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SIMULATION OF INFLUENCE OF DIFFERENT SOURCES GROUNDWATER LEVEL

A. M. EL MOLLA[1], MOHAMED. A .GAD [2],W. A. ABD ELGALIL[3], RANI FOUAD MOHAMED [4] AND OSAMA A. EL ASHRY[5]

1 PROF. OF IRRIGATION AND HYDRAULICS, AL AZHAR UNIVERSITY
2 ASSOCIATE PROF. OF IRRIGATION AND HYDRAULICS, AIN SHAMS UNIVERSIT
3 ASSOCIATE PROF. OF IRRIGATION AND HYDRAULICS, AL AZHAR UNIVERSITY
4 LECTURERS OF IRRIGATION AND HYDRAULICS, AL AZHAR UNIVERSITY
5 ASSISTANT LECTURER OF IRRIGATION AND HYDRAULICS, AL AZHAR UNIVERSITY

الملخص البحث:

تعتبر محاكاة تأثير مصادر المياه الجوفية المختلفة من الأهمية بمكان حيث ظهر في الآونة الأخيرة إرتفاع ملحوظ في منسوب المياه الجوفية في بعض المواقع والمعابد الأثرية الهامة الواقعة في المناطق المنخفضة نسبيا في منطقة أهرامات الجيزة الأثرية وأبو الهول وبدراسة المصادر المختلفة تبين أن أسباب زيادة المياه الجوفية يرجع ألي عدة عوامل زيادة معدلات رشح وتسرب المياه من شبكات المياه والصرف الصحي من هذه الكتل السكانية حيث بدأ الزحف العمراني يحاصر منطقة هضبة أهرامات الجيزة بصفة عامة وبصفة خاصة بدأ يقترب بطريقة عشوائية حول موقع تمثال أبو الهول والمعابد الأثرية المجاورة والتوسعات العمرانية وكذلك الأراضي الزراعية من كافة الاتجاهات وكذلك المياه المتسربة من الأراضي الزراعية عند بعض المناطق السكنية المتاخمة مباشرة لمنطقة أهرامات الجيزة ، وكذلك فندق وملعب جولف مينا هاوس، وتبطين ترعة المنصورية، وكذلك توقف محطة نزح المياه الجوفية بمنطقة الأهرام سعة 25000 م^3/يوم التي تبعد حوالي 2 كم من منطقة أبو الهول ، فقد بدأ هذا البحث بهدف رئيسي هو حماية منطقة أبو الهول من أخطار ارتفاع منسوب المياه الجوفية عن طريق عمل نمذجة للمياه الجوفية والنموذج المطبق (mod flow).

ABSTRACT

The simulation of the impact of various groundwater sources is of great importance. Recently, there has been a significant rise in groundwater levels in some important archaeological sites and temples located in the relatively low areas of the Giza Pyramids and Sphinx. Any number of factors increase the rates of filtration and leakage of water from the water and sanitation networks of these population blocs where the urban encroachment besieged the area of the Pyramids of the Pyramids in general and in particular began to approach randomly around the location of Such as the Sphinx and adjacent archaeological temples and urban expansions as well as agricultural land of all directions as well as water leaking from agricultural land in some residential areas adjacent directly to the Pyramids of Giza, as well as hotel and golf course Mena House, and lining the canal Mansouriya, 25000 m3 / day, which is about 2 km from the Sphinx, this research has started with the main objective of protecting the Sphinx from the dangers of rising groundwater levels by modeling groundwater and the mod flow model.

KEY WORDS:
Ground Water Modeling, Modflow, Influence Ground Water Rise, conceptual model, Numerical model.

MODEL STRATIGRAPHY

Historical data and recent borings were implented to generate stratigraphy across the domain of the model. Estimates of model edge stratigraphy were developed based on the geology area. Figures (1), the model was designed with six layers. They represent, from top: Upper sand layer and fill, Upper layer of clayey silt, Layer of silty sand, Lower layer of clayey silt, Lime stone layer at the left of the model, Lower layer of sand.

