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# GEOPHYSICAL CONTRIBUTION TO SITE LOCATIONS OF DESALINATION AND BRINE DISPOSAL GROUNDWATER WELLS IN SELECTED SITES - EGYPT

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**The water became insufficient due to the increasing demand with time to industrialization, cultivation and growing population. The researching of alternate sources for clean water is becoming an essential and vital thing. The goal of this study is sharing in construction of desalination plants depending on groundwater of less salinity than sea water of coastal areas under different lithological conditions to become a piolt model for surrounding areas. Also,solving the problem face tourist villages in the transportation of the necessary water for drinking, domestic uses and construction.Three study sites (I, II, III) are existed on coastal zones at Mediterranean Sea, Suez Gulf and Aqaba Gulf, respectively. Geoelectrical resistivity sounding and 2D imaging profiles are tools uniquely suited to such objective. The results of geoelectrical data interpretation revealed the geoelectrical parameters from resistivity and thickness also, the depth to water and its direction flow. According to these information, it can be detected the best site for drilled productive groundwater wells with less salinity to supply the desalination plant and other disposal bine wells to inject saline water of resulting desalinating process.**

**The results obtained from the interpretation led to different geoelectrical successions which are formed from a number of layers. They are grouped together in three main layers (A, B, C) at both sites (I &II) but four geoelectrical layer (A, B, C &D) at site (III). These geoelectrical successions divided into dry layers and other saturated layers. According to resistivity values the saturated layers divided into different saturated waterbearing units which are brackish, saline and more saline that affected by seawater intrusion.**

**According to the results of this study, it can be recommended the sites of productive drill wells that recharge the desalination plants. Generally, the locations of these kinds of wells will be existed far away the shore line whereas the large thickness with low salinity and suitable depth. The other disposal well will be existed near the coastal zone in the same trend of water flow. Also, it can be drilled more than one well for large quantity water but it must be considered the distance between them and safe yield to keep the groundwater condition long time.**

***Keywords:*** Vertical Electrical Soundings (VES), 2D imaging profiles, desalination wells, brine disposal wells, Coastal areas, Egypt.

## INTRODUCTION

All coasts of Egypt attracted by the attention of the government and the investors to plan a touristic projects in the last decade. Along these coast tens of tourist villages were build up and face some problems. One of the big problems there is the transportation of the necessary water for drinking, domestic uses and construction. The groundwater exploration is a trial to contribute solving for this problem. But the fresh groundwater in these sites expected few and brackish so the desalinization plant consider the alternative thing. The present study is dealing with this vital and essential subject by study three sites (I, II, III) on these coastal areas with different lithological conditions (Fig. 1) to become act as a model that can be performed in their vicinities. The first site (I) lies on Alexandria- Marsa Matruh Highway at Km70, northwestern coast of Mediterranean sea. The second site (II) lies on the west of Suez Gulf north El Zafrana city by 18 km and the third site (III) lies at the west of Aqaba Gulf south Taba city by km 25 southern Sinai.

The aim of this study is delineating the suitable locations in these three sites (I, II & III) for drilling groundwater water wells under different lithological conditions at coastal areas and become reliable to costruct desalinization plant. The present study concentrate to detecte the brakish groundwater zone to supply the desalinization plant that consider cheaper than water from sea. On the other hand delineate wells for injection and disposal of the salt water resulting from the desalinization process. Groundwater investigation in the coastal areas requires recording of subsurface changes along traverses perpendicular to the coast in order to detect any probable influence on thickness of the sedimentary succession and on groundwater. Geoelectrical resistivity sounding (VES) and 2D imaging profiles are tools uniquely suited to such objective. Many geoelectrical studies dealt with the subject related of groundwater desalinization as [1- 4]. The purpose of the geoelectrical survey was to recognize the subsurface geological and hydrogeological settings affecting the groundwater in the area and hence to find out a suitable sites for the drilling water wells. In addition to find out whether there is a lateral and vertical change in the lithological section from one place to another along the area.

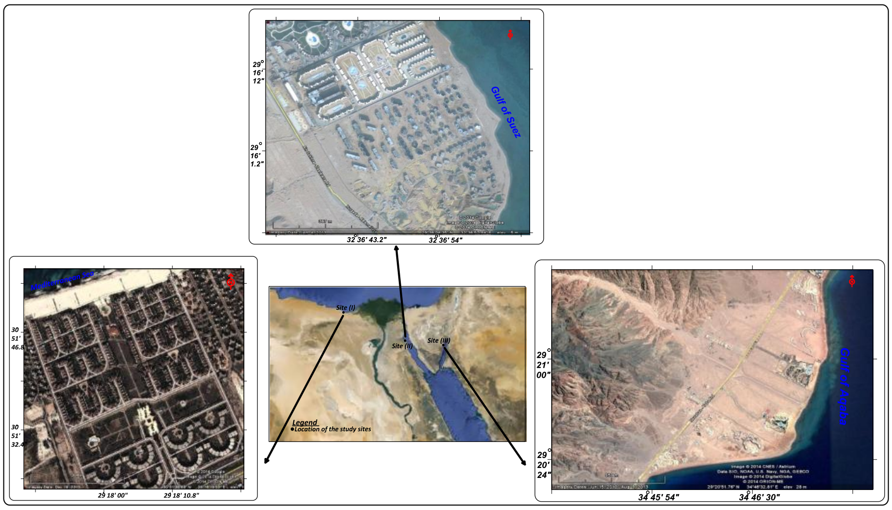


**Fig. (1):** The location map of the study three sites (I, II ,III)

## GEOLOGICAL BACKGROUND

Different geomorphologic and geological studies were carried out along these study selected sites (I, II, III) and its vicinities. Several studies have been contributed to site (I) at the northwestern Mediterranean coastal zone [5 – 14]. Also, the study of the Suez Gulf coast were been done by [7 & 15] and [16]. As well as the Aqaba Gulf coast studied by [17 -22]. The different geomorphologic and geological conditions that distinguished the study sites (I, II, III) are the follow:

### a. Geomorphological setting:

Coastal geomorphology deals with the origin and development of landforms occurring along the coastline. Generally the coastal areas are low slope towards the shore line. In the site (I), the average of ground elevation ranges from 2.5 to 7m above the mean sea level with a general slope northward towards the Mediterranean Sea. According to [11], the study area and its surroundings characterized by landforms such as ridges, depressions, dunes control the distribution of surface runoff and consequently the groundwater accumulation and storage. The area of this site (I) is lying on northern ridge at the coastal plain. The surface of the study site (II) is gently sloping towards the western coastal plain with ground elevation ranges from 1 to 12 m above the mean sea level. The coastal plain of Suez Gulf is bordered from the west by very rugged mountainous series forming the structural edge of the Red Sea [8]. Also this area located in the outlet of wadi Araba. The last study site (III) is located in delta of Wadi El Maehashi El Aala at the western coastal of Aqaba Gulf. This wadi represents a minor basin of the Gulf of Aqaba drainage system. It runs nearly in NW-SE direction. It drains from the water divide of wadi Watir to the west of the Aqaba Gulf. The selected study site (III) is characterized by a slightly undulated land surface that generally slopes eastward and southeastward towards the Gulf of Aqaba. The ground elevation ranges from 0.5 to 50m above sea level. The figure (2) shows the ranges of elevation values of the study three sites and their topographic surface in 3D shapes.

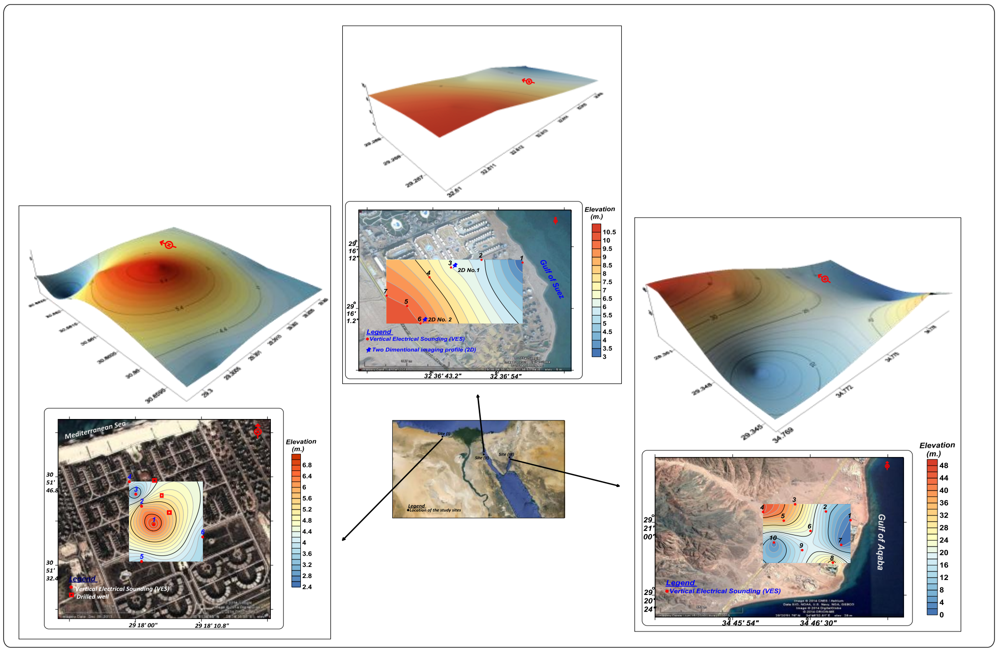


**Fig. (2):** Elevation counter maps of the study three sites (I, II ,III) and its 3D surfaces

According to the above mention of the different geomorphology features for the study three selected sites (I, II & III), it can be noticed that the first site (I) located between elongate ridges. The other two sites (II & III) located at the outlet of drainage basins.

## b. Geological setting:

Rocks of coastal areas are composed of materials ranging from hard rocks to relatively soft that belong to different geologic ages. The northwestern coastal zone is occupied by sedimentary rocks of Tertiary and Quaternary age [11]. The Miocene deposits are represented and underlay the Quaternary deposits in the study site (I) area. The Quaternary deposits are exposed and formed of a thin cover of drift sands and loamy deposits covering mainly low lying areas also the floors of the area dissecting the ridges. These deposits composed from oolitic and cardium limestone. The Miocene deposits are represented by Moghra Formation and underlie the

Quaternary deposits. The Suez Gulf area is occupied by sedimentary rocks belonging to Tertiary and Quaternary age [16]. The Quaternary deposits have a wide distribution in the study site (II) area. These deposits are consisted of calcareous sand and extend downward to mix with gravels, sands, and shale of successive subsurface layers to reach sea water intrusion. These deposits follow by layers of Tertiary age that consist of limestone and clay deposits. The southeastern part of Sinai along Gulf of Aqaba area occupied by deposits ranging from the Pre-Cambrian to Quaternary age. The Quaternary deposits in the study site (III) area consist of wadi deposits that overlies unconformable the basement rocks of Pre- Cambrian [14]. The Quaternary deposits cover the floor of the study site (III) area and extend eastward to the Gulf of Aqaba coastal plain. They are composed mainly of alluvial deposits of very coarse sand, gravels, and boulders of igneous and sedimentary origin embedded in a fine loamy and silty matrix. It is obvious that the three selected study sites (I, II & III) at coastal areas have different lithological conditions as mention above (Fig. 3). All these geologic setting have been effect on the groundwater occurrence.

