

Appendix D – Water Quality Flow Calculation Method

The Water Quality Flow (WQF) is the peak rate of discharge associated with the water quality storm or Water Quality Volume (WQV). This section describes the recommended method for calculating the WQF when designing flow diversion structures for off-line stormwater Best Management Practices (BMPs). The WQF is also used for the design of stormwater BMPs that are sized based on flow rate rather than volume, including grass channels and proprietary stormwater BMPs such as hydrodynamic separators, catch basins inserts, and media filters.

The WQF should be calculated using the design WQV and a modified Runoff Curve Number for small storm events. This method is used to estimate peak discharges for small storm events based on the approach described in Claytor and Schueler (1996).⁹⁴ This method is more appropriate than: 1) the traditional Natural Resources Conservation Service (NRCS) Curve Number methods, which are valuable for estimating peak discharge rates for storms greater than 2 inches but can significantly underestimate runoff from small storm events, and 2) the Rational Formula, which should only be used with reliable intensity, duration, and frequency (IDF) tables or curves for the storm and region of interest (Claytor and Schueler, 1996).

The design WQV (either 100% or 50% of the WQV depending on the applicable retention/treatment requirement, as described in [Chapter 4](#)), converted to watershed inches, should be substituted for the runoff depth (Q) in the NRCS TR-55 Graphical Peak Discharge Method.

1. Compute the NRCS Runoff Curve Number (CN) using the following equation, or graphically using Figure 2-1 from TR-55 (USDA, 1986)⁹⁵ (see Figure 1 below):

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

where:

CN = Runoff Curve Number

⁹⁴ Claytor, R. and T. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Ellicott City, MD.

⁹⁵ Soil Conservation Service. 1986. Urban Hydrology for Small Watersheds. USDA Soil Conservation Service Technical Release No. 55. Washington, D.C.

P = Design precipitation, inches (1.3 inches⁹⁶ for 100% of the WQV and 0.65 inches for 50% of the WQV)

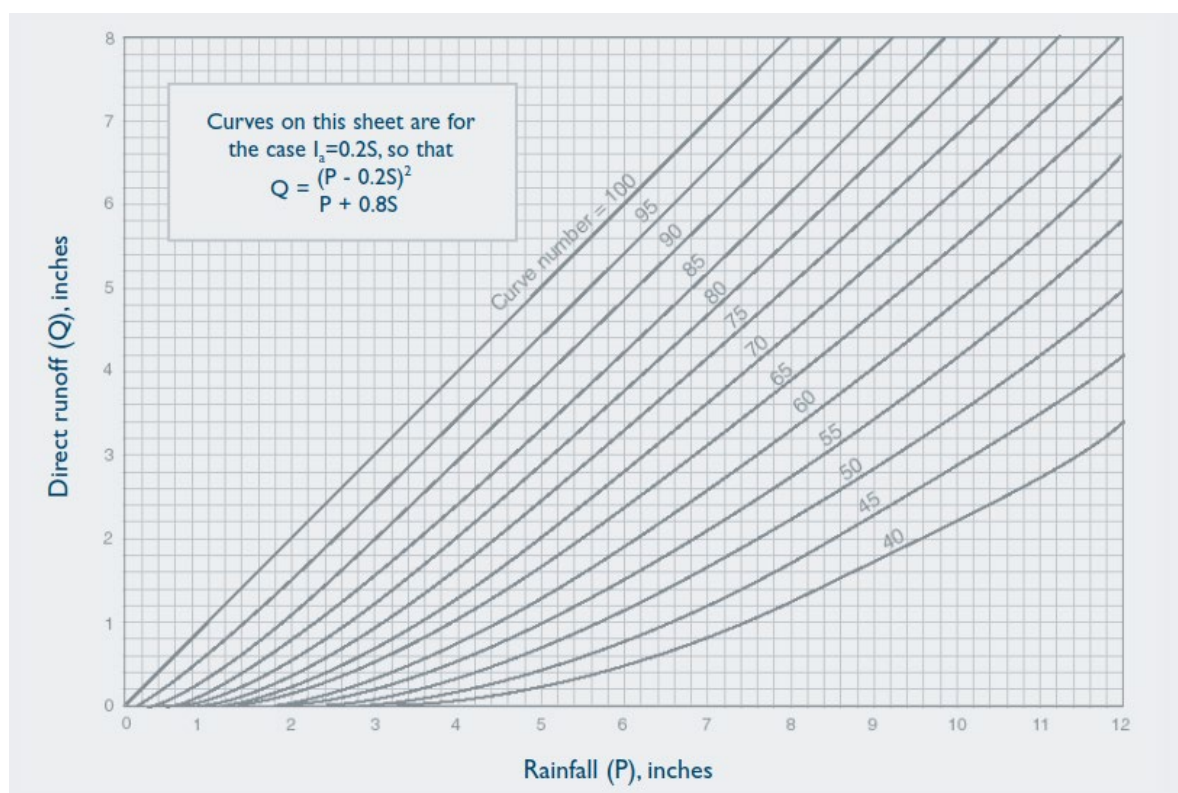
Q = Runoff depth (in watershed inches)

