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Delineation of Ground Water Potential Site by Integrated Geophysical Investigations: A Case Study

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Abstract:- An Integrated geophysical approach i.emagnetic impedance(lps1200) and Audio magneto telluric(ADMT 300s) survey was carried out in hard rock area of Pathalapattai village, Thiruverambur Block in Tiruchirappalli District of Tamil Nadu State, India, for delineation of groundwater-bearing zones that would be feasible for drilling deep bore wells for tapping good quantum of water. Groundwater movement that moves through fractures in hard rocks,can be delineated byintegrated geophysical surveys. A detailed survey of the area was done using a LPS1200 instrument to target fractured zones by magnetic impedance variation and favorable locations were selected for further study using ADMT 300s (2D Audio Magneto Telluric Scanner). Hence, the entire area (1 acre of land) was surveyed and only two places was the favorable where the magnetic impedance difference was encouraging. Those anomalous areas were scanned by 2D Audio magneto telluric scanner up to the depth of 300m. The technique has provided information on the subsurface lithology & structures up to 300 m depth. The study shows that the groundwater occurrence in the area is confined to fractured and weathered zones. One of the location was recommended to drill a bore well. Comparing and correlating these results with the drilling data, it is found to be good. It can be concluded that the established interpretation of 2D Audio Magneto Telluric data and LPS 1200 data pretty well correlates with the actual fracture depth and lithological conditions. Thus, the method not only aids in locating water aquifers but also helps to avoid bore hole failures.

Keywords:- *Hydrogeology; Geophysical survey, Magneto telluric, water well drilling, Ground water surevy.*

I. INTRODUCTION

The increasing population growth, advances in technology in agriculture, mining, road construction, etc. necessitates more water demand. This calls for effective groundwater resource development, management of which groundwater exploration and characterization play major roles. Therefore, there is a need for the invention and application of new geophysical techniques. In the last two decades, there has been great advancement in the application of geophysical tools in groundwater exploration. In many regions of Tamilnadu, scanty rainfall, adverse seasonal conditions, have rendered the need for groundwater exploration extremely necessary to meet the agricultural and domestic needs of the indigenous communities. But in order to ensure its sustainable consumption, groundwater management becomes crucial for the future of our freshwater resources.Many geophysical techniques have been used in the past for groundwater explorationlike Resistivity method, Seismic reflection method and Frequency domain electromagnetic Surveys though deemed to be the most successful and available technique for groundwater investigation but has its limitations. Even though the Electrical Geophysical Methods are commonly used in groundwater investigations, the current study aimed to apply the Audio Magnetotelluric (ADMT) method in prospecting suitable potential pockets for water well drilling to meetfor Agricultural needs.Now a days many bore holes were failures due to lack of geophysical technique knowledge, unknown local geological information, hydrogeological conditions.This method was chosen because the Vertical Electrical Sounding [VES] cannot ensure complete and dense space coverage but the Magnetotelluric methods can be used for deeper depths of investigation, good space sampling, easy interpretation and understand sub surface conditions. The long range positioning system (LPS 1200) is the very low frequency electromagnetic method (VLF – EM) provides a relatively fast approach to detect the fractures in rocks compared to many other geophysical methods. Therefore, this method has been the most popular electromagnetic (EM) tool for quick mapping of near – surface geologic structures as a reconnaissance tool for weathered layer thickness, in identifying deep water bearing fractures in bedrocks, in the reconnaissance mode, Magnetic Impedance profiles can be quickly run to identify anomalous areas for further detailed geophysical measurements.In the other hand held Natural Electric Field Geophysical Prospecting Instrument, referred to as the 2D Audio magneto telluric water detector (ADMT-300S) in this article, and was used for electromagnetic propagation. ADMT 300 S works by measuring the electric field component of the earth's magnetic field in different frequencies ("ADMT300S Operation Manual for S-Series") and can easily demarcate the potential points of aquifers.It can be used as a tool to provide a geolectric overview of the subsurface sequence of a particular area of interest.

