YOUTH AND WOMEN OPPORTUNITIES UGANDA [YWOU]

BOREHOLE SITING REPORT

REPORT FOR BOREHOLE SITING, DESIGN AND DRILLING, DRILLING SUPERVISION, PUMP TESTING AND COMPLETION REPORT OF 01 DEEP BOREHOLE IN AGIRIGIROI IN SERERE

DECEMBER 2018-JULY 2019

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1.0 Introduction

YOUTH AND WOMEN OPPORTUNITIES UGANDA [YWOU] secured funds from Mission Clean Water a grant and has been set part for construction of 01 deep borehole For Agirigiroi during the financial year 2018/2019. In order to assist in implementation of the project, a consultancy contract was signed between ***Erika Drilling Company and*** **YOUTH AND WOMEN OPPORTUNITIES UGANDA.** *This completion report overs a period of 6 months since funds were disbursed in September 2018 and its being presented to out-puts since drilling, pump testing, casting and installation*

The report is divided into two phases:

Phase I- Inception and Reconnaissance Study

Phase II Hydrogeological investigation and Borehole Siting phase

Phase III Supervision of borehole construction test pumping, casting and Hand pump installation

Phase IV- Final report writing

An inception field visit was carried out at the borehole site during October-November 2018 and the findings are contained in the report. Following are results of the Consultancy, for borehole siting, *drilling, pump testing, casting and installation*. This report is prepared to highlight activities carried out and the findings of the hydrogeological investigations and borehole-siting phase, *drilling, pump testing, casting and installation* of the project. The site for borehole drilling has been recommended after thorough analysis and interpretation of the available and collected data.

Table 1: Villages selected for hydrogeological investigations in Serere District under YWOU.

No.	Village	Parish	Sub county	County
1	Owiny Agule	Ojetnyang	Kateta	Serere

1.1 Objectives

The overall objective of the contractor was to assist the client to implement the borehole construction programme effectively and with high professional standards. This activity has been to determine for the village the most suitable locations for the drilling of deep boreholes that will supply the village communities with enough water. After siting and drilling the successful borehole will be equipped with hand pumps.

1.2 Approach

To assess the groundwater potential of the area, all available hydrogeological data, including the geological maps, topographical maps, existing reports, aerial photographs and borehole data have been analysed and are discussed in detail in the inception report. In this report, the regional geology, topography and other physical aspects based on existing reports, project documents and hydrogeological information are discussed.

The results of the borehole siting survey are given in Appendix A, Vertical Electrical Sounding (VES) and Profiles. The geophysical surveys were carried out in the village indicated by the client and focussed on the areas of generally higher groundwater potential. Intensive investigations for the ground water potential in the community-desired locations were carried out; however, the established location of the site for drilling was based on the availability of the groundwater as from interpretations of the survey results. Fortunately consensus was reached between the community and the Hydrogeologist over the location of the site. The aerial photograph interpretation of the area formed the basis of geophysical surveys. The aerial photographs reveal the location and extent of lineaments giving an indication of the fracturing of the underlying geology and indicates the recharge potential of shallow aquifers by means of catchment size analysis.

After approval of the Siting results, drilling, test pumping water quality analysis and pump installation will take place. According to survey interpretations, it is anticipated that the site established would provide enough water on drilling for installation of hand pumps.

2.0 General Information

2.1 Location and size

Serere District is located in the Eastern region of Uganda. It is bordered by the districts of Ngora in the east and the south, Kaliro and Pallisa in the west and South west and Soroti in the North east and Kaberamaido in the north. Physically, the district lies approximately between: Latitudes 1° 33'N and 1° 54'N Longitudes 30° 01'E and 34° 18'E

The climate of the district is modified by the large swamp area surrounding it. The rainy season is March to November, with a marked minimum in June, and marked peaks in April to May and August to October. December and January are the driest months. Of recent rainfall has been unreliable.

Rainfall

Serere District receives a mean annual rainfall of about 1350 mm. But since 1988 rainfall is low.

Temperature

Serere District generally records a mean annual maximum temperature of

around 31.3°C and a mean minimum of around 18°C. Its extreme highest temperatures are in the months of February when it records approximately 35°C while the month of December the lowest temperature is 9.6°C. The highest ever recorded was in February 1949 where temperatures reached 40°C.

Humidity

Relative humidity ranges from 66% to 83% at 0600GMT in the morning. However, it reduces much in the afternoon (35% - 57% at 1200GMT) thereby reducing chances of rainfall.

Wind

During the N.E monsoon the area is swept by a wind which has traversed Somalia, passed between the Abyssinian massif and Kenya highlands and the hills of Karamoja. The water vapour content of this wind is consequently low.

