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Estimation of Aquifer Hydraulic Properties to Model Groundwater in Selected Area in Diyala Governorate

A Thesis Submitted to the Council of College of Engineering, University of Diyala in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering

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بسم الله الرحمن الرحيم

أولم ير الذين كفروا أن السموات

والأرض كانتا رتقا ففتقناهما

وجعلنا من الماء كل شيء

حي أفلا يؤمنون

صدق الله العلي العظيم

الأنبيا - 30

SUPERVISOR'S CERTIFICATE

I certify that this thesis entitled "**Estimation of Aquifer Hydraulic Properties to Model Groundwater in Selected Area in Diyala Governorate** " was prepared by "**Sufyan Muter Jasim**" under my supervision in the University of Diyala in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.

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We certify that we have read the thesis titled **(Estimation of Aquifer Hydraulic Properties to Model Groundwater in Selected Area in Diyala Governorate)** and we have examined the student **(Sufyan Muter Jasim)** in its content and what is related with it, and in our opinion, it is adequate as a thesis for the degree of Master of Science in Civil Engineering.

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Date:

DEDICATION

To All People in My Heart, with Love, Respect and Gratitude

Sufyan M. Jasim

2019

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Sufyan Muter Jasim

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ABSTRACT

The groundwater resources are an important component of arid and semi-arid countries such as Iraq. The pumping tests are conducted in the shallow unconfined aquifer (Quaternary sediments) within Baquba Local Government Area, Diyala Provence, Iraq to estimate of the aquifer properties as there is limited information on aquifer parameters. Drawdown/Recovery data are recorded in seventeen single pumping wells and two monitoring wells at distances of 4 and 20 m from the pumping well in Abu-Khamis and Al-Othmania places, respectively. Type-curve matching of the drawdown/ recovery data are analyzed using Cooper-Jacob's Straight-line and Theis recovery methods. The ranges of the drilling wells depth are 15m to 38.4m. The aquifer saturated thickness ranges from 8 to 26 m. The outcomes of the pumping test data analysis show that the transmissivity values ranged between 124 to 541 m^2/day with an average value of 245.3m^2/day. The hydraulic conductivity ranged from 7.5 to 25.6 m/day with an average value of 14.5 m/day. The specific yield ranges from 0.05 to 0.28 with an average value of 0.12. The specific capacity of the wells ranged from 85 to 407 m^2/day with an average value of 216 m^2/day. The transmissivity values are analyzed according to Krasny Classification System (KCS) for identifying the transmissivity variations as well as the supply potential of the groundwater within the study area. The transmissivity classification results show that the

study area classifies as a high groundwater supply potential with slightly heterogeneous aquifer soil.

The numerical model is adopted by transferred the conceptual model into GMS 10.0.5-MODFLOW2000 which is constructed to solve the groundwater flow equation with a finite differences technique. Two types of boundary conditions are applied (Neumann and Dirichlet conditions). The Neumann boundary condition is applied around the study area and the Dirichlet boundary condition represented the Diyala River.

The model is calibrated by adjusted two parameters namely hydraulic conductivity and recharge rate. The best agreements between computed and observed head have been obtained. The sensitivity analysis results show that the hydraulic conductivity and recharge rate are a more sensitive parameter. After model calibrates, six different scenarios are investigated to study the impact of the discharge rate on the groundwater state. In these scenarios, the applying discharge rates are (current state, increasing about 25%, 50%, 75% and 100% above the current rate). Finally, proposed agricultural land with drilling new wells. The stress period that applied in transient state extended from (2018-2027) with ten-time steps.

The unsteady state model simulation results for these scenarios show that the computed annual maximum drawdown values for the next ten years, according to the five scenarios, were equal to 11.43, 11.94, 12.25, 13.63, and 14.05 m respectively, while the annual maximum drawdown value was recorded in the proposed scenario (current rate with the rates of the new wells) equal to 11.87 m. The outcomes of this study have revealed that the Baquba shallow unconfined aquifer can production effectiveness amount of water for the people in this area, as well as, increase in discharge rates indicate the possibility of drilling new wells within the study area without any mining of aquifer. Additionally, the model results reflect that the maximum values of the drawdown for the two regions of (Kanan and Buhriz) are very large, and according to this reason the management program is very important for dealing and manage the groundwater extraction in these regions.