II. STUDY AREA

The study area is one acre piece of land located at Pathalapattai village of Thiruverumbur Block in Tiruchirappalli District of Tamil Nadu State, India. It is located within latitudes of N10° 47‟ 41.46”, longitudes E78° 50‟ 49.056”. The major part of the district is underlain by Archaean crystalline metamorphic complex. The important aquifer systems encountered in the district are classified intoi) Fissured, fractured and weathered crystalline formations consisting of charnockites, Granite Gneisses and ii) Unconsolidated and semi-consolidated formations. The

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water bearing properties of crystalline formations which lack primary porosity depend on the extent of development of secondary intergranular porosity either through weathering or fracturing. These aquifers are highly heterogeneous in nature due to variations in lithology, texture and structural features even within short distances. Ground water generally occurs under phreatic conditions in the weathered mantle and under semi-confined conditions in the fissured and fractured zones at deeper levels. The thickness of weathered zone in the district is in the range of 2 to 25 m.

Fig. 1: Study Area Location Maps

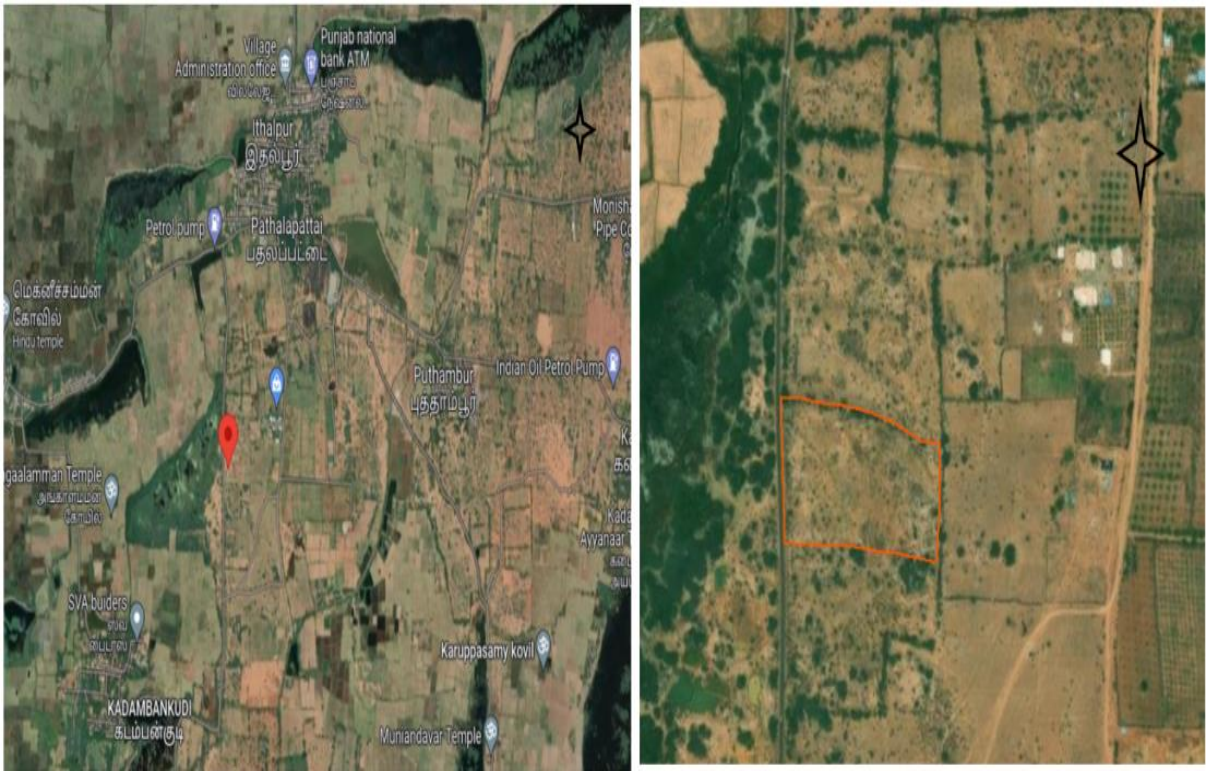

Fig. 2: Google image showing the study Area

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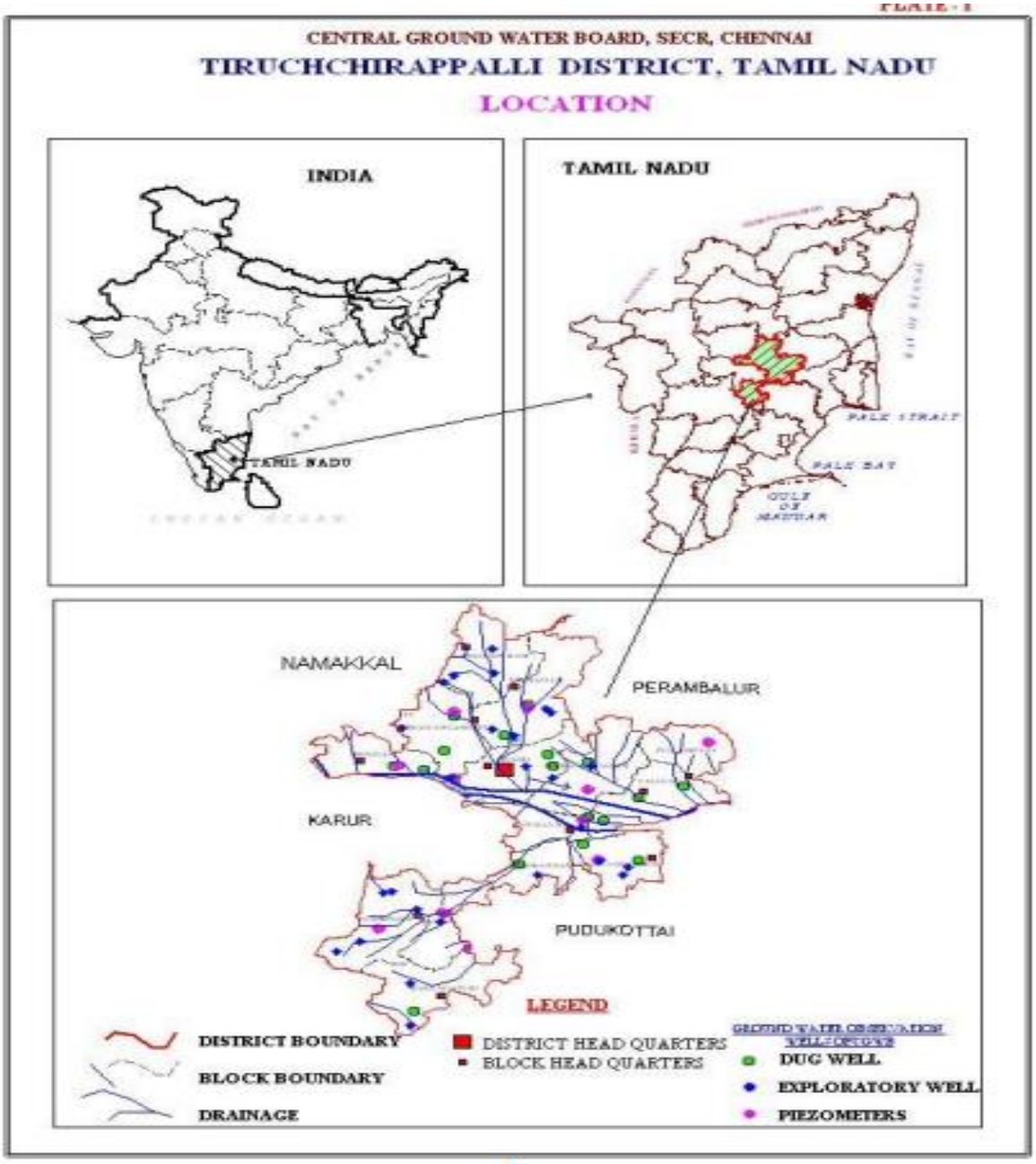

Fig. 3: Tiruchirappalli District Map

III. METHODOLOGY

A. Long Range Positioning system (LPS 1200)

Professionally engineered, advanced long range locator is designed on magneto impedance technology to define a site magnetic impedance difference in prospection of a fracture zone, the system is systematically crafted to continuously measure the differences in the site from receiving command to prepare the digital data which is further recorded to pinpoint a particular location of a well site (LPS 1200 Manual). The highly fractured area were identified through this detector. LPS 1200 shows the magnetic impedance difference at the two locations in the study area approximately 2 to 3 m length, which we can also consider as a minor level lineaments. In both the locations the fracture depths have been identified through LPS 1200 depth calculation inbuilt program. Accordingly the first location depth of calculated fracture was 104 feet, 268 feet, 743 feet, whereas at the second location the depth of calculated fracture was 87 feet, 206 feet, 582 feet.