The southwards passage of the inter-tropical convergence zone in October would appear to bring no more rain than is sufficient to produce a gradual falling off from the July peak.

Evapo-transpiration

There is relatively high rates of evaporation in Serere District as it lies near the equator.

Evaporations are particularly high in the dry seasons.

Vegetation

The vegetation in the district mainly comprise of wooded savanna, grass savanna, forests and riparian vegetation.

Forests

There are mainly medium altitude forests. There are no natural forests in the district only Plantations standing 30 - 46m high are found. These forests are being encroached upon.

Wooded savanna

These mainly consist of moist Acacia savanna associated with Hyparrhenia spp and combretum savanna associated with Hyparrhenia ssp. These are mainly formed in south western part of the district (Kasilo and Serere counties).

Grass savanna

These are mainly Hyparrhenia spp, Themeda and Imperata cylindricum.

Riparian vegetation.4.4 Riparian vegetation

Under this category certain scattered tree grasslands associated with Setaria incrassate Hyparrheria rufa, Accacia sayel Acaccia fistula, Balanities aegyptica and Terminalia spp occur. Cyperus papyrus is found in permanently water logged areas along the shores of Lake Kyoga and Agu swamp.

3.0 Geology, and Soils

Most of the areas in the district are underlain by rocks of the basement complex pre-Cambrian age which include: Granites, Mignalites, Gneiss, schists, quartzites

The soils fall mainly in four major units; Serere catena; and Metu complex series. These are mainly of the ferrallitic type (sandy sediments and sandy loams). They are well drained and friable. Bottom lands contains widespread deposits of alluvium.

3.1 Geology

Most of the area of Teso region including Serere District is underlain by mainly two types of rock systems of the basement complex (BC); namely, Cainozoic and Pre-Cambrian rocks.

(a) Cainozoic Rock System

Cainozoic rock system is basically Pleistocene to Recent rock material composed of sediments, alluvium, black soils, and moraines. This system is limited to the fringes of Victoria Nile.

(b) Pre-Cambrian Rock System

The rest of the District area is underlain with Pre-Cambrian rocks system. It is mainly wholly granitized or high to medium grade metamorphic formations, composed of undifferentiated gneisses including elements of partly granitized and metamorphosed formations. This is generally a zone of intrusive granite and granitoid gneisses, probably including Aruan gneisses and Nyanzian-Kavirondian gneisses and post-Kavirondian granites.

3.2 Hydrogeological environment

In general, the hydrogeological environment and groundwater conditions can be assessed by taking into account the characteristics of hard rock aquifers. There are two aquifer zones, namely the weathered rock often termed the regolith and the fractured bedrock. The regolith aquifer can store relatively large quantities of water; however, it often has rather limited water-transmitting capability. The main storage is the more porous clayey saprolite or uppermost sandy collapsed zone. In the fractured aquifer, the degree of interconnection varies considerably from area to area and the potential for groundwater depends on the interconnection. The contractor will therefore maximize the outputs of the boreholes by designing the borehole with the aim of tapping water in the overburden and fractured zone.

