GROUNDWATER RESOURCES SURVEY

SAMUEL NTHEI KING'OLA

EKALAKALA AREA

MASINGA DISTRICT

MACHAKOS COUNTY

WWK 1313 - 2012
September 2012

Waterwells (K) Ltd
P.O. Box 729–00502
Nairobi

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1. GENERAL

Eng. Samuel Nthei King'ola of P.O. Box 4260 – 00506 Nairobi owns about 1.4 hectares of land in the Ekalakala area of Masinga District in Machakos County. The property which is near Ekalakala Market is currently being used for subsistence agriculture which also includes a few cows and goats.

Masinga District is semiarid and all the rivers are seasonal except for River Tana and River Thika. The latter is a tributary of the former. In the project area, the local community fetches water from six sources. These are as follows:

- Tana River (Masinga Dam reservoir)
- Thika River
- Borehole
- Hand-dug wells
- Sand wells
- Rainfall roof harvesting

The Masinga Dam reservoir is on the Tana River and is about 8 kilometres north of Ekalakala Market. Thika River is located about 4 kilometres west of Ekalakala Market For these two sources, raw water is fetched with donkey/cow carts. Majority of the people use the more nearer Thika River.

The borehole which is about 500m north of the market centre was drilled in 1987 to a depth of about 120m. The other technical data of the borehole including the official registration number were not available. From this source, water is pumped to a water tank on a nearby hill and then it flows back by gravity to the consumers.

Due to the climatic nature of this area, it is advisable to have a more reliable source of potable water to avoid calamities especially during periods of extended droughts. The projected demand is about 20,000 litres of water per day for both domestic and horticultural use.

It is against the above background that Mr. Eliud Mwai of Waterwells (K) Ltd was commissioned by Eng. Samuel King'ola to carry out a hydrogeological survey for purposes of sinking a borehole.

2. GEOGRAPHICAL LOCATION

The project is located about 0.8 of a kilometre south of Ekalakala Market in Masinga District. The latter is within Machakos County. The project is on sloping terrain and the average elevation is about 1170m above mean sea level.

On the Universal Transverse Mercator coordinate system, the project is on approximately the following coordinates:

- 37M 0330466.
- UTM 9892220.

The project location is also shown in Figure 1 below.

