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Integrated Groundwater Studies at Wadi El-Farigh Area, West Nile Delta, Egypt

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ABSTRACT

Development of the Western Desert of Egypt is a main concern for Egypt to strengthen its role in National Economy and the development. This is being emphasized in the Western Desert water resources development Project. Therefore, the present study deals with evaluation of groundwater potentiality using hydrogeophysical and geological investigation tools. This work started in the summer of 2011 and continued until the summer of 2015.
The area of study is located south of Wad El-Natron depression, southwest of the Nile Delta and left the Cairo – Alexandria Desert Road. It extends in a WNW-ESE direction for about 90 km with an average width of about 10 km. As calculated by the present author Wadi El-Farigh depression has a catchment area of 1112.5 km2 enclosed between the contours of 120 m above sea level in the south and west and 4 m below sea level in north center part. It lies between latitudes 30º 00' 00" and 30º 30' 00" N and Longitudes 30º 00' 00" to 30º 50' 00", E. The area includes lands belonging to the two governorates of Behira and Giza. The low area of wadi El-Farigh depression is dominated by sand accumulation and rock fragment. To achieve these plan new sources of water must be available. This has been done by conducting a number of VES'S where interpreted by a comparison with the existing drilled borehole soil samples. The optimum resistivity model is obtained by matching method using "IPI2Win" Moscow State University, (2000) software for resistivity interpretation. The results of the quantitative interpretation of the resistivity curves has been represented as geoelectric sections, showing the thickness and true electric resistivity values of the different geoelectric layers. The sections showed five subsurface geoelectric units and the aquifer system is belonging to Moghra (Lower Miocene) and water samples of the investigated area is fresh to brackish. The T.D.S. for the analyzed water samples ranges from 252 ppm to 2572 ppm. Mapping of the aquifer distribution indicated that the depth to water in Miocene aquifer varies from 49 m at the area close to El Rayah El Naseri to 176.88 m at high topographic areas towards the west. The total salinity of the Miocene aquifer (Moghra aquifer) varies from fresh to slightly brackish water.
Keywords: WNW-ESE, Lower Miocene, Nile Delta, Groundwater, VES

I. INTRODUCTION

The areas under investigation occupy a portion of the Western Nile Delta region (Fig. 1). It lies between latitudes 30º 00' 00" and 30º 30' 00" N and Longitudes 30º 00' 00" to 30º 50' 00", E. It is considered as a depression of low relief (El-Tahrir gravel plan, Wadi El-Natrun depression and Wadi El-Farigh Depression).

The available studies are dealt with the geomorphology, geology, hydrogeology, hydrology and hydrogeochemistry. Shata (1947), (1953ttia (1975) (1982), Picard (1955), Said (1962), Seanad (1973) & Omara and Sanad (1975), El Shazly et al., (1975), General Petroleum Company "GPC" (1977, El Ghazawi and Atwa, 1994), El-Abd (2005), Shafeek (2015).

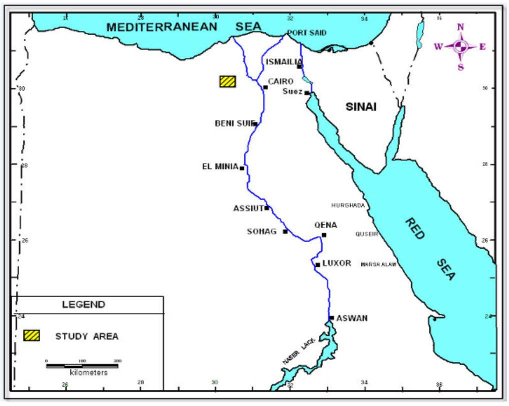


Figure 1. Location of the study area

The objective of vertical electrical sounding is to obtain depths, thicknesses and resistivity's of geological formation in multilayered subsurface. The geoelectrical resistivity survey is cared out within the present work aims to outline the thicknesses and electrical resistivities of the encountered geoelectrical geologic units. The vertical electrical sounding has been interpreted using the software "IPI2win" Moscow State University 2000. This program compares the field data with the data calculated for initially assumed layer model.