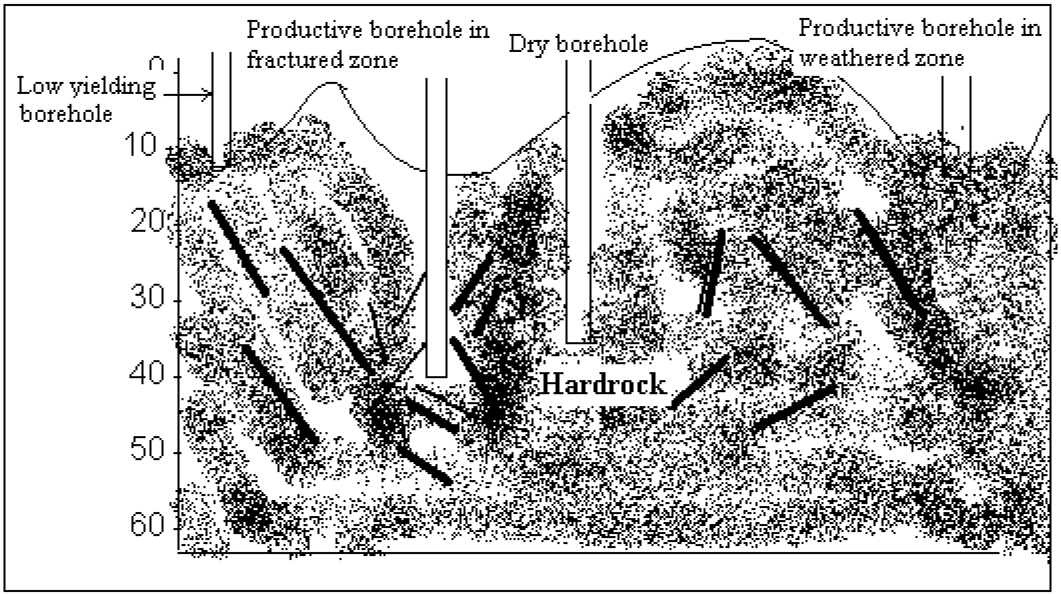


Figure 1: Aquifers in weathered and fractured zones in granite and gneisses

3.2.1 Groundwater potential

The presence of productive boreholes in these areas indicates that there is a fairly good groundwater potential. The boreholes obtained from the District record and Entebbe WRMD, indicate yields ranging from 0.5 to 5m^3/hr. The yields of the boreholes within the basement rocks depends on the number of saturated fractures intersected during drilling and whether any water in the saturated portion of the regolith has been tapped or not. The average depth for the new boreholes is 75m deep. From the borehole data; the area has medium ground water potential.

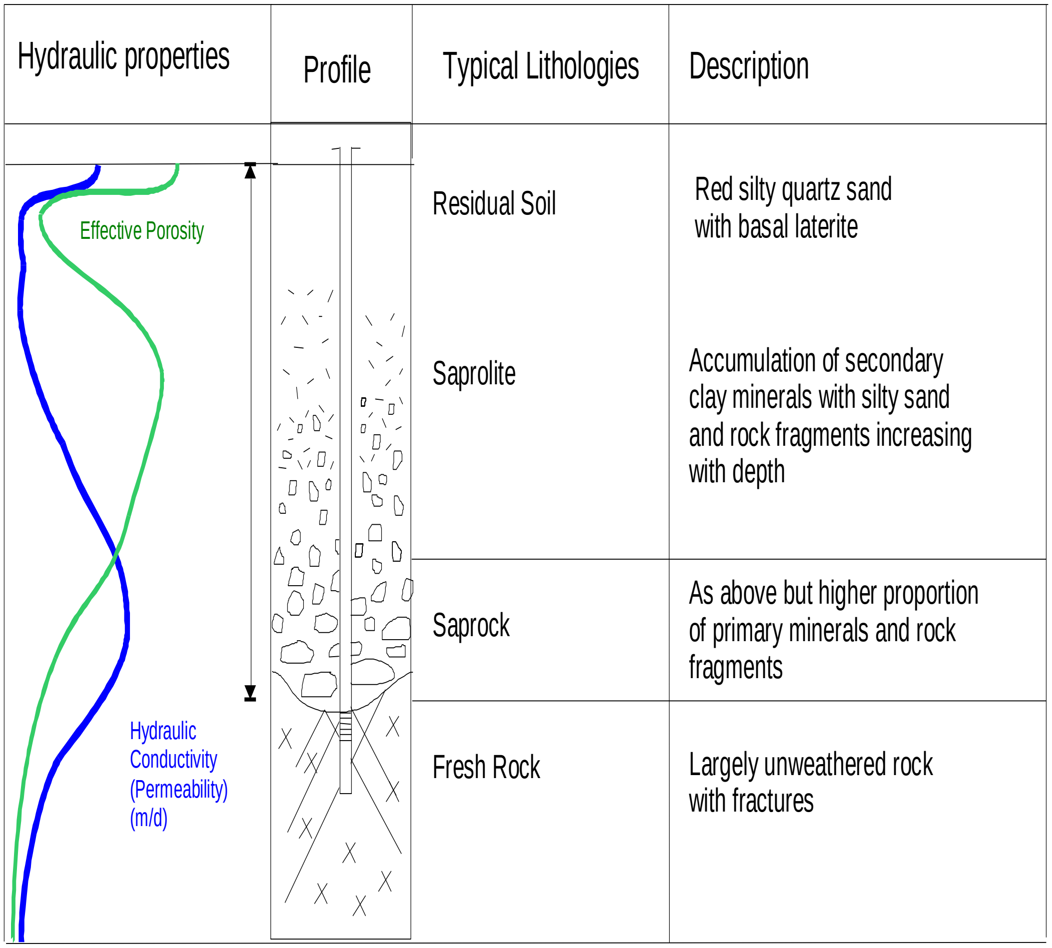


Figure: Schematic Profile of a Typical Basement Regolith Aquifer

The analysis of existing borehole data indicates an average first water strike depth of 24 m and a main water strike depth of 47.0m.

Groundwater conditions are usually confined or semi-confined, and the piezometric surface generally mirrors the local topography, with groundwater flow trending in the same direction as the surface water flow.

