GROUNDWATER EVALUATION OF SHENDAM TOWN AND ENVIRONS USING ELECTRICAL RESISTIVITY SOUNDING METHOD

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ABSTRACT

A geo-electrical resistivity survey was carried out around Shendam and its environs to determine the geo-electric sequences and its groundwater potential. A total of twenty eight (28) VES were carried out with current electrode or AB/2 spread ranging from 1.5 to 215 m and potential electrode (MN/2) ranging from 0.5 to 14 m. The interpretation was carried out using the WinResist computer software. The geo-electric sounding interpretation revealed three major geo-electric sequences, which consist of Topsoil, from 0 to 2.9 m, weathered basement (clay/clayey sands/sandy clays) from 2.9 to 50m and bedrock with varying thicknesses from 7 to 33 m and is characterised by resistivity value range categories of 14 to 1497 ohm-m, 10 to 50 ohm-m, and ≥ 1500 ohm-m. The geo-electric parameters from the geo-electric sounding interpretations enabled the preparation of geo-electric sections, isopach of weathered overburden and bedrock relief maps, which assisted in the production of groundwater potential map of the area. This study is expected to form a baseline guide for groundwater exploration and development for Shendam Town and its immediate environs.

Keywords: Shendam town, Hydrogeoelectric investigation, Geoelectric sequence, Groundwater potential.

INTRODUCTION

Shendam Town is the headquarters of Shendam Local Government of Plateau State and is strategically important because of its agricultural and economic activities.

The public water supply to the Town is from the Shendam dam, which supplies water through network of pipes, which were constructed about four decades ago. Access to good and adequate water supply over the last decade has become very difficult due to the rapid increased in population with little or no provision for water supply expansion. The water scheme supplies only the central old town settlement which constitutes only a quarter of the town population

Therefore, to cope with the ever increasing demand for potable water, the need for an expanded groundwater supply scheme (centralized or decentralized) has become cogent and urgent to augment the main water supply scheme and also to meet the needs of the immediate town outskirt settlement.

The study presents the results of geophysical (geo-electric) investigations for determination of groundwater potential of Shendam town and its immediate environs.Location and Physiography Shendam Town is situated on longitude 9.51^0 to 9.56^0E and latitude 8.86^0 to 8.89^0N. The climate is controlled by the position across the path of the seasonal migration of the inter tropical convergence zone (Ajaegbu, et al., 1992). The wet season begins around May and ends in September and the dry spell (Hamattan) begin from October and ends around April. The amount and distribution of rainfall, temperature, relative humidity and wind follows these two seasons.

The vegetation cover is typically guinea savannah and characterized by secondary vegetation of scattered trees, shrubs and grass savannah. Generally, the vegetation has been tempered by human activities mainly for agricultural purposes.

The main drainage networks around the area rise from the north eastern high grounds and flows southwards (Fig.1). The rivers are ephemeral in character.

GEOLOGY AND HYDROGEOLOGY

Shendam Town and environs lies within the crystalline Basement Complex environs of the Jos Plateau and consist mainly of Older Granite Migmatite Gneisses (Macleod et al., 1971).

Hydrogeologically, the study area falls within the crystalline basement complex and are classified as poor groundwater regions (du Preeze and Berber, 1965). However, despite the relatively poor hydrogeological characteristics of these basement rocks, they have remained a very important source of water supply for more than half of the population of rural areas in Nigeria (Offodile, 2002).

The weathered regoliths usually consist mainly of clays, sands, sandy clays and where generally thick, constitute the aquifers (Offodile, 1983). Highly tectonised basement rocks with incipient fractures, joints and folds are potential groundwater storage and flow zones and significant in basement surveys for groundwater development (Omosuyi et al., 2000).

The wells and boreholes drilled around the study area and within the immediate outskirt either by private or public agencies like the Millennium Development Goals, UNICEF, UNDP and State Rural Water Supply and Sanitation Agency is within the average depth of 20 to 30m, with yield ranging from 0.3 to 1.5 litres/seconds.