The results of such interpretation, in the form of layer thicknesses and true resistivities, are illustrated in geoelectric cross-sections, from which some isoperimetric maps can be portrayed, told delineate the subsurface geologic and hydrogeological aspects.

2. Regional Geomorphology:

The general land surface slopes gently to the northern and eastern directions. Landforms are classified into 3 geomorphic units (Fig.2). These geomorphic units from north to south are:

The alluvial plains: The alluvial plains constitute one of the most striking land features in the study area and extend between Rosetta branch and the eastern fringes of MaryuIt tableland.

The structural plains: The structural plains occupy a wide area to the south and west of the old alluvial plain. It consists of a number of alternating structural ridges and structural depressions, reflecting the impacts of both the Lithologic and structural factors. Old gravel surface stretch for a long distance on the gentle slopes of the structural plain as well as the escarpment bounding Wadi El Farigh on the northern side.

The shifting sand: Drift sands and sand sheets cover wide portions of the old alluvial plains and the lowest parts of the large depressions. Also there are a series of long, narrow parallel elongate sand dunes known as El Heneishat sand dune chains.

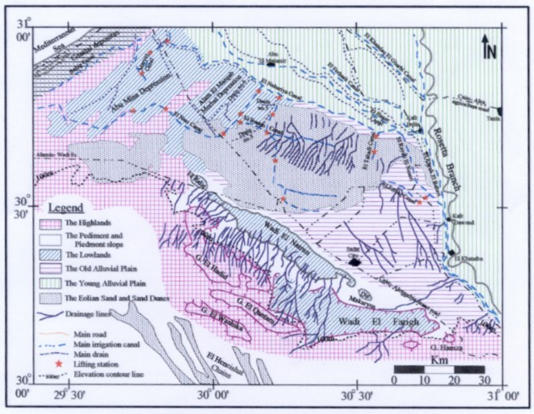


Figure 2. Geomorphologic map of the study area

3-Geologic settings:

The study area is covered by extensive sedimentary exposures ranging in age from Late Cretaceous to Quaternary. In subsurface the sedimentary section has a thickness of about 4000 m resting on the basement rocks. The Late Cretaceous sediments have a localized occurrence on the crest of the complicated folded structure to the west of El Giza (Abu Rawoash anticline). Eocene and Oligocene sediments are of limited distribution in the environs of Cairo (Fig. 3).

Miocene sediment: Miocene sediment is represented by El Moghra Formation, which covers the south and west of Wadi El Natrun and the area from Wadi El Farigh in the east to El Qattara depression in the west. In Wadi El Farigh the thickness of Miocene sediments is about 150 m, which is rapidly increases to about 900 m in the northwest direction, Moghra Formation is mainly composed of coarse sands, sandstone and clay interbeds with vertebrate remains and silicified wood, which becomes gravelly at base. The concerned formation rests unconformable on basalt sheets in several localities at surface as well as in the subsurface.

Pliocene sediments: Pliocene sediments have a wide distribution in Wadi El Natrun depression and its vicinities; it is divided from base to top into Wadi El Natrun Formation and El Hagif Formation. Wadi El Natrun Formation is classified into Muluk and El Solimaniya Members.

Quaternary deposits: Quaternary deposits cover wide stretches of the study area and it distinguished into different types as deltaic deposits and crust, alluvial deposits, , salt marshes and sabkha and Aeolian deposits. The thickness of the Quaternary sediments varies from 25 m to 350 m, it increases in the areas close to delta and decreases in the area close to Wadi El Natrun. Lithfacies of the Quaternary sediments are Sandy gravel, gravelly sand, slightly gravelly sand and sand.