3.3 Hydrogeology

Hydrogeological conditions in the granitic rocks are typical of Precambrian Basement terrain and aquifers occur in the weathered overburden (regolith) and in the fractured bedrock. In the Nyanzian System metavolcanics fracturing is thought to exercise significant control over the presence of aquifers. In Serere District, boreholes are typically drilled into fractured bedrock, which is required to provide sufficient transmissivity, but with the main storage still being provided by the overlying saturated regolith.

Optimum sites for boreholes thus exist where the overburden is thickest (i.e. improved potential for greater storage in the regolith) and a significant fracture zone is present in the underlying bedrock (increased potential for higher transmissivity). Since in-situ weathering is the primary process in overburden

development, and weathering is usually most intense in fractured rocks, such criteria frequently co-exist. Geophysical survey methods [electrical resistivity profiling and vertical electrical resistivity sounding (VES)] that both assess overburden thickness and the possible presence of bedrock fractures have thus been extensively used to identify sites for borehole drilling.
The analysis of existing borehole data indicates an average first water strike depth of 26.8 m and a main water strike depth of 47-75 m. Groundwater conditions are usually confined or semi-confined, and the piezometric surface generally mirrors the local topography, with groundwater flow trending in the same direction as the surface water flow.

4.0 Existing water sources

Quite a good number of Boreholes have been drilled in the sub counties of interest as per the list of existing boreholes from WRMD (Water resources Management Department) Entebbe (Appendix A). The background data on various old boreholes show the following characteristics.
The average borehole depth ranges from 47 to 80m
The average depths of water strikes range from 17 to 78m
The average yields range from 1.0 to 5.0 m^3/hr
The available drilling data for these boreholes was studied and statistical analysis and comparison with results of hydrogeological surveys was carried out to identify any correlation.

5.0 Hydrogeological investigation

Borehole siting was carried out by taking into consideration results of the desk studies, reconnaissance and community interests. The details of the methods used and the results obtained are summarised in the following sections.

5.1 Methodology

The real field investigations involved studying topographic expressions, lineaments, fractures/faults, vegetation appearance, geology followed by detailed Hydrogeological and Geophysical surveys in the community selected areas. The strategy was to identify sites with multi-layered aquifer system using geophysical and hydrogeological methods. The geophysical survey was done by means of resistivity measurements in the form of Profiles and Vertical Electrical Soundings using a Sting RI resistivity meter.

5.1.1 Profiling

The resistivity profiles were run with AB (current electrode separation) of 58 and 83m and a station interval of 10m, MN (potential electrode separation) was fixed at 10m. The aim of a survey with resistivity profiles is to map anomalous resistivity values. These may be caused by presence of a fractured zone and or deeper weathered section that may be favourable for groundwater abstraction. Profiles were run across the lineament features previously identified from the aerial photograph interpretation. Precise location of the Resistivity Anomaly (PLRA) method was used to determine lineament direction and investigate further the best identified VES for sites on the profile.

5.1.2 Resistivity sounding

Vertical Electrical Soundings were subsequently carried out on the centres of the best anomalies identified on Geo-electrical line profiles. A maximum 1/2AB of 120m was used with a 1/2MN of 0.5 and 5m. The soundings were carried out to get an insight on the differences in depth and type of the overburden. Interpretation of the sounding curves was carried out using a computer-modelling program known as RESIST. Modelling is based on a mathematical curve fitting procedure.

A correct interpretation took into account both the equivalence and suppression problems. The interpretation was guided by the calibration soundings conducted at the existing productive boreholes. The method is however very versatile in identifying resistivity responses that can relatively be correlated to higher accumulations of water, given the requisite preliminary data and geological analysis. The plots of the soundings are attached in Appendix A

5.2 Results of the investigations

The results are summarised in Table 2 below. For the two sites, the average depth to bedrock and maximum borehole depth are included. The boreholes all have medium-high potential. The detailed location maps for the sites are attached in Appendix A.

Table 2: Summary of interpreted results for the selected borehole site

Location Details	Expected water strike zones (m)	Expected Depth to rock (m)	Max BH depth (m)	Expected formation
Agirigiroi	25-75	17-27	80	Topsoil, Laterite, Clay, weathered rock, fractured rock

6.0 Observations

- All the sites if properly drilled can produce fairly good yields of water adequate for the communities.
- Accessibility to most of the sites is fairly good.
- The district staffs especially the water office and community development office, local leaders and community in general were very cooperative during the siting exercise. Both men and women participated in the exercise.
- Most of the sites were located in the preferred locations with assistance of the local leaders and Water User committees.
- After using the calibrations from the existing borehole it was realized that all these well will yield enough water for installation of hand pumps.