$$Q = \frac{WQV \text{ (cubic feet)}}{\text{Drainage Area (acres)}} * \frac{12 \text{ inches}}{\text{foot}} * \frac{\text{acre}}{43,560 \text{ square feet}}$$

where:

WQV = design Water Quality Volume (100% or 50% of the WQV)

Figure 1. Graphical Solution of Runoff Equation



Source: Figure 2-1 from TR55 (USDA, 1986).

Once the modified CN is calculated, either follow Steps 2 and 3 below or use a stormwater hydrologic/hydraulic model (e.g., HydroCAD or similar software) to calculate peak discharge (WQF). **This modified CN must be used when using a stormwater hydrologic/hydraulic model or analysis method to calculate the WQF.**

⁹⁶ Per NOAA Atlas 14, Upon the release of the next generations of this product the most recent value should be used.

2. Compute the time of concentration (t_c) based on the methods described in Chapter 3 of TR-55. A minimum value of 0.167 hours (10 minutes) should be used. For sheet flow, the flow path should not be longer than 100 feet.
3. Using the computed CN , t_c and drainage area (A) in acres, compute the peak discharge for the design water quality storm (i.e., WQF) as follows, which is based on the procedures described in Chapter 4 of TR-55:
 - Read initial abstraction (I_a) from Table 4-1 in Chapter 4 of TR-55 (see Figure 2 below); compute I_a/P ($P = 1.3$ inches for 100% of the WQV and 0.65 inches for 50% of the WQV).

Figure 2. Initial Abstraction (I_a) Values for Runoff Curve Numbers

Curve number	I_a (in)	Curve number	I_a (in)	Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	55	1.636	70	0.857	85	0.353
41	2.878	56	1.571	71	0.817	86	0.326
42	2.762	57	1.509	72	0.778	87	0.299
43	2.651	58	1.448	73	0.740	88	0.273
44	2.545	59	1.390	74	0.703	89	0.247
45	2.444	60	1.333	75	0.667	90	0.222
46	2.348	61	1.279	76	0.632	91	0.198
47	2.255	62	1.226	77	0.597	92	0.174
48	2.167	63	1.175	78	0.564	93	0.151
49	2.082	64	1.125	79	0.532	94	0.128
50	2.000	65	1.077	80	0.500	95	0.105
51	1.922	66	1.030	81	0.469	96	0.083
52	1.846	67	0.985	82	0.439	97	0.062
53	1.774	68	0.941	83	0.410	98	0.041
54	1.704	69	0.899	84	0.381		

Source: Table 4-1 in Chapter 4 of TR-55 (USDA, 1986).

- Read the unit peak discharge (q_u) from Exhibit 4-III in Chapter 4 of TR-55 (see Figure 3 below) for the appropriate t_c .

Note: NRCS has not developed unit peak discharge curves for the NOAA Atlas 14 rainfall distributions, including the NOAA_D rainfall distribution, which has replaced the NRCS Type III distribution for use in Connecticut for peak flow rate calculations (see [Chapter 4](#) of this Manual). The NRCS Type III rainfall distribution may be used for calculating the WQF using the TR-55 Graphical Peak Discharge method. The NOAA_D rainfall distribution is slightly less intense than the NRCS Type III distribution, so the resulting peak discharge will be conservative. The NOAA_D rainfall distribution should be used for calculating peak flow rates associated with stormwater quantity control design storms (2-year, 10-year, and 100-year, 24-hour events) described in [Chapter 4](#).

