REPORT ON

HYDROGEOLOGICAL STUDIES AND GEOPHYSICAL INVESTIGATIONS FOR SITING 1No. BOREHOLE FOR MECHANISATION AT THE

CAMP OF LONDON MINING COMPANY, LUNSAR

Prepared by:

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JULY, 2010

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1. INTRODUCTION

London Mining Company (LMC) CAMP is located at Lunsar. The authorities in charge of the mines want to explore the possibility of getting good source of groundwater for both commercial and domestic use.

In the quest to search for groundwater, the authorities of LMC engaged Edal Drilling Company Limited to undertake Hydrogeological Studies and geophysical investigations together with drilling of 1No. borehole at 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 at the site. This report documents the work carried out at the site on July 1, 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.

Geologically, the area is composed of Marampa formation which is a low grade Archean age greenstone belt consisting of banded ironstone and mafic to felsic schistose volcanic sediments. The rocks at this vicinity have acquired variable secondary porosity and permeability through jointing; the fracturing and shearing along which decomposition and weathering have taken place.

Hydrogeologically, this formation is interpreted to have good to reasonable yield, since rocks units here (Schluter T. Wright EP and Akuwumi) have undergone various degrees of tectonic activities that have resulted in fracturing and jointing in the rocks. The various rock units in the area include; ironstone and Schist, gneiss and mafic to felsic schistose volcanic sediments

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 on July 1, 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 SAS 1000/4000 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 Bed rock 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-high. Values ranging between 202ohm-m and 2008ohm-m, and averaging 1171ohm-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 202ohm-m and 406ohm-m with a mean of 304ohm-m for the (19m, 0.5m) separation. For the (40m, 5.0m) separation, the measured apparent resistivity values were in the range of 743ohm-m and 2008ohm-m with a mean of 1438ohm-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 A25m and A30m were selected for VES. The VES results and response curves at the three 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 LMC Camp is 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	A30/S1	1 2 3	0.8 3.8 -	0.8 3.0 -	8600 1400 250	 20-30 35-45		70
2	**A25/S2**	**1** **2** **3** **4**	**1** **6** **20** **-**	**1** **5** **14** **-**	**1000** **3200** **200** **1000**	 **15-25** **30-40**	**1st**	**70**

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 Marampa formation
- ♣ the formation has undergone moderate-slight degree of weathering which control groundwater occurrence and accumulation.
- ♣ Groundwater potential could be good to reasonable.

5.2 Recommendation

In this regard, it is recommended that,

- ♣ test drilling could be carried out at **A25/S2** to confirm the existence of aquifer system.
- ♣ the **maximum drilling depth** at this site should be **70m** below ground level. However, the supervisor may exceed this or go below this depth based on the field conditions.
- ♣ both physico-chemical and bacteriological test will be carried out on the borehole water samples from completed well.

FIG 1A: Resistivity Profiling results and corresponding responds curves along Profile A

RESISTIVITY PROFILING DATA SHEET- SCHLUMBERGER METHOD

Project: Private | Profile #: A | Length (m): 130
Date: 01-07-2010 | Station interval (m): 5 | Bearing: 145
Operator: Obeng | Region:
District: | COMMUNITY: London Mining Co. Camp -Lunsar

A M N B

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

Station No.	Electrode Seperation AB/2=19m, K=1133, MN/2= 0.5m ΔV 1	(ohm-m)	Remarks	Electrode Seperation AB/2=40m, K=495, MN/2= 5.0m ΔV 1	(ohm-m)	Remarks
0	1.305	1478.6		6.891	3411.0	LIMITED
5	1.0202	1155.9		5.6678	2805.6	
10	0.7492	848.8		2.3479	1162.2	
15	0.6651	753.6		1.9388	959.7	
20	0.4132	468.2		1.4217	703.7	
25	0.3049	345.5		0.9226	456.7	VES
30	0.1304	147.7		0.9464	468.5	VES
35	0.6429	728.4		1.3261	656.4	
40	0.5742	650.6		2.501	1238.0	
45	0.8513	964.5		4.342	2149.3	
50	1.192	1350.5		4.8911	2421.09	BOUNDARY