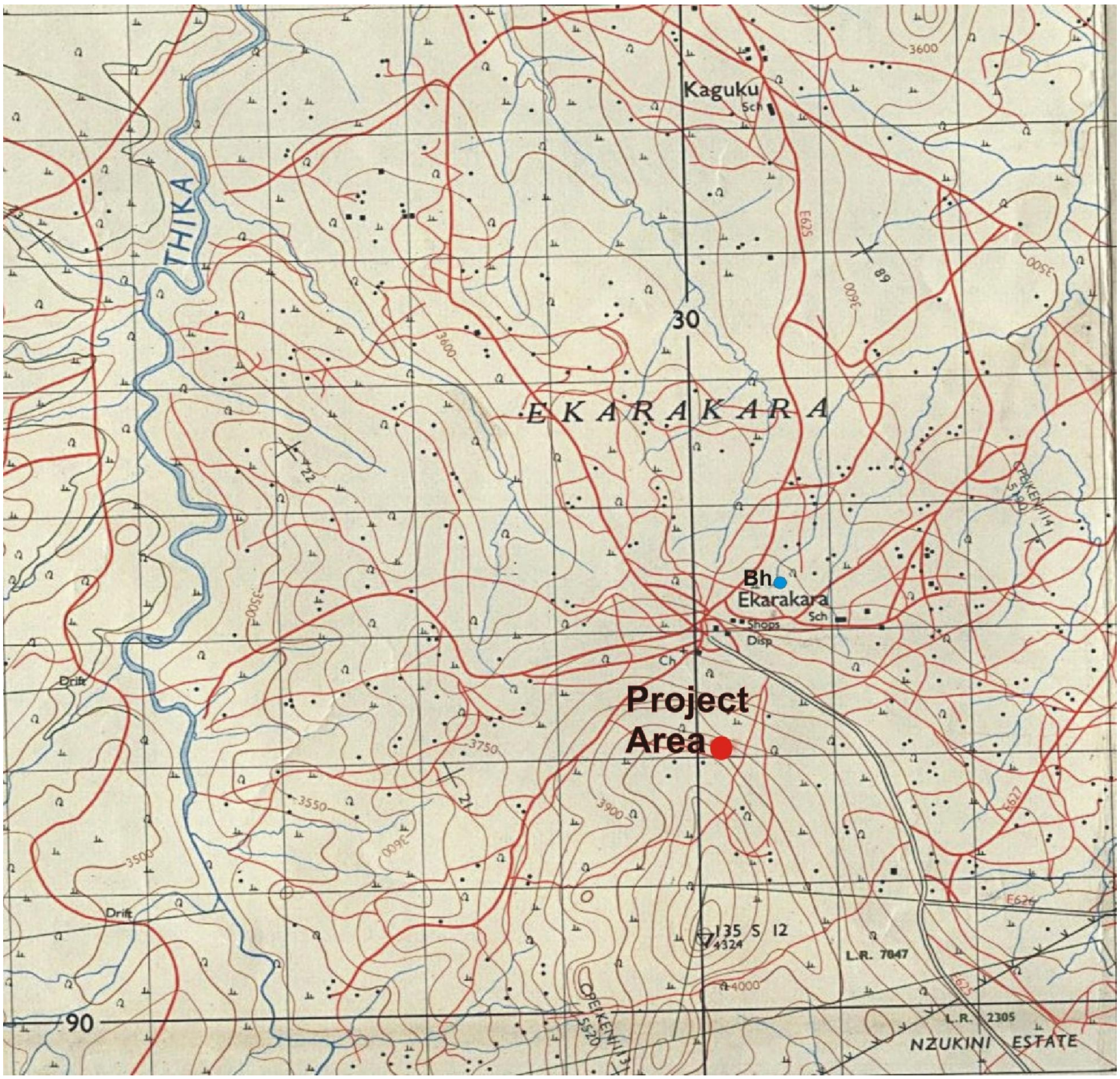


Figure 1: Project Location & Boreholes.

Scale: 1:50,000 (Ithanga Map Sheet 135/4)

A photograph of the project homestead is shown below.

3. CLIMATE

The climate in the study area is of the tropical semi-arid type. The rainfall is bimodal in character in that the long rains last from March to May while the short rains last from October to December. The mean annual rainfall for this area is about 600mm part of which percolates into the ground to form groundwater.

The rest of the precipitation is lost as surface runoff to the seasonal rivers which flow either northwestwards to the Thika River or northwards to the Tana River.

4. GEOLOGY

Physiographically, the project is located on the slopes of a hill. The general drainage is towards the north.

Generally, the area is characterized by metamorphic rocks of the Basement System, which are superficially weathered into grey sandy soils. Locally, the basement rocks are represented by gneisses and schists of semi-pelitic origin. The predominant representative rock is however, granitoid gneiss.

Outcrops of these basement rocks are occasionally displayed on the high grounds especially on the local hills and within the river valleys. Generally however, the solid geology is masked by a thick grass, bush and soil cover.

5. HYDROGEOLOGY

5.1 GROUNDWATER OCCURRENCE

In general, metamorphic rocks, which comprise the geology of the area, are not in themselves particularly permeable. They are compact and have virtually no intergranular (primary) porosity. On the other hand, hard rocks, mainly igneous and metamorphic, have a type of porosity that can be termed as fracture (secondary) porosity. This means that they can hold water in a network of cracks, joints, fractures and/or faults along the contact zones between various rock types. Similarly, when exposed to certain climatic conditions, these rocks are subjected to extensive weathering, which creates conditions favourable for the infiltration and storage of groundwater. The thickness of the weathered layer plays an important role in the determination of the amount of groundwater it can hold. Topography, drainage patterns, rainfall and evaporation are also some of the major factors that determine the amount and occurrence of groundwater.

Occasionally, due to structural adjustments caused by seismic disturbances, water could migrate from a potential aquifer to other areas but the aquifer material remains. These phenomena could lead one to giving misleading conclusions and hence, the occasional dry boreholes.

The mechanism of groundwater recharge and rate of replenishment of aquifers in igneous and metamorphic rocks depends mainly on the degree of weathering, tectonic conditions and fracturing. In the study area, recharge is by infiltration of the 600mm annual rainfall, either vertically or laterally, depending on the geometry of the weathering and rock fracturing and the nature of the terrain. Evapotranspiration is fairly high. For the greater part of the year except for rivers Tana and Thika, no surface water occurs anywhere in the area. Locally, the project area and surroundings are drained by seasonal rivers, which head to rivers Tana and Thika. Within the valleys of these rivers, riverbed recharge takes place.

5.2 GROUNDWATER POTENTIAL

Where fractured or weathered, boreholes have been successful in the basement rock system. Yields are, however, very variable depending on local hydrogeological and geomorphologic factors. As mentioned earlier, the project is on sloping terrain. This implies that most of the precipitation is lost as runoff and hence, percolation into the groundwater storage system is low.

