Shallow Geoelectric Sounding Application For Earthing Purpose In AL Diwaniayah Electric East- Substation Site/ South of Iraq.

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Abstract

Electrical Resistivity Method involving Shallow Vertical Electrical Sounding (VES) was carried out in four (4)locations in AL Diwaniyah Electrical East- Substation site, AL Diwaniyah province, South of Iraq, using the Wenner (α) array configuration with the aim of determining the conductive zone for establishing suitable earthling medium in the area. At each location, vertical electrical soundings with total spread of AB/3 = 30m were occupied with 'a' varying from 1m to 10 m. The acquired field data has been interpreted by Edwards formula, ID IPI2win software and Inverse slope methods. The result reveals between three (4) to five (5) geo-electric zones which comprise of essentially silty clay with fully water saturation condition . The resistivity ranges between 1.05 -7.3 ohm-m and thickness is 2.5 m . The curve types obtained from the study area were QH and QQ types. The results reveal the points characterized by a reasonable silty clay thickness that may serve the purpose of a good earthling medium /protective soil material in some of the locations.

Keywords: Wenner Configuration, Earthling medium and Clay horizon.

تطبيق التحري العمودي الجيوكهربائي الضحل لاغراض التاريض في موقع محطة الثانوية الكهربائية شرق الديوانية في الديوانية / جنوب العراق.

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الملخص

أجري مسح للمقاومة النوعية باستخدام الجس الكهربائي العمودي (VES) لأربعة مواقع في محطة كهرباء شرق الديوانية في محافظة الديوانية ,جنوب العراق، مستخدما طريقة النشر Wenner (α) لأجراء دراسة لتحديد الطبقة الموصلة كهربائيا والملائمة كأساس لتنصيب التأريض في موقع المحطة. كان اكبر طول النشر هو 30م و كانت حدود الفاصلة بين اقطاب النشر (1–10) م لكل موقع .فسرت المعلومات المسح بطرق معادلة ادوارد ,برنامج (IPI2win) و طريقة مقلوب الميل. أظهرت النتائج ان بوجود اربعة الى خمسة قواطع المتكون من طين و غرين المتشبعة كليا بالماء.و كان حدود قيمة المقاومية الكهربائية بين 1,05–7,3 اوم. م وسمكه 2,5م. منحنيات المقامية الكهربائية شملت انواع (QH) و (QQ). كما بينت النتائج ان هنالك نقاط تتصف بامتلاكها طبقة طينية و غرينية ذو سمك معتبر التي تفيد كمادة اساسية لأنشاء التأرض في المنطقة.

الكلمات الدالة: نشر فنر، وسط التأريض و نطاق الطين.

