Bachelor of Biosystems Technology
Faculty of Technology
South Eastern University of Sri Lanka

BSE 11022 – Hydrology and Meteorology

Assignment 2 **Professor M.M.M. Najim**

1. Compute rainfall intensity for 25-year return period due to a storm occurring for the duration of 1.5 h. Assume $K = 6.93$, $b = 0.53$, $a = 0.13$ and $d = 0.872$.

2. Determine the storm duration, if
   a) 25-years return period rainfall intensity of the storm is 5.0 cm/h
   b) $K = 5.12$, $b = 1.25$, $a = 0.156$ and $d = 0.75$

3. A seven hour storm over a basin of 1830 km^2 produced the rainfall intensities at half an hour interval are 4,9,20, 18,13,11,12,2,8,16,17,13,6 and 1 mm/hour. If the corresponding observation runoff is 73.2 x 10^6 m^3, estimate the Φ-index of the storm.

4. A storm during a dry weather flow has initial rainfall intensities of 8,12,40,38,30,26,28,5,16,32,36,24,14 and 4 mm/hr at half an hour interval. If the initial abstraction is 10 mm, what is the runoff volume of the basin which has the area of 600 km^2 and Φ-index is 20 mm/hr.

5. A houring rainfall of the following storm produces runoff of 6 cm. Calculate Φ-index and W-index.

Time	1	2	3	4	5	6	7	8
Rainfall	0.1	1.0	1.4	2.6	2.0	1.5	1.0	0.4

Assignment 3

1. Calculate the value of weighted runoff coefficient of the watershed from the following data.

Lanuse and topography	Cultivated land (flat, soil is sandy)	Pasture land (rolling, sandy soil)	Populated with flat topography and tight clay soil
Area (ha)	100	30	75

2. Calculate the time of concentration of 300 ha size watershed. The maximum length of drainage course is 350 m and average slope of it is 4 m/100 m.

3. Calculate the peak runoff rate for 10 years return period from a watershed of 175 ha area. The whole area is divided into three sub-parts based on the land use and soil texture. In which, first part of 100 ha land with 1% slope is kept under cultivation; the second part of 45 ha has 7% slope is engaged under pasture farming and remaining land with 12% slope is covered under forest. The other information are given as under:
    a) Max length of channel reach = 2500 m
    b) Average channel slope = 5%
    c) Rainfall depth = 3:58 cm

4. Find out the runoff rate for 25-years recurrence interval from a watershed of 40 hectares with following details :

Landuse/area (ha)	Slope %	Information capacity (cm/h)	Vegetal cover	Surface storage
Cultivate 25 ha	1	0.75	Less than 10% area is under good grass cover	Ponds are less than 2% of drainage ways
Pasture land 15 ha	5	1.00	About 90% area is under grass cover	Negligible

Also, assume the following
    a) Length and breadth ration of the watershed = 3
    b) Rainfall factor (r) = 1.0
    c) *Frequency factor (f)* = 1.3
    d) Shape factor (s) = 0.8

5. Calculate the runoff for 50 years recurrence interval from a watershed for AMC III if the total area of watershed is 50 ha in which 40 ha land is under row crop on terraced land area and remaining 10 ha and is under poor grass cover. Assume maximum rainfall depth as 15 cm that occur during 6 hour duration at 50 years recurrence interval and hydrological soil group as "C".

Assignment 2

1. $$i = \frac{KT^a}{(t+b)^d}$$

$$i_{25y} = \frac{6.93\,(25)^{0.13}}{(1.5+0.53)^{0.872}} \text{ cm/h}$$

$$= \underline{\underline{5.68 \text{ cm/h}}}.$$

2. $$i = \frac{KT^a}{(t+b)^d}$$

$$i_{25} = 5 \text{ cm/h}.$$

$$5 = \frac{5.12\,(25)^{0.156}}{(t+1.25)^{0.75}}$$

$$(t+1.25)^{0.75} = \frac{5.12\,(25)^{0.156}}{5}$$

$$(t+1.25)^{0.75} = 1.6919$$

$$t + 1.25 = (1.6919)^{\frac{1}{0.75}}$$

$$t + 1.25 = 2.016$$

$$t = 2.016 - 1.25$$

$$= \underline{\underline{0.766 \text{ h}}}.$$

3. Total runoff = 73.2×10^6 m^3

Area of basin = 1830 km^2 = 1830×10^6 m^2

Depth of runoff = $\frac{73.2 \times 10^6}{1830 \times 10^6}$ m

= 0.04 m = 40 mm

$$[(4-\phi) + (9-\phi) + (20-\phi) + (18-\phi) + (13-\phi) + (11-\phi) + (12-\phi) + (2-\phi) + (8-\phi) + (16-\phi) + (17-\phi) + (13-\phi) + (6-\phi)] \times \tfrac{1}{2} = 40$$

$$150 - 14\phi = 80$$

$$14\phi = 70$$

$$\phi = \frac{70}{14} = 5 \text{ mm/h}.$$

As there are intensities less than 5 mm/h

$$[(9-\phi) + (20-\phi) + (18-\phi) + (13-\phi) + (11-\phi) + (12-\phi) + (8-\phi) + (16-\phi) + (17-\phi) + (13-\phi) + (6-\phi)] \tfrac{1}{2} = 40$$

$$143 - 11\phi = 80$$

$$11\phi = 143 - 80 = 63$$

$$\phi = \frac{63}{11}$$

$$= \underline{5.73 \text{ mm/h}}$$

4.

