IJAIR
International Journal of Agriculture Innovations and Research
Volume 2, Issue 3, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 02/12/2013 | Accepted on : 16/12/2013 | Published : 27/12/2013

# Using Geophysical and Driller's Log for the Determination of Aquifer in Extreme OWE Region (Delta State - Nigeria)

**Molua O. Collins (Ph.D)**
Physics Department, College of Education, Agbor. Delta State, Nigeria
Email: moluaogom@hotmail.com

**Ighrakpata C. Fedelia (M.Sc.)**
Physics Department, College of Education, Warri. Delta State, Nigeria

**Onwuka. F Onwuka(Ph.D.)**
Physics Department, College of Education, Agbor. Delta State, Nigeria

***Abstract*** **– The aim of this work is to investigate the geophysical borehole logging of extreme Owa region (Delta State - Nigeria) with a view to determining the lithology of the area. The resistivity of the formation was carried out, using resistivity logs of short Normal (SN), long Normal (LN), and long lateral (LL). The results show that the interval between (0-12) m bears loose lateritic sand. The depth zone of (24-30) m, (30-49) m and (55-58) m consist of clay rich sandy stones, which is capable of bearing water. The intervals (110-116) m to (158-160) m shows whitish colour particles with light brown silty clay. Within the depth intervals of (62-78) m and (92-102) m with formation resistivities of maximum values up to 6500 (nm) and 6100 (nm) respectively. The interval (78-92) m with moderately low resistivity between (700 and 2400) m has moderate water bearing aquifer (clay sandy zone).**

***Keywords*** **– Well, Borehole, Owa, Resistivity and Aquifer.**

## I. Introduction

Geoelectrical methods are applied to map the resistivity structure of the underground. Rock resistivity is of special interest for hydro geological purposes: it allows discriminating between fresh water and salt water, between soft-rock sandy aquifers and clayey material, between hard rock porous/fractured aquifers and low-permeable clay stones and marlstones, and between water-bearing fractured rock and its solid host rock. Geophysical methods have been used to prospect for iron-ore, exploration for oil and gas, detecting faults, fractures etc. In recent times their uses have been extended to environmental studies such as mapping of contamination plumes from dumpsites. The choice of a particular method to use depends on the nature of the study, purpose, suitability of the method, comparative advantage reliability, among other considerations. As a tool for geophysical exploration, the resistivity method is based on the fact that the underlying rock materials have resistance to current and as such ohm's law is applicable to them. The term apparent resistivity is used when the earth is not homogeneous and it is a weighted average of the resistivities of the various formations. True resistivity is the measured resistivity when the earth is homogeneous.

The methods can be very useful and convenient to use when searching for groundwater; in the exploration of minerals, and to investigate clay deposits [1]. It can also be used to determined soil lithology with some degree of accuracy.

Two survey techniques-electrical profiling and vertical electrical sounding (VES) are distinguishable. In profiling, the electrodes have fixed spacing while moving the system along profile line progressively. This way changes in the resistivity of the earth as one moves along the profile is detected. Thus it measures the lateral variation in apparent resistivity, and faults or fractures can be detected.

In VES studies, electrode spacing is increased to obtained information from greater depths at a given location. In either technique, specific electrode arrangement is needed. Prominent electrode arrangements are the Stumberger, Wenner, and Dipole-dipole among others. The Schlumberger and Wenner arrangements have better resolving power than others; and Wenner is more quantitative than Schlumberger [2].

In the ground, the conduction of electricity occurs through the interstitial water present in the rock and which contains some dissolved salts invariably. Consequently, low resistivity usually indicates the presence of water (or clay) in formation, and therefore is as important as water salinity in establishing the true resistivity of a medium[3]. In recent studies by Osazuwa and Abdullhi [4] , DC resistivity method was found suitable and can successfully be applied in landfill investigation because, dissolved plume (Leachate) can influence resistivity or conductivity, dielectric constant, and magnetic susceptibility. Other factors which affect the resistivity of a formation are porosity and degree of saturation.

## II. Theory

Resistivity of the ground is measured by injected currents and the resulting potential differences at the surface. The general field layout is sketched in Below Fig1.