1. Introduction

It has been planned to set up Earthing system at East Al Diwaniyah Substation which provides Al Diwaniyah province fig.1 with electricity power ,that system is essential not only to provide the protection of people working in the vicinity of earthed facilities and equipments against danger of electric shock but to maintain proper function of electrical system. The process of transferring the immediate discharge of the electrical energy directly to the earth by the help of the low resistance wire is known as the electrical Earthing [1]. The electrical Earthing is done by connecting the non-current carrying part of the equipment or neutral of supply system to the ground.
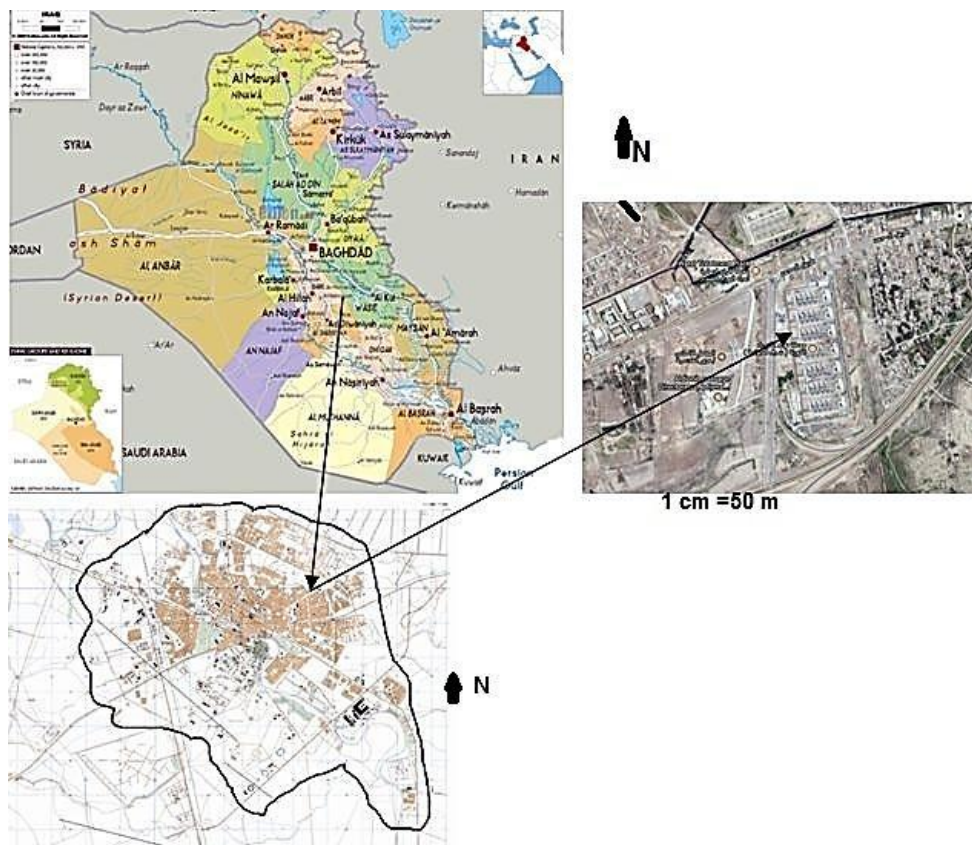

Fig. 1: map of the study area.

Soil resistivity is applied to determine the resistance or performance of an electrical grounding system. Electrical Resistivity geophysical method has been applied to determine the subsurface electrical resistivity for many purposes, Shallow Vertical Electrical Sounding (VES) using the Wenner array configuration with the aim of establishing suitable earthling

medium in the study area [2], vertical electrical sounding to delineate geoelectric units location for cathodic protection necessary for construction of civil engineering harbor project [3], Schlumberger vertical electrical sounding (VES) to determined corrosivity of the of the soil along a pipeline Route [4], assessment of corrosives probability and cathodic protection potentials of the subsurface layers to ascertaining the suitability of the subsoil information for the installation of gas pipelines [5]. Kareem conducted vertical electric sounding (VES) in Kirkuk substation to determine the conductive subsurface soil for establish Earthing system [6].

The present study aim is to delineating the subsurface geologic layers and determining the nature of the identified layers, the thickness of the low resistivity layer of the geoelectric layers within the study area, to estimate the depth extent to the top of the low resistivity layer and its suitability as an electrical system Earthling medium.

2. Geological setting

AL Diwaniyah city is situated in Mespotamia plain, the plain is built up [7] mostly by deltaic, lacustrine and fluviatile sediments connected mutually by many facial variations and replacing each other both horizontally and vertically. The top part of the sequence is usually lithologically very monotonous being composed of fluviatile flood silts with strong aolian admixture. The presence of marine sediments had been proved in this area too and therefore the existence of some brackish - estuarine deposits might be supposed as well. The thickness of the sediments reaches about 150-200 m. The Substation site is semi- leveled area generally covered by silty clay soil rounded by irrigation drainage channels in Eastern and Western south parts.

3. Material and Methodology

Four geoelectric Wenner(α) sounding points Fig. 2 (R1, R2.R3, R4) is carried out in the Substation site of total area 40000 m^2 with different spacing (a) (1, 2.5, 5 ,7.5 ,10)m, using ABEM SAS 300 Terrameter instrument. The apparent resistivity values were calculated and plotted against electrode spacing and interpreted qualitatively and quantitatively by the computer software 1D IPI2WIN. The results of the curves (layer resistivities and thicknesses) were determined .To control the resistivity and depth or thickness ranges of the target layer, the acquired data also interpreted later by Edwards [8] Formula to determine the median

