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The Effect of Wells' Spacing on the Recharge Rates

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Abstract: Egypt has suffered recently presence of floods leading to the destruction of properties and even lives and waste large amount of water and from this was the goal of this research is to reduce this disaster (floods) to protect the lives and properties not only that, But it also has the advantage of storing these huge amounts of water and making use of them in the future, We have found one of the best ways to deal with these cases is the artificial recharge projects. We have done a model that simulates the artificial recharge through a group of recharge wells to reach to the ideal distance between recharge wells to reach the highest efficiency in the well rates for the well.
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Keywords: Effect; Well; Space Recharge; Rate

1. Introduction

Egypt is one of the countries of the (Nile Basin (and this is a great advantage, unfortunately this feature has not protected it from entering the range of countries that will certainly suffer in the future from the lack of water resources unless we are correcting mistakes we have on the private level or General.

Artificial recharge projects are important for studying two of the most important sources of water; surface water and ground water, and studying the relationship between them and how to store the flooding storage optimization and not wasted it with understanding the behavior of groundwater under the influence of different factors in the various storage methods.

Artificial recharge projects face several problems. The researcher chose to study the problem of interaction between wells and each other and the extent of the impact of this interaction on the time required for the process of recharge as well as this impact on the recharge rates, whether negative or positive and the relationship expressing the number of wells necessary for an optimization recharge need to be investigated.

According to (UNEP, United Nations Environment Programme), artificial recharge of groundwater is the planned human activity of augmenting the amount of groundwater available through the works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers, resulting in a corresponding increase in the amount of groundwater available for abstraction.

It is interested in that section to discusses the reviewed literature in artificial recharge project and factors affecting groundwater recharge.

According to (Gene E Likens, in Encyclopedia of Inland Waters), groundwater recharge includes recharge as a natural part of the hydrologic cycle and human-induced recharge, either directly through spreading basins or injection wells, or as a consequence of human activities such as irrigation and waste disposal.

Artificial recharge with excess surface water or reclaimed waste water is increasing in many areas, thus becoming a more important component of the hydrologic cycle.

2. Theoretical Approach

The relationships between all parameters, affecting the recharge wells, were comprehended.

According to the dimensional analysis technique of Buckingham's π- theorem, the dimensional analysis is built up on principle of dimensional homogeneity. This principle stated that any equation expressing relationship between physical quantities must be dimensionally homogenous.

According to Buckingham π -theorem, the general form of the relationship between these variables is as follows:

$$\frac{q}{\sqrt{g}*h^{5/2}}=f(\frac{B_1}{B_2},\frac{h_1}{H_2},\frac{h_2}{h_w},\frac{h_t}{H},\frac{X}{Y},\frac{\mu_1}{\delta\sqrt{g}*H^{3/2}},\frac{k_{1x}}{k_{2x}},\frac{k_{1y}}{k_{2y}},\frac{k_{1z}}{k_{2z}},\frac{L_s}{H},\frac{D}{d}) \quad (1)$$

By making a geometrical similarity distorted scale and kinematic similarity distorted scale figured to:

- The maximum water height above the well in model is taken from 1.0 cm to 1.5 cm equivalent in prototype is 1 m to 1.5 m and the aquifer layer in sand tank model height is taken 45 cm; equivalent in prototype is 45 m.

- The dimension of sand tank model is 120 cm width and 120cm long is equivalent to prototype area 1200 m width and 1200 m long respectively.

B_1 = Length of sand tank model.
B_2= Width of sand tank model.
H= Height of water column.
h_1= Height of recharge layer.
h_2= Height of above layer.
X= Distance from original point @ X axis.
Q= Discharge of well.
G= Gravitational acceleration.
ρ = Mass density of fluid.
μ = Dynamic viscosity.
K_1x= Hydraulic conductivity from the soil of recharge layer @ X direction.
K_1y= Hydraulic conductivity from the soil of recharge layer @ Y direction.
K_1z= Hydraulic conductivity from the soil of recharge layer @ Z direction.
Ls= Length of screen.
D= Diameter of well screen.
D= Diameter of opening screen.

