From: Chow, V. T., D. R. Maidment and L. W. Mays, (1988), Applied Hydrology, McGraw Hill, 572 p.

5.5 SCS METHOD FOR ABSTRACTIONS

The Soil Conservation Service (1972) developed a method for computing abstractions from storm rainfall. For the storm as a whole, the depth of excess precipitation or direct runoff P_e is always less than or equal to the depth of precipitation P; likewise, after runoff begins, the additional depth of water retained in the watershed, F_a, is less than or equal to some potential maximum retention S (see Fig. 5.5.1). There is some amount of rainfall I_a (initial abstraction before ponding) for which no runoff will occur, so the potential runoff is $P - I_a$. The hypothesis of the SCS method is that the ratios of the two actual to the two potential quantities are equal, that is,

$$\frac{F_a}{S} = \frac{P_e}{P - I_a} \tag{5.5.1}$$

From the continuity principle

$$P = P_e + I_a + F_a \tag{5.5.2}$$

Combining (5.5.1) and (5.5.2) to solve for P_e gives

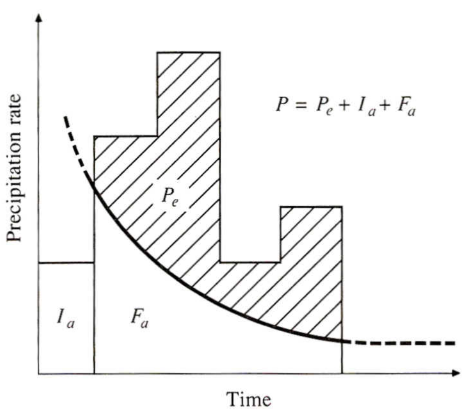

FIGURE 5.5.1
Variables in the SCS method of rainfall abstractions: I_a = initial abstraction, P_e = rainfall excess, F_a = continuing abstraction, P = total rainfall.

$$P_e = \frac{(P - I_a)^2}{P - I_a + S} \tag{5.5.3}$$

which is the basic equation for computing the depth of excess rainfall or direct runoff from a storm by the SCS method.

By study of results from many small experimental watersheds, an empirical relation was developed.

$$I_a = 0.2S \tag{5.5.4}$$

On this basis

$$P_e = \frac{(P - 0.2S)^2}{P + 0.8S} \tag{5.5.5}$$

Plotting the data for P and P_e from many watersheds, the SCS found curves of the type shown in Fig. 5.5.2. To standardize these curves, a dimensionless curve number CN is defined such that $0 \leq \text{CN} \leq 100$. For impervious and water surfaces CN = 100; for natural surfaces CN < 100. As an illustration, the rainfall event of Example 5.3.2 has $P_e = 4.80$ in. and $P = 5.80$ in. From Fig. 5.5.2, it can be seen that CN = 91 for this event.