### c. Hydrogeological setting:

The coastal of Mediterranean Sea is characterized by semi-arid climate with hot summer and rainy winter. The water bearing formation in the site (I) area belongs to the Pleistocene aquifer, It is composed of oolitic and cardium limestone [23]. The depth to water in the study area ranges from 2m to 6.1m as recorded from the water wells in this site. The salinity of water ranges from 606 to less than 1200 ppm. The Quaternary sand and gravel deposits form the main water-bearing strata in the study site (II) area having generally fresh to brackish water [24]. This aquifer is built up of sand and gravel with clay and limestone intercalations. The groundwater of the Quaternary aquifer occurs under free water table condition at depths varying between 9.4m and 39.9m. Its recharge depends mainly on the infiltration of surface runoff water and upward leakage from deep Pliocene and Miocene aquifers.The groundwater is being exploited from different water bearing formations in the Gulf of Aqaba area,. The Quaternary and Precambrian aquifers are only known in the site (III) area [25 - 27]. The Quaternary alluvium aquifer is the most exploitable water bearing formation in the study area. The available data of the water points in the area indicates that the depth to water varies from ranges between 2m and 35m, from ground surface. Figure (4) represents different hydrogeological cross sections in these study three sites (I, II & III).

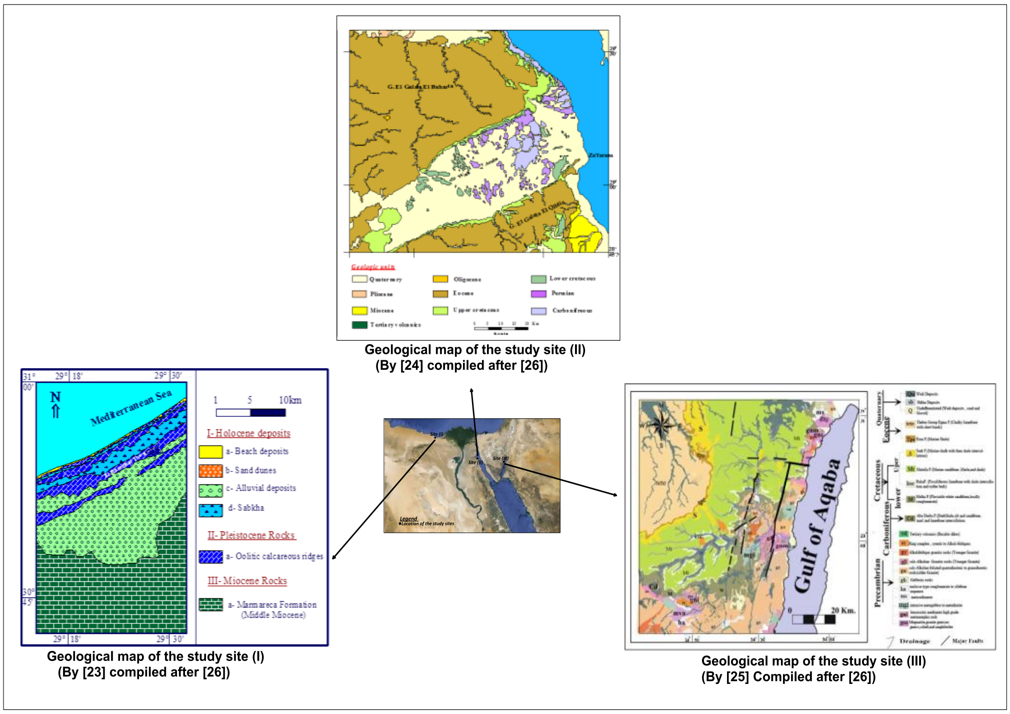


**Fig. (3):** Geologic maps of the study three sites (I, II ,III)

## FIELD DATA AND INTERPRETAION

Definition the objectives of this study is importance in selecting the geophysical techniques. Construct a complete study model by geophysical techniques deal with groundwater desalination in different coastal location in Egypt with varying lithological condition was considered the target of this study to become a pilot for surrounding areas. It necessary to apply different geoelectrical methods (1D&2D) to delineate the water flow, depth to water and thickness of the water bearing formation for detecting the best side of drilled productive and other rejected wells. These geoelectrical methods (1D & 2D) are adopted to fulfill the objectives of study.

The geophysical methods for the subsurface exploration can be contributed to the different phases of coastal environment characterization. [28] Have applied a combination of geophysical techniques at the Muravera plain in southern Sardinia, Italy having been significantly affected by water salinization. [29] used electrical resistivity methods for detecting subsurface fresh and saline water in the eastern Dead Sea coastal aquifers in Jordan. [30] delineates the groundwater condition in North West Sinai. [31] applied a direct current resistivity geoelectric technique to delineate salt water intrusion from the Gulf of Suez. Moreover, [32- 34] have performed geoelectrical surveys in different coastal area around the world. [35] applied electrical resistivity tomography (ERT) to map the salinity distribution in the subsurface in the Okavango Delta, a large inland delta in Botswana.

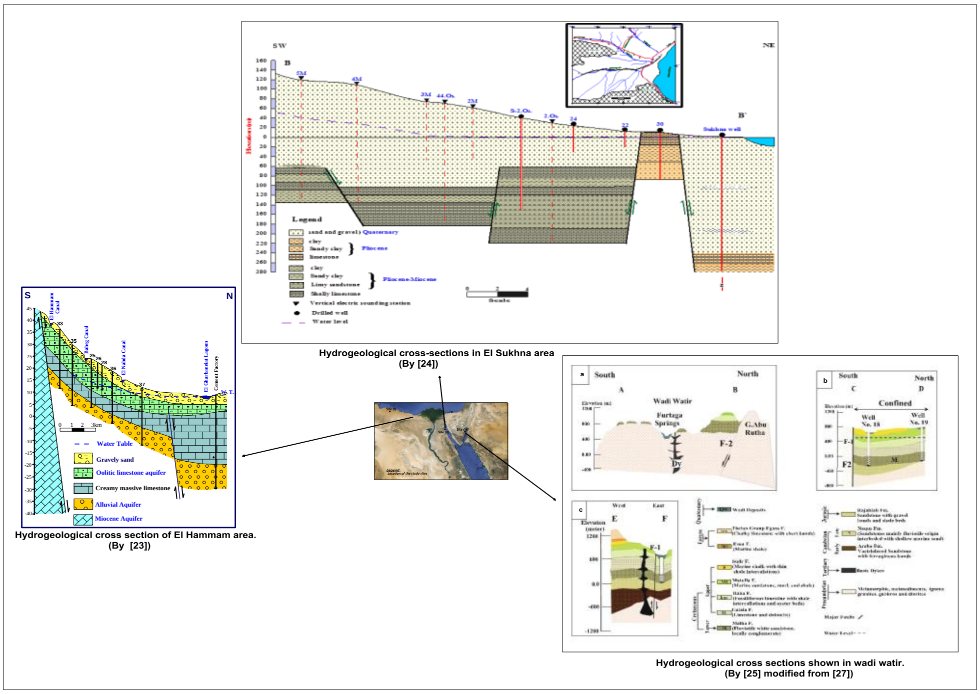


**Fig. (4):** Hydrogeological cross sections of the study three sites (I, II ,III)

Most of the electrical resistivity techniques require injection of electrical currents into the subsurface via a pair of electrodes planted on the ground. By measuring the resulting variations in electrical potential at other pairs of electrodes, it is possible to determine the variations in resistivity [36 - 38]. A conventional vertical electrical sounding (VES) survey is used for quantitative interpretation where the center point of the array remains fixed and the electrode spacing is increased for deeper penetration [39].

The Schlumbergere configuration was applied in the present study. The current electrode separation (AB) started 2m. and increased to reached to 1000 meters. This electrode separation was found to be sufficient to reach reasonable depth range that fulfills the aim of the study. An arbitrary initial model has been constructed in view of the overall shape of the sounding curves and refers to some surrounding geological and hydrological information. The Resist computer program [40] is used for the quantitative interpretation of the geoelectrical sounding curves. It is an interactive, graphically oriented, forward and inverse modeling program for interpreting the resistivity curves in terms of a layered earth model.

The surface Electrical Resistivity Tomography (ERT) is a useful tool to determine variations in soil resistivity with depth. This technique is widely used in many environmental and engineering studies also has been conducted in water covered areas [41- 43]. The resistivity changes along the vertical and horizontal directions can be more accurate using this 2D model. The survey technique involves measuring a series of constant separation traverses. In the present study the Wenner electrode array was applied where the measurements start at the first traverse with a unit electrode separation "a" equals 3 m and increases at each traverse by one unit i.e. 3, 9, 12,. . . . . ,n. to reach 30m. The measured imaging profiles were conducted to verify the results of Vertical Electrical Sounding (VES) especially the boundary between geoelectrical layers and the variation in groundwater condition. For the interpretation of the imaging data, the computer program RES2DINV, ver 3.4 written by [44] is used. It is a Windows based computer program that automatically determines a two dimensional (2D) subsurface resistivity model for data obtained from electrical imaging surveys [45].

The geoelectrical field measurements varies between Vertical Electrical sounding (VES) and 2Dimaging profiles in three study sites (I,II,III) (Fig.5). Seven geoelectrical sounding were carried as a grid to cover the study site (I) at the north western coastal zone. A reasonable seven geoelectrical sounding and two 2D imaging profiles with length reach 90m were carried to study site (II). The last site (III) ten geoelectrical sounding were carried as a grid to cover this site.

The direct current resistivity meter "Terrameter" model SAS 1000C was used for measuring the resistance "R" with high accuracy. The accurate locations (latitudes and longitudes) of the sites of the geoelectrical measurements and their elevations relative to sea level were determined using the geographic positioning system (GPS) GPS apparatus (Trimble type) contact with nine satellites and topographic map scale 1:50,000.