Photo (1): Sand tank model

Primarily, an experimental program was designed; prepared the sand tank model; arranged the measuring devices and executed the experimental work and measurements to the parameters under investigation were undertaken. During this phase the researcher conducted several runs during which the incorporated parameters were varied.

All experiments were achieved in the Hydraulics Laboratory in the Faculty of Engineering of Al- Azhar University in Cairo, Egypt. The sand tank **Photo (1).**

3.1 The Dimensions of The Sand Tank Were as Follows:

Length = 120 cm
Width = 120 cm
Height = 80 cm

3.2 Two Observation Wells; Their Coordinates Were as Follows:

Observation well (no. 1) = 60 cm @ axis X & 90 cm at axis Y.

Observation well (no. 2) = 60 cm @ axis X & 70 cm at axis.

3.3 Data of Wells & Perforation

Can be explained data of wells and perforation in table (1).

Table (1) Data of wells & perforation

Symbol	Definition	Dimension	Units
Ls	Length of screen	4.5	cm
D_{out}	Outer diameter of well screen. (photo 2)	2.5	cm
D_{in}	Inner diameter of well screen.	2	cm
d	Diameter of opening screen. (photo3)	0.5	cm
N	Number of opening	18	no.
ao	Total area of opening	3.534	m2
Perf.r	Percentage of perforation	10	%

3.4 Coordinates of Wells

All coordinates start from the Original point (0, 0) and the following.

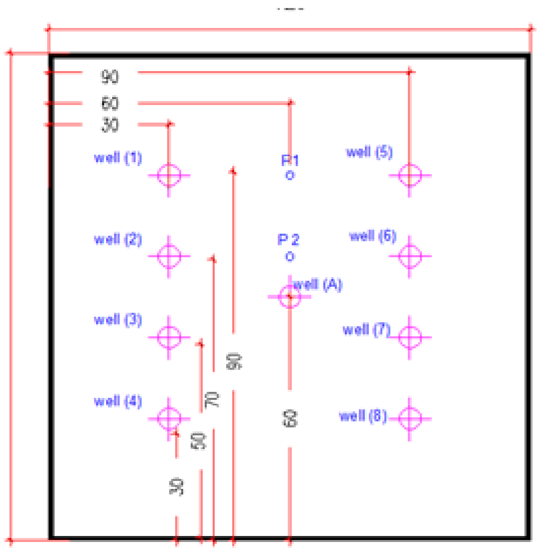

Figure (1): Coordinates of wells

3.5 Control of the Water Level

Establishment the weir to control the water level as well as easy to change the height of water above the wells in order to ensure the stability of water level at the level of all wells. **Figure (2)**

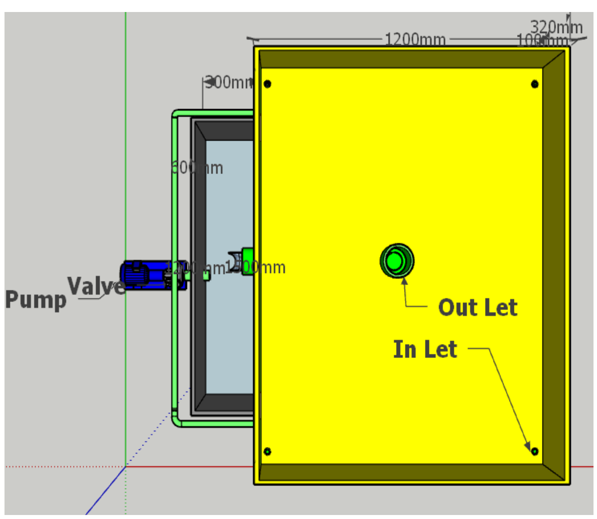

Figure (2): Control of the water levels

3.5 Establishing the water supply system & connecting parts

The weir was installed over the sand tank was connected wells installed in the bottom of the sand tank with the weir channel with was placed, in front of the weir channel to store any surplus of water in order to ensure that the calculation of the amount of water calculated in each experience carefully and then be pulling water from the water reservoir through pump to the weir and lifted the water inside it to the required level and then enter the water in the weir channel Which be to the static level of water inside to ensure stability in the recharge rates for all the wells**. Figure (3, 4).**

