

## Investigation of water table depths in some selected areas of IMO State, Nigeria

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### Abstract

Water from borehole has become an inevitable alternative for water supply in cities and communities of Imo State, Nigeria. This is caused by the dilapidation and the moribund condition of government owned treatment plant and the extinction of most rivers and streams within the state. The researcher used empirical method predicated on the geophysical survey conducted on the sample study areas of Orodo Mbaitolu, Egwuedu Njaba, Umusasa Orlu, Umudiato Orlu, Ehime Mbano and Nekede Owerri. The appropriate instrument of vertical electrical sounding was used to establish the lithological units of the areas and the total drilling depths of the boreholes. With the information from the lithologic units and total drilling depths, the various water table depths for these areas were established. The recommended water tables depths for Orodo Mbaitolu, Egwuedu Njaba, Umusasa Orlu, Umudiato Orlu, Ehime Mbano and Nekede Owerri, were 102m, 150m, 48m, 45m, 75m and 105m, respectively.

**Keywords:** water table depth, geophysical survey, lithology, groundwater

### 1. Introduction

Groundwater has become a veritable and popular source of water in Imo State due to the absence and non-availability of public water as previously provided, by government. The necessity of water to life cannot be overstated and as a result, there is massive and rampant exploitation and exploration of our groundwater.

Apart from the surface water in the form of rivers, streams and springs, the groundwater has become a succor to individual families and communities in Imo State. The drive to the increased demand to ground water has been exacerbated by the neglect of our rivers, streams and springs which had led to the extinction of many of such surface water bodies. Ground water is normally stored in water bearing geologic formations called aquifers. Boreholes are drilled to these aquifers to exploit the abundant water present in these formations. Accessibility to the groundwater is only possible when the depth at which the water in the sub-surface can be tapped in abundance, continuously and unhindered and this depth is known as water table depth. This research is necessary as it will guide water consumers, engineers and prospective groundwater exploiters on the water table depth and the best method to assess the water.

#### 1.1 Groundwater

Groundwater is widely distributed under the ground and it is replenishable. Groundwater is generally defined as the underground water that occurs in the saturated zone of variable thickness and depth below the ground. The possibility of the occurrence of groundwater depends mainly on the porosity of the rock and the permeability of rocks. Groundwater is relatively free from pollution and can easily be developed at a least possible cost and time. Groundwater occurs below the ground surface of the earth. It occurs in two zones namely: saturated zone and zone of aeration.

#### 1.1.1 Saturated Zone

This is the zone in which the water is saturated and it is often called the groundwater zone. The saturated zone gets its water from the rain water which enters the ground through the pores and percolates and accumulates within the saturated zone to form groundwater. Water from other sources such as rivers, canals and reservoirs percolates below the ground to constitute groundwater.

#### 1.1.2 Zone of Aeration

The space above the water table and below the ground surface is known as the zone of aeration. Water exists in this zone by molecular attraction. The gravity water (i.e. moving water) moves through the zone and the water at this zone is not at hydrostatic pressure. Its thickness varies from place to place. As a zone that lies between the water table and ground surface, it is unsaturated but it contains both water and air. Water in the zone is held by molecular and capillary fringe zone sandwiched by the intermediate zone.

The soil water zone is immediately below the ground surface and the roots of crops take water from the zone for its transpiration. The capillary fringe zone is above the water table. The intermediate zone sandwiches the soil water zone and the capillary fringe zone. The saturated zone is of great importance to the engineer as the concentration and interest are on the occurrence and movement of water within the saturated zone.

#### 1.2 Groundwater recharge

Groundwater recharge is the water from rainfall and other sources which passes through the zone of aeration and enters the saturated zone where the groundwater is accumulated. Water from the rains enters the soil through its pores and seeps through as recharge to replenish the groundwater. Groundwater recharge replenishes water withdrawals from the groundwater. When the groundwater recharge is less than the

water withdrawals, this poses a great danger to the groundwater of any community, town or city. The problems of ground investigation lie in its occurrence and recharge. The modern trends are to create more opportunities for recharge of groundwater from natural sources such as rain, percolation dams etc.

