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STORING OF STORM BY MULTIPLE RECHARGE WELLS IN HETEROGENEOUS AQUIFERS

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ملخص البحث

قد عانت مصر فى الفترة الأخيرة من وجود سيول تؤدى إلى إهدار الممتلكات بل والأرواح بالإضافة إلى إهدار كمية كبيرة من المياه وإنطلاقا من هذا كان هدف هذا البحث هو الحد من هذه الكارثة (السيول) لحماية الأرواح والممتلكات ليس ذلك فحسب ولكن تحويلها إلى ميزة أيضاً وهى تخزين هذه الكميات الهائلة من المياه والإستفادة منها فى المستقبل وقد وجدنا أن إحدى أفضل الطرق للتعامل مع هذه الحالات هي مشاريع التغذية الإصطناعية فقمنا بعمل نموذج يحاكى التغذية الإصطناعية عن طريق مجموعة من آبار الشحن للوصول إلى الوقت الأمثل لمعدلات الشحن المختلفة .

1. 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 the optimal time for different shipping rates.

2. 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 of wells with each other and the extent of the impact of this interaction on the time required for the process of recharge and the impact on the recharge rates, whether negative or positive and the relationship to the number of wells necessary for an optimization recharge.

3. Literature Review

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.

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

4. Theoretical Approach

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

According to the dimensional analysis technique of Buckingham's π- theorem where methods of dimensional analysis are 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:

$$\phi\left(\frac{B1}{H},\frac{B2}{H},\frac{h1}{H},\frac{h2}{H},\frac{hw}{H},\frac{ht}{H},\frac{x1}{H},\frac{x2}{H},\frac{x3}{H},\frac{x4}{H},\frac{x5}{H},\frac{y1}{H},\frac{y2}{H},\frac{q1}{H^2\sqrt{H\,g}},\frac{V}{H\rho\sqrt{H\,g}},\frac{k1x}{\sqrt{H\,g}},\frac{k1y}{\sqrt{H\,g}},\frac{k1z}{\sqrt{H\,g}},\frac{k2x}{\sqrt{H\,g}},\frac{k2y}{\sqrt{H\,g}},\frac{k2z}{\sqrt{H\,g}},\frac{a.o}{A.s},\frac{Ls}{H},\frac{D}{H},\frac{d}{H}\right) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

When $\frac{hw}{H}$ = height water ratio, $\frac{a.o}{A.s}$ = perforation ratio

4.1Geomerrical Similarity Distorted Scale

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 vertical scale ratio from similarity is:

$L_{vr}= L_{vm}/L_{vp}$ ………… (2)

The vertical scale is taken = $L_{vr}= L_{vm}/L_{vp}$ = .45/45 =1/100

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

- The vertical scale ratio from similarity is:

$L_{hr}= L_{hm}/ L_{hp}$ ………… (3)

The horizontal scale is taken = $L_{hr}= L_{hm}/ L_{hp}$ = 1.2/1200 = 1/1000.

- Area ratio from similarity is:

$$Ar = \frac{Ap}{Am} = (Lh)r * (Lv)r \quad \ldots\ldots\ldots\ldots (4)$$

The maximum area in model is Am= 1.44 cm^2

Where:

L_m is the length of the model;

L_P is the length of the prototype;

A_m is the area of the model;

A_p is the area of the prototype;

L_{vr} is the vertical length scale;

L_{hr} is the horizontal length scale;

4.2 Kinematic Similarity Distorted Scale

In order to undergo a simulation between the model and prototype, all kinematic parameters should be similar. This is described, as follows:

- Time ratio from similarity is:

$$\frac{T_m}{T_p} = \frac{\sqrt{H_m}}{\sqrt{H_p}} = L_{vr}^{0.50} \rightarrow T_r = \frac{T_m}{T_p} = \sqrt{\frac{1}{100}} = \frac{1}{10} \quad \ldots\ldots\ldots\ldots (5)$$

Time in model ranged between 150~360 min corresponding to 1500~3600 min in a prototype.