depth (Z_e =a *0.51) and the resistivity is given by (ρ=a2πR). Inverse slope also is applied upon the acquired field data, the spacing (a) of the measured electrodes is draw on (X) axis against the Four geoelectric Wenner(α) sounding points Fig. 2 (R1, R2.R3, R4) is carried out in the Substation site of total area 40000 m^2 with different spacing (a) (1, 2.5, 5 ,7.5 ,10)m, using ABEM SAS 300 Terrameter instrument. The apparent resistivity values were calculated and plotted against electrode spacing and interpreted qualitatively and quantitatively by the computer software 1D IPI2WIN. The results of the curves (layer resistivities and thicknesses) were determined. To control the resistivity and depth or thickness ranges of the target layer, the acquired data also interpreted later by Edwards [8] Formula to determine the median depth (Z_e =a *0.51) and the resistivity is given by (ρ=a2πR). Inverse slope also is applied upon the acquired field data, the spacing (a) of the measured electrodes is draw on (X) axis against the inverse of the corresponding resistance reading value in the field (1\R) in (Y) axis, the identified straight line segments of drawn curves inverse slope (ΔX/ΔY) which essentially reflects the resistivity condition of the subsurface , will give the resistivity each segment by of multiplication that slope by (2π), and The points of intercepts give the thickness of the various interfaces. The geophysical data are presented as Table, sections and curves.

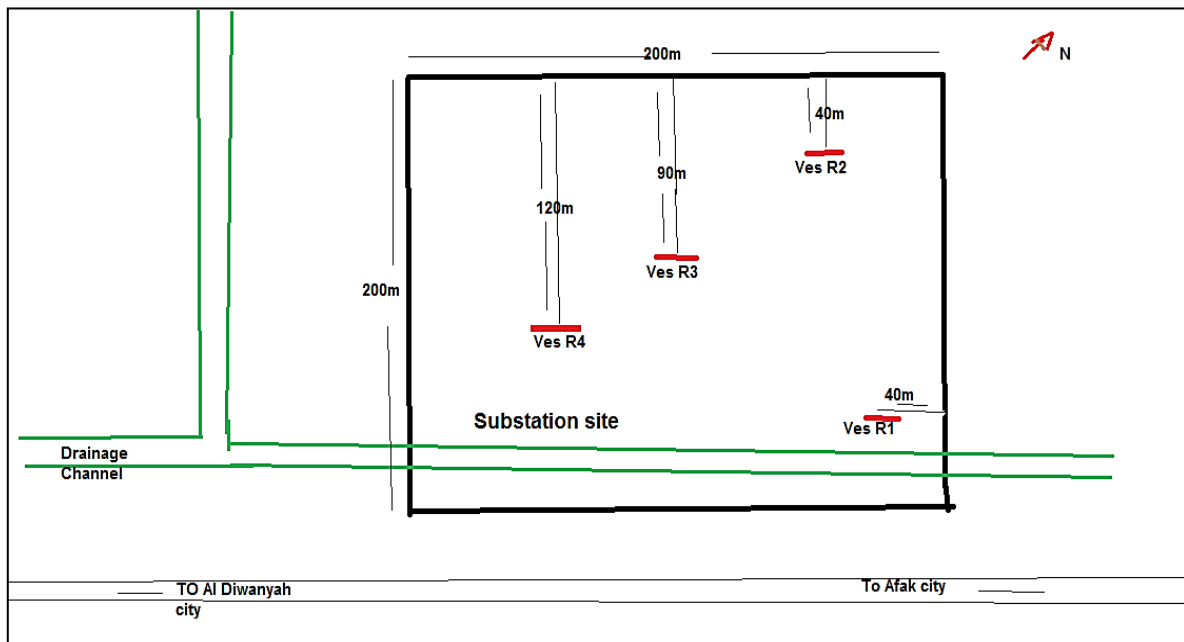**Fig. 2:** Substation site plan showing the Ves lines.