Two pairs of electrodes are required: electrodes A and B are used for current injections, while electrodes M and N are for potential difference measurements. For a homogeneous ground and an arbitrary electrode arrangement (Fig.1A) the resistivity $\rho$ (unit: Ohm*meter, Ωm) as the relevant petrophysical parameter can be calculated from the current I and the potential difference U by

$$\rho_A = K.\frac{U}{I}$$

K is called geometric factor (unit: meter) and can be calculated from the
Electrode spacing by

$$K = \frac{1}{2\pi}.\left[\left(\frac{1}{AM} - \frac{1}{BM}\right) - \left(\frac{1}{AN} - \frac{1}{BN}\right)\right]$$

International Journal of Agriculture Innovations and Research
Volume 2, Issue 3, ISSN (Online) 2319-1473

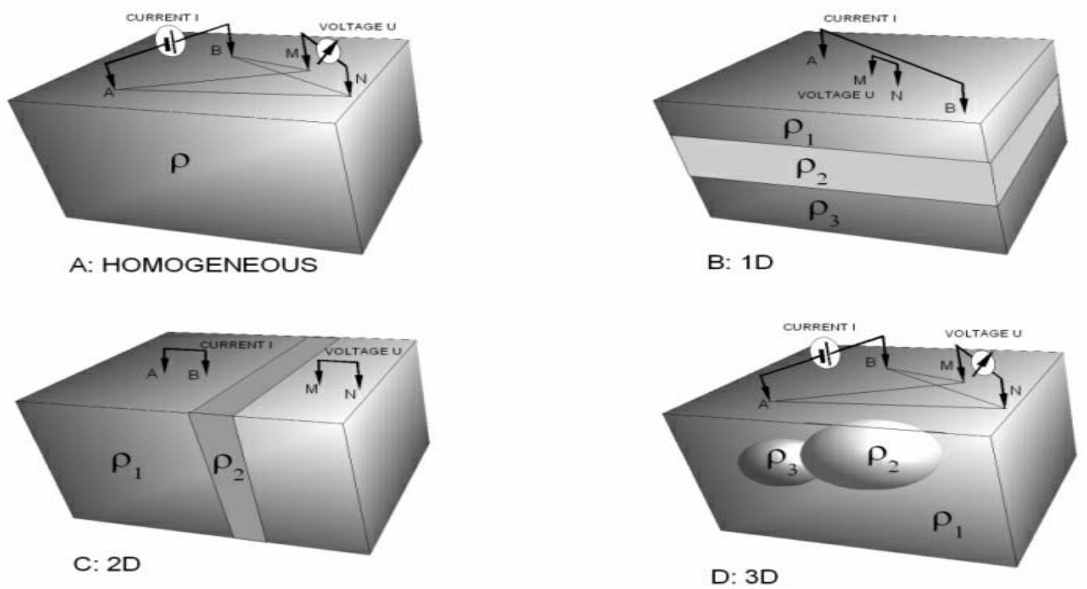


Fig.1. Electrode arrangement for apparent resistivity measurements, A: homogeneous Ground, B: layered ground, C: 2D resistivity distribution in the ground, D: 3D resistivity distribution in the ground