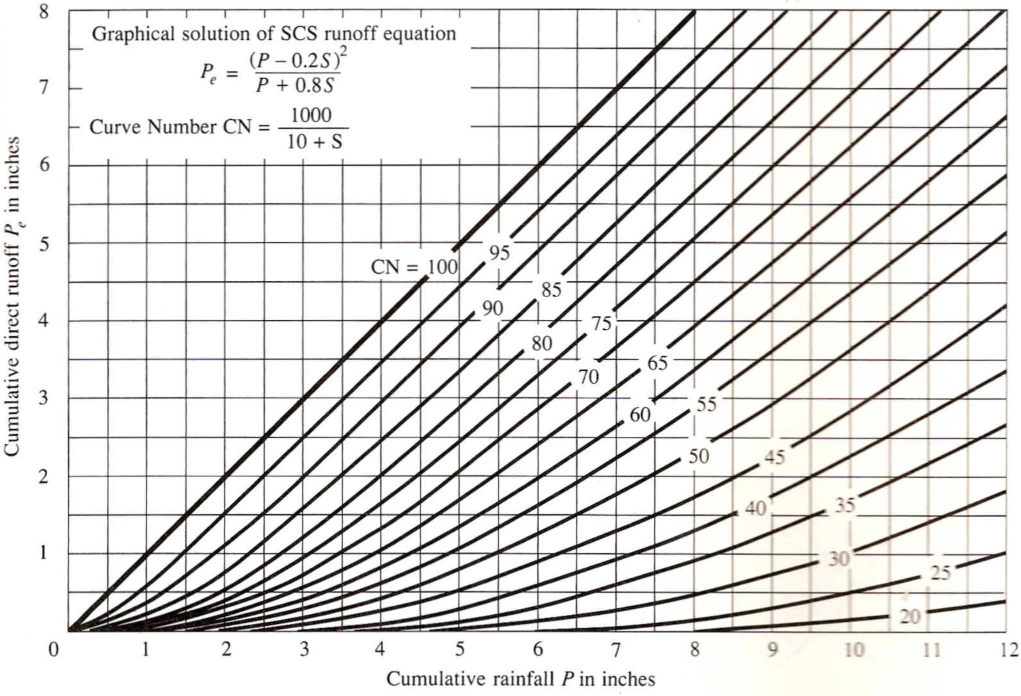

FIGURE 5.5.2
Solution of the SCS runoff equations. (*Source:* Soil Conservation Service, 1972, Fig. 10.1, p. 10.21)

The curve number and S are related by

$$S = \frac{1000}{\text{CN}} - 10 \qquad (5.5.6)$$

where S is in inches. The curve numbers shown in Fig. 5.5.2 apply for normal *antecedent moisture conditions* (AMC II). For dry conditions (AMC I) or wet conditions (AMC III), equivalent curve numbers can be computed by

$$\text{CN(I)} = \frac{4.2\text{CN(II)}}{10 - 0.058\text{CN(II)}} \qquad (5.5.7)$$

and

$$\text{CN(III)} = \frac{23\text{CN(II)}}{10 + 0.13\text{CN(II)}} \qquad (5.5.8)$$

The range of antecedent moisture conditions for each class is shown in Table 5.5.1.

Curve numbers have been tabulated by the Soil Conservation Service on the basis of soil type and land use. Four soil groups are defined:

Group A: Deep sand, deep loess, aggregated silts

Group B: Shallow loess, sandy loam

Group C: Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay

Group D: Soils that swell significantly when wet, heavy plastic clays, and certain saline soils

The values of CN for various land uses on these soil types are given in Table 5.5.2. For a watershed made up of several soil types and land uses, a composite CN can be calculated.

Example 5.5.1 (After Soil Conservation Service, 1975). Compute the runoff from 5 inches of rainfall on a 1000-acre watershed. The hydrologic soil group is 50 percent Group B and 50 percent Group C interspersed throughout the watershed. Antecedent moisture condition II is assumed. The land use is:

40 percent residential area that is 30 percent impervious

12 percent residential area that is 65 percent impervious

TABLE 5.5.1

Classification of antecedent moisture classes (AMC) for the SCS method of rainfall abstractions

	Total 5-day antecedent rainfall (in)	
AMC group	**Dormant season**	**Growing season**
I	Less than 0.5	Less than 1.4
II	0.5 to 1.1	1.4 to 2.1
III	Over 1.1	Over 2.1

(*Source:* Soil Conservation Service, 1972, Table 4.2, p. 4.12.)

TABLE 5.5.2
Runoff curve numbers for selected agricultural, suburban, and urban land uses (antecedent moisture condition II, $I_a = 0.2S$)

Land Use Description	Hydrologic Soil Group A	B	C	D
Cultivated land[1]: without conservation treatment	72	81	88	91
with conservation treatment	62	71	78	81
Pasture or range land: poor condition	68	79	86	89
good condition	39	61	74	80
Meadow: good condition	30	58	71	78
Wood or forest land: thin stand, poor cover, no mulch	45	66	77	83
good cover[2]	25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.				
good condition: grass cover on 75% or more of the area	39	61	74	80
fair condition: grass cover on 50% to 75% of the area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious)	81	88	91	93
Residential[3]:				
Average lot size — Average % impervious[4]				
1/8 acre or less — 65	77	85	90	92
1/4 acre — 38	61	75	83	87
1/3 acre — 30	57	72	81	86
1/2 acre — 25	54	70	80	85
1 acre — 20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]	98	98	98	98
Streets and roads:				
paved with curbs and storm sewers[5]	98	98	98	98
gravel	76	85	89	91
dirt	72	82	87	89

[1]For a more detailed description of agricultural land use curve numbers, refer to Soil Conservation Service, 1972, Chap. 9

[2]Good cover is protected from grazing and litter and brush cover soil.

[3]Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[4]The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[5]In some warmer climates of the country a curve number of 95 may be used.