There is only one borehole in the vicinity of the project. The borehole is located near Ekalakala Market about 800m north of the project. This borehole was drilled by the government and then handed over to the local Ekalakala community to operate and maintain. It is currently being managed commercially by a committee on behalf of the community.

The technical data for the borehole are however, not available. What is known is that the borehole was drilled in 1987 to a depth of about 120 metres. The water quality is good.

5.2.1 Borehole Specific Capacities (S), Transmissivities (T)

The borehole specific capacities could have been calculated for those boreholes with pumping water levels. The calculation is based on the formula $S=Q/d$ (Driscol, 1986) where Q is the yield during the test pumping and d is the drawdown. The transmissivity T is calculated using the Logan's formula i.e. $T=1.22Q/d$. However, since there are no borehole data, this could not be done.

6. HYDROCHEMISTRY

Information on chemical water quality from other far away boreholes indicates that the water is generally well mineralized and could be slightly hard and occasionally brackish. The fluoride content is however, within acceptable limits.

7. GEOPHYSICAL INVESTIGATION

The objective of geophysical investigation in a study area is to provide information on the geological and structural set-up and hence groundwater occurrence. A number of geophysical methods are in use in groundwater prospecting, namely, resistivity, seismic (refraction) method, electromagnetic methods, etc. The electrical resistivity method is the most widely used and was therefore applied in this project.

7.1 BASIC PRINCIPLES OF THE RESISTIVITY METHOD

The resistivity of the earth materials can be studied by measuring the electrical potential distribution produced at the earth's surface by an electrical current that is passed through the earth. The resistivity method applied in the project area was the Vertical Electrical Sounding Method.

7.2 VERTICAL ELECTRICAL SOUNDING (VES)

When carrying out a resistivity sounding, current is led into the ground by means of two electrodes. Two other electrodes situated at the centre of the array measure the potential field generated by the current. From the observations of the current strength and the potential difference and taking into account the electrode separations, the ground resistivity can be determined. During a resistivity sounding, the separation between electrodes is increased in steps (Schlumberger Array), which causes the flow of current to penetrate progressively to greater depths. By plotting the observed resistivity values against the depth on double logarithmic paper, a resistivity curve is formed depicting the variation of resistivity with depth.

7.3 FIELD WORK

Fieldwork was carried out on August 24, 2012. The fieldwork comprised mainly of geological, hydrogeological and geophysical survey. Three geoelectrical soundings were conducted within the project area to determine the nature of the subsurface geology. The VES locations are shown approximately on Figure 2 below.

