Effect of dewatering on the phreatic surface in sand in a confined area

G P Panda, and C. Vipulanandan[1], Ph.D., P.E.
Center for Innovative Grouting Material and Technology (CIGMAT)
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204-4003
E-mail: gppanda@uh.edu,cvipulanandan@uh.edu Phone: (713) 743-4278

Abstract: In this study MODFLOW groundwater modeling program was used to investigate the effect of pumping rate and compare it to the analytical model.

1. Introduction

One of the mathematical models that simulate aquifer behavior is the MODFLOW model. Development of modular finite difference model started around 1980 and four major releases have been made. MODFLOW is a three-dimensional model that simulates flow in non - homogeneous, non – isotropic saturated and unsteady porous environments. Many studies have been performed worldwide that used the MODFLOW model for various fields of aquifer management. Rayne et al.(1998) have simulated urban underground water of Estrogen Bay(Wisconsin, USA) and determined the recharge place of fresh water wells in that area.Ramireddygari et al.(1999) al have examined the structural effects of basin and irrigation on groundwater levels to study the interaction between rivers, aquifers. They in order to combined surface water model with the MODFLOW model. Thorley and Callander have simulated groundwater using the MODFLOW model in Christchurch, New Zealand.

2. **Objectives**

The objective was to investigate the drawdown from well by using MODFLOW program and compare it to an analytical model.

3. Material and Methods: From the fundamental principle of conservation of mass of fluid, mathematical model has been developed to describe groundwater flow. Given a representative elementary volume (REV) of porous medium, a general equation for conservation of mass for the volume is expressed as:

Rate of inflow-Rate of outflow= Rate of change.

Q = -*K i A* where Q is the discharge, K the hydraulic conductivity, i the hydraulic gradient and A is the area of flow.

A general groundwater flow equation may be written in Cartesian form as:

$$\frac{\delta}{\delta xi}\left(Kij\,\frac{\delta h}{\delta xj}\right) = \mathrm{S}\,\frac{\delta h}{\delta t} + W \quad (1)$$

Where S is the specific storage, L^{-1}; W the volumetric flux per unit volume (- for outflow and +for inflow), T^{-1} ; and K is the hydraulic conductivity.

The model properties used for simulating the well are

Area of Influence	1.21km^2
Thickness	20mtr.
Horizontal permeability (kx)	0.0001(m/s)
Vertical permeability (ky)	0.0001(m/s)
Lateral permeability (kz)	0.0001(m/s)
Ground Head Boundary Conductance	0.00001
Pumping Rate	10L/s
Specific Storage	0.00001L^{-1}
Specific Yield	0.2

The permeability values were compared by using the unconfined aquifer equation

$$\mathrm{K}=\frac{Q\,\ln(\frac{r1}{r2})}{\pi(h1^2-h2^2)}, \quad (2)$$

where k is the hydraulic conductivity of aquifer,Q=flow rate from the pumped well.
r1=radius from pumped well to the farthest point.
r2=radius from pumped well to nearest observation well.
Ha=saturated thickness of aquifer.