Initial abstraction 10 mm.

First half an hour rainfall 4 mm.

Second half an hour rainfall 6 mm

Therefore, rainfall received during first hour is lost as initial abstraction.

ϕ = 20 mm/hr

Rainfall excess on half an hour basis

$= (40-20) + (38-20) + (30-20) + (26-20) + (28-20) + 0 + 0 + (32-20) + (36-20) + (24-20) + 0 + 0$

$= 94$ mm

Rainfall excess in hourly basis $= \frac{94}{2} = 47$ mm

Runoff volume = Area of basin × Rainfall excess or Runoff depth

$= 600 \times 10^6 \text{ m}^2 \times \frac{47}{10^3} \text{ m}$

$= 282 \times 10^5 \text{ m}^3$

5.

$$(0.1-\phi)+(1.0-\phi)+(1.4-\phi)+(2.6-\phi)+$$
$$(2.0-\phi)+(1.5-\phi)+(1.0-\phi)+(0.4-\phi)=6\text{ cm}$$

$$10-8\phi = 6\text{ cm}$$

$$8\phi = 4$$

$$\phi = 0.5\text{ cm/h}$$

There are some intensities less than 0.5 cm/h

$$(1.0-\phi)+(1.4-\phi)+(2.6-\phi)+(2.0-\phi)+$$
$$(1.5-\phi)+(1.0-\phi) = 6\text{ cm}$$

$$9.5-6\phi = 6$$

$$6\phi = 3.5$$

$$\phi = \frac{3.5}{6} = \underline{\underline{0.583\text{ cm/h}}}$$

$$W\text{ index} = \frac{P-R-S}{t_r}$$

$$= \frac{10-6-0}{8} = \frac{4}{8} = \underline{\underline{0.5\text{ cm/h}}}.$$

Assignment 3

1. $$C_w = \frac{C_1 a_1 + C_2 a_2 + C_3 a_3}{a_1 + a_2 + a_3}$$

$$= \frac{(0.3 \times 100) + (0.16 \times 30) + (0.40 \times 75)}{205}$$

$$= \underline{\underline{0.32}}$$

2. $$T_c = 0.02\, L^{0.77}\, S^{-0.385}$$

$$= 0.02\, (350)^{0.77}\, (4/100)^{-0.385}$$

$$= \underline{\underline{6.28 \text{ min.}}}$$

3.

Area	Land use	slope	C
100	Cultivation	1%	0.50
45	Pasture	7%	0.36
30	Forest	12%	0.50

$$C_w = \frac{(100 \times 0.5) + (45 \times 0.36) + (30 \times 0.50)}{175}$$

$$= 0.46$$

$$T_c = 0.02\, L^{0.77}\, S^{-0.385}$$

$$= 0.02\, (2500)^{0.77}\, (5/100)^{-0.385}$$

$$= 26.2 \text{ min.}$$

$$I = \frac{\text{Rainfall Depth}}{T_c}$$

$$= \frac{3.58\ cm}{(26.2/60)\ h} = 8.2\ cm/h.$$

$$= 82\ mm/h$$

$$Q = \frac{CIA}{360} = \frac{0.46 \times 8.2 \times 175}{360} \quad (\times 10)$$

$$= 18.34\ m^3/s$$

4.

Land use/Area(ha)	Relief	Infiltration	Vegetal cover	Surface storage	Total (W)
Cultivated land (25)	2*	15**	15***	15	47
Pasture land (15)	10*	2**	5	10	27

*Relief 5% - 10% → 10 to 20

∴ 0 - 5 is 0 - 10

1% is 2

5% is 10

** Infiltration from 0.25 - 0.75 cm/h → 15

Infiltration from 0.75 - 2 cm/h → 0 - 10

∴ 1 → 2

*** Vegetal cover < 10% grass → 15

50% good grass cover → 10

90% → 5

Weighted $W = \dfrac{w_1 a_1 + w_2 a_2}{a_1 + a_2}$

$= \dfrac{(47 \times 25) + (27 \times 15)}{40}$

$= \dfrac{1175 + 405}{40}$

$= 39.5$

From graph Area = 40 ha

W = 39.5

∴ Peak discharge is $\underline{\underline{2.2\ m^3/s}}$

5. AMC III Recurrence interval 50 years

Land use	CN
Row crop on terraced land	80
Pasture land	86

weighted CN = $\dfrac{CN_1 A_1 + CN_2 A_2}{A_1 + A_2}$

Weighted CN (for AMC II) = $\dfrac{(80 \times 40) + (10 \times 86)}{50}$

$= 81.2$

Converting AMC II curve number to AMC III

From table conversion factor is 1.14

∴ CN (for AMC III) = 81.2×1.14

$= 92.6$

Calculation of retention capacity S

$$CN = \frac{2540}{25.4 + S}$$

$$92.6 = \frac{2540}{25.4 + S}$$

$$25.4 + S = \frac{2540}{92.6} = 27.43$$

$$S = 2.03$$

Calculating Peak flow

$$Q_{peak} = \frac{(P - 0.2S)^2}{P + 0.8S}$$

$$= \frac{(15 - 0.2 \times 2.03)^2}{15 + 0.8 \times 2.03}$$

$$= \underline{\underline{10.76 \text{ cm}}}$$