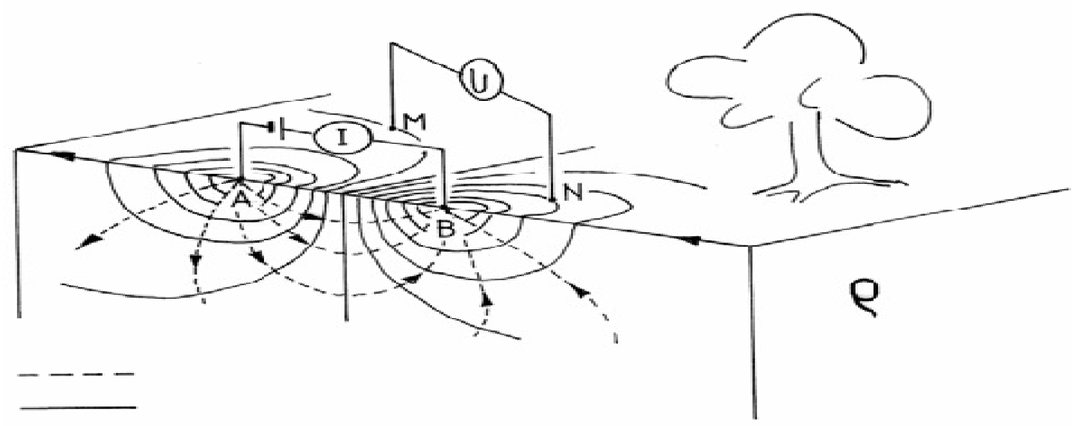


Fig.2. Current flow lines and equipotentials in a homogeneous ground

Over inhomogeneous ground (Figs.1B – 1D). From Figs. 1B –1D it is obvious that the resistivities and the shapes of the different geological units contribute to $\rho_A$. Different from the homogeneous ground (Fig.1A) and the true resistivity $\rho$, the apparent resistivity $\rho_A$ depends also on the location of the electrodes with respect to the geological units. Resistivity soundings are done by selecting an appropriate electrode configuration (see, e.g., Figs.1B –1D), by systematically changing and/or moving its configuration, and by sampling the related apparent resistivities $\rho_A$. This data set is computer-processed with the aim to get the underground true resistivity distribution, which has to be interpreted in terms of geological structures.

In general, a distinction is made whether one has to do with a horizontally Layered earth (commonly in sedimentary rocks), with elongated, so called two-dimensional geological structures (e.g., dikes, fracture zones), or with arbitrarily shaped structures (e.g., lenses, karst caves). Accordingly, the terms 1D (vertical electrical sounding, VES), 2D (electrical imaging) and 3D (electrical mapping, horizontal electrical sounding, HES, resistivity tomography) geoelectrics are frequently used. Vertical (1D) electrical soundings are applied to a horizontally or approximately horizontally layered earth. Geological targets maybe e.g. sedimentary rocks of different lithologies, layered aquifers of different properties, sedimentary rocks overlying igneous rocks, or the weathering zone of igneous rocks. In the most favorable case, the number of layers,

Their thicknesses and resistivities are the outcome of a VES survey. The basic idea of resolving the vertical resistivity layering is to stepwise Increase the current-injecting electrodes AB spacing, which leads to an increasing Penetration of the current lines and in this way to an increasing influence of the deep-seated layers on the apparent resistivity $\rho_A$ (Fig.3). The step-wise measured apparent resistivities are plotted against the current electrode spacing in a log/log scale and interpolated to a continuous configuration, by curve. This plot is called sounding curve, that is the base of all data inversion to obtain the resistivity/depth structure of the ground.

International Journal of Agriculture Innovations and Research
Volume 2, Issue 3, ISSN (Online) 2319-1473

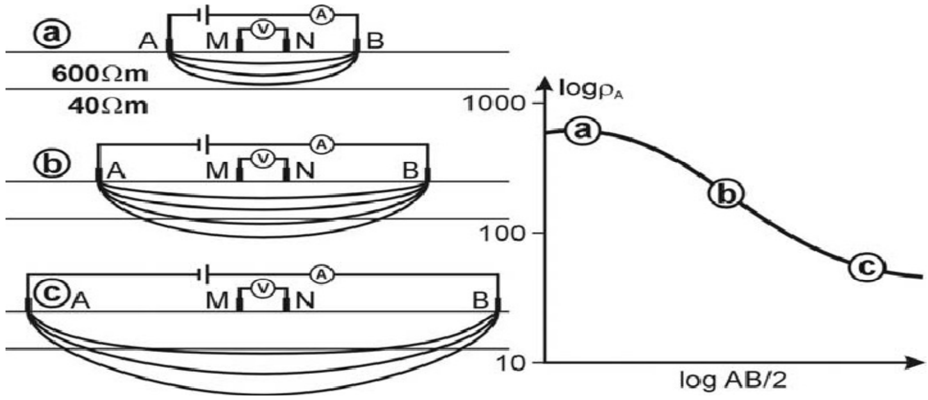


Fig.3. Apparent resistivity measurements, with increased current electrode spacing leading to increased penetration depths of the injected current. Results are compiled in the sounding curve

## III. Location of Study Area

This study was conducted in Owa –Agbor metropolis. Agbor is situated between latitude $6^0$ 15' and $9^0$ 90' N and longitude $6^0$ 11' and $8^0$ 79' E in Delta State Nigeria. Agbor metropolis is also known as Orogodo comprising of Boji-Boji Agbor in Ika South Local Government Area and Boji-Boji Owa in Ika North Local Government Area respectively. It is classified under the humid tropical rainforest zone. There are two distinct seasons characterized by seven months (April – October) of wet season and five months (November – March) of dry season. Mean rainfall is 3500mm while temperature ranges from $270^0$C -$30^0$C.

