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WELL INFLUENCED RADIUS EFFECTS ITS' STORATIVITY, TRANSMISSIVITY AND GROUNDWATER HYDRAULIC CONDUCTIVITY AT MONOFIYA REGION.

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ABSTRACT

The main object of this study is to conduct a surveying and collecting data for some groundwater wells constructed for the purpose of agricultural reclamation in the Monofiya region. In order to determine the values of those variables wells to study the rely on the reclamation and cultivation of new land. This study was to collect data and reports pumping test of wells included in the study. This was done through the drilling companies designed such as Regwa, Gwasom and Hawwary company. Through these data have been determined the well influence radius effects of transmissivity, stroativity and hydraulic conductivity.

The obtained results indicted that the groundwater wells which have been constructed at Monofiya region, useable to irrigation new reclaimed areas, because less total dissolved solids content estimated the highest concentration about 760 mg/1 and the ratio in the range of allowable according to the FAO. Regarding estimated values of stroativity, transmissivity and hydraulic conductivity, found that the less values was .31, 1370 m^2/day, 105 m/day, respectively. So can pump amount of water of 250 m^3/hr with intervals of 12 hours. Furthermore estimated the value of influened radius 120 m, therefore it must take into account that dimension when creating a heighoring wells.

INTRODUCTION

It has to be noticed that groundwater wells constructed in the Monofiya region, useable to irrigation reclaimed land. Must take into account when applying mathematical equations for groundwater flow and selection equations calculate variables wells and aquifer follows equations unconfined aquifer due to the presence of the surface layer of clay, that leads aquifer in that region is unconfined. The duration of constant rate testing will depend on the size and importance of the well field development, the environmental sensitivity of the aquifer. However, constant rate testing will usually last at least 1 day and commonly up to 10 days, depending on discharge rate and the potential for delayed yield.

Fadlelmawla and Dawoud (2007) they found, the delta region is characterized by sediments surface increase the proportion of clay, silt, sand, soft and low in the proportion of coarse sand from the area of the nile valley. The aquifer is consists of sand and gravel, gravel multi sizes punctuated lenses clay limited fish The thickness of the aquifer extends from 100 m at Cairo to 1000 m when the coast and the spread of these deposits belong to the era Pleistocene (million years and the upper limit of these layers is similar to port cover mud (clay cap aquitard). While, the range of thickness (20 m) in the south to the delta (60 m) in the north delta which is due to the composition of the modern age (Holocene) (ten thousand years old). Always different from the thickness of the reservoir layers from site to site depending on geological conditions and the structure characteristic of this region, ranging between 200-900 m.

Laeven (1991) stated that, the clay surface layer toppings semi-permeable aquifer in the Delta, this layer is a Nile alluvium deposits belong to the modern era (Hollocene), which represents the first thousand years of the history of recent life era. Embaby (2003) mentioned that, this layer defines class type and the degree of confinement aquifer of groundwater in the Delta. This layer contains on the surface water in the Delta, where the water level represents the top water table, it's consider aquifer of surface water, but not exploitable. source waters of this aquifer is leaking from irrigation water and leachates from the Delta-intensive irrigation systems

Aquifers Criteria

Ferris et al. (1962) mentioned that, the storativity of a confined aquifer is defined as the volume of water released from storage per unit surface area of a confined aquifer per unit decline in hydraulic head. Storativity is also known by the terms storage coefficient. Johnson (1967) mentioned that, specific yield is sometimes called effective porosity, unconfined storativity, or drainable pore space. Small interstices do not contribute to the effective porosity because the retention forces in them are greater than the weight of water. Hence, no groundwater will be released from small interstices by gravity drainage.

Matthess (1982) found that, water can only move through pores that are interconnected. Hard rocks may contain numerous unconnected pores in which the water is stagnant. Water in 'dead-end' pores is also almost stagnant, so such pores are excluded from the effective porosity. They do play a role, of course, when one is studying the mechanisms of compressibility and solute transport in porous media.

