



Ain Shams University
Faculty of Engineering
Irrigation & Hydraulics Department

A Multi-Component Rainfall/Runoff Model for Engineering Applications

A Thesis Submitted for the Partial Fulfillment of the
Master Degree
Civil Engineering - Irrigation & Hydraulics [2018]

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(وَقُلْ رَبِّ زِدْنِي عِلْمًا)

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STATEMENT

This thesis is submitted to the Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University in the partial fulfillment of the requirements for the Degree of Master in Civil Engineering.

The work in this thesis was carried out in the Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University from 2012 to 2018.

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

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ABSTRACT

The Rainfall/Runoff transformation process is the response of any given watershed in transforming a rainfall event into the corresponding flow hydrograph. This process can be estimated through rainfall and discharge measurements or be simulated through Rainfall/Runoff (Hydrologic) modeling. Generally, as gauged watersheds are not available (especially in arid and semi-arid regions); Hydrologic modeling is the most commonly used approach to simulate the process of rainfall/runoff transformation.

Hydrologic models vary in their degrees of complexity and accuracy. The available hydrologic models can be divided into three major types: Lumped models, Distributed models, and Semi-Distributed models. Lumped models are simple to apply but cannot determine flow hydrographs. On the other hand, distributed models are very complex models that provide high accuracy but still distributed models can not satisfy engineering applications due to the unacceptable runtime taken by some of these models. The semi-distributed models are the most widely used for engineering applications as they are much more accurate than lumped models and at the same time less complex than distributed models. The semi-distributed models are mainly divided into two sub-groups: (1) Network Techniques (e.g., HEC-HMS flood hydrograph package), and (2) Time-Area (TA) techniques. The idea of this research is to blend the powers of the two worlds to develop an accurate and practical model suitable for engineering applications.

In this research, historical and previous studies and researches in the same field are discussed and rainfall-runoff observed data were collected for some

of the available gauged watersheds in order to be used in the verification of the results of this research.

The work methodology includes the development of an automated hydrological model using GIS capabilities to analyze terrain raster data and apply hydrologic and hydraulic basics to produce a spatially distributed unit hydrograph for each watershed, in addition to estimating some hydrological parameters for these watersheds (i.e., area, time of concentration & weighted CN values).

The results of the developed model were verified using the collected rainfall-runoff observed data, and then the model is applied to several case studies to show the comparison between the results of the developed model and the results of other practically applied hydrologic models in engineering applications.

The main conclusion from this research is that spatially distributed unit hydrographs are more recommended to be used in hydrologic processes (simulations) as the watershed actual response is better simulated using this technique than the lumped unit hydrographs in the sense of consideration of spatial variation in travel times within the same watershed which affects the resultant shape of the runoff hydrograph and peak discharge value as well.

Keywords: Rainfall\Runoff, Hydrology, Modeling, GIS, Gridded Runoff Hydrograph

Table of Contents

CHAPTER 1 INTRODUCTION	1-1
1.1 Overview.....	1-1
1.2 Problem Definition.....	1-2
1.3 Research Objectives	1-4
1.3.1 Main Objectives	1-4
1.3.2 Sub-Objectives	1-4
1.4 Methodology and Approach	1-5
1.5 Thesis Organization.....	1-6
CHAPTER 2 LITERATURE REVIEW.....	2-1
2.1 Introduction	2-1
2.2 Excess Rainfall and Direct Runoff	2-2
2.3 Travel Time	2-2
2.4 Time of Concentration	2-3
2.4.1 Kirpich formula	2-3
2.4.2 NRCS (SCS) formula	2-4
2.4.3 Velocity formula.....	2-5
2.5 Lag Time.....	2-7
2.6 Synthetic Unit Hydrograph (SUH).....	2-7
2.6.1 NRCS (SCS) Dimensionless Unit Hydrograph	2-9
2.6.2 Snyder's Unit Hydrograph.....	2-12
2.6.3 Clark Unit Hydrograph	2-15