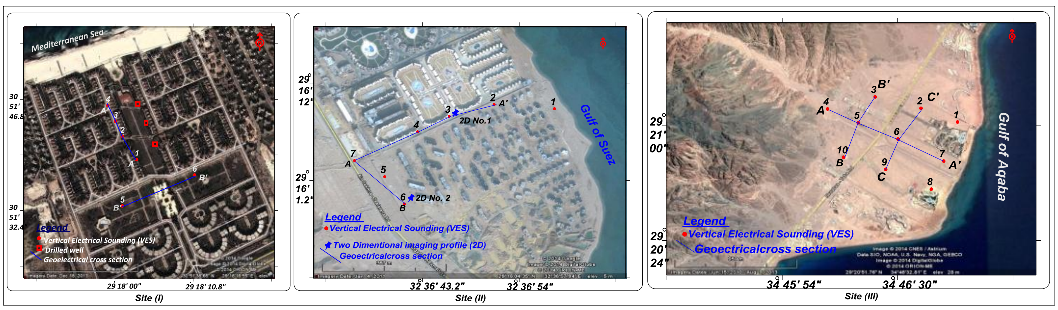


**Fig (5):** The geoelectrical field measurements in the study three sites (I, II, III) and directions of the geoelectrical cross sections

## DISCUSSION OF RESULTS

The interpretation of vertical electrical sounding curves includes correlation of similar layers. The sounding curves are interpreted first qualitatively and then quantitatively. The qualitative interpretation gives a descriptive analysis about the range of the measured resistivity values, the significance of these values, the approximate number of the geoelectrical layers and the relative physical relationship between the successive layers as reflected by the type of the sounding curves. Also it gives preliminary information about the continuity of the layers throughout the studied area or along a certain direction and reflects the degree of homogeneity or heterogeneity of an individual layer. The quantitative interpretation process is related to the mathematical basis and formulas according to which the measurements are to be carried out. This has been much facilitated during the last few decades by the advance in computer sciences and the availability of a diversity of software incorporating the mathematical basis and yielding the required subsurface information. They are interactive, graphically oriented, forward and inverse modeling programs for interpreting the resistivity curves in terms of a layered earth model. The interpretation proceed from the fact that the two geoelectrical parameters (resistivity and thickness) can be obtained when complete matching occurs between a measured field curve and a theoretical curve calculated from initial proposed model parameters. The available information about the regional and local geologic setting of the area is taken into consideration in assigning the lithology to the resulting resistivities.

The study of seawater intrusion and its impact on the groundwater aquifer implied the application of high resolution two-dimensional (2D) geoelectrical imaging (Tomography) measurements. The shape and boundary between fresh water, brackish and saline water are delineated by using this techniques especially in the area free from groundwater wells and less geological information. Electrical resistivity values are related to geological parameters of the subsurface and, in particular, resistivity values are controlled by the types of rocks and fluid. Then, the high resolution electrical images are a powerful tool to identify conductive zones for the saltwater intrusion phenomena. The results of the quantitative interpretation of the geoelectrical resistivity sounding in these three study sites (I, II & III) are discussed in the term of geoelectrical parameters of resulting geoelectrical layer, i.e. resistivity and thickness. The general geologic setting is visualized and described in view of number geoelectrical cross sections concerned the study sites (I, II, III) in different directions. These sections illustrate the geoelectrical sequence, lateral and vertical variation of the different layers along the profile direction.

## 1. The first study site (I) at the northwestern coast:

The Qualitative interpretation of the field curves (Fig. 6) for the study site (I) indicates the following:

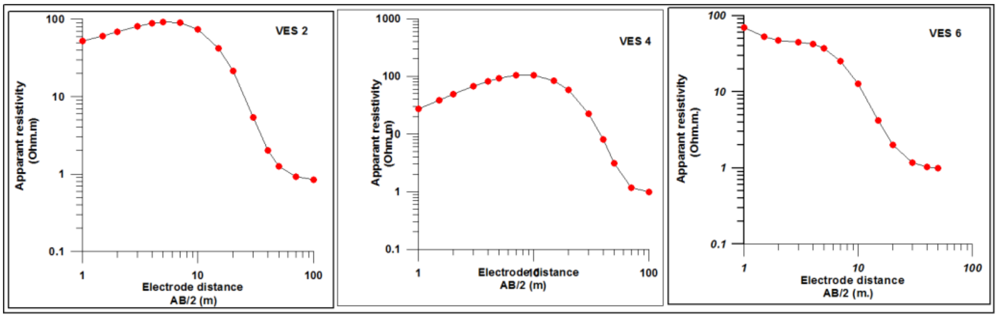


**Fig. (6):** Examples of the vertical electrical sounding curves in the study site (I).

1. The general types of the vertical electrical sounding curves in the area are characteristic by general type KQQ type curve of five or six geoelectrical layers of low resistivity with depth due to increase the sea water intrusion with depth.
2. The resistivity values in the first cycles of the resistivity curves represent the surface and near surface variations. However, they reflect heterogeneity characterizing of the first layers. In going downwards on the field curves (The second cycles), the filed curves show nearly the same type which reflects homogeneity and continuous aerial extension of the deep layers i.e. the area has field curves terminate with Q type.
3. From a visual inspection of these type curves, it is noticed that the resistivity of the water bearing formations decreases with depth due to increase in salinity and effect of seawater intrusion.

The quantitative interpretation of the field curves of the study site (I) revealed that the geoelectrical succession is formed of a number of layers, being grouped together in three main layers (A, B, C). The table (1) represents the results of Vertical Electrical Sounding interpretation. The surface layers (A) is composed of wadi filling sand and clay with a wide range of resistivity varying from16.6 to 55.8 Ohm.m. The wide range of resistivity is due to different composition. The thickness of this layer is not exceeding 0.7m. The layer "B" is dry with resistivity values varying from 64.8 to 407.6 Ohm.m. This layer is composed of oolitic and cardium limestone and clay and its thickness range from 1.39 to 5.2 m.

The layer "C" represents the water bearing formation in the study area of site (I) and consists of oolitic and cardium limestone. According to the resistivity values, it can be differentiated into three units (C1, C2, and C3). The unit (C1) represents the upper part of the water bearing formation. It has a resistivity value varying from 11 to 17.3 Ohm.m decreases northward to the Mediterranean Sea. The thickness of this unit ranges from .59 to 2.16 m. The unit "C2" underlies unit "C1" with resistivity value varying from 2.54 to 4.52 Ohm.m. The thickness of this unit ranges from 6.08 to 13.6 m and increase southward, while its resistivity decreases to northward. The unit "C3" is the last layer with resistivity value varying from 0.797 to 1.09 Ohm.m. The base of this unit has not been reached due to sea water intrusion, which prevents the penetration of the electric current to go deeper.

**Table (1):** The interpreted Vertical Electrical Sounding stations at site (I):

| VES No. | Elev. (m.) | Surface layer (A) | | Dry layer(B) | | Saturated layer (C) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Unit (C1) | | Unit (C2) | | Unit (C3) |
| | | *P (Ohm.m)* | *h (m)* | *P (Ohm.m)* | *h (m)* | *P (Ohm.m)* | *h (m)* | *P (Ohm.m)* | *h (m)* | *P (Ohm.m)* |
| 1 | 7 | 558.400 | 0.378 | 622.100 | 5.200 | 11.000 | 2.160 | 4.080 | 13.600 | 0.883 |
| 2 | 5.9 | 44.580 | 0.700 | 161.700 | 3.680 | 15.870 | 1.470 | 3.038 | 11.100 | 0.797 |
| 3 | 4.4 | 141.000 | 0.500 | 407.600 | 2.700 | 17.300 | 1.170 | 4.170 | 10.200 | 1.090 |
| 4 | 2.5 | 16.600 | 0.600 | 752.200 | 1.390 | 16.000 | 0.590 | 4.520 | 7.800 | 0.893 |
| 5 | 3.6 | 23.600 | 0.600 | 638.800 | 2.210 | 14.000 | 0.840 | 2.617 | 6.700 | 0.898 |
| 6 | 3.6 | 133.800 | 0.380 | 64.800 | 2.385 | 12.000 | 0.607 | 2.540 | 6.080 | 0.925 |

Two geoelectrical cross sections have been constructed from the quantitative interpreted data of the soundings in the study area of site (I). Geoelectrical cross sections (A-A') and (B-B') cross the area in S - N and W - E directions, respectively. To avoid unnecessary repetition, this would facilitate comparisons among these sections. Such geoelectrical cross sections would complete the hydrogeophysical picture and determine the thickness and extension of the water bearing formation. The main observations and conclusions from these sections are:

1- Generally, the geoelectrical cross sections consist of complete geoelectrical successions of three geoelectrical layers "A", "B", and "C" (Figs.7 & 8).
2- Vertically, it is noticed that the decrease in the resistivity values is due to the salinity of water bearing formation decreasing downwards in the study area due to the effect of seawater intrusion.
3- The thickness of the successive layers shows decreasing values towards the north and east trend.
4- The depth to water decreases northward and as the interpreted from the geoelectrical study exhibits values ranges between 2 m and 5m.
5- There are three units ("C1","C2"&"C3") of layer "C" represent different resistivity values act as waterbearing units with different saturated quality of groundwater.