De Marsily (1986) found in, fractured rocks, water only moves through the fractures, even if the un fractured matrix blocks are porous. This means that the effective porosity of the rock mass is linked to the volume of these fractures. A fractured granite, for example, has a matrix porosity of 1 to 2% but its effective porosity is less than 1% because the matrix it self has a very low permeability.

Wösten et al. (2000) showed that, for practical work in ground water hydrology, where water is the prevailing fluid, it's necessary to know the hydraulic conductivity. It is defined as the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. Farid (1980) showe that, since the beginning of the modern studies of groundwater Delta was many attempts to determine hydraulic parameters and them credit for that have been conducting a few experiments in some places in the Delta for this purpose adopted analyze data these experiments mainly on how Theim to equilibrium and Thies cases of non-equilibrium was conclude 100 m/day average value of hydraulic conductivity. It is these values that the aquifer groundwater in the Delta can be considered within the water-rich aquifers and can be exploited under certain conditions and policy.

Boonstra, and Kselik (2002) showed that, the transmissivity is the product of the average hydraulic conductivity and the saturated thickness of the aquifer. Consequently, transmissivity is the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer, as aquifer may consist of soil layers.Transmissivity estimates from single-well tests in unconfined aquifers also are affected by discharge rate, test duration. Halford (2008) studid, the estimates by analysts were more accurate than mechanistic estimates of transmissivity. Analysts improved transmissivity estimates most where known transmissivity values ranged between 250 and 5000 m^2/d. More than 90 percent of these transmissivity estimates were within a factor of two of the known values. Interpretation did not significantly improve transmissivity estimates or remove bias where known transmissivity values ranged between 10 and 100 m^2/d.

MATERIALS AND METHDOS

A pumping test is a controlled field procedure to determine the hydraulic properties of water bearing geologic units. It is a practical, reliable method of estimating well performance, well yield, the zone of influence of the well and aquifer characteristics (the aquifer’s ability to store and transmit water, aquifer extent, presence of boundary conditions and possible hydraulic connection to surface water). Pumping tests can last from hours to days or even weeks in duration, depending on the purpose of the pumping test, but traditional pumping tests typically last for 24 to 72 hours. The pump rate should be great enough to stress the well, but not so great as to cause the well to be pumped dry. During the pump test, the water level in the well must be measured and recorded at regular intervals starting at the time pumping begins and continuing until pumping stops

Types of pumping test

a. **Step drawdown test**

b. **Constant rate (test)**

The step test is normally followed by a period of recovery, such that the aquifer approximately returns to pre-pumping conditions. This is likely to be at least 1 day, following step testing of 8h duration. Typically, some form of constant rate testing will then follow. Constant rate testing will usually be designed to ascertain:

1. The hydraulic properties of the aquifer.
2. Whether the operational rate and drawdown can be sustained in a stable condition. Over a protracted period, or whether yield drops.
3. Whether water quality changes during the duration of the test.

The duration of constant rate testing will depend on the size and importance of the well field development, the environmental sensitivity of the aquifer. However, constant rate testing will usually last at least 1 day and commonly up to 10 days, depending on discharge rate and the potential for delayed yield. This is usually adequate to allow enough data to be collected for derivation of values for aquifer properties. Indeed, the first few hours of data will often be the most useful for this purpose and intensive data collection during this interval will be required.

Choose a pumping rate associated borehole size and casing size of the well so as to affect the wall of the well and cause deterioration in construction and a stress on the screen as a result of choosing a higher pump rate is appropriate for size. Table (1) show selecting the pumping rate and according to the different size diameters.

Evaluation of pumping final test for one of the well. That estimate was conducted through installation of measuring devices the level water and adjust electromagnetic flowmeter for the measurements of discharge and electric control unit. It is clearly, Fig (1) shows the places installation of these devices and how connected them inside the well in preparation for recording the results of water level of the well, while summarized steps evaluation of pumping final test as follows;

1. Determine the height of the measurement point and be fixed length of the test period, usually that point orifice the well casing.
2. Adjust the hours stop run with the beginning of operation of the pump.
3. Using the monitoring devices are monitoring the static water level before operating and the dynamic level after operating directly.
4. Connect the electrical to operate of the pump on the discharge action and take into account the size diameter of the well pipes when choosing the discharge.
5. Taking into account the preservation for pressure and discharge constant to pump.
6. Registration start time and water levels in the well and discharge for the pump.
7. Continuation measuring the drawdown in pumping wells with continued pumping (preferably using devices with a light signal or voice in the measurement process).
8. Record the readings with times associated with discharge in specials tables to type test.
9. Should taking recovery data to review the accuracy of the data pumping.