7.0 Problems encountered

Delays in Siting

In Kateta Sub-county, many detailed geophysical investigations were carried out, due to the very low ground water potential of the area and narrow fractures. Very long profiles and many VES's was carried out. This caused a lot of delays in siting. As the contract proceeded, the Precise Location of Resistivity Anomalies (PLRA) method was introduced, in order to locate the centre of the fracture zone at the profiles.

Agirigiroi was actually re-visted several times to establish a site, after calibration of the site the near school, a point/site was identified and recommended as a site for drilling as results were far much better than the previous results visited previously.

Assistance from communities

Carrying out geophysical investigations requires training of helpers. In Agirigiroi village investigated, people had to be trained, in order to have proper results. This was time consuming, and as the investigations proceeded, the Contractor embarked on hiring a few people that had been trained to assist the contractor in siting.

Communities were expected to clear the areas/bush for detailed investigations. Good enough the communities were very responsive and extensive investigations were done.

Community site selection/acceptance

Other problems encountered during siting were mobilisation based. The community had not received any participatory training on how to select the areas to investigate. The community chose site basing on population and preference but it did not turn out to be the case of their choice.

It did not matter whether the site was located in a place that was hydrogeologically not favourable like ridges. As a result, when the Hydrogeologist started carrying out investigations away from the site chosen on purely social criteria, the community was not willing to cooperate. In this case where the actual sites fell in land belonging to other people other than the school, this necessitated negotiations with the new landowners who would sometimes not be present leading to delays

After investigations have been carried out, the landowner is supposed to sign on the location map sheet that she/he has accepted to have his portion of land taken for borehole construction. And since this step comes

at the end of the geophysical investigations, in case the land owner refused to sign on the location place, that meant that the Hydrogeologist had to repeat the investigations, or select an alternative site from any of the ones that would have been made.
Luckily enough this didn't happen in Agirigiroi because community was willing and interested in having a borehole

8.0 Conclusions and recommendations

All the sites can easily be managed with Air-rotary drilling method with the necessary drilling fluids.

It is anticipated according to interpretations and comparison with existing data that, if properly drilled, the boreholes will be able to produce enough water for installation of hand pumps.
The selection of the most suitable sites has been based on groundwater potential, convenience of site location relative to community preference, environmental impact of surroundings on site and site on the surroundings, construction risks, cost of construction of the borehole, and, accessibility.
The borehole depths recommended are the maximum allowed and should never be exceeded. However it should be noted that the supervisor unilaterally or in consultation with the driller if necessary would decide the final depth of any borehole depending on the quantity of water realized and can even recommend drilling deeper if the depth recommended is a continuous aquifer and enough water is not struck up to that depth.
The statistics for depth to rock showed that in most parts of Serere, the rock is greater than 20 m from the surface, predicting medium yielding boreholes.
Our overall conclusion is that the siting has been successfully completed, and that the results are good.
The site in Agirigiroi needs deep drilling, so a very competent contractor should be given the contract.

9.0 The contractor carried out drilling and construction supervision in Kateta SC in Agirigiroi community.
9.1 Drilling
The drilling of 01 deep borehole was carried out by ERIKA contractors and supervised by the district water Engineer. The contractor was assigned forms in advance and the contractor drilled exact location identified during the siting and designated by the supervisor .The driller then rigged up above the site and drilled borehole to the depth specified in the sitting report or whenever enough water was realised to the satisfaction of the supervisor .Competent formation was generally encountered and their rotary drilling method was employed in both regolinth and bedrock.Yield estimates were made for all the measurable strikes. Lithoological samples were collected at the intervals of 1 meter as per the contract.

The Contractor Mobilises the equipment to the site

The Compressor takes position to start drilling

The rig starts the drilling process

Drilling in Progress

The water signs already out-water is seen from the site

The Rig drills the well

Summary of Drilling results

Village	Parish	S/C	Air Lift Yield (m^3/h)	Drilled Depth	Borehole Design
Agirigiroi	Omagara	Kateta	8.77	64.39	B

Borehole Designs

The driller in consultation with the supervisor prepared borehole designs .Both designs A and B were used throughout the contract .Equifer zones were completely lined with uPVC screens to maximise the yield of the borehole suitable gravel pack was used in the borehole and covered completely the upper most screen and an additional 3M of gravel was added to allow for settling during well development

The upper 3M of the annular space between casings and borehole wall were grouted using cement slurry to provide an effective seal to entry of contaminants .The borehole was vertically drilled and cased straight

The supervisor often performed verticality tests during and after drilling .However he did not exceed 4mm per 100mm between ground level and the bottom of the borehole.