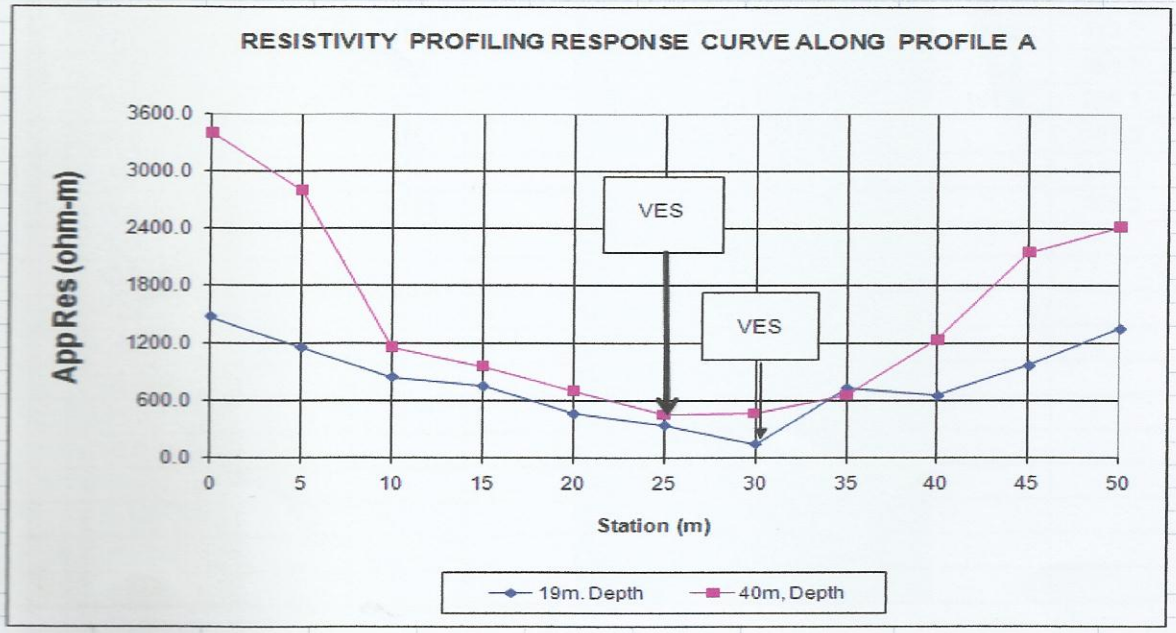


FIG 2A: SCHLUMBERGER VES & MODEL AT A30/S1

LMC Camp-Lunsar - A30/S1

Client : London Mining Co.	Community : LMC Camp-Lunsar
Project : Private	Sounding Number : A30/S1
District :	Coordinates East :
Date : 01-06-2010	Coordinates North :
Field Operator : Obeng	GPS Datum :
Interpreted by : Obeng	Azimuth : 145

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			348.7400			821.7		
2.0	11.8			97.7560			1151.7		
3.0	27.5			44.5110			1223.6		
4.0	49.5			24.9520			1234.6		
5.0	77.8			13.1510			1022.5		
6.0	112			8.9540			1005.6		
8.0	200			4.1790			837.0		
10.0	313			1.9270			603.9		
15.0	706	63		0.4440	7.2210		313.5	453.7	
20.0	1,256	118		0.1840	4.5380		231.1	534.6	
25.0	1,963	188		0.1030	2.1950		202.2	413.7	
30.0	2,827	275		0.0660	1.3230		186.6	363.7	
35.0	3,848	377		0.0420	0.7940		161.6	299.3	
40.0		495			0.5280			261.3	
50.0		778			0.4070			316.5	
60.0		1,123			0.3190			358.3	
70.0									
80.0									
100.0									
125.0									
150.0									
175.0									
200.0									