Where:

T_m is the time of the model;

T_p is the time of the prototype;

T_r is the time ratio;

5. Experimental Work

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):** dimensions and observation wells Coordinates represented as following data:

1. The dimensions of the sand tank were as follows
2. Length = 120 cm
3. Width = 120 cm
4. Height = 80 cm

5. Two observation wells were opened, indicating the rise of water inside the soil. Their coordinates were as follows :
6. observation well (no. 1)= 60 cm @ axis X & 90 cm at axis Y
7. observation well(no. 2)= 60 cm @ axis X & 70 cm at axis Y

Photo (1): sand tank

5.1 Data of Wells & Perforation

Table (1): Data of wells & perforation

Symbol	Definition	Dimension	Units
L_s	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_1	Number of opening	18	no.
a_o	Total area of opening	3.534	m2
Perf.r	Percentage of perforation	10	%

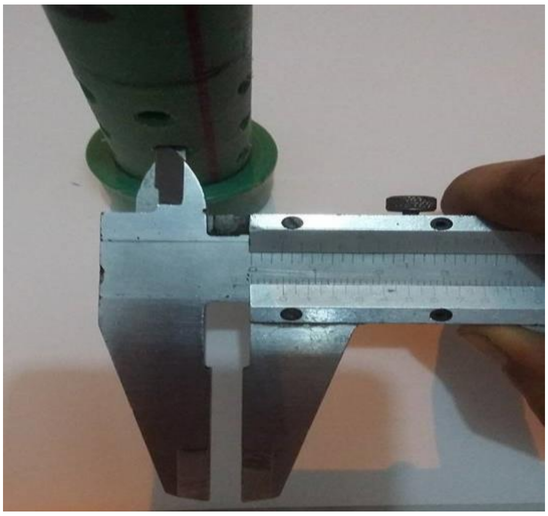

Photo (3): Diameter of opening **Photo (2):** Outer diameter of well

5.2 Coordinate of Wells

All coordinates start from the Original point (0, 0) and the following table (2) and Figure (1) dimensions are in centimeters:

Table (2): Coordinate of wells

no. of well	Coordinate at axis X	Coordinate at axis Y
W_A	60	60
W_1	30	90
W_2	30	70
W_3	30	50
W_4	30	30
W_5	90	90
W_6	90	70
W_7	90	50
W_8	90	30