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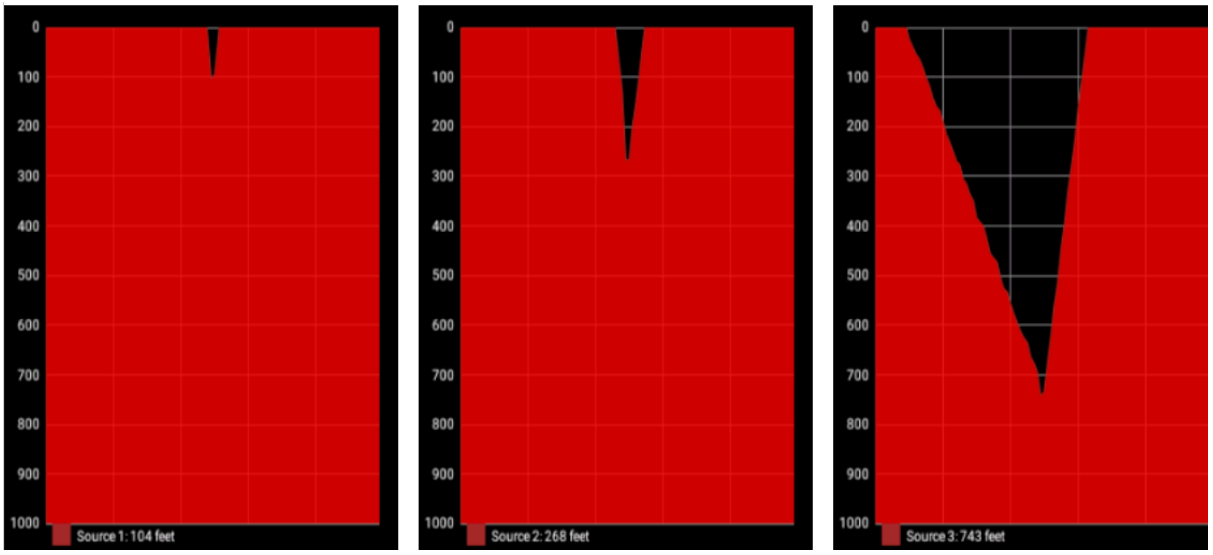

Fig. 4: Traverse A/Point 1 Fracture depth (VLF-LPS1200)

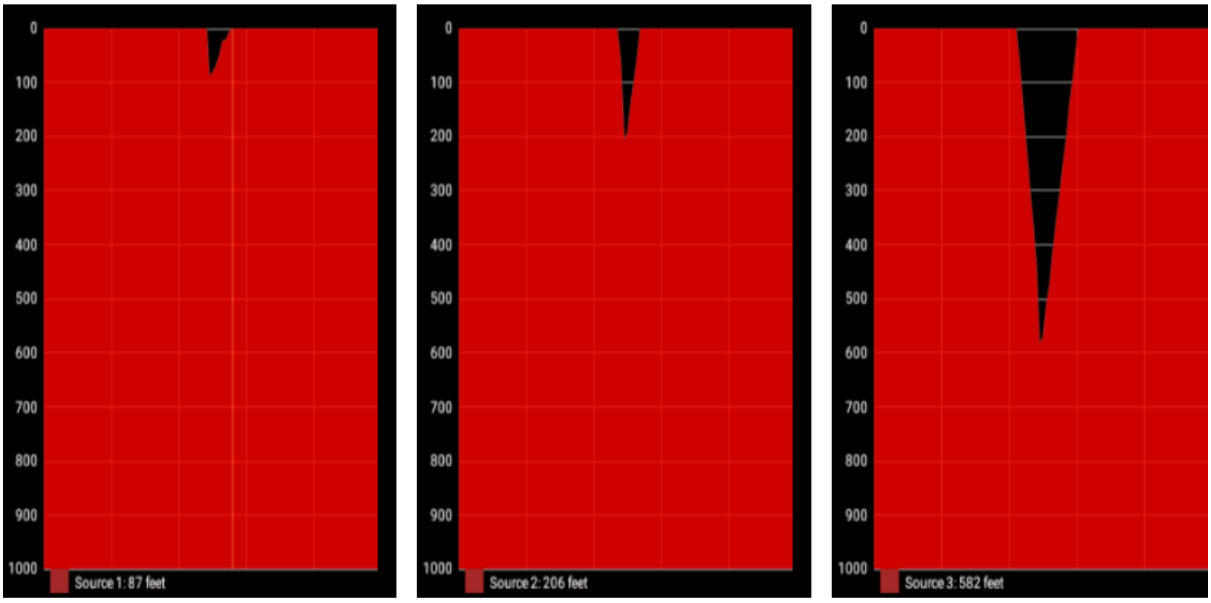

Fig. 5: Traverse B/ Point 2 Fracture depth (VLF-LPS1200)