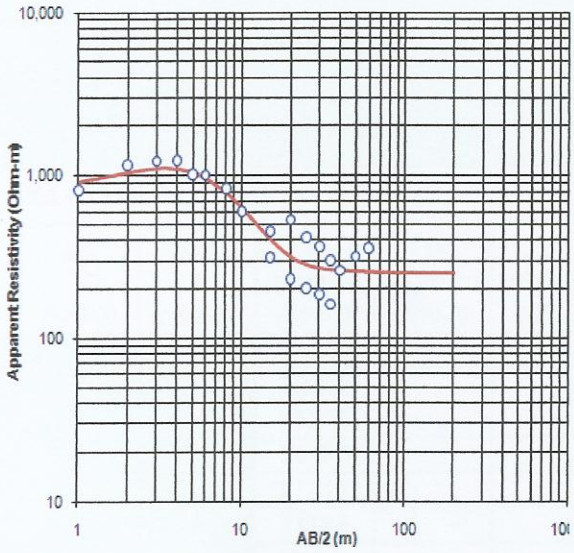
Client : London Mining Co.
Project : Private
District :
Date : 01-06-2010
Field Operator : Obeng
Interpreted by : Obeng

Community : LMC Camp-Lunsar
Sounding Number : A30/S1
Coordinates East :
Coordinates North :
GPS Datum :
Azimuth : 145

LMC Camp-Lunsar - A30/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	821.7	919	9,527	1
2.0	1151.7	1,046	11,150	1
3.0	1223.6	1,106	13,845	1
4.0	1234.6	1,099	18,478	1
5.0	1022.5	1,045	515	1
6.0	1005.6	966	1,547	1
8.0	837.0	790	2,224	1
10.0	803.9	635	995	1
15.0	313.5	405	8,310	1
20.0	231.1	314	6,936	1
25.0	202.2	281	6,169	1
30.0	186.6	268	6,595	1
35.0	161.6	262	10,138	1
15.0	453.7	405	2,406	1
20.0	534.6	314	48,515	1
25.0	413.7	281	17,701	1
30.0	363.7	268	9,199	1
35.0	299.3	262	1,372	1
40.0	261.3	260	3	1
50.0	316.5	256	3,600	1
60.0	358.3	254	10,773	1



Model Parameters						
Model Layer	Resistivity (Ohm-m)	Resistivity Range	Thickness (m)	Thickness Range	Depth (m)	Depth Range
1	860		0.8		0.8	
2	1400		3		3.8	
3	250					
4						
5						
6						
7						
8						

Root Mean Squared Error: 95

D:\Documents and Settings\Cyril Greenwood\My Documents\LMC CAMP BOREHOLE DRILLING Folder\[LMC CAMP A30-S1.xls]Data

Geoelectrical Model

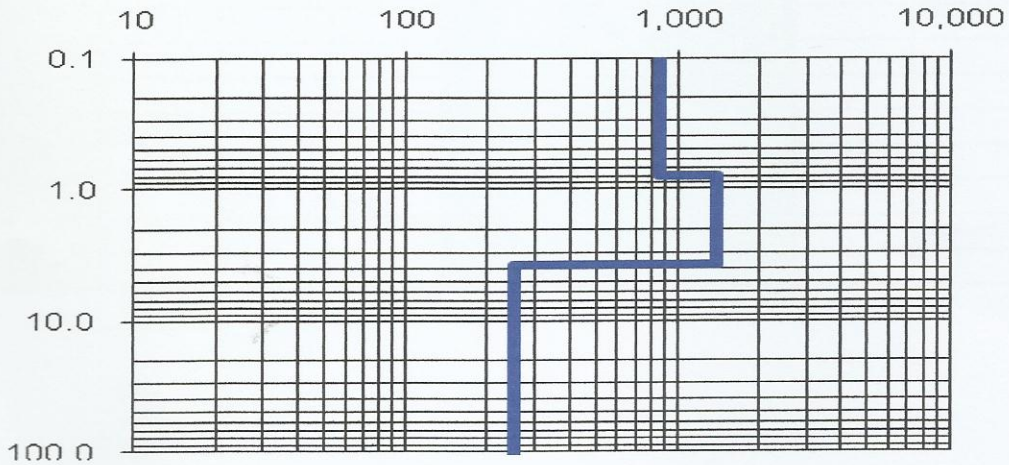


FIG 2B: SCHLUMBERGER VES RESULTS & MODEL AT A25/S2

LMC Camp-Lunsar - A25/S2

Client : London Mining Co.	Community : LMC Camp-Lunsar
Project : Private	Sounding Number : A25/S2
District :	Coordinates East :
Date : 01-06-2010	Coordinates North :
Field Operator : Obeng	GPS Datum :
Interpreted by : Obeng	Azimuth : 145

