CE 374K Sample Problems for Chapters 5 and 6

Problem 5.5.4

5.5.4 (*a*) Compute the runoff from a 7-in rainfall on a 1500-acre watershed that has hydrologic soil groups that are 40 percent group A, 40 percent group B, and 20 percent group C interspersed throughout the watershed. The land use is 90 percent residential area that is 30 percent impervious, and 10 percent paved roads with curbs. Assume AMC II conditions.

(*b*) What was the runoff for the same watershed and same rainfall before development occurred? The land use prior to development was pasture and range land in poor condition.

Solution:

5.5.4.

(a) The computations follow the method outlined in Example 5.5.1 of the textbook. The weighted curve number is the weighted average of the curve numbers corresponding to the different land uses in the watershed, where the weights are the percentage areas dedicated to each use. The computations are summarized in Table 5.5.4-1. The weighted curve number is

$$CN = (2444 + 2984 + 1654)/100 = 70.8$$

The potential maximum retention is given by Eq. (5.5.6) from the textbook

$$S = 1000/CN - 10 = 1000/70.8 - 10 = 4.12 \text{ in}$$

and the excess rainfall depth P_e is given by Eq. (5.5.5) from the textbook, with rainfall depth $P = 7$ in,

$$P_e = (P - 0.2S)^2/(P + 0.8S) = (7 - 0.2 \times 4.12)^2/(7 + 0.8 \times 4.12)$$

$$= 3.70 \text{ in}$$

which corresponds, for watershed area $A = 1500$ ac, to a runoff volume

$$V_d = P_eA = 1500 \times (3.70/12) = 473.0 \text{ ac.ft}$$

Land Use		Hydrologic Soil Group								
		A			B			C		
		Pct.	CN	Prod.	Pct.	CN	Prod.	Pct.	CN	Prod.
Residential (30 % imp.)	90	36	57	2052	36	72	2592	18	81	1458
Roads	10	4	98	392	4	98	392	2	98	196
		40		2444	40		2984	20		1654

Table 5.5.4-1. Weighted curve number after development.

(b) Before development, the weighted curve number is computed from Table 5.5.4-2, giving

$$CN = (2720 + 3160 + 1720)/100 = 76$$

so that

$$S = 1000/CN - 10 = 1000/76 - 10 = 3.15 \text{ in}$$

and, with P = 7 in,

$$P_e = (P - 0.2S)^2/(P + 0.8S) = (7 - 0.2 \times 3.15)^2/(7 + 0.8 \times 3.15)$$

$$= 4.25 \text{ in}$$

which corresponds, for watershed area A = 1500 ac, to a runoff volume

$$V_d = P_e A = 1500 \times (4.25/12) = 532.1 \text{ ac.ft}$$

Land Use	Hydrologic Soil Group								
	A			B			C		
	Pct.	CN	Prod.	Pct.	CN	Prod.	Pct.	CN	Prod.
Pasture/Range	40	68	2720	40	79	3160	20	86	1720
	40		2720	40		3160	20		1720

Table 5.5.4-2. Weighted curve number prior to development.

Problem 6.3.1

6.3.1 A discharge measurement made on the Colorado River at Austin, Texas, on June 11, 1981, yielded the following results. Calculate the discharge in ft^3/s.

Distance from bank (ft)	0	30	60	80	100	120	140	160
Depth (ft)	0	18.5	21.5	22.5	23.0	22.5	22.5	22.0
Velocity (ft/s)	0	0.55	1.70	3.00	3.06	2.91	3.20	3.36

Distance	180	200	220	240	260	280	300	320	340
Depth	22.0	23.0	22.0	22.5	23.0	22.8	21.5	19.2	18.0
Velocity	3.44	2.70	2.61	2.15	1.94	1.67	1.44	1.54	0.81

Distance	360	380	410	450	470	520	570	615
Depth	14.7	12.0	11.4	9.0	5.0	2.6	1.3	0
Velocity	1.10	1.52	1.02	0.60	0.40	0.33	0.29	0

Solution:

6.3.1.

The computations follow the method outlined in Example 6.3.1 of the texbook. Col. (2) of Table 6.3.1 shows the distance of each measurement point to the river bank. Each measurement represents the conditions up to halfway between this measurement and the adjacent measurements on either side. For example, for the second measurement, the incremental width is Δw = [(60 - 30) + (30 -0)]/2 = 30 ft, as shown in Col. (3) of Table 6.3.1. The corresponding area increment is $\Delta A = \Delta wd = 30 \times 18.5 = 555$ ft^2, as shown in Col. (6) of the table, and the incremental discharge is obtained by multiplying this value by the velocity in Col. (5), so that $\Delta Q = v\Delta A = 0.55 \times 555 = 305.3$ cfs, as shown in Col. (7) of Table 6.3.1. The remaining incremental discharges are similarly computed and added to yield a total discharge Q = 17,711 cfs.

(1) Point no.	(2) Distance from initial point (ft)	(3) Inc. Width Δw (ft)	(4) Depth d (ft)	(5) Velocity v (cfs)	(6) Area ΔA (ft²)	(7) Discharge ΔQ (cfs)
1	0	15	0.0	0.00	69.4	0.0
2	30	30	18.5	0.55	555.0	305.3
3	60	25	21.5	1.70	537.5	913.8
4	80	20	22.5	3.00	450.0	1350.0
5	100	20	23.0	3.06	460.0	1407.6
6	120	20	22.5	2.91	450.0	1309.5
7	140	20	22.5	3.20	450.0	1440.0
8	160	20	22.0	3.36	440.0	1478.4
9	180	20	22.0	3.44	440.0	1513.6
10	200	20	23.0	2.70	460.0	1242.0
11	220	20	22.0	2.61	440.0	1148.4
12	240	20	22.5	2.15	450.0	967.5
13	260	20	23.0	1.94	460.0	892.4
14	280	20	22.8	1.67	456.0	761.5
15	300	20	21.5	1.44	430.0	619.2
16	320	20	19.2	1.54	384.0	591.4
17	340	20	18.0	0.81	360.0	291.6
18	360	20	14.7	1.10	294.0	323.4
19	380	25	12.0	1.52	300.0	456.0
20	410	35	11.4	1.02	399.0	407.0
21	450	30	9.0	0.60	270.0	162.0
22	470	35	5.0	0.40	175.0	70.0
23	520	50	2.6	0.33	130.0	42.9
24	570	47.5	1.3	0.29	61.8	17.9
25	615	22.5	0.0	0.00	7.3	0.0
Total		615				17711.3

Table 6.3.1. Discharge computations.