**1.3 Aquifers**

This is defined as water bearing geologic formation or stratum which is capable of transmitting water through its pores at a rate sufficient for economic extraction by wells. Geologic formation which can be regarded as good aquifers include unconsolidated gravels, sands, alumni, lake sediments, glacial deposits, sand stones, limestones with cavities (caverns), formed by action of acid water, granites and marbles with fissures and cracks weathered gneisses, and schists, heavily shattered quartzites, vesicular basalts etc. Aquifers have various types and they include aquiclude, aquifuge and aquitard.

Aquiclude is a geologic formation which can absorb water but cannot transmit significant amounts. Typical examples of aquiclude include clays and shales. Aquifuge is a geologic formation with no interconnected pores and therefore cannot absorb nor transmit water and its examples include basalts and granites. An aquitard is a geologic formation with impervious nature, it has the ability to transmit water, but at a very slow rate. It has insufficient water for withdrawal through pumping.

**1.3.1 Properties of Aquifers**

The properties of aquifers include porosity, specific yield, specific retention, coefficient of permeability, transmissibility, storage coefficient and specific storage. Porosity is a measure of the water-holding capacity of any geologic formation. When the porosity is high, the water holding capacity is low, porosity is defined as the ratio of volume of voids  $V_v$  to the total volume of soil  $V$ . it is normally denoted by  $n$  and it is equal to;

$$n = \frac{V_v}{V} \times 100\% \dots\dots\dots 1.1$$

Specific yield is defined as the quotient of volume of water  $V_w$  in a geologic formation which can be extracted by the force of gravity (i.e pumping) and the total volume of the saturated geologic formation. This can be stated mathematically; Specific yield  $S_y =$

$$\frac{V_w}{V} \times 100\% \dots\dots\dots 1.2$$

**Specific Retention:** is the quotient of the volume of water,  $V_r$  which can be retained and the total volume ( $V$ ) of the saturated aquifer and it is stated thus, Specific Retention =

$$S_r = \frac{V_r}{V} \times 100\% \dots\dots\dots 1.3$$

Since the total volume of voids  $V_v$  equal to the sum of volume of water extracted  $V_w$  and the volume retained  $V_r$  it can therefore be stated that,

$$V_v = V_w + V_r \dots\dots\dots 1.4$$

Dividing both sides of the equ. 1.4 by the total volume of aquifer,  $V$ ,

$$\frac{V_v}{V} = \frac{V_w + V_r}{V}$$

Converting both sides of the equ. 1.5 Into percentage we have;

$$\frac{V_v}{V} \times \frac{100}{1} = \left( \frac{V_w + V_r}{V} \right) = 100$$

$$\frac{V_v}{V} \times \frac{100}{1} = \frac{V_w}{V} \times \frac{100}{1} + \frac{V_r}{V} \times \frac{100}{1}$$

$$\Rightarrow n = S_y + S_r \dots\dots\dots 1.6$$

The coefficient of permeability  $K$  is the discharge per unit area of soil mass per unit hydraulic gradient. The coefficient of permeability can also be called the hydraulic conductivity.

Transmissibility is defined as the discharge of water, transmitted through a unit width of an aquifer under a unit hydraulic gradient.

Storage coefficient of an aquifer is the volume of water released from a prism of unit cross sectional area as the water table drops by a unit depth. It can also be called storativity. Specific storage is the storativity per unit saturated thickness of the aquifer.

**1.4 water table depth**

Water table depth can be defined as the vertical distance from the ground surface to the starting point of the saturation zone of the groundwater surface profile. This depth varies from place to place due to variations in the thickness of the aeration zone of each locality. Water table depth lies within the saturated zone. The water table commences immediately at the end of the capillary fringe zone. It is known as the phreatic surface because at all points on the water table the pressure is atmospheric. The distance from the ground surface to the point of commencement of the saturation zone is known as the water table depth.

