.

Rational Method

The Formula

The rational formula is:

$$Q = C\,i\,A$$

Where:

Q = Peak rate of runoff in cubic feet per second
C = Runoff coefficient, an empirical coefficient representing a relationship between rainfall and runoff
i = Average intensity of rainfall for the time of concentration (T_c) for a selected design storm
A = Drainage area in acres

Procedure

The general procedure for determining peak discharge using the Rational Method is as follows:

Step 1: Determine the drainage area (in acres.)

Step 2: Determine the runoff coefficient (C).

If the types of land use and the soil cover are homogeneous for the entire drainage area, then a runoff coefficient can be determined directly from Table 2.

If the drainage area contains multiple land uses or soil conditions, deciding on a C value becomes slightly more complicated. The drainage area should be divided into sections, with an area calculated for each section and a C value assigned to each area. A weighted average C is calculated as follows:

$$\text{Weighted Average "C"} = \frac{\text{Total CA}}{\text{Total Area}}$$

$$\frac{(\text{area landuse}_1) \times \text{"C"} = CA_1}{(\text{area landuse}_2) \times \text{"C"} = CA_2}$$
$$\frac{[\text{continue for each landuse}]}{\text{Total Area} \qquad \text{Total CA}}$$

Step 3: Determine the hydraulic length or flow path that will be used to determine the time of concentration. Also, determine the types of flow (or flow regimes) that occur along the flow path.

Step 4: Determine the time of concentration (T_c) for the drainage area.

The time of concentration equals the summation of the travel times for each flow regime.

There are numerous methods used to calculate the travel time for each of the flow regimes.

Step 5: Determine the intensity using the time of concentration.

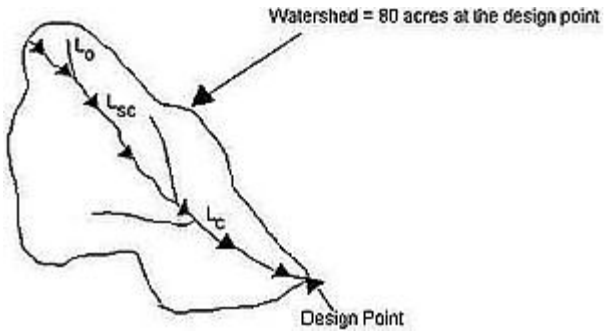
The intensity is determined using the time of concentration and the I-D-F curve for the county. I-D-F curves for Virginia can be found in the Chapter 4 Appendix of Virginia Stormwater Management Handbook.

Step 6: Input the drainage area, C value, and intensity into the formula to determine the peak rate of runoff.

Example

Given Information

A project is to be built in southwest Campbell County, Virginia. The following information was determined from field measurement and/or proposed design data:



Drainage Area: 80 acres

30% - Rooftops (24 acres)
10% - Streets and driveways (8 acres)
20% - Average lawns @ 5% slope on sandy soil (16 acres)
40% - Woodland (32 acres)

L_O = 200 ft. (4% slope or 0.04 ft./ft.); average grass lawn.
L_{SC} = 1000 ft. (4% slope or 0.04 ft./ft.); paved ditch.
L_C = 2000 ft. (1% slope or 0.01 ft./ft.); stream channel.

Goal

Your goal is to find the peak runoff from the 2-year frequency storm.

Solution

1. Drainage area (A) = 80 acres (given).

2. Determine the runoff coefficient (C):

	Area	x	C		
Rooftops	24	x	0.9	=	21.6

Streets	8	x 0.9	=	7.2
Lawns	16	x 0.15	=	2.4
Woodland	32	x 0.10	=	3.2
Total	**80**			**34.4**

$$C = \frac{34.4}{80} = 0.43$$

3. Determine flow regimes:

A. Overland flow (L_O) = 15 minutes (using Seelye chart).

B. Shallow concentrated flow (L_{SC}):

1. Velocity = 4 feet/second (using Diagram 1).

2. L_{SC} = 4.2 minutes (based on the following calculations).

$$\text{Support Capacity} = \frac{(\text{Sledge weight}) \times D_2}{(D_1 - D_3) \times (\text{Rebar area})}$$

C. Channel flow (L_C):

1. Change in elevation = 20 feet (based on the following calculations).

2000 feet × 0.01 = 20 feet

2. L_C = 13 minutes (using Kirpitch chart).

4. Time of Concentration = 32.2 minutes (based on the following calculations).

$$T_c = L_o + L_{sc} + L_c$$

$$T_c = 15 + 4.2 + 13$$

$$T_c = 32.2$$

5. Intensity = 2.3 in/hr (based on 2-year storm I-D-F curve for Pittsylvania County).

6. Ppeak discharge = 79.1 cfs (based on the following calculations).

$$Q = C\ i\ A$$

$$Q = (0.43)\ (2.3)\ (80)$$

$$Q = 79.1$$