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LIST OF SYMBOLS

Symbols and Terminology	Definition	Dimension
SPI	Standard precipitation index	dimensionless
t	Time	day
tp	Pumped time	day
Δt	Recovery time	min
t_o	Initial time of pumping test at zero	min
t'	Recovery time	min
T	Transmissivity	m^2/day
K	Hydraulic conductivity	m/day
k	Permeability of porous media	m/day
S_y	Specific yield for the porous medium	%
S_S	Specific storage of the porous	L^{-1}
w	A volumetric flux per unit volume representing sources & sinks of water	T^{-1}
S_C	Specific capacity	m^2/day
Q	Discharge rate	m^3/day
s'	Adjusted drawdown	m
s	Measured drawdown	m
Δs	Residual drawdown difference (slope of the line per one log cycle)	m
h	Saturated thickness	m
WS	Water surplus	mm
WD	Water decrease	mm
VSR	Volume surface runoff	m^3/year
GR	Groundwater recharge	m^3/year
x, y ,z	Cartesian coordinates	m
Kxx	Hydraulic conductivity in x-direction	L/T
Kxx	Hydraulic conductivity in y-direction	L/T
Kzz	Hydraulic conductivity in z-direction	L/T
h	Potentiometric head	m
RMSE	Root mean squared error	m
SEE	Standard error of the estimate	m
CC	Correlation coefficient	dimensionless
Normalized	Normalized root mean squared error	%

σcal	Calculated standard deviations	m
σobs	Observed standard deviations	m
COV xcal	Covariance of calculated value	m
COV xobs	Covariance of observed value	m
μ	Dynamic viscosity of fluid	kg/m.s
ρ	Fluid density	kg/m3
g	Acceleration of gravity	m/s^2
I	Hydraulic gradient	dimensionless
R	Influence radius of the well	m
r	Radius of pumping well	m

LIST OF TERMINOLOGY

Symbols and Terminology	Definition
AQTESOLVE	
C-B-P	Cooper-Bredehoest-Papadopulos
SDT	Step drawdown test
APT	Aquifer performance test
GMS	Groundwater modeling system
MODFLOW	USGS modular three-dimensional finite difference groundwater flow model
PMWIN	Processing model flow for windows
1D	One dimension
2D	Two dimension
3D	Three dimension
MCM	Million-cubic meters
MCMY	Million-cubic meters per year
AMA	Active management area
PEST	Model-independent parameter estimation and uncertainty analysis
i	Cell row
j	Cell column
w	a volumetric flux per unit volume representing sources & sinks of water
ADI	Alternating direction implicit
HK	Hydraulic conductivity parameter
RCH	Groundwater recharge parameter
IAEA	International atomic energy agency
GIS	Geographic information system
USDA	United States department of agriculture
USGS	United states geological survey
DEM	Digital elevation model
MODPATH	A particle-tracking post-processing model for MODFLOW
MT3DMS	A modular three-dimensional transport model for the simulation of advection, dispersion, and chemical reactions of dissolved constituents in groundwater

	systems
ART3D	A three-dimensional analytic reactive transport model
FEMWATER	A three-dimensional finite element, saturated/unsaturated, density driven, flow and transport model
UTCHEM	A multi-phase flow and transport model
SEAM3D	A reactive transport model used to simulate complex biodegradation problems involving multiple substrates and multiple electron acceptors
SEEP2D	A two-dimensional steady state finite element, seepage analysis model
MODFLOW-NWT	A newton formulation for MODFLOW
RT3D	A modular computer code for simulating reactive multispecies transport in 3-dimensional groundwater systems

CHAPTER ONE
INTRODUCTION

1.1 Background

In many areas of the world, the increase in requesting for water has laid expansion pressure on subsurface water resources. In the arid and semi-arid region, climate change is a major factor affecting both surface water and groundwater resources. These changes led to a sharp decrease in surface water resources, which led to the seeking another resources of water and development the method of exploitation (Kubba 1998).

The problem of severe and increasing drought in Iraq is one of the most serious environmental issues. Iraq is testified four evident dry seasons in 2000, 2006, 2008 and 2009. Eleven Iraqi governorates are influenced by drought in late 2008. The highest drought magnitudes are specified in the governorates of Basrah, Babil, Ninewa, Diyala, and Kirkuk. The predicted values of the Standard Precipitation Index (SPI) indicate that moderate to severe droughts are expected at some sites starting from the beginning of 2017 to 2026 (Lück 2014).

Also, groundwater is testified decreases in quantity and an increase in salinity. The groundwater data indicates seasonal fluctuations in the water supply that continues to decrease, indicating that the quantities of groundwater used are exceeding renewable groundwater. Groundwater levels are predictable to reducing due to expectant droughts. Therefore, groundwater levels are expected to decreases (Lück 2014).

The Diyala Governorate is suffered from a hard hydrological drought in 2008, as known the hydrological drought have a direct effect in descending the level of water in reservoirs and dams like Hamreen that is considered the vital source of water in Diyala Provence. However, in the Diyala governorate drought started in the governorate in 2000 and continued up to 2011 indicating that Diyala is currently considered a drought susceptible region (region with probable effects ensuing from a lacking water balance) (Lück 2014).

1.2 Statement of Research Problem

In order to mitigate the water shortage, the government of Iraq through the General Authority for Groundwater (Diyala- Branch) drilled a lot of wells in many areas in Baquba district. The wells drilled in Baquba area are geared toward increase due to the huge demand to the water that has been used for different purposes including agricultural, domestic and industrial as well as other purposes.