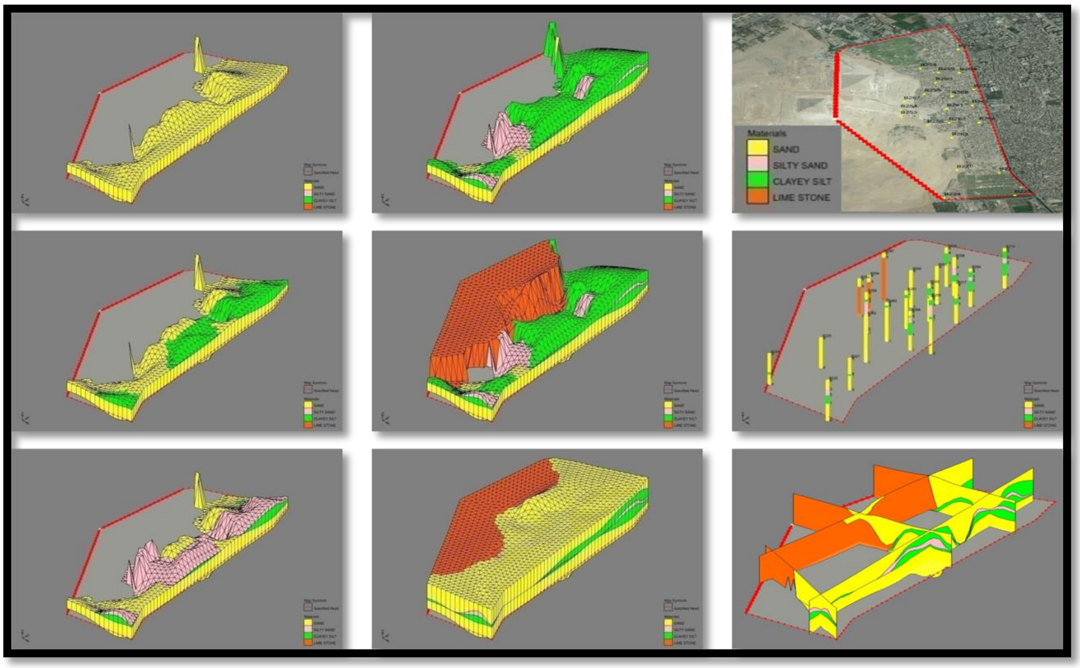


Figure (1) Stratigraphic Conceptual Model for study area

The aquifer parameters were specified based on developed information and collected data collected. The aquifer parameter (i.e. hydraulic conductivity, K) is specified to the model. Its determined from the pumping tests. Accordingly, the aquifer transmissivity, T, is obtained, which is related to conductivity “T =K H”. H is aquifer thickness. The specific yield is specified. It controls the stresses propagation speed in the aquifer.

The information was employed to initiate the aquifer parameters before the model calibration process. Adjustments were achieved to match field measurements, as possible. Figures (2) present the calibrated hydraulic conductivities to each layer. As the aquifer thickness is 40 m, it was used to convert conductivities into transmissivities.

