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# Hydro-Geophysical Survey Report

## Detailed Ground water Exploration Report for ONE (01) Production Water Borehole for ST. MUGAGGA BOYS HOME, JINJA DIOCESE.

**HYDRO-GEOPHYSICAL SURVEY REPORT**
**16th Feb 2021**

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## 1.0 INTRODUCTION

Water is an essence food and basic component of life. The need for water is strongly ascending and has a diversified function, which is not only important for drinking purposes but is also vital for any developmental activities. Nowadays, the use and sustainability of water is getting more complex due to population growth, urbanization and industrialization. Any development is related either directly or indirectly with water utilization.

For any developmental activity, both surface and groundwater sources are the main components depending on their quality and availability. Groundwater has become immensely important for the different water supply purposes in urban and rural areas of both the developed and developing countries.

Geophysical survey incorporates the Vertical Electrical Sounding (VES) and Horizontal Profiling (HP) activities. The Vertical Electrical Sounding (VES) is currently being very popular with groundwater investigations due to its simplicity. Vertical electrical sounding (VES) is one to provide valuable information regarding the vertical successions of subsurface geo-materials in terms of their individual thicknesses and corresponding resistivity values. It is rapid and much effective in estimating aquifer thickness of an area and is cost effective technique for groundwater study.

### 1.1 Site Location

The client requested for identification of site at:

Village: LUBAGA
Sub- County: SOUTH WEST DIOCESE
District: JINJA CITY

**Coordinates:**

Latitude: N0˚27’12.3768”

Longitude: E33˚12’45.2772”

Elevation: 1063m

The above place was surveyed and considered for borehole drilling for access of clean and safe water for the cemetery.

The project is orientated at Construction of one (01) borehole that will aid in Provision of Safe Sustainable Underground water in order to improve on the living conditions of institution through reducing water borne diseases.

This report is prepared to highlight activities carried out and the findings of the hydrogeological investigation for the borehole-siting phase of the program. The area under investigation has been thoroughly analyzed.

## 1.2 Project Area

ST. MUGAGGA BOYS HOME is in Jinja District, JINJA DIOCESE. The District is found in Busoga sub-region, in the Eastern Region of Uganda. It is approximately 81 kilometres (50 mi), by road, east of Kampala, the capital and largest city of Uganda.

It sits along the northern shores of Lake Victoria, near the source of the White Nile. The city sits at an average elevation of 1,204 metres (3,950 ft) above sea level.

Jinja District is bordered by Kamuli District to the north, Luuka District to the east, Mayuge District to the south-east, Buvuma District to the south, Buikwe District to the west, and Kayunga District to the north-west. The district headquarters at Buwenge are located 96 kilometres (60 mi), by road, east of Kampala, Uganda's capital and largest city.

The Site (VES Point) is located in the premises of ST. MUGAGGA BOYS HOME; North of Jinja Diocese Cathedral. It is approximately 1km off Clock Tower Round about, Jinja.

## 1.3 Geographical and Physical Setup

### Topography

For the purposes of this report, the geographical coordinates of Jinja are 0.439 deg latitude, 33.203 deg longitude, and 3,832 ft elevation.

The topography within 2 miles of Jinja contains only modest variations in elevation, with a maximum elevation change of 463 feet and an average elevation above sea level of 3,833 feet. Within 10 miles contains only modest variations in elevation (942 feet). Within 50 miles also contains very significant variations in elevation (1,129 feet).

The area within 2 miles of Jinja is covered by cropland (45%), artificial surfaces (23%), and grassland (11%), within 10 miles by cropland (50%) and water (24%), and within 50 miles by cropland (35%) and water (30%).

### Rainfall

The district has an annual mean of 1180mm with the highest rainy days in the months of March to May with April receiving the highest rains. Lesser rains are normally registered in the months of June to August but occasionally heavy rains are received leading to a fair rainfall distribution throughout the year. December to February and May to August are the dry periods for the district with the latter being the longest and receiving the least amount of rains. The annual mean rainfall is about 1500mm.