## IV. Geology of Niger Delta

The area covered by this study, Owa in Agbor, Forms part of Delta State which is part of Niger Delta. The geology of Delta State (and hence geology of the study area) is therefore aptly described by the geology of the Niger Delta.

The predominant depositional environment type is marine, mixed and continental. These are represented by the Benin, Agbada and Akata formations. An engineering consultant [5] has estimated that one million cubic metres of sand is carried towards Mushin every year. The Niger-Benue system contributes a sediment load of 0.02$km^3$/year which is deposited mostly on top of the Delta [6]

## V. Result and Interpretation

Table 1, presents lithological information on the drill holes of Owa borehole. Table 2 presents geophysical log data for the spontaneous potential (SP) and resistivity plots. Figure 5, shows plot of the SP and resistivity log for the drill-hole. Figure 6 shows resistivity pot of short normal (SN) and long normal (LN) with scale adjustment.

Lithologically, the combined results of SP and resistivity log interpretation very well corroborate the driller's log. The lithological materials penetrated by the drill hole basically consist of sand/fine coarse/ medium grained and clay of various textural composition and colour shades. The interval between (0-12) m bears loose laterie sand. The depth zone of (24-30) m, (30-49) m and (55-58) m consist of clay rich sandy stones, which is capable of bearing water. The intervals (110-116) m to (158-160) m shows whitish colour particles with light brown silty clay depicting possible existence of soft pan condition with high drilling penetration rate.

Figure 6, with close examination of the three resistivity log curves shows that the drill-hole has low resistivity (450nm) at the depth zone of (32-48) m and the zone should bears water which will drill down through the gravel pick to the bottom. Excessive dry condition is observed within the depth intervals of (62-78)m and (92-102)m with formation resistivities maximum values up to 6500 (nm) and 6100(nm) respectively. The interval (78-92) m with moderately low resistivity between (700 and 2400) m has moderate water bearing aquifer (clay sandy zone).

At the zone of 11m, it show that the drill hole because effectively saturated. The interval between the 11m-depth horizon and the total logged depth of 160m presents resistivity values generally around (500-1900) nm range. This interval (48m) continuous depth is assigned water saturated status. Reported comparatively resistivity of this wet zone (and indeed the entire logged interval) relative to know range water bearing sand clay. The particle size distribution analysis results confirm the entire interval of saturated sand clay as clean aquifer materials that could support high well yield. The bottom most section (135-152) m with least fine fraction is however selected for screen placement.

## VI. OWA Well Design and Completion

Figure 4 shows the schematic of well completion and design for the Owa borehole. Allowing for about one-meter drill-depth loss to bottom settlement, this design basically stipulates as follows:

- (152 – 154m: bottom bug (sump)
- (152-135)m: screen
- 135 to surface: steel casing.

Placement of intake portion of submersible pump at 130m (443ft) would allow a 5m (17ft) clearance between screens and pump. This is deemed to be well adequate for any envisaged draw down occasioned by well pumping.