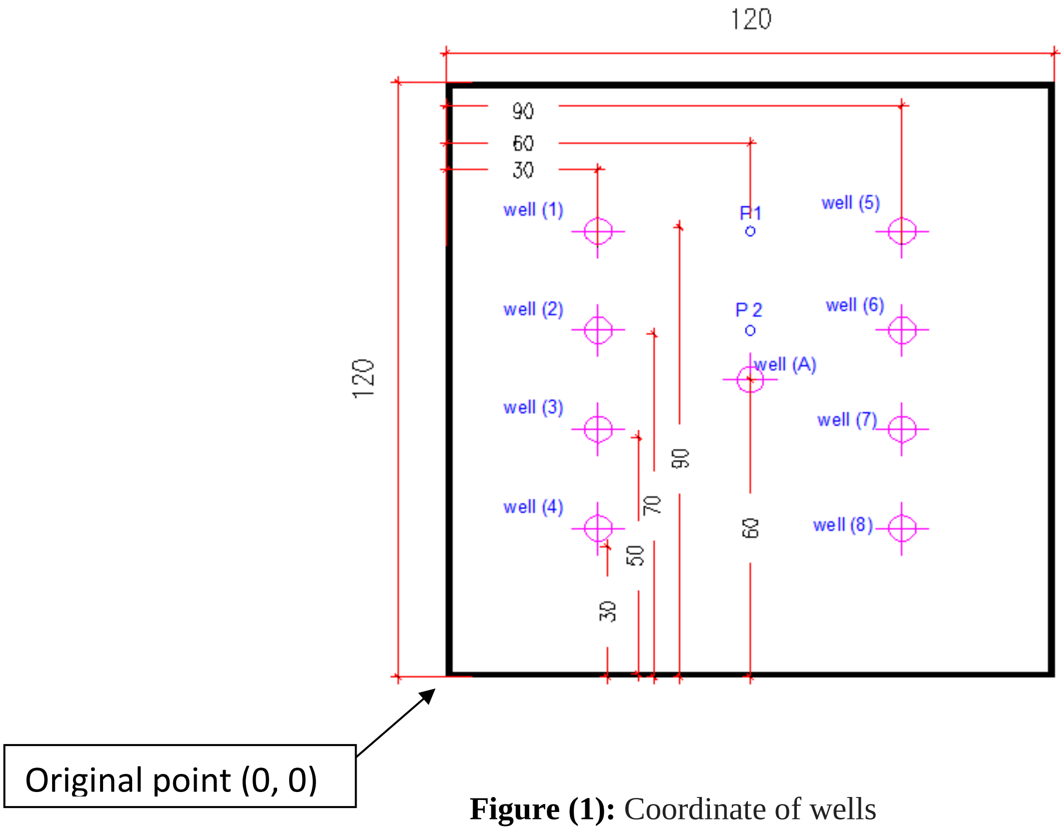

Figure (1): Coordinate of wells

5.3 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), Photo (4).

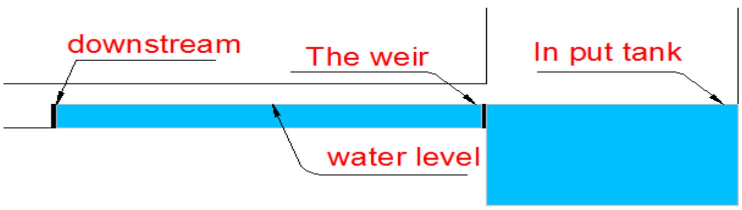

Figure (2): Definition Sketch for Control of the water level

Photo (4): Control of the water level

5.5 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)

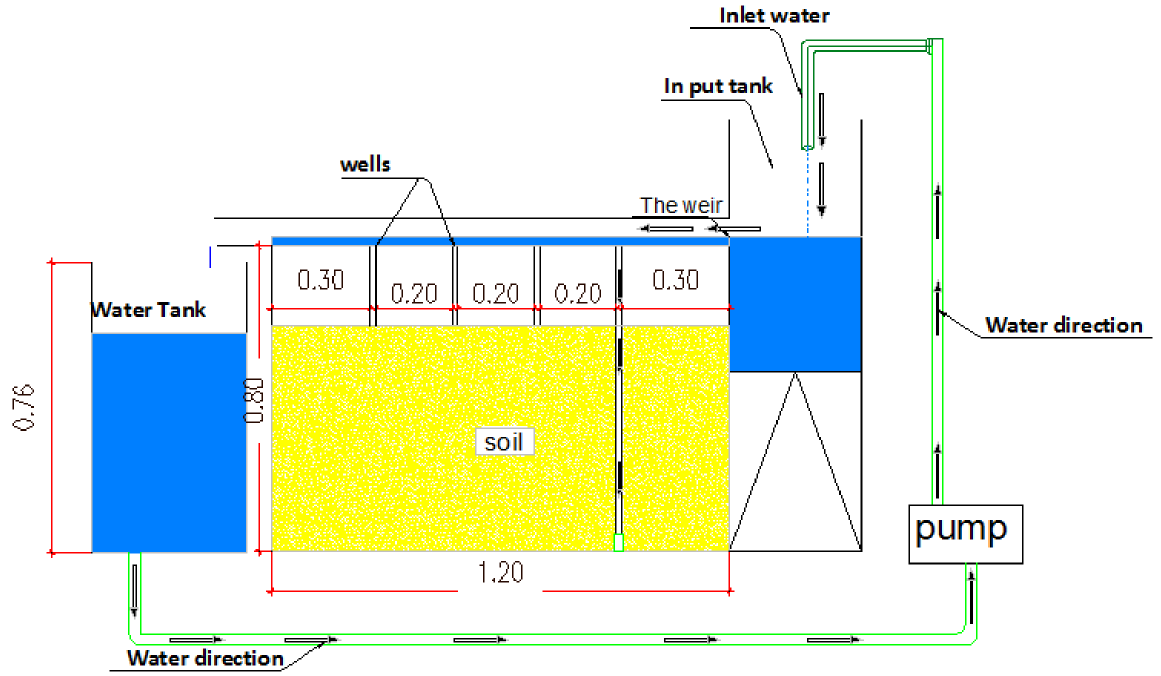

Figure (3): connection of all parts of sand tank model

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 follows:

