TAMOVIC NIGERIA LIMITED

Site Location	Test Point	Depth of Penetration in (mm)	No. of blows (N)	Relative Density	Angle of Shearing Resistance (o)	Allowable Approximate Bearing Capacity (KN/sqm)	Recommended
Gaskiya Local Government Area - Zaria		000 - 300	20	Medium	30-35	66.6	Recommended BC = 250 KN/m2
	1	301 - 600	119	Very Dense	40-45	396.3	
		000 - 300	23	Medium	30-35	76.6	
	2	301 - 500	142	Very Dense	>45	472.9	
					@550mm Average BC =	253.1	
Saada Primary School Makarfi Local Government Area		000 - 300	43	Dense	35-40	143.2	Recommended BC = 120 KN/m2
	1	301 - 600	110	Very Dense	>45	110.0	
		000 - 300	39	Dense	35-40	129.9	
		301 - 600	28	Medium	30-35	93.2	
	2	601 - 900	14	Medium	30-35	46.6	
		901 - 1200	36	Dense	35-40	119.9	
		1201 - 1500	126	Very Dense	>45	630.0	
					@1050mm Average BC =	181.8	
Gangarida, Ikara Local Government Area		000 - 300	42	Dense	35-40	139.9	Recommended BC = 100 KN/m2
		301 - 600	65	Very Dense	40-45	216.5	
	1	601 - 1000	89	Very Dense	>45	296.4	
		901 - 1200	61	Very Dense	40-45	203.1	
		1201 - 1500	64	Very Dense	40-45	213.1	
		000 - 300	34	Dense	35-40	113.2	
		301 - 600	36	Dense	35-40	119.9	
		601 - 900	51	Dense	35-40	169.8	
	2	901 - 1200	33	Dense	35-40	110.9	
		1201 - 1500	30	Dense	35-40	99.9	
		1501 - 1800	35	Dense	35-40	116.6	
		1801 - 2000	19	Medium	30-35	95.0	
					@1750mm Average BC =	157.9	
Dawakin Bassa, Local Government Area - Kaduna		000 - 300	36	Dense	35-40	119.9	Recommended BC = 100 KN/m2
		301 - 600	30	Medium	30-35	99.9	
		601 - 1000	13	Medium	30-35	43.3	
	1	901 - 1200	17	Medium	30-35	56.6	
		1201 - 1500	30	Medium	30-35	99.9	
		1501 - 1800	34	Dense	35-40	113.2	
		1801 - 2000	20	Dense	30-35	100.0	
		000 - 300	58	Very Dense	40-45	193.1	
		301 - 600	40	Dense	35-40	133.2	
		601 - 900	87	Very Dense	>45	289.7	
	2	901 - 1200	85	Very Dense	>45	283.1	
		1201 - 1600	112	Very Dense	>45	280.0	
					@1800mm Average BC =	151.0	

TAMOVIC NIGERIA LIMITED

Site Location	Test Point	Depth of Penetration in (mm)	No. of blows (N)	Relative Density	Angle of Shearing Resistance (o)	Allowable Approximate Bearing Capacity (KN/sqm)	Recommended
Zunkwa Local Government Area Zagon-Kataf Kaduna		000 - 300	56	Very Dense	40-45	186.5	Recommended BC = 300 KN/m2
	1	301 - 600	41	Dense	35-40	136.5	
		601 - 900	113	Very Dense	>45	376.3	
		000 - 200	169	Very Dense	>45	845.0	
	2	>200	Refusal	Very Dense	>45	>845	
					@500mm Average BC >	300.0	
Zambina-Kaura Local Government Area - Kaduna		000 - 300	25	Medium	30-35	83.3	Recommended BC = 70 KN/m2
		301 - 600	32	Dense	35-40	106.6	
		601 - 1000	21	Medium	30-35	69.9	
	1	901 - 1200	20	Medium	30-35	66.6	
		1201 - 1500	29	Medium	30-35	96.6	
		1501 - 1800	25	Medium	30-35	83.3	
		1801 - 2000	16	Medium	30-35	80.0	
		000 - 300	27	Medium	30-35	89.9	
		301 - 600	15	Medium	30-35	50.0	
		601 - 900	16	Medium	30-35	53.3	
	2	901 - 1200	23	Medium	30-35	76.6	
		1201 - 1500	17	Medium	30-35	56.6	
		1501 - 1800	29	Medium	30-35	96.6	
		1801 - 2000	13	Medium	30-35	65.0	
					@2000mm Average BC =	76.7	
Maigamo-Lere Local Government Area - Kaduna		000 - 300	48	Dense	35-40	159.8	Recommended BC = 80 KN/m2
		301 - 600	35	Dense	35-40	116.6	
		601 - 1000	19	Medium	30-35	63.3	
	1	901 - 1200	20	Medium	30-35	66.6	
		1201 - 1500	24	Medium	30-35	79.9	
		1501 - 1800	27	Medium	30-35	89.9	
		1801 - 2000	17	Medium	30-35	85.0	
		000 - 300	52	Very Dense	40-45	173.2	
		301 - 600	13	Medium	30-35	43.3	
		601 - 900	12	Medium	30-35	40.0	
	2	901 - 1200	20	Medium	30-35	66.6	
		1201 - 1500	28	Medium	30-35	93.2	
		1501 - 1600	19	Medium	30-35	190.0	
					@1800mm Average BC =	97.5	

