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**FACTORS AFFECTING GROUNDWATER FLOW IN
WADIES ADJACENT TO NILE DELTA AQUIFER**

By

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Statement

This dissertation is submitted to the Faculty of Engineering-Ain Shams University for the degree of Master of Science (M.Sc.) in Civil Engineering (Irrigation and Hydraulics).

The work included in this thesis was carried out by the author in the department of Irrigation and Hydraulics, Faculty of Engineering-Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

Date : / / 2010

Name : Samah Hassan Mahmoud

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To my mother soul

*To my husband and
my daughters*

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ABSTRACT

Groundwater studies have become of great concern because the water supply of which system relies heavily on groundwater as a main source. In Egypt there are many aquifer systems of which the Nile Delta aquifer is considered as one of the most important aquifers.

In this work, an attempt has been done to describe the criteria and methodologies to understand and evaluate the factors that affect on the groundwater flow in the eastern Nile Delta aquifer, and to study all effects which have been caused by the ancient water Nile branches. Environmental problems such as salinization, pollution water, logging and mounding of groundwater levels affect the development in eastern Nile Delta region.

In the eastern Nile Delta region there are many new development areas which have been planned based on surface and groundwater sources. According to the rapid and continuous development some problems appeared such as: water logging, water mounding and, water quality deterioration this problem appeared in El-Obour City that lies about 37km from Cairo in Heliopolis basin. A continues affects severely on the foundations and even the first living floors of villas , buildings, and factories in the industrial zones .

In order to analyze the problem and propose a solution, many studies were conducted. These studies include Topographic survey, Geophysical survey and Resistivity soundings, geotechnical analysis of soil samples taken from eighteen 18 pore hole, water levels in nineteen 19 piezometer.

These studies were done to analyze the hydrogeological conditions in the study area and to identify soil characteristics.

The data obtained from 106 vertical electrical sounding which have been done using schlumberger system. These aids to find the type and extant of the aquifer layers.

Hydrological and geological studies were conducted and GIS packages were used as an interface to derive a set of vector and raster maps that show the different characteristics of the study area.

A literature survey was done to review the previous studies and research works related to the study topic. Also, the mathematic approach was prepared including theories and laws governing the flow in porous media. The governing equations and boundary equations are presented. In order to simulate the existing conditions and study the effect of the proposed solutions, a numerical model was constructed using the Visual MODFLOW Package. The constructed numerical model was calibrated using the field observed data. The calibrated model was used to predict the response of the aquifers to the proposed solution.

The main conclusions and recommendations for future studies are presented.

List of Symbols

| | | |
|------------|--|----------------|
| A | Compressibility of water | $[LT^2M^{-1}]$ |
| A_{ij} | Conductance matrix | $[L^2T^{-1}]$ |
| A_e | Elemental area | $[L^2]$ |
| a_T | Transversal dispersivity | $[L]$ |
| a_L | Longitudinal dispersivity | $[L]$ |
| a_V | Vertical dispersivity | $[L]$ |
| B_{ij} | Storage matrix | $[L^2]$ |
| B | Compressibility of the aquifer | $[LT^2M^{-1}]$ |
| b' | Thickness of the layer that represents the stream bottom | $[L]$ |
| C | Concentration of the solute | $[ML^{-3}]$ |
| C_n | Courant number | |
| C'' | Ratio between the mass held on the solid surface and the mass of the solids in solution | |
| C_{in} | Concentration of the inflowing water in the case of infiltration or the average concentration in the aquifer in the case of abstraction of water | $[ML^{-3}]$ |
| d' | Effective grain diameter | $[L]$ |
| d_i | Thickness of the aquitard | $[L]$ |
| D'_{ij} | Hydrodynamic dispersion-diffusion coefficient | $[L^2T^{-1}]$ |
| D_{md} | Molecular diffusion coefficient | $[L^2T^{-1}]$ |
| D_0 | Diffusion coefficient in a free water system | $[L^2T^{-1}]$ |
| Δt | Time step size | $[T]$ |
| Δ | Elemental cross-sectional of area of cubic element perpendicular to the pore-water velocity | $[L^2]$ |
| e | Element number | |
| e_1 | (x) complementary error function= $1-\text{erf}(x)$; | |
| G_I | Apacitance matrix | $[L^2]$ |
| g | Gravity Acceleration | $[LT^{-2}]$ |
| h | Hydraulic head | $[L]$ |

| | | |
|--------------------------------|--|---------------------|
| k | Permeability | $[L^2]$ |
| K_j | Hydraulic conductivity tensor | $[LT^{-1}]$ |
| K_v | Vertical hydraulic conductivity of the aquitard | $[LT^{-1}]$ |
| K_d | Distribution coefficient | $[L^3M^{-1}]$ |
| K' | Hydraulic conductivity of the layer that represents the stream bottom | $[LT^{-1}]$ |
| J_i | Dispersive flux | $[LT^{-1}]$ |
| l_i | Aquitard resistance i | $[T^{-1}]$ |
| λ | Decay constant | $[T^{-1}]$ |
| m | Aquifer thickness | $[L]$ |
| N_e | Total number of element | |
| μ | Viscosity | $[ML^{-1}T^{-1}]$ |
| n_e | Effective porosity | |
| N_p | Total number of the nodal points | |
| $N_{(x,y)}$ | (y) shape function | |
| ν | Kinematic viscosity | $[L^2T^{-1}]$ |
| $\partial h / \partial x_j$ | Hydraulic gradient in the J-direction | |
| $\partial c / \partial x_i$ | Concentration gradient in the direction i | $[ML^{-4}]$ |
| P_n | Peclet number | |
| P_{ij} | Solute tran. Conductance matrix | $[L^2T^{-1}]$ |
| $\pm Q_i$ | Sink or source flow rate at the node i | $[L^3T^{-1}]$ |
| Q_G | Concentration of the solute of a source or sink of a strength which is assumed to be known | $[ML^{-3}T^{-1}]$ |
| q_i | Average discharge in the direction i | $[L^3T^{-1}L^{-2}]$ |
| $\hat{\Gamma}_{\text{liquid}}$ | Water filled area perpendicular to the direction of Darcy's velocity | $[L^2]$ |
| Re | Reynold's number | |
| ρ | Density of water | $[ML^{-3}]$ |
| R | Retardtion factor | |
| r | Distance from the pumped well | $[L]$ |
| ρ_b | Bulk density of the porous media | $[ML^{-3}]$ |

| | | |
|---------------------|--|-----------------------------|
| ρ_{dry} | Dry matrix material | $[\text{ML}^{-3}]$ |
| S | Storativity of the aquifer | |
| S_0 | Specific storativity | $[\text{L}^{-1}]$ |
| T | Transmissivity of the aquifer | $[\text{L}^2\text{T}^{-1}]$ |
| t | Time | $[\text{T}]$ |
| t_{50} | Half-life of the isotop | $[\text{T}]$ |
| V | Velocity resultant | $[\text{LT}^{-1}]$ |
| V_b | Elemental balk volume | $[\text{L}^3]$ |
| V_e | Is the volume of the element | $[\text{L}^3]$ |
| $W(u,r,B)$ | Hantush well function | |
| ∇ | Vertical-delta $(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z})$ | $[\text{L}^{-1}]$ |
| ! | The factorial | |
| Γ | Time factor | |

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