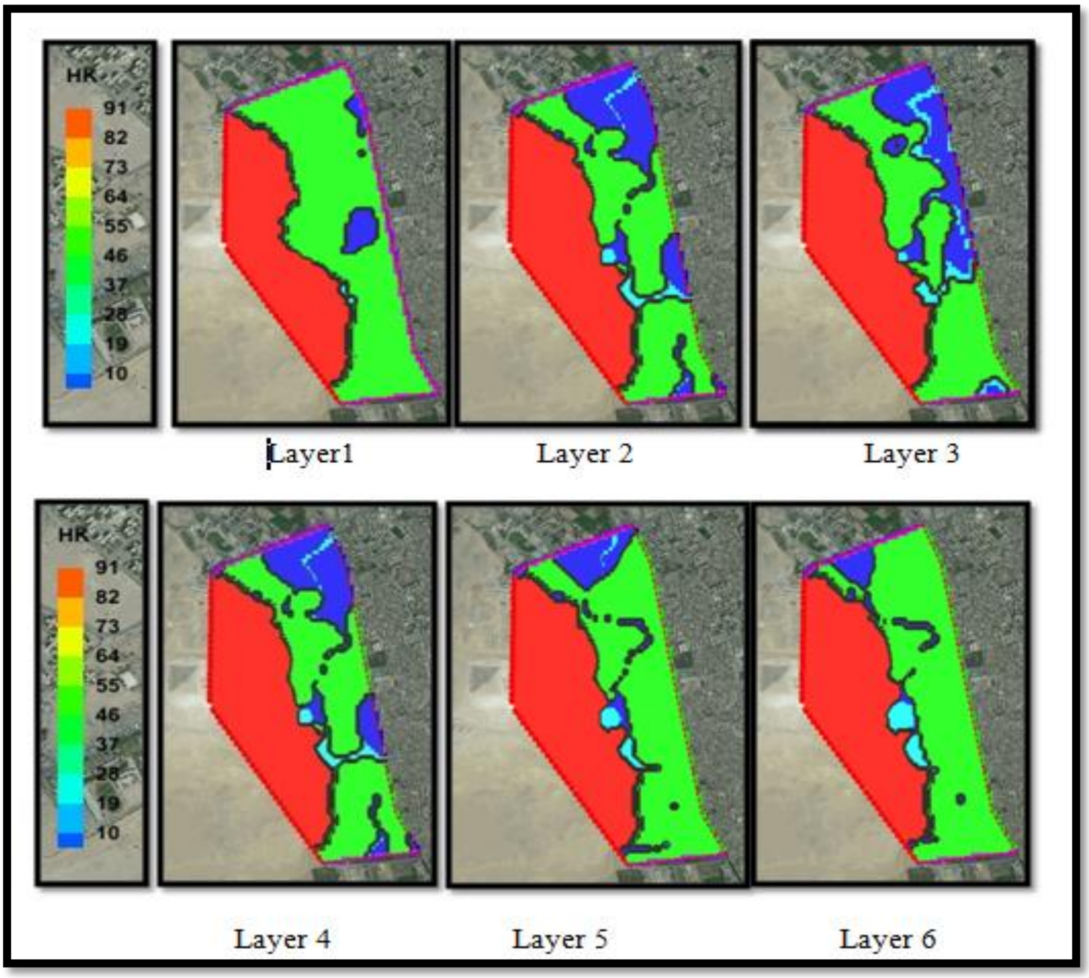


Figure (2) Hydraulic Conductivity (m/day)

After the calibration process, the conductivity for limestone in layers1to 6 was 100 m/day (i.e. T =4000 m^2/day). The lower alluvium hydraulic conductivity in layers 2 and 4 was 1m/day (T = 40m^2/day).This was within the available pump test results. The northeast area,layers1and 6 was 40m/day (T = 1600 m^2/day).This was slightly above pump test results, near Mena House. The little data at the model northwest corner was based on boring information. During calibration lowering the conductivity, to be as clay, enhanced the results. This area is assumed to be clay-like with a conductivity of 1 m/day .The upper alluvium sand and the lower hydraulic conductivities were assumed 40 m/day, and 1 m/day for confining clayey silt in layers 2 and 4, respectively. For the silty sand, it was assumed 8 m/day. Additionally, the vertical hydraulic conductivity was assumed 1/4 of the horizontal, except for limestone (1/1).

BOUNDARY CONDITIONS

Boundary conditions were assumed: ***West boundary:*** No flow (i.e. groundwater flow was assumed parallel to boundary). ***North boundary:*** specified head was linear from east to west to be 18.5 to 17 m ASL based on monitoring well measurements. ***South boundary:*** specified head was linear from east to west to be 19 to 17 m ASL based on monitoring well measurements. ***East boundary:*** Partial hydraulic connection to Mansouriah Canal was simulated in MODFLOW as head-flow dependant with a calibrated value of conductance (i.e. It was linear from north to south to be 18.5 to 19 m

ASL from recorded measurements, where the conductance ranged between 0.1 m^2/day and 5 m^2/day).

RECHARGE

This section elaborates the different recharge sources; figure (3), as follows: ***Recharge due to precipitation:*** This is due to the average annual rainfall, which is 29 mm in Cairo, during November till May. This is a very small quantity compared to the aquifer recharge. In Nazlet El Semman, there is a portion of the rainfall runs off on the impervious pavement. This amount runs into the drainage system. On Pyramids Plateau, the groundwater is very deep. Accordingly, rainfall evaporates before reaching water table. ***Recharge from Nazelt El Semman leakage:*** Nazlet El Semman population is48,300 in year 2010.Their water consumption is19,000m^3/day. 30% is not considered as it is un-metered, where leakage is estimated to be 15 to 20% (i.e. at 17%, 3,230 m^3/day is distributed over 820,911 m^2). ressults in an average of 0.0039 m/day, On the other hand, leakage from the sewers is small due to the limited pressures. In addition, recharge comes out in spots. Furthermore, TDS and nitrate develop sewer system leakage. Higher concentrations were detected by Cairo University (2008).Moreover, high values were detected close to Sphinx, while low values were observed at Nazlet El Semman. ***Course of irrigation in Mena House Golf:*** The recharge rate is 420 m^3/day. It was documented by ECG, over 158,168 m^2. The results are 0.0027 m/day in average. ***Developments in Fayoum Road and near places:*** Based on aerial photos, recharge was applied outside Nazelt El Semmanand golf course. Nazelt El Semman has got insufficient information to estimate recharge rate. Accordingly, an initial recharge rate was assumed, which was adjusted during calibration. ***Course of Mena House Golf:***. A recharge 0.0026 m/day was implemented to 843,184 m^2 of agricultural area southeast of the grid.