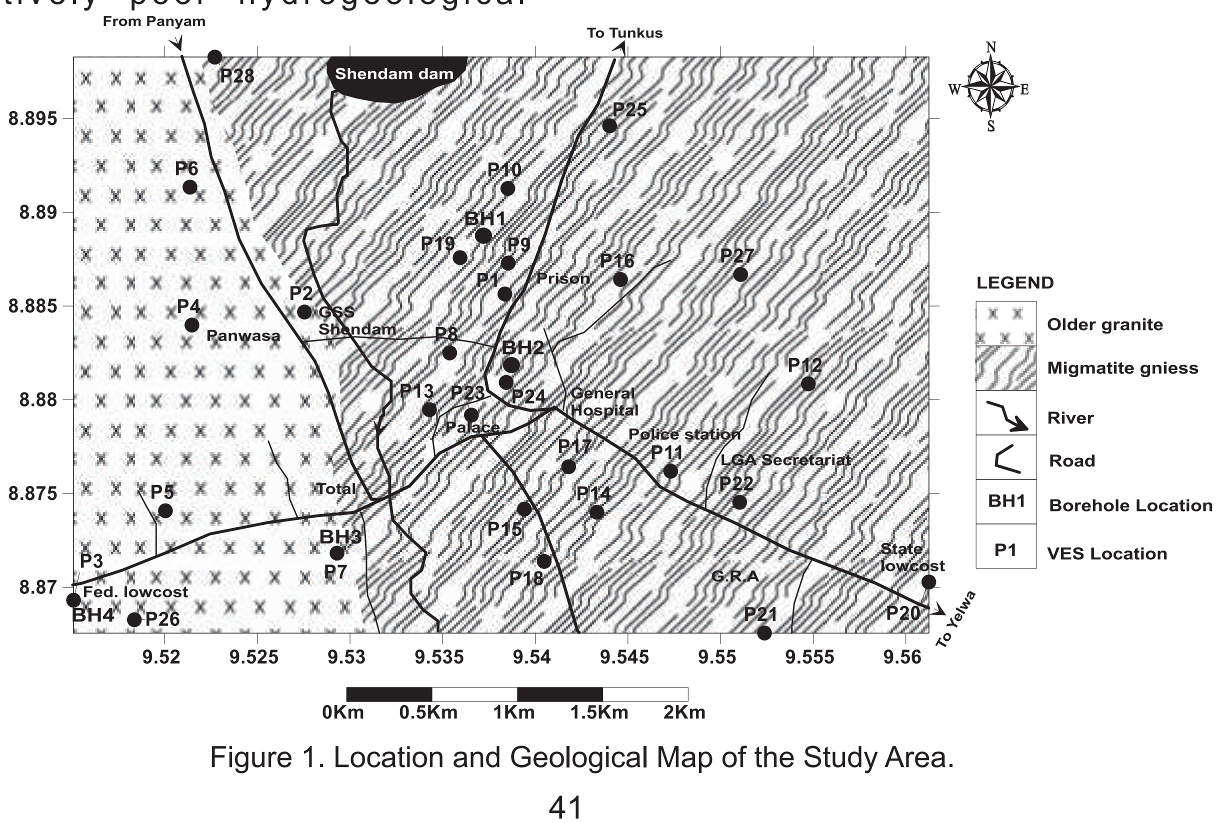
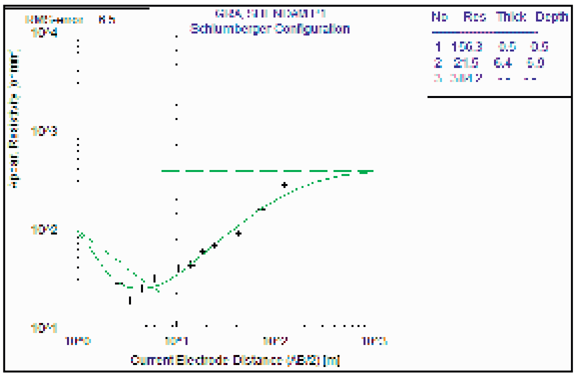


Figure 1. Location and Geological Map of the Study Area.

