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GROUND WATER CONTROL METHOD SIMULATION IN SPHINX AREA"

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Abstract - *In terms of the importance of preserving the area of the Sphinx, pyramids, temples and monuments of Egypt, where population growth will introduce new sources of water will certainly increase the rise of groundwater levels, began with the main objective is to protect the Sphinx from the dangers of rising groundwater levels. Through the development of the research objectives, the research methodology was planned. This methodology includes an introduction to the importance of the research topic, 5 stages of investigation. The theoretical stage, the data collection stage, the numerical modeling phase, the analytical stage and the theoretical stage. The previous research in the field of groundwater was presented to utilize the previous studies through simulations, which are collected. The data collection stage, where a complete picture of the area was filmed. Numerical Emphasis several alternatives have been proposed to limit the rise of groundwater in the Sphinx region in order to keep it from deteriorating. In addition, the Sphinx was designed before and after the implementation of alternatives to predict the impact of such countermeasures. For the analytical phase, numerical modeling results were analyzed and the impact of the proposed measures analyzed. With regard to the deductive phase, conclusions were made; recommendations were proposed and an appropriate measure was commended in order to preserve the region from the risk of rising groundwater. By modeling groundwater using mod flow, calibrating the model to verify its validity in all cases and suggesting measures (alternatives) to counter the rise of groundwater in the Sphinx (sinks, horizontal wells, vertical barriers), and simulating the Sphinx Before and after the implementation of the proposed alternatives to predict the impact of these measures. The results of the numerical modeling were analyzed and the impact of the five proposed measures was evaluated.*

Key Words: Ground Water Modelling; Mod-flow; conceptual model; Numerical model; Drain; Horizontal well; Barrier; vertical wells.

1. PROPOSED ALTERNATIVES

Based on the results of the previous researches that investigated the study area, several alternatives and their combinations were proposed. These are, as follows: -Linear drains in trenches, Combined Linear drains and Barrier, Horizontal well, Combined horizontal well and Barrier, Barrier and vertical wells.

2. LINEAR DRAINS IN TRENCHES

Based on the linear drain system simulation, it was recommended to lower the drain by an additional 0.5 m. Thus, the trench invert should be lowered by 1.5 m. Accordingly, the (13.00) m target level is achieved in Sphinx Area. In addition, the flow to the drain would be 11050 m3/d, figure (1).

Finally, one of the most important features least total cost and the most important disadvantages greatest construction impact. Finally, one of the most important features least total cost and the most important disadvantages greatest construction impact.

Drain Flow 11050 m3/d

Drain Elevation 11.95 - 12 m

Figure (1) Calculated Groundwater Levels for Linear Drain

3. COMBINED LINEAR DRAINS AND BARRIER

Based on the simulation of the linear drain system with a barrier, it was recommended to lower the drain system by an additional 0.5 m. Thus, the trench invert should be lowered by 1.5 m. Accordingly, the (12.00) m target level is achieved in the Sphinx Area. In addition, the flow discharging into the drain would be 9805m3/d, figure (2).

As for cost, total cost (L.E) 69 million Including capital cost (45 million), operation and maintenance (24 million) up to 40 years.

Finally, one of the most important features high drawdown and the most important disadvantages greatest construction impact and high total cost.

Drain Flow 9805 m3/d

Drain Elevation 11.95 - 12 m

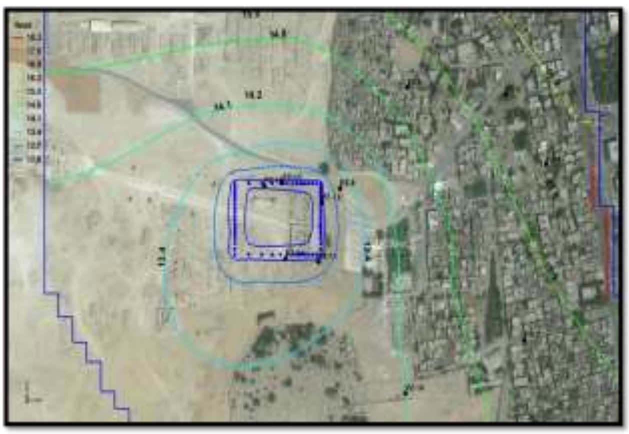
Figure (2) Calculated Groundwater Levels for Liner Drain- with barrier

4. HORIZONTAL WELL

Based on the simulation of the horizontal well, it was recommended to lower the horizontal well by an additional 0.5 m. Thus, the horizontal well invert should be lowered by 1.5 m. Accordingly, the (12.00) m target level is achieved in the Sphinx Area. In addition, the flow discharging into the horizontal well would be 11500m3/d, figure (3).

As for cost, total cost (L.E) 54 million Including capital cost (30 million), operation and maintenance (24 million) up to 40 years.

Finally, one of the most important features small Implementation period and the most important disadvantages requires importation of equipment and materials and high capital cost.



