AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Irrigation and Hydraulics Department

A Spatially Variable Numerical Model for the Estimation of Runoff Hydrographs

A Thesis Submitted in Partial Fulfillment for the Requirements of the Degree of Master of Science in Civil Engineering

(Irrigation and Hydraulics)

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DEDICATION

I wish to dedicate this work to who patiently supported me throughout all stages of preparing it,

TO

MY WIFE

STATEMENT

This dissertation is submitted to Ain Shams University, Faculty of Engineering for the degree of M.Sc. in Civil Engineering. 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 the thesis has been submitted for a degree or qualification at any other University or Institution. The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

Remah Farid Mohamed Ali Foda

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THESIS SUMMARY

Rainfall-runoff modeling is one of the most important engineering applications in hydrology, in which the process of transforming rainfall hyetograph into a runoff hydrograph is simulated.

The majority of commonly used rainfall-runoff models are not capable of incorporating spatially distributed rainfall and other hydrological data which became more available through satellite imaging and rainfall radar scan. Therefore, development of advanced hydrologic models adopting spatially variable input is considered highly desirable.

In this research, a GIS based rainfall-runoff model was developed with advanced capabilities including calculation of infiltration losses incorporating the spatiotemporal variability of it, implementing spatially distributed rainfall data (e.g. rainfall grids) as input to the model, performing the excess rainfall-runoff transformation using an advanced grid-based computation algorithm for spatially varied hydraulic radius calculation and implementation of flow path response functions for runoff flow routing, and the capability of simulating any number of watersheds simultaneously to reduce the hydrologic design time.

Previous research work in rainfall-runoff modeling was reviewed with special attention to the theories related to grid-based travel time calculations and runoff flow routing.

A custom Visual Basic (VB) code was developed under the environment of Esri ArcGIS software constituting four main modules for a) geomorphologic analysis, b) rainfall input processing and precipitation loss calculation, c) grid-based flow velocity calculation, and d) runoff flow routing and hydrograph generation. The developed model included custom VB modules developed to perform hydrologic calculations by implementing various theoretical formulas adopted for use in the model, in addition to several standard functions already available in ArcGIS software.

The model was tested, calibrated, and validated using the recorded rainfall and runoff data of two case studies. The first was Walnut Gulch Experimental Watershed (WGEW) encompassing about 150 square kilometers in the semi-arid region of southeastern Arizona in USA ; and the second was Wadi Sudr Experimental Watershed (Egypt) of about 380 square kilometers.

The model was also applied in a hypothetical engineering design case, in eastern desert of Egypt, in order to present various model capabilities and test its performance.

Research conclusions were presented and recommendations were provided for future research work.

Key words:

rainfall - runoff - modelling - watershed - arid – GIS

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