TAMOVIC NIGERIA LIMITED

Site Location	Test Point	Depth of Penetration in (mm)	No. of blows (N)	Relative Density	Angle of Shearing Resistance (o)	Allowable Approximate Bearing Capacity (KN/sqm)	Recommended
Kushe-Kagargo Local Government Area Kaduna		000 - 300	44	Dense	35-40	146.5	Recommended BC = 120 KN/m2
		301 - 600	36	Dense	35-40	119.9	
		601 - 1000	29	Medium	30-35	96.6	
	1	901 - 1200	37	Dense	30-35	123.2	
		1201 - 1500	46	Dense	30-35	153.2	
		000 - 300	26	Medium	30-35	86.6	
		301 - 600	20	Medium	30-35	66.6	
		601 - 900	26	Medium	30-35	86.6	
	2	901 - 1200	33	Dense	35-40	109.9	
		1201 - 1500	37	Dense	35-40	123.2	
				@1500mm Average BC =		111.2	
Asso-Jemma Local Government Area - Kaduna		000 - 300	26	Medium	30-35	86.6	Recommended BC = 80 KN/m2
		301 - 600	19	Medium	30-35	63.3	
		601 - 1000	33	Medium	30-35	109.9	
	1	901 - 1200	30	Medium	30-35	99.9	
		1201 - 1500	17	Medium	30-35	56.6	
		1501 - 1800	29	Medium	30-35	96.6	
		1801 - 2000	12	Medium	30-35	60.0	
		000 - 300	66	Very Dense	40-45	219.8	
		301 - 600	62	Very Dense	40-45	206.5	
	2	601 - 900	32	Dense	35-40	106.6	
		901 - 1200	16	Medium	30-35	53.3	
		1201 - 1500	36	Dense	35-40	119.9	
				@1750mm Average BC =		106.6	
Sabon-Gida-Kaura Local Government Area Kaduna		000 - 300	88	Very Dense	40-45	293.0	Recommended BC = 140 KN/m2
		301 - 600	25	Medium	30-35	83.3	
	1	601 - 1000	23	Medium	30-35	76.6	
		901 - 1200	39	Dense	35-40	129.9	
		1201 - 1500	43	Dense	35-40	143.2	
		000 - 300	52	Dense	35-40	173.2	
		301 - 600	19	Medium	30-35	63.3	
	2	601 - 900	17	Medium	30-35	56.6	
		901 - 1200	18	Medium	30-35	59.9	
		1201 - 1500	50	Dense	35-40	166.5	
		1501 - 1600	18	Dense	35-40	180.0	
				@1500mm Average BC =		129.6	

TAMOVIC NIGERIA LIMITED

Site Location	Test Point	Depth of Penetration in (mm)	No. of blows (N)	Relative Density	Angle of Shearing Resistance (o)	Allowable Approximate Bearing Capacity (KN/sqm)	Recommended
Murchia-Sabon Gari Local Government Area - Kaduna		000 - 300	26	Medium	30-35	86.6	Recommended BC = 60 KN/m2
		301 - 600	12	Medium	30-35	40.0	
	1	601 - 1000	10	Medium	30-35	33.3	
		901 - 1200	15	Medium	30-35	50.0	
		1201 - 1500	29	Medium	30-35	96.6	
		000 - 300	56	Very Dense	40-45	186.5	
		301 - 600	13	Medium	30-35	43.3	
	2	601 - 900	11	Medium	30-35	36.6	
		901 - 1200	10	Medium	30-35	33.3	
		1201 - 1500	18	Medium	30-35	59.9	
				@1500mm Average BC =		66.6	

PROJECT - **BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF ADDITIONAL CLASSROOMS FOR PRIMARY SCHOOLS IN THE FEDERAL REPUBLIC OF NIGERIA**

CONTRACT – **GROUND SOUNDING INVESTIGATION VERTICAL ELECTRIC SOUNDING**

IN

KADUNA STATE, PLATEAU STATE, AND NIGER STATE

BY

TAMOVIC NIGERIA LIMITED

TABLE OF CONTENTS

1.0 GENERAL INTRODUCTION

Yachiyo Engineering Company Limited under the JICA Assisted Water Supply Scheme of the Federal Government UBE programme awarded the contract to carry out geophysical survey in various towns and villages of Kaduna, Plateau and Niger States respectively to Messrs. Tamovic Nigeria Limited.