METHOD OF STUDY

The study involved the geo-electrical resistivity measurement across the entire town where accessibility is available (Figure 1). The survey was conducted using the Schlumberger array (vertical electrical sounding) technique. The current electrode (AB/2) and potential electrode separations was varied from 1.5 to 215 m and from 0.5 to 14 m respectively. The field readings were carried out using Allied Ohmega earth resistivity meter. A total of 28 VES were conducted around the area. The field data was interpreted using a computer simulated program, WinResist version 1.0 (Vander Velpen, 1998, 2004).



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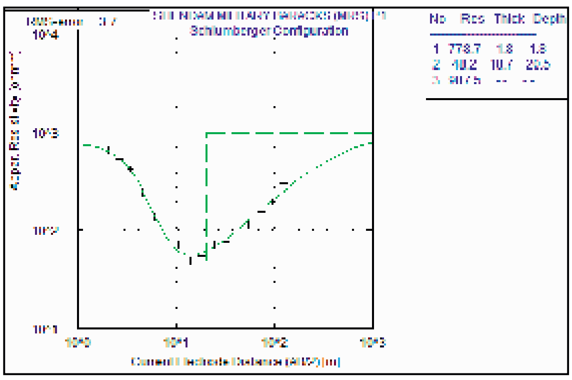

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Figure 2. Typical VES curves in the study area.

Table 1: Summary of VES Interpretation

VES No.	Depth (m) d1/d2----dn	Resistivity (ohm-m) I1/ I2---- In	Curve type
1	1.7/18.52/8	317/35/279	H
2	1.2/8.2/19.9/8	14/8/160/864	H
3	2.0/23.9/8	332/21/793	H
4	1.6/9.4/8	1060/42/722	H
5	1.3/31.5/8	477/26/148	QH
6	2.9/10.9/8	163/12/664	HA
7	2.0/10.2/8	258/28/380	H
8	1.3/7.0/8	53/10/1043	HA
9	1.5/16.7/8	392/52/1921	HA
10	1.7/19.6/8	592/67/1006	HA
11	2.0/19/ 8	380/23/479	H
12	0.7/17/8	639/29/339	QH
13	1.1/10.3/8	415/16/1344	HA
14	10.7/8	20/566	A
15	1.2/10.1/8	94/8/751	HA
16	1.7/28.2/8	1057/40/576	QH
17	0.5/19.3/8	280/29/754	HA
18	0.8/15/8	896/32/300	QH
19	1.2/8.2/8	1497/10.7/1040	H
20	1.9/19.2/8	303/46/360	H
21	0.6/7.6/8	339/33/415	HA
22	0.6/10/8	30/23/4345	HA
23	1.3/15/8	391/29/512	H
24	0.9/4.6/14/8	440/73.3/126/50/622	HKA
25	1.9/28/8	61/5/222	H
26	0.7/5.5/15.4/21/8	213/90/458/560/501	HA
27	1.3/10.7/42.8/8	277/300/125/701	QH
28	2.1/11.8/17.9/8	501/152/231/1093.7	H

The VES locations co-ordinates were determine in the field by the use of Garmin Etrex 12 channel global positioning system. The maps were produced using Surfer 11 GIS program.

RESULTS AND DISCUSSION

Geo-electric Resistivity Soundings and Interpretations

The computer model interpretation of the 28 VES are as shown in Table 1. Figure 2 shows the typical VES curves within the study area:

A correlation of the VES model curves interpretation with borehole logs in the study area showed a good correlation of 80-90 % (Figure 3).

Geo-electric Sequence

The VES data interpretation delineates three major lithologic/geologic units: the topsoil or lateritic layer, the weathered layer and the bedrock. The geo-electric sections were taken in three directions NW-SE, N-S and W-S (Figure 4) in an attempt to correlate the geo-electric sequence across the study area. The resistivity in the topsoil ranges from 14 to 1497 ohm-m. The layer thickness is variable from 0.5 to 2.9 m with 80 % preponderance in the 0.2 to 3.1 m thickness (Table 1).