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			467.5500			1101.6		
2.0	11.8			143.1200			1686.1		
3.0	27.5			90.1200			2477.3		
4.0	49.5			61.4440			3040.3		
5.0	77.8			35.0430			2724.7		
6.0	112			9.9060			1112.6		
8.0	200			4.9100			983.4		
10.0	313			2.8860			904.4		
15.0	706	63		0.9980	18.7850		704.7	1180.3	
20.0	1,256	118		0.4360	9.5480		547.6	1124.8	
25.0	1,963	188		0.2840	4.2170		557.4	794.9	
30.0	2,827	275		0.1060	2.2240		299.6	611.4	
35.0	3,848	377		0.0782	1.6100		300.9	607.0	
40.0		495			1.0170			503.2	
50.0		778			0.9220			716.9	
60.0		1,123			0.5470			614.3	
70.0									
80.0									
100.0									
125.0									
150.0									
175.0									
200.0									

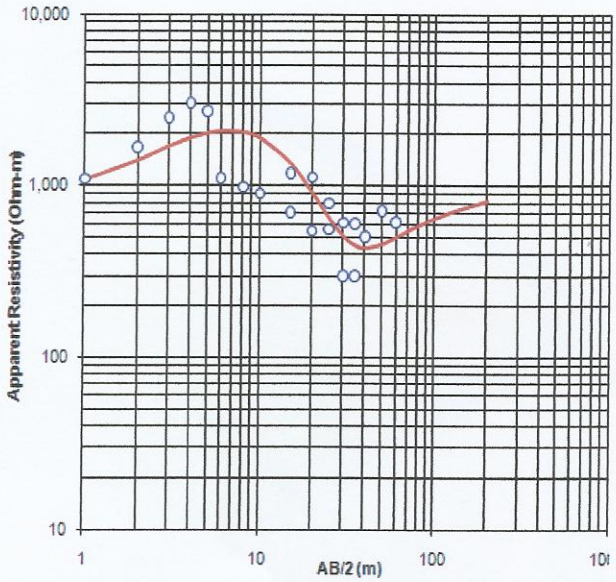
Client : London Mining Co.
Project : Private
District :
Date : 01-06-2010
Field Operator : Obeng
Interpreted by : Obeng

Community : LMC Camp-Lunsar
Sounding Number : A25/S2
Coordinates East :
Coordinates North :
GPS Datum :
Azimuth : 145

LMC Camp-Lunsar - A25/S2

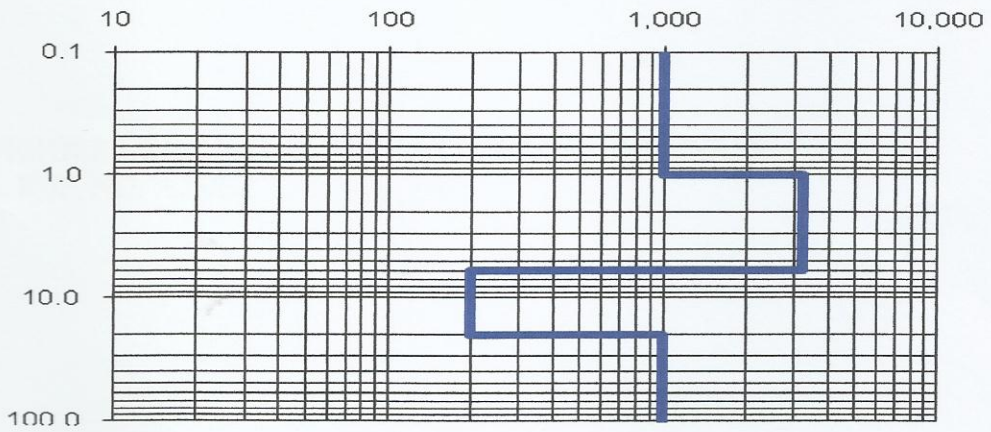
GeoVES 1.3
MS Excel based modelling of Vertical Electrical Soundings in the Schlumberger Array using Gosh linear filters