4. Results and Discussions

The sounding curves are essentially (QH) (R1,R2,R3) and (QQ) (R4) types with maximum five geoelectric layers Fig. 3. The (QH) type it indicates the relative high value resistivity in the top reflect the tope soil, following by reducing in the resistivity represents the high moisture of silty clay, then ending with the relatively higher value in the lower part of the curve, the (QQ) type indicates the of decreasing downward of the resistivity values which indicates continuation of that saturation condition for the same lithology.
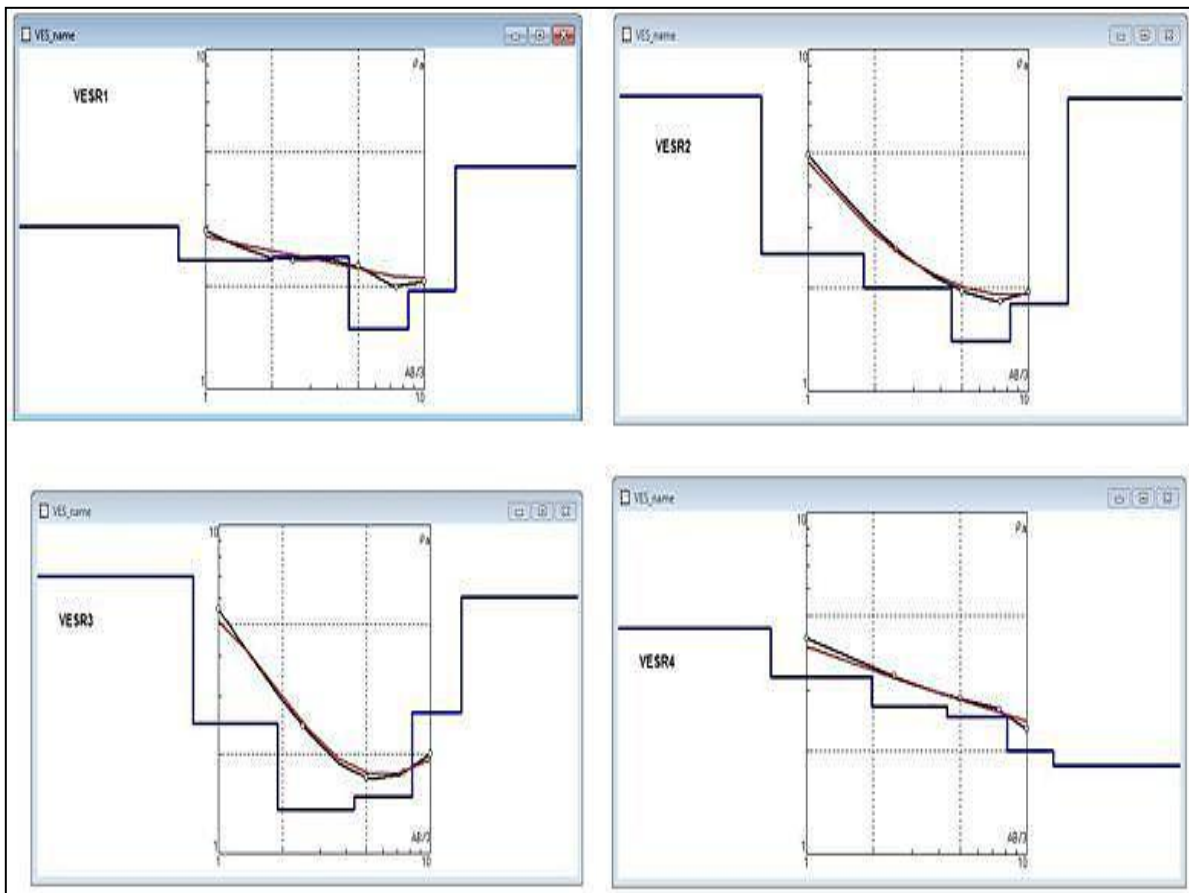

Fig. 3: the vertical electric soundings curves (R1,R2,R3,R4).

