REPORT ON

HYDROGEOLOGICAL STUDIES AND GEOPHYSICAL INVESTIGATIONS FOR SITING 1No. BOREHOLE FOR MECHANISATION AT SIERRA LEONE BOTTLING COMPANY LIMITED IN FREETOWN

Prepared by:

EDAL DRILLING COMPANY

49 WATERLOO STREET

FREETOWN

SIERRA LEONE

TEL:

APRIL 2010

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1. INTRODUCTION

Sierra Leone Bottling Company Limited is located Dwarzak, Freetown. Though the Company already has two boreholes at their premises, it needs a third one as the two are not enough to meet their daily production and other activities.

In the quest to search for a groundwater, the authorities of Sierra Leone Bottling Company Ltd engaged Edal Drilling and Consultancy Company Limited to undertake a Hydrogeological Studies and geophysical investigations as well as drilling of 1No. borehole to add to the other two on the site.

The studies were, among others, to provide enough data and information to be used in assessing the possibility of striking fresh underground water in the alternative of a borehole in the site. This report documents the work carried out at the site on the April 2010.

2. BACKGROUND OF THE STUDY AREA

Background information was obtained by means of a study consisting of the acquisition of previous work (Geophysics, Drilling logs, Geo-electrical logs of the area) carried out in and around the study area, geological and Topographical Maps of the area. Based on that, a siting strategy was deployed.

The topography is generally undulating.

Geologically, the area is composed of a layer complex sand clay and gabbro. The rocks in Duraplast Residency have acquired variable secondary porosity and permeability through jointing, fracturing and shearing along which decomposition and weathering have taken place.

Hydrogeologically, the rocks in the area have high- medium water potential since the rocks have undergone various degree of tectonic activities that have resulted in fracturing and jointing in the rocks. The various rock units in the area include; Gabbro, Anortosite etc.

3. FIELD WORK

3.1 Field Reconnaissance Survey

The aim of the reconnaissance survey was to select target areas for geophysical survey. The field reconnaissance survey was undertaken together with the Technical Manager (Kartout Nabil) and the Electrical Supervisor (James Kargbo). The reconnaissance took place on April 10, 2010 and the activities that were carried out involved;

- Geomorphologic survey of areas not identified during desk study but could be significant in hydrogeological studies; and
- Demarcation of area for traverse lines for geophysical survey.

3.1.1 Selection of Traverse Lines

Traverse line was run on the basis of geomorphologic and physical features such as vegetation, stream direction as well as any significant hydrogeological features encountered in the premises. The traverse line was perpendicular to the major strike direction of the geological formation of the area.

One traverse line was run in the NE-SW direction. The rational behind the selection of this traversing trend was to intercept the major trend of NW-SE fractures in the area.

3.2 Geophysical Survey

The Geophysical survey consisted mainly of Electrical Resistivity Profiling and Vertical Electrical Sounding (VES) using DZD 6A Multifunction Electrical meter.

3.2.1 Resistivity Profiling

Resistivity Profiling was carried out along the traverse line using the recommended Schlumbeger configuration. Two depths of 19m and 40m were investigated, using the electrode separations of (L/2, a/2) given by 19m, 0.5m and (40m, 5.0m). The electrode separations (19m, 0.5m) and (40m, 5.0m) were assumed to probe the weathered layer and bedrock respectively (WRRI, 1994).

3.2.2 Selection of VES Points

The profiling results were plotted on a linear scale, and preliminary interpretation was done on the field to select the best anomalous points for Vertical Electrical Sounding

(VES). The VES points were restricted to areas where relatively lower apparent resistivities were recorded on the horizontal profiles.

Two (2) points were selected for VES. The VES points were marked with pegs with inscription on them.

3.2.3 Vertical Electrical Sounding (VES)

Vertical Electrical Sounding (VES) was carried out with the aim of determining the formation resistivities and the depth to bedrock, as well as finding the possibility of obtaining fracture at depth the sounding points.

The Schlumberger electrode configuration and the expanding procedure were used for the VES. Data control was ensured by plotting the VES results on the field as VES measurements were in progress. Unreasonable values that registered high standard deviation (sd) greater than unity were rejected and sounding repeated at the same spot several times until reasonable values were recorded. Changing the position of the electrodes and varying the current input ensured this.

4. DATA ANALYSIS AND INTERPRETATION

4.1 Geophysical Survey

The electrical resistivity profiling result and its corresponding response curves is presented in Fig 1A, whiles the Vertical Electrical Sounding results and corresponding curves are presented in fig 2A- 2B.