Water table can also be described as the surface of water level in an unconfined aquifer at which the pressure is atmospheric. It is also a level at which the water will stand in a well drilled in a confined aquifer. The water table fluctuates whenever there is a profound recharge or withdrawal from the aquifer. The water table is in motion responding through adjustment of its surface to create a balance between the inflow (recharge) and out flow (extraction).

It has been observed that water table follows the topographic features and it is high below ridges and low below valleys. At times, the topographic ridge and water table ridge may not coincide and there may be flow from one aquifer to the other aquifer and this is called watershed leakage. At any place where the water table intersects the ground surface, a seepage surface or a spring is created.

Perched water table is created when a small ground water body is separated from the main ground water body by a relatively small impermeable stratum. Well drilled beyond the perched water table through the small impervious stratum

locating the main groundwater gives much yield. Conversely wells drilled at the level of the perched water table gives less yield and dries up fast.

### 1.5 Exploitation of groundwater in imo state

Groundwater has been an alternative source of water in Imo State due to the absence of public water which is normally reticulated to serve the citizens. The major source of water, supply to Imo State capital has been the Otamiri treatment plant. The treatment plant has not been operational for the past years and the citizens had resorted to the exploitation of the available groundwater through the drilling of boreholes to meet up with their water needs.

The problem of water supply in the state was worsened by the neglect of water resources as many rivers, springs, and streams have gone into extinction. In the past, these streams, springs and rivers have been a source of water to communities and towns. In the face of this problem the only available option is the groundwater exploration and exploitation. The craze of drilling boreholes in Imo State has been a subject of worry and concern to professionals owing to the uncoordinated and indiscriminate manner through which these projects were being executed.

## 2. Methodology

The empirical method of research was employed in this work. The empirical methods applied included the pre-drilling geological survey, geophysical survey and instrumentation.

### 2.1 pre-drilling geological survey

This is an important investigation which must be carried out at any borehole site before the actual drilling operation commences. The pre-drilling geological survey was carried out at all the sites to establish such vital information as viability of the project at the given site, estimated drill depth, type of geologic formation to be encountered and the correct drilling equipment to be applied.

### 2.2 geophysical study

Resistivity is an electrical property of rock materials that is related to their lithology. With this, the determination of the subsurface distribution of resistivity from measurements on the surface yielded vital information on the sub-surface formations.

This investigation was done by passing into the earth direct current. Four electrodes were used at the surface, one pair for introducing current into the earth while the other pair was used for measuring potential associated with the current. The potential drop ratio is used to obtain the resistivity. The resistivity method was targeted at obtaining the apparent resistivity  $e_a$  from the four electrodes with the formular;

$$e_a = 2\pi \frac{G \Delta V}{I}$$

The vertical electric sounding (VES) was carried out once in the sites.

### 2.3 Instrumentation

Data were acquired with an ABEM Terrameter (SAS) 300B with a crystal digital readout and automatic signal averaging microprocessors. With the combination of SAS 2000 booster and SAS log 200, the ABEM Terrameter (SAS) 300B can be used to take consecutive readings automatically and the results were averaged continuously. The continuously updated running was presented automatically on the display facility. This continues until the operator is satisfied with the stability of the result.

### 2.4 processing of data

The raw data collected from the field were processed by applying the appropriate constants and analysed using the FORTRAN Resistivity 2-D Inverse computer program.

### 2.5 geological description of study areas

All the study areas are located within the Imo State in the South Eastern geo-political zone of Nigeria. The study areas include Nekede Owerri, Ehime Mbano, Umuna Orlu, Orodo Mbaitolu, Njaba, and Umudiato Orlu.

#### 2.5.1 Geological Formation of Study Area

The study areas fall within the geologic zone of Benin and Ameki formation. Benin formation is a good aquifer with a profound recharge replenishment of  $2.5 \times 10^6$  m<sup>3</sup>/yr. Benin formation comprises alternating layers of sands, sandstones and loams with clays. Sand forms the most prevalent and dominant component of the layers to the tune of over 90% with high permeability, transmissivity and storage coefficient. The Ameki formation characterizes the Imo formation and it is made up of green-grey clayey sandstone and sandy clay stone. It is bifurcated into lower and upper Ameki. Coarse sandstones are the major component of the upper Ameki while massive dark grey to brown sandy mudstones is the composition of the lower Ameki beds. The sand compositions of the lower beds are intercalated with shales, lignites and calcereous shales. This formation is aquiferous but not to the same extent as the coastal plain sands. It has lower transmissivity coefficient because of high content of shale.