The scope of the job was to access the groundwater potential of the various schools with a view of drilling productive boreholes for the benefiting communities.

The investigation was carried between 20th of November to 7th of December, 2003. The report covers the geophysical investigation for ground water carried out for successful execution of borehole construction projects in 20 towns and villages of the 3 States.

During the investigation, a total number of 40 Vertical Electrical Sounding (VES) stations with the current electrode spacing (AB/2) equal or less than 400m were established in the entire investigation areas. The variation in distances depend on availability of space. In most of the surveyed site, it also becomes difficult to get AB/2 = 400 on a straight line as a result of wares and obstruction, hence, the limitation to AB/2 = 240 – 300.

Collection/Collation of geophysical data was carried out with particular reference to those relating to geological and hydrogeological aspects. The final analysis of all the acquired data may reveal suitable area(s) for sitting productive boreholes.

1.1 TOPOGRAPHY AND DRAINAGE

The general topography of the project sites matched with the geologic setting of the areas in relation to the geology of the North - Central Nigeria. It is flat with a few highly undulated high lands. Massive rock exposures were seen dotting some areas.

Streams in this areas depend on rainfall for their recharge and thus, the volume of water in these streams vary considerably with the quantity of rainwater.

1.2 CLIMATE AND VEGETATION

The geographical location of the project areas lies within the wet and dry climates according to Thornwaites classification method. The vegetation falls within the guinea Savannah which is influenced by two main seasons, viz; raining and dry seasons. The rainy season starts from the month of April and ends in October. It is characterized by flooding of the flood plains, high infiltration and aquifer recharge as well as high humidity and low evapotranspiration. Annual rainfall range from 1200mm to 1400mm and because of the moderate rainfall, there is high vegetation cover especially where farming activities are not intensive. Dry season on the other hand starts from the month of November and ends in March. During these times, temperatres are high except during the time of harmattan, when there is low relative humidity and high evapotranspiration.

2.0 GENERAL GEOLOGY

Geologically, Nigeria lies within the mobile belt which is roughly located between the older West Africa craton and Central African and Congo craton. This area is occupied by crystalline and sedimentary rocks. The crystalline igneous and Metamorphic rocks are collectively known in Nigeria as the Basement Complex which covers about 50% of the total area and the Sedimentary rocks occupy the remaining 50% of the surface area of the Country and rest directively on the Basement Complex.

The middle Niger Basin is the area occupied by the "Nupe Sandstone" which is a gently down warped trough. About 70% of the basin is covered by flat-lying to gently rolling plains. The buried Precambrian to probably palacozoic basement complex is directly overlain by rounded to sub-rounded coarse conglomerates, clay-sand-pebble admixtures.

Field observation from the ground survey confirmed that the site lies wholly on the basement complex rocks. Basement complex rocks comprises migmatites, granites, quartzites, gneisses etc, which in their unaltered forms are regarded as aquiclude and of no hydrogeological importance. Deformation and weathering has given the rock units some secondary porosity and can be regarded as aquifer. Two aquifer units are associated with the basement complex as follows:-

a. Weathered unconsolidated materials on the top residual soil. This is usually unconfined or semi-confined.

b. Partly weathered and fractured basement which is normally below the first aquifer unit

Aquifer potential of the weathered unconsolidated materials or the over burden depend on its thickness or level of weathering or fracturation. This implies that groundwater occurrence in the basement area is localized and have no regional spread. Geophysical survey is therefore necessary to delineate the fractured zones and areas of high overburden thickness.

3.0 GEOPHYSICAL INVESTIGATION

One of the most relevant geophysical survey method for ground water prospecting in the basement complex areas is the Electro-resistivity method.

i. Vertical Electro-Resistivity Sounding (VES), also known as depth probe was employed using schlumberger configuration to know the water bearing in a typical (VES) probe.

This techniques work on the theory that variation in conductivity of the subsurface alters the form of the current flow within the sub-surface thus affecting the distribution of the electrical potential. The more the electrodes are farther apart the deeper the current penetration. Detailed theory and mathematical formulae have been skipped in this report.