4.1.1 Resistivity Profiling

The interesting feature of resistivity profiling interpretation is the identification and selection of anomalous points or zones. These anomalous points or zones in this area are generally resistivity values below the average resistivity values along a given profile line.

On the average, the measured apparent resistivity values for the (19m, 0.5m) and (40m, 5.0m) were medium-low. Values ranging between 69.5ohm-m and 147ohm-m, and averaging 108ohm-m were recorded.

The general high to medium resistivity values recorded in the area could indicate shallow overburden thickness and slight weathering as well as fracture development conditions in the area. The groundwater potential in this area could be variable ranging between high and medium.

The measured apparent resistivity values range between 69.9ohm-m and 147.5ohm-m with a mean of 108ohm-m for the (19m, 0.5m) separation. For the (40m, 5.0m) separation, the measured apparent resistivity values were in the range of 79ohm-m and 106ohm-m with a mean of 91hm-m. In general, high resistivity values were recorded with the (40m, 5.0m) than the (19m, 0.5m) separation along the traverse. Well-defined anomalous points of low resistivity values were selected for Vertical Electrical Sounding.

4.1.2 Vertical Electrical Sounding (VES)

Based on the results of the resistivity profiling, the points A12m and A21 were selected for VES. The VES results and response curves at the two points are presented in Fig 2A – 2B. The interpretation was carried out using the RESIST software.

4.2 Selection of Promising Points

The selection of points for test drilling at Sierra Leone Botling Company Limited been done by considering the thickness of the various layers of the subsurface structure and their corresponding apparent resistivity from the analyses of VES results as well as the behaviour of the anomalous points during the profiling.

The ranking of the VES points in order of preference for test drilling is presented in table 1 below.

Table 1: The rank list of VES points in order of preference for test drilling

RANK	VES POINT	LAYER	DEPTH (m)	THICK-NESS (m)	APPARENT RESISTIVITY (Ohm-m)	POSSIBLE WATER ZONES (m)	RANKING	MAX DRILLING DEPTH (m)
1	A12/S2	1 2 3	1 6 -	1 5 -	160 380 30	25-30 45-55		60
2	**A21/S1**	**1** **2** **3**	**1** **25** **34** -	**1** **24** **10** -	**115** **400** **5**	**20-30** **52-60**	**1st**	**60**

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the analyses of the entire results, and in line with the aims of the study, the drawn conclusions are;

- ♣ the study area is composed of the Freetown complex
- ♣ the formation has undergone slight degree of weathering which control groundwater occurrence and accumulation.
- ♣ Groundwater potential could be medium to low.

5.2 Recommendation

In this regard, it is recommended that,

- ♣ test drilling could be carried out at **A21/S1** with A12/S2 as alternative site to confirm the existence of aquifer system.
- ♣ the **maximum drilling depth** at this site should be **60m** below ground level. However, the supervisor may exceed this based on the field conditions.
- ♣ Hydrofracture may be deployed when the yield is low to increase the airlift yield.
- ♣ both physico-chemical and bacteriological test should be carried out on the borehole water samples from completed well.

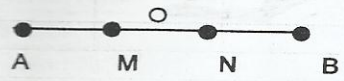
FIG 2A: Resistivity Profiling results and corresponding responds curves along Profile A

RESISTIVITY PROFILING DATA SHEET- SCHLUMBERGER METHOD

Project: Private
Date: 10-04-2010
Operator: Obeng
District:

Profile #: A
Station interval (m): 3
Region:
COMMUNITY: Sierra Leone Bottling Co. Ltd, Freetown

Length (m): 30
Bearing: 135



$$K = \frac{AM*AN}{MN} * 3.142 \qquad p = K* \frac{\Delta V}{1}$$

Station No.	Electrode Seperation AB/2=19m, K=1133, MN/2= 0.5m			Electrode Seperation AB/2=40m, K=495, MN/2= 5.0m		
	ΔV 1	(ohm-m)	Remarks	ΔV 1	(ohm-m)	Remarks
0	0.1302	147.5		0.2108	104.3	
3	0.1037	117.5		0.19204	95.1	
6	0.0987	111.8		0.1889	93.5	
9	0.0897	101.6		0.1795	88.9	
12	0.0742	84.1		0.1715	84.9	VES
15	0.1061	120.2		0.1972	97.6	
18	0.07501	85.0		0.1909	94.5	
21	0.0617	69.9		0.1593	78.9	VES
24	0.086	97.4		0.1613	79.8	
27	0.0908	102.9		0.1746	86.4	LIMTIED
30	0.0997	113.0		0.192	95.0	