### Vegetation

The District is characterized by evergreen vegetation with many seasonal wetlands and few areas with savanna type of vegetation.

### Climate

District level information has been used while describing the Municipality climate. The site lies within the Lake Victoria climatic zone, with little seasonal variation in temperature, humidity, and winds throughout the year. The district's climate can be related to its situation, elevation, the major air currents and the occurrence of a large mass of water (Lake Victoria) within the district.

### Temperature

Because of the Jinja's proximity to Lake Victoria, during the day, a strong lake breeze modifies the would be high temperatures and makes the climate a rather pleasant one. The mean temperature for Jinja is at 28.40c and the lowest recorded 15.90c for 1963 – 1999 (source Department of Meteorology, 2000).


***Figure 2**: A map showing location of Jinja district.*

## 2.0 Background

The project was intended for a hydro-geophysical survey for drilling one (01) production borehole in the Boys home; a site presented by the client.

The Borehole-siting process entailed carrying out detailed geophysical survey in order to identify potential spot within the site area having substantial groundwater potential for drilling deep production well with yield of production borehole able to sustainably serve the Institution with clean and safe water.

The project is oriented at provision of adequate safe water at (or within proximal walk-distance to) the beneficiaries as a means of improving working conditions through reducing the level of waterborne diseases, in support of the Millennium Development Goals (MDG).

### 2.0.1 Objectives

The main objectives of this groundwater exploration survey were:

i. Identification of site locations using surface geophysical methods for a successful drilling of a well with good yields for production borehole.
ii. Strategically locating the water source at (or in proximal walk-distances) to the beneficiaries.
iii. Appropriate integration of water source into the fragile sanitation and Working conditions of the beneficiary communities in order to minimize inter-groundwater contamination, thus ensuring sustainable safety of the water.
iv. Contribute to attainment of millennium-development-goals (MDG) in conformity to international-water-and-sanitation-sphere standards oriented at: provision of adequate safe-water, in proximal walk-distances to the beneficiaries.

### 2.0.2 Goal

The overall objective of this consultancy is to provide services to assist the implementation of the borehole construction program.

## 3.0 Implementation

The project was implemented in 4 phases namely:

Phase 1: Inception studies, area(s) familiarization, and Reconnaissance.

Phase 2: Desk studies (analysis of existing water sources data, Maps and Aerial photo Interpretations)

Phase 3: Detailed Geo-physical surveys

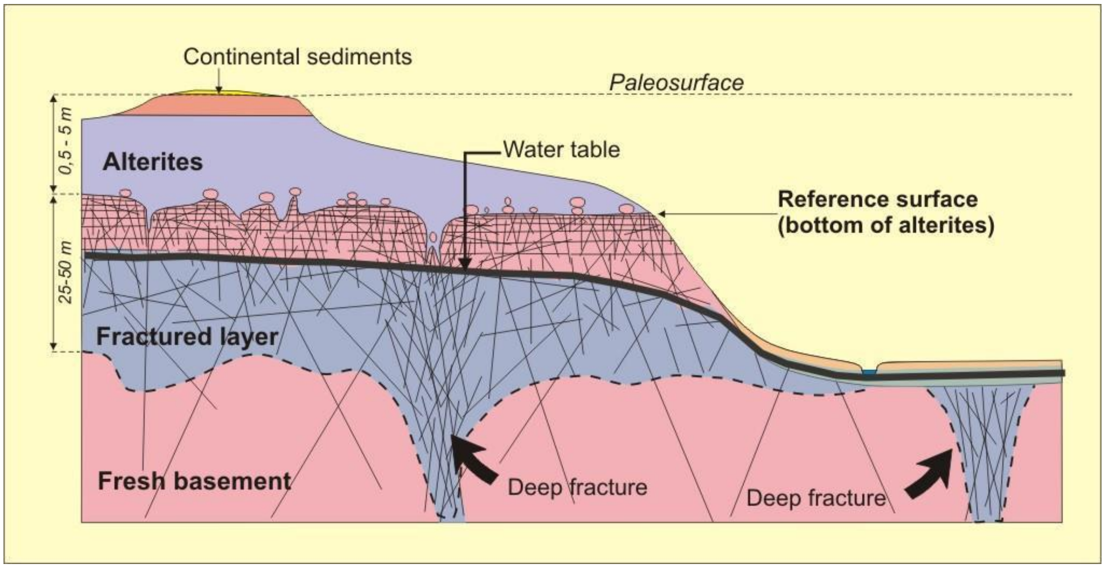
Phase 4: Geophysical data analysis, documentation and reporting.

