AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
IRRIGATION AND HYDRAULICS DEPARTMENT

"DEVELOPMENT OF A WATERSHED MODEL IN ARID REGIONS"

BY

Eng. AHMED HASSAN FAHMI

A Thesis
Submitted in Fulfillment
of the Requirements for the
Degree of

Doctor of Philosophy

in Civil Engineering
(Irrigation & Hydraulics)

Supervised By

Prof.Dr. MOSTAFA M. SOLIMAN

Professor of Irrigation and Hydraulics, Faculty of Engineering, Ain Shams University, Cairo - Egypt

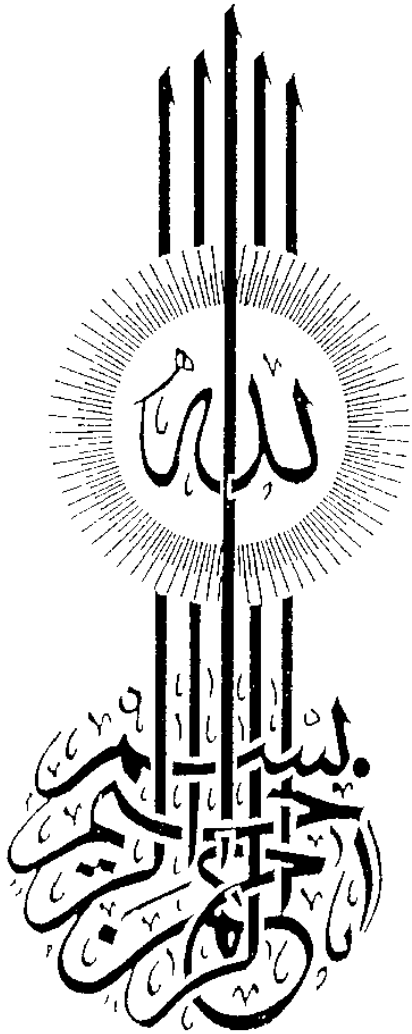
Prof. Dr. HASSAN ALI IBRAHIM

Ex - Director of the Water Resources Research Institute, Water Research Center (NWRC), Ministry of Public Works and Water Resources, Egypt

Dr. AHMED ALI ALI HASSAN

Assistant Professor, Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University, Cairo-Egypt

Cairo, Egypt 1995


بسم الله الرحمن الرحيم

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
IRRIGATION AND HYDRAULICS DEPARTMENT

"DEVELOPMENT OF A WATERSHED MODEL IN ARID REGIONS"

BY

Eng. AHMED HASSAN FAHMI

A Thesis
Submitted in Fulfillment
of the Requirements for the
Degree of

Doctor of Philosophy

in Civil Engineering
(Irrigation & Hydraulics)

Supervised By

Prof.Dr. MOSTAFA M. SOLIMAN

Professor of Irrigation and Hydraulics, Faculty of Engineering, Ain Shams University, Cairo - Egypt

Prof. Dr. HASSAN ALI IBRAHIM

Ex - Director of the Water Resources Research Institute, Water Research Center (NWRC), Ministry of Public Works and Water Resources, Egypt

Dr. AHMED ALI ALI HASSAN

Assistant Professor, Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University, Cairo-Egypt

Cairo, Egypt 1995

بسم الله الرحمن الرحيم

Examiners Committee

Signature

1- Prof. Dr. KAMAL H. H. HEFNI

Ex-Director of Ground Water Research Institute, Water Research Center, Ministry of Public Works and Water Resources, Cairo-Egypt.

2- Prof. Dr. ABD EL-MOHSEN EL-MONGY

Professor of Harbors, Inland Navigation, and Shore Protection Eng., Faculty of Eng., Irrigation and Hydraulics, Ain Shams University, Cairo-Egypt.

2- Prof. Dr. MOSTAFA M. SOLIMAN

Professor of Irrigation and Hydraulics, Faculty of Eng. , Ain Shams University, Cairo - Egypt.

4- Prof.Dr. HASSAN ALI IBRAHIM

Ex-Director of Water Resources Research Institute, National Water Research Center (NWRC), Ministry of Public Works and Water Resources, Cairo-Egypt.

Date : November 14, 1995

Secondly; the snowmelt process

snowmelt represents a significant factor in the hydrological study of the area. The physical process of snowmelt was briefly explained and empirical equations were applied. The excess from exponential loss equations were presented. The evaluation of the equivalent water volume due to snow was obtained using empirical relations. These relations depend on collected data; as the temperatures and snow depths in different locations and on estimated degree-day factor obtained from Linsly experimental curve. This equivalent water volume of the snow is the most probable source of the stored groundwater in the area of wadi Feiran.

The developed rainfall relations together with the geological and morphological characteristics of the studied area were applied. Different unit hydrograph methods were used to estimate the hydrographs at the study area outlet. One of the most popular rainfall-runoff models, according to the US Army Corps of Engineers - Hydrologic Engineering center (HEC-1), was used. The model output had proved an excellent adequacy and applicability in solving different field problem.