Table (1): Well casing and borehole size diameter for desired pumping rate

Borehole size, in.	Casing size, in.	Pumping rate, m^3/h.
6	4	less than 4.54
8	6	4.54 to 22.7
10	8	17 to 39.7
12	10	34.1 to 90.8
14	12	79.5 to 136
20	16	136 to 295
24	20	295 to 409
28	24	409 to 681

Analysis variables aquifers and wells

1) Storativity, (S)

In a confined aquifer, storativity is defined by Ferris et al. (1962)

$$s_x = s_f b \quad \text{……… (1)}$$

Specific storage is related to the compressibilities of the aquifer and water function as in the form:

$$s_f = \rho_w g(\alpha + \eta\beta) \quad \text{……… (2)}$$

Storativity in an unconfined aquifer, is given by (Lohman,1972) as :

$$s = s_y + s_x \quad \text{……… (3)}$$

Because $s_s b$ is typically small in comparison to s_y, storativity in an unconfined aquifer is often simply equated with specific yield.

El Shazly et al (2006) assumed that, the bottom of the aquifer that is located at a depth of down well screens equals twice the length of well screens;

$$b = 2\,L_s \quad \text{……… (4)}$$

By direct compensation for variables Eqn (3) through those previous equations produces Eqn (5) are used to determine the storativity of these wells.

$$S = s_y + \left[2\,L_s\left(\rho_w\, g(\alpha + \eta\beta)\right)\right] \quad \text{……… (5)}$$

where:
S = storativity, dim;
sy = specific yield, dim;

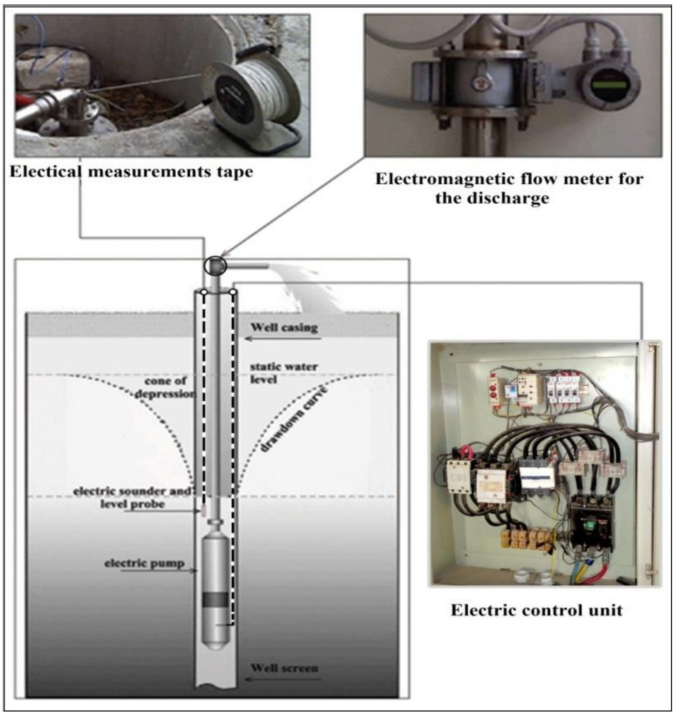

Fig. 1: Shows the measurements to perform the step-drawdown test.