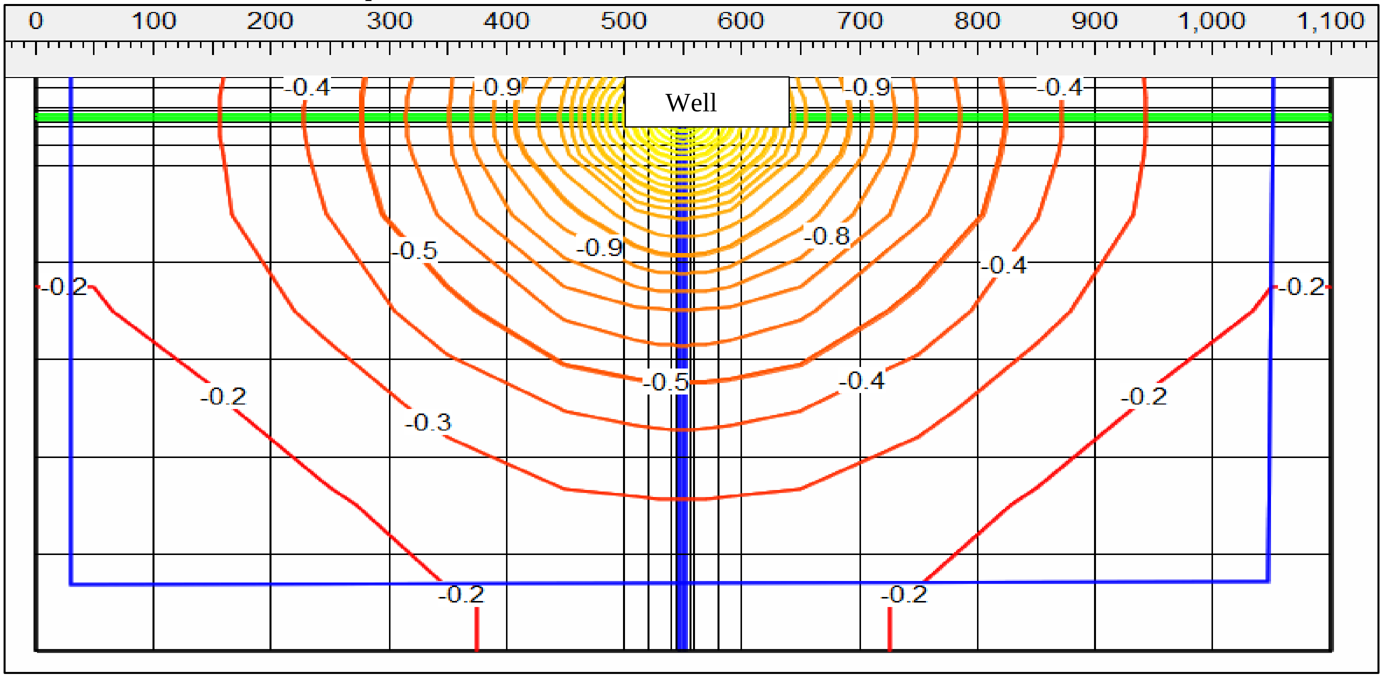

Figure 1: Top View of water drawdown from well reducing the water level after 100 days. (MODFLOW)

The model is simulated to predict the water drawdown from the aquifer for 100days.The general head boundary and multi node well package available in Model has been used to run the simulation. Initial water level before the start of test was 0mtr and after 100 days the contours in figure 1 indicates the piezo metric surface over the area of influence. The MODLFOW package predicts the drawdown and contour level at different locations.