NUMERICAL MODEL CALIBRATION

Calibration process is the most important stage in any numerical model implementation. During this stage, the model parameters are tuned to provide results similar to the measured quantities, Calibration was carried out for scenario according to the achieved measurements to the groundwater, in spite of the fact that there was some uncertainties regarding the aquifer (e.g. rates of well extraction rates, recharge, canal and river elevations). Consequently, assumptions were put forward to simulate the average conditions for the scenario and calibration scenario were carried out. For calibration scenario, the aquifer hydraulic characteristics and boundary conditions were adjusted to balance the results. Accordingly, GMS software calculated the calibrated parameters in order to achieve the least difference between calculated and observed results. In addition, the mean error and mean absolute error were estimated(i.e. if the mean error is 0, the differences are positive, while the mean absolute error is an absolute value that calculates the total average. This value indicates the average difference between calculated and observed values. During this calibration process, a steady state condition was assumed and the 14piezometers contours, near Sphinx, were obtained for 1989. The calculated and observed results, ***AMBRIC 1990***, were compared; figure (4). The mean error indicated that the calculated values were 0.034 m high. The mean absolute error signposted the calculated and observed values difference was 0.55 m. The Root Mean Square error was 0.65.Figure (5) indicates the piezometer groundwater elevation agreed to observations in Sphinx Area (i.e. limestone), where these values are slightly higher in alluvium.

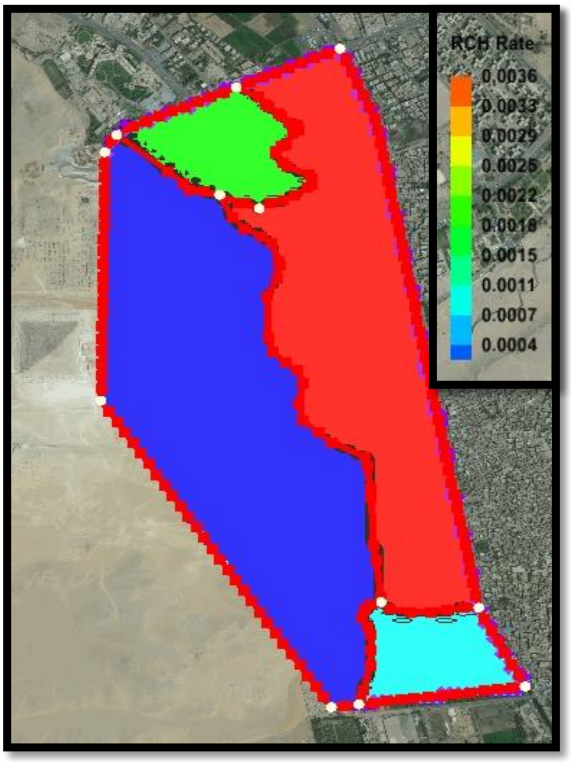


Figure (3) Applied Recharge (m/day).

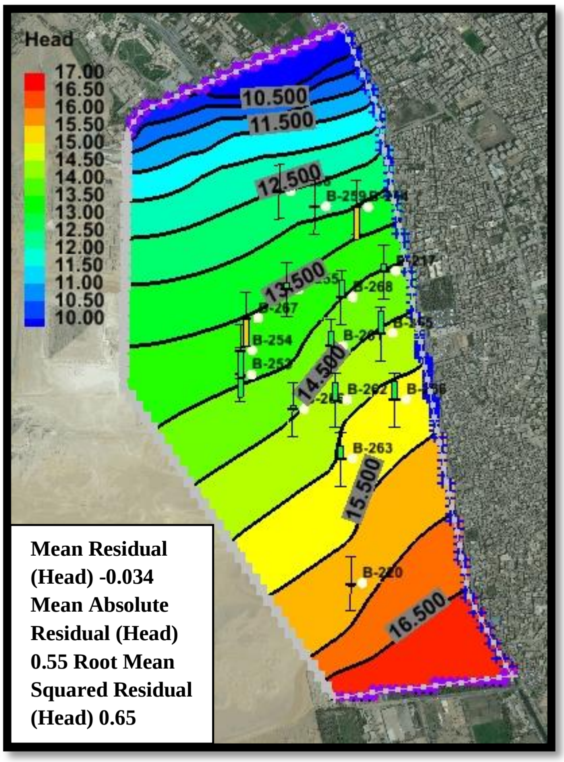


Figure (4) 1989 calibration results.

