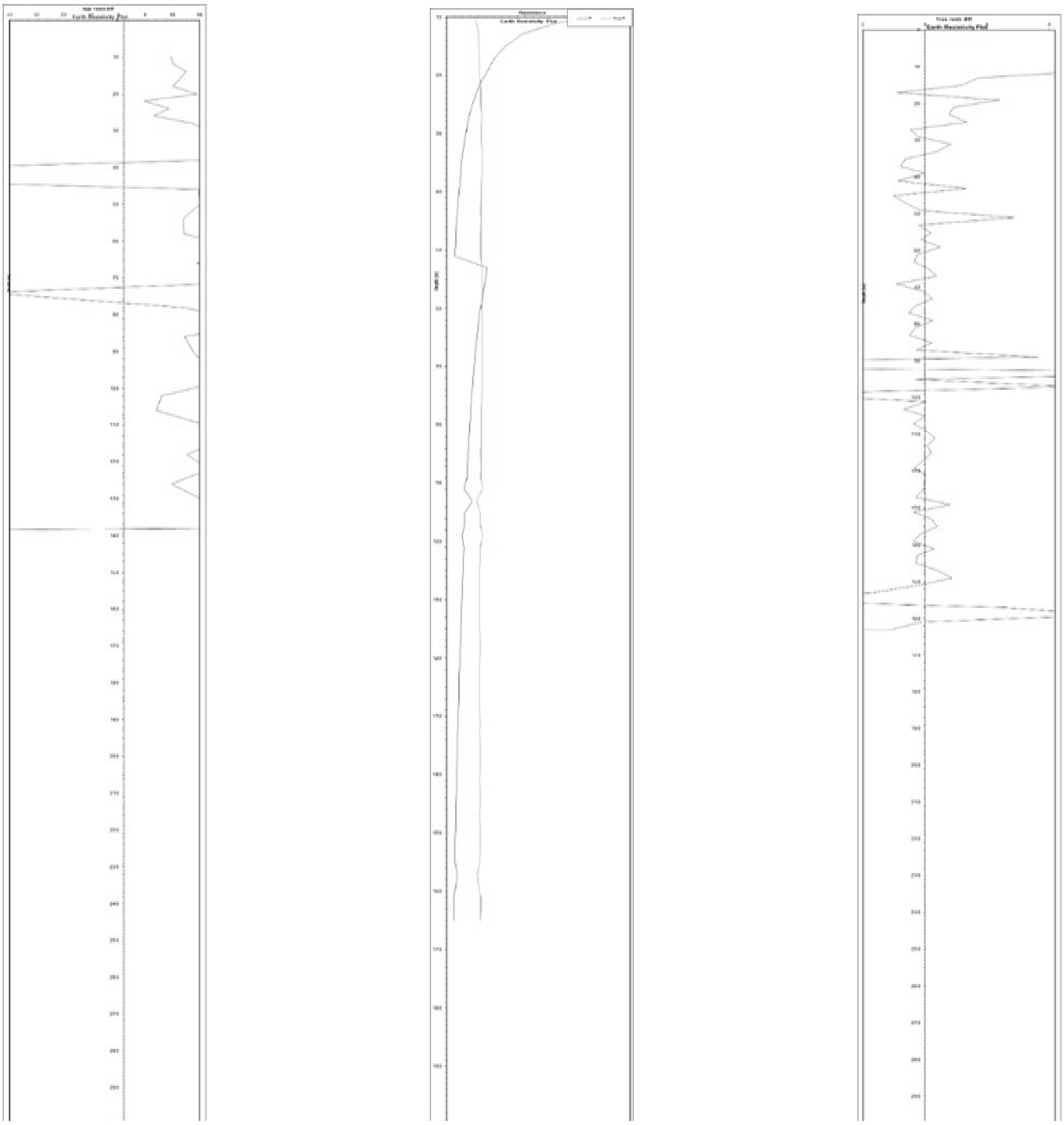


Figure 7: VES Curve at Location 6

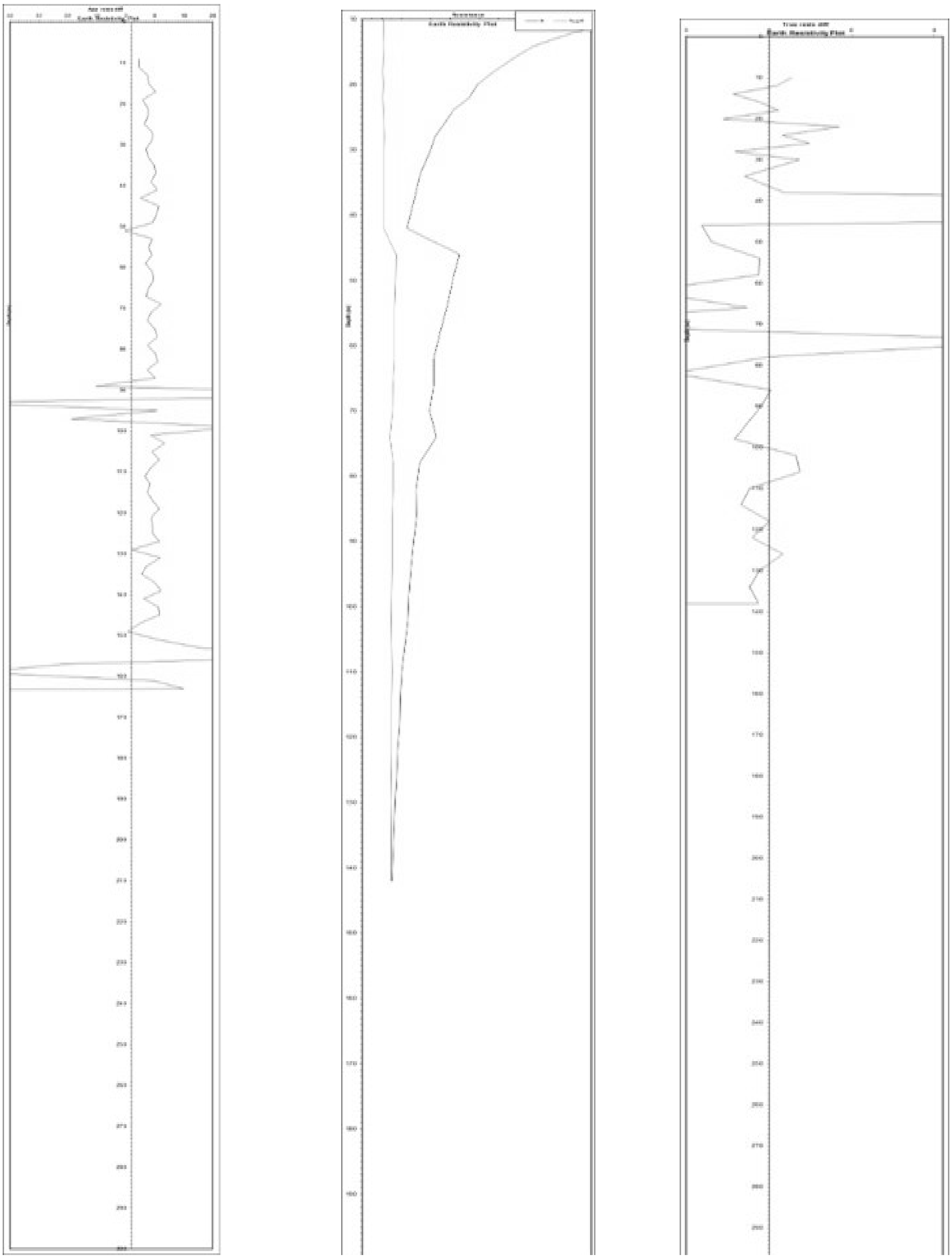
X. CONCLUSION

Ground water exploration has been carried out in part of the Siruvadi Village, Marakkanam Taluk, Villupuram District in Tamil Nadu using VES Schlumberger electrode configuration. Electrical resistivitymethod has proven to be successful and highly effective in the identification and delineation of subsurface structures. The interpretation of the VES data indicates the presence of two, three, four layers in the study area. In this study, an attempt has been made to assess the resistivity values for various layers. The most part of the study area is dominated by the A and H type curve which reveals the number of subsurface layers, their thickness and their water bearing capacity within the study .VES based on Schlumberger method, Identified water bearing zone are50m,70m,40m,60m,80m and 73m depth.The investigated VES (VES POINT 5,Depth at 80m) point suggested as high yielding well bore point among the study area.



(a) (b) (c)

Figure 8 A, B, C: APPARENT RES PLOTVS DEPTH



(d) (e) (f)

Figure 8 D, E, F: APPARENT RES PLOT VS DEPTH

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