Hz. well pumping 11500 m3/d

Hz. well Elevation 12 m

Figure (3) Calculated Groundwater Levels for Horizontal well

5. HORIZONTAL WELL WITH THE BARRIER

Based on the simulation of the horizontal well with the barrier, it was recommended to lower the horizontal well by an additional 0.5 m. Thus, the trench invert should be lowered by 1.5 m. Accordingly, the (12.00) m target level is achieved in the Sphinx Area. In addition, the flow discharging into the horizontal well would be 9000m3/d, figure (4).

As for cost, total cost (L.E) 69 million Including capital cost (45 million), operation and maintenance (24 million) up to 40 years.

Finally, one of the most important features high drawdown and the most important disadvantages requires importation of equipment and materials and high capital cost.

Hz. well pumping 9000 m3/d

Hz. well Elevation 12 m

Figure (4) Calculated Groundwater Levels for Horizontal well- with barrier

6. BARRIER

Based on the barrier simulations, the calculated groundwater levels are presented on figure (5). The16.25m target level was not achieved in Sphinx Area. This indicated that it is not recommended to use the barrier, as it does not achieve the desired goal but when used on low permeable layers achieves the target level and reduce the ground water level to (11.08) m.

As for cost, total cost (L.E) 39.6 million Including capital cost (9.6 million), operation and maintenance (30 million) up to 40 years.

Finally, one of the most important features least running cost and the most important disadvantages greatest construction impact and high capital cost.

Barrier with vertical well pumping 400 m3/d

Figure (5) Calculated Groundwater Levels for Barrier

7. CONCLUSIONS

Based on the obtained results and their analysis, the following conclusions were deduced:

- Alternative I and III (Linear drains and horizontal wells) are the economic measures and could reduce the groundwater table to a target level of (12.00) m. However, alternative I is the most economic.
- Alternative II and IV (Linear drains and horizontal wells with barrier) could reduce the groundwater table to a target level of (12.50) m. However, it is relatively uneconomic as the barrier could not be implemented, as it requires a low-permeable layer to prevent vertical flow.
- Alternative V(barrier) did not achieve the target level in Sphinx Area. Therefore, it is not recommended to use it at places with layers with high hydraulic conductivity, but when used on low permeable layers achieves the target level and reduce the ground water level to (11.08) m.

8. RECOMMENDATIONS

Based on the deduced conclusions, the following recommendations were suggested:

- Regarding the Engineering practice, the following are suggested:
  - ✓ The first and third alternative (Linear drains and horizontal wells) is suitable to preserve the area of the Sphinx from the damage of groundwater, where the security level (12.00) m above the sea level and preferably the first alternative (linear drain) as it is economically feasible and recommend to put it on 1.5 m of the security level.
  - ✓ The second and fourth (Linear drains and horizontal wells with barrier) alternative is suitable to preserve the area of the Sphinx from the damage of groundwater, where it achieves a more secure level is economically inappropriate in addition to the use of vertical barriers in this area does not fit the nature of the layers in the area of lime limestone highly hydraulic conductivity where does not prevent the vertical flow, Groundwater security is not achieved at the Sphinx for the above reasons. It was studied only to illustrate its effect on the assumption of a low hydraulic conductivity layer and is only suitable in areas with green or soil injection with a research that prevents vertical flow.
  - ✓ Alternative V is not recommended to be implemented, as it does not achieve the target level.
  - ✓ vertical wells are used where there has been security level, but you must be careful where the highest value will be recorded for the decline of alternatives, but easily characterized by implementation and less to create value.
  - ✓ The choice should be governed by the economic condition, the applicability of the measure without affecting the tourism in the Sphinx Area and Scalable to increase the expected groundwater level.

9. SUMMARY FOR STUDY ALTERNATIVES.

After completion of the study of all alternatives from the point of drawdown and subsidence resulting from that drawdown and the cost of each alternative for the following is a summary of the study in the following table to facilitate the process of comparison between alternatives and choose the best alternative of all interfaces.

NO	ALTERNATIVE	HEAD (ASL-M)	PUMPING RATE (CMD)	VERTICAL DISPLACEMENT (MM)	CAPITAL COST (LE)	TOTAL RUNNING COST (LE) /40 YEARS	TOTAL COST(LE)	THE BEST RANKING
1	LINEAR DRAIN	(12.05)	11050	1.4	15000000	24,000,000	39,000,000	1
2	LINEAR DRAIN WITH BARRIER	(12.08)	9805	2	45,000,000	24,000,000	69,000,000	6
3	HORIZONTAL WELLS	(11.90)	11500	2.4	30,000,000	24,000,000	54,000,000	3
4	HORIZONTAL WELLS WITH BARRIER	(12.00)	9000	2	45000000	24,000,000	69,000,000	5
5	BARRIER WITH BASE PLUG	(11.08)	400	1.7	30,000,000	9,600,000	39,600,000	4
6	BARRIER	(16.25)	0	0	15,000,000	-	15,000,000	7
7	VERTICAL WELLS	(12.05)	25000	5	7,200,000	43,200,000	50,400,000	2

Table (1) Summary for Study Alternatives

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