Table (3): Falling-head test results

Trial Number	**h_0** (cm)	**h_1** (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-head equation

$$k = \left(\frac{dt^2 . L}{dc^2} \right) * \ln\left(\frac{h_o}{h} \right) \qquad \text{(6)} \ldots\ldots\ldots\ldots$$

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

7. Cases Of Experiment

7.1 In case number one during operating only one well (well A) it was observed that if the water level raised by 1.25 % of the total height and the perforation ratio by 5 % of the area screen, the recharge rate was 0.632 cubic meter per day per well.

The results of these trials can be summarized in following **Table (4)** and **Chart (1)**

Table (4): All trails from (height water ratio 1.25 % & perforation ratio 5 %) & save time

Open well	Time / min	save time %
A only	**360**	**100%**
1 + 2	**332**	**15.74%**
A + 2	**288.5**	**19.86%**
A + 1	**259**	**28.06%**
1 + 3	**285.25**	**27.60%**
1 + 4	**295**	**25.13%**
1 + 5	**300**	**23.86%**
1 + 6	**295**	**25.13%**
1 + 7	**309**	**21.57%**
1 + 8	**320**	**18.78%**

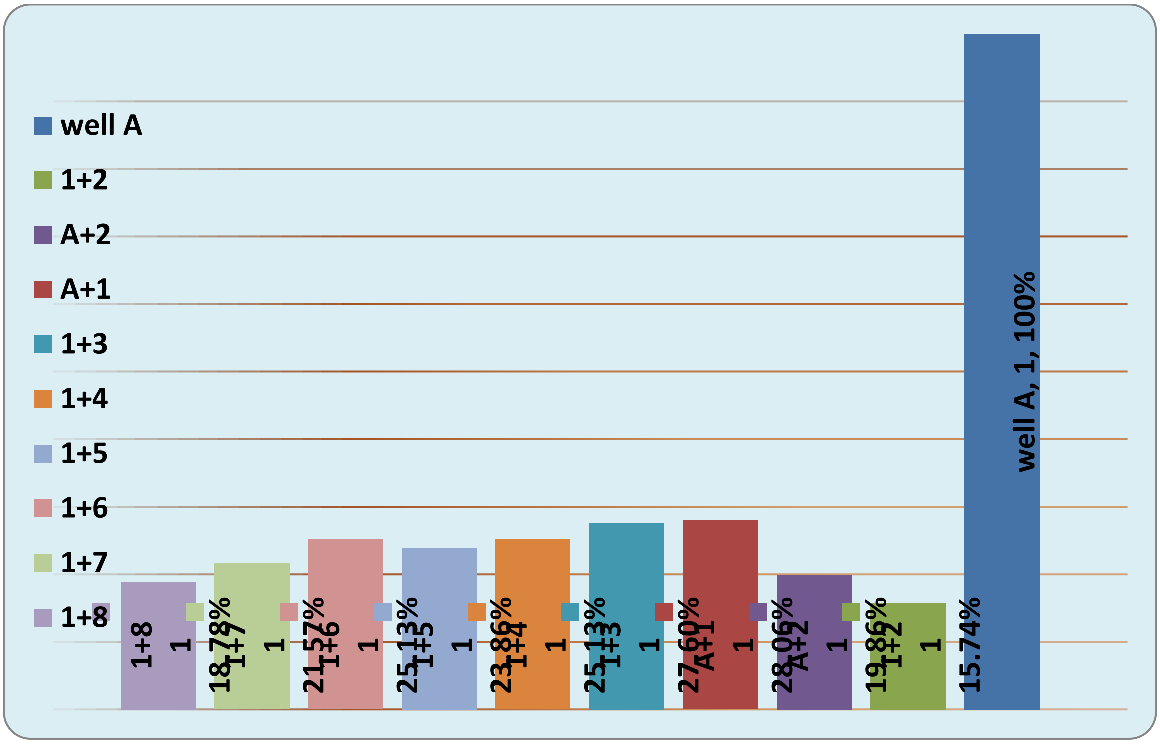