The second layer is weathered layer (sands, sandy clay and clays) and its resistivity varies from 10 to 50 ohm-m (Table 1 & Figure 3), the layer thickness varies from 7-33 m. This layer is characterized by low to moderate resistivity. The low resistivity characteristics in this type of layers are usually, and most-likely, controlled by its water saturation (Omosuyi et al., 2003.

The third layer or bedrock is characterized by high resistivity values from > 1500 ohm-m to infinity. However, VES Nos. P7, P21 and P24 (Fig.4) revealed values of < 50 to 168 ohm-m within the bedrock region and could be attributed to fracturing/shearing of the basement and possibly saturation by water (Olayinka & Olorunfemi, 1992 Longpia et al., 2013).

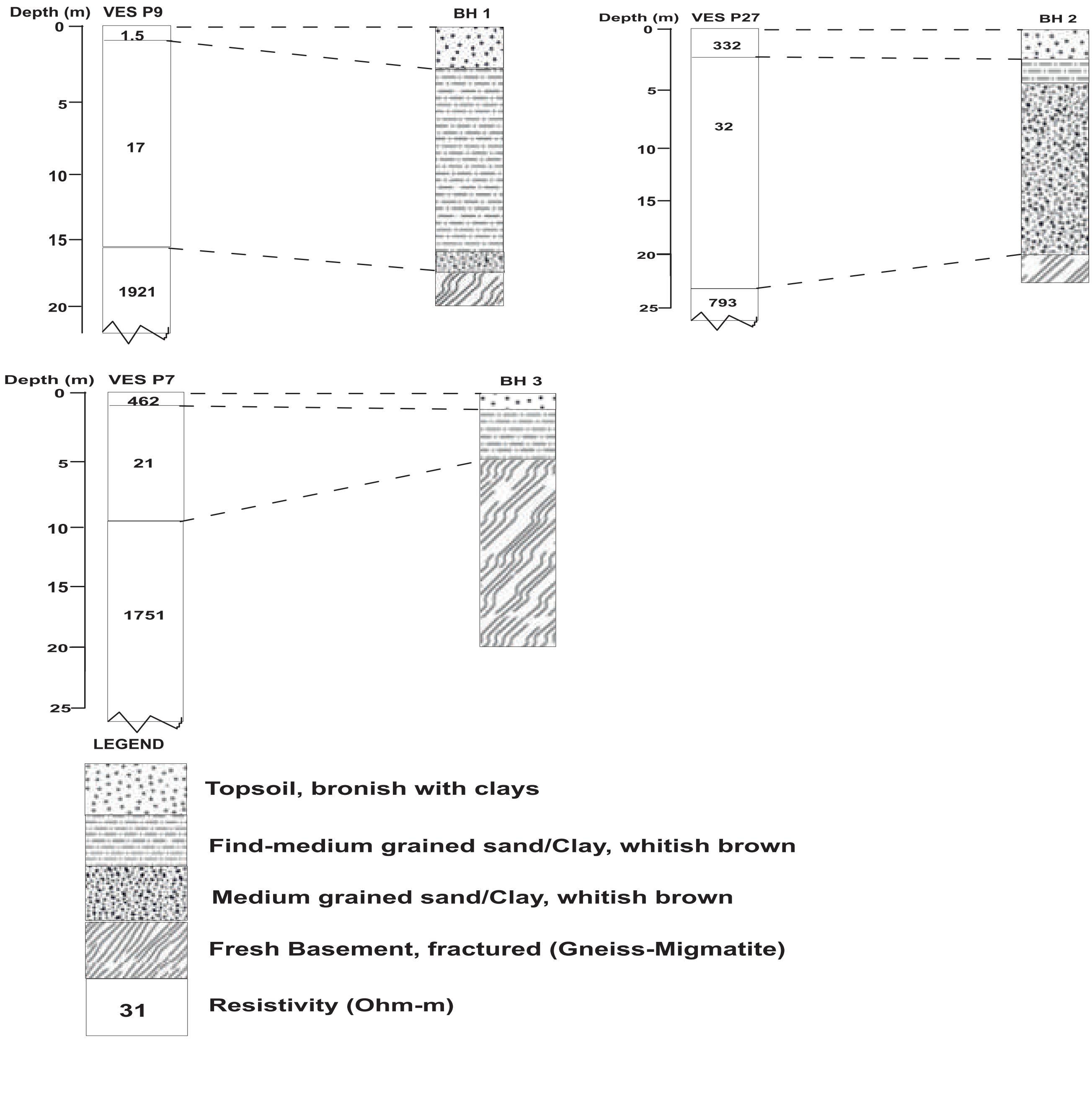

Figure 3. VES-borehole correlation

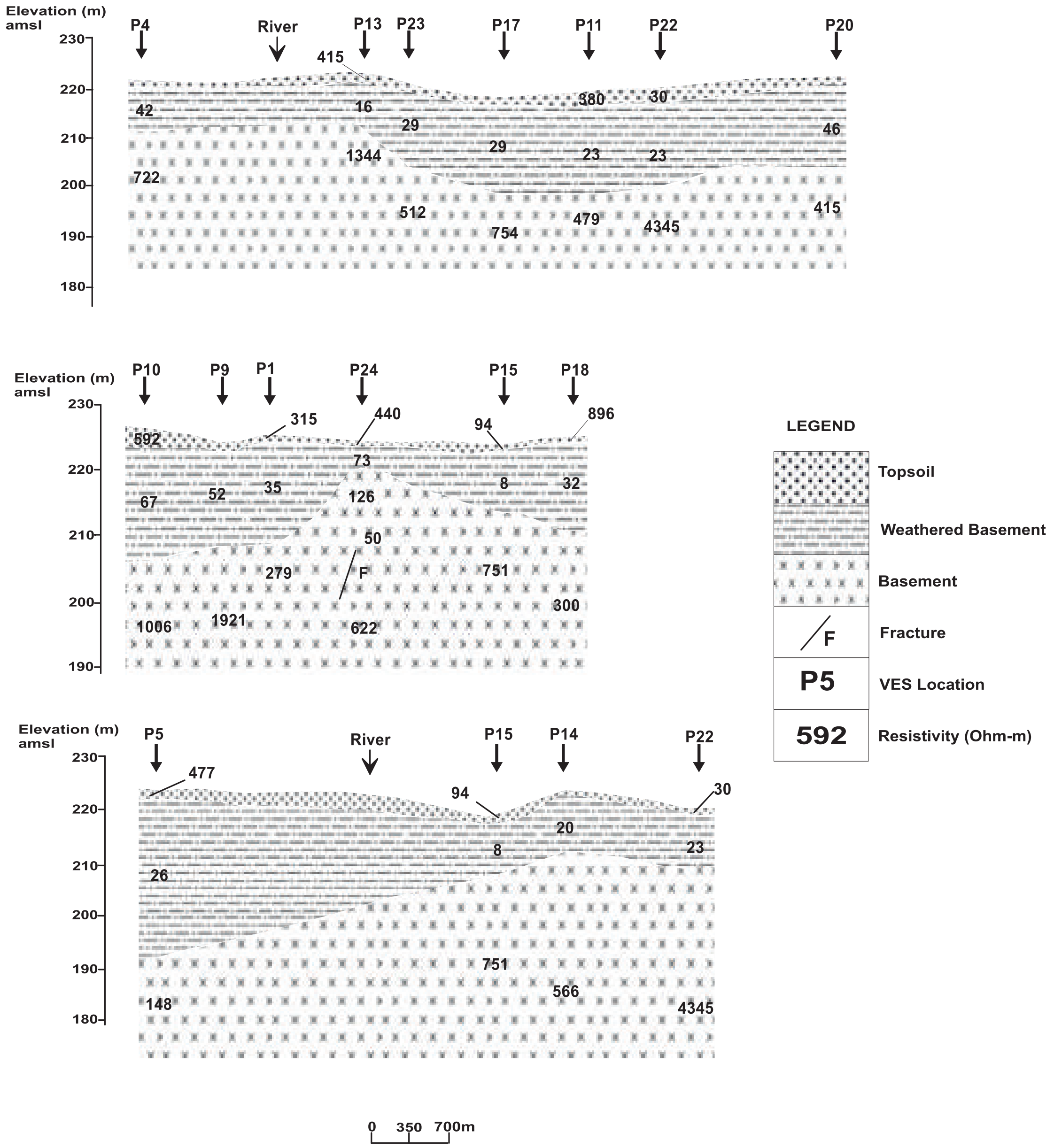

Figure 4. Geo-electric Section in S-N, SW-NE and NW-SE Directions.