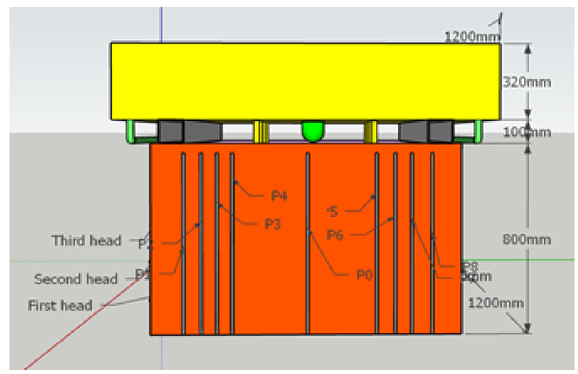

Figure (3): Connection of all parts of sand tank model (3Dview)

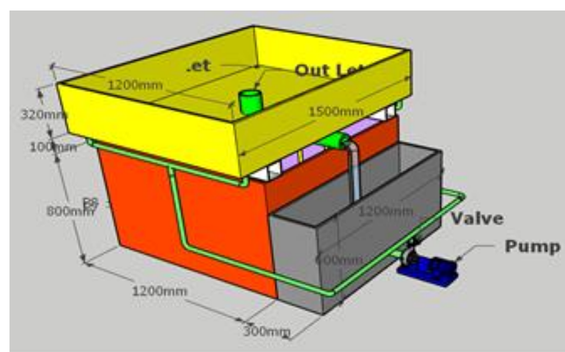

Figure (4): Connection of all parts of sand tank model (side view)

3.6 Determining hydraulic conductivity of soil

Three experiments were achieved in the hydraulics laboratory and take the average between them to increase the accuracy of the results and the results were as **Table (2):**

Table (2): Falling-heads test results

Trial No.	**ho** (cm)	**h1**(cm)	**Time** (sec)	**K** (cm/s)
1	99	75	16	0.004910661
2	75	50	20.5	0.005597396
3	50	25	20	0.009808033

From the above data and applying falling-heads equation.

$$k = \left(\frac{dt^2 . L}{dc^2}\right) * \ln\left(\frac{h_o}{h}\right) \quad (2)$$

The average of hydraulic conductivity = **5.86 meter/day**

3.7 Cases of Experiment

In the laboratory, several multiple distances between wells were studied and can be summarized in the following table (3)

Table (3): Between the distance and the recharge rate

Q (m3/d)	Distance (cm)	Open well
0.59	20	1 + 2
0.81	32	A + 2
0.95	42	A + 1
1.06	60	2+6

4. Numerical Modeling

Groundwater flow and contaminant transport models are being extensively used in the studies related to groundwater systems. Groundwater flow models are used to calculate the rate and direction of movement of groundwater through aquifers and confining units in the subsurface.

4.1 Calibration of Model

When enter the input data and no change in default of specific yield (zero specific yield) where results not satisfactory and the big error were shown in the monitoring wells, **Figure (5).**

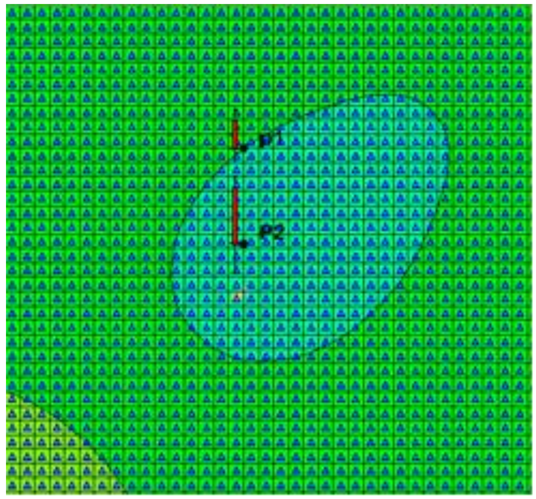

Figure (5): Monitoring wells for (zero specific yield)

Attempts continued until the good readings of the monitoring wells were achieved specific yield = 43 % **Figure** (6).

