Egy. J. Pure & Appl. Sci. 2014; 52(1):37-46

Egyptian Journal of Pure and Applied Science

Impact of Wells's Design on Their Productivity in Selected Areas in the Western Desert, Egypt.

El Sabri, M. A. Shedid*

Hydrology department, Desert Research Center, Cairo, Egypt,

ARTICLE INFO

Article history:
Received 07 July 2014
Accepted 23 August 2014

Keywords:
Well's design;
gravel pack;
well corrosion;
well encrustation;
head loss;
aquifer loss.

ABSTRACT

Proper groundwater development in any area requires efficient management tools for well fields or individual wells. The selected areas in El Tamneen area in Darb El Arbeen and East El Owinat in the southern part of the Western Desert have a great importance for agricultural development in the last few years. Activity for groundwater development was started in these areas since the early 1960's. At the present time, these areas suffer a variety of problems where groundwater levels declined, the wells productivity are dropped and some well failure. The groundwater potentiality is changing between high to medium in the areas. The main problems in the selected areas are recorded with groundwater quality and quantity deterioration and shortage of well life span (from 5 to 10 years in many cases). The present study deals with specific area in which several water wells were drilled within the time between 1999 and 2012, most of these wells are not will designed and don't comply with the specifications set by the Companies which dealt with the drilling processes. However, other nearby drilled wells exists still now in good condition and don't suffer from these problems. Such problems were detected by the present author during his visits to the study areas. The present investigation show that local steel casing of low resistance to corrosion or six bar resistance UPVC with short screen length, large ring slot openings and using gravel pack of large size from calcareous materials or without any gravel pack are the main reasons of well failure. The current field investigations proved that groundwater quality and quantity deterioration are mainly attributed to poor well design, over pumping and return flow after irrigation.

Introduction

Two areas are selected for the present investigation, El Tamneen and East El Owinat areas. El Tamaneen area occupies the middle part of Darb El Arbaein project which is bounded by longitudes 30^0 15$^-$ and 30^0 30$^-$ E and latitudes 23^0 50$^-$ and 24^0 10$^-$ N with total area of about 140 km^2 (**Fig.1**). The new reclaimed lands in the study area are expected to face problems in water requirements for the near future as groundwater is heavily exploited since the year 1999. The recharge to the Nubian aquifer may not be sufficient to support the water demands for the development plan (2430 feddans). This may lead to continuous decline in the groundwater levels and quality.

On the other hand, the East El Oweinat project area is considered as one of the great projects for agricultural expansion in Egypt, which depends on groundwater extraction from the Nubian Sandstone aquifer. It occupies an area of about 12085 km^2 between latitudes 22^0 00 and 23^0 00 N and longitudes 28^0 00 and 29^0 00 E (**Fig. 1**). The present new reclamation project of East El Oweinat area is divided into 22 square areas, each area has a 10 x 10 km (about 24000 feddans). The proposed number of wells for each area is 83 wells with discharge rate about 230 m^3/h for 15 hour daily for each well to irrigate 120 feddans. The reclaimed area is planned to reach 227000 feddans which will need about 1884 wells for irrigation [1].

The Nubian sandstone in El Tamaneen area (Darb El Arbeen) and East El Owinat area is considered as a part of the great Nubian basin which is characterized by Basement rocks outcrops at the eastern and southern extremities of the Western Desert as well as in many isolated areas associated with fault lines. The Precambrian shield, in Egypt and adjacent areas is covered by clastic sedimentary rocks (up to 3000 m) ranging in geologic age from Cambrian to Quaternary [2]. The water bearing rocks in the selected areas have a

* Corresponding author.
E-mail address: elsabri63@hotmail.com

thickness varies between few meters to 500 meters. They built up of sandstones interbeded with lateral and vertical varying silt, clay and shale.

The main objective of the present work concerns with the definition of main reasons behind well failure in the selected area in order to recommend a new proper well design. To fulfill this objective an extensive field survey program was carried out to collect and update the available information. Well inventory data were implemented during the year 1999 (Ministry of Water Resources and Irrigation) and 2012 (present author) in order to collect and update well inventory information in the form of tables and maps for well location, well discharge calculation, well design and hydraulic parameters.

On the other hand, groundwater quality is deteriorated in specific locations. The problem is attributed to many reasons; corrosion and encrustation of dissolved minerals in groundwater, using short screen length, large ring slot opening, gravel pack from calcareous materials and installing local steel casing of low resistance [3]. Therefore, it is important to investigate well design parameters and their impact up on water productivity in the above mentioned area. The recorded well life in some locations extends for less than five years and their productivity was sharply decreased.