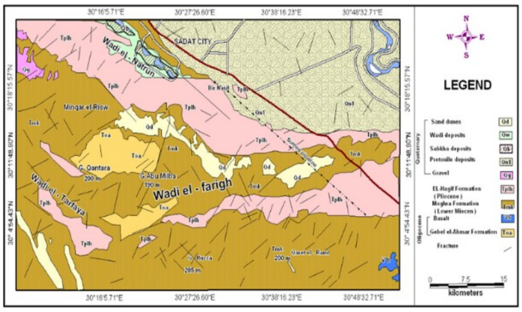


Figure 3. Geologic map of west Nile Delta, Egypt, (Conoco, 1987).

The structural elements are the most important factors controlling the groundwater conditions. Folds, faults, unconformities and basaltic intrusions mainly affect the area of study. The area of study is mainly affected by two-fold system; i) the NE-SW folds' system (Syrian Arcs); represented by Abu Roash domal structure and ii) the NW-SE (clysmic) folds system; represented by Wadi El Farigh and Wadi El Natron anticlinal structure. Moreover, the study area is affected by three normal faults systems in the NW-SE (Clysmic) system, NE-SW (Aqaba) and E-W (Tethys)directions.

4-The Electrical Resistivity Sounding:

The D.C. electric survey was performed at 54 Vertical Electrical Sounding (VES) set in Wadi El-Farigh as showing as (Fig..4). The well-known Schlumberger configuration of electrode separation starting from AB/2 = 1 m. up to 500 m. and to 1000 m. is selected and applied. In the present study, the vertical electrical Sounding has been interpreted using the software "ipi2win" Moscow State University 2000. This program compares the field data with the data calculated form initially assumed layer model. The initial model was constructed based on the lithological succession from the available wells drilled in the investigated areas.

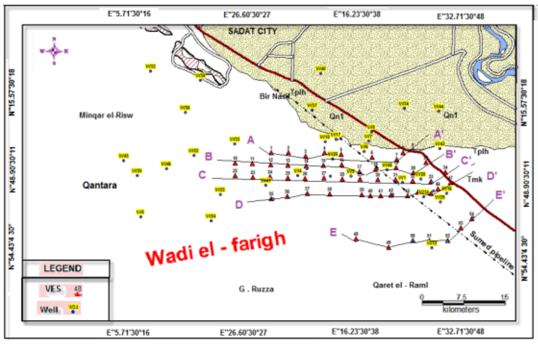


Figure 4. Abase map for well &VES'es locations in Wadi El-Farigh

Interpretation of Electrical Resistivity Data:
Interpretation of the vertical electrical soundings (VES) was done to determine the thickness (or depth) and true resistivity of the interpreted geoelectric units that reflect lithological layers. The vertical electrical soundings have been correlated with available boreholes wadi El-Farigh as shown in Fig. (5). thus, a reliable control can be achieved for portraying the subsurface picture in the area of study to help in constructing geoelectric cross sections.

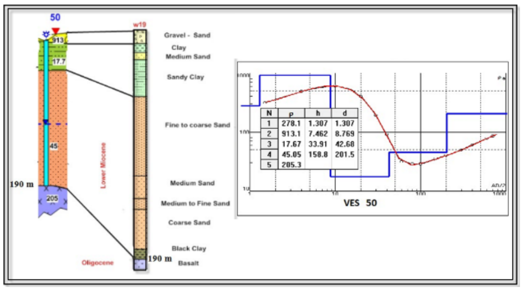


Figure 5. Calibration of VES'es No. 50 result with lithological data of well 19.

Geoelectric Cross-Sections

Five geoelectric sections were constructed (Figures, 6 - 10). Four geoelectric units were represented with different resistivity values and thickness, hereunder the most reliable features of these sections;

1) the topmost unit acquires relatively high values of resistivity (ranging from 14 Ohm.m to1353 Ohm.m) of surface soil, which probably represents the top surface layer of wadi deposits.
2) The second geoelectric layer is implicated by relative low electric resistivity values that range between 9 Ohm.m and 20 Ohm.m, which correspond to sandy clay in the section A, silt clay, and sand in other sections. The thickness of this layer varies from 37.7 m to 67.65 m.