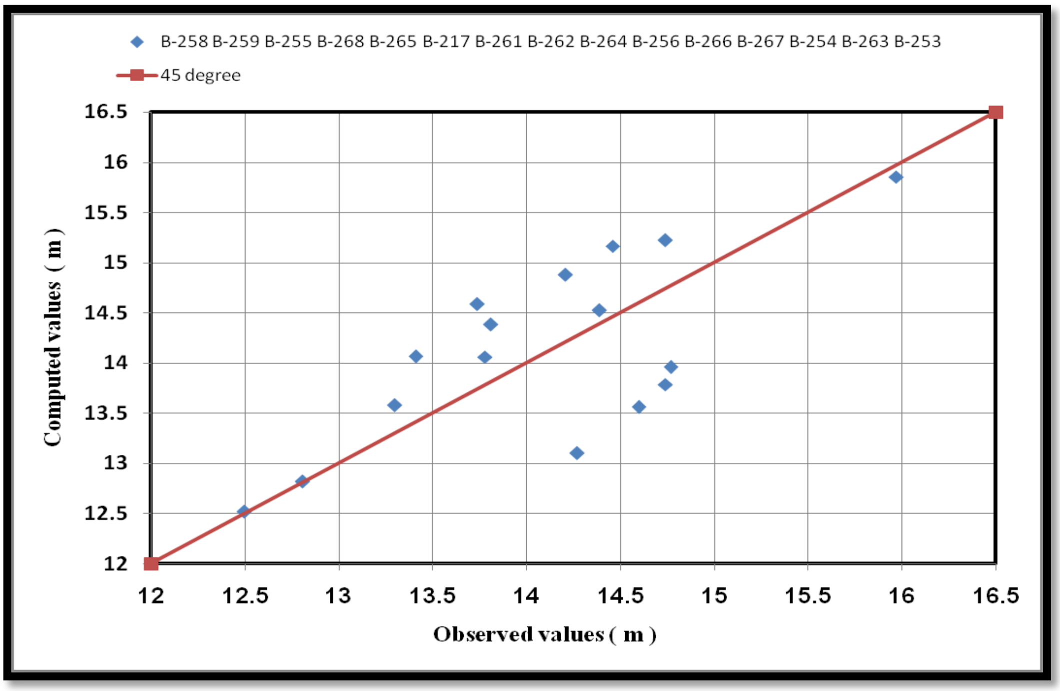


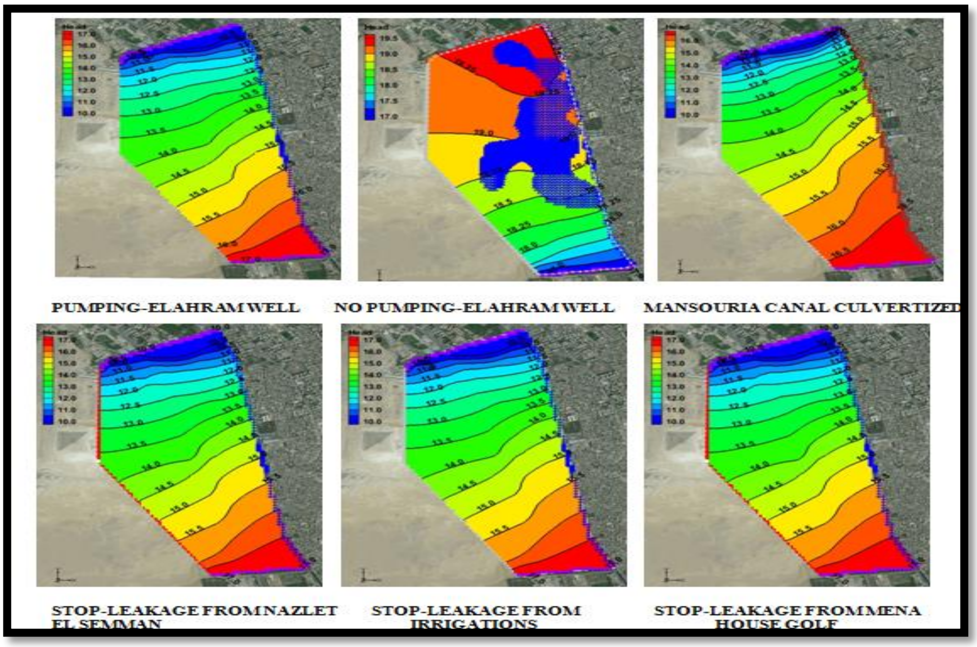
Figure (5) Computed Vs. Observed values- Scenario Calibration Results1989

