Chapter 6

Runoff Hydrographs

Introduction

Unit Hydrographs

Unit hydrographs represent the time distribution of runoff as a result of one inch of effective rainfall uniformly distributed over a basin for a specified duration. A unit hydrograph for a drainage basin can be derived from observations of runoff from the basin as a result of several storms. Once derived, the unit hydrograph can be used to calculate runoff from the basin for any precipitation depth and duration.

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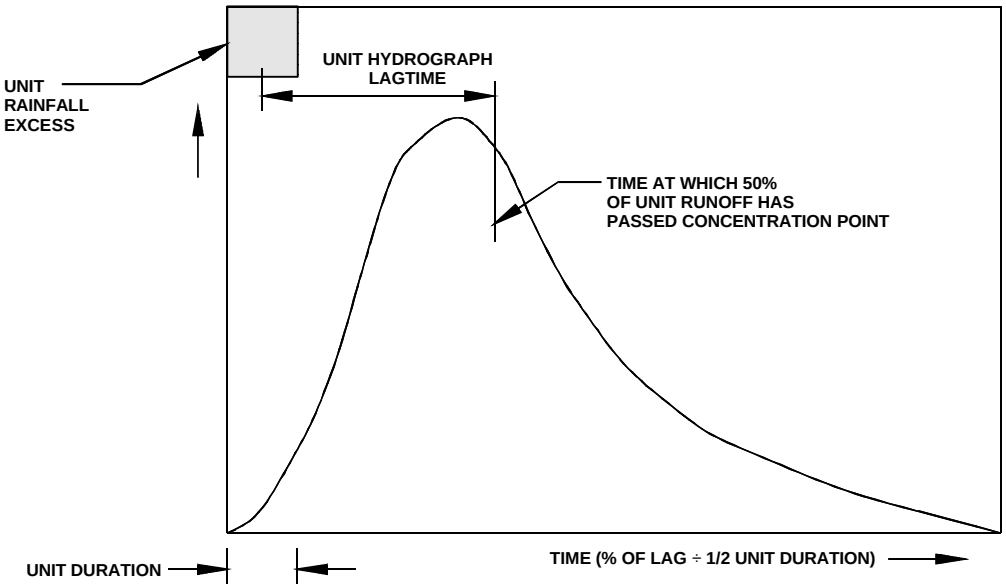
Introduction (continued)

Synthetic Unit Hydrographs

Synthetic unit hydrographs are widely used when flow data is not available. Synthetic unit hydrographs are based on unit hydrographs developed from recorded flood events in several hydrologically similar basins. A synthetic unit hydrograph as illustrated below has dimensionless units of time, a percent of basin lag plus 50 percent of the unit duration, as the abscissa and unit flow from one square mile area subject to one inch of runoff as the ordinates.



DIMENSIONLESS UNIT HYDROGRAPH

The Synthetic Urban Unit Hydrograph

The Sacramento method uses the Bureau of Reclamation dimensionless urban unit hydrograph to calculate runoff. The urban unit hydrograph was developed based on many urban watersheds throughout the United States. The applicability of the unit hydrograph in Sacramento County was confirmed by successful comparisons of recorded runoff for several drainage basins and storms with the runoff calculated using the urban unit hydrograph.

Calculating Runoff Hydrographs

Overview

The following information is required to calculate runoff hydrographs for ungaged basins.

- synthetic unit hydrograph - a relationship representing the variation of runoff over time
- lag time of the basin - the time required for 50% of the ultimate basin runoff to occur at the basin outlet
- unit duration - the duration of the time increment between ordinates of the unit hydrograph
- area of the basin.

The Synthetic Urban Unit Hydrograph

The relationship between discharge and time for the dimensionless urban unit hydrograph is given in Table 6-1 (disk).

Lag Time

The temporal distribution of the unit hydrograph is a function of the basin lag time. The lag time is defined as the time required for 50 percent of the volume of runoff to reach the basin outlet and can be calculated using one of two methods. Selection of a method depends on the available information and the purpose of the runoff analysis.

Basin "n" lag equation

- general planning level analyses
- basins with undeveloped conveyance systems.

Lag calculated from travel time components

- conveyance system design
- detailed runoff analyses of an existing developed conveyance system.

Further information on calculating the basin lag time is given in Chapter 7.

Unit Duration

The unit duration is the incremental period of time for which hydrograph ordinates are calculated. The unit duration should be approximately the lag time divided by 5.5 to provide adequate definition of the runoff hydrograph.

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Calculating Runoff Hydrographs (continued)

Calculation Procedure

The procedure below outlines the steps used in SACPRE to compute an urban unit hydrograph.

Computing Urban Unit Hydrographs	
Step	**Description**
1	Determine basin lag time (hrs) and area (sq mi).
2	Determine unit duration (hrs).
3	Calculate Lag Time + Unit Duration/2.
4	Calculate volume of runoff resulting from 1 inch of rainfall on basin area, in 1-day cfs. V = Basin area x 26.89 The conversion factor, 26.89, is used to convert 1 inch of rainfall excess to over 1 square mile in 24 hours to runoff expressed in 1-day cfs.
5	Calculate unit graph points as % of Lag + Unit Duration/2, up to 600%.
6	Determine dimensionless synthetic unit hydrograph ordinates from Table 6-1 (disk).
7	Calculate unit hydrograph ordinates by multiplying V from Step 4 by dimensionless synthetic unit graph ordinates in Step 6.
8	The ordinates in Step 7 are in cubic feet per second as a result of 1 inch of rain over the basin. To get ordinates as a result of any other rain depth multiply by the rain depth, in inches.

Unit Hydrographs in SACPRE

SACPRE will generate unit hydrographs for drainage basins based on the urban unit hydrograph, the basin area and the basin lag. The unit hydrographs created by SACPRE are used as input to HEC-1, which calculates runoff hydrographs based on the effective precipitation over the basin.

Base Flow

Introduction

There are two types of contributions to a stream flow hydrograph. There is the direct runoff which is determined using the unit hydrograph previously described and base flow which is a result of releases of water from subsurface storage.

Application

Channels may convey base flow during most of the year. Base flow is considered the normal day-to-day flow from groundwater, spring contributions, or even from landscaping runoff. **A study of the Sacramento area determined that base flow is not significant for most drainage studies and therefore was not included in SACPRE**.[6] However, base flow may be considered for large scale watershed planning studies, where its presence has been demonstrated.

Base Flow in HEC-1

The base flow contribution to a runoff hydrograph can be calculated in HEC-1. Table 6-2 (disk) lists base flow parameters used in HEC-1 for Sacramento County based on stream flow records for Dry Creek near Roseville. Additional discussion of base flow is provided in the COE HEC-1 User's Manual.