This report includes details of all activities carried out in each phase, field data sets, GIS-location maps, hydro-geological, geophysical analyses and interpretations, suitable site selections, recommendations per site, and conclusions. The report briefly highlights both technical hindrances or social difficulties encountered, and general remarks.

## 4.0 Hydrogeology

### 4.0.1 Occurrence of Groundwater

Groundwater generally occurs in the weathered rock or overburden (regolith) and in the fractured rock. The recharge of shallow aquifers, found in the overburden or in fractured upper part of the bedrock is generally dependent on the size of the catchment area and the lithological character of the overburden. The presence of weathered and fractured quartzite and granite between the depths of 37m-83m and below generally associated with weathered zones may enhance the chances of medium-high yielding boreholes.




### 4.0.2 Groundwater recharge

With reasonably simple means, it is not possible to calculate for a particular area, how much the average ground water recharge is per year. However for purposes of obtaining a reasonably good estimate of the mean ground water recharge as basis for further estimates these approaches are found adequate.

- Comparison with average and low flow data from gauging stations in the area.
- Comparison with stream flow measurements in the area, if representative data are available.
- Comparison with other much more detailed studies in comparable areas.

## 5.0 Familiarization and Reconnaissance

This was carried out for all areas in which the surveys were planned. It involved: technical-visual assessment of geographical layout of the areas, patterns of locations of existing boreholes (other water sources), drilling-success rate(s), awareness creation interviews with Local leaders, and beneficiary's preferential locations considering proximity, walking distances and the security zone. During the process, resistivity profiling lines to cover the area were planned by taking GPS coordinates of terminal points (start/end) and other key features.

The presence of functioning boreholes in this project area is an indication of groundwater potential. Existing data shows most functioning boreholes drilled in the project area have an average yield of 4.5$m^3$/h and above. The yields are generally Medium-high and the potential for groundwater is fairly good according to the previously drilled boreholes.