3.1 FIELD PROCEDURE FOR VES DATA COLLECTION

Field procedure involved passing artificial current through the current electrode into the sub-surface and measuring the potential difference through the potential electrodes. ABEM terrameter SAS 300 with all the accessories was used for the entire survey. Schlumberger configuration was employed and the maximum current electrode spread was between 240 - 410m and with this spread, penetration depth of 120 - 200m was achieved.

Vertical Electro-resistivity Sounding (VES), was carried out in 40 locations and were marked as (VES 01 – 02) in each location.

3.2 INTERPRETATIONS

Preliminary interpretation of all sounding points was done in the field by the method of curve matching. The field curve was compared with a set of standard master curves. The ancillary point method was particularly used in the curve matching technique.

Further interpretation was done by the use of a personal computer. The computer programme (OFFIX) used is based on the concept presented by Merrick (1977). The purpose is to computerize a layered earth model whose theoretical apparent resistivity curve agrees as closely as possible (in a least square sense) with the field curve, Mooney 1975). It may be applied to a selection of field configuration such as schlumberger, Wenner and bipole-dipole arrays.

3.2.1 QUANTITATIVE AND QUALITATIVE INTERPRETATIONS

The interpreted VES results are shown on Tables 1, 2 & 3. Field data are attached as appendix 1. The Computer plotted resistivity type curves with their geo-electric models as (Appendix 2).

TABLE 1: INTERPRETED VES RESULTS FROM KADUNA STATE

SN	VES NO	ρ_1 (ohm-m)	h_1(m)	ρ_2 (ohm-m)	h_2(m)	ρ_3 (ohm-m	h_3(m)	ρ_4 (ohm-m	H (m)
1.	K45 01 K45 02	104.3 173.8	6.09 2.05	122.6 84.48	1.92 4.65	2151.3 633.3	- -	- -	8.01 6.70
2	k5 01 k5 02	11.82 80.32	2.94 1.19	30.60 13.45	27.95 1.58	27.70 65.32	10.81 26.47	2117 5279	41.71 29.25
3	K44 01 k44 02	30.24 82.55	5.14 1.50	28.72 7.46	28.05 1.08	46283 282.0	- 2.93	- 16006	33.19 10.02
4	k30 01 k30 02	182.1 163.7	3.34 2.54	12.02 677.7	7.06 1.48	5828 7.56	- 4.28	- 112278	10.41 8.32
5	k17 01 k17 02	2494 4547	9.72 1.72	172.8 14006	67.59 4.05	3129 158	- 26.78	- 3003	77.31 34.23
6	k13 01 k13 02	1110.4 1125	1.11 1.60	167.3 82.69	17.48 3.70	46.14 171.3	20.95 68.07	1622 148.6	39.54 73.38
7	k49 01 k49 02	389.4 581.3	2.76 5.36	994 1763	3.87 2.45	506 61.16	15.89 5.89	14230 203102	22.53 13.71

TABLE 2: INTERPRETED VES RESULTS FROM PLATEAU STATE

SN	VES NO	ρ_1 (ohm-m)	h_1(m)	ρ_2 (ohm-m)	h_2(m)	ρ_3 (ohm-m	h_3(m)	ρ_4 (ohm-m	H (m)
1.	P1 01 P1 02	1588.5 1474.7	4.94 8.43	66.74 79.65	24.47 39.85	361 1014	- -	- -	29.42 48.29
2	P30 01 P30 02	260.2 338.3	3.07 4.95	233.8 136.6	18.63 5.73	77.57 49.39	36.75 10.20	3599 11285	58.46 20.89
3	P22 01 P22 02	86.53 106.2	2.50 1.84	52.0 67.53	3.85 5.72	306.7 56.97	4.52 11.19	26024 8384	10.88 18.75
4	P2 01 P2 02	524.7 245.2	1.17 5.49	204.7 13.47	5.06 5.14	17.88 90.03	7.71 3.08	- 2235	13.94 13.94
5	P39 01 P39 02	210.4 250.8	1.26 3.20	792.3 5685	2.10 2.39	150.1 41.95	1.2 2.37	- 6281	5.34 7.98
6	P8 01 P8 02	189.3 276.0	2.22 2.99	8.37 14.62	4.78 7.45	94.63 154.3	2.98 4.33	141523 92758	9.99 15.27