Ls = is length of screens in well, m;

ρ_w = density of water, kg/m3;

g = acceleration of gravity, m/hr ^{2};

α = compressibility of the aquifer skeleton, m^2/N;

η = porosity, dim;

β = compressibility of water (4.4x10^{-10}), m^2/N;

b = aquifer thickness, m;

2) Pumping Tests

By analyzing the output drilling of these wells found it located in unconfined aquifer. Therefore when applying mathematical equations for groundwater flow and selection equations to calculate well variables and aquifer has to follow that equations for unconfined aquifer due to the presence surface layer of clay, that leads aquifer at that region is unconfined (Thiem analysis, 1906).

$$Q = \frac{2.73}{2} K \left[\frac{h_s^2 - h_d^2}{\log(\frac{R}{r_w})} \right] \quad \text{......... (6)}$$

$$R = \sqrt{2.25\ T \frac{t}{s}} \quad \text{......... (7)}$$

$$T = \frac{1.22Q}{s^{'}} \quad \text{......... (8)}$$

$$s^{'} = s_w - \frac{s_w^2}{2b} \quad \text{......... (9)}$$

where:

Q = well discharge rate, m^3/day;

K = The hydraulic conductivity, m/day;

h_s = is level static for water in well, m;

h_d = is level dynamic for water in well, m;

R = is radius of influence of the pumping well, m.;

r_w = is radius of the well, m;

$s^{'}$ = is the corrected drawdown, m;

T = is transmissivity, m^2/day;

b = is the thickness of the saturated aquifer, m.;

RESULTS AND DISCUSSION

The present study focused on surveying and collecting data for some groundwater wells constructed for the purpose of agricultural reclamation in the Monofiya region. In order to determine the values of those variables wells to study the rely on the reclamation and cultivation of new land. It is clearly, from Table (2) summarized of wells data collected during the research period in the Monofiya region, which includes; number of the well, the well name, type of the well, the company designed, location coordinates, depth of borehole, final depth, diameter of pipes, static water level (S.W.L), total dissolved solids (T.D.S) and pH.

Table (2): Collected and resulted of wells data at the Nile delta region.

Well NO	Well type	Location Coordinates				Depth, m;	Diameter, in;	h_s,m;	T.D.S , mg/1;	pH
D_1	Productive*	N	30°	35`	19.4"	100	10"	5.60	451	6.95
		E	31°	05'	40.3"					
D_2	Productive**	N	30°	35`	41``	100	10"	6.65	760	7.25
		E	30°	59`	45.9``					
D_3	Productive***	N	30°	24`	44.5``	103	10"	7.75	555	6.7
		E	30°	58`	33.6``					

h_s : static water level, m; T.D.S : total dissolved solids content, mg/1;
*** (Co. Regwa, 2012) ** (Co. Gwasom, 2012) *** (Co. Hawwary, 2012)**

Studying the total dissolved solids from well data collected in Delta wells ranging from 451-760 mg l^{-1}, comparisons of proportions FAO degrees find it in degrees slight to moderate. As well as the degree of PH found that those in 3 wells ranging 6.95 - 8.15, that parentage water are judged to be normal. Therefore, at the extracted water found to be suitable for agricultural purposes directly does not need to be addressed. Thus, we can drilling any wells in those areas for the purpose of agricultural reclamation without fear of water salinity.

Evaluation the storativity (S)

By results of constant pumping tests (discharge) for 3 wells in the Monofiya region, variables have been identified for each well, which include the discharge (Q), the time of the experiment (t), the static water level (h_s), and the dynamic level (h_d), consequently calculate the drawdown of levels water in the well (s_w). Recorded constant pumping tests results for 3 wells in the Table (3), respectively. To calculate storativity is used Eqn (5).

To estimate Eqn (5) variables refer to lithological description and designer per well data were collected. In order to determine the type of rock corresponding to the well screens, Because it's component rock for layers of the aquifer. As a yield of compensation procedure in Eqn (5) to calculate the storativity (S) for wells from collected data, Table (4) is clarified those calculations as input collecting data with it results.

Regarding, the data recorded in Table (4) for the mean values of aquifer thickness and compressibility of the aquifer skeleton and porosity of rocks reservoir water and storativity, it is clearly noticed that, the storativity values ranging between 0.21 - 0.33. This in agreement with other reported data by (Lohman, 1972) found that, the storativity of unconfined aquifers, which varies with specific storage and aquifer thickness, typically ranges from 0.1 to 0.3.