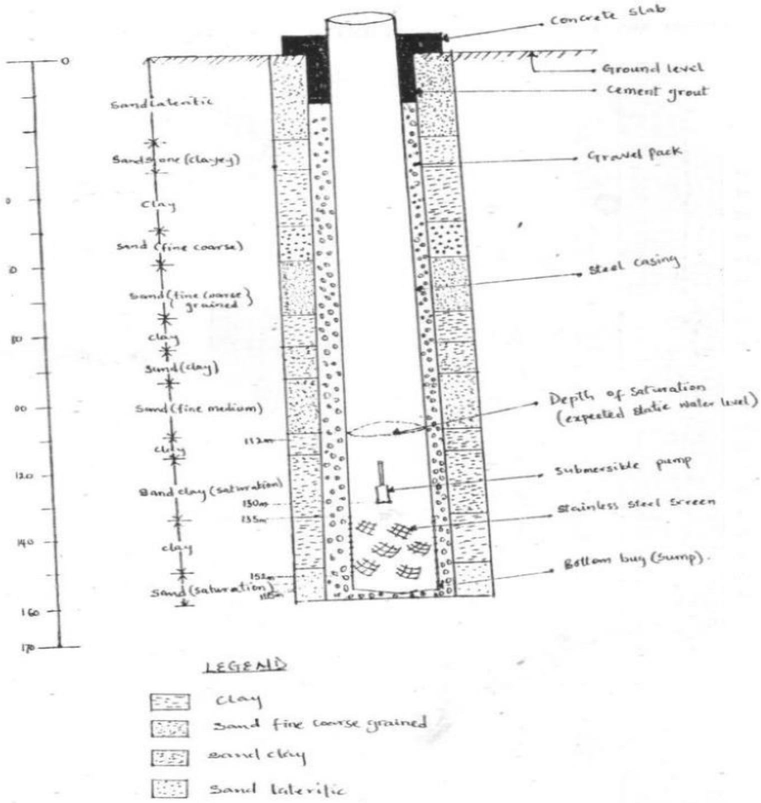


Fig.4. Owa well completion design

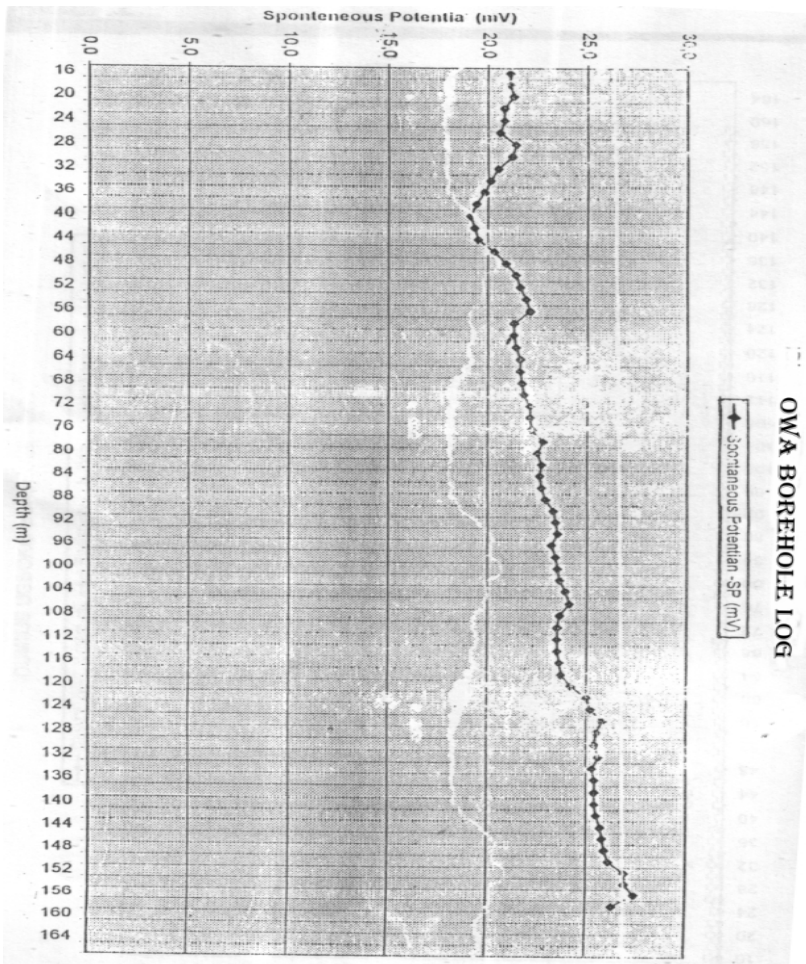


Fig.5. Spontaneous Potential-SP (mv) graph

International Journal of Agriculture Innovations and Research
Volume 2, Issue 3, ISSN (Online) 2319-1473

