General Information for Urban Hydrology and Runoff

A. Introduction

Urban stormwater hydrology includes the information and procedures for estimating flow peaks, volumes, and time distributions of stormwater runoff. The analysis of these parameters is fundamental to the design of stormwater management facilities, such as storm drainage systems for conveyance of surface runoff and structural stormwater controls for quality and quantity. In the hydrologic analysis of a site, there are a number of variable factors that affect the nature of stormwater runoff from the site. Some of the factors that must be considered include:

- Rainfall amount and storm distribution
- Drainage area size, shape, and orientation
- Ground cover and soil type
- Slopes of terrain and stream channel(s)
- Antecedent moisture condition
- Storage potential (floodplains, ponds, wetlands, reservoirs, channels, etc.)
- Watershed development potential
- Characteristics of the local drainage system

The typical hydrologic processes of interest in urban hydrology are related to:

- Precipitation and losses (rainfall abstractions)
- Determination of peak flow rate
- Determination of total runoff volume
- Runoff hydrograph (flow vs. time)
- Stream channel hydrograph routing and combining of flows
- Reservoir (storage) routing

The practice of urban stormwater hydrology is not an exact science. While the hydrologic processes are well-understood, the necessary equations and boundary conditions required to solve them are often quite complex. In addition, the required data is often not available. There are a number of empirical hydrologic methods that can be used to estimate runoff characteristics for a site or drainage subbasin; the methods presented in this section have been selected to support hydrologic site analysis for the design methods and procedures included in this manual:

- Rational method
- NRCS Peak Flow method (SCS Curve Number)
- NRCS Urban Hydrology for Small Watersheds (TR-55, 1986; WinTR-55, 2003)
- U.S. Geological Survey (USGS) regression equations

These methods have been included since the applications are well-documented in urban stormwater hydrology design practice, and have been verified for accuracy in duplicating local hydrologic estimates for a range of design storms. The applicable design equations, nomographs, and computer programs are readily available to support the methods.

Table 2B-1.01 lists the hydrologic methods and circumstances for their use in various analysis and design applications. Table 2B-1.02 includes some limitations on the use of several of the methods.

1. **Rational Method:** The Rational method is recommended for small, highly-impervious drainage areas, such as parking lots, roadways, and developed areas draining into inlets and gutters.

   The Rational method (see Section 2B-4) may be used in both the minor and major storm runoff computations for relatively uniform basins in land use and topography, which generally have less than 40 acres. The averaging of runoff coefficients for significantly different land uses should be minimized where possible. For basins that have multiple changes in land use and topography, or are larger than 40 acres, or both; the design storm runoff should be analyzed by other methods. These basins should be broken down into subbasins of like uniformity and routing methods applied to determine peak runoff at specified points.

   If the Rational method is not used, TR-55, Urban Hydrology for Small Watersheds (NRCS) (see Section 2B-5), may be used for drainage areas up to 2,000 acres. For areas larger than 2,000 acres, TR-20 or an approved alternative may be used. When computer programs are used for design calculation, it is important to understand the assumptions and limits for the maximum and minimum drainage area or other limits before it is selected.

2. **NRCS Peak Flow Method:** The NRCS Peak Flow method (also known as the SCS Curve Number method) may be utilized as an alternative to the Rational method. The NRCS Peak Flow method (Section 2B-5) can be utilized for larger drainage areas (up to 2,000 acres). Like the Rational method, use of this method should be limited to basins with relatively homogeneous curve numbers and an overall curve number greater than 40.

   The NRCS Peak Flow method does not contain an expression for time; therefore, the equation does not account for storm intensity or duration. This prohibits the use of this method for calculating runoff from a specific storm event (e.g. 5 year, 1 hour storm).

3. **Modified Rational Method:** The Modified Rational method is one of the simplest methods for developing a hydrograph and routing a storm. Due to its simplicity, the Modified Rational method is also one of the least accurate routing methods. However, this method can be sufficient for routing storms from small drainage areas (up to 5 acres) with significantly varied runoff coefficients.

4. **NRCS Tabular Hydrograph Method (TR-55):** The Tabular Hydrograph method described in the NRCS' Urban Hydrology for Small Watersheds (TR-55) is applicable to non-homogeneous areas beyond the limitations of the Rational method. This method has wide application for existing and developing urban watersheds and can be utilized for estimating the effects of land use change as well as the effects of proposed structures. The method is limited to drainage areas less than 2,000 acres with a time of concentration less than or equal to 2 hours.

5. **Other Methods:** For drainage areas larger than 2,000 acres, or for situations where the methods described above are not appropriate, TR-20, HEC-1, HEC-HMS, or other approved alternatives may be used.

Table 2B-1.01: Applications of Hydrologic Methods

Method	Rational Method	NRCS Peak Flow	Modified Rational	NRCS TR-55
Channel protection volume (CPv)				✓
Overbank flood protection (Qp_5)				✓
Extreme flood protection (Qf)				✓
Storage facilities			✓	✓
Outlet structures				✓
Gutter flow and inlets	✓	✓		
Storm sewer piping	✓	✓		✓
Culverts	✓	✓		✓
Small ditches	✓	✓		✓
Open channels	✓	✓		✓
Energy dissipation				✓

Small storm hydrology and low impact development (LID) methods (utilized for water quality based design) as well as water balance calculations (utilized for permanent pond / wet detention design) are discussed in the Iowa Stormwater Management Manual (ISMM).

