amathematical model for the dynamic optimal utilization of ground water in egypt

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Hydrosystems is originally coined by V.T. Chow to collectivelydescribe the technical areas of hydrology, hydraulics and water resoures.Here we are concerned with the mathematical modelling of problemsin water project design, analysis, operations, and management.The development of mathematical simulation models in the early1970 [22] provided groundwater planners with quantitative techniques foranalyzing alternative groundwater pumping or recharge schedules.Although simulation models provide the resource planner withimportant tools for managing the groundwater system, the predictivemodels do not identify the optimal groundwater development, design, oroperational policies for an aquifer system. Instead, the simulation modelsprovide only localized information regarding the response of thegroundwater system to pumping and/or artificail recharge. In contrast,groundwater optimization models can identify the optimal groundwaterplanning or design alternatives in the context of the system's objectives andconstraints. Optimization modelling was originallyintroduced in the early1974 by E. Aguado[2]. In subsequent works, optimizationmodels has beendeveloped by several authors [19,20,21,33,36,44,45,48].This thesis aims to introduce a mathematicalmodel to deduce theoptimal dynamic utilization of groundwater in Egypt. It consists of fivechapters.-VlChapter1 is an introduction to groundwater systems, model building,and the groundwater in Egypt.Chapter 2 introduced a Safe-Yield Model using Inventory Theory.In this chapter we deduced the Safe-Yield Abstraction of the four regionsin Egypt under the assumption that the demand is a continuous randomvariable.Chapter 3 introduced a mathematical model which gives the optimaldynamic utilization of the Nile Delta aquifer. In this chapter we assumedthat the aquifer has a transient condition and it is assumed to behetergenious, anisotropic and semiconfined aquifer. We deduced theresponse equations from its governing equation by using the finitedifference method [40], and built the optimization model using the optimalcontrol approach [22], in which the response equations become a subset ofthe constraints. The optimization model that is solved numerically is alinear system maximization problem.Chapter 4 introduced a mathematical model which gives the optimalcontrol of the Nile Delta aquifer. In this chapter we extend Ladon's model[21] to the time-dependent leaky aquifer. The resulting optimization modelis a nonlinear optimization problem.Chapter 5 presented a mathematical model which gives the optimalcontrol of the South Western region to the Nile Delta. In this chapter weassumed that the

aquifer has a transient, isotropic and unconfinedcondition. The resulting optimization model is also a nonlinear optimizationproblem.NotationsThe following notations are used in what follows:Notation Its meaningRIGWL.E.G~hfSTKResearch Institute of Groundwater.Egyptian Pound.Water table in grid I and period k.Head in grid I and period k.Thickness of aquitard cap in grid 1.Pumping in grid I and period k.Upper bound of pumping in period k.Lower bound of pumping in period k.Safe yield abstraction in period k.Lower bound of heads in period k.Upper bound of heads in period k.Storativity coefficient of the Nile Delta aquifer.Transmissivity of the Nile Delta aquifer.Hydraulic conductivity of the Nile Delta aquifer.Vertical hydraulic conductivity of the Nile Delta aquiferPumping in control node I and period k.Head in control node I and period k.Water demand in neriod k.