During drilling, daily activity records detailing the activities at the site were made.

Well development

After installation of casings, screens and gravel pack, the borehole was developed to remove finer materials like native clays, sand, drilling fluids deposited on the borehole walls during the drilling process from the borehole and immediate surroundings (gravel pack and equifer). Well development was done by continuous airlift water cleared, to the satisfaction of the supervisor on site.

Borehole yields were measured during the well development using a 20L bucket and recorded as thee driller's yield of the well.

Pump Testing the well for 48 Hours people begin to take water

Test pumping supervision

Overview

For every successfully drilled borehole it is important to carry out a pumping test. This will provide data on aquifer performance and the quantity of water that can be drawn out in the given time. The data is also used to determine the depth at which to place the pump. It is during the same process that a sample of water is collected and taken for lab analysis of physico-chemical analysis of that aquifer.

The contractor supervised the pumping test of the boreholes. The borehole was pump tested for 48 hours and allowed to recover to at least 90% of the draw down created before terminating the test.

During all pumping test operation, once the flow had been determined and preliminary adjustments made the measured discharge rates were maintained within 5% of the required rate for the duration of the test.

Water quality sampling

Water samples (1L) were collected from all the boreholes and taken to national water and sewage corporation central laboratory in Bugolobi for physico- chemical analyses.

Community participation

The local community was very helpful. They made site accessible to the drilling equipment by making access routes, loading and offloading equipment and material, provided security and offered food to the crew. But the community was not involved in the actual drilling, as the contract never provide for it.

ontractor relationship

The contract that the contractor cooperated to follow the instructions of the supervisor, particularly with regard to drilling depth, and in compliance with technical specification and borehole design. In this respect the drilling superintendent and the crew were cooperative and the contractor followed instructions to the best of their ability and were quite communicative.

The contractor carried out all works as instructed by the supervisor in a thorough and workman-like manner and upto professional standards. He carried out operations with satisfaction of supervisor n site.

Problems encountered

- Collapsing formation. This was not a common problem but when it was collapsing the contractor had to use temporary casings to stabilize the collapsing formation in the hole and this resulted in delay and spending more days on site.
- Accessibility. This was not a problem at all the beginning of drilling. The contractor was shown the site and satisfied with the accessibly. However, the contractor was able access all the sites in the contract.
- Mechanical breakdowns. These were not frequent, so there was no need for the contractor had to get a sub-contractor which work to be done in time.

Conclusion

The borehole offered to ERIKA DRILLING and completed on schedule. The contract was executed according to the provision therein, and all the boreholes were drilled, and test pumped correctly and according to DWD standards. All the wells with estimated drillers yield greater than $0.5m^3$/hr. was test pumped and sample collected for water quality analysis. The water quality results of the boreholes were found acceptable for human and livestock consumption. The borehole was cast and installed

Casting of the new Borehole

Casting of the Borehole in Progress

Fixing of the water hand pump

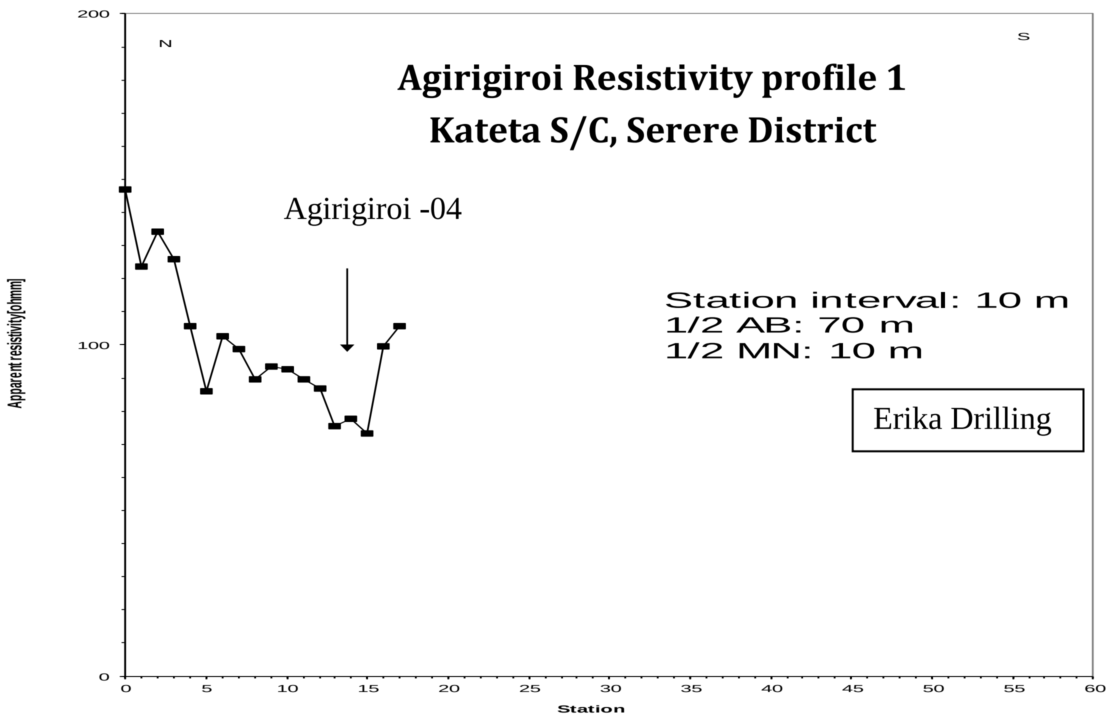
YES the water is on as the children and elders look on