Generally, the values of storativity depends on the aquifer thickness. This also, can be clearly seen within the Fig (2). Where the plotted curve shows the effect of the aquifer thickness on its storativity, for 3 wells in various sites with the same specifications in terms of the types of rock formation and the same depth and diameter.

Table (3) :Results data of constant discharge test to 3 wells

Time, min	Discharge (Q), m^3/h			Water Level, m			Drawdown (S_w), m		
	Well No.			Well No.			Well No.		
	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
0	0	0	0	5.60	6.65	7.75	0.00	0.00	0.00
1	300	300	300	9.79	12.19	13.19	4.19	5.54	5.44
2	300	300	300	9.85	12.25	13.25	4.25	5.60	5.50
3	300	300	300	9.88	12.31	13.30	4.28	5.66	5.55
4	300	300	300	9.91	12.36	13.36	4.31	5.71	5.61
6	300	300	300	9.94	12.40	13.40	4.34	5.75	5.65
8	300	300	300	9.96	12.44	13.44	4.36	5.79	5.69
10	300	300	300	9.98	12.47	13.48	4.38	5.82	5.73
20	300	300	300	10.02	12.54	13.51	4.42	5.89	5.76
30	300	300	300	10.05	12.64	13.53	4.45	5.99	5.78
50	300	300	300	10.08	12.72	13.60	4.48	6.07	5.85
70	300	300	300	10.10	12.76	13.67	4.50	6.11	5.92
90	300	300	300	10.11	12.81	13.82	4.51	6.16	6.07
100	300	300	300	10.12	12.83	13.90	4.52	6.18	6.15
120	300	300	300	10.13	12.85	14.12	4.53	6.20	6.37
180	300	300	300	10.18	12.91	14.21	4.58	6.26	6.46
210	300	300	300	10.19	12.94	14.23	4.59	6.29	6.48
270	300	300	300	10.20	13.01	14.27	4.60	6.36	6.52
300	300	300	300	10.21	13.03	14.31	4.61	6.38	6.56
480	300	300	300	10.21	13.12	14.33	4.61	6.47	6.58
540	300	300	300	10.22	13.14	14.34	4.62	6.49	6.59
600	300	300	300	10.22	13.16	14.35	4.62	6.51	6.60
720	300	300	300	10.22	13.19	14.37	4.62	6.54	6.62
840	300	300	300	10.23	13.21	14.38	4.63	6.56	6.63
900	300	300	300	10.23	13.22	14.39	4.63	6.57	6.64
960	300	300	300	10.24	13.23	14.40	4.64	6.58	6.65
1020	300	300	300	10.25	13.23	14.41	4.65	6.58	6.66
1080	300	300	300	10.25	13.24	14.42	4.65	6.59	6.67
1140	300	300	300	10.25	13.25	14.43	4.65	6.60	6.68
1260	300	300	300	10.25	13.25	14.43	4.65	6.60	6.68
1440	300	300	300	10.25	13.25	14.43	4.65	6.60	6.68

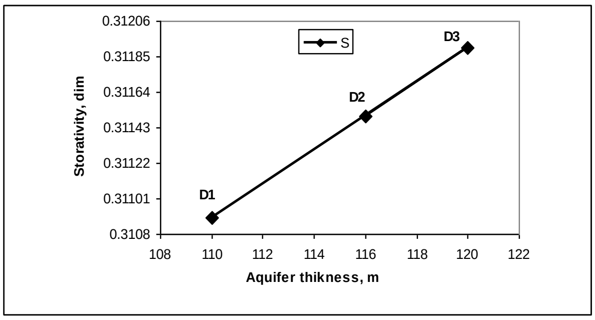

Fig. 2 : Show the effect of aquifer thickness on its storativity.

