

**MATHEMATICAL MODELLING OF URBAN WATERSHEDS  
FOR DRAINAGE AND ENVIRONMENT IMPROVEMENT**

**CASE STUDY OF TWO CATCHMENTS IN  
GREATER COLOMBO AREA**

**M.Eng in Environmental Engineering and Management**

**Department of Civil Engineering  
University of Moratuwa  
Sri Lanka**

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*Submitted By:*

**Eng. P.P.Ghnanapala**

72611

*Supervised By:*

**Dr. N.T.S. Wijesekera**

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628.2 (348.7)

072611



University of Moratuwa

**72611**

**November 2000**

**STATEMENT:**

" This thesis was submitted to the Department of Civil Engineering of the University of Moratuwa, Sri Lanka, as a partial fulfillment of the requirements for the degree of Master of Engineering in Environmental Engineering and Management "



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.....  
P.P.Ghnanapala

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## ABSTRACT

Due to the increase in population in the urban area more and more land is necessary for living. Therefore reclamation of marshy land in urban areas has taken place over the years without giving due consideration for stormwater drainage. It was observed that the flooding prolongs mainly due to the insufficient drainage sizes together with reduction in detention / retention areas. As a result there is uncontrolled flooding causing enormous problems. The disruption of business and community activities accelerate deterioration of the environment and increases health risks etc. In the planning process it is important, therefore, to be able to assess the probable impact of urbanization upon the magnitude of flood peaks.

In the light of above while designing a drainage system it is very important to know the peak discharge at required locations. Such an assessment could be made by several methods. In this study two mathematical models have been used to obtain the required results. They are:



1. the Basic Model HEC-1 that has been used to estimate Runoff and
2. HEC-RAS model that has been used to establish the Rating Curve.

In Sri Lanka especially in urban areas basic statistical data such as runoff data, land use data and important tested parameters are not available to assist runoff values for the designing of a drainage system.

However, availability of statistical data and literature to assess peak discharge is limited and hence, parameters are assumed based on available information and judgements. The objective of this study is to provide solutions to the drainage issue due to urbanization by studying urban hydrology and identifying the necessary parameters to model urban watersheds. Based on this the objectives are identified as follows:

1. Study the behavior of rainfall and runoff of urbanized area.
2. Develop a mathematical model for the drainage system.

3. Identify the important parameters and their values for mathematical modeling of watersheds to calculate peak runoff.

Two urban watersheds were gauged mathematically and modelled using the HEC model to identify the behaviour for urban watersheds in Colombo and also to identify parameters applicable to these.

The study area consists of two locations independent of each other but quite close within the Greater Colombo Area. They are:

1. Torrington watershed consisting of 290 ha located within the heart of Colombo &
2. Badowita - Attidiya watershed consisting of 270 ha located within the periphery of the Greater Colombo.

The distinct difference between the two areas is in the land use, which is a vital factor that contributes to the run-off. The stream network and storage area identified in both watersheds were linked to establish the model. Required data such as rainfall, land use, events of flood records, tide level data were collected and checked before using in the model.



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Land cover of the watersheds showed that in the urbanized areas the pervious extent was approximately 62% while in less urbanized areas the pervious extent was about 76%. Average Curve Numbers for the urbanized areas were 95 and 70 for impervious and pervious areas respectively.

The HEC rainfall-runoff model developed for both watersheds produced very good peak discharge matching and hence these models could be used for drainage environment improvement projects in urban areas. It was also found that Curve Number values, so obtained appear to be realistic and could be easily used for similar watersheds instead of general values.

Canal network of both watersheds were modelled and rating curves were developed and verified for both gauging stations. The established model for urban areas can be used for rehabilitation of existing drainage systems as well as for designing of new drainage systems.

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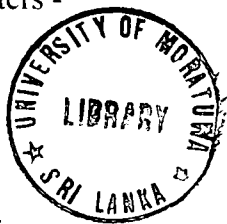


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A	-	Catchment area ( ha )
C	-	Average runoff coefficient
F	-	Fall of water level (m)
h	-	Canal water level (m MSL)
I	-	Rainfall intensity (mm/hr)
n	-	Manning's coefficient
Q	-	Discharge (m <sup>3</sup> /s)
s	-	Water Surface Slope / Slope of main drainage
T <sub>C</sub>	-	Time of Concentration.



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## List of Abbreviations

ACEXS	-	Accumulated Excess in inches (mm)
ACRAN	-	Accumulated Rainfall depth in inches (mm)
AMC	-	Antecedent Moisture Condition
b/w	-	Breath / width of the canal
CN	-	Curve Number
d/s	-	Down stream
HEC-1	-	Hydrologic Engineering Center - Flood Hydrograph Package 1
HEC- HMS-	-	Hydrologic Engineering Center - Hydraulic Modeling System
HEC- RAS -	-	Hydrologic Engineering Center - River Analysis System
IA	-	Initial Surface Moisture Storage Capacity
$q_o(t)$	-	Observed Flows
$q_o(\text{mean})$	-	Mean of Observed Flows
$q_o(\text{peak})$	-	Observed Peak
$q_s(\text{peak})$	-	Calculated Peak
$q_s(t)$	-	Calculated Flows
QRCSN	-	Flow at which an Exponential Recession begins on the Receding Limb of the Computed Hydrograph
RTIOR	-	Ratio of a Recession Limb Flow Occurring One Hour Later
SCS	-	Soil Conservation Service
STRTQ	-	Initial Flow in the River
TRA	-	Trapezoidal Canal
UR	-	Urbanization Reaches
u/s	-	Upstream

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