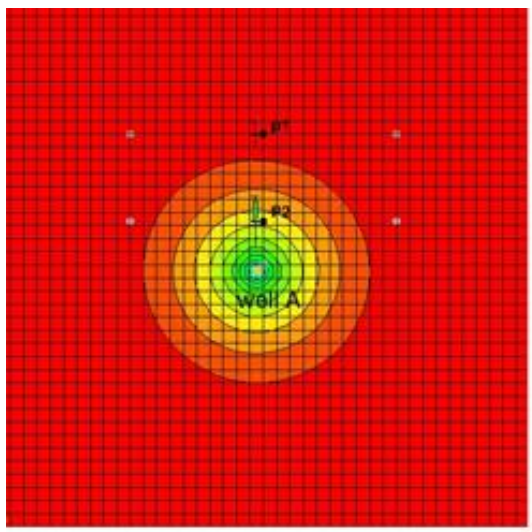

Figure (6): Monitoring wells for (43% specific yield)

Upon reaching the previous case, the accuracy of the monitoring wells exceeded 95%, that is, the error rate does not exceed 5%.

4.2 Estimation of Dimensions, Distances and Field Recharge Rates

4.2.1 In this case is the operation of the well (A) only and used area is 1200 meters length,1200 width meters, and the recharge layer depth is 45 meters with a hydraulic conductivity 5.86 (m/d) the recharge rate was 6150 m3/d the monitoring wells readings were as follows in **Figure 7.**

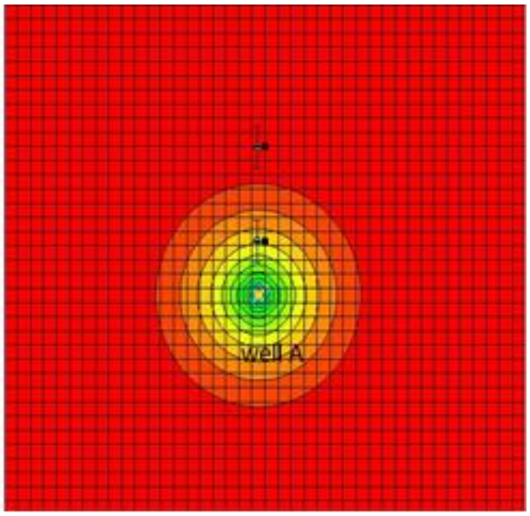

Figure (7): Monitoring wells for (open well A only)

4.2.2 In this case is the operation of the well (1), well (2) and used area is 1200 meters length,1200 width meters, and the recharge layer depth is 45 meters with a hydraulic conductivity 5.86 (m/d) the recharge rate was 3350 m3/d per well the monitoring wells readings were as follows in **Figure (8)**

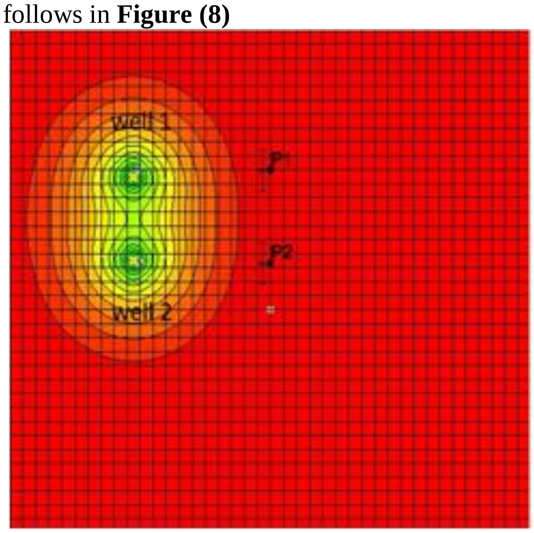

Figure (8): Monitoring wells for (open well 1,2)

4.2.3 In this case is the operation of the well (A), well (2) and used area is 1200 meters length,1200 width meters, and the recharge layer depth is 45 meters with a hydraulic conductivity 5.86 (m/d) the recharge rate was 4580 m3/d per well The monitoring wells readings were as follows in a **Figure (9)**