Data		Model		
AB/2 (m)	Measured Apparent Resistivity (Ohm-m)	Modelled Apparent Resistivity (Ohm-m)	Model Error	Included in Model (1=yes)
1.0	1101.6	1,093	76	1
2.0	1686.1	1,418	71,630	1
3.0	2477.3	1,714	583,058	1
4.0	3040.3	1,918	1,259,440	1
5.0	2724.7	2,043	465,223	1
6.0	1112.6	2,102	978,236	1
8.0	983.4	2,070	1,181,416	1
10.0	904.4	1,912	1,014,659	1
15.0	704.7	1,359	428,437	1
20.0	547.6	915	135,193	1
25.0	557.4	649	8,391	1
30.0	299.6	512	45,015	1
35.0	300.9	452	22,873	1
15.0	1180.3	1,359	32,011	1
20.0	1124.8	915	43,936	1
25.0	794.9	649	21,280	1
30.0	611.4	512	9,913	1
35.0	607.0	452	23,972	1
40.0	503.2	435	4,600	1
50.0	716.9	458	67,196	1
60.0	614.3	502	12,680	1



Model Parameters						
Model Layer	Resistivity (Ohm-m)	Resistivity Range	Thickness (m)	Thickness Range	Depth (m)	Depth Range
1	1000		1		1	
2	3200		5		6	
3	200		14		20	
4	1000					
5						
6						
7						
8						

Geoelectrical Model



EDAL DRILLING COMPANY LIMITED

1 NO. BOREHOLE DRILLING REPORT AT LMC CAMP, LUNSAR
GEOPHYS. REF. NO. A25/S2

JUNE, 2010

Edal Drilling Co. Ltd

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Borehole Drilling log

DAILY LOG FOR DRILLING SUPERVISION

CONTRACT		DATE	2/7/2010
LOCATION/CODE	WELL NO.: EDC/LMCBH-0	CONTRACTOR	EDAL DRILLING COMPANY LIMITED
TIME START OF WORKING HR	END OF WORKING HR	WEATHER	RAINNY/ CLOUDY /SUNNY
DATE 2/7/2010	3/7/2010	DURATION OF RAIN	
		COMMUNITY	LMC Camp, Lunsar
DEPTH OF HOLE(m)	65	GEOPHYSICS	
DEPTH CASED (m)	21	REF. POINT	A25/S2

LITHOLOGICAL BOUNDARIES AND SAMPLES OF FORMATION

DEPTH OF CONTACT ZONE		DRILLING PROCESS			DESCRIPTION OF FORMATION	YIELD	REMARKS (Drilling Methods Including Change of Bit)
DEPTH	SAMPLE	FROM	TO	SPEED (M/MIN)			
0	5	10:46	10:50	1.25	(0 -6) Red - brown latertic soil		(0 - 25)m Air Drilling With 10" DTH
5	10	10:59	11:05	0.625	(6 - 14) Light-yellowish clay soil		"
10	15	11:25	11:30	1	(14 - 25) Pink- brown completely weathered rock	Moist	"
15	20	13:54	14:10	0.3125	"	Wet	"
20	25	9:09	9:24	0.3333	"	H20	(22 - 65)m Air Drilling with 6.5" DTH
25	30	9:28	9:46	0.2778	(25 - 40)m Ash- gray moderately weathered rock	"	"
30	35	9:49	10:06	0.2941	"	"	"
35	40	10:09	10:25	0.3125	"	"	"
40	45	10:29	10:44	0.3333	(40 - 65)m Gray slightly- fresh crystalline rock	1.5L/S	"
45	50	10:46	11:05	0.231	"	1.5L/S	"
50	55	11:09	11:37	0.1786	"	1.7L/S	"
55	60	11:41	12:10	0.1724	"	1.4L/S	
60	65	12:15	12:44	0.1699	"	1.3L/S	
		Ph	Static Water Level:		AQUIFER ZONE(S):		