Test Hand Pumping of the new water source

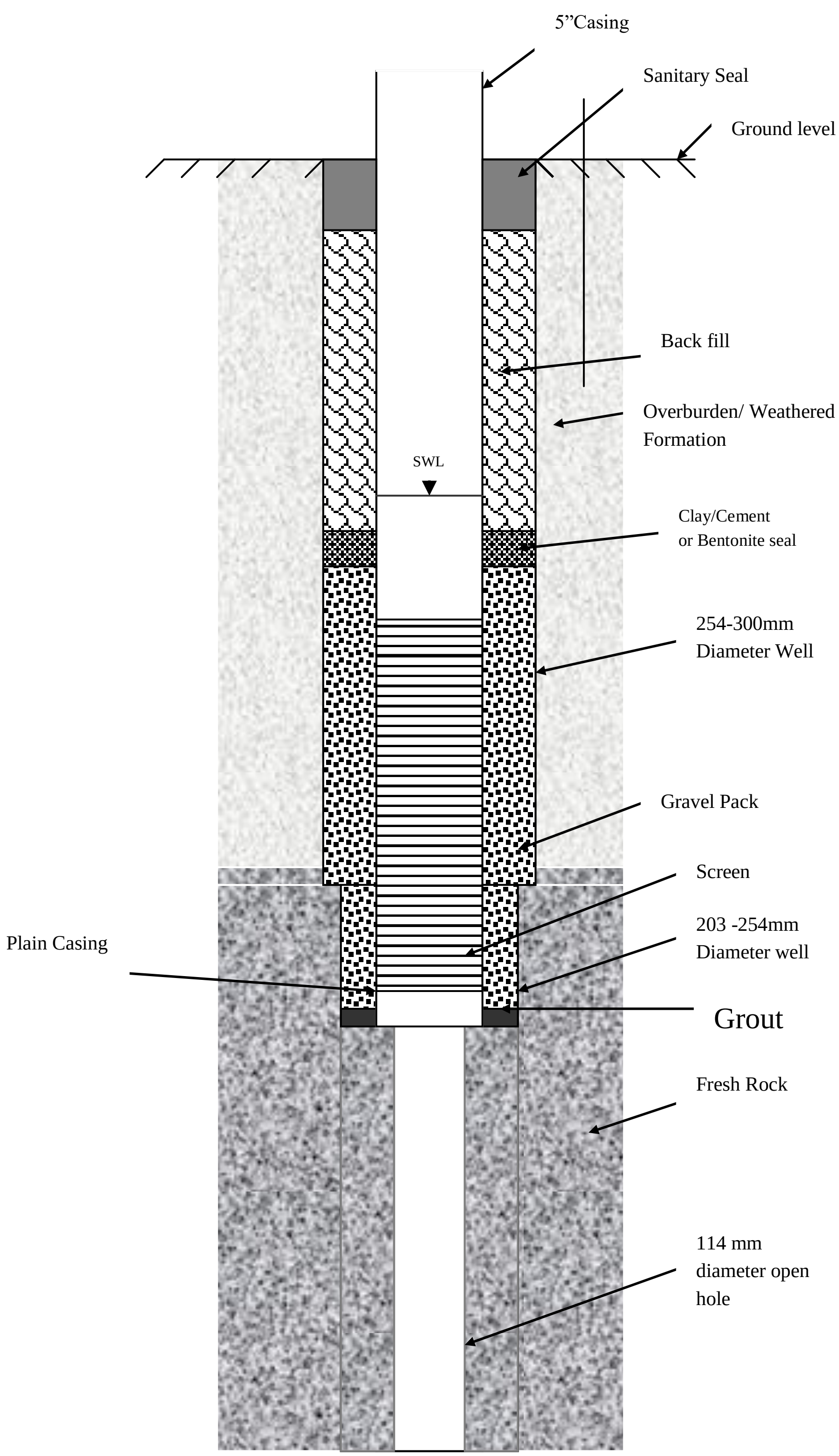
Excited Community drinking clean water from the new source

