Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

SKU: 9780134751979-SOLUTIONS

Chapter 1-Answer Key

CONCEPT CHECK

1.1 What is the hydrologic cycle? What are the pathways that precipitation falling onto the land surface of the Earth is dispersed to the hydrologic cycle?

ANSWER:

The hydrologic cycle is a continuous process in which water is evaporated from water surfaces and the oceans, moves inland as moist are masses, and produces precipitation if the correct vertical lifting conditions exist.

A portion of precipitation (rainfall) is retained in the soil near where it falls and returns to the atmosphere via evaporation (the conversion of water to water vapor from a water surface) and transpiration (the loss of water vapor through plant tissue and leaves). Combined loss is called evapotranspiration and is a maximum value if the water supply in the soil is adequate at all times. Some water enters the soil system in infiltration which is a function of soil moisture conditions and soil and may reenter channels later as interflow or may percolate to recharge the shallow ground water. The remaining portion of precipitation becomes overland flow or direct runoff which flows generally in a down-gradient direction to accumulate in local streams that then flow into rivers.

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.2 Who is responsible for the first recorded rainfall measurements? Describe the technique used to obtain these measurements.

ANSWER:

The first recording was obtained in the seventeenth century by Perrault. He obtained his data by comparing measured rainfall to the estimated flow in the Seine River to show how the two were related.

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.3 Explain the difference between humidity and relative humidity.

ANSWER:

Humidity is a measure of the amount of water vapor in the atmosphere and can be expressed in several ways. Specific humidity is a mass of water vapor in a unit mass of moist air while relative humidity is a ratio of the air's actual water vapor content compared to the amount of water vapor at saturation for that temperature.

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.4 Explain how air masses are classified. Where are these types of air masses located?

ANSWER:

They are classified in two ways: the source from which they are generated, land (continental) or water (maritime), and the latitude of generation (polar or tropical).
These air masses are present in the United States. The Continental polar emanates from Canada and passes over the northern United States. The maritime polar air mass also comes southward from the Atlantic Coast of Canada and affects the New England states. Another maritime polar comes from the Pacific and hits the extreme northwestern states. The maritime tropical air masses come from the Pacific, the Gulf of Mexico and the Atlantic (these affect the entire Southern United States). Continental tropical air masses from only during the summer. They originate in Texas and affect the states bordering the north.

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.5 List seven major factors that determine a watershed's response to a given rainfall.

ANSWER:

Drainage Area
Channel Slope
Soil Types
Land Use
Land Cover
Main Channel and tributary characteristics-channel morphology
The shape, slope and character of the floodplain

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

PROBLEMS

1.6 A lake with a surface area of 1260 acres was monitored over a period of time. During a one-month period, the inflow was 36 cfs, the outflow was 30 cfs, and a 1.6-in. seepage loss was measured. During the same month, the total precipitation was 4.3 in. Evaporation loss was estimated as 6.0 in. Estimate the storage change for this lake during the month.

ANSWER:

A = 1260 acres
T = 1 month
I = 36 cfs
O = 30 cfs
G = 1.6 in.
P = 4.3 in.
E = 5 in.

I-O+P-G-E = ΔS

First convert inflow and outflow into inches

Inflow = $36\frac{ft^3}{s} * \frac{1ac}{43560ft^2} * \frac{12in}{1ft} * \frac{3600s}{1hr} * \frac{24hr}{1day} * \frac{30days}{1month} * \frac{1}{1260\ acres} = 20.40\ in$

Outflow =

$$30\frac{ft^3}{s} * \frac{1ac}{43560ft^2} * \frac{12in}{1ft} * \frac{3600s}{1hr} * \frac{24hr}{1day} * \frac{30days}{1month} * \frac{1}{1260\ acres} = 17.00\ in$$

ΔS = 20.40 in. – 17.00 in. + 4.3 in. - 1.6 in. – 5 in. = **1.1 in.**
ΔS in volume = $1.1in * \frac{1ft}{12in} * 1260\ acres$ = **115.5 ac-ft**

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.7 A 5-acre apartment complex receives 1.25 in./hr. of rain for 6 hours. During the storm event, 0.1 in/hr. of water evaporates, and a volume of 15 acre-inches accumulates on the lot. The rest leaves the lot as runoff. Assume that there is no infiltration in this scenario.