Borehole Drilling Record

Geophysics ref.No. **A25/S2**	Edal Drilling Company Limited 49 waterloo Street Sierra Leone , Freetown			BH status:	**Successful** X **Dry**
	BOREHOLE RECORD				
Community	LMC 'S Camp, Lunsar	BH ref. No.	EDC/LMCBH-03	Nat. grid ref.	
Drilling contractor	EDAL	Drill rig	Super DTH	Method	AIR
Drilling start date	1/7/2010	Compl. date	3/7/2010	Operator	RAJU
TEST PUMPING		Date:	19/07/2010	Top of screen *	m
Dynamic WL *	m	Pump type		Static WL *	m
Static WL *	m	Pumping rate (Q)	m³/h	Potential drawdown	m
Drawdown (s)	m	Duration	18 h	Potential yield	m³/h
* Levels to ground level datum		Specific capacity (Q/s)	m³/h/m	Depth of borehole *	65 m

BI' SIZE & TYPE	PROFILE	TIME/ DEPTH M/MIN	WATER ZONES CUMULATIVE Q (l/min)	WELL DIAGRAM with STATIC AND DYNAMIC WATER LEVELS
10" DTH	Red-brown lateritic soil (0–5)			Concrete Sanitary Seal
	Light-yellowish clay soil (5–15)			Gravel Pack
	Pink-brown completely weathered rock (15–25)			
6.5" DTH	Ash -gray moderately weathered rock (25–40)			4" uPVC Screen Pipe
	Grsy slightly weathered -fresh rock (40–65)			4" uPVC Plain Pipe Bottom Plug Seal

EDAL DRILLING COMPANY LIMITED

BOREHOLE DEVELOPMENT FORM

PROJECT: LMC

Date: 3rd July, 2010

Community: LMC Camp, Lunsar

District:

Geophysics Ref. No. A25/S2

Depth (m): 65

Static Water Level (m): ———

Tot time of Developmt: 2Hrs

Time		Position of pipe BGL (m)	Yield (l/m)	Pressure (bar)	Observations
From	To				
09 : 49	10 :19	6 0	85	220	Very dirty water with sediments flushed out
09 :19	11 :49	63	85	220	Clean and clear water flushed out

Edal Drilling Co. Ltd

AQUIFER DATA SHEET

Community: LCM Camp, Lunsar

Date: 21/07/2010

Geophys. Ref. No. A25/S2

Tested by: Obeng

Borehole No.

Height of datum above ground level (m): 0.6

Borehole depth (m): 65

Static level below datum (m): 3.99

Pump setting (m): 47

DISCHARGE						RECOVERY		
Time (hr)	Time (min)	Water level Below datum (m)	Draw down (m)	Discharge rate(l/s)	Observation	Time (hr)	Water level Below datum	Draw down(m)
	0	3.99	0				20.16	16.17
	1	5.02	1.03				17.77	13.78
	2	6.31	2.32				17.26	13.27
	3	7.21	3.22	1.91			16.66	12.67
	4	7.27	3.28				16.14	12.15
	5	7.34	3.35				15.69	11.7
	6	7.42	3.43				15.21	11.22
	7	7.53	3.54				14.72	10.73
	8	7.69	3.7				14.25	10.26
	9	7.81	3.82				14.04	10.05
	10	7.93	3.94	1.44			13.88	9.89
	12	8.17	4.18				13.46	9.47
	14	8.31	4.32				13.13	9.14
	15	8.38	4.39				12.94	8.95
	20	8.57	4.58	1.14			12.62	8.63
	25	8.76	4.77				12.57	8.58
	30	8.96	4.97				12.44	8.45
	35	9.14	5.15				12.27	8.28
	40	9.35	5.36				12.18	8.19
	45	9.56	5.57				12.09	8.10
	50	9.74	5.75				12.00	8.01
	55	9.92	5.93				11.89	7.90
	60	10.01	6.02				11.78	7.79
	70	10.29	6.3				11.51	7.58