CHAPTER 2

HYDROLOGY

2.8 Water Quality Storm – Volume and Peak Discharge

2.8.1 Overview

The following procedure is a variation of the methodology presented in SCS Technical Release 55 (TR-55) to calculate storm runoff volume, peak rate of discharges and hydrographs. This procedure is applicable to small storm events. The following procedures outline the use of this variation of the SCS-TR 55 method. Conventional SCS Methods underestimate the volume and rate of runoff for rainfall events less than 2". This discrepancy in estimating runoff and discharge rates can lead to situations where a significant amount of runoff by-passes the filtering treatment practice due to an inadequately sized diversion structure or leads to the design of undersized grass channels.

2.8.2 Water Quality Volume

The direst runoff, WQ_R, is calculated using the following:

$$WQ_R = 1.2'' * (R_v) \qquad \textbf{(Eq 2.8.2-1)}$$

$$R_v = 0.05 + (I) * .009 \qquad \textbf{(Eq 2.8.2-2)}$$

Where: WQ_R = water quality runoff (watershed inches)
R_v = the weighted volumetric runoff coefficient
I = Percent Impervious as a whole number

To calculate the water quality volume (WQ_v) in cubic feet or acre-feet, multiply WQ_R by the contributory area and make the appropriate conversion of units.

$$WQ_V = \frac{WQ_R}{12} A \qquad \textbf{(Eq 2.8.2-3)}$$

Where: WQ_R = water quality runoff (watershed inches)
A = pm-site area

2.8.3 Water Quality Storm – Peak Discharge

The following procedure relies on the volume of runoff computed using the Small Storm Hydrology Method (Pitt, 1994) and utilizes the NRCS, TR-55 Graphical Peak discharge Method (USDA, 1986).

The peak discharge equation is:

$$Q_p = q_u * A * WQ_R \qquad \textbf{(Eq 2.8.3-1)}$$

Where: Q_P = peak discharge (cfs)
q_u = unit peak discharge (cfs/mi^2/in)
A = drainage area (mi^2)
WQ_R = water quality runoff (in)

The input requirements for this method are as follows:

1. T_c – hours
2. Drainage area – acres
3. Type II rainfall distribution
4. 24-hour design rainfall
5. CN value

2.8.4 Computations

Computations for the peak discharge method proceed as follows:

2.8.4.1 The 24-hour rainfall depth for the water quality storm event has been determined to be 1.2 inches. The runoff is computed per section 2.8.2.

2.8.4.2 The runoff curve number, CN, is computed from the following equation using the water quality runoff calculated in step 1:

$$CN = 1000 / \left[10 + 5 * P + 10Q - 10 * \left((WQ_R)^2 + 1.25 * WQ_R * P \right)^{1/2} \right]$$

(Eq 2.8.4-1)

2.8.4.3 The CN value is used to determine the initial abstraction, I_a, from Table 2.7.3-1, and the ratio I_a/P is then computed. (P = water quality storm of 1.2 inches.)

2.8.4.4 The watershed time of concentration is computed using the procedures in Section 2.6.5 and is used with the ratio I_a/P to obtain the unit peak discharge, q_u , from Figure 2.7.2-1. If the ratio I_a/P lies outside the range shown in Figure 2.7.2-1, either the limiting values or another peak discharge method should be used.

2.8.4.5 The peak runoff rate is computed using equation 2.8.2-3.

2.8.5 Limitations

The accuracy of the peak discharge method is subject to specific limitations, including the following:

2.8.5.1 The watershed must be hydrologically homogeneous and describable by a single CN value.

2.8.5.2 The watershed may have only one main stream, or if more than one, the individual branches must have nearly equal time of concentrations.

2.8.5.3 Hydrologic routing cannot be considered.

2.8.5.4 Accuracy is reduced if the ratio I_a/P is outside the range given in Figure 2.7.2-1.

2.8.5.5 The weighted CN value must be greater than or equal to 40 and less than or equal to 98.

2.8.6 Example

Assume a 3.0 acre small shopping center having a 1.0 acre flat roof, 1.6 acres of parking and a 0.4 acre open space (sandy soil), for a 1.2 inch rainfall event and no disconnection of impervious surfaces. The time of concentration is 10 minutes.

Part 1 Calculate the weighted volumetric runoff coefficient using equation 2.8.2-2:

$\%I = 2.6/3(100) = 86.7\%$
$R_v = 0.009(I)+0.05$
$R_v = 0.83$

Calculate the "Water Quality Runoff" (WQ_R) using equation 2.8.2-1:

$WQ_R = 1.2(R_v) = 1.00$ in.

Part 2 The runoff curve number, CN using equation 2.8.4-1:

for: WQ_R – 1.00"

P + 1.2 inches (storm event)

$CN=1000/[10+5*1.2"+10*1.00"-10((1.00")^2+1.25*1.00*1.2")^{1/2}]$
CN = 98

Part 3 Using the CN value, the value of I_a is determined from Table 2.7.3-1 and the ratio I_a/P is computed:

$I_a = 0.041$ for CN 98, $I_a/P = 0.041/1.2" = 0.034$

Part 4 The ratio of I_a/P and the time of concentration are used to determine the unit peak discharge from Figure 2.7.2-1.

T_c = 10 minutes = 0.17 hours
Read q_u = 850 csm/in (using the graph for I_a/P = 0.10)

Part 5 Calculate the Peak Discharge for "Water Quality Storm" using equation 2.8.3-1:

$Q_p = q_u * A * WQ_v$

A = 3.0 acres/640 ac/ mi^2 = 0.0047 mi^2

Q_p = (850 csm/in)* (0.0047 mi^2)* (1.00")

Q_p = 4.0 cfs

END OF SECTION 2.8