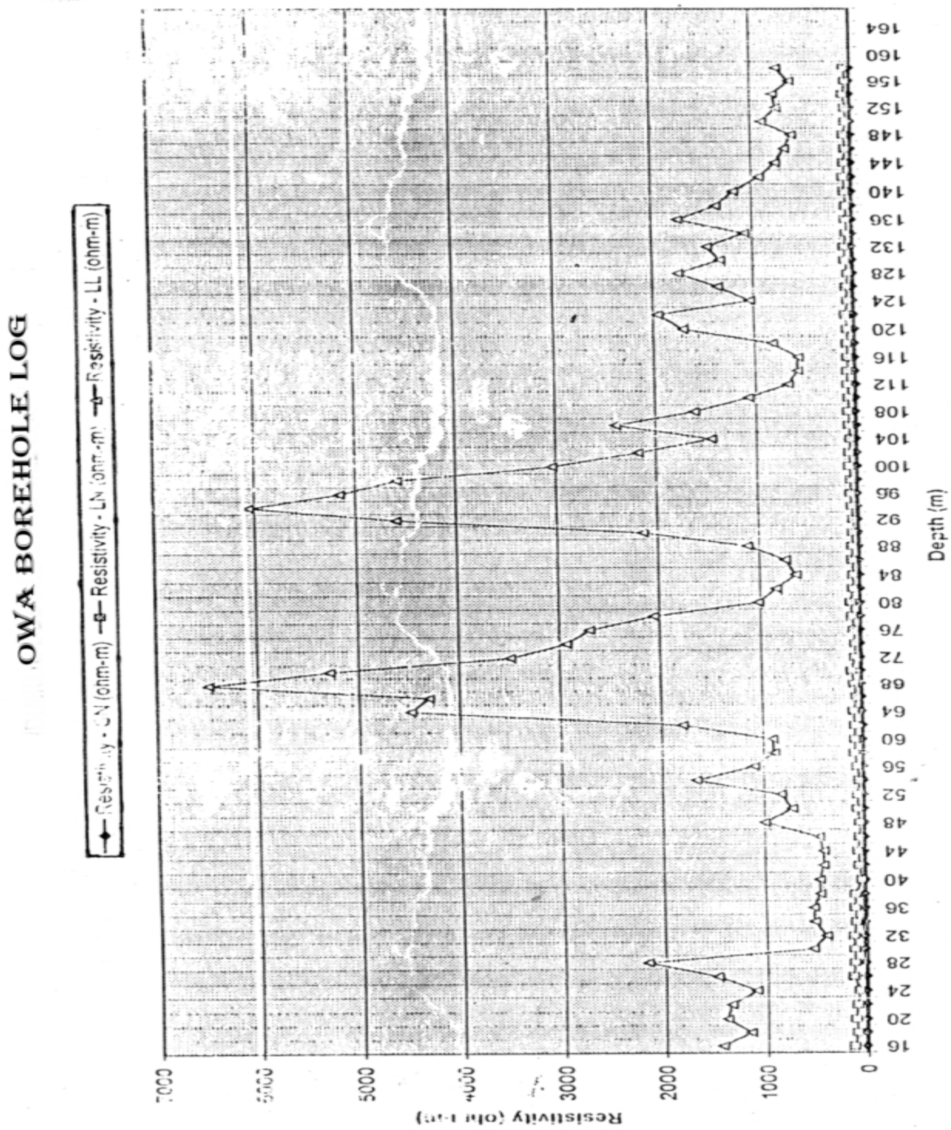


Fig.6. Short Normal (SN), long Normal (LN) and long lateral (LL) plots with scale adjustment

Table 1: Owa Borehole Lithology Description

| S/N | Interval (m) | Sample Description |
|---|---|---|
| 1 | 0-12 | Sand-lateritic reddish brown |
| 2 | 12-24 | Sand,fine-coars grained,gravelley,brownish |
| 3 | 24-30 | Clayey sandstone brownish |
| 4 | 30-49 | Clay, light brown |
| 5 | 49-55 | Sand, fine-coarsed grained gravelley,whitish |
| 6 | 55-58 | Clay,sandy,whitish |
| 7 | 58-73 | Sand,fine-coarsed grained gravelley,whitish |
| 8 | 73-85 | Clay,gravelley,brownish |
| 9 | 85-91 | Sand,fine-coarsed gravelley,whitish |
| 10 | 91-110 | Sand,fine-medium grained, whitish |
| 11 | 110-116 | Silt,claye,light brown |
| 12 | 116-134 | Sand,fine-medium grained,whitish |
| 13 | 134-140 | Sand,fine coarse grained,whitish |
| 14 | 140-143 | Sand, with silty clay,very light brown |
| 15 | 143-151 | Sand, fine coarse grained, whitish |
| 16 | 151-158 | Sand fine-coarsed grained,gravelley,whitish |
| 17 | 158-160 | Clay, light gray into whitish |

Table 2: Geophysical Log Data For The Spontaneous Potential And Resistivity.