Communities are excited including washing their hands

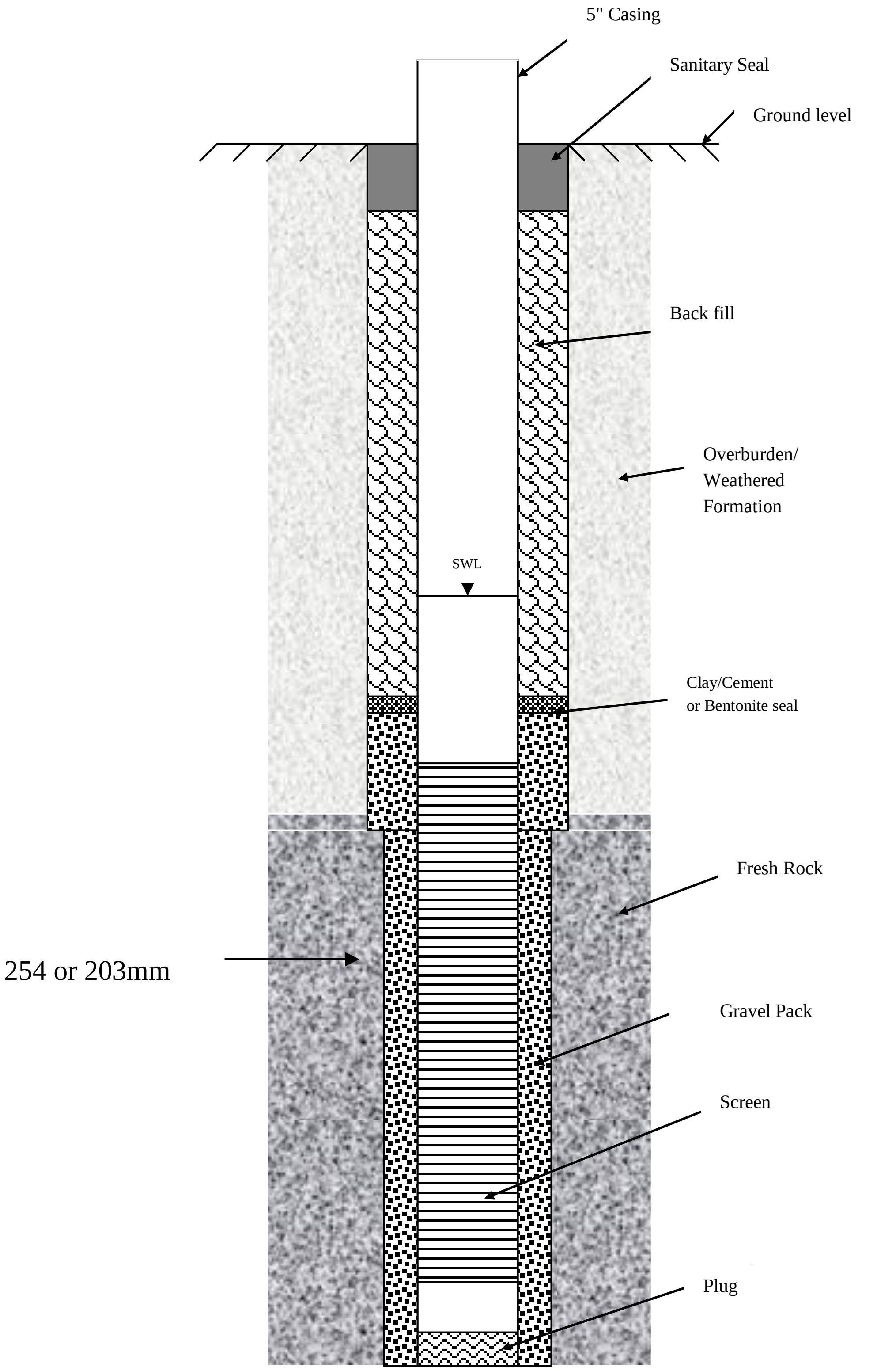
APPENDIX A
GEOPHYSICAL DATA (VES AND PROFILES)
Agirigiroi



APPENDIX B
PROPOSED BOREHOLE DESIGNS



Proposed Well Design 1. Last portion of the well is open.



Proposed Well Design 2. Casing the Entire Depth of the well.