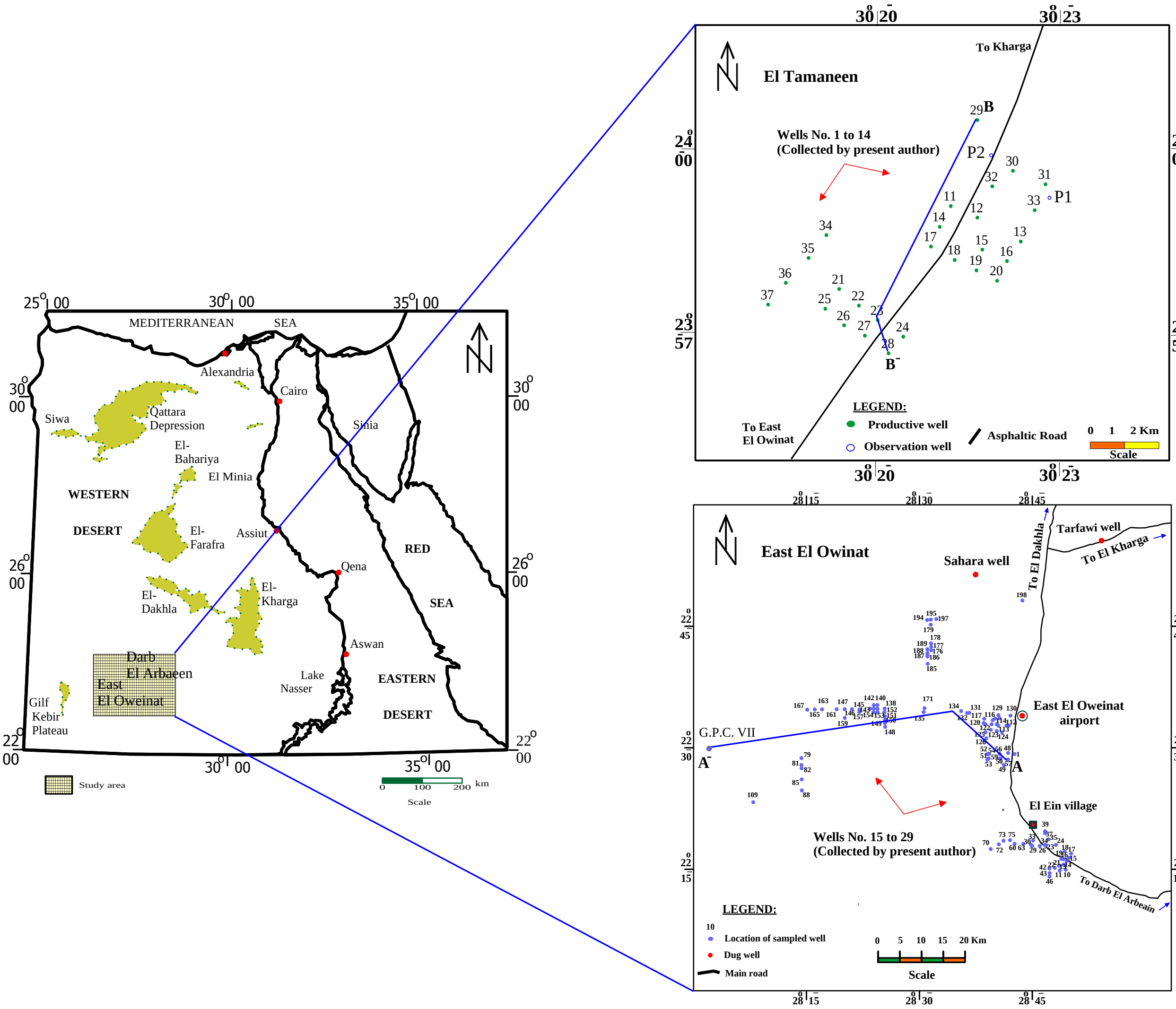

Fig. 1: Key map showing well locations and the directions of lithostratigraphic correlation cross sections (A - A⁻ and B - B⁻).

Aquifer system

Hydrogeologically, the Nubian Sandstone aquifer in el Tamaneen area is exploited through twenty seven deep wells (Table 1). They are pumped with a discharge rate of about 150 m^3/h for 12 hour/day to irrigate about 2430 feddans. The regional hydrogeological section constructed along Darb El Arbaein area (Fig. 2, section A - A⁻) shows that the study area forms a local basin surrounded by two uplifting structures.

The groundwater is available from three successive water bearing units capped by shale beds of Dakhla Formation and underlined by the basement complex. The total thickness of the Nubian water bearing units ranges from 174 m in the eastern part of the aquifer (well No. 16) to 242 m in the west (well No. 35), with a general increase towards the west and south directions.

Table 1: Hydrogeological data in El Tamaneen area. (measurements of depth to water and TDS are carried out by present author, 2012).

Well No.	Ground elevation (m) (a.m.s.l.) ***	Nubian Sandstone thickness (m) ***	Basement surface (m) (m.s.l.) ***	Water bearing units thick. (m) ***	Depth to water (m) 1999	Depth to water (m) 2012	TDS (ppm) 2007 and 2012	Piezometric surface (m) (m.s.l.) 1999 ***	Depletion In period
11 (1)	145.9	425	-279.1	237	20.92	62.50	1160 - 1340	+124.98	41.5
12	142.2	425.5	-283.3	216	16.5	-		+125.7	-
13 (2)	133.8	441	-307.2	213	9.25	-	1426 - 1747	+124.55	-
14	145.2	385.5	-240.3	198	18.4	45.4		+126.8	27.1
15 (3)	135.38	423	-287.62	198	12.2	-	1450 - 1697	+123.18	-
16	131.33	401	-269.67	174	7.9	-		+123.43	-
17 (4)	144.1	485	-340.9	229	17.8	-	1478 - 1688	+126.3	-
18 (5)	140.66	472	-331.34	218	15.15	-	1460 - 1756	+125.51	-
19	135.00	496	-361.00	232	11..33	-		+123.67	-
20	130.5	505	-374.5	220	8.09	48.25		+122.41	48.2
21 (6)	148.16	490	-341.84	220	22.5	-	1640 - 1756	+125.66	-
22	144.46	490	-345.54	220	19..3	-		+125.16	-
23 (7)	141.39	535	-393.61	228	15.64	48.7	1492 - 1892	+125.75	33.0
24 (8)	136.2	500	-363.8	214	13.25	-	1755 - 2136	+122.95	-
25	149.66	496	-346.34	230	22.1	-		+127.56	-
26	145.60	500	-354.4	227	21.1	59.56		+124.5	38.4
27 (9)	144.80	500	-355.2	212	16.00	-	1588 - 2284	+128.8	-
28 (10)	138.6	501	-362.4	210	12.08	-	1870 - 2403	+126.52	-
29 (11)	150.2	393	-242.8	231	25.85	-	916 - 1162	+124.35	-
30	141.69	365	-223.31	191	15.9	-		+125.79	-
31 (12)	138.63	397	-258.37	209	11.2	70.00	1212 - 1429	+127.43	59.8
32	142.66	409.5	-266.84	228	17.9	-		+124.76	-
33	131.1	418	-286.9	204	15.64	-		+115.46	-
34	152.42	486	-333.58	232	27.00	-		+125.42	-
35	157.6	501	-343.4	242	17.8	64.25		+139.8	46.4
36	159.2	457	-297.8	211	24.43	53.3		+134.77	28.8
37 (13)	160.6	451	-290.4	206	29.43	-	1660 - 1897	+131.17	-
P1	133.2	-	-	-	12.5	54.15		+120.70	41.6
P2 (14)	152.2	-	-	-	25.2	-		+127.0	-

Note: *** Data collected after the Ministry of Water Resources and Irrigation [4].