The pseudo-section Fig. 4 reveals this variations in the subsurface, it covers generally with low resistivity constituents, there are decreasing with the depth gradually up to bottom (R4) and with relative increasing for (R1, R2, R3), low resistivity amplitude essentially indicates silty clay water saturated zones.
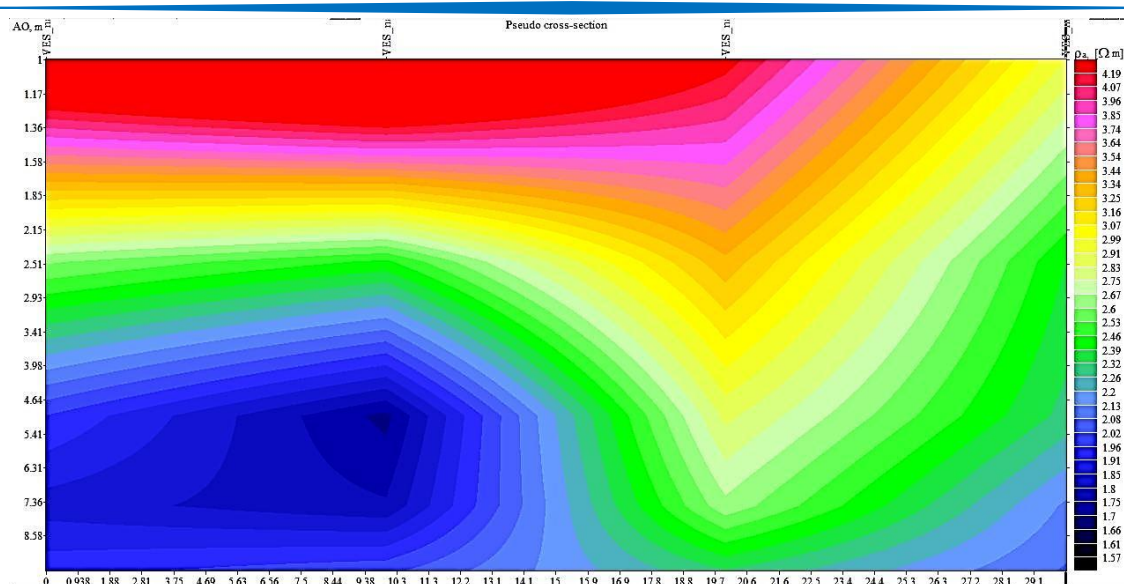
Fig. 4: Pseudosection of the study area.

One-dimensional (VES) data was carried out using an interactive inversion code IPI2Win. The depth variations are further highlighted in the Geoelectric section obtained from individual one-dimensional inversion of the sounding data carried out in the study area.

Table 1: The geoelectric interpretations results of the study site.

Station no	Edwards method result		Inverse slope method result			IPI2win software result		
	ρ(Ω.m)	Z_e(m)	ρ(Ω.m)	H(m)	d(m)	ρ(Ω.m)	H(m)	d(m)
R1	2.91	0.519	2.3	4.85	4.85	3	0.75	0.75
	2.35	1.29	1.5	2.6	7.45	2.39	1.27	2.02
	2.35	2.59	2.55			2.45	2.5	4.52
	1.93	3.89				1.5	3.9	8.42
	2.07	5.19				1.95	5.45	13.87
						4.45		
R2	4.91	0.519	2.6	5	5	7.3	0.6	0.6
	2.4	1.29	1.42	2.5	7.5	2.5	1.17	1.77
	2.04	2.59	2.7			2	2.68	4.45
	1.78	3.89				1.4	3.8	8.25
	1.94	5.19				1.8	6.65	14.9
						7.2		
R3	5.53	0.519	3.4	2.9	2.9	6.98	0.76	0.76
	2.44	1.29	1.05	2.5	5.4	2.5	1.14	1.9
	1.57	2.59	2.8			1.36	2.5	4.4
	1.93	3.89				1.5	3.8	8.2
	2	5.19				2.68	5.8	14
						6		
R4	4.27	0.519	4.2	1.9	1.9	4.58	0.69	0.69
	3.32	1.29	2.4	5.6	7.5	3.3	1.29	1.98
	2.85	2.59	1.57			2.7	2.37	4.35
	2.73	3.89				2.5	3.8	8.15
	2.32	5.19				2	5	13.15
						1.8		

