ES476 RATIONAL Runoff EXERCISE KEY TASK 5-3

GS407/507 River Environments – Fluvial Hydrology Problem Set

Using the equation lists on p. 35-47 of your field guide, and the unit conversion charts on p. 123-130, solve the following problems. Show all of your math work and calculations!

1. The rational runoff method predicts peak runoff rates (discharge = vol / time) from data on rainfall intensity (i.e. rainall into drainage basin) and watershed characteristics (e.g. underlying bedrock type and infiltration capacity). The governing equation is:

$$Q_{pk} = 0.278CIA$$

Where Q_{pk} = peak discharge of drainage basin in m^3/sec, I = rainfall intensity in mm/hr, C = infiltration factor of watershed (asphalt/concrete = 0.80, thin soil over bedrock = 0.40), and A = drainage basin area in km^2. "URBAN" "FOREST" C = 0.40

A. Determine the peak discharge (in cubic meters per second) for a drainage basin experiencing a rainfall event with the following characteristics: drainage area = 10,000 acres, rainfall intensity = 1.25 cm/hr, and substrate = loamy soil over sandstone. Show all of your work.

$Q = 0.278CIA$

$Q_{pk} = (0.278)(0.4)\left(12.5\frac{mm}{hr}\right)(40.47\,km^2) = 140.6\ m^3/sec$ ★

$40.47\,km^2 = Area = 10{,}000\,ac\left(4.047\times10^{-3}\frac{km^2}{ac}\right)$

$I = 1.25\frac{cm}{hr}\left(\frac{10\,mm}{cm}\right) = 12.5\frac{mm}{hr}$

B. If a drainage basin has an area of 175 km^2 and experiences a 30 mm/hr rainfall event with a 500 m^3/sec peak discharge, calculate the infiltration factor for the watershed. Show all of your work. Based on your answer, is this watershed likely rural/forest or highly urbanized? Explain your reasoning.

$Q = 0.278\,CIA$

$C = \frac{Q}{(0.278)IA} = \frac{500\ m^3/sec}{(0.278)\left(30\frac{mm}{hr}\right)(175\,km^2)} = 0.34$

MOST LIKELY RURAL; has high INFILTRATION low RUNOFF

C. If 30% of a forested, 1000 km^2 watershed is urbanized, calculate the anticipated peak runoff associated with a 0.5 in/hr rainfall event.

Forest Area $0.7(1000\,km^2) = 700\,km^2$

URBAN Area $0.3(1000\,km^2) = 300\,km^2$

$I = 0.5\frac{in}{hr}\left(\frac{25.4\,mm}{in}\right) = 12.7\frac{mm}{hr}$

$Q_p = 0.278(0.4)(12.2\frac{mm}{hr})(700\,km^2)$ 988.6 m^3/sec

$Q_p = 0.278(0.8)(12.7\frac{mm}{hr})(300\,km^2)$ 847.3 m^3/sec

TOTAL 1835.9 m^3/sec

2. If a river channel has a discharge of 5 ft^3/sec and a cross-sectional area of 5 m^2, calculate the average velocity of the river in m/sec. Show all of your math work.

$Q = V_{EL}\,A_{xsec} \Rightarrow V_{EL} = \frac{Q}{A} = \frac{\left(5\frac{ft^3}{sec}\right)\left(\frac{1\,m^3}{35.31\,ft^3}\right)}{5\,m^2}$

$V_{EL} = 0.028\ m/sec$ ★

3. Empirical data show that hypothetical watersheds in the western Cascades have peak flood discharges every 2-3 years as described by the following equation:

$$Q_{2.33} = 34.5A^{0.93}$$

Where Q = peak discharge in ft^3/sec and A = drainage area of a given basin in acres. Calculate the expected peak discharge for a drainage basin with an area of 125 km^2. Show all of your work.

$A = (125\,km^2)\left(\frac{247.1\,ac}{km^2}\right) = 30{,}887.5\,ac$

$Q_{2.33} = (34.5)(30{,}887.5)^{0.93}$

$Q = 516{,}793\ \frac{ft^3}{sec}$ ★