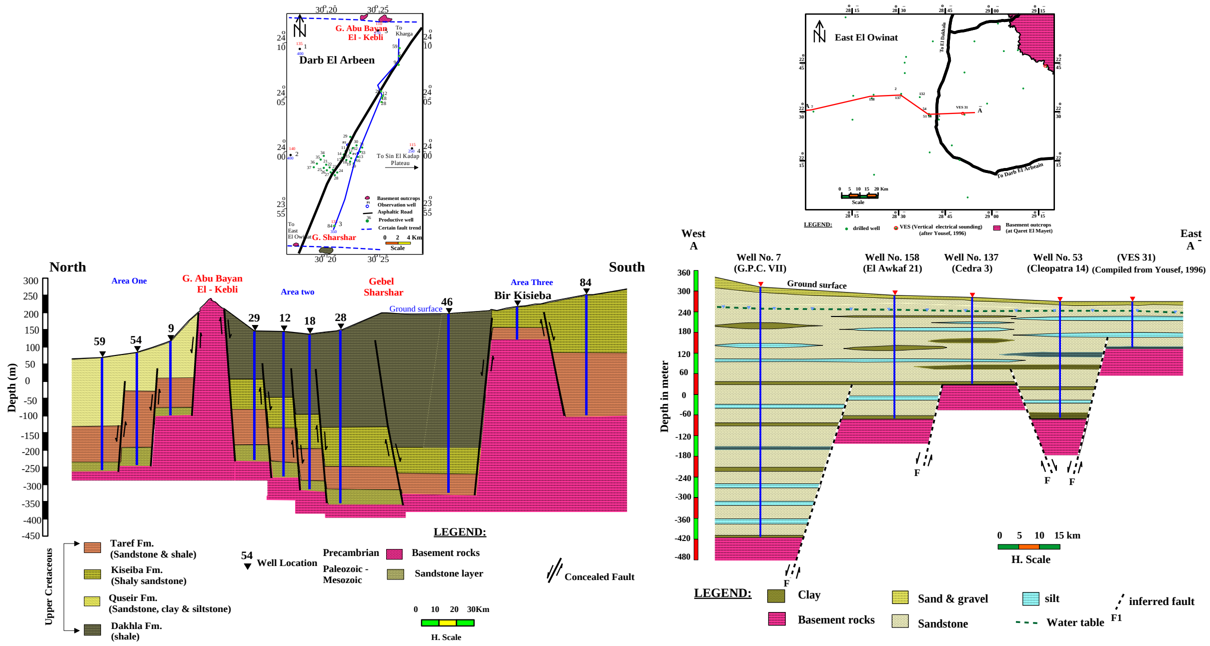

Fig. 2: Hydrogeological cross section A – A- and B – B- (modified after Fattah [5] and after Dahab et al [6]).

On the other hand in East El Owinat area the hydrogeological data in Table (2) and the hydrogeological section (Fig. 2, section B - B⁻) show that the penetrated succession is built up of fine to medium grained sand and sandstone intercalated by thin beds of clay and siltstone of definite continuation. This situation has led to hydraulic connection between the upper and lower water bearing sandy and sandstone layers to be acted as one hydraulic unit. The depth to basement and hence the total thickness of the sandy layers increases towards the southwest, west and northwest while it crops out at the northeast, e.g. Qaret El Mayet locality.

The available data through the years 1999 and 2012 indicates that the groundwater conditions in the two areas are characterized by an unsteady state of flow due to the continuous activity of reclamation areas since 1960. The piezometric surface for the year 1999 in el Tamaneen area ranges between +115.46 m (in the eastern part) and +131.17 m (in the west) [7]. The groundwater flows generally from west to east (Fig. 3).

On the other hand, in East El Owinat area the groundwater levels range from +254.91 m at the southwest to +220.00 m (amsl) at the northeast and hence the groundwater flow is mainly from southwest towards northeast direction (Fig. 3). The following investigations are defined and their impact are distinguished:

i - Recharge - discharge records

The estimated annual recharge to the aquifer in El Tamaneen area is 10.50835 million m^3/year [8]. Reclamation area needs about 14.57835 million m^3/year for irrigation purposes. The present annual discharge from the present wells exceeds the required demand by about 4.07 million m^3/year.

The groundwater inflow across the southwestern front of East El Owinat area is estimated using the Darcy approach [9] and flow net map after Dahab, et al [6]. It is estimated to be equal about 38.067 million m^3/year. While agricultural expansion needs 291.87million m^3/year [10].

ii- Decline of groundwater levels and deterioration of groundwater quality

According to measurements of depth to water and TDS carried out by the present author (tables 1 and 2) (2012) the following can be concluded:

The extensive pumping of groundwater in the studied areas exerts a decline in groundwater levels and increasing of groundwater salinity. Accordingly, reclamation in El Tamaneen area exerts a shortage in the aquifer reserves represented by continuous drop in groundwater levels. The local depletion for the years 1999 and 2012 ranges between 28 m and 59 m (Table. 1). The relative increase of salinity values towards south compared to those of the northern part (as indicated from the salinity contour map and salinity variation diagram) (Figs. 4 and 5) is attributed to the marked increase in the thickness of the productive zone in addition to the increase of clay facies at the southern portion. The middle parts represent a transition zone as it is considered a zone of relatively continuous pumping. However, in Darb El Arbeen area as a whole, the nonhomogenity of lithology and complicated structure cause disturbance in groundwater level and salinity. For East El Owinat area a drop in groundwater level ranges between 4.0m and 10 m during the years 2002 and 2012 (Table. 2) is observed due to the same reasons (Figs. 4 and 5).

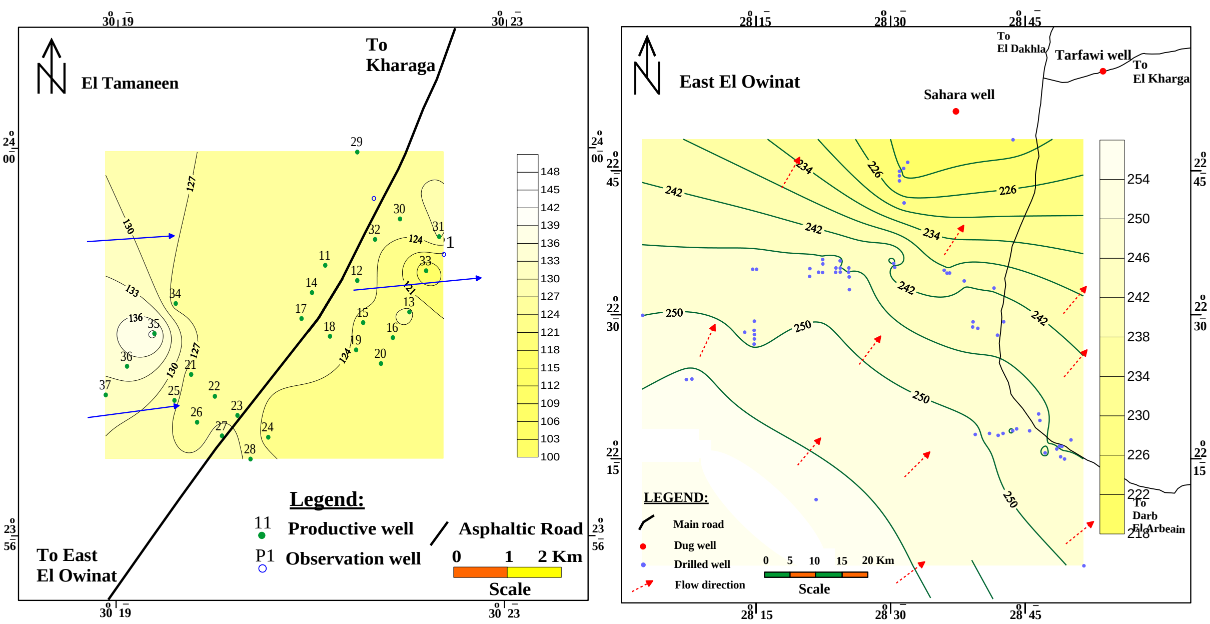

Fig. 3: Flow direction in El Tamaneen and East El Owinat area (present author, 2012).