B. Audio Magneto Telluric Scanner (ADMT 300S)

Is a passive geophysical exploration method that uses high frequency Electromagnetic (EM) signals (10,000 Hz – 5 Hz) to investigate from shallow to very deeper depths. AMT [Audio magneto telluric] measures naturally occurring EM signals on the ground to characterize the electrical conductivity of the subsurface (Chave and Jones, 2012; Simpson and Bahr, 2005). AMT penetrate deeper compared to other geophysical techniques that uses artificially generated fields, such as Direct Current Electrical and Transient Electromagnetic Method (TEM). Audio Magnetotelluric method is an electromagnetic passive-source inductive method used for inferring Earth's subsurface electrical conductivity. The subsurface conductivity is calculated from temporary surface measurements of the magnetic and electric fields. The EM signals that were used in AMT and Magnetotelluric (MT) surveys comes from two external sources (outside of the earth). Generally, these natural EM signals are generated in the atmosphere and magnetosphere. MT signals (low frequencies < 1 Hz) are generated by the interaction between the earth's magnetosphere and the solar wind, sunspot activity, and auroras. High-frequency sources (> 1 Hz) in the audio range (AMT) are generated by thunderstorms and lightning worldwide (Simpson and Bahr, 2005). These interactions of the EM signals create telluric currents that flows in horizontal directions in the Earth's crust (Simpson and Bahr, 2005). The telluric currents then produce the magnetic signal that was measured in MT and MT surveys. In AMT, the aim is to measure the both the Electric and the magnetic variations created by the telluric currents using sensors in different directions (orthogonal direction). The measured data set is called time series, which later is converted to frequency domain in the data processing stages. The transfer function (the complex impedance matrix) is then estimated from the frequency domain of the measured field. Once the MT data are processed and analyzed forward modeling and inversion algorithms are used to produce resistivity distribution models (1-D, 2-D and 3-D).

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C. Survey Equipment

ADMT 300 series handheld underground water detector uses the natural earth field source without going through artificial field that is omitted clumsy power supply system in order to achieve the simple, light weight. After data collection, the instrument through the unique built-in computing functions to achieve the automatic presentation graph, the collected data can also be transferred to a computer drawing to form a cross-sectional map, the geological layer structure can be quickly determined by a clear understanding of cross-sectional map water (aquifer) specific information.

Fig. 6: 2D AMT Equipment

D. Principle of MT Survey

ADMT 300 Series Geophysical Water Prospecting Instrument is referred to Advanced Electrical Field Detectors which works on the basis of electrical resistivity strength change in sub-surface by measuring natural electric field. It analyzes the electrical resistivity, find location depth, flow direction, water quantity in near & deep sub-surface. Major advantage of the detector depends on the frequency choosing and anti – jamming in natural electric field which gives the results of combined the advantage from methods of MT, frequency Test, TEM (Transient Electromagnetic) respectively.

It uses the natural electric field as a working source & resistivity contrasts to identify the presence of underground rocks and minerals or groundwater. Magneto telluric (MT) is an electromagnetic geophysical method for inferring the earth's subsurface electrical conductivity from measurements of natural geomagnetic and geo-electric field variation. Magnetic fields in the frequency range of 1 Hz to approximately 20 kHz are part of the audio magneto telluric (AMT) range.

Depth of investigation depends on the transmitted frequency and resistivity of the subsurface. Lower the frequency, greater the depth of penetration. The prospecting technique is based on natural electrical field which is influenced by resistivity contrast of underground minerals and ground water. Without heavy power supply, it uses low frequency signals & natural electric field as signal source. Equipment is automatically controlled by micro PC with a high resolution of measuring accuracy of 0.001 mill volts. The output will be in the form of 2 D profile with anomalous zones & in conjunction with results, geological & hydro geological conditions, recommendations are provided. Currently this is one of the most updated and effective detecting method in the world. It can be widely used for detailed and general survey of underground water detecting, geothermal and other energy prospecting work.

After data collection by the unique built-in computing functions, the instrument can automatically draw curve graph and profile map with one button, according to the profile map, you can clearly understand the geological structure and quickly determine the location of ore body (seam), hollow (cave), water (aquifer) etc.