RESISTIVITY PROFILING RESPOSE CURVE ALONG PROFILE A

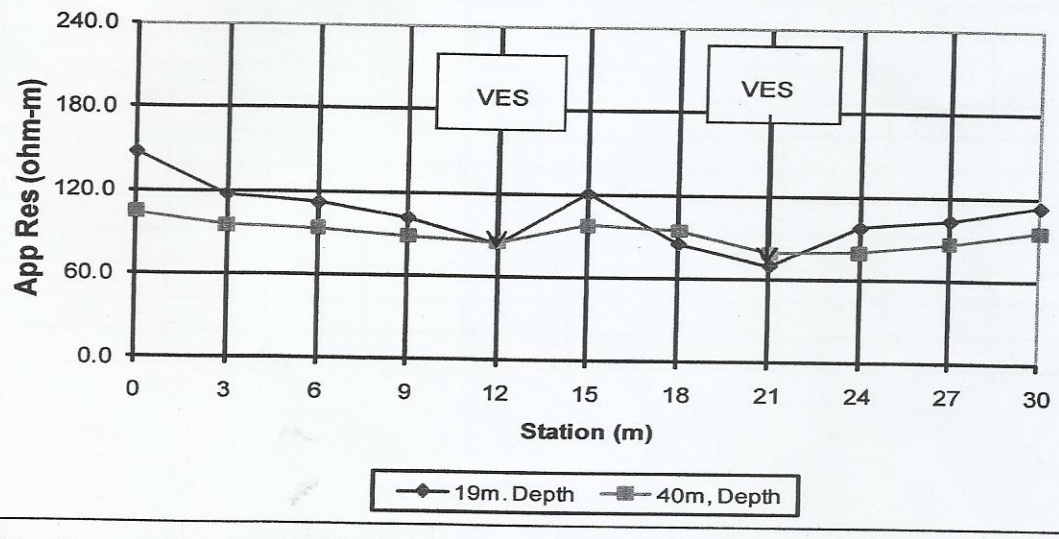


FIG 3A: SCHLUMBERGER VES & MODEL AT A12/S2

SIERRA LEONE BOTTLING CO.LTD. - A12/S2

Client : SIERRA LEONE BOTT.	Community : SIERRA LEONE BOTTLING CO.LTD.
Project : Private	Sounding Number : A12/S2
District :	Coordinates East :
Date : 10/04/2010	Coordinates North :
Field Operator : OBENG	GPS Datum : GPS datum
Interpreted by : OBENG	Azimuth : 135

Schlumberger Array VES Field Data

AB/2 (m)	MN(m) 1.0 *(MN-1)*	MN(m) 10 *(MN-2)*	MN(m) 30 *(MN-3)*	ΔV/I *(MN-1)*	ΔV/I *(MN-2)*	ΔV/I *(MN-3)*	ρ (ohm-m) *(MN-1)*	ρ (ohm-m) *(MN-2)*	ρ (ohm-m) *(MN-3)*
1.0	2.4			66.0480			155.6		
2.0	11.8			21.6660			255.2		
3.0	27.5			10.5980			291.3		
4.0	49.5			5.6918			281.6		
5.0	77.8			3.3509			260.5		
6.0	112			2.3150			260.0		
8.0	200			0.9531			190.9		
10.0	313			0.5228			163.8		
15.0	706	63		0.1291	2.8018		91.2	176.0	
20.0	1,256	118		0.0665	1.0352		83.5	122.0	
25.0	1,963	188		0.0182	0.3604		35.7	67.9	
30.0	2,827	275		0.0091	0.2676		25.7	73.6	
35.0	3,848	377		0.0053	0.2017		20.4	76.0	
40.0		495			0.1698			84.0	
50.0		778			0.1323			102.9	
60.0		1,123			0.0952			106.9	
70.0		1,532			0.0601			92.0	
80.0									
100.0									
125.0									
150.0									
175.0									
200.0									