Isopach Map of the Overburden

Figure 5 is a contour of the overburden layer thickness over the VES stations conducted

in the study area. The overburden thickness is variable from 8 to 30 m. The area with overburden thickness of 20 to 30 m are generally limited in extend and are isolated. These areas are on VES P5, P8, P16, P25 and P27.

Related geophysical studies in basement terrain revealed that areas with relatively thick overburden have good groundwater potential (Dan-Hassan and Olorunfemi, 1991). Therefore, these identified and isolated areas in the study are the high potential and priority areas for groundwater development.

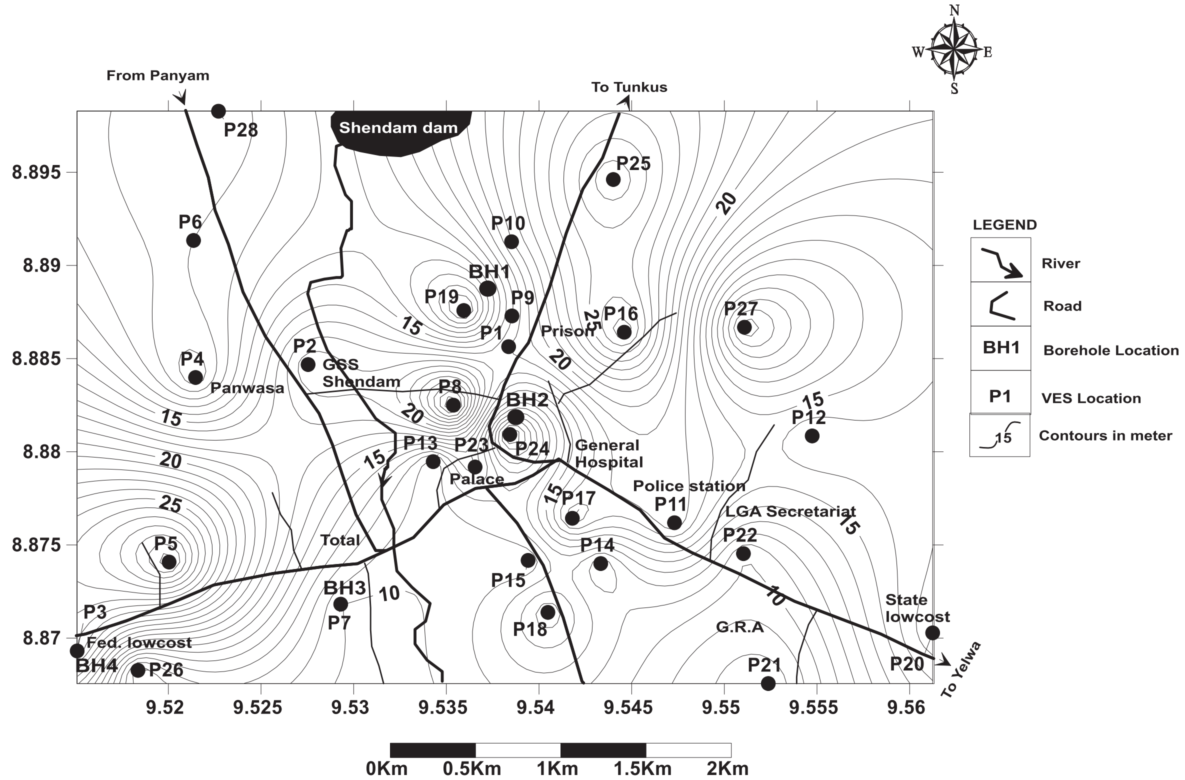

Figure 5. Isopach Map of the Study Area.