| S/N | Depth(m) | Spontaneous Potential SP(mv) | Resistivity (Ohm-m) | | |
|---|---|---|---|---|---|
| | | | Short Normal | Long Normal | Long Lateral |
| 1 | 0 | | | | |
| 2 | 2 | | | | |
| 3 | 4 | | | | |
| 4 | 6 | | | | |
| 5 | 8 | | | | |
| 6 | 10 | 21.2 | 50.38 | 164.71 | 32083.12 |
| 7 | 12 | 21.1 | 17.32 | 164.11 | 6470.64 |
| 8 | 14 | 21.2 | 21.80 | 108.91 | 10941.08 |
| 9 | 16 | 21.2 | 19.94 | 136.30 | 1447.13 |
| 10 | 18 | 21.2 | 18.61 | 106.68 | 1170.13 |
| 11 | 20 | 21.3 | 2.27 | 122.43 | 1400.12 |
| 12 | 22 | 20.9 | 21.43 | 108.50 | 1360.11 |
| 13 | 24 | 20.8 | 23.00 | 85.43 | 1110.113 |
| 14 | 26 | 20.7 | 20.92 | 145.90 | 1490.14 |
| 15 | 28 | 21.4 | 28.60 | 129.76 | 2180.21 |
| 16 | 30 | 21.3 | 29.98 | 129.75 | 540.04 |
| 17 | 32 | 20.4 | 30.80 | 131.40 | 410.02 |
| 18 | 34 | 21.2 | 31.56 | 106.28 | 520.04 |
| 19 | 36 | 19.7 | 26.86 | 115.66 | 530.05 |
| 20 | 38 | 19.3 | 24.82 | 113.02 | 460.06 |
| 21 | 40 | 19.2 | 21.01 | 43.72 | 460.04 |
| 22 | 42 | 19.3 | 21.13 | 69.47 | 424.05 |
| 23 | 44 | 19.6 | 21.98 | 75.21 | 420.05 |
| 24 | 46 | 20.4 | 18.20 | 59.48 | 462.06 |
| 25 | 48 | 20.8 | 13.65 | 55.19 | 1000.09 |
| 26 | 50 | 21.3 | 16.45 | 73.97 | 723.06 |
| 27 | 52 | 21.15 | 15.67 | 67.86 | 834.09 |
| 28 | 54 | 21.8 | 15.98 | 50.69 | 1668.15 |
| 29 | 56 | 22.2 | 15.13 | 67.01 | 1094.12 |
| 30 | 58 | 21.2 | 17.17 | 95.22 | 894.07 |
| 31 | 60 | 21.1 | 23.20 | 91.97 | 907.09 |
| 32 | 62 | 21.3 | 15.91 | 85.61 | 1793.16 |
| 33 | 64 | 21.7 | 22.06 | 93.20 | 4490.43 |
| 34 | 66 | 21.5 | 21.11 | 63.55 | 4310.44 |
| 35 | 68 | 21.6 | 23.07 | 85.42 | 6490.65 |
| 36 | 70 | 21.9 | 18.94 | 105.01 | 5290.64 |
| 37 | 72 | 22.3 | 21.31 | 70.12 | 3490.36 |
| 38 | 74 | 22.2 | 20.17 | 62.12 | 2930.28 |
| 39 | 76 | 22.1 | 20.18 | 76.21 | 2700.28 |
| 40 | 78 | 22.7 | 17.72 | 90.13 | 2060.18 |
| 41 | 80 | 22.4 | 18.18 | 100.35 | 1017.09 |
| 42 | 82 | 22.5 | 16.70 | 72.54 | 838.06 |
| 43 | 84 | 22.6 | 17.41 | 68.47 | 640.07 |
| 44 | 86 | 22.7 | 22.73 | 74.14 | 743.06 |
| 45 | 88 | 22.8 | 16.23 | 74.38 | 1112.14 |
| 46 | 90 | 23.1 | 18.85 | 61.11 | 2150.22 |
| 47 | 92 | 23.2 | 20.11 | 60.27 | 4600.48 |
| 48 | 94 | 23.3 | 19.45 | 67.00 | 6060.67 |
| 49 | 96 | 23.0 | 18.72 | 79.92 | 5160.50 |
| 50 | 98 | 23.3 | 18.28 | 70.51 | 4590.47 |
| 51 | 100 | 23.6 | 15.18 | 82.37 | 3040.32 |
| 52 | 102 | 23.5 | 17.92 | 78.69 | 2180.21 |
| 53 | 104 | 23.8 | 18.56 | 69.87 | 1448.13 |
| 54 | 106 | 24.2 | 15.93 | 81.31 | 2400.23 |
| 55 | 108 | 23.5 | 21.29 | 87.48 | 1611.15 |