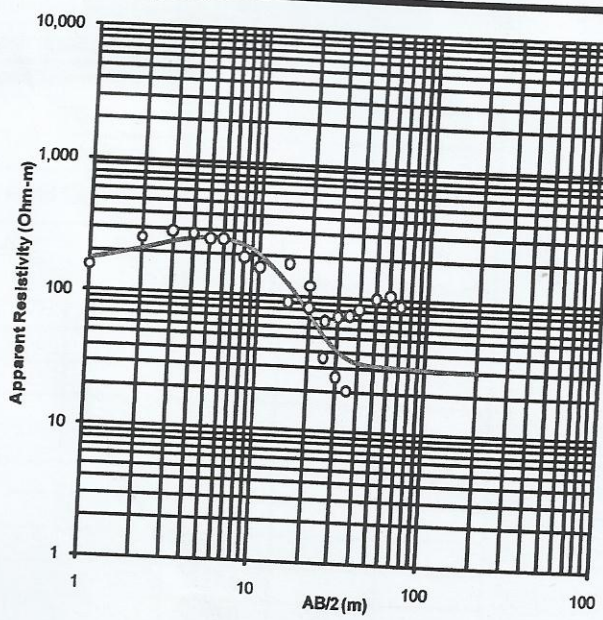
Client : SIERRA LEONE BOTT.
Project : Private
District :
Date : 10/04/2010
Field Operator : OBENG
Interpreted by : OBENG

Community : SIERRA LEONE BOTTLING CO.L
Sounding Number : A12/S2
Coordinates East :
Coordinates North :
GPS Datum : GPS datum
Azimuth : 135

SIERRA LEONE BOTTLING CO.LTD. - A12/S2

GeoVES 1.3
MS Excel based modelling of Vertical Electrical Soundings in the Schlumberger Array using Gosh linear filters

Data		Model		
AB/2 (m)	Measured Apparent Resistivity (Ohm-m)	Modelled Apparent Resistivity (Ohm-m)	Model Error	Included in Model (1=yes)
1.0	155.6	171	245	1
2.0	255.2	209	2,176	1
3.0	291.3	239	2,704	1
4.0	281.6	257	614	1
5.0	260.5	263	5	1
6.0	260.0	259	0	1
8.0	190.9	235	1,937	1
10.0	163.8	200	1,321	1
15.0	91.2	121	903	1
20.0	83.5	74	83	1
25.0	35.7	51	234	1
30.0	25.7	40	205	1
35.0	20.4	35	216	1
15.0	176.0	121	3,007	1
20.0	122.0	74	2,263	1
25.0	67.9	51	287	1
30.0	73.6	40	1,123	1
35.0	76.0	35	1,677	1
40.0	84.0	33	2,613	1
50.0	102.9	32	5,087	1
60.0	106.9	31	5,730	1
70.0	92.0	31	3,725	1



Model Parameters							
Model Layer	Resistivity (Ohm-m)	Resistivity Range		Thickness (m)	Thickness Range	Depth (m)	Depth Range
1	160			1		1	
2	380			4		5	
3	30						
4							
5							
6							
7							
8							

Geoelectrical Model

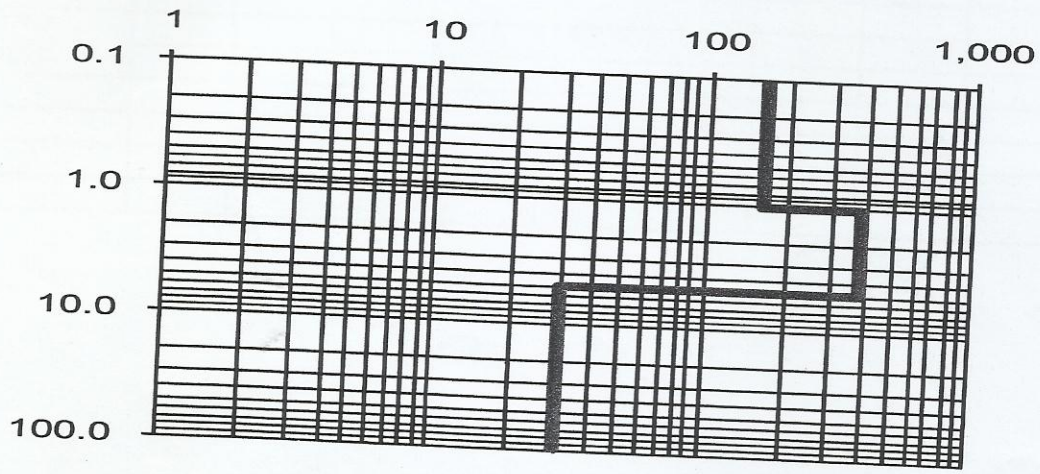


FIG 2B: SCHLUMBERGER VES RESULTS & MODEL AT A21/S1

SIERRA LEONE BOTTLING CO. LTD - A21/S1

Client : SIERRA LEONE BOTT.	Community : SIERRA LEONE BOTTLING CO. LTD
Project : Private	Sounding Number : A21/S1
District :	Coordinates East :
Date : 10/04/2010	Coordinates North :
Field Operator : OBENG	GPS Datum : GPS datum
Interpreted by : OBENG	Azimuth : 135°