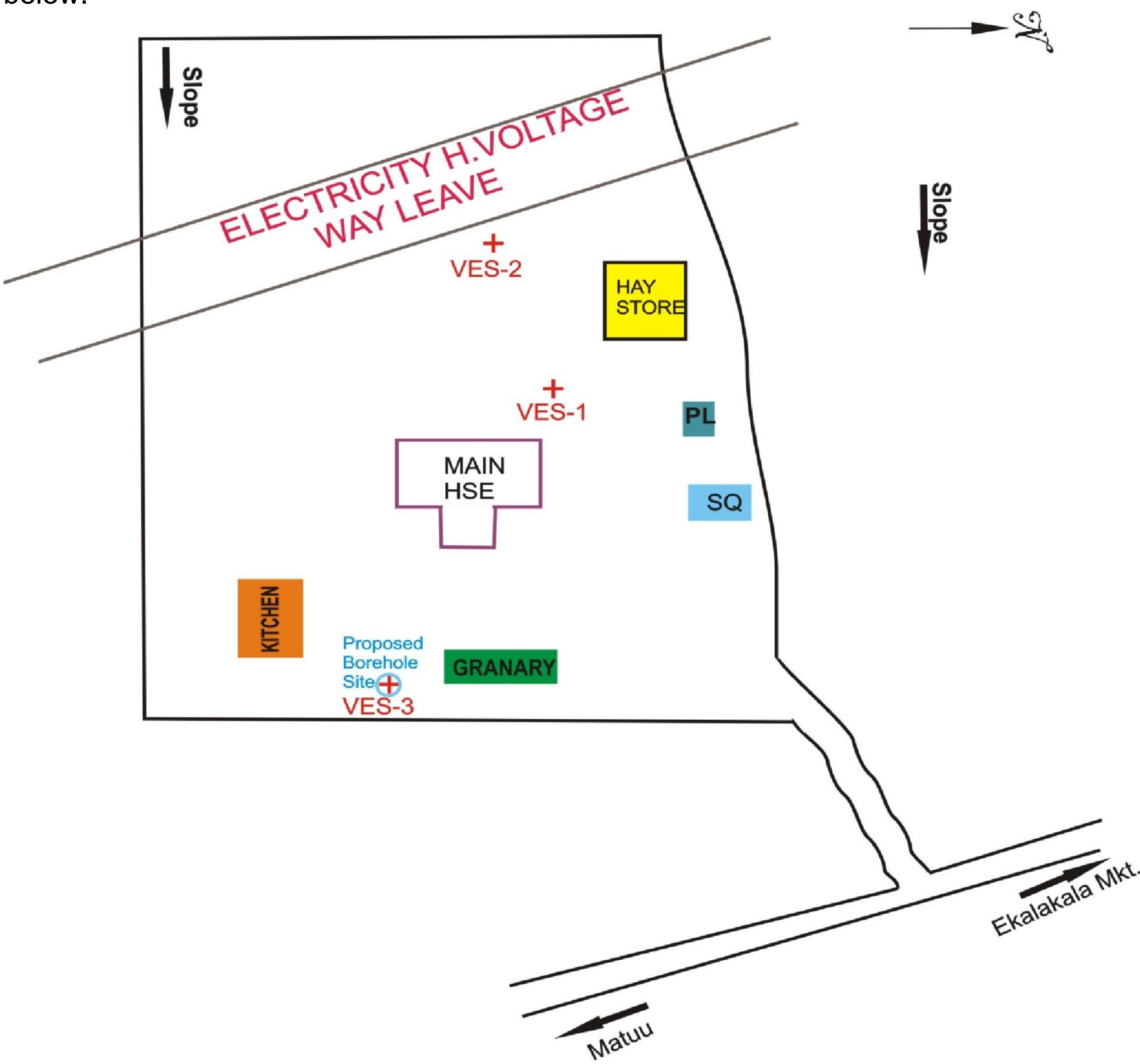


Figure 2: Project Plan (NTS)

7.4 INTERPRETATION

The interpretation of the VES data was carried out using a computer program specific to this type of geophysical survey. The true ground resistivities and their corresponding depths were calculated and then interpreted in terms of geological nature as shown in the table below.

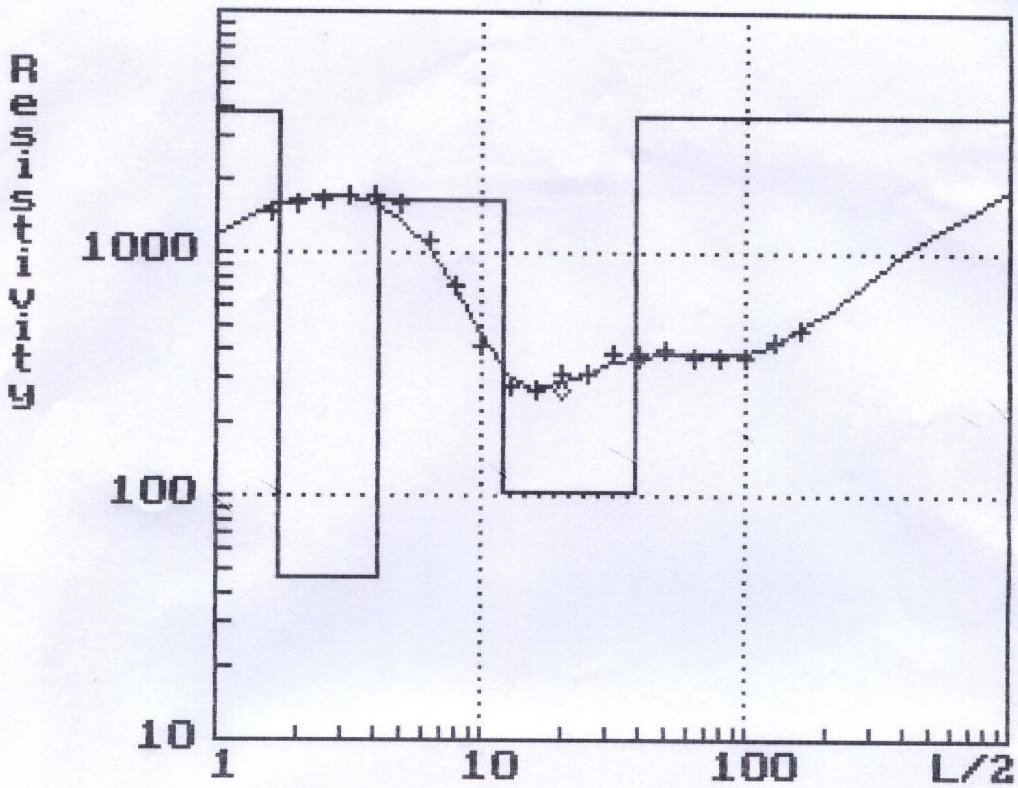
The geological nature gives light regarding possible aquifer presence.