3) **T**he third geoelectric layer is characterized by moderate electric resistivity values ranging between 30.7 Ohm.m and 98 Ohm.m. This layer can be interpreted as water saturated sand. However, the thickness of this layer is ranging from 155.1 m to 208 m.
4) The fourth geoelectric layer is implied by low resistivity values varying from 19.5 Ohm.m to 51 Ohm.m, which correspond to water saturated sand. The depth from surface to this main aquifer ranges from 224.7 m to 259 m as showing as Fig. (6).

Figure (7) reflects that the second resistive layer (ranging from 9 Ohm.m to 861Ohm.m), while the second layer is mainly sand and gravel with clay intercalation, which thickens towards the west. Below this layer, there is the fine, medium to course sand with clay intercalations. This layer, which forms the main aquifer, is thick and may be internally subdivided into two parts according to their resistivity values (13 Ohm.m to125 Ohm.m). The sand/clay ratios as well as the gravel intercalation percentage are higher at the sites of VES'es 13, 18, and 19. The last geoelectric layer consists mainly of sand and basaltic sheet with resistivity ranging between 23 Ohm.m and 303 Ohm.m. This layer is dissected by normal and reverse faults. The depth to this main aquifer ranges from 95.2 m to 188.6 m.

In the section C-C (Fig. 8), the deepest fourth geoelectric layer comprises high resistivity values due to the existence of basaltic sheet. This layer exhibits below VES'es 23, 24,25,26,27, and 28. The depth to this main layer ranges from 130.7 m to 207.2 m. several normal faults dissected area.

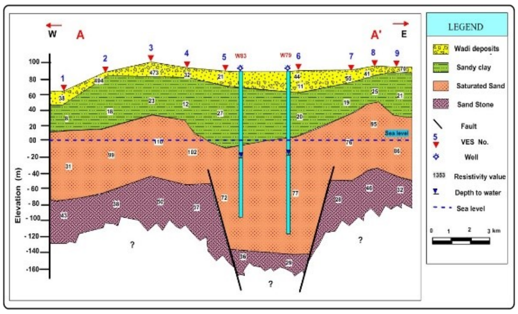


Figure 6. Subsurface geoelectric cross section A - A'.

However, in figure (9), the water-bearing zone reflects resistivity values ranging between 25 Ohm.m. to 96 Ohm.m while it's thickness varies from 64.4 m to 147.5 m. The deepest fourth geoelectric layer of high resistivity values due to the existence of basaltic sheet.

The Geoelectric section E-E, (Fig. 10) represent that the third geoelectric layer is characterized by moderate electric resistivity values ranging between 45 Ohm.m and 95 Ohm.m. This layer can be interpreted as water bearing sand. However, the thickness of this layer ranges from 129.1 m to 166.3 m. The last geoelectric layer consists mainly of sand and basalt with resistivity ranging between 29 Ohm.m and 233 Ohm.m. was dissected by two normal faults. The depth to this layer which was considered as the main aquifer ranges from 185.5 m to 228 m. (Fig. 10).

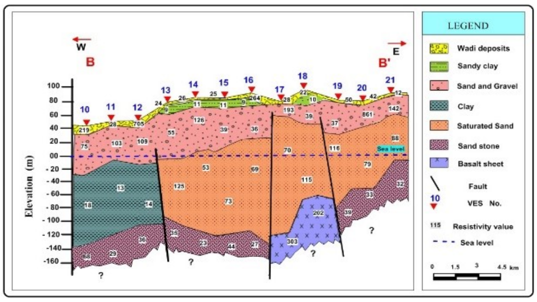


Figure 7. Subsurface geoelectric cross section B - B'.