E. Methodology of Field Survey:

By the M, N electrode probe (transducer) via a cable earth's magnetic field to electrical signal input to high impedance input stage, after the anti-jamming exchange amplification, frequency selection, select the desired operating frequency, and then by the A / D sampling, central processor (CPU) for data processing. Where in the entire measurement process, high-speed central processing unit (CPU) of the control, instrumentation automatic range conversion and automatic frequency selection. Finally it displays the measured data and curves graph, and then click “profile “the instrument will automatically draw profile map directly on the LCD of instrument, also can Output measurement data, curve graph and profile map by USB cable to computer for analysis and making geological interpretation.

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F. Data Acquisition

MN electrode were placed 10m distance along the direction of LPS 1200 locatorresponded line and here after it is called " Traverse 1''. The M N two electrode bar equidistance is 10meters, both M N have moved to next station after finished measurementof the station 1. Similarly next five stations data were taken and MN electrode space was 10m and each station spacing was 1m interval maintained throughout the survey. Total Two profile lines length of 15m, 15m for Traverse 1 and Traverse 2 conducted and data were taken. The collected field data were processed and inverted using AIDU 1.2.6 in built software to obtain the 2D profile map of subsurface resistivity model.

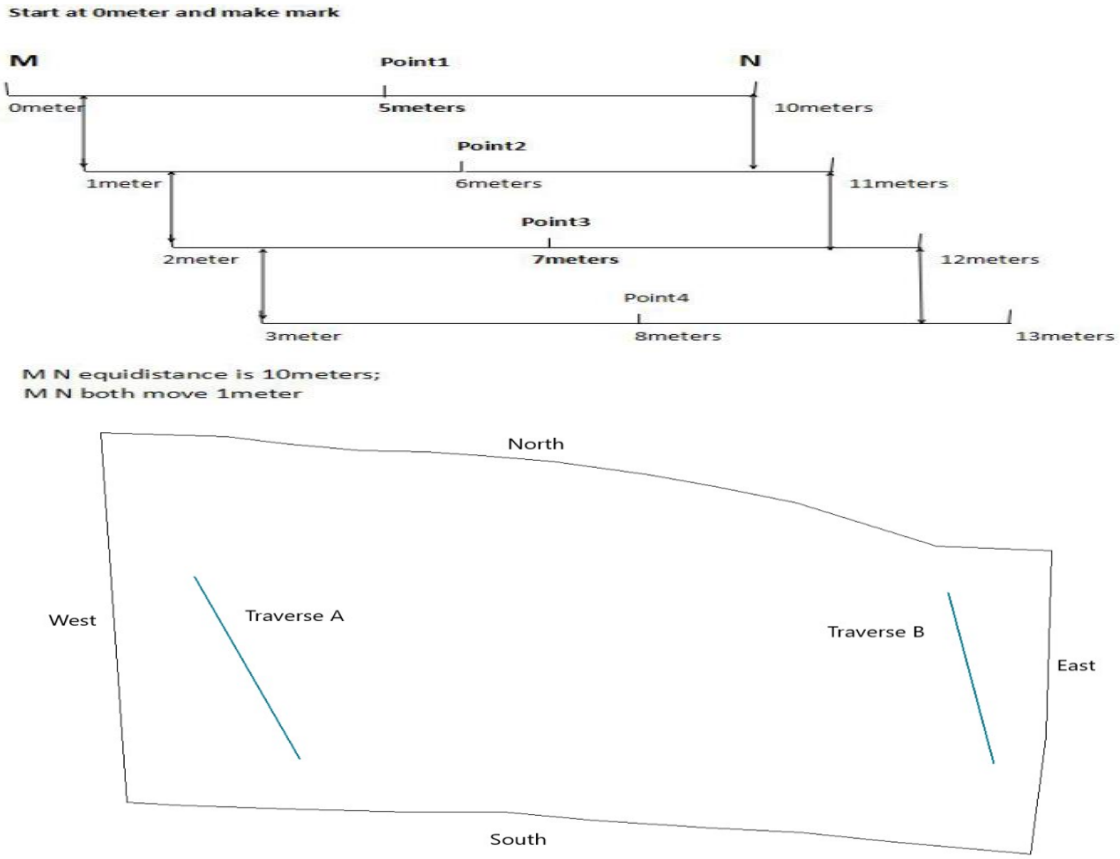

Fig. 7: Survey Line Location Layout

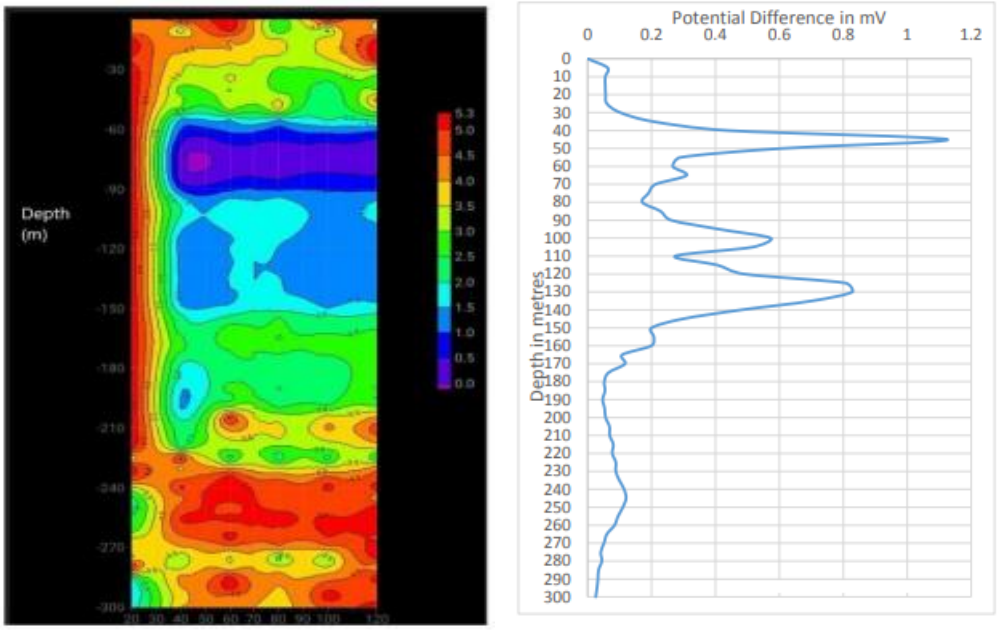

Fig. 8: Traverse A - Two-dimensional-apparent geo-electrical resistivity pseudo-section _Graph –Station 100

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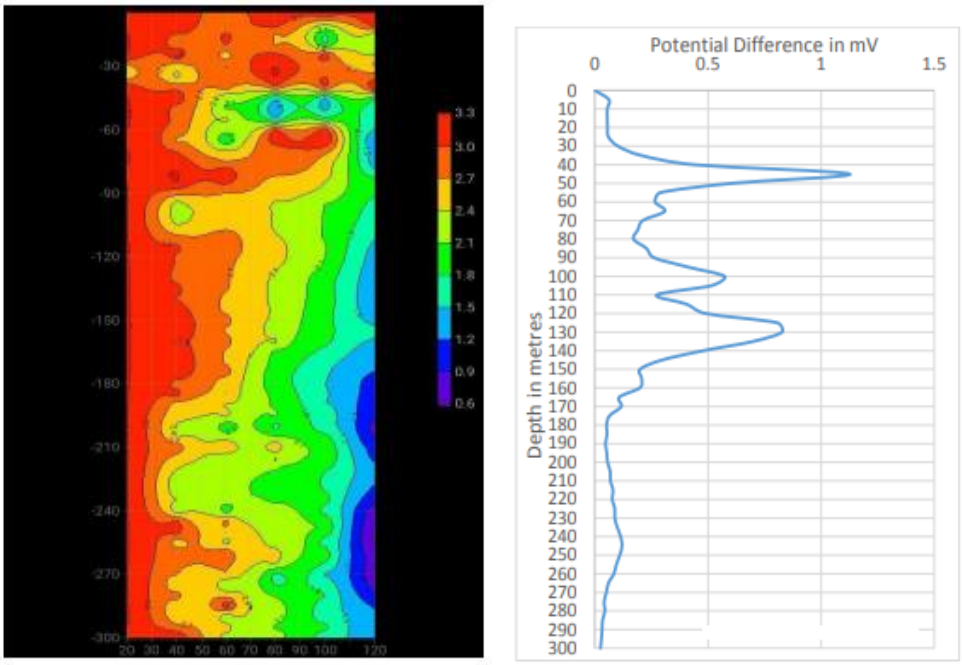