Table (4): Variables values for the storativity

Well	Rock types	s_y	L_s, m	b, m	α	η	S
D_1	Sand, coarse	0.30	55	110	10^{-8}	0.30	0.3109
D_2	Sand, coarse	0.30	58	116	10^{-8}	0.30	0.3115
D_3	Sand, coarse	0.30	60	120	10^{-8}	0.30	0.3119

Evaluation transmissivity (T) of the aquifer

For calculating the transmissivity must estimate the value of the coefficient corrected drawdown (s') through the Eqn (9), and knowing the discharge value of constant pumping tests results are calculated the transmissivity (T) from the Eqn (8). The observation results of transmissivity recorded in Table (5), we find that the transmissivity related radius of influence as in Fig (3). It is clear that increasing the radius of influence increased transmissivity, at the same time, at less drawdown the water level inside the well.

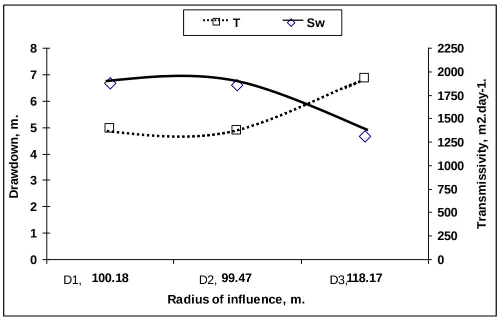

Fig. 3 : Effect of the radius of influence on both the transmissivity and the drawdown.

Evaluation the radius of influence (R) of well

Determine the nearby wells that will be used during the test if it's likely they will be affected, this well depends on radius of influence. Eqn (7) can be used to determine the radius of influence (R). This diagram in Fig (4) show drawdown of dynamic water level and after the pumping to a fixed period of time. Note that in the beginning the pumping the great downward occurs of water level in the well and with continued pumping the downward prove at a certain time. Through the diagram we can determine the nearby wells that will be used during the test if it's likely they will be affected, this well depends on radius of influence.

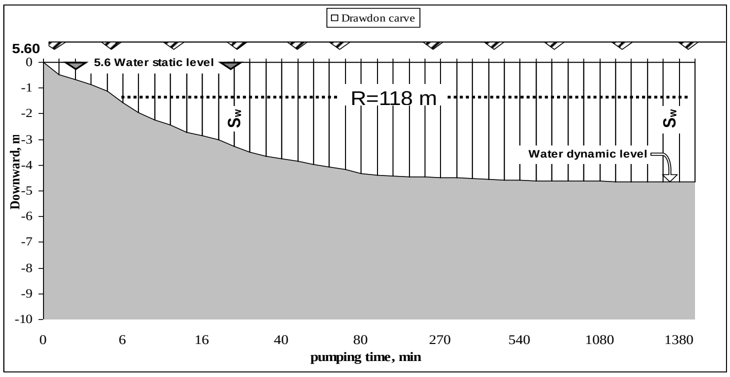

Fig 4 : Drawdown water level curve for well No. D_1

Evaluation the hydraulic conductivity (K)

Furthermore, knowing the value of the radius of influence (R), and radius of the well (r_w), possible to estimate the value of the hydraulic conductivity for wells that collected data, through the Eqn (6).
The relationship between hydraulic conductivity and transmissivity and radius of influence is plotted curve as Fig (5). It is clearly in Fig (5) the value of hydraulic conductivity increasing by increased the value of transmissivity and radius of influence.

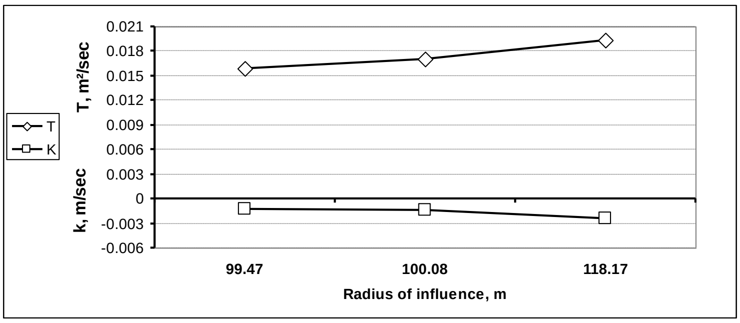

Fig. 5 : Diagram shows the relationship between hydraulic conductivity and transmissivity and radius of influence.