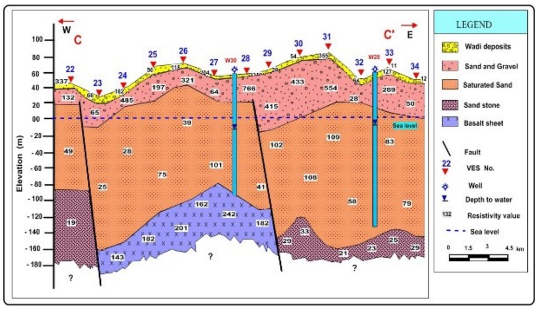


Figure 8. Subsurface geoelectric cross section C - C'.

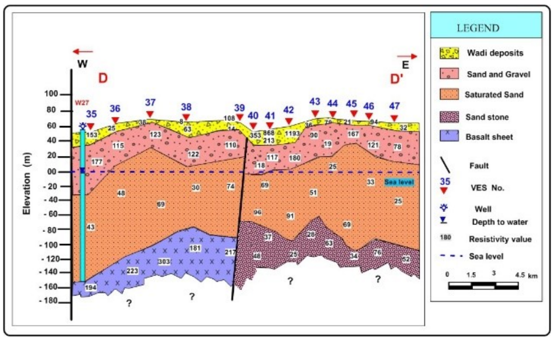


Figure 9. Subsurface geoelectric cross section D - D'.

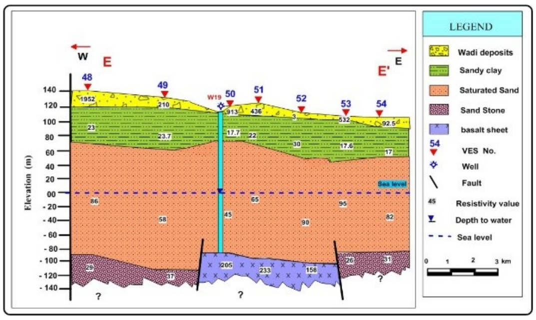


Figure 10. Subsurface geoelectric cross section E - E'.

5-Hydrogeological Conditions:

From the hydrogeological point of view, special emphasis is given to the following topics:

1-Surface water system: The surface water system is mainly Rosetta branch, El Rayah El Beheri, El Rayah El Nasseri and smaller canals. Such water system is subjected to infiltration to the groundwater aquifers. The canals are cutting the Nile silt and sandy clay deposits, discharging their water into the cultivated land.

Groundwater aquifers:

The main water bearing formations in the study area are; the Quaternary aquifer, the Pliocene aquifer, the Lower Miocene aquifer (Moghra), and the Oligocene aquifer.

Miocene aquifer covers a wide area south and southwest of Wadi El Natron and it is mainly composed of coarse sands and clay lenses intercalation (Fig.11). The saturated thickness of the Lower Miocene aquifer varies from 741 m in the western portion, 179 at K52 east Cairo-Alex. Desert Road and 16 m at Gebel Khashm El Kalb. Miocene aquifer has been deposited on the basaltic sheet at different levels; in the form of horst and graben-like structures. The amount of groundwater stored in Miocene aquifer is about $25.9X10^9$ m^3 and the amount of withdrawal which equals the drawdown in groundwater is about $0.036X10^9$ m^3/year.

The saturated thickness of the Miocene aquifer (Fig. 12) is controlled by the prevailing structural conditions in the area. The maximum saturated thickness attains about 169m, and thins out in the northeastern direction to reach about 27 m at the Khasm El Kalb area. Regionally this thickness increases in northwest direction (El Ghazawi and Attwa, 1994).