Umudiato Orlu and Ehime Mbano lie within the transition of the Benin and Ameki formations while Nekede, Umusasa Umuna Orlu, Njaba and Umudiato Orlu, belong to the Benin geological formation. The geological map of the study area is shown in fig. 3;

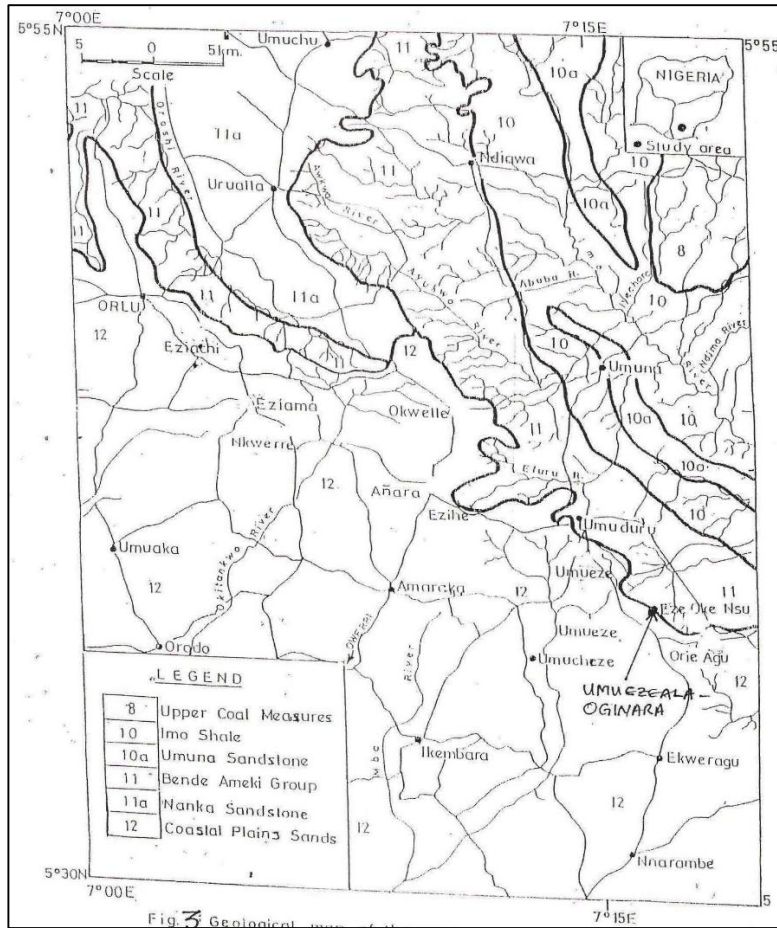


Fig 3: Geological map of the study area (modified from sheet 79, GSH)

### 3. Result presentation and analysis

#### 3.1 presentation of results

The results of the Vertical Electrical Sounding with the lithology of the study areas are shown in figure 3.1