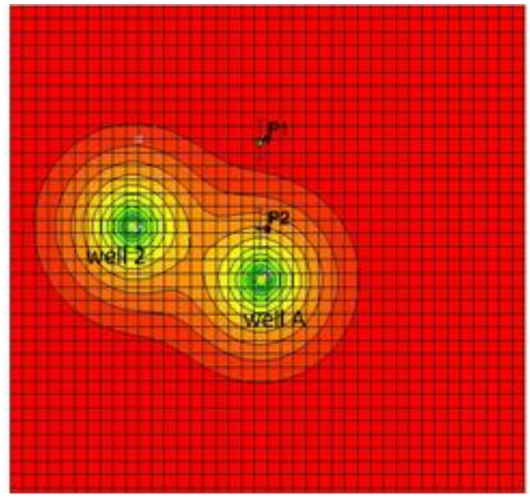

Figure (9): Monitoring wells for (open well A, 2)

4.2.4 In this case is the operation of the well (A), well (1) and used area is 1200 meters length, 1200 width meters, and the recharge layer depth is 45 meters with a hydraulic conductivity 5.86 (m/d) the recharge rate was 5377 m3/d per well the monitoring wells readings were as follows **Figure (10).**

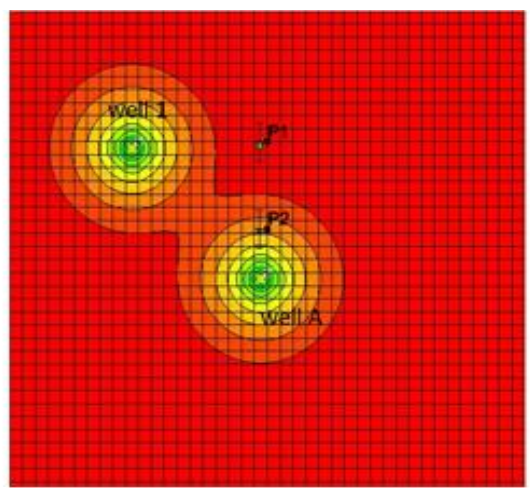

Figure (10): Monitoring wells for (open well A, 1)

4.2.5 In this case is the operation of the well (2), well (6) and used area is 1200 meters length,1200 width meters, and the recharge layer depth is 45 meters with a hydraulic conductivity 5.86 (m/d) the recharge rate was 6150 m3/d per well The monitoring wells readings were as follows in **Figure (11)**

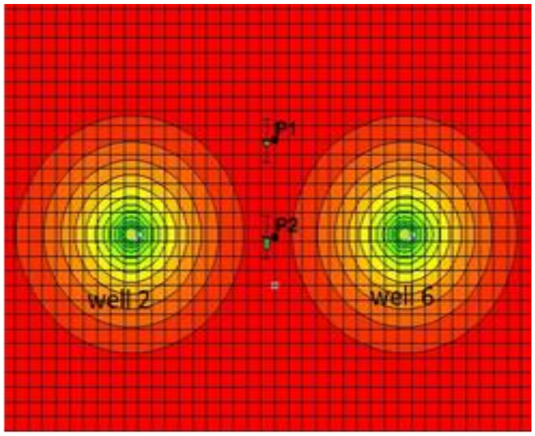

Figure (11): Monitoring wells for (open well A, 1)

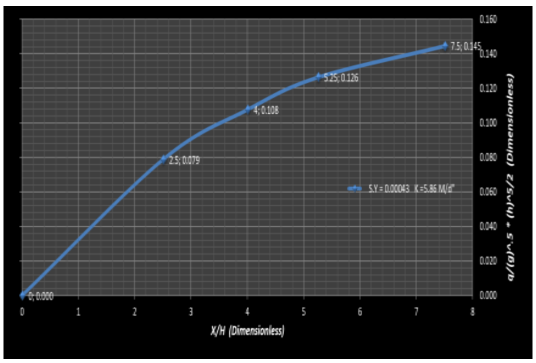

Figure (12) Design Chart

From the above, it is possible to deduce the next curve from which it is possible to deduce the charge rate of the well by knowing the distance between the wells and vice versa. **Figure (12)**

5 Conclusion

- When estimating the optimum distance between wells, the maximum benefit from the well capacity is achieved.

- It is recommended to simulate any flow filed before constructing wells in order to obtain the optimum distance between them.

- It is recommended to calibrate the screen perforation before using it; to make sure that it will allow the required rate, because the type, thickness, material and the density of perforation have a significant impact on recharge rates.

- A design chart has been reached to find the optimum distance between wells for cases similar to the current study.

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