Table 2: Hydrogeological data in East El Oweinat area (measurements of depth to water and TDS are carried out by present author, 2012).

Well No.	Ground elevation (m) (a.s.l)	Nubian Sandstone thickness (m)	Basement top surface (m) (a.s.l)	Depth to water (m) 2002 ***	Depth to water (m) 2012	TDS (ppm) 2002 - 2012	Water level (m) (a.s.l) (2002)	Depletion In period
1 (15)	+ 273.48	186.66	+ 80.98	29.10	33.2	317 - 402	+ 244.38	4.1
2	+ 280.94	202.50	+ 68.44	33.7	-	-	+ 247.24	-
3	+ 288.60	243.50	+ 35.10	39.03	-	-	+ 249.57	-
4	+ 307.12	416.50	- 124.38	52.21	-	-	+ 254.91	-
5 (16)	+ 274.36	421.70	- 153.94	27.45	33.4	514 - 622	+ 246.91	5.95
6	+ 290.33	611.70	- 341.67	-	-	-	-	-
7	+ 309.79	706.00	- 408.21	59.85		-	+ 249.94	-
9	+ 277.38	317.78	- 43.72	31.80	-	-	+ 245.58	-
10 (17)	+ 278.00	295.11	- 22.00	30.80	36.2	553 - 642	+ 247.20	5.4
12	+ 276.03	297.83	- 28.32	29.96	-	-	+ 246.07	-
16	+ 276.57	317.06	- 43.54	31.10	-	-	+ 245.47	-
17 (18)	+ 273.88	294.16	- 22.78	29.27	35.3	836 - 942	+ 244.61	6.03
19	+ 274.85	309.45	- 37.37	29.76	-	-	+ 245.04	-
20	+ 275.62	313.05	- 39.93	28.54	-	-	+ 247.08	-
27	+ 281.50	-	-	34.00	-	-	+ 247.08	-
35	+ 276.71	-	-	29.80	-	-	+ 246.91	-
51 (19)	+ 266.33	342.00	- 83.77	22.57	28.1	932 - 1024	+ 243.66	5.53
53	+ 269.35	331.00	- 69.65	25.50	-		+ 243.85	-
54	+ 266.12	342.00	- 83.88	22.75	-		+ 243.37	-
62	+ 280.37	437.00	- 169.63	28.24	-		+ 244.97	-
64	+ 280.83	454.00	- 179.17	29.90	-		+ 250.47	-
69	+ 281.02	442.00	- 168.98	32.55	-		+ 248.28	-
70 (20)	+ 282.05	451.00	- 172.95	32.70	39.2	603 - 702	+ 249.02	6.5
89	+ 292.90	339.00	- 61.10	31.90	-	-	+ 249.45	-
90	+ 293.43	-	-	44.00	-	-	+ 249.43	-
91 (21)	+ 301.05	-	-	51.50	57.2	402 - 522	+ 249.55	5.7
92	+ 302.45	342.00	- 51.55	53.00	-	-	+ 249.45	-
93	+ 295.70	-	-	46.00	-	-	+ 249.70	-
104	+ 297.10	-	-	47.55	-	-	+ 249.55	-
109 (22)	+ 308.56	-	-	53.57	60.2	389 - 490	+ 254.99	6.63
111	+ 309.58	-	-	55.00	-	-	+ 254.58	-
113	+ 262.82	-	-	21.20	-	-	+ 241.82	-
118	+ 270.49	-	-	28.85	-	-	+ 241.64	-
131 (23)	+ 264.92	309.00	- 55.08	26.59	36.7	313 - 410	+ 238.33	10.11
132	+ 262.56	322.00	- 68.44	24.16	-	-	+ 238.40	-
133	+ 263.60	299.00	- 38.40	25.20	-	-	+ 238.40	-
137	+ 269.55	231.00	+ 30.55	29.50	-	-	+ 240.05	-
138	+ 280.20	346.25	- 70.05	34.84	-	-	+ 245.36	-
139 (24)	+ 279.59	353.25	- 76.66	33.58	41.2	648 - 842	+ 246.01	7.62
140	+ 281.64	352.75	- 76.11	35.12	-	-	+ 246.52	-
141	+ 282.34	345.50	- 71.16	34.58	-	-	+ 247.76	-
144	+ 283.09	334.50	- 57.91	35.45	-	-	+ 247.64	-
146 (25)	+ 284.21	348.50	- 70.29	36.47	42.1	648 - 738	+ 247.74	5.63
148	+ 286.92	-	-	38.2	-	-	+ 248.72	-
151	+ 283.34	-	-	35.47	-	-	+ 247.87	-
152	+ 278.56	344.25	- 71.69	32.82	-	-	+ 245.74	-
153 (26)	+ 280.95	344.00	- 69.05	33.82	41	798 - 910	+ 247.13	7.18
154	+ 281.23	341.20	- 68.27	34.87	-	-	+ 246.36	-
155	+ 283.47	352.00	- 78.53	35.22	-	-	+ 248.25	-
156 (27)	+ 285.56	344.25	- 66.69	37.40	42.2	776 - 858	+ 248.16	4.8
157	+ 285.21	345.00	- 66.79	37.00	-	-	+ 248.21	-
158	+ 283.24	344.00	- 66.76	35.27	-	-	+ 247.97	-
167 (28)	+ 294.90	344.00	- 55.10	47.05	52.2	649 - 744	+ 247.85	5.15
168	+ 296.20	-	-	48.33	-	-	+ 247.87	-
175	+ 256.65	260.00	- 13.35	29.20	-	-	+ 227.45	-
179	+ 249.33	246.00	- 4.67	28.60	-	-	+ 220.70	-
190	+ 249.64	-	-	27.00	-	-	+ 222.64	-
191	+ 250.05	-	-	27.55	-	-	+ 222.50	-
193	+ 250.00	-	-	26.67	-	-	+ 223.33	-
196	+ 248.86	375.50	- 135.14	28.25	-	-	+ 220.61	-
198 (29)	+241.25	275.50	-43.75	21.25	26.4	507 - 612	+ 220.00	5.15

Note: *** After El Osta [1].