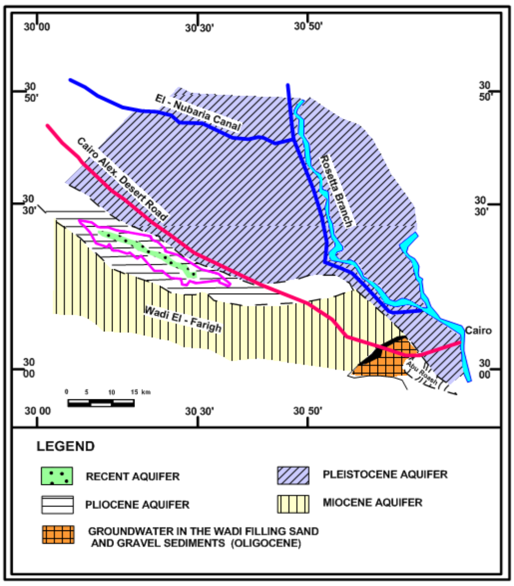


Figure 11. Distribution of aquifers in the west Nile Delta

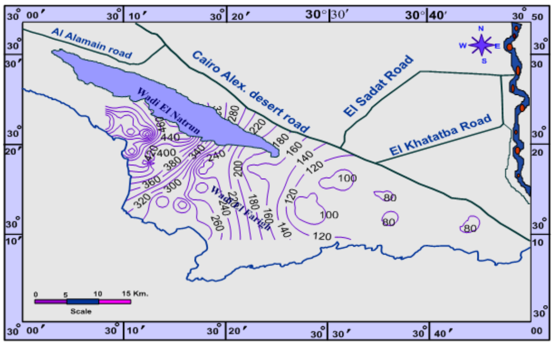


Figure 12. Thickness contour map of the Miocene aquifer (Shafeek, 2015).

The southeastern boundaries of the lower Miocene aquifer are delimited by a set of faults with downthrows to the north where the Oligocene basaltic sheet is highly elevated (from + 150 m to + 30 m) above the regional potentiometric surface of the Lower Miocene aquifer (+2 m) (Fig. 13) accordingly, this aquifer is hydraulically connected with the underlying Oligocene aquifer. The northern boundary of Lower Miocene aquifer is bounded by many faults. South Wadi El Natron, this aquifer is bounded by NW- SE faults with their down throwing sides to the east where the Lower Miocene is uplifted in the front of the Pliocene aquifer.