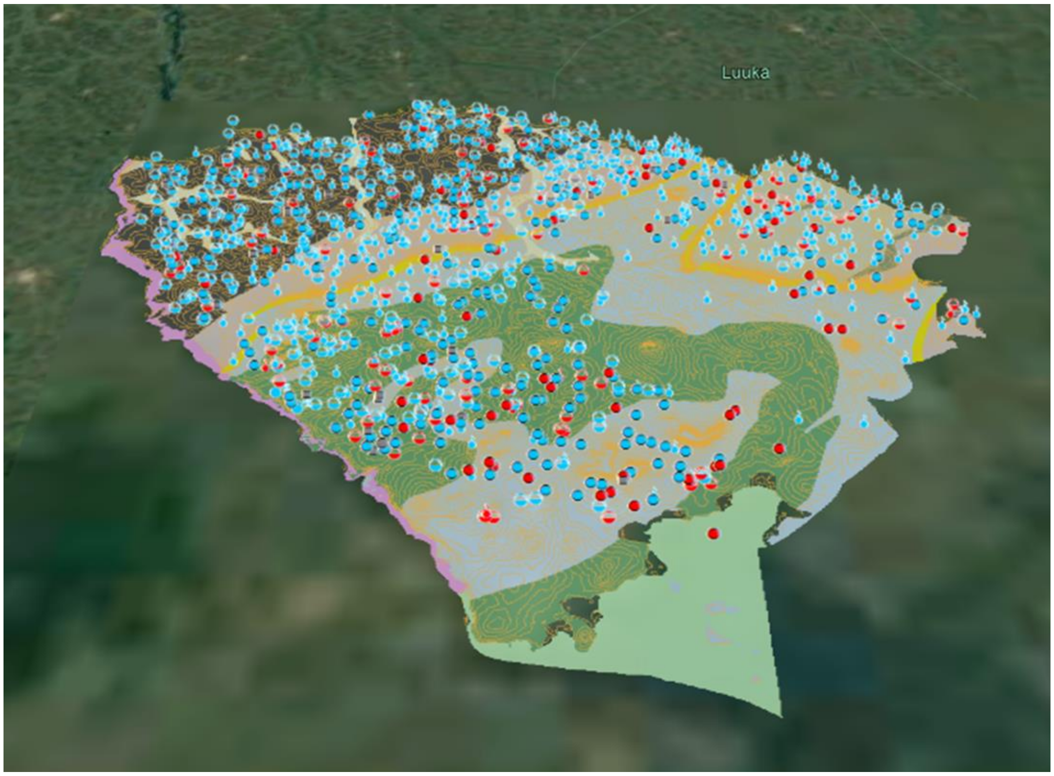



***Figure 3:*** *Map Showing locations of previously drilled and new wells in Jinja District*

## 5.1 Desk Studies

The existing hydrogeological data including topographic and hydrogeological/geological maps reports and borehole construction data were studied. The purpose was to understand the hydrogeology of the project area and plan for proper field investigations. A topographic map was used to identify features like existing rivers, abandoned rivers, valleys and vegetated areas that are indicators of availability of groundwater. A geological map was used to obtain information on the lithological characteristics and weathering products. The existing drilling logs showed the underlying lithology, water strikes, well yields and expected drilling depths.

## 5.2 Detailed Geo-physical survey

The geophysical survey involved geo-electric Resistivity measurements by running profiles to detect anomalous zones along the profile. In addition, parallel profiling was done at sections where anomalies were detected as confirmatory tests with a more precise potential length. Vertical Electrical Soundings (VES's) were made at prioritised spots to have an insight on the vertical layering, hence detect the presence and size of fractured / weathered formations as potential zones of ground water abstraction.

In all Resistivity-profiling patterns, profiles were run to cut through the anticipated topographic lineaments at acute angles, thus anomalous readings were expected along approaching the topographic structural lineaments, though some anomalies were encountered at high altitude points.

Results were achieved using schlumberger array of electrodes where, the four electrodes are positioned symmetrically, the current electrodes on the outside and the potential electrodes on the inside. To change the depth range of the measurements, the current electrodes are displaced outwards while the potential electrodes in general, are left at the same position. When the ratio of the distance between the current electrodes to that between the potential electrodes becomes too large, the potential electrodes must also be displaced outwards otherwise the potential difference becomes too small to be measured with sufficient accuracy.

Current and potential electrode positions are marked from the measuring point of STING R1 such that AB/2 = Current electrode spacing and MN/2 = Potential electrode spacing. The electrodes are driven into the earth in a straight line to make a good contact with the earth. The values of AB/2 increases as the measurements progress while the potential electrodes separations are guided accordingly. The potential electrodes are kept at small separations relative to the current electrodes separations. During the field work taking a reading, the resistivity meter performs automatic recording of both voltage (V) and current (I), stacks the results, computes the resistance in real time and digitally displays it. The apparent resistivity value is the product of the geometric factor and the resistance recorded in the resistivity meter. Apparent values of resistivity plotted against current electrode spacing (AB/2) gives a characteristic VES curve that is interpreted.

**Note:**

Resistivity-profiling was carried out, using STING RI IP Earth Resistivity meter, and all profiles were configured to: Shrumberg-set up with: ½ AB=90m, $^{1}/2$MN=5.0m, 2.5m and inter-station intervals of 5m. GPS-receivers were used to obtain coordinates of start/finish points of profiles. For VESs, the maximum ½ AB was 120m, while ½ MN of: were varied from 0.5m, to 5m, and finally to 20m in order to ensure reliable signal strength.