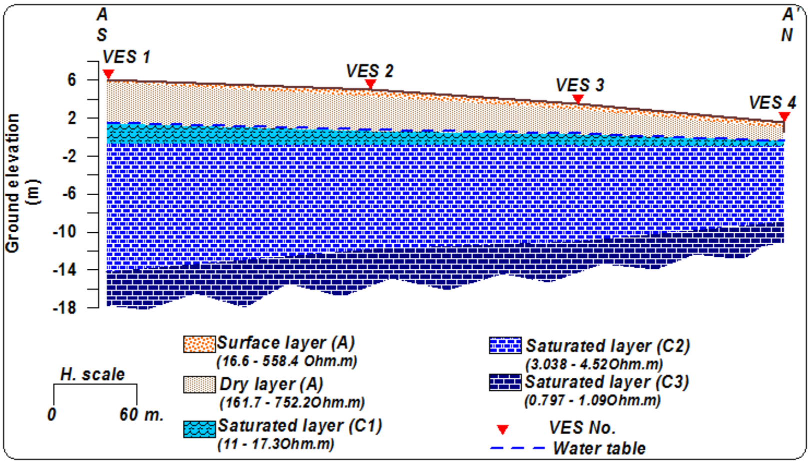


**Fig. (7):** Geoelectrical cross section AA' at site (I)

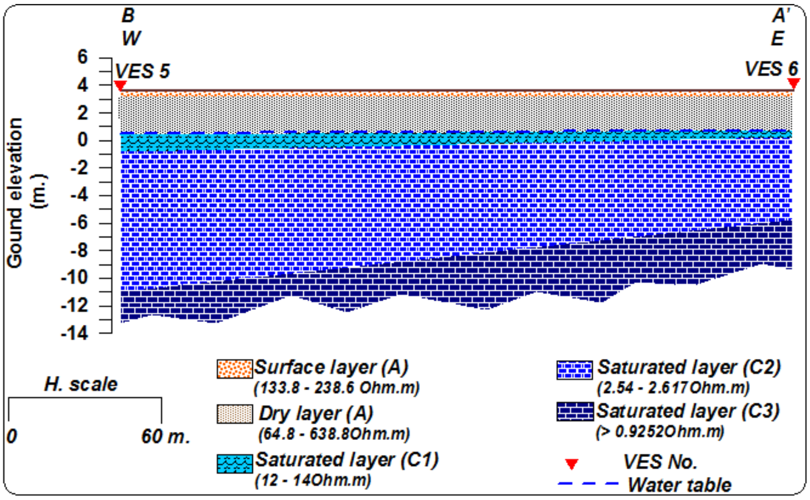


**Fig.(8):** Geoelectrical cross section BB' at site (I)

## 2. The second study site (II) at the west of Suez Gulf:

The visual inspection of the Vertical Electrical Sounding (VES) curves (Fig. 9) in the study site (II) reveals the following preliminary features concerning the subsurface:

1. The high resistivity values are restricted to the surface or near surface layers (AB/2 = 1 -10). On the other hand, the low resistivity values are mostly displayed by the last investigated layer (AB/2 = 10 - 100 m.). This reflects the variation of electrical resistivity, and consequently lithology with depth.
2. The relatively wide range of high apparent resistivity of the surface layer points out in view of the general geology of the area to a corresponding

wide range of dry sedimentary rocks. Similarly the narrow range of low resistivity observed for the last layer indicates a conductive rock such as clay, being is also expected to be present with depth in the area.

***3.*** Most of the sounding curves show three zones with KQQ types. The significance of such resistivity curve type is that the surface layer in the sedimentary section is not homogeneous, while, both the middle and last part of the curves are more or less homogeneous all over the area.

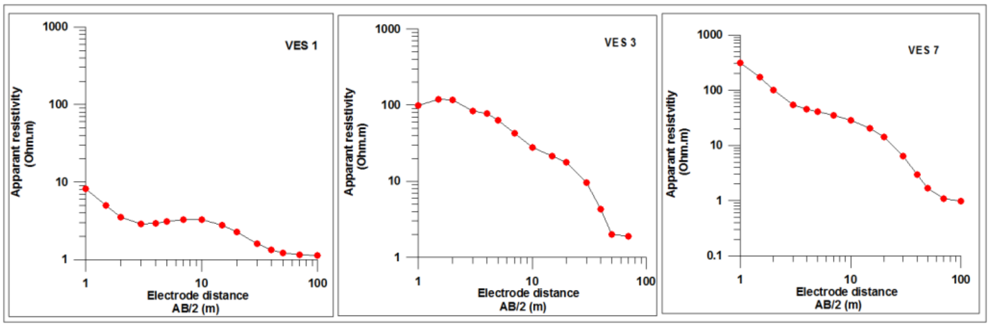


**Fig. (9):** Examples of the vertical electrical sounding curves in the study site (II).

The quantitative interpretation (Table 2) of the geoelectrical sounding curves of the study site (II) reveal that the geoelectrical succession consists from three layers (A, B, C). The geoelectrical layer "A" acts as surface layer consisting of dry sand, gravel, silt and clay. Its resistivity values vary from 22.71 to 3149 Ohm.m. The large differentiated in the resistivity values due to the presence of sabkha in some place that cause decreases the value of resistivity. The thickness of this layer is not exceeding 0.719 m. The second geoelectrical layer "B" acts as dry layer consisting of sand and gravel. Their resistivity value varies from 2.329 to 103.3 Ohm.m and their thickness ranges of 2.314 and 8.5 m.

The last detected layer is "C" acts as waterbearing layer which divided into two units (C1 & C2) according to differentiated in resistivity values. The upper one "C1" represents resistivity values vary from 6.434 to 15.74 Ohm.m. It consists of sand, gravel and intercalation from clay and calcareous deposits saturated with water. The thickness of this layer shows values vary from 3.485 to 5.0666 m. The lower one "C2" represents resistivity values not exceed 1.49 Ohm.m. The end of this layer not detected from geoelectrical study but the previous geology study shows its thickness reach to 120m. This layer is affected by sea water intrusion according to the resistivity values.

**Table (2):** The interpreted Vertical Electrical Sounding stations at site (II):

| VES No. | Elev. (m.) | Surface layer (A) | | Dry layer (B) | | Saturated layer (C) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Unit (C1) | | Unit (C2) |
| | | ρ (Ohm.m) | h (m) | ρ (Ohm.m) | h (m) | ρ (Ohm.m) | h (m) | ρ (Ohm.m) |
| 1 | 3.000 | 14.900 | 0.495 | 2.329 | 2.314 | 6.434 | 3.483 | 1.105 |
| 2 | 5.700 | 78.310 | 0.719 | 58.596 | 3.511 | 12.720 | 3.850 | 0.998 |
| 3 | 6.500 | 115.400 | 0.583 | 92.230 | 4.752 | 15.740 | 4.286 | 1.490 |
| 4 | 8.000 | 3149.000 | 0.267 | 101.300 | 6.992 | 13.060 | 4.919 | 0.752 |
| 5 | 10.000 | 22.710 | 0.497 | 103.800 | 8.200 | 10.040 | 4.765 | 0.539 |
| 6 | 10.000 | 100.300 | 0.490 | 209.000 | 8.500 | 15.190 | 4.906 | 0.912 |
| 7 | 10.000 | 544.800 | 0.558 | 33.900 | 8.122 | 16.030 | 5.067 | 0.946 |

Geoelectrical cross sections (A-A') and (A-B') are constructed from the quantitative interpreted data of the soundings in the study area of site (II) (Figs 11 & 12). The first cross section (A-A') traversed in SW - NE and the other (A-B') in NW - SE directions. The main observations and conclusions from these sections are:

1- The results of the sounding interpretation show three geoelectrical layers (A, B & C). The first layer acts as surface layer and the second layer (B) is dry .The last one (C) is saturated with water.
2- The resistivity values in these cross sections represent decreasing downward due to the effect of sea water intrusion and clay content.
3- There is a decrease in thickness values of successive layers notice towards the coastal of Suez Gulf in eastern direction.
4- The depth to water bearing layer increases towards the western direction as the maximum depth record at VES No. 7 which reaches to 9 m.
5- There are two units ("C1"&"C2") of layer "C" represent different resistivity values act as water bearing units with different saturated quality of groundwater.

The 2D imaging profiles were done to achieve more accurate results especially the boundary between different saturated units in the study site (II) area. The quantitative interpretation of the two 2D imaging profile (Figs.12, 13) represented changing in resistivity and thickness values horizontally and vertically directions. It exhibits three geoelectrical zones (A, B & C). The first zone "A" represents surface layer with resistivity values larger than 30 Ohm.m. It shows different lithological content from sand, gravel and silt with thickness not exceed 9 m. The second zone "B" represents a relative decrease in resistivity values ranging between 5 and 30 Ohm.m. It consists from sand and gravel saturated with water. Its thickness decreases towards eastern direction that ranges between 5 and 10 m. The last zone "C" represents a lowest resistivity values in the two 2D imaging profiles that not exceed 5

Ohm.m. It consists from sand and gravel saturated with sea water. Its thickness increases towards western direction to reach 15m.