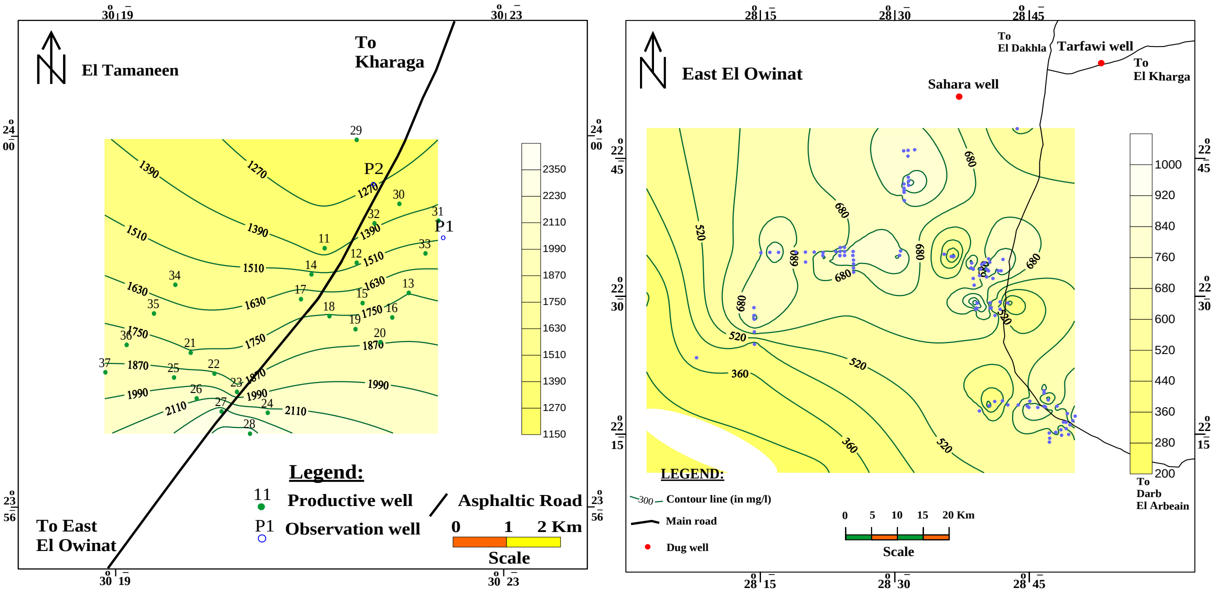

Fig. 4: Salinity contour map in El Tamaneen and East El Owinat area, (present author, 2012).

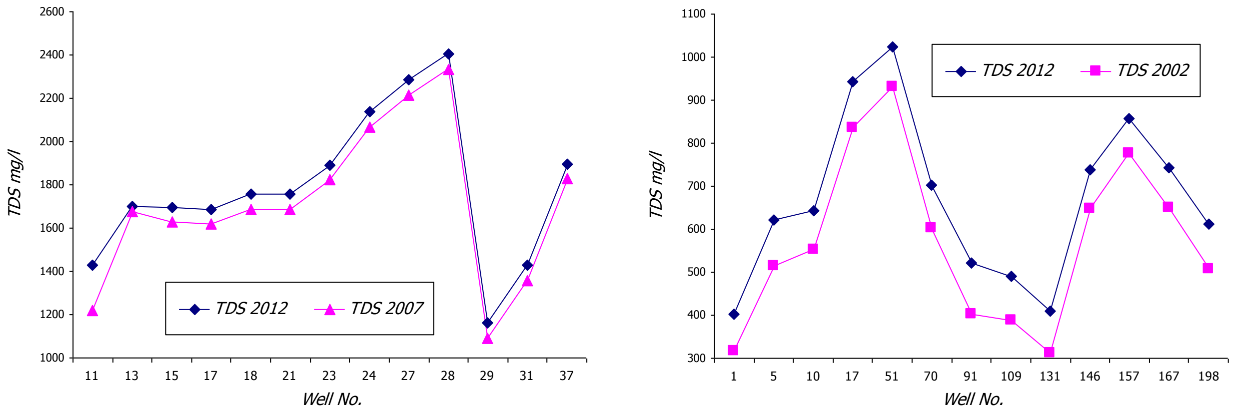

Fig. 5: Salinity variation during the years 2007 and 2012 in El Tamaneen andyears 2002 and 2012 in East El Owinat area.

Moreover, the salinity distribution map in East El Owinat shows many local high closure salinity areas especially at the central and northern parts of the area. Again, the high salinity recorded at the mentioned localities during years 2002 and 2012 is mainly attributed to the effect of intensive groundwater extraction for agriculture and leaching processes for the silt and clay intercalations.

iii- Well design criteria and its productivity

The materials used during well construction such as gravel pack, well casing and the effect of well corrosion and well incrustation have a direct impacts upon well productivity. They have direct control upon head loss and groundwater quality [11].

a- Head loss

The observed drawdown in a pumping well is equal to the head loss and is attributed to the sum of all aquifer loss and well loss. Aquifer loss depends on the type of the aquifer, the hydraulic conductivity and the ratio of the partial penetration.

The well loss depends on the well construction, development methods and the maintenance activities, which have been in operation for some times (Fig 7). General head loss formula is expressed as:

Total losses = aquifer losses + well losses

In the deteriorated wells, the step drawdown tests clear that: the well loss ranges between 40% and 45% while the aquifer loss ranges between 55% and 60%. The aquifer head loss in the well is equivalent to aquifer loss and is controlled by the following factors:

*** Flow type:**

The flow of groundwater in an unconsolidated sediment is laminar flow, where turbulent flow develops when pores or hydraulic gradient is large. The type of flow can be identified by Reynolds number [12] as:

$$\mathbf{Re = (\rho * v * d)/ n}$$

Where: ρ is density of water (1 kg/ m^3), v is the velocity of water (m/s), d is the main grain diameter (m) and n is the viscosity of water ($0.95*10^3$ kg/m*s). The turbulent flow starts at Reynolds number between 1 and 10 depends on the range of grain size and shape. Partial penetration causes the flow to have vertical component near the well when the distance is less than one and half of the saturated thickness. The factors reduce the amount of well discharge in the case of full penetration depends on well screen, aquifer thickness, well radius and drawdown in well bore. The well loss occurs at or near borehole face is due to use of mud in ordinary drilling method (Fig. 6).

Drilling mud containing clay may penetrate into the aquifer and decrease the permeability of the well surroundings and influenced by the quantity of clay, silts, and fine sand, which build up the aquifer. Well loss cannot be easily quantified. This loss in the laminar flow may indicate important well loss.

*** Well screen length**:

The balance between well screen and required discharge rate was studied by Walker [13] by applying the following equation:

$$\mathbf{L = Q/(A_e * V_c * 7.48)}$$

Where: L is length of screen (feet), Q is the discharge rate (gpm), A_e is the effective open area /foot of screen (ft^2/ft) approximately 1/half actual open area and V_c is the critical velocity (ft/m) where velocity above which sand particles are transported (ft^2/m). The length of the screen ranges between 30 m and 70 m in most wells and less than 30 m in the deteriorated wells in the two areas.