## 5.3 Siting Method

The siting methodology was adjusted to the hydrogeological conditions and the local experience, but in general following the procedure stipulated in the terms of works.

Detailed hydro-geological and geophysical surveys were carried out at two major groundwater potential areas within the available area.

Geophysical surveys were carried out in the areas where detailed hydrogeological surveys were carried out to investigate the variation of subsurface conditions with depth. This was done to determine the following:

- Estimation of depth to rock
- The sequence of high and low resistivity
- Estimating regolith thickness and depth to water bearing zones Estimating drilling depths

### 5.3.1 Vertical Electrical Sounding (VES) - Resistivity Sounding

This method is useful for estimating the depth to different formations and water bearing strata as well as the thickness of different rock formations. Detailed soundings were carried out at four separate locations and marked with wooden pegs.

The uniform static electrical field can be created in field conditions to measure soil electrical resistivity or conductivity in situ. However, most modern geophysical methods, such as four-electrode profiling and vertical electrical sounding apply non-uniform electrical field to soils through the point electrodes (Figure 4). The electrical resistivity measured with these methods is termed apparent or bulk electrical resistivity, to distinguish it from the resistivity measured in laboratory in homogeneous samples with uniform electrical field. The electrical profiling method is based on the same four-electrode principle as the conductivity cell (Figure 4). The electrical field is distributed in a soil volume, which size can be estimated from the distance among AMNB electrodes. The geometric factor (K) can be precisely derived from the array geometry based on the law of electrical field distribution. Using the Laplace's equation in polar coordinates, Keller and Frischknecht (1966) derived the electrical potential functions around the source (A and B) and measuring (M and N) electrodes. The geometric factor K can be obtained for central-symmetric four-electrode array of AMNB configuration (Figure 4) as K=π[AM][AN]÷MN. Where [AM], [AN], and [MN] are the distances (m) between the respective electrodes.

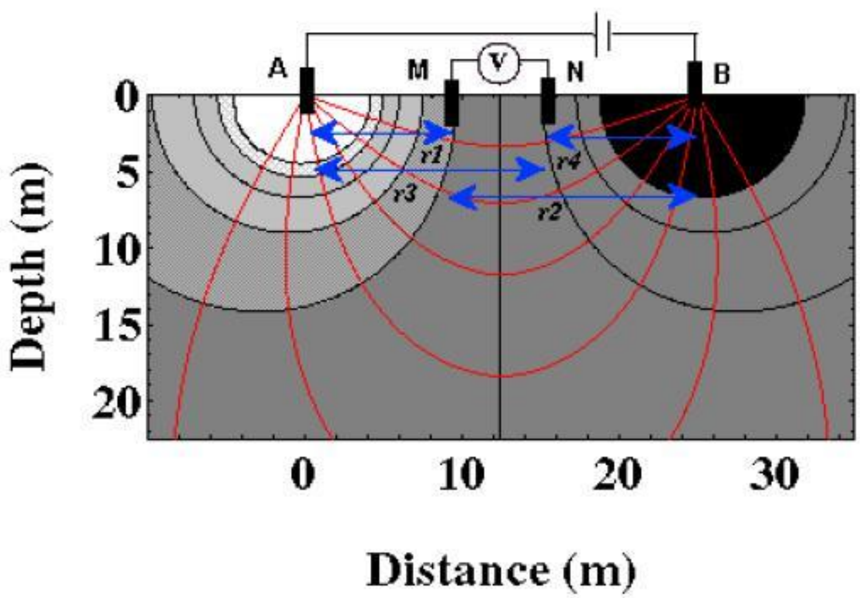



***Figure 4****: Scheme of the four-electrode method. Electrical field lines are shown with thin curvilinear.*

## 5.4 Results and Discussion

The Vertical Electrical Soundings were carried out at the selected areas. A total of two VES points were surveyed. The UTM coordinates, i.e., Easting and Northing, of the sounding points were obtained with the help of a GARMIN II GPS receiver in Adindan datum.