The geoelectric section Fig. 5 reveals the distribution of different subzones resistivity and corresponded thickness. The computed section explained by five zones (layers) model, the top zone having resistivity of 3-7.3 ohm-m Table 1 and thickness of 0.6-0.76 m, this is followed by the zone having resistivity 2.39-3.3 ohm.m and thickness of1.14-1.29 m followed by zone having the resistivity of 1.36-2.7 ohm-m and a thickness of 2.37-2.68 m is underlain zone having a resistivity of 1.4-2.5 ohm-m and thickness of 3.8-3.9 m. Beyond this zone is the having the resistivity of 1.8-2.68 ohm-m and thickness of 5-6.65 m. The section is lasted with final zone of 1.8-7.2 ohm-m.
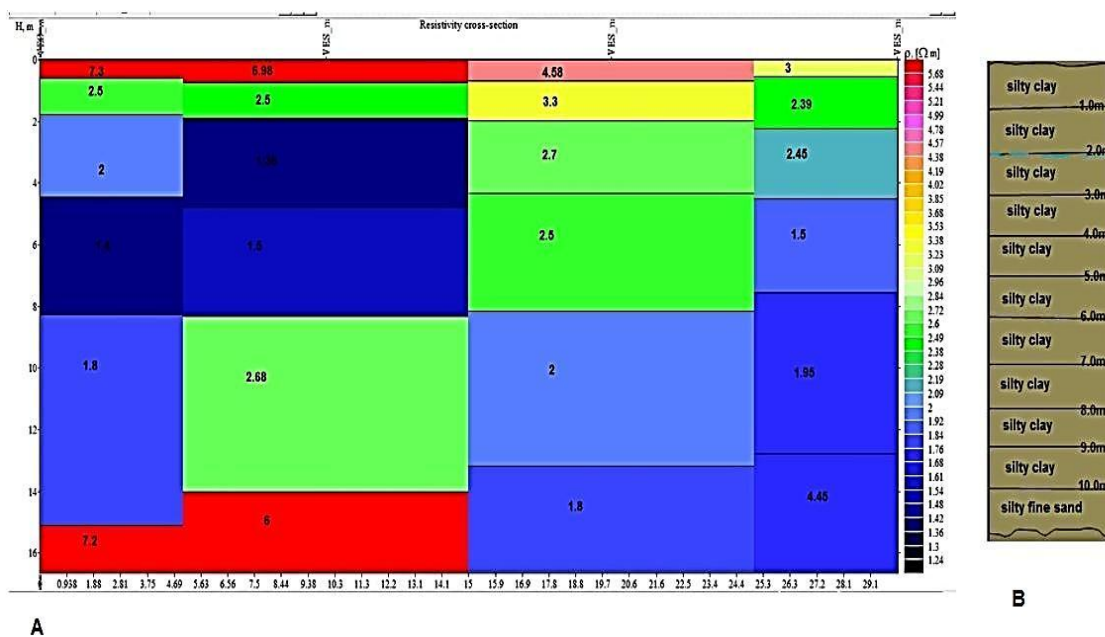

Fig. 5: Geoelectric section of the study area (A) and the drilled borehole log(B).

The available drilled borehole log Fig. 5 in the studied site shows that the subsurface has relatively homogeneous lithology, it is essentially compose of clayey silt with fully water saturation condition indicates that low variation resistivity values((1.36-7.2)ohm.m), as the site map Fig. 2 shows the Substation is located nearby many drained channels which assured of seepage process of the irrigation water explain that reduction in the resistivity values. The three interpreted method results suggest the table locates within the second zone which overlaid relative highly resistive tope zone, the borehole log denote that it is at (2.0) m depth.

The Inverse slope method curves Fig. 6 showed only three layers structure (zones) this might due to the equivalence principle in the electric resistivity method which combined