CALIBRATION SUMMARY

The model was calibrated for scenario with different nature and location. This level of calibration is considered extensive, in terms of groundwater models. This is attributed to the fact that the number of conditions with measurements is rarely available. Confident with the model results it was apparent that it could simulate the Pyramids Plateau aquifer system. In particular, the observed hydraulic discontinuity between the limestone and alluvium aquifer is reproduced in the model. Groundwater flow modeling retains an inherent and unavoidable level of uncertainty. This is particularly true for limestone aquifers, where flow occurs in fractures and lineaments that are non-uniform. This level of uncertainty should be considered in the interpretation of results.

EVALUATION OF POTENTIAL SOURCES

The model was tooled to investigate the causes of groundwater rise. This was achieved by removing the potential groundwater source (i.e. Nazlet El Semman leakage) or changing the corresponding boundary condition. in terms of the groundwater elevation with the accompanied action for alluvium and limestone, under the steady state conditions (i.e. after several years). The greater effect is at ending the contribution of El Ahram well field. This caused a groundwater rise of 5.15 m at Sphinx, which explains the rise in 2007. According to the model, the steady state was not reached and the rise was predicted to be 4.25 m (i.e. as was observed). Stopping leaks of water supply and wastewater systems in Nazlet El Semman, which is impossible, would lower groundwater levels at Sphinx by 1.07 m. On the other hand, the effect in alluvium would be greater, which was estimated at 1.45 m. The large difference between alluvium and limestone aquifers is attributed to the hydraulic separation. As for the recharge from Mena House Golf course, irrigation is estimated to be 0.09 m in the limestone and 0.12 in alluvium. In addition, recharge from irrigation in agricultural areas south of the site is estimated to be 0.04 m in the limestone and 0.03 in the alluvium. The influence of Mansouria Canal (as a culvert) is 0.75 in alluvium, while 0.47 in limestone, as it was attributed to the "specified head" boundary condition. The above results are elaborated on figures (6) to (9).