Chart (1): All trails from (height water ratio 1.25 % & perforation ratio 5 %) & save time

7.2 In case number two during operating only one well (well A) it was observed that if the water level raised by 1.875 % of the total height and the perforation ratio by 5 % of the area screen, the recharge rate was Increased by 21 % per well. The results of these trials can be summarized in following **Table (5)** and **Chart (2)**

Table (5): All trails from (height water ratio 1.875 % & perforation ratio 5 %) & save time

Open well	Time / min	save time %
A only	285.5	100%
1 + 2	255.5	17.58%
A + 2	220	22.94%
1 + 3	230.5	25.65%
A + 1	206	27.85%
1 + 4	201	35.16%
1 + 5	203.5	34.35%
1 + 6	205	33.87%
1 + 7	227	26.77%
1 + 8	234	24.52%

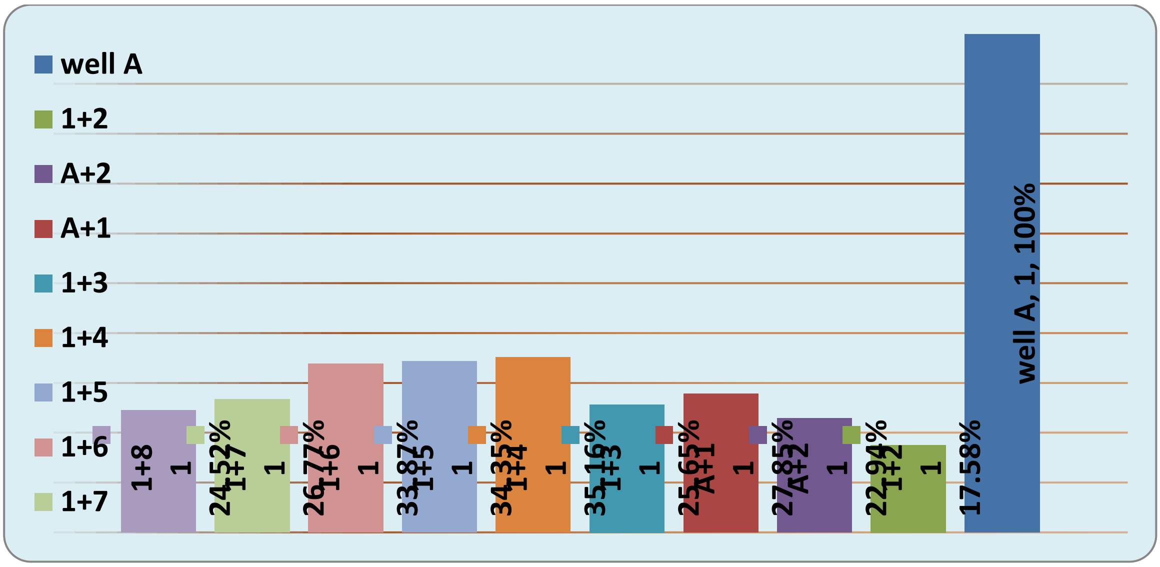

Chart (2): All trails from (height water ratio 1.875 % & perforation ratio 5 %) & save time.

7.3 **In case number three** during operating only one well (well A) it was observed that if the water level raised by 1.25 % of the total height and the perforation ratio Increased by 10 % of the area screen, the recharge rate was Increased by 28.1 % per well.