correlated resistivity values, but its curve shapes is comforting the geoelectric resistivity curve types, the minimum resistivity value is 1.05 ohm.m and maximum is 4.2 ohm.m which reflect the silty clay saturated subsurface composition.
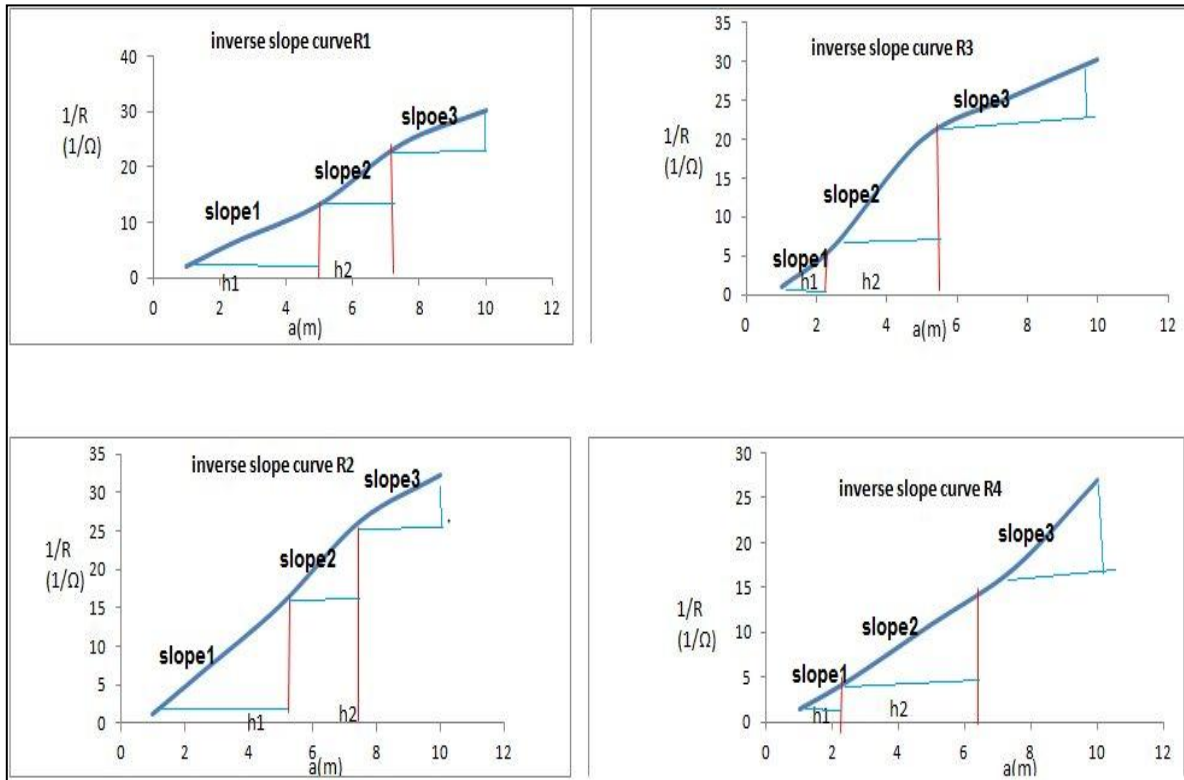

Fig. 6: Inverse slope curves (R1, R2, R3, R4).

The interpreted data (resistivity and depth)of the three applied methods are plotted to draw relations for comprehend the obvious picture about the Substation situation relates the dimension of the most conductive zone which is necessary to be the foundation for the Earthing system tools Fig. 7.
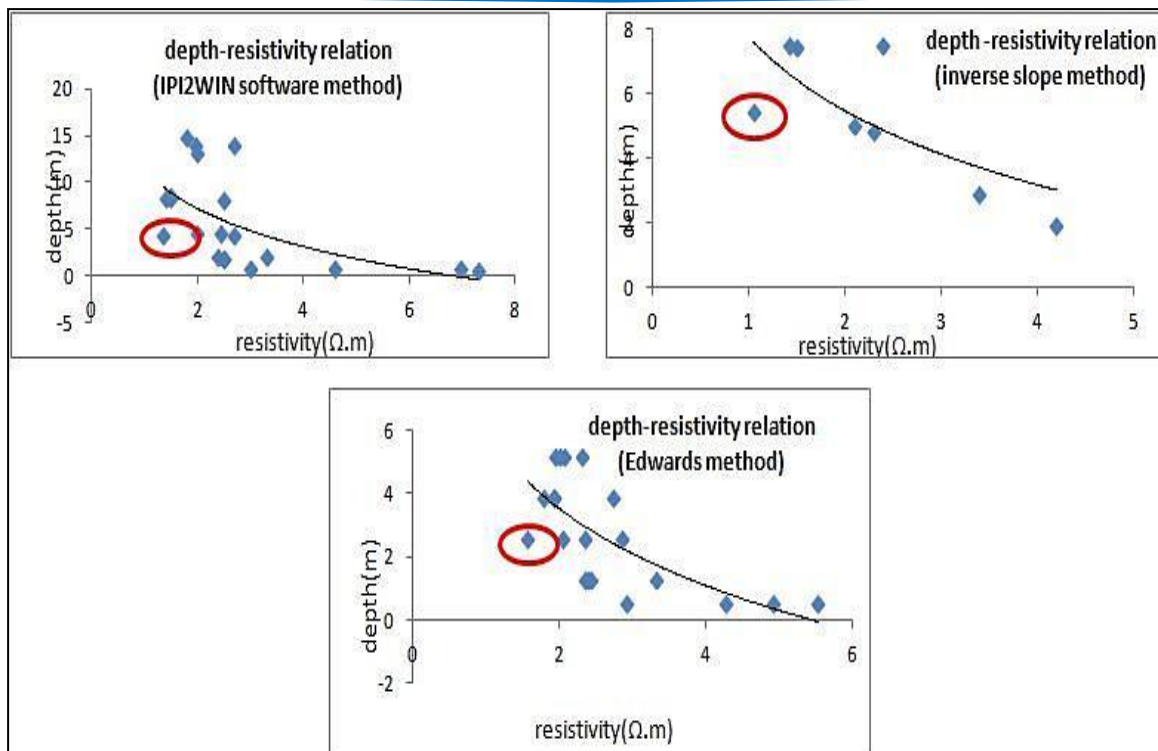
Fig. 7: The geoelectric interpreted depth-resistivity relations.