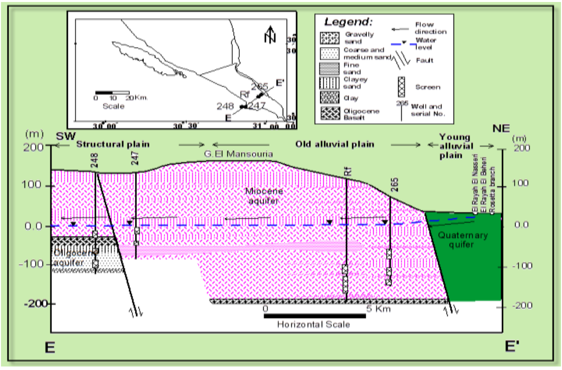
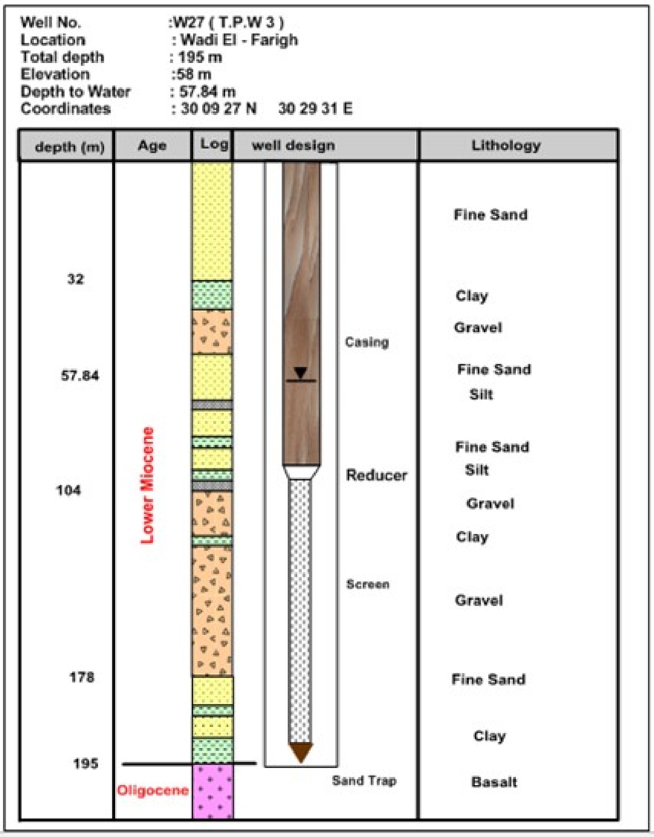
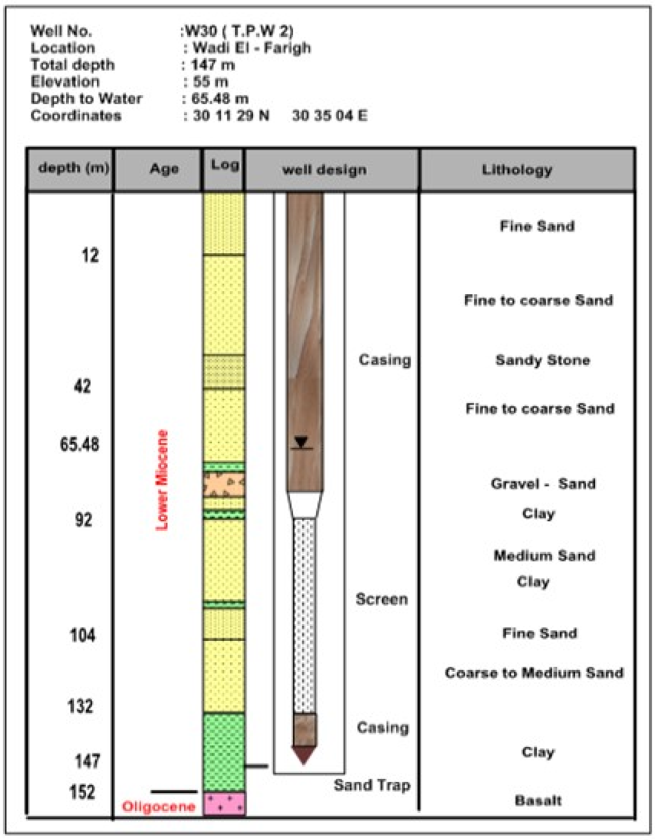


Figure 13. Hydrogeological Cross Section E-E' (Al Abd, 2005).

II. CONCLUSION

The quantitative interpretation of the vertical electrical soundings in wadi El- Farigh is composed essentially of four geoelectric layers. The ground water in wadi El-Farigh is available from an aquifer system belonging to Lower Miocene times (Moghra aquifer.). The total thickness of the Miocene sediments is varying from 75 m in the northeastern portion to about 250 m at Wadi - El Natron, regionally this thickness increases in northwest direction The depth to water in Miocene aquifer varies from 49 m at the area close to El Rayah El Naseri to 176.88 m at high topographic areas towards the west The groundwater in the Miocene aquifer flows westward. through Wadi El Farigh. This movement is mainly controlled by an old buried Nile channels which divert groundwater flow towards Wadi El Natron depression. **T**he depth to top of Moghra Aquifer (third layer) varies from about -25 m 65 to m from sea level The depth to top of Moghra Aquifer increases in north and north west and decreases in southeast direction. The depth to bottom of Moghra Aquifer (third layer) varies from about -8 m -175 to m from sea level The depth to bottom of Moghra Aquifer increases in north and north west and decreases in southeast direction.





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