Table (5): Evaluation criteria variable values of s', T, R and K.

Well	Q, m^3/day	h_2, m	h_1, m	s_w, m	r_w, m	t, day	s', m	T, m^2/day	R, m	K, m/day
D_1	7200	5.6	10.25	4.65	0.127	1	4.55	1929.82	118.17	212.464
D_2	7200	6.65	13.25	6.6	0.127	1	6.41	1369.88	99.47	116.221
D_3	7392	7.75	14.43	6.68	0.127	1	6.49	1388.69	100.08	105.870

Generally, the values of all calculated variables are coefficient corrected drawdown (s'), and transmissivity (T), and the radius of influence (R) for each well, and hydraulic conductivity, were recorded in Table (5).

CONCLUSION

It could be concluded that the groundwater wells which have been constructed at Monofiya region:

1. Useable to irrigation new reclaimed area, because less total dissolved solids content estimated the highest concentration about 760 mg/1 and the ratio in the range of allowable according to the FAO.
2. When applying mathematical equations for groundwater flow and selection equations to calculate well variables and aquifer has to follow that equations for unconfined aquifer due to the presence surface layer of clay, that leads aquifer at that region is unconfined.
3. When creating a neighboring wells at this region have to takes into account the value of influence radius 120 m between wells to avoid overlap between them, and avoiding increases drawdown of dynamic water level in neighboring wells.
4. From estimation of stroativity, transmissivity and hydraulic conductivity of groundwter wells at that region, it can pump amount of water of 250 m^3/hr with intervals of 12 hours, hence the transmissivity was estimated by 2000 m^2/day.

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تأثيرات نصف قطر دائرة تأثير البئر علي معامل التخزين والسماحيه ومعامل التوصيل الهيدروليكي للمياه الجوفية بمنطقة المنوفية.

الشحات بركات البنا ، علي السيد أبو المجد و أحمد محمود بدر
قسم الهندسة الزراعية – كلية الزراعة- جامعة المنصورة

أجريت هذه الدراسة بهدف دراسة متغيرات بعض آبار المياه الجوفية التي أنشأت بمنطقة المنوفية لدراسة مدي الإعتماد علي المياه الجوفية المستخرجة من تلك الآبار في الاستصلاح والاستزراع. لذلك تم إجراء مسح ميداني لثلاث آبار تقع بتلك المنطقة من قبل شركات حفر الآبار بالقاهرة خاصة شركة (ريجوا – الهواري – جواسوم).

تم تجميع نتائج التقارير الإنشائية وتقارير تجارب الضخ لتلك الآبار بهدف تحديد خواص المياه الناتجة منها دراسة تركيز الأملاح بها ومقارنتها بنسب منظمة الأغذية والزراعة العالمية فوجد أنها في حدود المسموح به.

توضح النتائج تقدير نصف قطر دائرة تأثير البئر الواحد فوجد أنها تصل إلي 120 متر لذلك يوصي بعدم إنشاء أبار متجاورة إلا بعد تلك المسافة تجنبا لحدوث تداخل بين تلك الآبار مما يزيد من حدة مخروط الهبوط الحادث بالبئر. وفي نفس الوقت تم تقدير السماحية فثبت أن قيم السماحية ترتبط بمعدل التوصيل الهيدروليكي فلوحظ أن قيمها تزداد بزيادة قيم تلك المعامل وكذلك زيادة نصف قطر تأثير البئر. وأشارت النتائج أيضا نظرا لكبر معدل السماحية وكذلك زيادة قيمة معامل التوصيل الكهربي لآبار تلك المنطقة فنستطيع ضخ المياه منها بمعدل يصل إلي 250 م^3/ ساعة ولمدة تشغيل تصل إلي 12 ساعة يوميا مما يدل علي ارتفاع معدل شحن آبار تلك المنطقة. لذلك نوصي باستخدام تلك الآبار في عمليه استصلاح الأراضي الجديدة والإعتماد عليها مباشره في عملية الري دون أي معالجات.

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