VES No.	DEPTH (m)	RESISTIVITY (Ohm-m)	GEOLOGICAL NATURE
1.	0 – 1	2117	Compact laterite
	1 – 3	943	Lateritic soil
	3 – 13	126	Highly weathered basement
	>13	478	Fresh basement
2.	0 – 1	1423	Compact laterite
	1 – 3	825	Lateritic soil
	3 – 17	100	Highly weathered basement
	>17	431	Fresh basement
3.	0 – 0.2	378	Sandy soil
	0.2 – 2	3777	Compact laterite
	2 – 4	46	Highly weathered basement (clay?)
	4 – 12	1678	Fresh basement
	12 - 39	104	Highly weathered/fractured basement
	>39	3694	Fresh basement

Table : Summary of Interpreted Geophysical Data.

The VES graph and model of the most viable site (VES-3) is shown below.

VES



Project Name SAMUEL KING'OLA
Location EKALAKALA,MASINGA/MACHAKOS
Coordinates 37M 0330494;UTM 9892260
Direction
Date 24-8-12
ELEV. 1169m, near the easten boundary

Disk VES FILES
File EKALAK-3
Data EKALAK-3
WATERWELLS (K) LTD
Date 27-8-12
Schlumberger

L/2 (m)	Rho (Ohm.m)	L/2 (m)	Rho (Ohm.m)	L/2 (m)	Rho (Ohm.m)
1.6	1444.0	10.0	407.0	40.0	373.0
2.0	1569.0	13.0	285.0	50.0	396.0
2.5	1617.0	16.0	272.0	63.0	371.0
3.2	1696.0	20.0	317.0	80.0	366.0
4.0	1683.0	20.0	271.0	100.0	374.0
5.0	1556.0	25.0	320.0	130.0	436.0
6.3	1104.0	32.0	377.0	160.0	491.0
8.0	740.0	40.0	390.0		

Resistivity (Ohm.m)	Depth (m)
377.7	0.2
3777.2	1.7
46.3	4.1
1677.9	12.3
104.3	38.6
3694.1	

8. CONCLUSION AND RECOMMENDATIONS

The terms of reference for the study of the project area were, among other things, to carry out a hydrogeological survey for purposes of assessing the possible presence of exploitable groundwater resources. Geologically, the project area is made up of metamorphic rocks of the basement system. The rocks have been superficially weathered into either sandy, lateritic soils or clay soils. The basement system rocks unlike the volcanic or sedimentary rocks are not very conducive to groundwater percolation and storage.

Despite the above observation, boreholes drilled in similar geological set-up elsewhere have been successful. A good example is the community borehole in Ekalakala Market. This is an indication of a fair amount of recharge. Aquifers are likely to comprise of either fissured or weathered basement. The geophysical survey indicates the likelihood of an aquifer at site VES–3.

After examining all the available information – geological, hydrogeological and geophysical, it has been concluded that a borehole project could be viable.

In light of the above conclusions, it is recommended that:

a) A borehole be drilled at site VES - 3 which is shown in Fig. 2, to a maximum depth of **100 metres.**

The site is at the following coordinates:

- 37M 0330494.
- UTM 9892260.

The proposed borehole drilling site was pegged and shown to the following people:

- Eng. Samuel Nthei King'ola - Client
- Mrs. Petronila Ndulu Nthei - Client's wife
- Mr. William King'ola Mwange - Client's father

b) After drilling, the borehole be fitted with:

i) A water master meter to monitor the rate of groundwater abstraction.

ii) An airline to monitor the fluctuation of the water table

REFERENCES

- Geology of the Mwingi Area. Report No. 38 by A.F. Crowther of 1957.
- Waterwells (K) Ltd Hydrogeological Report No. WWK 1040 - 2010 for Mr. Mutunga Kikoma, Eendei-Kithyoko area-Yatta District
- Waterwells (K) Ltd Hydrogeological Report No. WWK 1095 - 2010 for Winzyeei Primary School, Winzyeei area-Migwani District
- Waterwells (K) Ltd Hydrogeological Report No. WWK 1299 - 2012 for Stella Malia Makonge, Ngongoni area-Migwani District