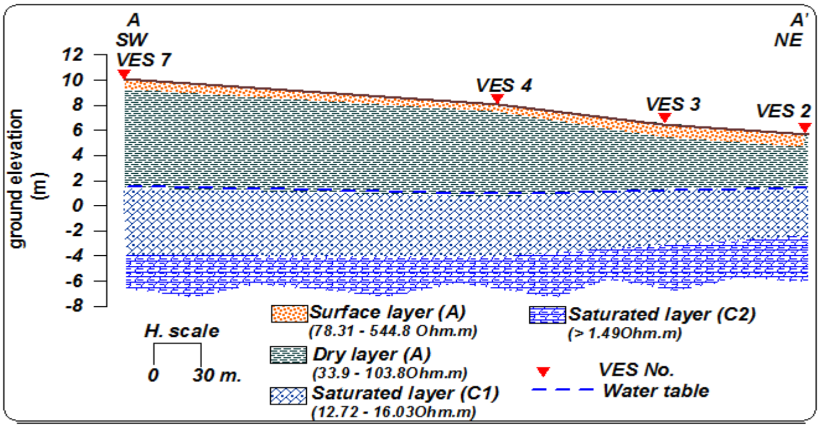


**Fig. (10):** Geoelectrical cross section AA' at site (II)

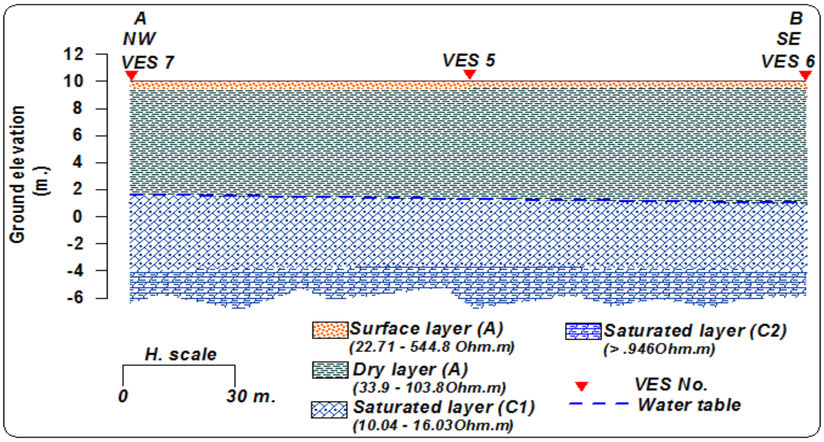


**Fig. (11):** Geoelectrical cross section AB at site (II)

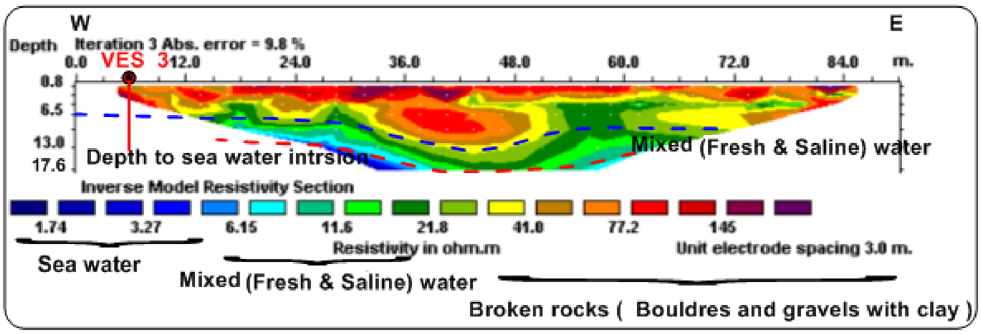


**Fig. (12):** The interpreted 2D imaging profile at VES No.3.

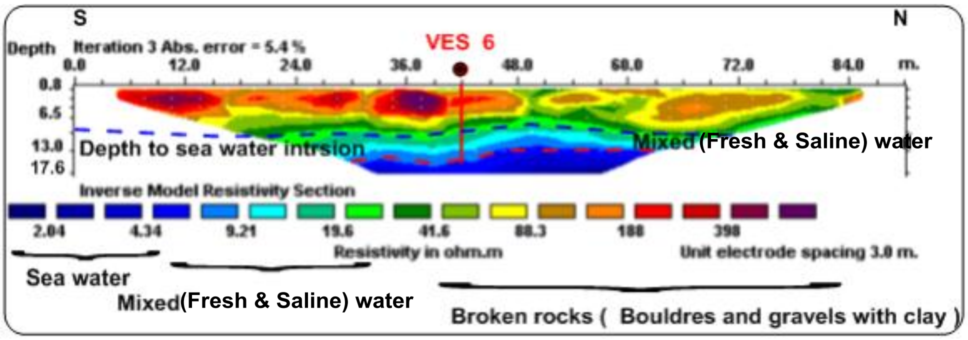


**Fig.(13):** The interpreted 2D imaging profile at VES No.6.

The 2D imaging profiles is applied in the study site (II) to confirm the results of the geoelectrical sounding especially the boundary between successive layers as there is no log data of groundwater wells. Two 2D imaging profiles are measured at VESes No. 3 & 6 (Fig.5) with length 90m. in E –W and S – N direction, i.e. one of them is parallel to the coastal zone and other is perpendicular to it. The interpretation leads to three zones with vertical and horizontal changes in resistivity values and thickness.

## 3. The third study site (III) at the west of Aqaba Gulf:

The Qualitative interpretation for the field curves (Fig. 14) of the study site (III) indicates the following:

1. Most of sounding curves are found to start with high resistivity values, followed by a general drop in the apparent resistivity with increasing electrode separation. The high resistivity indicates dry gravelly and sandy sediments and boulders.
2. Generally, the resistivity values on the first and second cycles (AB/2 = 1 – 100) of the resistivity curves are represented the surface and near surface variations. However, they reflect heterogeneity characterizing of the first layers. In going downwards on the field curves (third cycle AB/2 = > 100), they show nearly the same type, which reflects homogeneity and continuous aerial extension of the deep layers.
3. From the Vertical Electrical Sounding (VES) curves two main sectors ("A" & "B") can be deduce. Sector "A" of the western side of the study site (III) has field curves terminate with H-type ($\rho 1>\rho 2<\rho 3$) whereas the high resistivity values reflects the upper surface of basement rocks or the base of the aquifer. Sector "B" of the eastern side of the study site (III) has field curves terminate with K-type ($\rho 1<\rho 2>\rho 3$) or Q-type ($\rho 1>\rho 2>\rho 3$) reflects increasing in salinity of water and presence of clay intercalation.

*4.* It can be noticed from sounding curves that the thickness of geoelectrical layers increases gradually towards the Gulf. The basement rocks with its high resistivity values appears at shallow depth in sector "A", while it goes more deeper in sector "B".

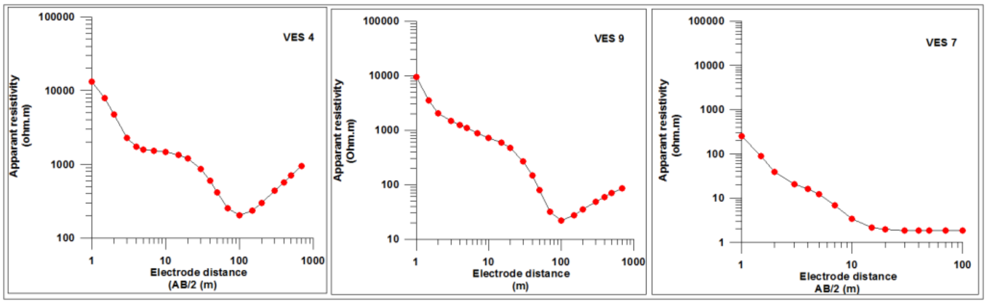


**Fig. (14):** Examples of the vertical electrical sounding curves in the study site (III).

The quantitative interpretation of the field curves of the study site (III) reveal that the geoelectrical succession is formed of a number of layers which are grouped together in four main zones (A, B, C, D), (Table 3). The Surface geoelectrical "A" has a wide range of resistivities varying from 90.39 - 28489 Ohm.m. This variation in resistivity is mainly due to the lithologic variation of dry gravel, some boulders, sand, sandy clay and silt composing the top cover of area deposits, while its thickness varies not large 0.6 m. The dry zone "B" is composed of sand, gravels, boulders, silt and clay. Its resistivity is varies from 11.76 to 1617.8 Ohm.m reflecting the heterogeneity in lithology, while its thickness ranges from 0.7962 to 31.6 m with general decreasing towards the Gulf of Aqaba.

According to the resistivity values and lithology, layer "C" is represented the water bearing formation. It can be differentiated into two units (C1, C2 and C3). The upper unite "C1" consists of wadi deposits with resistivity ranges from 5.955 to 131 Ohm.m. The thickness of this unit ranges from 2.031 to 14.25 m. The second unit "C2" of the waterbearing layer "C" has low resistivity values ranging from 1.801 to 89.84 Ohm.m. It consists of the same deposits of unit "C1".

The last detected layer in the study site (III) is "D" and mainly consists from the crystalline basement rocks. According to the resistivity values, it can be divided to two units (D1 & D2). The upper unit "D1" represents the water saturated fractured basement rocks. It exhibits relatively high resistivity values ranging of 140.6 and 180 Ohm.m and having thickness vary from 9.234 to 10.66 m. The last detected unit in the study site (III) is "D2". It exhibits the highest resistivity values in the study area, ranging from 2114 to 7180 Ohm.m. Also it represents the base of the aquifer in the study area. This layer is not detecting in all sounding stations especially the nearest locations to the Aqaba Gulf.

**Table (3):** The interpreted Vertical Electrical Sounding stations at site (III):

| VES No. | Elev. (m.) | Surface layer(A) | | Dry layer (B) | | Saturated layer (C) | | | | Basement layer(D) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Unit (C1) | | Unit (C2) | | Unit (D1) | | Unit (D2) |
| | | ρ (ohm.m) | h (m) | ρ (ohm.m) | h (m) | ρ (ohm.m) | h (m) | ρ (ohm.m) | h (m) | ρ (ohm.m) | h (m) | ρ (ohm.m) |
| 1 | 1.820 | 410.10 | 0.50 | 113.00 | 0.80 | 11.32 | 2.32 | 1.60 | *** | *** | *** | *** |
| 2 | 12.220 | 12170.00 | 0.53 | 711.50 | 10.61 | 24.97 | 13.25 | 6.97 | 54.75 | 140.60 | 9.23 | 2114.00 |
| 3 | 35.210 | 27818.00 | 0.50 | 481.40 | 31.60 | 131.00 | 14.25 | 21.71 | 56.51 | 88.26 | 14.53 | 7180.00 |
| 4 | 46.520 | 1048.70 | 0.60 | 687.10 | 28.38 | 25.80 | 11.65 | 89.84 | 32.37 | 162.50 | 11.53 | 501.00 |
| 5 | 36.410 | 2544.00 | 0.55 | 643.65 | 30.59 | 99.97 | 12.79 | 12.00 | 55.66 | 150.00 | *** | *** |
| 6 | 21.130 | 107248.00 | 0.37 | 1307.60 | 19.40 | 30.00 | 9.03 | 8.03 | 51.21 | 163.60 | *** | *** |
| 7 | 0.550 | 792.00 | 0.41 | *** | *** | 23.00 | 2.89 | 1.82 | *** | *** | *** | *** |
| 8 | 2.110 | 90.39 | 0.50 | 11.70 | 1.79 | 5.96 | 2.03 | 2.15 | *** | *** | *** | *** |
| 9 | 16.500 | 35913.00 | 0.37 | 807.70 | 13.99 | 68.70 | 12.30 | 12.00 | 55.30 | 180.00 | *** | *** |
| 10 | 33.110 | 28489.00 | 0.43 | 1617.80 | 26.14 | 96.35 | 14.86 | 11.91 | 50.43 | 170.00 | 10.04 | 3395.00 |

Three geoelectrical cross sections (A-A'), (B-B') and (C-C') are constructed from the interpreted data of the soundings and available geologic information (Fg.5). One of them (A-A') is crossing the area of site (III) in NW - SE direction (Fig.15) and two others (B-B'), (C-C') in S - N direction (Figs. 16 & 17). The main observations and conclusions from these sections are:

1- Generally, the geoelectrical cross sections consist of a geoelectrical successions of four geoelectrical layers "A", "B", ”C” and "D" . The last layer (D) is not detected in all sounding station especially the eastern part of the study site (III) area.

2- The resistivity values of these layers increase towards the north western direction of the area which is attributed to increasing percentage of coarse grains and decrease of clay percent.

3- The thickness of dry layer "B" decreases toward the Gulf of Aqaba, while the thickness of the saturated layers ("C1", "C2", "D1") increases in the same direction.

4- It is noticed that the basement rocks shows a general dip towards the eastern direction.

5- There are three saturated units ("C1","C2" & D1) represent different resistivity values with different saturated quality of groundwater.

## GROUNDWATER CONDITION

The demand for water is increasing with time due to industrialism, cultivation and growing population. Researching about alternate sources for clean water is becoming an essential and vital thing because the water became insufficient. In these situations brackish, highly saline waters and seawater can provide useful sources for purification [46]. It has become necessary to adopt different desalination techniques to convert saline water resources into good water quality [47]. Desalination is the removal of salts from water to produce a water of lesser salinity than the source water. Saline water can be converted into potable water by various methods such as distillation, solar evaporation, freezing, electrodialysis, ion exchange and reverse osmosis membrane [48]. When selecting the most suitable process for water desalination, it is essential to realize for what purpose the fresh water will be used.