Schlumberger Array VES Field Data

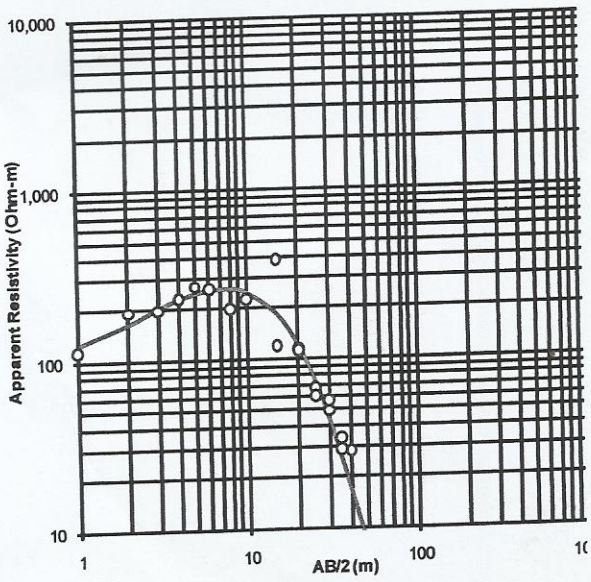
AB/2 (m)	MN(m) 1.0 (MN-1)	MN(m) 10 (MN-2)	MN(m) 30 (MN-3)	ΔV/I (MN-1)	ΔV/I (MN-2)	ΔV/I (MN-3)	ρ (ohm-m) (MN-1)	ρ (ohm-m) (MN-2)	ρ (ohm-m) (MN-3)
1.0	2.4			48.5540			114.4		
2.0	11.8			16.4220			193.5		
3.0	27.5			7.1811			197.4		
4.0	49.5			4.7062			232.9		
5.0	77.8			3.5116			273.0		
6.0	112			2.3377			262.6		
8.0	200			0.9967			199.6		
10.0	313			0.7261			227.5		
15.0	706	63		0.5518	1.9116		389.6	120.1	
20.0	1,256	118		0.0918	0.9479		115.3	111.7	
25.0	1,963	188		0.0345	0.3217		67.7	60.6	
30.0	2,827	275		0.0201	0.1800		56.8	49.5	
35.0	3,848	377		0.0076	0.0907		29.2	34.2	
40.0		495			0.0583			28.8	
50.0		778			0.0064			5.0	
60.0		1,123			0.0057			6.4	
70.0		1,532			0.0032			4.9	
80.0									
100.0									
125.0									
150.0									
175.0									
200.0									

Community : SIERRA LEONE BOTTLING CO. L
Sounding Number : A21/S1
Coordinates East :
Coordinates North :
GPS Datum : GPS datum
Azimuth : 135°

SIERRA LEONE BOTTLING CO. LTD - A21/S1

GeoVES 1.3
MS Excel based modelling of Vertical Electrical Soundings in the Schlumberger Array using Gosh linear filters

Data		Model		
AB/2 (m)	Measured Apparent Resistivity (Ohm-m)	Modelled Apparent Resistivity (Ohm-m)	Model Error	Included in Model (1=yes)
1.0	114.4	126	140	1
2.0	193.5	167	725	1
3.0	197.4	204	49	1
4.0	232.9	232	1	1
5.0	273.0	250	538	1
6.0	262.6	261	4	1
8.0	199.6	264	4,198	1
10.0	227.5	251	561	1
15.0	389.6	186	41,451	1
20.0	115.3	121	31	1
25.0	67.7	74	40	1
30.0	56.8	44	157	1
35.0	29.2	27	7	1
15.0	120.1	186	4,344	1
20.0	111.7	121	84	1
25.0	60.6	74	179	1
30.0	49.5	44	27	1
35.0	34.2	27	59	1
40.0	28.8	16	156	1
50.0	5.0	8	7	1
60.0	6.4	5	1	1
70.0	4.9	5	0	1



Model Parameters						
Model Layer	Resistivity (Ohm-m)	Resistivity Range	Thickness (m)	Thickness Range	Depth (m)	Depth Range
1	115		1		1	
2	400		6		7	
3	5					
4						
5						
6						
7						
8						

Geoelectrical Model