2.7 Hydrologic Models	2-18
2.7.1 Lumped Models	2-18
2.7.2 Distributed Models	2-21
2.7.3 Semi Distributed Models.....	2-23
2.8 Spatially Distributed (Grid-Based) Unit Hydrograph.....	2-27
CHAPTER 3 DATA COLLECTION.....	3-1
3.1 Introduction	3-1
3.2 Wadi Sudr	3-2
3.3 Wadi Al Meliha.....	3-7
CHAPTER 4 METHODOLOGY AND MODEL DEVELOPMENT.....	4-1
4.1 Introduction	4-1
4.2 Work Methodology	4-2
4.3 Model Development	4-2
4.3.1 Overview.....	4-2
4.3.2 Input Data	4-3
4.3.3 Main Processes and Components	4-6
4.3.4 Model Interface	4-19
4.3.5 Model Output	4-22
CHAPTER 5 RESULTS AND DISCUSSION	5-1
5.1 Introduction	5-1
5.2 Model Verification	5-2
5.2.1 Wadi Al Meliha.....	5-3
5.2.2 Wadi Sudr	5-10

5.3 Model Application.....	5-21
5.4 Model Results	5-21
5.4.1 Egypt.....	5-21
5.4.2 KSA.....	5-23
5.4.3 Oman	5-27
5.5 Discussion	5-29
CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS	6-1
6.1 Introduction.....	6-1
6.2 Conclusions.....	6-2
6.3 Recommendations and proposed future studies	6-3
REFERENCES.....	A

List of Figures

Figure 2-1: NRCS dimensionless unit hydrograph (SCS, 1985)	2-10
Figure 2-2: Snyder unit hydrograph	2-14
Figure 2-3: Time-area isochrones and histogram for Clark's method	2-15
Figure 2-4: Example of Hydrologic Network technique inside HEC-HMS	2-25
Figure 2-5: Example of a runoff hydrograph using Time Area (TA) technique	2-26
Figure 3-1: The location of the two experimental watersheds	3-2
Figure 3-2: Wadi Sudr watershed area and streams network	3-3
Figure 3-3: Rainfall storm 11-03-1994 hyetograph for wadi Sudr watershed	3-4
Figure 3-4: Wadi Sudr observed hydrograph (11-03-1994)	3-4
Figure 3-5: Rainfall storm 02-03-1997 hyetograph for wadi Sudr watershed	3-5
Figure 3-6: Wadi Sudr observed hydrograph (02-03-1997)	3-5
Figure 3-7: Rainfall storm 07-02-1999 hyetograph for wadi Sudr watershed	3-6
Figure 3-8: Wadi Sudr observed hydrograph (07-02-1999)	3-6
Figure 3-9: Wadi Al Meliha watershed area and streams network	3-7
Figure 3-10: Rainfall storm 25-02-1992 hyetograph for wadi Al Meliha watershed	3-8
Figure 3-11: Wadi Al Meliha observed hydrograph (25-02-1992)	3-9
Figure 3-12: Rainfall storm 11-03-1994 hyetograph for wadi Al Meliha	3-9
Figure 3-13: Wadi Al Meliha observed hydrograph (11-03-1994)	3-10
Figure 4-1: Fill sinks process	4-7
Figure 4-2: Flow direction process	4-8
Figure 4-3: Sample of slope grid	4-9
Figure 4-4: Flow accumulation process	4-10
Figure 4-5: Sample of the Area Upstream grid	4-11
Figure 4-6: Sample of the Stream Link grid	4-12
Figure 4-7: Sample of the Watershed grid	4-13
Figure 4-8: Sample of the Spatially varied hydraulic radius grid	4-14
Figure 4-9: Sample of the Velocity grid	4-15
Figure 4-10: Sample of the Travel time grid	4-17
Figure 4-11: Sample of the Spatially distributed unit hydrograph grid	4-18
Figure 4-12: STA-UH model interface	4-20
Figure 4-13: Schematic diagram for the STA-UH model processes	4-20