The three relation curves show the minimum and maximum resistivity and depth of the Substation site different subsurface zones , those curvse are in a goocorrelation, the encircle points represents the most conductive zone with its own thickness and depth which suitable as foundation for Earthing system.

5. Conclusion

Geoelectrical investigation using Wenner(α) sounding electrical resistivity method carried out in the Electric Substation site, subsurface is delineated four to five geologic zones composed of essentially saturated silty clay zones characterized generally by low electrical resistivity (1.05-7.3)ohm.m. Despite the whole subsurface soils has excellent performance as of low resistance materials but the extreme conductive zone is determined which is suitable to set up Earthing system located in Ves (R3)station ,its resistivity is (1.05-1.57) ohm.m, the thickness is (2.5)m, the median depth is (2.59)m, the depth to top is (1.9-2.9)m, the maximum depth to bottom is(4.4-5.5)m.

References

[1] Swapnil.G.S.,Nitin R. B., **"Desgin of Earthing System for H/V AC Substation"**, International Journal of Advances Engineering & Technology, 6(6), 2597 (2014).

[2] Akinlalu A.A., Bawallah M., Adiat K.A.N., Ajayi-Gidi, I.O. and Osanyingbemi B. **" The Use of Vertical Electrical Sounding (VES) for Earthling Protection Design"**, International Journal of Research Studies in Science, Engineering and Technology, 2(4), 1 (2015).

[3] Mohamaden M. I., **"Electric Resistivity Investigation at Nuweiba Harbour Gulf of Aqaba, south Sinai, Egypt"**, Egyptian Journal of Aquatic Research 31(1), 58 (2005).

[4] Kenneth S. O., Godwin O., **"Predicting Soil Corrosivity along a Pipeline Route in the Niger Delta Basin Using Geoelectrical Method: Implications for Corrosion Control"**, Scientific Reseach Publishing Engineering Journal, 5, 237 (2013).

[5] Adeoti L ., Ishola K. S., Adesanya O., **"Subsurface Investigation Using Electrical Resistivity and Standard Penetration Test as Guide for Gas Pipeline Installation in Lekki Peninsula"**, Lagos Electronic Journal of Geotechnical Engineering, 18, 2791 (2013).

[6] Weaam M. Karem, **"Application Electrical Resistivity Sounding for Earthing purpose in Kirkuk Transformation Station (33/132kv)/Kirkuk"**, Procceding of First Geological Conference Kirkuk University /College of Science 25-26/11/2012, 55 (2012).

[7] S. Z . Jassim and J. C. Goof., **" Geology of Iraq"**, Dolin, Prague and Moravian Museum, Brno, Czech Republic, (2006).

[8] L. S. Edwards, **"A modified pseudosection for resistivity and IP."**, Geophysics, 42, 1020 (1977).