TABLE 3: INTERPRETED VES RESULTS IN NIGER STATE

SN	VES NO	ρ_1 (ohm-m)	h_1(m)	ρ_2 (ohm-m)	h_2(m)	ρ_3 (ohm-m	h_3(m)	ρ_4 (ohm-m	h_4(m)	H (m)
1.	N5 01 N5 02	41.92 258.6	2.67 1.30	326.4 121.7	33.28 2.89	32194 710.4	- 30.48	- 4568	-	35.96 34.69
2	N12 01 N12 02	97.04 101.6	7.25 2.51	61.93 95.22	12.07 3.14	31.44 54.22	11.03 25.89	2450 267.4	- -	30.36 31.55
3	N7 01 N7 02	110.7 33.09	1.16 0.606	998.6 1713	3.23 3.27	67.97 33.28	11.64 7.49	1875 33364	- -	16.05 11.37
4	N13 01 N13 02	211.7 386.7	2.77 1.75	1073.4 213.6	1.42 8.00	5.45 106.5	2.28 24.41	86427 578.5	- -	6.48 34.17
5	N16 01 N16 02	125.4 123.8	1.38 4.70	36.76 37.50	2.76 6.77	1131.2 13856	20.29 -	265.5 -	16.62 -	41.07 11.48
6	N19 01 N19 02	66.05 174	2.17 2.30	26.72 502.5	10.21 5.04	2408 34.57	- 14.71	- 1585.4	- -	12.38 22.07
7	N11 01 N11 02	273.4 2355	1.86 0.946	1354 205.1	2.67 12.33	70.13 47.67	6.47 8.64	466905 89364	-	11.01 21.9

4.0 DISCUSSION OF RESULTS

From table 1, column II shows the total thickness (H) of the weathered section in all the sounding points after interpretation. Four to five different layers were deciphered in most of the sounding points while in some cases three distinct layers were deciphered.

The first layer in all cases is either lateritic or sandy top soil. This is followed by sandy clay second layer before the coarse sandy third layer. The coarse sand grades into gravelly/pegmaitite form of layer in most of the sounding points.

5.0 RECOMMENDATION

The interpreted results of the geo-electrical survey together with the basic surface geological information and hydro-geological field reconnaissance revealed subsurface conditions that can easily lead to comprehensive deduction of promising locations for borehole drilling.

The field data for the 40 sounding station (Appendix 1) have been interpreted and the results in Table 1, 2 and 3 for Kaduna, Plateau

and Niger State respectively. The computer plotted curves with their geo-electric section is presented as Appendix II.

Therefore the recommended borehole locations are as follows:-

5.1 **RECOMMENDATION FOR KADUNA STATE**

Zangonaya
The recommended depth to be drilled is 50 ± 10 metre at K45 02

Cangarida
K5 01 is recommended to a depth of 45 ± 10m

Kaya
K44 01 is recommended for drilling to a depth of 50 - 55m.

Dawaki Bassa
K30 02 is recommended for drilling to a depth of 55 - 60m.

Zambina
The recommended depth is 50 ± 10m at K17 01.

Safiogida
K13 01 is recommended for drilling to a depth of 60 ± 10m.

Kushe
K49 02 is recommended to a drilling depth of 50m.

5.2 **RECOMMENDATION FOR PLATEAU STATE**

Kwakwi Station LEA
The recommended site is at P1 01 to a depth of 50m.

LEA Maijuju
P30 01 is recommended for drilling to a depth of 70 - 80m.

Gyangyang LEA
The recommended depth of drilling is 60m at sounding point P22 02

Angwa Hausawa
P2 01 is recommended for drilling to a depth of 50m.

Pilot Central Bashar
P39 02 is recommended for drilling to a depth of 50m. The yield here may be very low due to the high resistivity value recorded.

Kuka Primary School
P8 02 is recommended to be drilled to a depth of 70 – 80m.

5.3 **RECOMMENDATION FOR NIGER STATE**

Bakin – Iku
The yield may be low as there is no clear evidence of fracturing in the bedrock. However, if any attempt must be made N5 01 is recommended to a depth of 70m.

Etsu Nuhu
The recommended point is N12 02, to a depth of 60 – 70m.

Ibrahim Tako
Recommended point is N7 02 to a depth of 70 – 80m.

Makafu UBE Primary School
Recommended point is N13 02 to a depth of 70 – 80m.

Karaya Nomadic
Recommended point is N16 01 to a depth of 80 – 85m.

Bangi Central
The recommended depth of drilling is 60 – 65m at sounding point N19 02.

Rafi Mota
Low yield is also anticipated, but for a handpump borehole, the overburden water may likely sustain the borehole, hence, N11 02 is recommended for drilling to a depth of 55 – 60m.