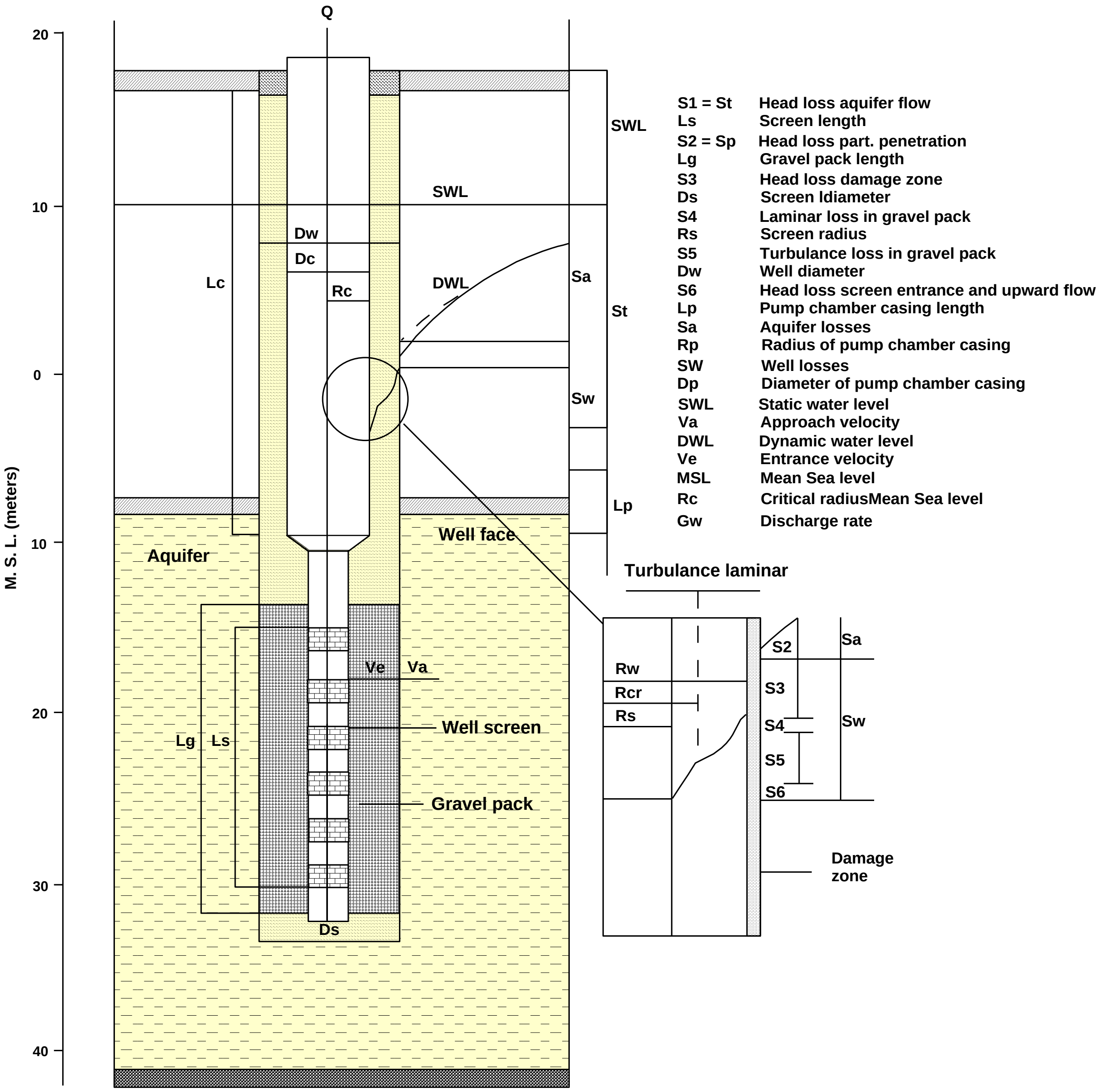

Fig. 6: Graphical diagram of the damage zone and impacts in a production well [14].

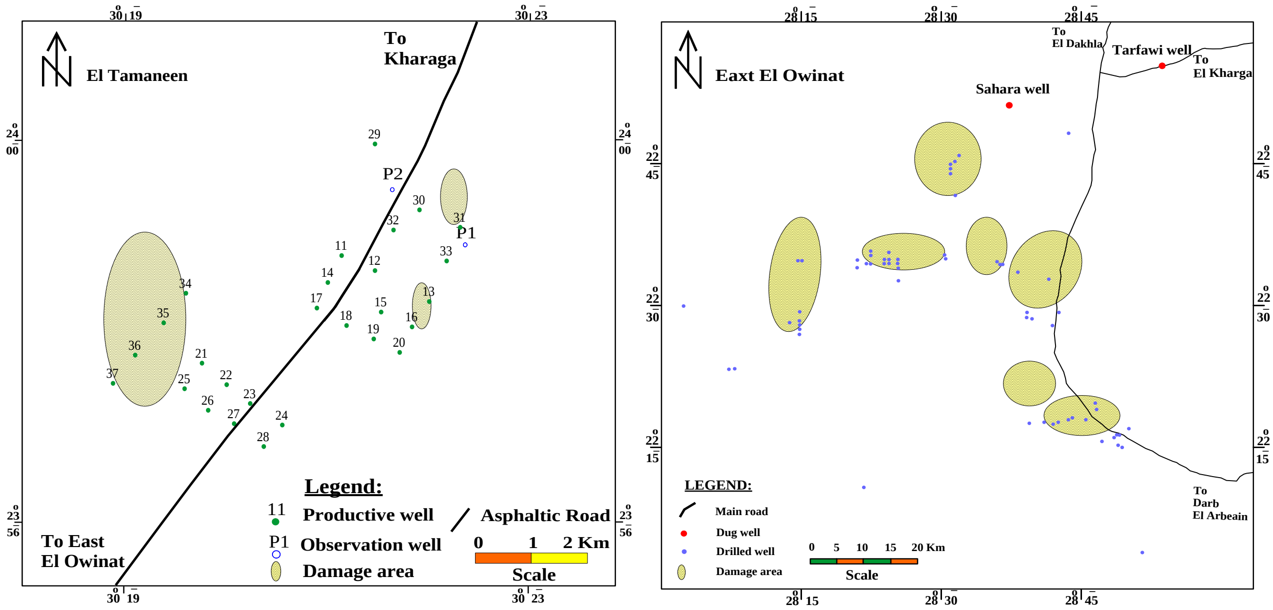

Fig. 7: Deteriorated locations in El Tamaneen and East El Owinat areas, 2012.

*** Screen slot size:**

According to Johnson [11] for homogenous formation which is composed of fine uniform sand, the size of screen opening (slot size) is the size of sieves that pass 50% to 60% of the sample. The sixty percent value is used when groundwater is not particularly corrosive. For heterogeneous formation, a large slot size that corresponding to a 70% passing value is used. In the selected areas (El Tamaneen and East El Owinat) ring slot opening was installed in some productive wells through which sand particles were transported inside well casing which lead to reducing the productivity of the wells and hence complete failure abandoned it. Also, narrow silky slotted opening used sometimes retard the water inflow leading to decrease in well productivity. The screen opening ranges between 0.7 mm and 1 mm the good productive wells and less than 0.7 m in the deteriorated wells in the two areas.