Table 2B-1.02: Limitations of Hydrologic Methods

Method	Size Limitations	Comments
Rational	40 acres	Method can be used for drainage areas with similar land uses for estimating peak flows and for the design of small site or subdivision storm sewer systems. *Should not be used for storage design.*
NRCS Peak Flow	0 to 2,000 acres	Method can be used for estimating peak flows for storm sewer or channel design. *Should not be used for storage design.*
Modified Rational	0 to 5 acres	Method can be used for estimating peak flows and developing simple hydrographs from small drainage areas with significantly different runoff coefficients.
NRCS TR-55	0 to 2,000 acres	Method can be used for estimating peak flows and developing hydrographs for all design applications. Can be used for low-impact development hydrologic analysis.

B. Definitions

Depression Storage: Depression storage is the natural depressions within the ground surface and landscape that collect and store rainfall runoff, either temporarily or permanently.

Hydrograph: A hydrograph is a graph of the time distribution of runoff from a watershed.

Hyetograph: A hyetograph is a graph of the time distribution of rainfall over a watershed [rainfall intensity (in/hr) or volume vs. time].

Infiltration: Infiltration is the process through which precipitation enters the soil surface and moves through the upper soil profile.

Interception: Interception is the storage of rainfall on foliage and other intercepting surfaces, such as vegetated pervious areas, during a rainfall event.

Peak Discharge: The peak discharge (peak flow) is the maximum rate of flow of water passing a given point during or after a rainfall event (or snowmelt).

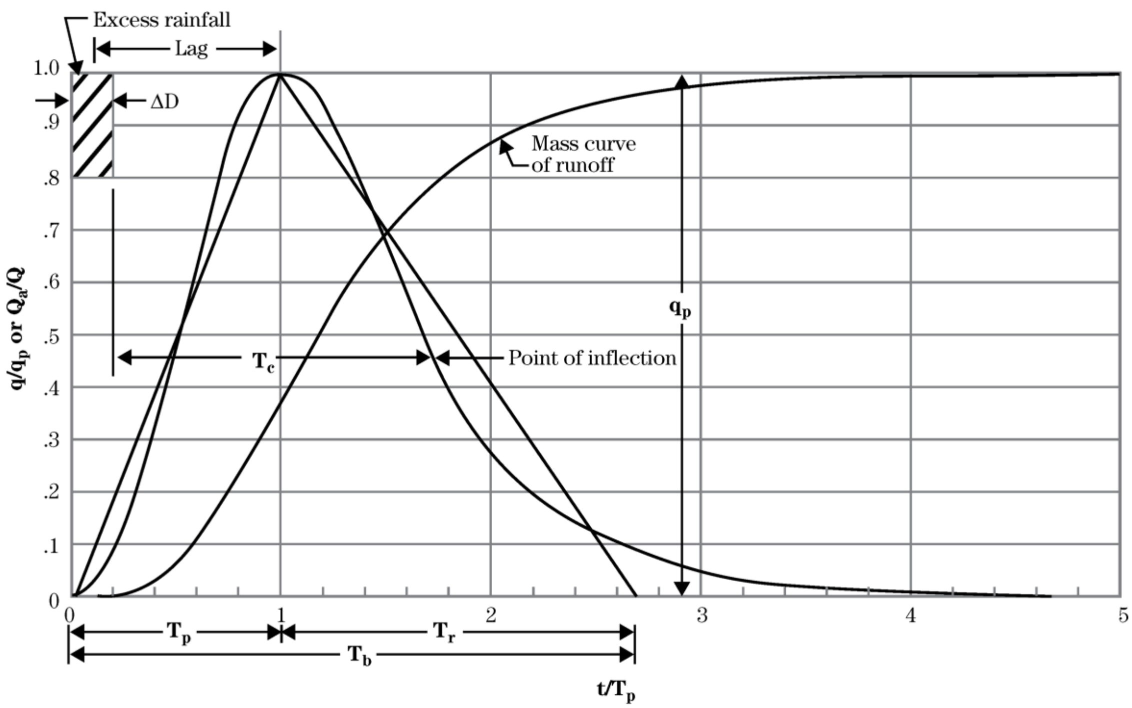
Rainfall Excess: After interception, depression storage, and infiltration have been satisfied, rainfall excess is the remaining water available to produce runoff.

Runoff Volume: The runoff volume represents the volume of rainfall excess generated from the watershed area. The runoff volume is often expressed in watershed-inches or acre-feet. The runoff volume for a rainfall event can also be represented by the area under the runoff portion of the hydrograph

Travel Time (T_t) and Time of Concentration (T_c): Travel time is the time it takes for water to travel from one location to another in a watershed. T_t is a component of the time of concentration, T_c, which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system

Unit Hydrograph: The hydrograph resulting from 1 inch of rainfall excess generated uniformly over the watershed, at a uniform rate, for a specified period of time. There are several types of unit hydrographs. The use of unit hydrographs to create direct runoff hydrographs is discussed in more detail in Section 2B-5.

Figure 2B-1.01: NRCS Dimensionless Curvilinear Unit Hydrograph and Equivalent Triangular Hydrograph



Source: NRCS NEH Part 630, Chapter 16A

C. References

USDA Natural Resource Conservation Service. *National Engineering Handbook - Part 630*. Chapter 16: Hydrographs. 2007.