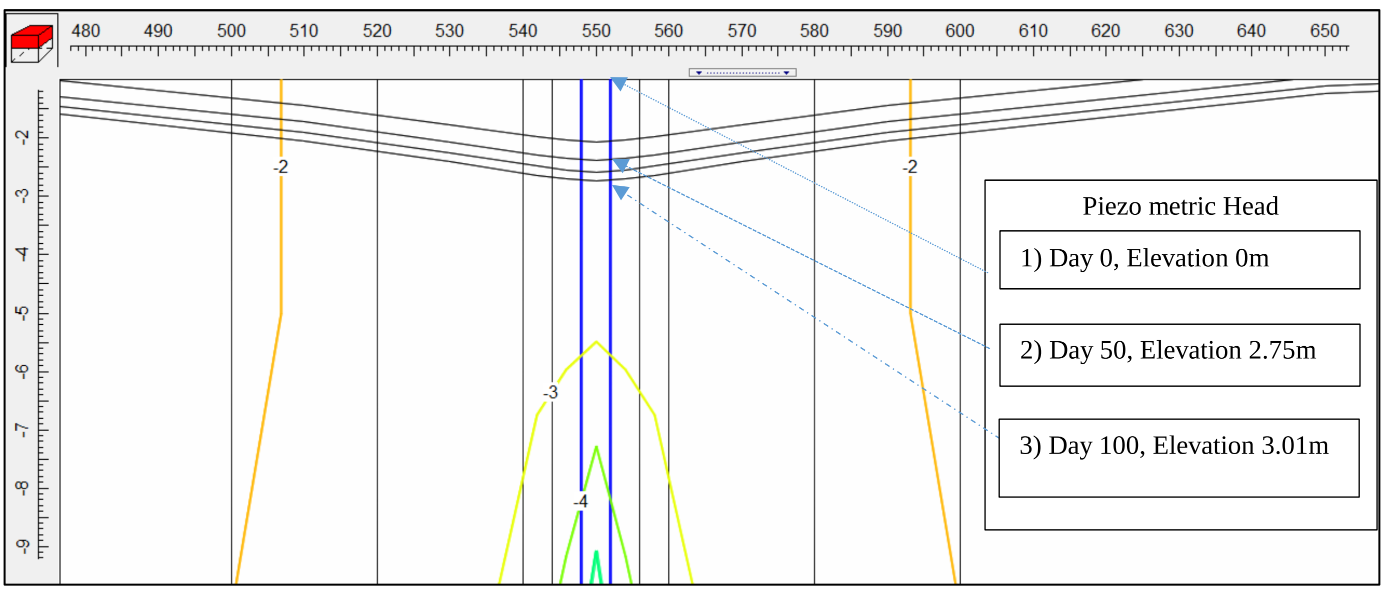

Figure 2: Side View of the phreatic surface up to 100 days.(MODFLOW)

In figure 2, the black line indicates the reduction in water level at various time intervals. Gradually with passing time the piezo metric head drops at the well location. Numerical simulation for 100 days showed that the piezo metric height around the well dropped by 3. 38m from the initial water level. The drawdown from the well after different intervals has been plotted.

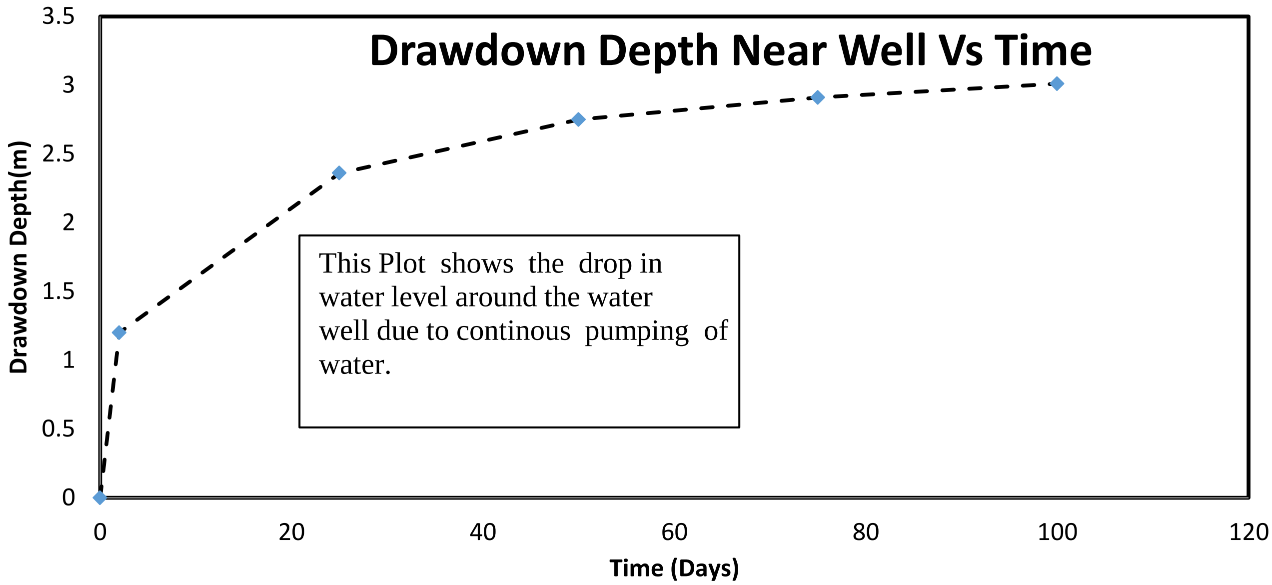

Figure 3: Water drawdown level at different time period.

The permeability values obtained from the equation 2 is 0.000081mtr /sec which are close to the initial assumed horizontal and lateral permeability.

5. Conclusion: Modular finite difference flow model can be used predict water drawdown from a well for any length of time. The input parameters used to run the simulation match with the analytical model showing the accuracy the model for predicting water drawdown and ground water flow.

6. Acknowledgements: This study was supported by the Center for Innovative Grouting Materials and Technology (CIGMAT), University of Houston, Houston, Texas

7. References

1) Purjenaie A, Moradi M., Noruzi A, Majidi A. *"Prediction of Aquifer Drawdown Using MODFLOW Mathematical Model (Case Study: Sarze Rezvan Plain, Iran)"* Geosciences 2012, 2(5): 112-116
2) Khadri S F R, Pande C. "*Ground water flow modeling for calibrating steady state using MODFLOW software: a case study of Mahesh River basin, India"* Model. Earth Syst. Environ. (2016) 2:39