The Vertical Electrical soundings were made using the following equipment:

i. IGIS signal stacking based Signal Enhancement Earth Resistivity Meter Model SSR–MP–ATS, which is powered by a rechargeable battery.
ii. Wires and Reels
iii. Stainless steel electrodes
iv. Accessories such as alligator clips and hammer.

The Schlumberger electrode configuration with maximum half current electrode separation (AB/2) of 100 to 130m was used for the sounding survey. Current is injected into the ground using two current electrodes, A and B, placed at a distance AB/2 apart; and the potential drop that occurs between two other electrodes, M and N, placed near the center of the current electrodes is measured (Figure 5). The current electrode separation, AB/2, is progressively increased in steps so as to increase the depth of investigation, and at each step the measured current and potential readings are used to obtain the apparent resistivity of the ground.

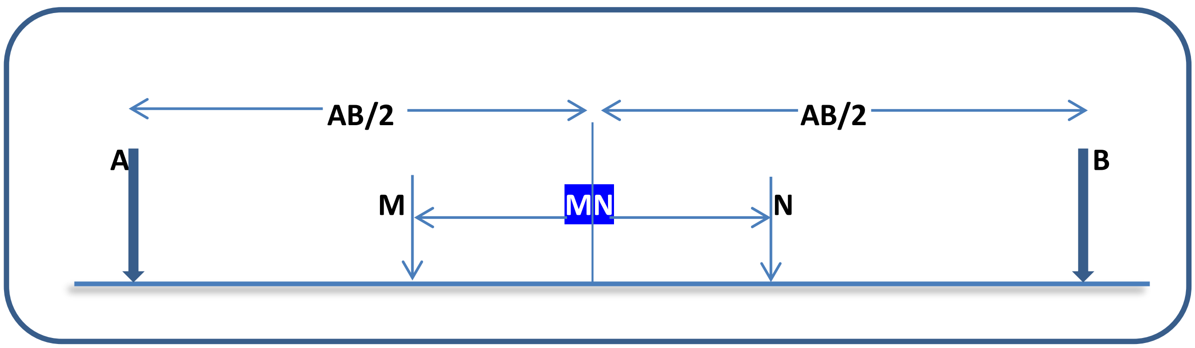
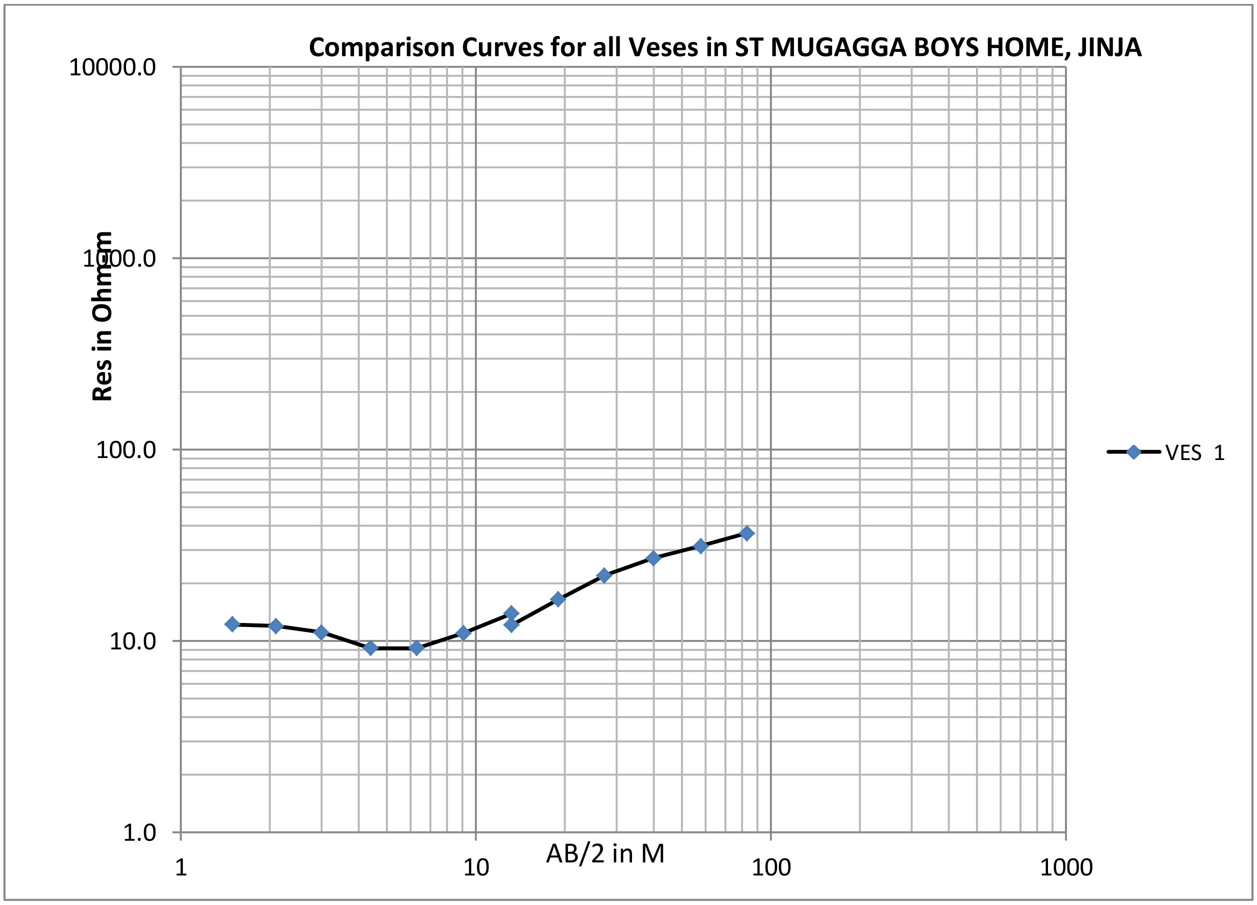