The results of these trials can be summarized in following **Table (6)** and **Chart (3)**

Table (6): All trails from (height water ratio 1.25 % & perforation ratio 10 %) & save time

Open well	Time / min	save time %
A only	260	100%
1 + 2	231.5	18.77%
A + 2	202.5	22.12%
1 + 3	213.5	25.09%
A + 1	184	29.23%
1 + 4	185.5	34.91%
1 + 5	190	33.33%
1 + 6	180	36.84%
1 + 7	184	35.44%
1 + 8	190.5	33.16%

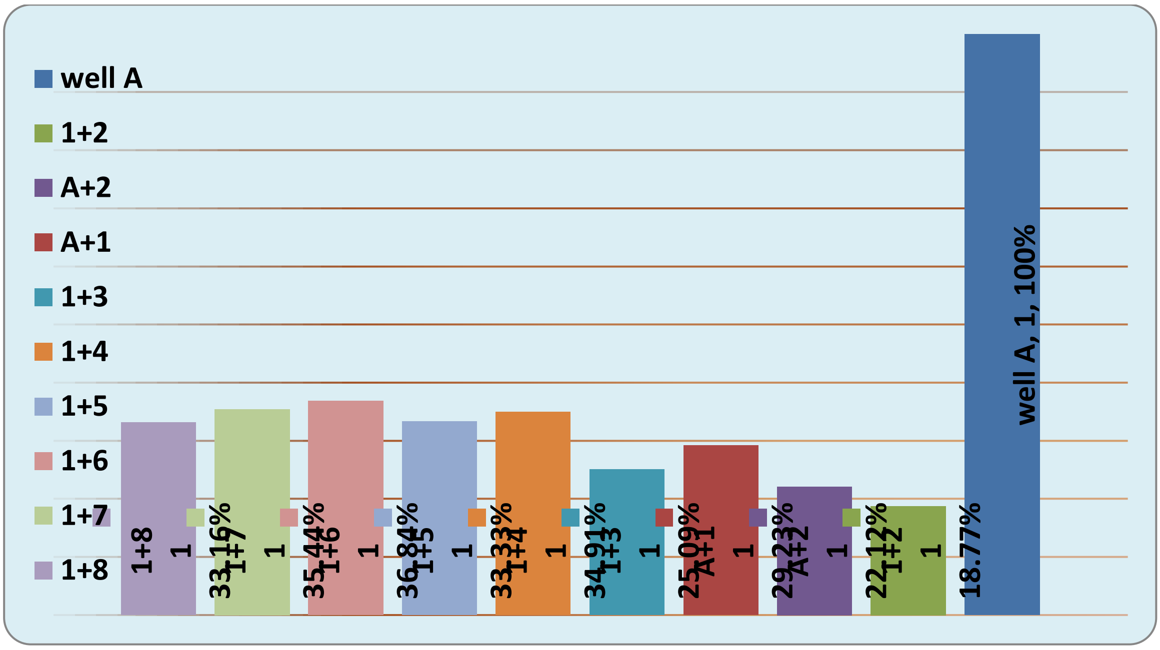

Chart (3): All trails from (height water ratio 1.25 % & perforation ratio 10 %) & save time

7.4 In case number four during operating only one well (well A) it was observed that if the water level raised by 1.875 % of the total height and the perforation ratio Increased by 10 % of the area screen, the recharge rate was Increased by 41.69 % per well.

The results of these trials can be summarized in following **Table (7)** and **Chart (4).**

Table (7): All trails from (height water ratio 1.875 % & perforation ratio 10 %) & save time

Open well	Time / min	save time %
A only	195	100%
1 + 2	200.5	14.50%
A + 2	171.5	12.05%
1 + 3	180	23.24%
A + 1	146.5	24.87%
1 + 4	166	29.21%
1 + 5	160	31.77%
1 + 6	155	33.90%
1 + 7	159	32.20%
1 + 8	174	25.80%