Basement Relief Map

Basement relief map (Figure 4) is the contour of elevation of the bedrock over the established VES stations. The map essentially reveals the topography of the bedrock across the study area. Generally, bedrock reliefs are characterized by depressions and ridges and are identifiable. The significance of basement relief in hydrogeologic studies as established in several other studies are groundwater collecting troughs (Olorunfemi & Okhue, 1992, Bala & Ike 2001). Apparently, the zones of depression (D) and ridges (R) are characterized by thick and thin overburden respectively. Therefore, the depressions coupled with thick overburden cover are priority zones for groundwater resources development (Figure 5 and figure 6)

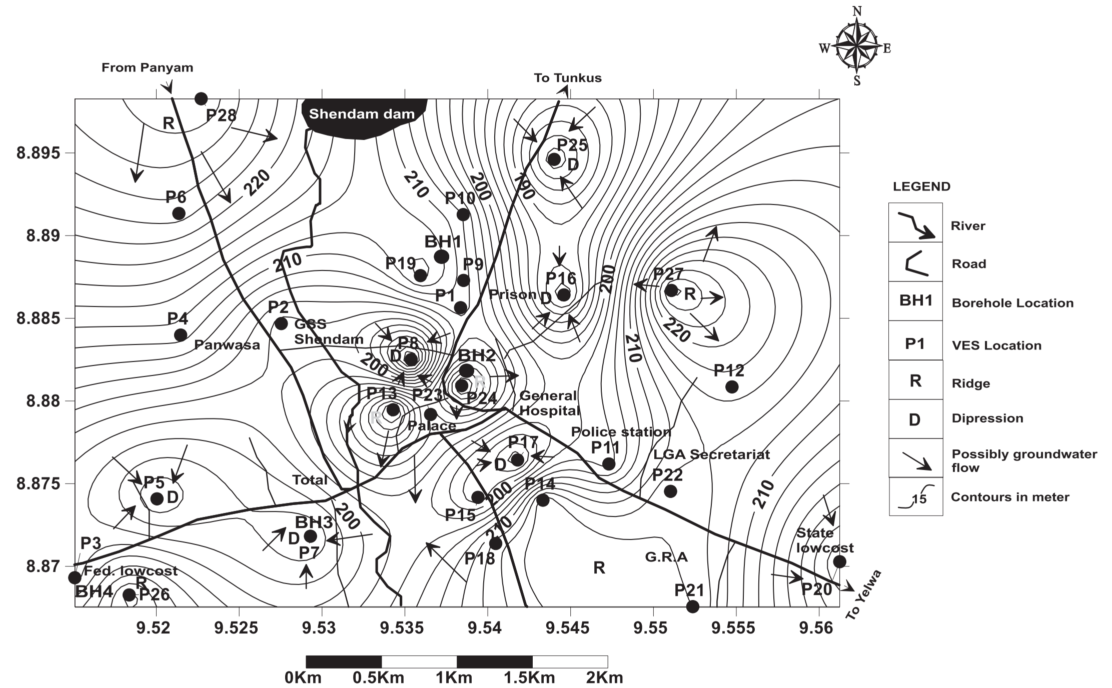

Figure 6. Bedrock Relief/Groundwater flow of the Study Area.

Groundwater Potential Evaluation. Significance of the weathered Overburden & Bedrock Relief

In crystalline basement hydrogeology, weathered overburden thickness with constituent material type, bedrock relief and structural settings are main factors in groundwater resources evaluation (Omosuyi et al., 2003). The regolith and weathered basement layer are characterized by low to moderate resistivity, which may suggest saturation by water, constitutes the main aquifer (Balogun et al., 2000). Delineating relief/structures of the bedrock is very significant and hence the cardinal objective in basement groundwater surveys. Depressions filled with overburden materials and fractured bedrock constitute reliable and sustainable aquifer unit (Balogun et al., 2000; Omosuyi et al., 2003).

In the groundwater potential assessment isopach maps, bedrock relief/structural maps and geo-electric sections prepared from the geo-electric parameters of the geo-electric sounding interpretations were used. The maps and sections revealed thick overburden, which generally overlies the areas with depressions. The groundwater potential characterization map (Figure 7) of the study area is produced based on aquifer geo-electric parameters established in terms of lateral and vertical extends. For this purpose, groundwater potential classification areas with overburden thickness of 20-30 m, 15-20 m and <15 m are classified as high, medium and low potentials, respectively.