Figure 4-14: Schematic flow chart for the STA-UH model processes.....	4-21
Figure 4-15: Sample of the Watersheds shapefile.....	4-22
Figure 4-16: Sample of the Watersheds attributes table.....	4-23
Figure 4-17: Sample of the Streams network shapefile.....	4-23
Figure 4-18: Sample graph of the spatially distributed unit hydrograph	4-24
Figure 4-19: The tabulated form of the spatially distributed unit hydrograph	4-24
Figure 4-20: Sample of the spatially distributed unit hydrograph in HEC-HMS	4-25
Figure 5-1: S.D. Unit Hydrograph for wadi Al Meliha watershed	5-5
Figure 5-2: Comparison between simulated hydrograph and observed hydrograph for wadi Al Meliha storm (11-03-1994)	5-6
Figure 5-3: Comparison between simulated hydrograph and observed hydrograph for wadi Al Meliha storm (25-02-1992)	5-8
Figure 5-4: S.D. Unit Hydrograph for wadi Sudr watershed.....	5-14
Figure 5-5: Comparison between simulated hydrograph and observed hydrograph for wadi Sudr storm (11-03-1994)	5-15
Figure 5-6: Comparison between simulated hydrograph and observed hydrograph for wadi Sudr storm (02-03-1997)	5-17
Figure 5-7: Comparison between simulated hydrograph and observed hydrograph for wadi Sudr storm (07-02-1999)	5-19
Figure 5-8: Comparison between flow hydrographs for Wadi Al Areesh watershed.....	5-23
Figure 5-9: Comparison between flow hydrographs for Wadi Ed Dawasser watershed.....	5-25
Figure 5-10: Comparison between flow hydrographs for Wadi Fatma watershed.....	5-26
Figure 5-11: Comparison between flow hydrographs for Wadi Bani Khurus watershed.....	5-28

List of Tables

Table 2-1: NRCS dimensionless unit hydrograph ordinates	2-10
Table 2-2: Runoff Coefficients for Rational formula (HEC 22, 2009)	2-20
Table 3-1: The locations of the runoff gauges for the two experimental watersheds	3-2
Table 3-2: Summary of the selected storm events for Wadi Sudr watershed.....	3-3
Table 3-3: Summary of the selected storm events for Wadi Al Meliha watershed....	3-8
Table 4-1: Manning's roughness coefficient values for different terrain types (HEC 22, 2013)	4-5
Table 5-1: Morphological and Hydrological parameters for wadi Al Meliha Watershed	5-3
Table 5-2: Spatially distributed unit hydrograph ordinates for Wadi Al Meliha.....	5-4
Table 5-3: Comparison between the simulated and observed peak runoff for wadi Al Meliha storm 11-03-1994	5-7
Table 5-4: Comparison between the simulated and observed peak runoff for wadi Al Meliha storm 25-02-1992	5-9
Table 5-5: Morphological and Hydrological parameters for wadi Sudr Watershed	5-10
Table 5-6: Spatially distributed unit hydrograph ordinates for Wadi Sudr	5-11
Table 5-7: Comparison between the simulated and observed peak runoff for wadi Sudr storm 11-03-1994	5-16
Table 5-8: Comparison between the simulated and observed peak runoff for wadi Sudr storm 02-03-1997	5-18
Table 5-9: Comparison between the simulated and observed peak runoff for wadi Sudr storm 07-02-1999	5-20
Table 5-10: Morphological and Hydrological parameters for Wadi Al Areesh watershed.....	5-22
Table 5-11: Morphological and Hydrological parameters for Wadi Ed Dawasser watershed.....	5-24
Table 5-12: Morphological and Hydrological parameters for Wadi Fatma watershed.....	5-26
Table 5-13: Morphological and Hydrological parameters for Wadi Bani Khurus watershed.....	5-27

List of Abbreviations

HEC	Hydrologic Engineering Center
HMS	Hydrologic Modeling System
TA	Time Area
SCS	Soil Conservation Service
NRCS	Natural Resources Conservation Service
CN	Curve Number
GIS	Geographic Information System
SDUH	Spatially Distributed Unit Hydrograph
S.D.	Spatially Distributed
T_t	Travel time
L or LFP	Longest flow path, the distance between the hydraulically most distant point to the outlet
V	Average velocity of the water drop between the two points
T_c	Time of concentration
S	Slope of the longest flow path
Y	Average watershed slope
R_i	Hydraulic radius at point of interest
A_{i-us}	Accumulated area upstream the point of interest
P_{i-e-us}	Average excess rainfall depth upstream the point of interest
S_{i-us}	Average slope of the watershed upstream the point of interest
V_i	Average flow velocity
n_i	Average manning's roughness coefficient
S_i	Longitudinal slope
T_t	Lag time