Finally, the hydrological system that can be used for a watershed model to simulate the hydrological phenomenon in wadi Feiran, which is an arid region, has been developed.

LIST OF SYMBOLS

a	Constant;
a_o	Constant;
a_1	Constant;
a_2	Constant;
a.s.l	Above sea level;
A	Basin area or subbasin area;
AI	The cumulative area as a function of total subbasin area;
AK	The loss rate coefficient at the beginning of the time interval or the potential loss rate;
ALOSS	The potential loss rate during the time interval;
b	Constant;
c	A conversion factor;
C	Coefficient = kn;
°C	Degree centigrade;
cfs	Cubic feet per second;
cm	Centimeter;
C_p	The storage coefficient;
Cu-m	Cubic meter;
CUML	The cumulated loss determined by summing the actual losses computed for time interval;
d_s	Depth of snow cover;
d_w	Depth of water storage in the snow;
D_f	Degree day factor;
Dec.	December;
DLTK	The incremental increase in the loss rate coefficient during the first DLTKR of accumulated loss;
DLTKR	The amount of the initial accumulated rain loss during which the loss rate coefficient is increased;
e	Exponent;
ERAIN	The exponent of the precipitation for rain loss function that reflects the influence of

	precipitation rate on basin-average loss characteristics;
°F	Degree fahrenheit;
Feb.	February;
Fig.	Figure;
FRZTP	Freezing Point;
G_s	Water equivalent (density) of snow;
GMA	General Meteorological Data;
hr.	Hour;
in	Inch;
I_{av}	Average rainfall intensity;
IDF	Intensity Duration Frequency;
$I(\tau)$	The excess precipitation ordinate;
IUH	Instantaneous Unit Hydrograph;
I_t^T	Intensity of rainfall having duration t and recurrence interval T;
Jan.	January;
K_o	Von Karman's coefficient = 0.38 to 0.40;
km	Kilometer;
kn	Estimated mean Manning's 'n' for all the channels within an area and it is a measure of the hydraulic efficiency of the watershed;
ln	Natural logarithm;
L	Length of the longest watercourse;
L_{ca}	Length along the watercourse to the point opposite the centeroid;
Lag	Time from the center of mass of rainfall excess to the peak of the hydrograph;
m	Meter;
min.	Minute;
mln	Million;
mm	Millimeter;

M	Effective snowmelt;
M_d	Daily melt in the elevation zone;
M_s	The amount of melt in depth of water caused by a rainfall;
Max.	Maximum;
Min.	Minimum;
n	Constant;
n_o	Number of observed hydrograph ordinates;
p	Atmospheric pressure;
P(j)	j^{th} rainfall excess hyetograph ordinate;
ppm	Part per million;
PRCP	Precipitation;
Q_{AVG}	Average observed discharge;
Q_{COMPi}	Computed hydrograph ordinate for time period i;
Q_{max}	The maximum flow of unit hydrograph;
Q_{OBSi}	Observed hydrograph for time period i;
Q_p	Peak discharge;
Q(i)	i^{th} discharge hydrograph ordinate;
Q(t)	Direct runoff at time t;
R	Rainfall depth;
RTIOK	Parameter analogous to those used in the rainfall exponential loss rate;
RTIOL	The ratio for rain loss coefficient of exponential loss curve to that corresponding to 10 inches or mm more of accumulated loss;
R_t^T	Rainfall depth having duration t and recurrence interval T;
R_1^{10}	Rainfall depth having duration 1-hr and recurrence interval 10-yr;
S	Watercourse slope;
S_p	Specific heat of the air;
STDER	Root mean square error;
STRKR	The starting value of loss coefficient on exponential recession curve for rain losses (snow free ground);

STRKS	Parameter analogous to those used in the rainfall exponential loss rate;
t	Rainfall duration in minutes;
T	Return period in years;
T_a	Air temperature;
T_{av}	Average daily air temperature;
T_b	Time of base of the unit hydrograph;
T_{bm}	Base melt temperature;
T_f	The fraction of time of concentration;
T_p	The time from the start of rainfall excess to the max. discharge;
T_w	The wet-bulb temperature;
Temp.	Temperature;
TDS	Total Dissolved Solids;
Tot.	Total
U	Wind velocity;
U.H.	Unit Hydrograph;
U(n)	n^{th} unit hydrograph ordinate, with $n = i-j+1$;
$U(t, \tau)$	The appropriate IUH ordinate;
U.S.S.R	Union of Social Soviet Republics;
v_p	Vapor pressure of the air;
vol.	Volume
W.	Wadi;
WRRI	Water Resources Research Institute;
WT_i	The weight for the square difference between ordinate for i;
x, z	Levels at which the wind velocity, temperature, and vapor pressure are measured respectively;
yr	Year;
Z_o	Roughness parameter = 0.25;
Δt	The computed time interval or the duration of unit excess; and
ρ	Air density.