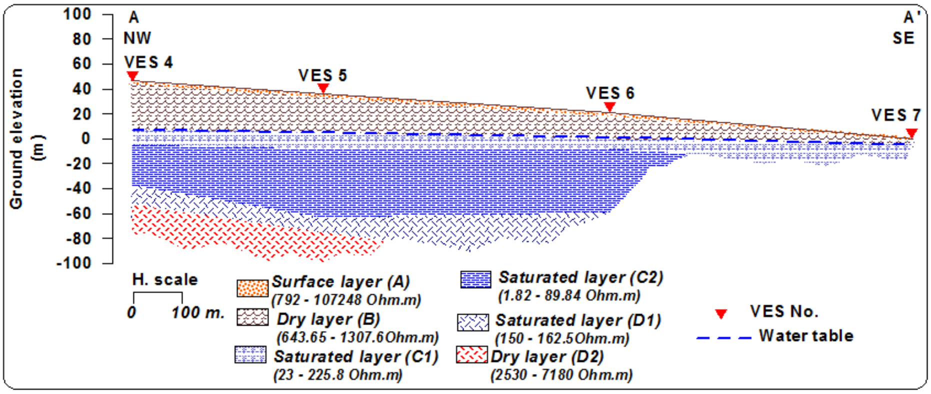


**Fig. (15):** Geoelectrical cross section AA' at site (III)

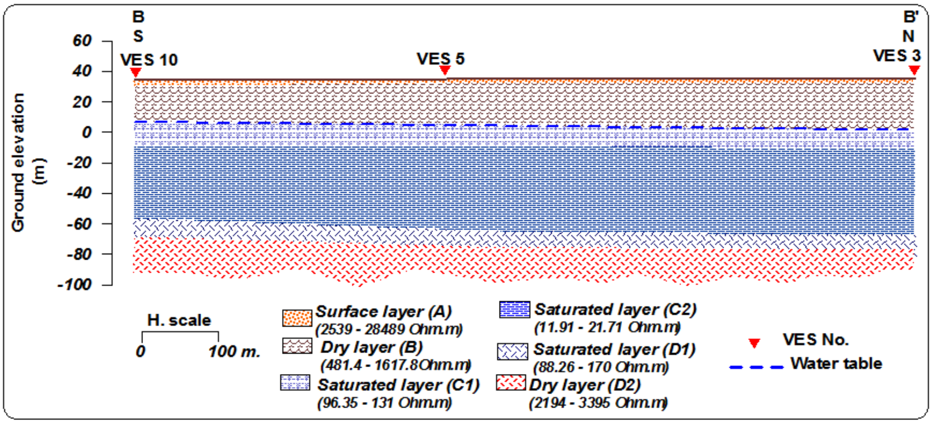


**Fig. (16):** Geoelectrical cross section BB' at site (III)

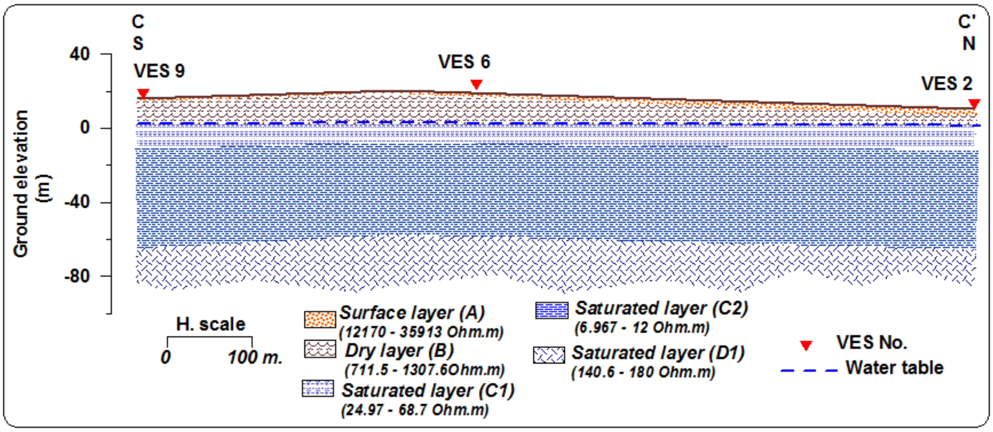


**Fig. (17):** Geoelectrical cross section BB' at site (III)

Source water for desalination can include seawater, groundwater, and municipal wastewater. Seawater intrusion is the subsurface flow of seawater into a subsurface water body. The higher density of seawater allows it to flow beneath the fresher water and move inland. Because seawater has very high salt content, the influx causes a degradation of water quality. This results in higher water treatment costs. Brackish groundwater extraction near the coast could exasperate seawater intrusion. It is imperative to determine the safe yield of the water body when considering a water source for water supply. Safe yield of a groundwater basin or aquifer system is defined as the amount of water that can be withdrawn from it without producing an undesirable effect [49].

The design and construction of seawater desalination systems primarily depend on the salinity of the available water, the substances contained in the water, and the parameters required for product water. It is therefore necessary to design the systems on an individual basis, which is often associated with low costs. Standard systems offered at suitable prices often only represent a compromise, as these frequently do not sufficiently meet the individual needs of the customer. The desalination process produces a salt concentrate. Among the disposal methods in use are surface water discharge, discharge to sewers, deep well injection, land application, evaporation ponds/salt processing, and brine concentration. Which option is used depending mostly on the plant location and desired efficiency. For the groundwater desalination plants, surface water discharge, sewer discharge, and land application can increase the salt load in the receiving waters and soils, which may contaminate water resources and reduce soil fertility. Evaporation ponds often require large land areas and are appropriate only in arid climates and, like other brine concentration techniques; it typically requires impervious disposal areas to prevent contamination of freshwater supplies and soils. Deep well injection is not permitted in many locations, but those that do require permits monitoring wells, and completion in deep confined aquifers to ensure that freshwater supplies are not contaminated.

The groundwater conditions in the study three coastal sites (I, II, III) explain by counter maps constructed from the result of geoelectrical data interpretation and available hydrogeological information. The depth to water contour maps from ground surface exhibit the thickness of above dry layer on saturated units. The water table contour maps related sea levels represent the trend of flow direction. Also, isoresistivity contour maps show the direction of groundwater quality according to resistivity values. The groundwater quality becomes relatively good as increasing resistivity values in saturate units. The isopach contour maps show the thickness of saturated units.These maps help in detecting the suitable sites for drilling groundwater water wells for supplying the desalinization plant and other wells for injection and disposal of the salt water resulting from the desalinization processes. The detail description of the groundwater conditions in the study three sites (I, II, III) are the following:

- ***The study area of site (I):***

As mention above the saturated units (C1, C2 & C3) of the study site (I) is belonged to the Pleistocene aquifer and composed of oolitic and cardium limestone. The depth to water contour map (Fig. 18a) represents values ranging between 1.8 m and 5.8 m. with decreasing value towards the coastal of Mediterranean Sea. The largest depth to water value records at VES No1. The water level contour map (Fig. 18b) represents flow direction northwards whereas, the largest water level records at VES No.1 then decrease to lowest value at VES No. 4 in northern direction. The salinity of existing drilled water wells ranges from 606 to 1200 ppm.

According to the resistivity values obtained from the interpretation of geoelectrical sounding in site (I) three saturated units (C1,C2 & C3) can be detected. Figure (19) shows contour maps to both isoresistivity and isopach of these saturated units (C1, C2 & C3). The unit (C1) has relatively high resistivity values than other units (C2, C3) that range from 11 to 18 Ohm.m) (Fig. 19a). It can be considered as brackish saturated unit with thickness varying from 0.59 and 2.16 m. Generally, the thickness of this units (C1) is decreasing towards the northern direction and is recorded maximum values 2.16 m. at VES No. 1. (Fig. 19b). The unit (C2) exhibits low resistivity than the above units (C1) and can be considered as saline saturated unit. It has resistivity ranging from 2.45 to 4.52 (Fig. 19c) whereas, the maximum record values (4.52 Ohm.m) at VES No.3. The thickness of this unit (C2) (Fig. 19d) is larger than the above one and exhibits values ranging from 6.08 to 13.6 m. The maximum thickness values (13. 6m) records at VES No.1 and decrease northwards. The last saturated unit (C3) can be considered as more saline saturated unit and affected by sea water intrusion. It has resistivity values not exceed 1.09 Ohm.m. (Fig. 19e). The minimum resistivity value (0.51 Ohm.m) recorded at VES No. 4.

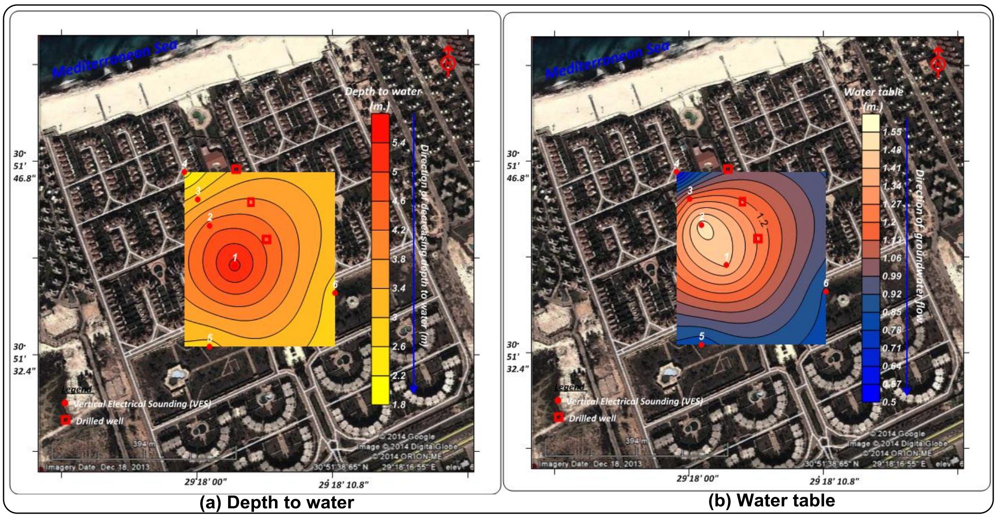


**Fig. (18):** Contour maps of depth to water and water table of site (I)

Therefore, the best locations of drill productive groundwater wells are at VESes No.1, 2 with total depth reaches 12m. It can be drilled two productive groundwater wells around both VESes No.1, 2 with sufficient distance not less 100m. to prevent drawdown of water table during pumping because the small thickness of the brackish and saline unit (C1&C2). If there is no sufficient distance the productive groundwater wells can be alternative time done. The design of these wells are consisted from casing beside the dry layer (5m) then filter beside the brackish (C1) and saline (C2) units to avoid increasing of water salinity. Economically as mention above, desalinization of the brackish water is much cheaper than desalinization of sea water. While the best location for injection well is at VES No.4 due to its distance from the production wells and it lies down water flow near to the shore line to prevent the groundwater pollution.