- Substituting the design WQV, converted to watershed inches, for runoff depth (Q), compute the WQF from the following equation:

$$WQF = (q_u)(A)(Q)$$

where:

WQF = Water Quality Flow (cubic feet per second, cfs)

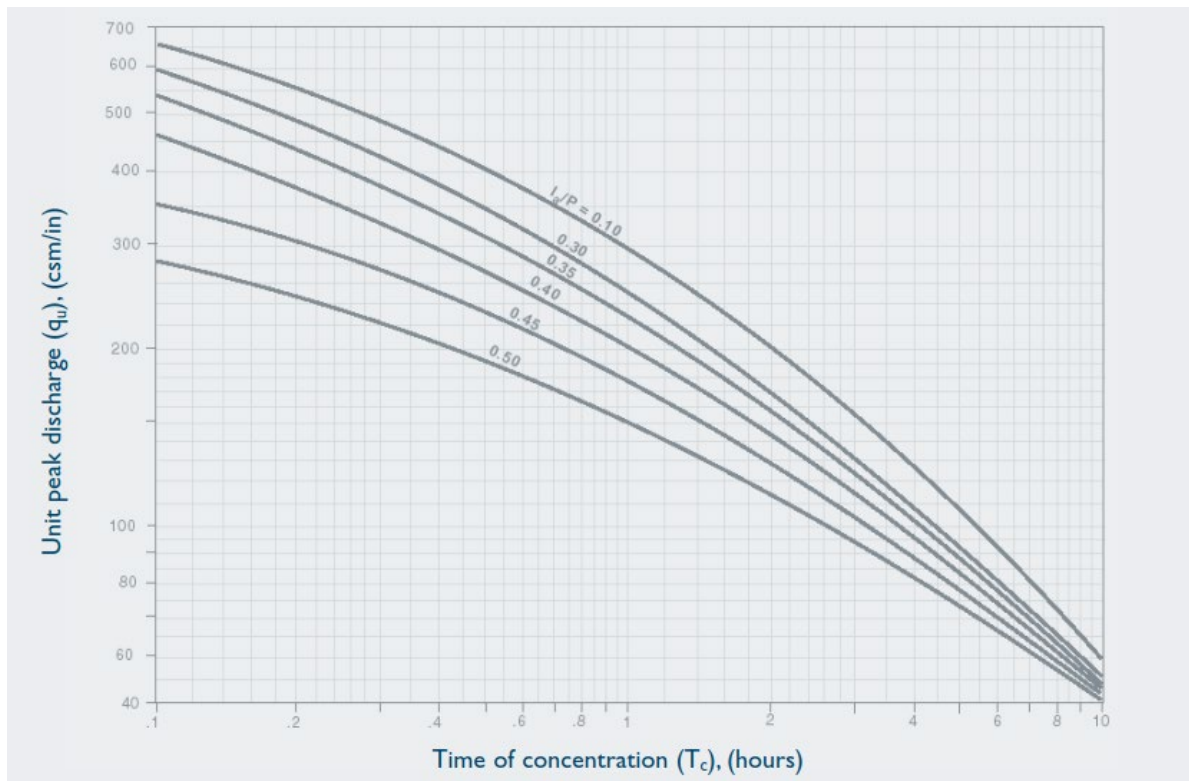
q_u = unit peak discharge (cfs, per square mile, per inch of runoff, csm/in)

A = drainage area (square miles)

Q = runoff depth (in watershed inches)

$$Q = \frac{WQV \text{ (cubic feet)}}{\text{Drainage Area (acres)}} * \frac{12 \text{ inches}}{\text{foot}} * \frac{\text{acre}}{43,560 \text{ square feet}}$$

Figure 3. Unit Peak Discharge for NRCS Type III Rainfall Distribution



Source: Exhibit 4-III in Chapter 4 of TR-55 (USDA, 1986).