PUMPING-ELAHRAM WELL

NO PUMPING-ELAHRAM WELL

MANSOURIA CANAL CULVERTIZED

STOP-LEAKAGE FROM NAZLET EL SEMMAN

STOP-LEAKAGE FROM IRRIGATIONS

STOP-LEAKAGE FROM MENA HOUSE GOLF

Figure (6) Calculated Groundwater Levels in Sphinx for model simulation

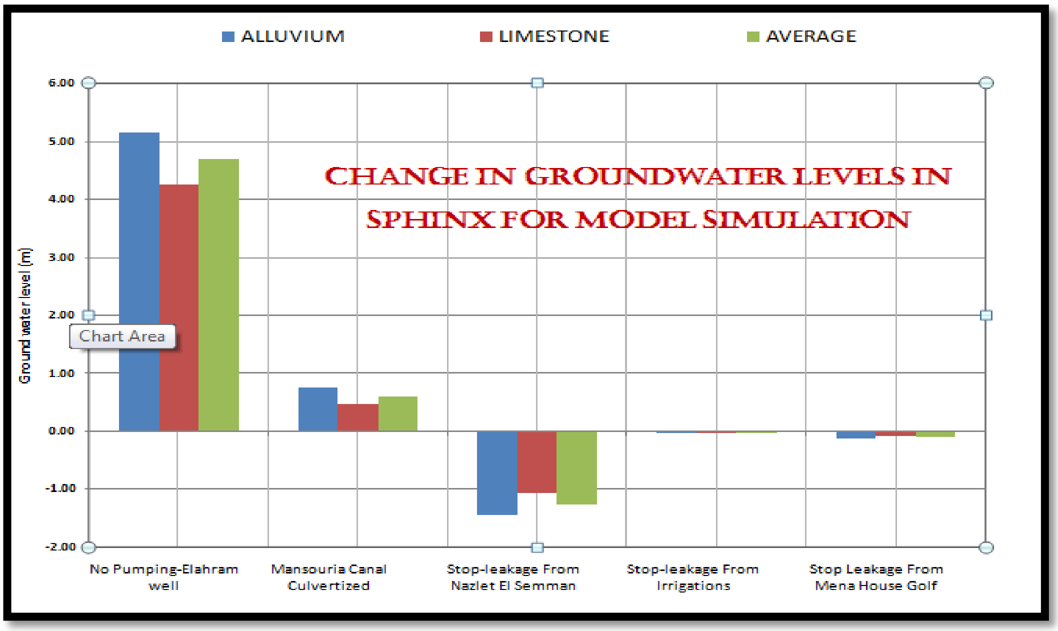


Figure (7) Groundwater Level changes in Sphinx Area

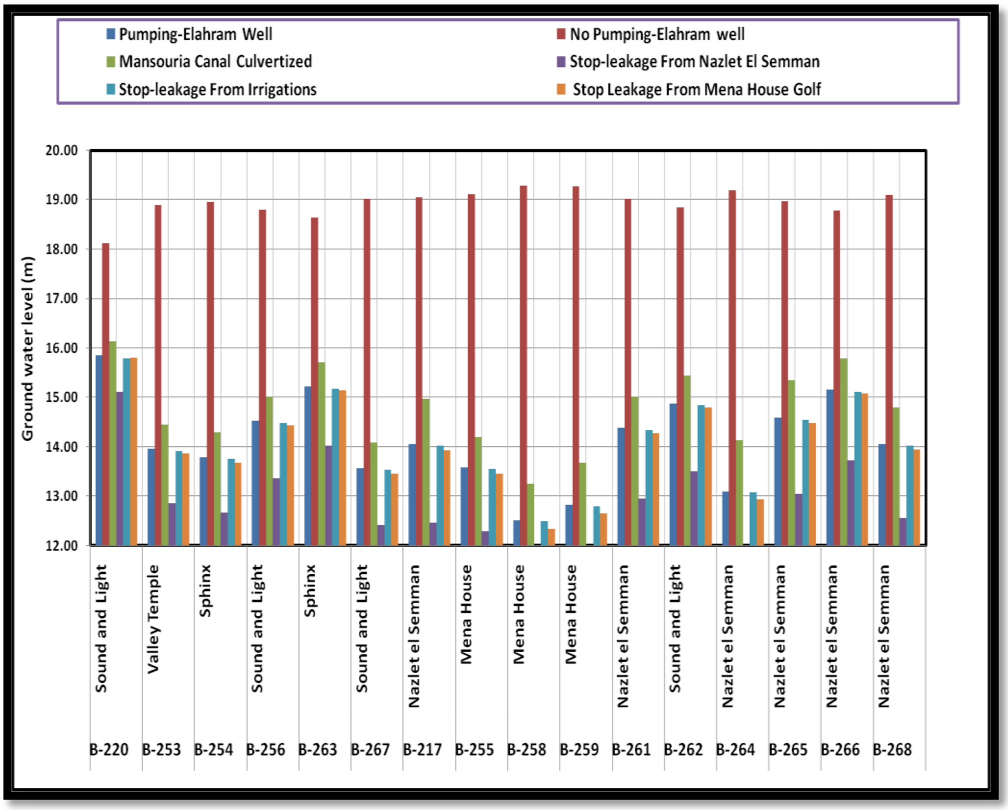


Figure (8) Influence of Different Sources on Groundwater Levels in Sphinx Area

Based on the above results, it can be concluded that the high groundwater levels observed at the Sphinx in 2007-2008 were due to the natural groundwater regime in the area, mostly driven by the water level in the Nile River. Leakage in Nazlet El Semman, irrigation recharge from the Mena House, and seepage from the Mansouriah Canal all contribute to raise groundwater levels in the area, but only by relatively small amounts. The fact that groundwater levels were lower prior to 2006 was due to the drawdown from the El Ahram well field, located 2.2 km north of the Sphinx. This drawdown masked the overall groundwater level regime in the area. Thus addressing the groundwater recharge from the different sources outlined above is not expected to lower groundwater levels to the desired target levels.

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