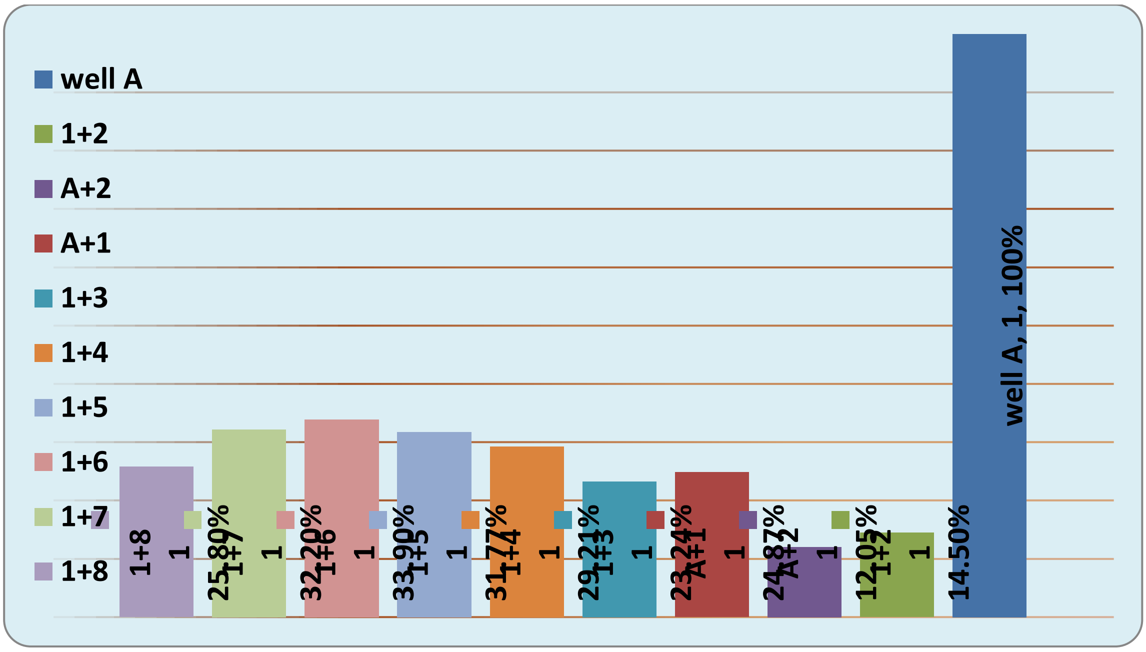

Chart (4): All trails from (height water ratio 1.875 % & perforation ratio 10 %) & save time

8. 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.

8.1Calibration 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, Photo (5).

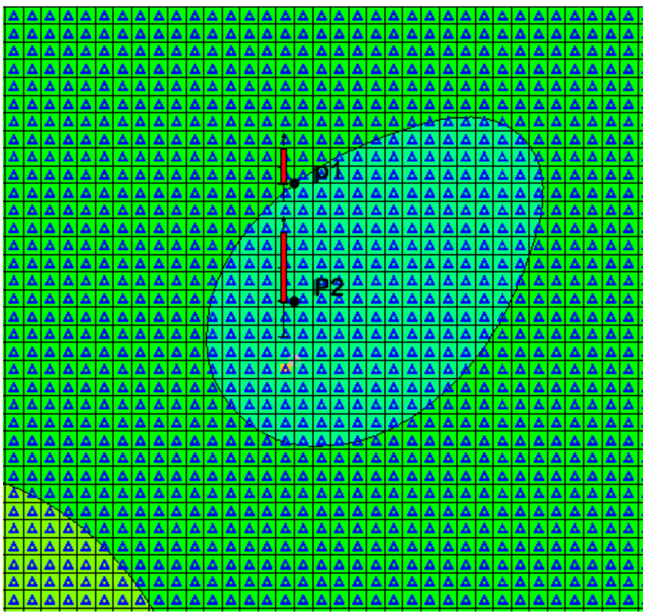

Photo (5): monitoring wells for (zero specific yield)

When the value of specific yield was change, the monitoring wells show some response, Photo (6).