| | | | | | |
|---|---|---|---|---|---|
| 56 | 110 | 23.6 | 15.04 | 74.40 | 1070.10 |
| 57 | 112 | 23.4 | 12.97 | 86.44 | 678.06 |
| 58 | 114 | 23.3 | 15.69 | 84.45 | 584.09 |
| 59 | 116 | 23.5 | 13.31 | 78.26 | 575.07 |
| 60 | 118 | 23.6 | 17.96 | 79.92 | 823.06 |
| 61 | 120 | 24.3 | 12.03 | 75.43 | 1710.18 |
| 62 | 122 | 25.2 | 14.35 | 88.09 | 1959.19 |
| 63 | 124 | 25.1 | 18.62 | 63.95 | 1036.11 |
| 64 | 126 | 25.7 | 19.14 | 71.72 | 1354.12 |
| 65 | 128 | 25.6 | 18.77 | 58.03 | 1752.18 |
| 66 | 130 | 25.2 | 18.84 | 85.21 | 1324.11 |
| 67 | 132 | 25.4 | 18.76 | 88.67 | 1456.13 |
| 68 | 134 | 25.1 | 17.75 | 62.75 | 1077.14 |
| 69 | 136 | 25.4 | 17.24 | 70.73 | 1745.15 |
| 70 | 138 | 15.3 | 16.76 | 62.54 | 1357.12 |
| 71 | 140 | 25.3 | 18.00 | 75.84 | 761.07 |
| 72 | 142 | 25.7 | 16.08 | 84.41 | 925.09 |
| 73 | 144 | 25.8 | 17.13 | 75.83 | 761.07 |
| 74 | 146 | 25.7 | 16.87 | 60.28 | 760.05 |
| 75 | 148 | 25.6 | 17.79 | 73.17 | 598.04 |
| 76 | 150 | 26.2 | 17.35 | 51.07 | 590.10 |
| 77 | 152 | 26.8 | 18.17 | 53.96 | 743.06 |
| 78 | 154 | 26.7 | 18.23 | 71.92 | 774.06 |
| 79 | 156 | 27.3 | 18.61 | 47.43 | 611.08 |
| 80 | 158 | 26.2 | 15.47 | 59.07 | 737.07 |

## VI. Conclusion

Results from down-hole geophysical logs and driller's log information on the Owa borehole center confirms the dominant presence of sand/fine coarse grained and clay. A total logged depth of 160m holds for the borehole. An effective depth to water saturation level of 112m is interpreted and a rather phreatic behaviour is expected for the aquifer. That is, static water level in the completed borehole will be anywhere around 112m from the surface.
Considering the 155m depths to the bottom lying permeable sand/clay horizon, an effective thickness of saturated aquifer material of 43m (143ft) is guaranteed for the borehole. Similarly, expected standing water column above top of screen is 23m (77ft). Allowing about 5m (17ft) clearance between pump intake and top of screen, a 18m (60ft) and more column of water is expected above the pump, it should be noted that reduction of the recommended pump intake depth of 130m will optimize the resultant borehole discharge.

## Recommendations

Geophysical logging should always be carried out on every borehole be it oil well or water well after drilling to the total depth. This is particular important in areas where enough information is not available on the information and formation fluids. The geophysical logs should be interpreted in conjunction with the sample description, by competent personnel for a decision on screen and casing position.

The interpretation of SP curve aid in lithology (mineral) identification and permits the determination of formation of water resistivity, therefore the log should be carried out first in order to determine the driller's depth and lithological formation.

## References

[1] Ujuanbi, O.,(2000):Investigation of Clay Deposites in The northern Part of Edo state using The Electrical Resistivity methods. Unpublished Ph.D Thesis submitted to A.A.U Ekpoma.
[2] Tagg, G.F. (1934): Interpretation of Resistivity Measurements. Trans. A.I.M.M.N. 110, pp. 135-147.
[3] Dauda, O.F. Application of Electrical Resistivity Method to hydro-geological problems of the Benin formation (Unpublished B.Sc project, Geology department, Uniben). 1989
[4] Osazuwa I.B and Abdullhi N.K (2008),Geophysical techniques for the study of groundwater pollution: A Review Nigerian journal of physics , Nigerian Institute of Physics Vol 20
[5] Nedeco, (Netherland Engineering Consultants) (1961): The Waters of the Niger Delta. The Hague 317pp.
[6] Burke, K. (1972): Lonshore Drift, Subnarine Canyons and Sumarine Fans in the Development of the Niger Delta; Am. Assoc. Petroleum Geophysists Bull. Vol. 56 pp. 1975 – 1983