- ***The study area of site (II):***

The water bearing units (C1&C2) in site (II) area is being of the Quaternary age. Its deposits are consisted from sand and gravel with clay and limestone intercalations. The depth to water decreases towards the eastern direction (Fig. 20a). Its values range between 2 m and 11 m. whereas, the largest depth to water value (9 m.) is recorded at VES No.6. The water level contour map (Fig. 20b) represents flow direction towards the eastern trend whereas; the largest water level is (1.5m.) recorded at VES No.2 then decrease to lowest value (0.2 m.) at VES No. 1.

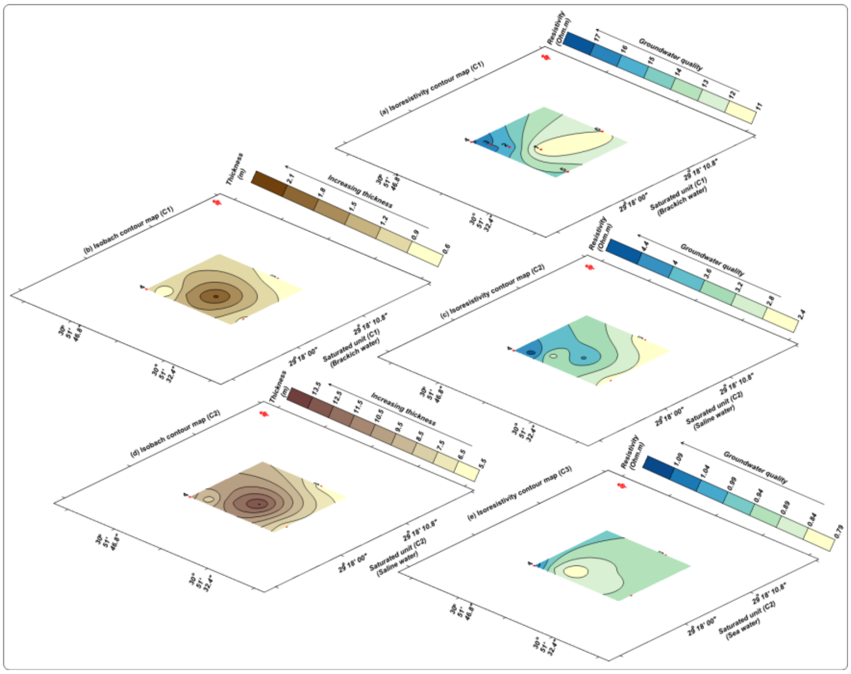


**Fig. (19):** Contour maps of resistivity and thickness of saturated water units, site (I)

The interpretation of geoelectrical sounding at site (II) area revealed two saturated units (C1 & C2). Figure (22) shows contour maps to both isoresistivity and isopach for these saturated units (C1 & C2). The saturated unit (C1) with brackish groundwater has relatively higher resistivity than unit (C2) (Fig. 21a). Its resistivity values are ranging from 6 to 16 Ohm.m decreasing towards the eastern direction. This meaning the groundwater quality becomes more saline as the effect of sea water of the Suez Gulf. The thickness of unit (C1) generally decrease towards the eastern direction with values ranges from 3 to 5 m. (Fig. 21b). The unit (C2) exhibits low resistivity than the above units (C1) and become more saline water. It has resistivity not exceed 1.5 Ohm.m. (Fig. 21c). Generally, the isoresistivity contour maps exhibits decreasing in resistivity values towards the eastern and southern directions.

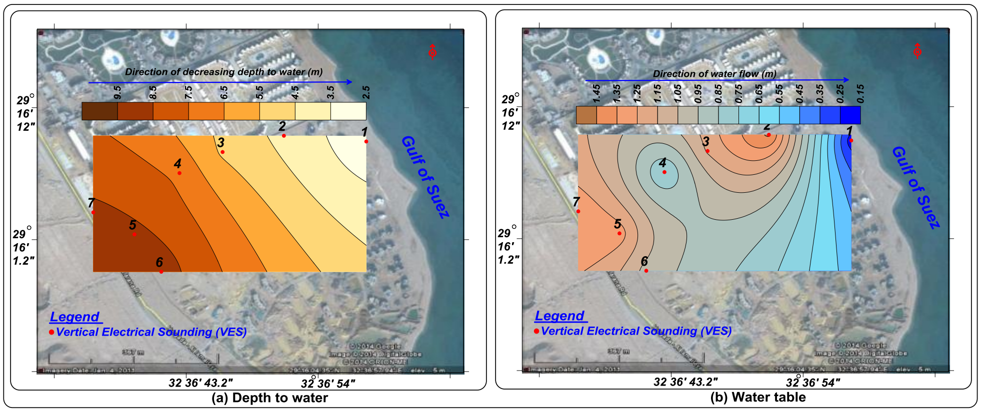


**Fig. (20):** Contour maps of depth to water and water table of site (II)

Therefore, the best locations of drill productive groundwater wells are at VESes No.5, 6&7 with total depth reaches 100m. The previous geology information referred that the Quaternary deposits at this site area more than 100m depth. It must be considered the distance between the two successive drilled wells whereas the distance must be not less than 150m to prevent drawdown of water level during pumping from it. According to this, it has no sufficient distance, it is an alternative work to gain the require amount for desalination plant. Also the alternative work for drilled wells is suitable during periodic maintenance and troubles to any wells. As the depth to water reaches 10m the filters must be existed at 30m for safe drawdown and suitable place for pump. The best location of injection wells are the area near shore line of the Suez Gulf at VESes 2, 3 &4 with depth reach 125m.

- ***The study area of site (III):***

The Quaternary and Precambrian aquifers are detected in the site (III) area. The deposits of Quaternary aquifer (C1& C2) are consisted of sand and gravel with clay but the basement rocks are related to the Precambrian aquifer (D1). The depth to water as shows in figure (22a) decreases towards the eastern and southern directions. Its values range between 1 m and 31 m. whereas, the largest depth to water value (31 m.) recorded VES No.5. The water level contour map (Fig. 22b) represents flow direction towards the eastern trend whereas; the largest water level (17.5 m.) is recorded at VES No.4 then decreasing to lowest value (0.4 m.) at VES No. 7.

The interpretation of geoelectrical sounding at site (III) area revealed three saturated units (C1, C2 & D1). Figure (23) shows contour maps to both isoresistivity and isopach for these saturated units (C1, C2 & D1). The unit (C1) has relatively high resistivity values than other units (C2, D1) that ranging from 6 to 131 Ohm.m) (Fig. 23a). It can be considered as brackish saturated unit with thickness vary from 2 and 15 m. The unit (C2) exhibits low resistivity than the above units (C1) and can be considered as saline saturated unit. It has resistivity ranges from 2 to 12 Ohm.m (Fig. 23c). The thickness of this unit (C2) is larger than the above one and exhibits values ranging from 32 to 56 m. (Fig. 23d). The last saturated unit (D1) can be considered as more saline saturated unit and affected by sea water intrusion. It has resistivity values ranging from 88 to 180 Ohm.m. (Fig. 23e).The base of this unit is not detected in all sounding stations especially at the eastern side. The isopach contour map of this unit exhibits decreasing in its values towards the eastern and southern directions.

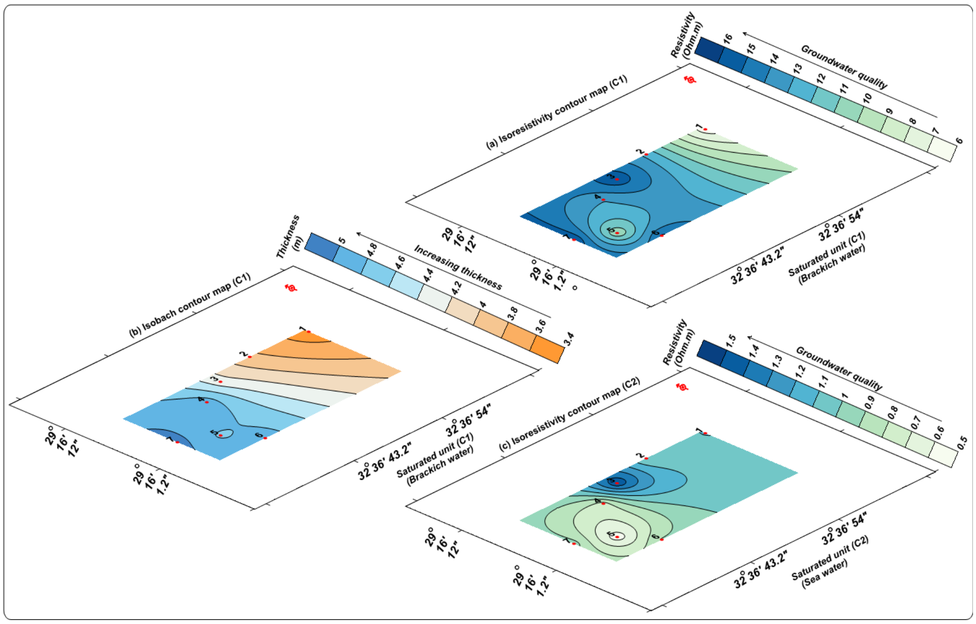


**Fig. (21):** Contour maps of resistivity and thickness of saturated water units, site (II)

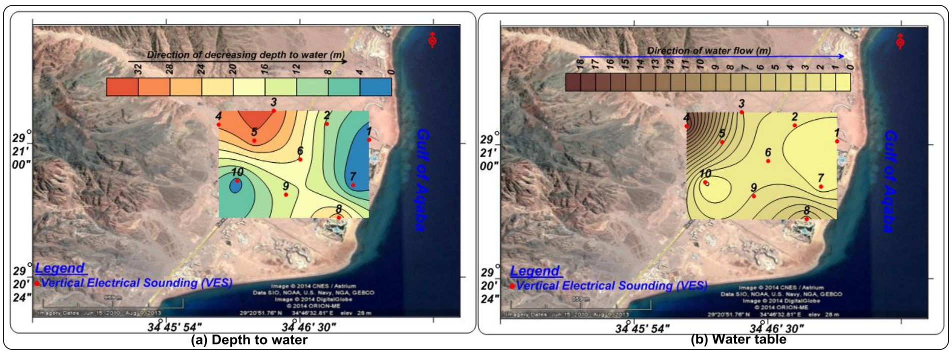


**Fig. (22):** Contour maps of depth to water and water table of site (III)

Therefore, the sites of VES Nos. 3, 4 and 5 are suitable for drilling production water wells under the previous conditions due to large thickness of coarser sediment, higher permeability and relatively better water quality with total depth reach 120m. While the site of VES No.7 is suitable for drilling injection well due to its distance from the production wells and it lies down water flow near to the shore line to prevent the groundwater pollution.