Fig. 9: Traverse B - Two-dimensional-apparent geo-electrical resistivity pseudo-section _Graph-Station 120

IV. RESULT AND DISCUSSION

The 2D ADMT model reveals a conductive nature of the study area with varying volt values of 0.5–5.3 millivolt across the two profiles. The two traverses (A, B) shows the lowest resistivity values @ depth ranges 30-50m , 60–90m, 150-210m of traverse A, 40m-80m, 120m-130m, 180-210m, 240-280m@traverse B.In general, the low resistivity nature of the subsurface materials can be explained with various subsurface mechanisms, such as the presence of fluids within interconnected pore spaces and fluids in high permeability zones associated with faults. Therefore both the traverse A, B sub surface data clearly indicate the positive sign of potential well points. Accordingly Traverse A, Station 40 to station 120 between this distances was suggested for drilling, similarly on Traverse B, Station No 90 to 120 between this distances was suggested for drilling.Based on above report the bore hole was drilled at Traverse A – Station no 60 up to the depth of 470 feet/ 143 m.

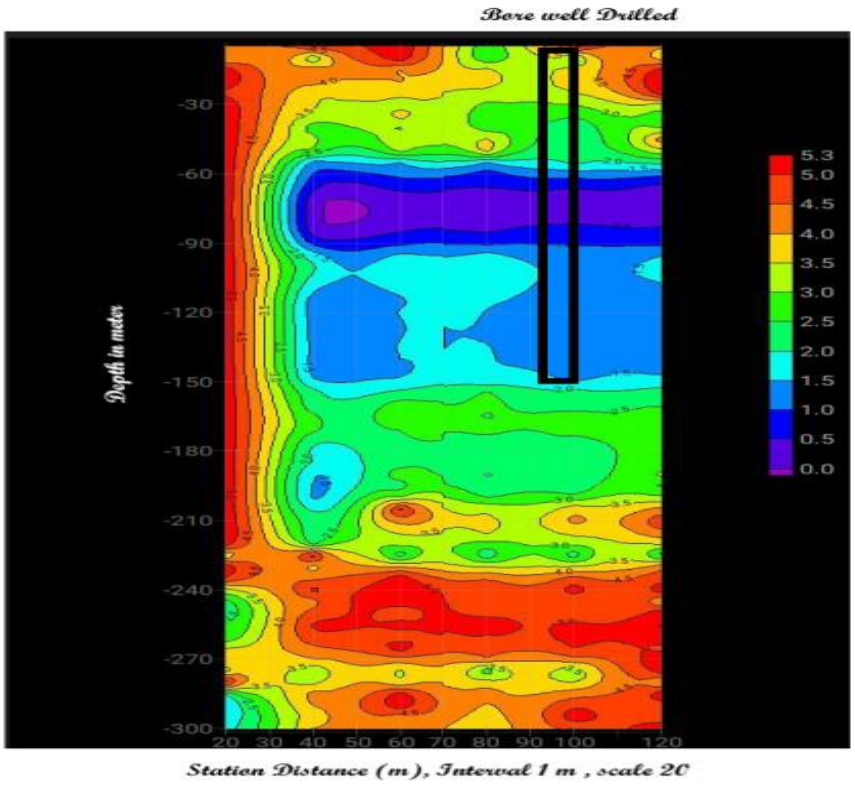

Fig. 10: Bore well drilling location

Fig. 11: Bore hole drilling

V. CONCLUSION

The present study demonstrates that the integrated use of geophysical techniques is an efficient tool for assessing groundwater potential, based on which suitable locations for groundwater withdrawal could be identified. Geophysical investigation revealed the underlying lithology to be made up of top soil, weathered layer and fractured basement. The 2D audio magnetotelluric geophysical technique has successfully been applied to delineate potential zones of aquifers, potential in terms of location and depth-to fractured zones. The technique has provided information on the lithology and structural relationships with in the investigative depth up to 300m for hydrogeological purpose. The study shows that the groundwater occurrence in the area is mainly controlled by fractured and weathered zones. The AMT method is effective in the exploration of groundwater with in the any kind of sub surface Geological environment. This method is effective and relatively cheaper in investigating great depths with dense space sampling as compared to deep electrical sounding even though it is very sensitive to the surface and urban noises due to the level of the urbanization of the study area.

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