*** Gravel pack**:

Gravel pack was used to increase the specific capacity of the well, minimize sand flow through the screen, aid in the construction of the well and to minimize the rate of encrustation by using a large screen opening. In order to select the suitable gravel pack ratio the following formula must be used to calculate the ratio of mean size:

$$GPR = (50\% \text{ of gravel pack})/(50\% \text{ of formation})$$

When the gravel pack ratio (GPR) ranges from 4 to 5, the wells generally have a high efficiency [3]. On the other hand when GPR ranges from 7 to 10 wells have considerably less efficiency. Good gravel pack should consists of siliceous materials, clean, smooth, uniform, well rounded grain and its thickness ranges from 5cm to 20cm. The application of gravel pack should be technically considered in the tool of instillation and for the time of replacement (low rotary speed).

Bad gravel pack cast of the steel casing was used for the construction of wells in the selected areas (less than 3 mm in size). This will decrease the specific capacity and increase sand flow through the screen in the two areas.

*** Well casing and casing life:**

The extension of casing life depends mainly on installing the casing with a relatively thick wall and the resistance of the casing to corrosion. Cleideinst formula [15] was used to estimate the collapse resistance of casing

$$P_c = [(2E)/(1 - U^2) * ((1)/((d/t) *((d/t) - 1)^2)]$$

Where: P_c is the critical collapse pressure (psi), E is the modulus of elasticity, U is Poisson's ratio d = O.D. of pipe (inch) and t is wall thickness of the pipe (inch).

The low cast steel casing (Bridge steel type) may decrease the well caseing life in El Tamaneen and East El Owinat area.

*** Well corrosion**:

Corrosion can severely limit the useful life of a well through screen slot opening enlargement followed by sand pumping failure, strength reduction followed by collapse of well screen or casing and re-deposition of corrosion product followed by screen blockage.

The high value of dissolved iron (Fattah [5] and Dahab et al [6]) can be considered the main source for well corrosion in El Tamaneen and East El Owinat studied areas.

*** Well encrustation**:

Encrustation is a result of the collection of material in and around the screen opening and the voids of water bearing formation. The causes of encrustation are precipitation of calcium and magnesium carbonates, deposition of clay and silt, presence of iron bacteria in groundwater and presence of slime-forming organisms.

Longelier [16] stated that high pH more than 7.5, carbonate hardness more than 300 mg/l, dissolved iron more than 1.0 mg/l dissolved manganese more than 0.5 mg/l and dissolved inorganic carbon less than 50 mg/l increase potential encrustation in groundwater solution. The high value of pH, dissolved iron and dissolved manganese [5,6] can be considered the main source for well encrustation in El Tamaneen and East El Owinat area.

b - Aquifer loss and well loss in the studied areas

The aquifer penetrated thickness in El Tamaneen ranges between 365m and 505m. The estimated transmissivity and hydraulic conductivity of the studied aquifer by Nagaty [17] showed wide variation that could be attributed to the rapid lateral facies changes as well as the variation in the thickness of the productive water bearing units.

On the other hand the aquifer thickness in East El Owinat area ranges between 186m and 706m. They have values ranging from 238.65 m^2/day to 2745.5 m^2/day for transmissivity and from 2.71 m/day to 19.98 m/day for hydraulic conductivity. The wide range of both parameters is mainly attributed to the rapid lateral facies changes as well as the variation of the aquifer thickness [6].

According to the result of step draw-down tests carried out by Ministry of Water Resources and Irrigation [4] and El Osta [1] in the two areas, the estimated well loss ranges between 15% and 25% while the aquifer loss ranges between 75% and 80% (high hydraulic efficiency for the good productive wells). In the deteriorated wells the well loss reaches to 45% and aquifer loss is 55% (low hydraulic efficiency for wells). In spite of the provided data about the wells efficiency by contractor Companies the investing poor well design of production wells such as unsuitable screen slot size, bad gravel pack, well clogging ..etc, affects its well efficiency and productivity.

Evaluation of the groundwater wells and recommended well design

The damaged areas during the years 1999 and 2012 are shown in figure (7). The drop of groundwater quantity and deteriorated quality for the wells in the studied areas are due to the excessive drawdown of well interference and high influence of well loss. The optimal well depth in the two areas depends on accurate definition of the aquifer lithological description, suitable aquifer thickness and technical consideration of well design.

Table (3) shows the recommended parameters for proper well design [18]. According to these parameters and by correlation the actual design of most wells in the studied areas (most of wells are partial penetrated wells having screen length less than 60 m, screen size less than 1.25 mm and using bad gravel pack), the discharge of the wells must be decreased by the increasing of well life time.

Figure (8) shows the optimal well depth in El Tamaneen and East El Owinat areas, this depth depends on the following parameters:

- Accurate definition of aquifer lithological description.
- Suitable aquifer thickness.
- Technical consideration of well design.

Conclusions and recommendations:

From the study of the hydrogeological setting of the two selected areas and results of analyses of well design the following can be concluded:

- Most productive wells show depths ranging from 180m to 700m, these depths partially penetrated the Nubian sandstone aquifer while only few wells (less than 10% of the total wells) are fully penetrated the aquifer.
- Well construction methods in the selected two areas were carried out through rotary drilling methods where life time of the wells ranges from 5 to 10 years due to bad selection of the well locations without considering groundwater flow directions, suitable well spacing to prevent any interference due to pumping which is higher than the anticipated discharge of the wells and bad design of wells.
- It is expected that with a continuous deterioration in groundwater on local scale (well scale), the deterioration might be occur at regional scale (aquifer scale).
- Special percussions are needed to decrease groundwater deterioration such as good well design, suitable irrigation methods and updating the existing groundwater development.
- In general the deterioration of groundwater in the two selected areas is related to hydrogeological and technical consideration such as bad management plan in the area and around it.

To avoid the problems associated with productive wells such as drop of level, decline of efficiency and productivity and increase of salinity, the following considerations should be applied:

- Geophysical well logging before the design to get proper screen depth.
- Using construction materials from UPVC of 10 bar for well depths less than 120m and 16 bar for depth more than 120m.
- Using diameter of well (casing and screen) not less than10 inch for depth less than 120m and not less than12 inch for depth more than 120m.
- Carrying out sufficient and good well development.

Table 3: The recommended parameters for proper well design [18].