***Figure 5:*** *Representation of Schlumberger electrode configurations.*

### 5.5 Geophysical data Processing, analysis, and presentation.

The VES is done by injecting a low current into the ground through stainless steel electrodes and then after the resistance of the earth material is measured during the passage of the current simultaneously. The VES data collected in the field was initially interpreted using geophysical resistivity measurement software just to get the layer parameters. Hydro geological modeling and interpretation of VES's data was done using Winsev™, EarthIMAGER-1D™ and VES™software.

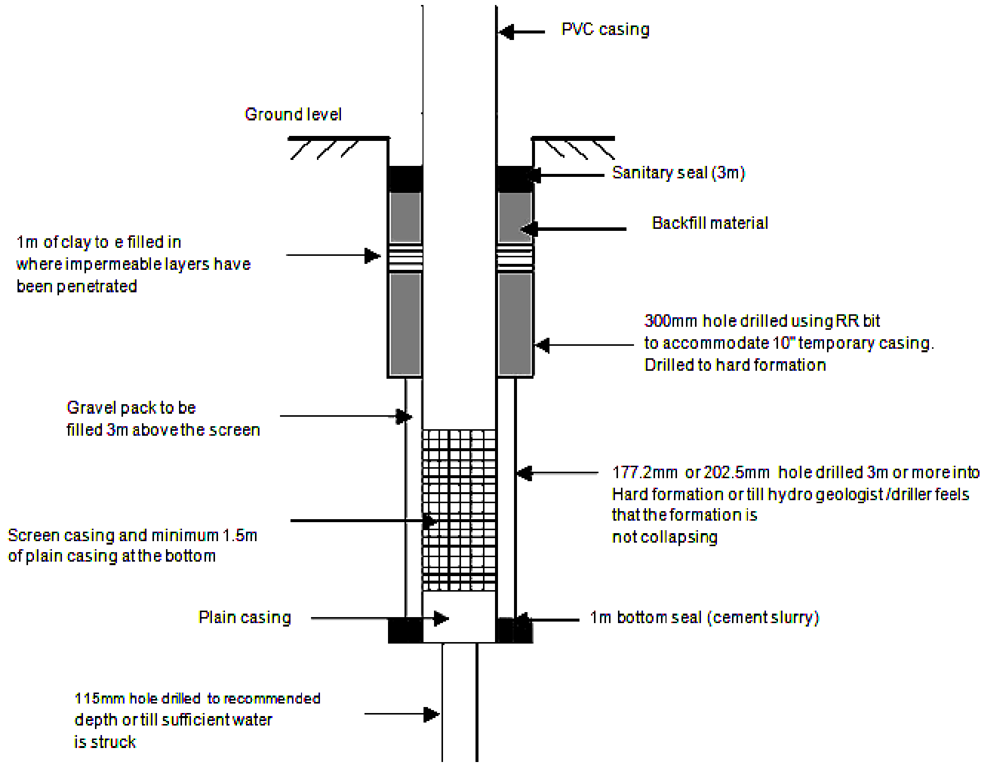
| **AB/2** | VES 1 |
|---|---|
| 1.5 | 12.2 |
| 2.1 | 12.0 |
| 3 | 11.1 |
| 4.4 | 9.2 |
| 6.3 | 9.2 |
| 9.1 | 11.0 |
| 13.2 | 13.9 |
| 13.2 | 12.1 |
| 19 | 16.5 |
| 27.3 | 22.0 |
| 40 | 27.1 |
| 58 | 31.4 |
| 83 | 36.6 |




| Site location: (ST MUGAGGA BOYS HOME, JINJA DIOCESE, JINJA DISTRICT) | | | |
|---|---|---|---|
| First priority peg No. | **VES-1** | **Coordinates:**<br>Latitude: N0˚27'12.3768"<br><br>Longitude: 33˚12'45.2772" | |
| Is it recommended for Drilling? | **YES** | | |
| Expected DTB (m) | **35m** | Altitude (m) | **1063 meters** |
| Recommended drill depth (m) | **85m** | Accessibility to village | **Good (Tarmac Road)** |
| Anticipated base rock formation | **Laterite** | Rig accessibility to site | **GOOD** |
| Site's expected yield potential | **Medium-High** | Contact person for details and direction. | |
| **Remarks:** | | **VES-1 is first priority for drilling, exhibits relatively low resistivity anomalous values, and VES characteristics are typical of good yielding BHs in the area.** | |

## 6.0 Proposed Borehole Design

The proposed borehole design is based on the likely rock behavior intercepted during drilling process.




## 7.0 Conclusion & Recommendations

In the project area, there are several interconnected aquifer units available for groundwater exploitation. The aquifer types are most likely interconnected with the degree of interconnection varying considerably from area to area and the exploitable groundwater potential largely dependent on this interconnection.

The main goal of the study was to select potential well locations for water supply purposes. Among the several disciplines the preconstruction study, i.e., site investigation, which includes geological, Hydrogeological and Geophysical investigations were conducted. Accordingly, the work resulted in the identification of one development site (VES 1 Point), and recommended for borehole drilling.

**Recommendations;**

i. The client should ensure a penetrable area for Drilling Rig to access the VES point easily.
ii. The drilling crew is advised to mobilize and install temporary casings during drilling, as the sites are expected to have collapsing formation.
iii. Maximum recommended depth should be drilled to exhaust the aquifer zones.
iv. Upon drilling completion, Pumping test should be carried out to evaluate the sustainability of the water resource and consequently determine proper pump intake.
v. Well qualified personnel appointed by the client/Consultant should time to time supervise all the drilling works up to completion and finally certifies the work done in order to avoid conflicts of interest.
vi. Construction of a perimeter fence around the water points should be properly done before the source is used as part of hygiene and sanitation.