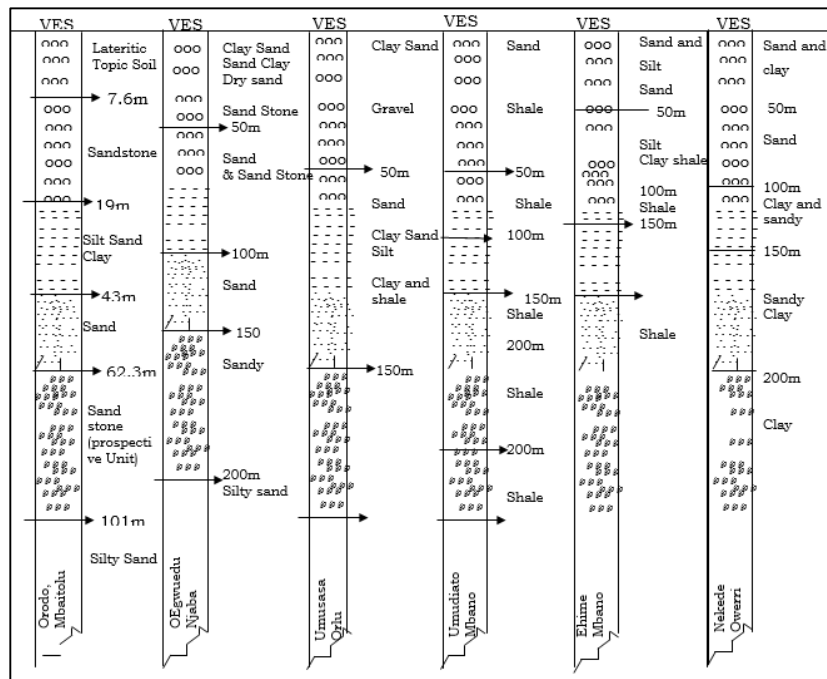


Fig. 3.1: Vertical Electrical Sounding and Lithology Results Note that the above diagram is not drawn to scale.

The results of the geophysical survey in terms of depths are presented in table 3.1.

**Table 3.1:** Maximum Depths of Drilling in the sample Areas.

S/N	Study Area	Drilling Maximum Depth
1.	Orodo Mbaitolu	> 101.00
2.	Egwuedu Njaba	> 200.00
3.	Umusasa Orlu	> 150.00
4.	Umudiato Orlu	> 200.00
5.	Ehime Mbano	> 150.00
6.	Nekede Owerri	> 200.00

The resistivity which is an electrical property of rocks and it is also related to the lithology of the geological formation was obtained and put into a computer modeled curve as shown in fig. 3.2.

**3.2 Result analysis**

It can be observed from figure 3.1 that the major lithologic

units within the subsurface in the sample study areas are laterite, sand, silt, day, shale, sandy clay, clayey sand etc. The results will guide the drillers to know when to install the screens. For instance in the Nekede Owerri sample study area, the screens should be installed within the pure sand zone. Generally, the down – hole geophysical logging will help the drillers to identify the appropriate depth for the screen installation. The depths of the water table will assist the drillers to know the depth of their drilling. In the Ehime Mbano the study area, it can be observed that lithologic units within the subsurface are sand, silts and clay. Based on this finding the location is viable for a borehole drilling project and efforts should be made to install the screen within the sand units. For other study areas it was observed that the drilling of boreholes there will be highly viable due to the nature of the lithologic units. From the lithologic units of the study areas the depths of drilling are recommended. These depths of drilling are considered as the water depth and they are shown in table 3.2.

**Table 3.2:** Recommended Water Depths for the study Area

S/N	Study Area	Recommended Water Table (Depth of drilling)
1.	Orodo Mbaitolu	102.00
2.	Egwuedu Njaba	150.00
3.	Umusasa Orlu	48.00
4.	Umudiato Orlu	45.00
5.	Ehime Mbano	75.00
6.	Nekede Owerri	105.00

Aquifers with high yield were actually located at the recommended drill depth. Geophysical survey as conducted had helped in ensuring that viable water borehole was sunk in these areas and provided an economic framework of achieving these boreholes without any form of wastage arising from unviability and abandonment.

**4. Conclusions and Recommendations**

**4.1 Conclusion**

With geophysical survey carried out in the study areas, it was possible to entrench the usage of the right drilling equipment, establish the drill depth and minimize cost. This paves way for proper planning and efficient execution of the project. With the work, it was clear at what point the screen would be correctly installed. With the lithological units, it was possible to recommend accurately the depth of drilling which invariably represents the water table depth.

**4.2 Recommendations**

Based on the findings of this research the following recommendations are hereby given:

1. Geophysical survey should be carried out for all borehole drilling projects in Imo State.
2. Professionals in the water resources engineering including geologists should be engaged in borehole drilling.

**5. References**

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