Zone of recommended well depth (m)	Well discharge (m3/hr)	Penetration ratio	Screen length (m)	Screen size (mm)	Gravel pack size (cm)
70 - 100 (m)	**60 - 80**	**Fully**	**24 - 30**	**0.75 – 1.0**	**0.2 – 0.3**
70 - 100 (m)	**70 - 90**	**Fully**	**30 - 36**	**0.75 – 1.0**	**0.2 – 0.3**
180 -240 (m)	**100 - 120**	**Not less than 80%**	**40 - 60**	**1.0 – 1.25**	**0.3 – 0.5**
220 - 260 (m)	**110 - 130**	**Not less than 80%**	**40 - 60**	**1.0 – 1.25**	**0.3 – 0.5**

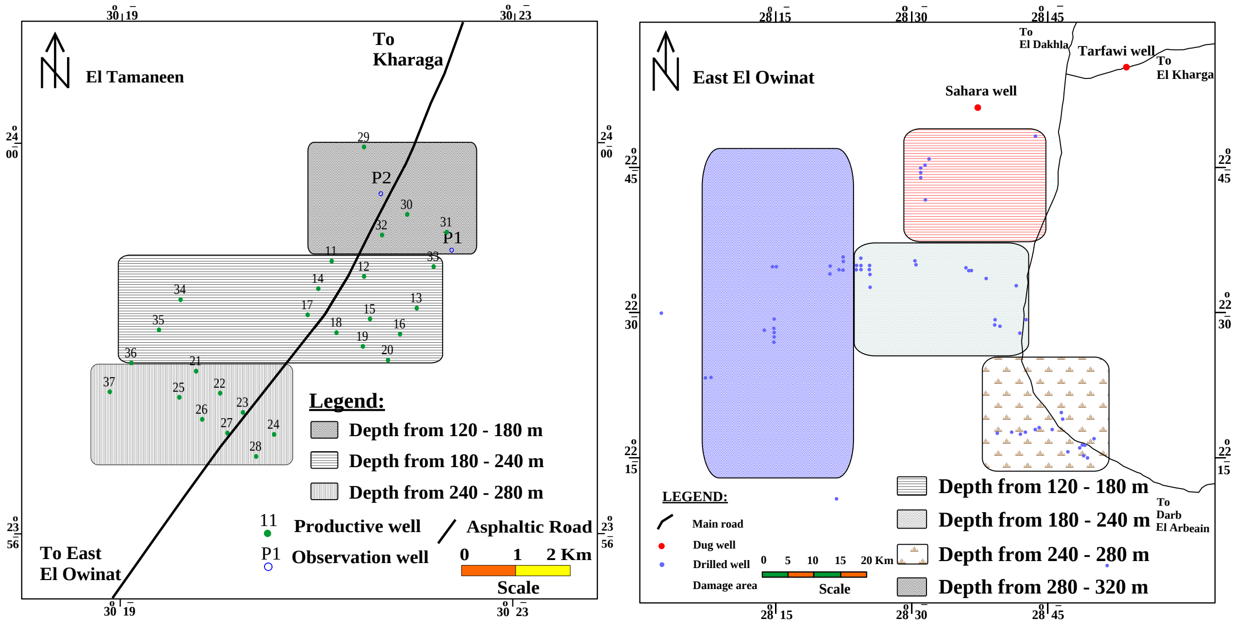

Fig. 8: Optimal well depth in El Tamaneen and East El Owinat areas, 2012.

References

1) **El Osta, M. M. (2006).** Evaluation and management of groundwater in East El Oweinat area, Western Desert, Egypt., Ph.D. Thesis, Geology Dept., Fac. of Sci., Minufiya Unvi., 215p.
2) **Ezzat, M. A. and Abuel Atta (1974).** Exploration of groundwater in El-Wadi El-Gedid project area (New Valley), part II, hydrogeological conditions, Dakhala-Kharga area. Ministry of Agriculture and Land Reclamation, Cairo.
3) **Driscoll, F. G. (1986).** www,Worldcat. Org/ title/ Groundwater-and-wells/ odc/ 13571512.
4) **Ministry of Water Resources and Irrigation (1999).** Hydrogeological data of water wells in Darb El Arbaein area, South Western Desert, Egypt, Internal report.
5) **Fattah, M. K. (2004).** Hydrogeological studies of Darb El Arbein South El Kharga Oasis. Ph.D. Thesis, Geology Dept., Fac. of Science, Minufiya University, 260p.
6) **Dahab, K. A., Abdel Baki, A. A. and El Osta, M. M. (2008).** The Impact Of Land Reclamation Activities On Groundwater Occurrence And Quality In East El Oweinat Area, Western Desert, Egypt. 7th Intern. Conf. on Geochemistry, Fac. Sci., Alex. Univ., Alex., Egypt, 6 - 7 Sept. V III,: 47 - 71.
7) **Korany, E. A., Fathy, R. G. and Nagaty, M. El. (2002).** Contributions to the hydrogeology of Nubia sandstone aquifer in the middle part of Darb El-Arbaein area, South Western Desert, Egypt. Sedimentology of Egypt, ISSN 1110 – 2527. *Journal of the Sedimentology Society of Egypt*, 10: 119 - 143.
8) **El Osta, M. M. and El Sheikh, A. E. (2008).** Evaluation of groundwater potential in the Nubian Sandstone Aquifer System in Abu Bayan-G. Sharshar Area, South Kharga Depression, Western Desert, Egypt Egyptian J. Desert Res., 58(2): 261-275.
9) **Darcy, H. P. G. (1856).** Les fontaines publique del la ville de Dijon V. Dalmant , Paris,: 590-594.
10) **Ministry of Agricultures (1997).** Groundwater development plan in the East El Oweinat area., Internal report. 263p**.**
11) **Johnson, E. E. Inc. (1966).** Groundwater and wells. Sc. Paul, Minnescia, Edward E. Johnson Inc.
12) **Walton, W. C. (1970).** Groundwater resources evaluation, New York, Mc Graw - Hill.
13) **Walker, W. H. (1967).** "When not to acdize". Groundwater, 5(2): 36 – 40, 4 refs. 270.
14) **RIGW, (1990).** Hydrgeological inventory and groundwater development plan Western Nile Delta region (Internal Report).
15) **Cleindeinst, W. V. (1939).** A Rational Expression for Critical Collapse Pressure of Pipe Under External Pressure. A. P. I. Drill. And Prod. Pract.,: 383 – 391.
16) **Longelier, W. F. (1936).** The Analysis Control of Anti - Water Treatment. Jour. Of the Am. Water Assoc., 28: 1500 – 1520.
17) **Nagaty, M. El. (2003).** Hydrogeological studies of Nubia Sandstone aquifer in the middle part of Darb El – Arbeain area, South Western Desert, Egypt. *Ph.D. Thesis*, Geology Dept., Fac. of Science, Ain Shams University, 172p.
18) **Gaame, O. M. (2005).** Evaluation of well design west of the Nile Delta region with emphases on Wadi El Natrun and Wadi El Farigh areas. GRMENA, 1: 333 – 348.