# Rainfall runoff modeling using HEC-HMS

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*The goal of this exercise is to setup a rainfall runoff model using HEC-HMS and estimate the affect of future urbanization on the hydrologic response of a catchment.*

## INTRODUCTION

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) developed by US Army Corps of Engineers. It is designed to simulate the precipitation-runoff processes of dendritic watershed systems. The model can be applied to large river basin for water supply and flood hydrology to small urban or natural watershed runoff. Hydrographs produced by the program can be used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, wetlands hydrology, and systems operation.

## STUDY AREA AND DATA

This exercise uses data from the 5.51 square mile Castro Valley watershed located in northern California, USA. The watershed contains four major catchments (Figure 1). Precipitation data for a storm that occurred on January 16, 1973 is available for three gages in the watershed: Proctor School, Sidney School, and Fire Department.

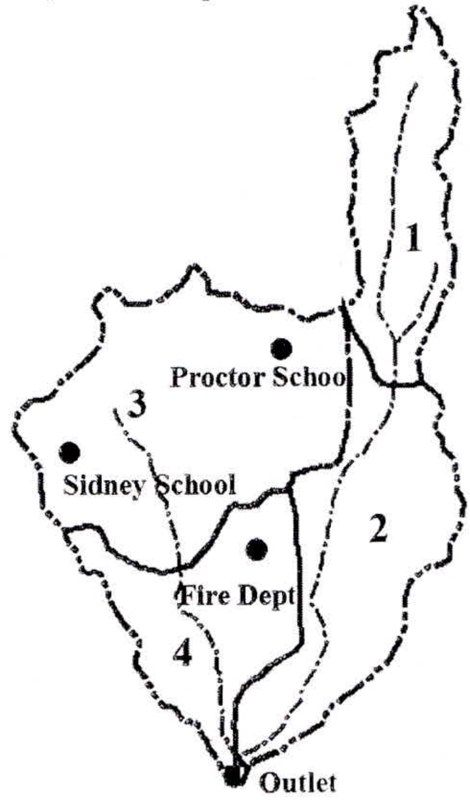

Figure 1: Castro Valley Creek watershed.

The model is prepared with initial constant loss, Snyder unit hydrograph transform, and recession base flow methods from the parameter data shown in Tables 1 – 6.

Table 1: Subbasin initial and constant loss method and Snyder transform method data.

| **Subbasin** | | **Loss Parameters** | | **Transform Parameters** | |
|---|---|---|---|---|---|
| ID | Initial *in* | Constant *in/h* | Impervious *%* | tp *h* | Cp |
| 1 | 0.02 | 0.14 | 2 | 0.20 | 0.16 |
| 2 | 0.02 | 0.14 | 8 | 0.28 | 0.16 |
| 3 | 0.02 | 0.14 | 10 | 0.20 | 0.16 |
| 4 | 0.02 | 0.14 | 15 | 0.17 | 0.16 |

Table 2: Subbasin area and baseflow data.

| **Subbasin Parameters** | | **Baseflow Parameters** | | |
|---|---|---|---|---|
| ID | Area *sq-mi* | Initial Flow *cfs/sq-mi* | Threshold *ratio-to-peak* | Recession *constant* |
| 1 | 0.86 | 0.54 | 0.1 | 0.79 |
| 2 | 1.52 | 0.54 | 0.1 | 0.79 |
| 3 | 2.17 | 0.54 | 0.1 | 0.79 |
| 4 | 0.96 | 0.54 | 0.1 | 0.79 |

Table 3: Routing criteria for reaches.

| **ID** | **From** | **To** | **Method** | **Sub-reaches** | **Parameters** |
|---|---|---|---|---|---|
| Reach-1 | Subbasin-1 | East Branch | Muskingum | 7 | K = 0.6 h, x = 0.2 |
| Reach-2 | Subbasin-3 | West Branch | Modified Puls | 4 | in = out, Table 2.4 |

Table 4: Storage-discharge data for Reach 2.

| **Storage** *ac-ft* | **Outflow** *cfs* |
|---|---|
| 0 | 0 |
| 0.2 | 2 |
| 0.5 | 10 |
| 0.8 | 20 |
| 1.0 | 30 |
| 1.5 | 50 |
| 2.7 | 80 |
| 4.5 | 120 |
| 750 | 1,500 |
| 5,000 | 3,000 |

Table 5: Precipitation gage weights.

| Subbasin | Proctor School | Fire Dept. | Sidney School |
|---|---|---|---|
| 1 | 1.00 | 0.00 | 0.00 |
| 2 | 0.20 | 0.80 | 0.00 |
| 3 | 0.33 | 0.33 | 0.33 |
| 4 | 0.00 | 0.80 | 0.20 |

Table 6: Precipitation at Fire Dept.

| Time | Rainfall *in* | Time | Rainfall *in* |
|---|---|---|---|
| 16Jan1973, 03:10 | 0 | 16Jan1973, 06:30 | 0.07 |
| 16Jan1973, 03:20 | 0 | 16Jan1973, 06:40 | 0.07 |
| 16Jan1973, 03:30 | 0.01 | 16Jan1973, 06:50 | 0.07 |
| 16Jan1973, 03:40 | 0.01 | 16Jan1973, 07:00 | 0.02 |
| 16Jan1973, 03:50 | 0.08 | 16Jan1973, 07:10 | 0.04 |
| 16Jan1973, 04:00 | 0.03 | 16Jan1973, 07:20 | 0.03 |
| 16Jan1973, 04:10 | 0.05 | 16Jan1973, 07:30 | 0.02 |
| 16Jan1973, 04:20 | 0.03 | 16Jan1973, 07:40 | 0.03 |
| 16Jan1973, 04:30 | 0.02 | 16Jan1973, 07:50 | 0.03 |
| 16Jan1973, 04:40 | 0.05 | 16Jan1973, 08:00 | 0.01 |
| 16Jan1973, 04:50 | 0.05 | 16Jan1973, 08:10 | 0.03 |
| 16Jan1973, 05:00 | 0.02 | 16Jan1973, 08:20 | 0.02 |
| 16Jan1973, 05:10 | 0.02 | 16Jan1973, 08:30 | 0.01 |
| 16Jan1973, 05:20 | 0.04 | 16Jan1973, 08:40 | 0.03 |
| 16Jan1973, 05:30 | 0.03 | 16Jan1973, 08:50 | 0.01 |
| 16Jan1973, 05:40 | 0.09 | 16Jan1973, 09:00 | 0 |
| 16Jan1973, 05:50 | 0.08 | 16Jan1973, 09:10 | 0.01 |
| 16Jan1973, 06:00 | 0.03 | 16Jan1973, 09:20 | 0.06 |
| 16Jan1973, 06:10 | 0.04 | 16Jan1973, 09:30 | 0.02 |
| 16Jan1973, 06:20 | 0.03 | 16Jan1973, 09:40 | 0.04 |

Total rainfall at Proctor and Sidney are 1.92 inch and 1.37 inch respectively.

## EFFECT OF FUTURE URBANIZATION

Consider how the Castro Valley watershed response would change given the effects of future urbanization. The meteorologic model and control specifications remain the same, but a modified basin model must be created to reflect anticipated changes to the watershed. In Subbasin-2 the percent imperviousness changed from 8% to 17 % and the Snyder $t_p$ in unit hydrograph from 0.28h to 0.19 h.

## BIBLIOGRAPHY

Matthew J. Fleming (2010) Hydrologic Modeling System HEC-HMS Quick Start Guide V3.5

William A. Scharffenberg and Matthew J. Fleming (2010) Hydrologic Modeling System HEC-HMS User's Manual V-3.5