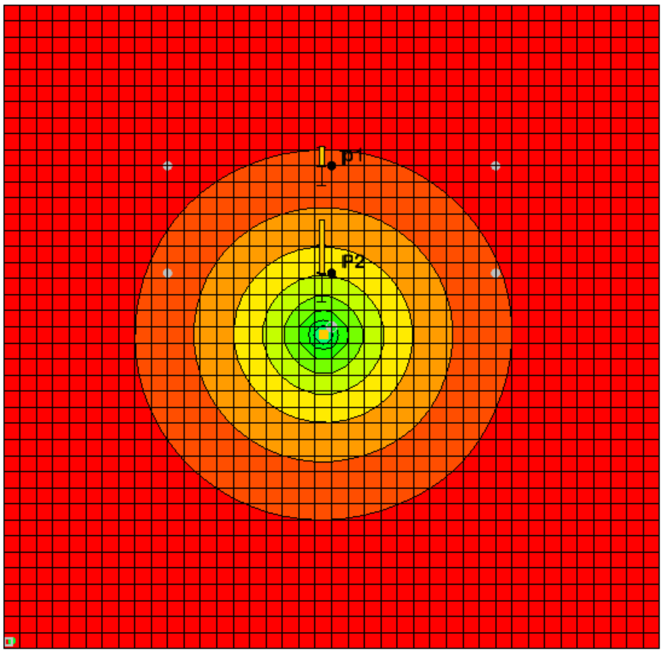

Photo (6): monitoring wells for (20% specific yield)

Attempts continued until the good readings of the monitoring wells were achieved specific yield = 43 % Photo (7)

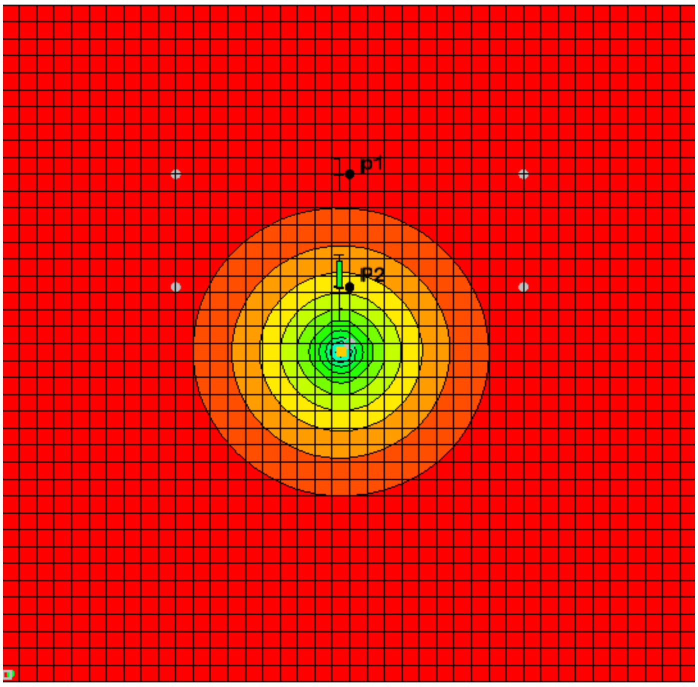

Photo (7): monitoring wells for (43% specific yield)

9. Summary and Conclusions:

When the water ratio raised from 1.25% to 1.875% accordingly the recharge rate increased by 21 % per well and the perforation ratio Increased from 5 % to 10 % of the area screen, the recharge rate was Increased by 28.1 % per well.

In case number one when condition of height water ratio 1.25 % & perforation ratio 5 % the optimum time was between well(A) and well (1) when the save time is 28.06 % from the total time

In case number two when condition of height water ratio 1.875 % & perforation ratio 5 % the optimum time was between well (4) and well (1) when the save time is 35.16 % from the total time.

In case number three when condition of height water ratio 1.25 % & perforation ratio 10 % the optimum time was between well (6) and well (1) when the save time is 36.84 % from the total time .

In case number four in condition of height water ratio 1.875 % & perforation ratio 10 % the optimum time was between well(6) and well (1)when the save time is 33.90 % from the total time.

10.References

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