## CONCLUSIONS AND RECOMMENDATIONS

The present study is a trial to participate in desalination of groundwater in coastal areas. Three selected sites (I, II & III) were chosen at Mediterranean Sea, Suez Gulf and Aqaba Gulf respectively. These selected sites have different lithological content and therefore different waterbearing conditions. This study is dealing with this vital and essential subject by study three sites (I, II, III) on these coastal areas with different lithological conditions to become act as a model that can be performed in their vicinities. The aim of study is finding out suitable sites for drilling some groundwater water wells for supplying the desalinization plant and other wells for injection and disposal of the salt water resulting from the desalinization process. The geoelectrical techniques from geoelectrical sounding (1D) and two dimensional imaging profiles (2D) were applied. The obtained results from interpretation led to different geoelectrical successions which are formed from a number of layers. They are grouped together in three main layers (A, B, C) at both sites (I &II) but four geoelectrical layer (A, B, C &D) at site (III). These geoelectrical successions divided to dry layers and other saturated layers. According to resistivity values the saturated layers divided to different saturated waterbearing units which are brackish, saline and more saline that affected by seawater intrusion.

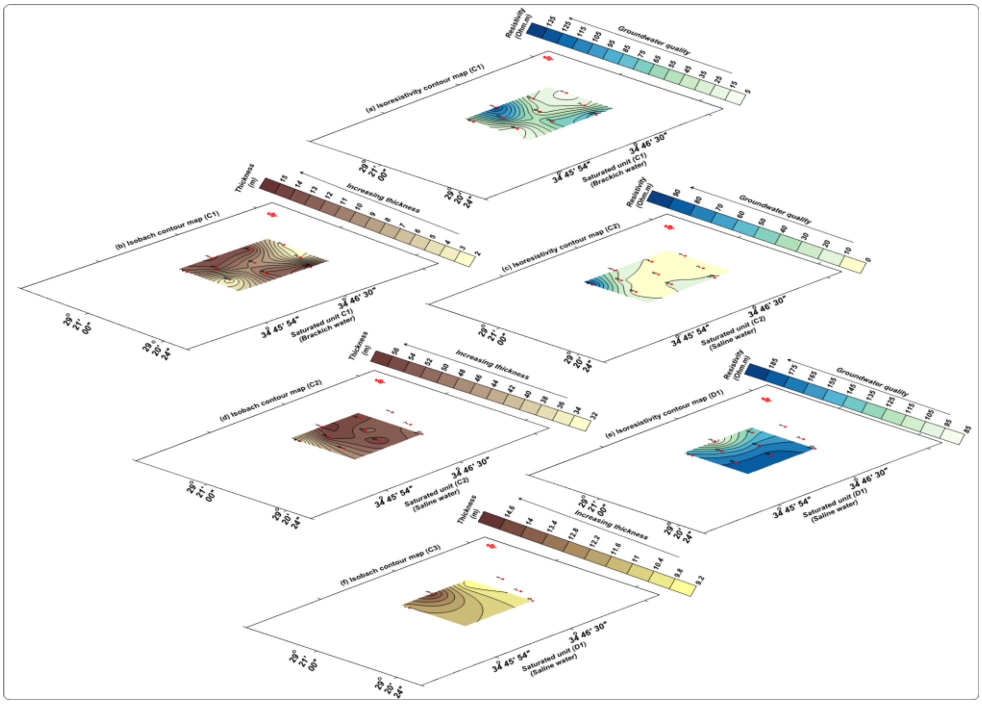

**Fig. (23):** Contour maps of resistivity and thickness of saturated water units, site (III)

The data of the depth to water from ground surface exhibit the thickness of above dry layer on saturated units and the water table related sea levels represent the trend of flow direction. Also, the resistivity values indicata the direction of groundwater quality as increasing resistivity values in saturate units. All these results used in constructed contour maps that help in detecting the suitable sites for drilling groundwater water wells for supplying the desalinization plant and other wells for injection and disposal of the salt water resulting from the desalinization processes. The best locations of drill productive groundwater wells are at VESes No.1, 2 with total depth reaches 12m. and at VESes No.5, 6&7 with total depth reaches 100m. in site (II) in addition at VES Nos. 3, 4 & 5 in site (III) with total depth reach 120m. While the best location for injection well is at VES No.4 in site (I) and at VESes 2, 3 &4 in site (II) finally at VES No.7. due to its distance from the production wells and it lies down water flow near to the shore line.

The recommendion of this study is exploiting the brackish water layer which is considered as the strategic water supply. Economically, desalinization of the brackish water is much cheaper than desalinization of sea water. In exploiting the brackish water zone, wells should not penetrate the saline water. There are some important things to respect as follows:

***1.*** The productive wells must be existed before the injection wells to prevent pollution.
***2.*** The radius of casing pipe and filter for productive wells is around 8 – 10 inches and for injection wells around 10 – 12 inches.
***3.*** Electrical log is more essential to delineate the following:
- The successive different layer and the boundary between them.
- The clay layer existed in waterbearing layers.
- The best design for wells.
- Detecting salinity degree with depth.
- The suitable depth for both productive and injection wells

***4.*** Carrying pumping test is useful to delineate the hydrologic parameter especially safe yield.
***5.*** It must be considered that the depth of filter in injection well is lowering in its level than in productive well by 25m during design wells process. It prevents the mixing of disposal water that resulted from desalination process with the water of productive wells.
***6.*** Detecting the degree salinity of water is useful to design the ability of desalination plant.
***7.*** Economically, it must be detected the potential of productive wells whereas, the third is used and the remains injected to disposal wells.
***8.*** It must be respect the environmental laws related this process.

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# مساهمة جيوفيزيائية لتحديد مواقع أبار لتحلية المياه الجوفيه والتخلص من المياه المالحة فى اماكن مختاره - مصر

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*قسم الاستكشاف الجيوفيزيائى - مركز بحوث الصحراء*

المساهمه الجيوفيزيائيه فى تحديد مواقع ابار لاقامة محطات تحليه معتمده على المياه الجوفيه منها ذات ملوحة أقل من ملوحة البحر على المناطق الساحليه لتلبية الاحتياجات المائيه لهم مما يغنيهم الاعتماد على المياه المنقوله هو الهدف الرئيسى من تلك الدراسه. ولتحقيقه تم عمل قياسات جيوكهربيه راسيه و اخرى ثنائية الابعاد فى المناطق المحدده للدراسه و هى ثلاث مناطق (I, II, III). الاولى على ساحل البحر الابيض المتوسط و الثانيه شرق خليج السويس و الاخيره شرق خليج العقبه حيث يمكن اعتبارهم كنموذج يمكن تطبيقه على المناطق المجاوره لهم هذا بالاضافه الى كونهم فى ظروف جيولوجيه مختلفه. من نتائج تلك القياسات للطبقات الحامله للمياه الجوفيه نستخلص سمكها و العمق لسطح المياه واتجاه حركتها المتوقع مع امكانية تحديد افضل الاماكن لحفر ابار انتاجيه ذات ملوحه اقل نسبيا. تلك الابار الانتاجيه توفر المياه اللازمه لتغذية محطات التحليه التى تقام عليها. هذا بالاضافه الى تحديد اماكن لابار صرف يتم خلالها التخلص من المياه المالحه الناتجه من عملية التحليله عن طريق الحقن. و كلا من هذه الابار لها التصميم المناسب.

اسفرت نتائج تحليل القياسات الجيوكهربيه الى وجود ثلاث طبقات متعاقبه (A, B, C) فى كلا من المنطقه الاولى (I) والثانيه (II). و كانت الطبقه الثالثه (C) هى المشبعه بالمياه الجوفيه و تم تقسيمها الى نطاقين (C1, C2) حسب الاختلافات فى قيم المقاومه النوعيه والتى تشير الى نوعيات مختلفه من المياه الجوفيه ذات الملوحه الاعلى كلما اتجهنا الى اسفل. كذلك السمك لهذه الطبقه الحامله للمياه الجوفيه (C) يزداد كلما اتجهنا عكس الساحل. اما فى المنطقه الثالثه (III) فالنتائج تظهر اربعة طبقات متعاقبه (A, B, C, D). و كانت الطبقه الحامله للمياه الجوفيه مقسمه الى طبقتين (C) (D) , حسب المحتوى الصخرى لها. فالاولى (C) تتكون من رواسب العصر الرباعى كالرمل و الحصى وتداخلات من الطين اما الطبقه الاخرى (D) فتتكون صخور القاعده. تلك الطبقات تم تقسيمها الى نطاقات مختلفه حسب قيم المقاومه والتى لها دلاله نسبيه على نوعية المياه الجوفيه. فالاولى (C) امكن تقسيمها الى نطاقين (C1, C2) الاولى (C1) اقل سمكا و ملوحه من الاخرى التى تليها (C2). اما الطبقه الاخيره (D) فامكن تقسيمها حسب قيم المقاومه النوعيه الى نطاقين (D1, D2) و التى لم يتم التوصل اليها عند جميع مواقع الجسات الجيوكهربيه الراسيه و خاصة فى الاتجاه الشرقى لتلك لمنطقه (III) و ذلك لتداخل ماء البحر و ايضا انحدار تلك الطبقه الى

اسفل كلما اتجهنا الى الساحل. و اظهرت النتائج ايضا ان الطبقه الاولى (D1) مشبعه بالمياه الجوفيه فى اماكن التشققات بتلك الصخور القاعديه.

وطبقا لنتائج هذة الدراسة أمكن التوصيه باماكن الابار الانتاجيه التى تغذى محطات التحليه اعتمادا على المياه الجوفيه ذات الملوحات الاقل و السمك الاكبر والعمق المناسب و البعيده عن الشريط الساحلى لتلك المناطق الخاضعه للدراسه. و ابار اخرى لصرف المياه الناتجه من عمليات التحليه وهى غالبا قريبه من الساحل وفى اتجاه حركة المياه الجوفيه. كما انه تم التوصيه بحفر اكثر من بئر انتاجى فى نطاق المواقع المحدده فى حالة الرغبه للحصول على كميات اكبر من المياه الجوفيه ولكن بمراعاة المسافه بين الابار و ساعات التشغيل لكل منها. وهذا ما يحدده قياسات تجارب السحب الامن التى يجب تنفيذها لتحقيق الاستفاده القصوى. و بناءا على تلك الدراسه تم التنفيذ فى بعض الاماكن و جاءت النتائج متوافقه مع ما تم ذكره سابقا.