To understand the groundwater presence and the nature of its movement, the hydraulic aquifer parameters are needed to develop a mathematical model for groundwater in Baquba district zone.

1.3 Research Objective

Estimate hydraulic aquifer parameters by conducting several field pumping tests for Baquba district required to development a mathematical for this region.

1.4 Methodology

To achieve the aim of this study, a research methodology is developed considering the various area of work necessary to perform and get the results. This methodology can be summarized as follows:

1. A comprehensive review of the previous studies to identify the methods that can be used to estimate aquifer parameters as well as which mathematical models should be used to simulate groundwater flow.
2. Collections of available data which are used to do the field works as well as create a conceptual model.
3. Using groundwater modeling system (GMS) to implement a groundwater simulation model.
4. Calibrating the model to match with the conditions of the area of study.
5. Sensitivity analysis for input parameters of the model
6. Applying different scenarios.
7. Analyzing and discussion of results, as well as stating conclusion and recommendations.

These steps are shown in Figure (1.1).

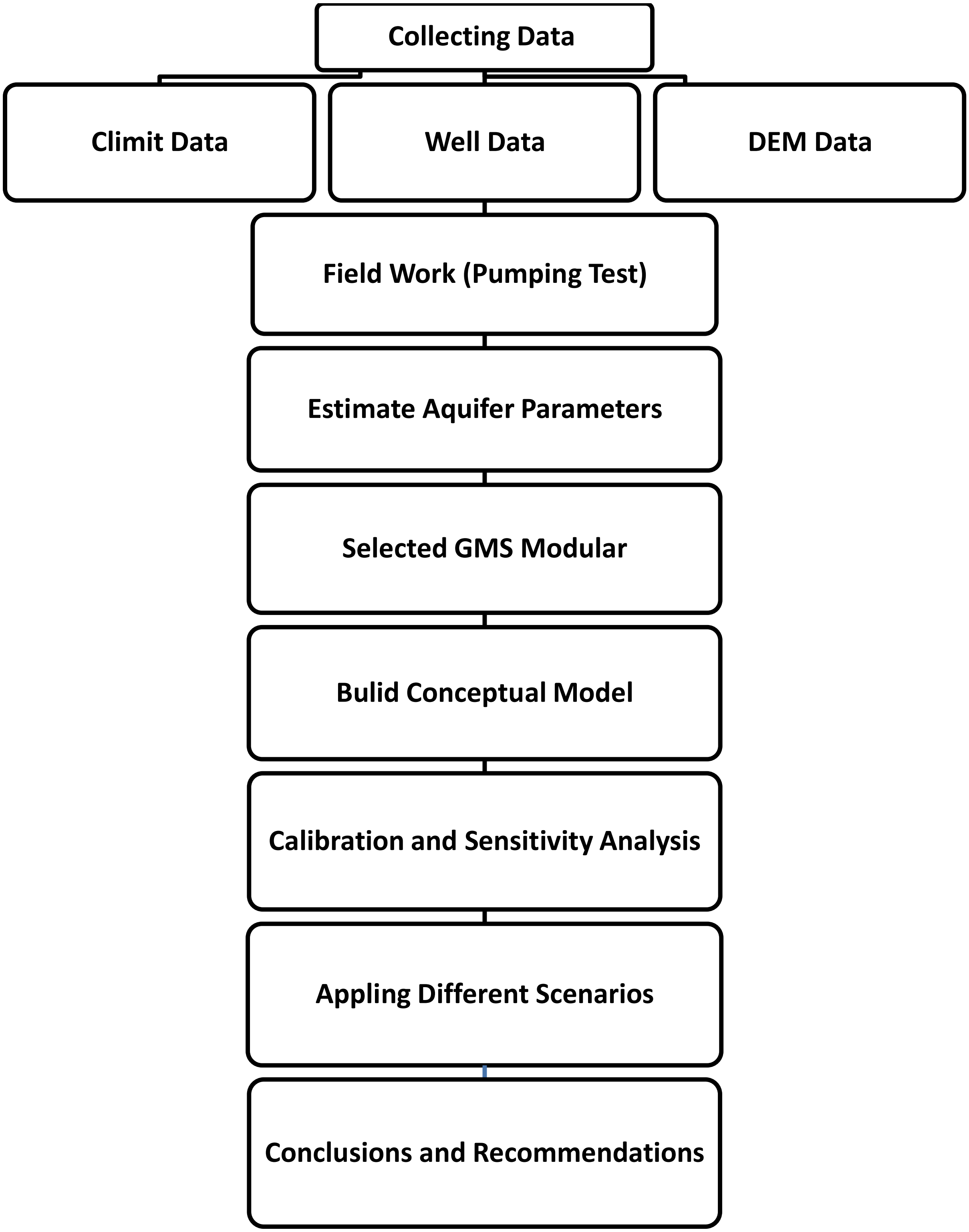

Figure (1.1): Methodology of the study.