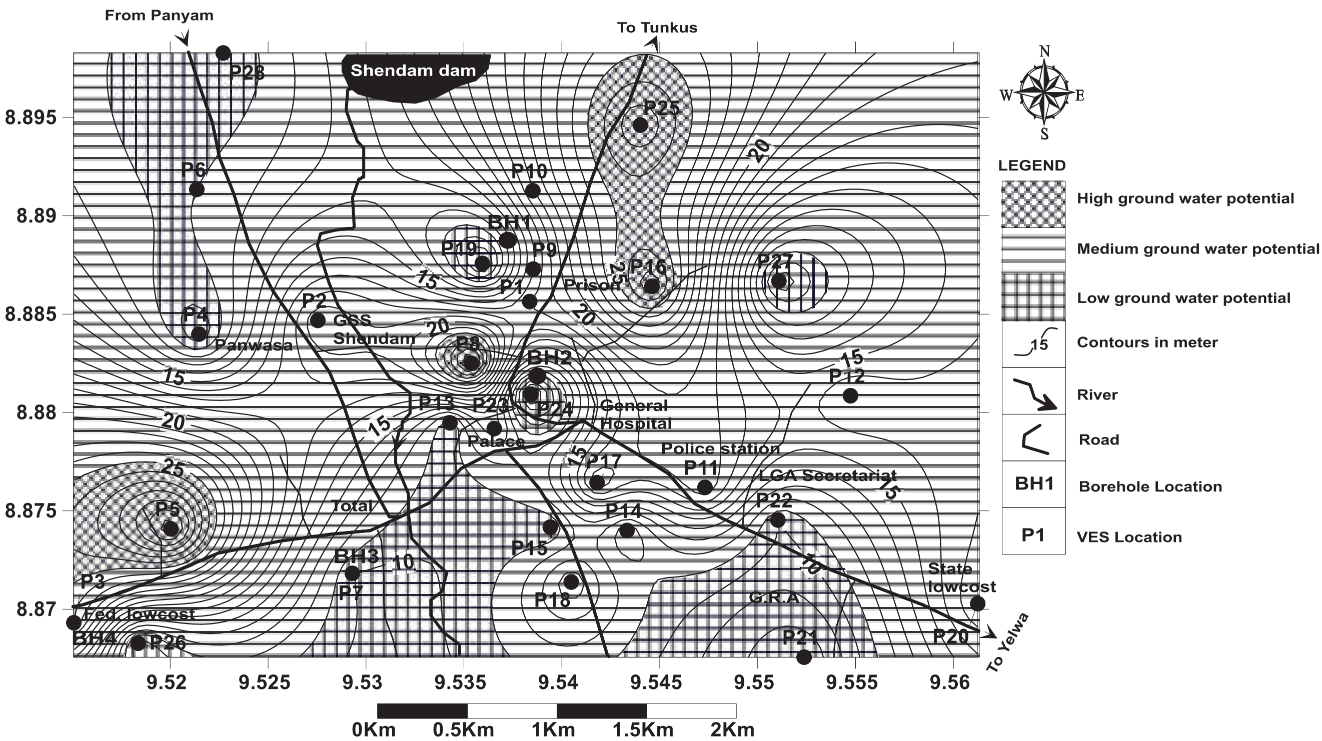

Figure 7. Groundwater Potential Map of the Study Area.

CONCLUSION

The VES interpretations as obtained from the overall survey were used to produce relevant maps (Isopach/basement relief) and sections (geoelectric and lithologic sections) with geologic/hydrogeologic significance. The findings of the study are as follows:

i. Thick overburden areas fall within the bedrock depressions and are zones apparently with high groundwater potential.

ii. Zones with thick overburden and bedrock fractures interconnected are the reliable and sustainable aquifers

iii. The result is meant to be used as a general guide for groundwater resources development within the study area. However, the high groundwater resources potential zones are recommended for development as decentralized mini schemes for the areas where they occur.

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