(a) Using a water balance, determine the total volume of runoff generated by the storm and calculate the runoff coefficient.

(b) Calculate the peak flow rate during the storm (Hint: use the Rational Method).

ANSWER:

(a)

Set up the water balance:
P-R-E=ΔS

Put all variables in the same units:
P = 1.25 in./hr or P = 7.5 in
E = 0.1 in/hr or E = 0.6 in.
R=?

ΔS=(15ac-in)/(6 hr)=2.5 ac-in/hr
(2.5 ac-in/hr)/(5 acres) = 0.5 in/hr

ΔS = 0.5 in/hr or ΔS=3 in

Plug values into water balance:

1.25 in/hr-R-0.1 in/hr = 0.5 in/hr	or	7.5 in –R-0.6 in = 3 in
R=1.25 in/hr-0.1in/hr-0.5in/hr		R = 7.5 in – 0.6 in – 3 in
= 0.65 in/hr		=3.9 in
R=(0.65in/hr)*(6 hr)=3.9 in		R = (3.9 in)*(5 acres)
(3.9 in)*(5 acre)=**19.5 acre-inches**		**R = 19.5 ac-in**

R = 19.5 ac-in

The runoff coefficient is a ratio of the amount of water that actually becomes runoff versus the amount that falls as precipitation. The higher the amount of impervious surfaces the higher the runoff coefficient.

Calculate the runoff coefficient:
C=R/P C=0.65/1.25 or C=R/P=3.9 in/7.5in

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

C = 0.52

(b)

Use the Rational Method to calculate Q:
Q=CiA
Q=(0.52)*(1.25in/hr)*(5 acres)

Q = 3.25 cfs

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.8 In a given year, a watershed with an area of 3000 km^2 received 110 cm of precipitation. The average rate of flow measured in a gage at the outlet of the watershed was 29 m^3/sec. Estimate the water losses due to the combined effects of evaporation, transpiration, and infiltration due to ground water. How much runoff reached the river for the year (in cm)?

ANSWER:

A = 3000 km^2

P = 110 cm

R = 29 m^3/sec

Assuming $\Delta S = 0$ in the span of the year

ET+G = P-R

Convert R to cm

$R = 29 \frac{m^3}{s} * \frac{100cm}{1m} * \frac{3600s}{1hr} * \frac{24hr}{1day} * \frac{365days}{1year} * \frac{1}{3000\ km^2} * \frac{1km^2}{(1000m)^2}$ = **30.48 cm is runoff**

ET + G = 110 cm – 30.48 cm = **79.52 cm**

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.9 Using the data from problem 1.8, what is the runoff coefficient?

ANSWER:

Runoff coefficient = R/P = $\frac{30.48cm}{110cm}$ = **0.277**

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.10 In a given month, a watershed with an area of 7km^2 received 63cm of precipitation. During the same month, the loss due to evaporation was 12cm. Ignore losses due to transpiration and infiltration due to ground water. What would be the average rate of flow measured in a gage at the outlet of the watershed in m^3/s?

ANSWER:

A = $7km^2$ = 7,000,000 m^2

P = 63cm

E = 12cm

Here precipitation is the inflow I-E = O

O = 63cm-12cm = 51cm in 1 month over an area of 7km^2, so

$$O = \frac{51cm}{1\ month} * \frac{1\ month}{30\ days} * \frac{1\ day}{24\ hr} * \frac{1hr}{3600s} * \frac{1m}{100cm} * 7E6\ m^2 = \mathbf{1.38}\ \frac{m^3}{day}$$

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.11 Plot Eq. (1–4) as a graph (e_s vs. T) for a range of temperatures from -30°C to 40°C and a range of pressures from 0 to 70 mb. The area below the curve represents the unsaturated air condition. Using this graph, answer the following:

(a) Select two saturated and two unsaturated samples of air from the dataset of pressure and temperature given below:

Pressure (mb): {10, 20, 30}

Temperature (°C): {10, 20, 30}

(b) Let A and B be two air samples, where A: (T = 30°C , P = 25 mb) and B: (T = 30°C , P = 30 mb). For each sample, determine the following:

(i) Saturation vapor pressure

(ii) Dew point

(iii) Relative humidity

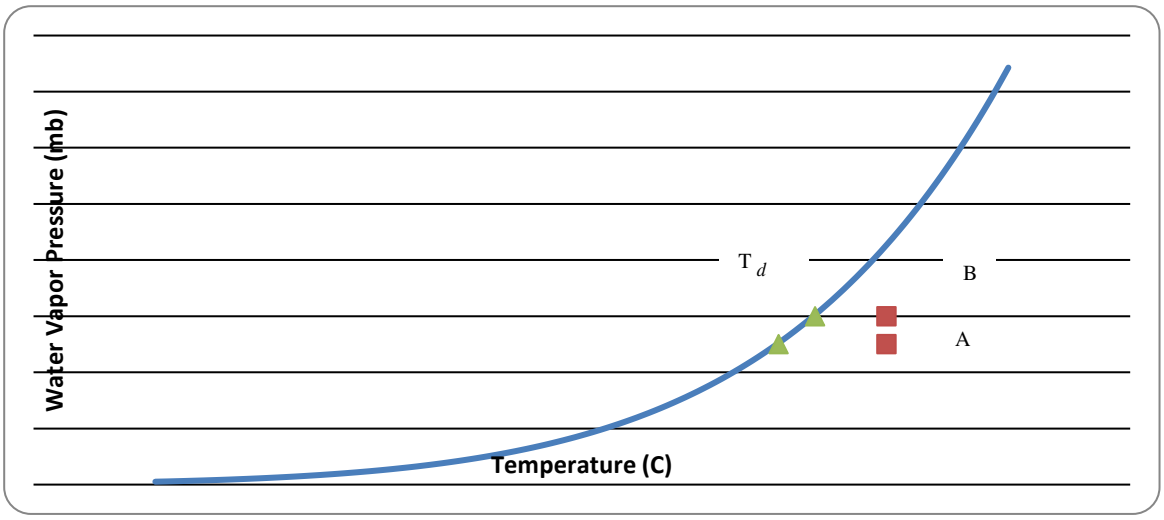
(c) Suppose both samples A and B were cooled to 15°C What would be their relative humidity? What would be their dew point temperature?

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.11 cont'

ANSWER:



The graph can be made using a program like Excel

Equation (1–4): $e = 2.7489\times10^{8} \exp\left(\frac{-4278.6}{(T_d + 242.79)}\right)$

a) Saturated samples of air: **T = 10 °C, P = 20 mb**

T = 10 °C, P = 30 mb

Unsaturated samples of air: **T = 10 °C, P = 10 mb**

T = 20 °C, P = 20 mb

b) **A = (T = 30 °C, P = 25 mb)**

B = (T = 30 °C, P = 30 mb)

i. Saturation Vapor Pressure is a function of temperature. For both samples A and B, T = 30 °C so

$e_{sa} = e_{sb} =$ **42.41 mb**

ii. Dew point is a measure of water vapor pressure

For sample A, $e^a = 25\text{mb} \rightarrow T^d =$ **21.14 °C**

For sample B, $e^b = 25\text{mb} \rightarrow T^d =$ **24.14 °C**

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.11 cont'

iii. Relative humidity is the ratio of the actual vapor pressure to the saturation vapor pressure

$$\text{Sample A} = \frac{25}{42.41}\cdot 100 = 59\%, \quad \text{Sample B} = \frac{30}{42.41}\cdot 100 = \mathbf{71\%}$$

c) In 15 °C, both samples have become saturated:

Their relative humidity is **100%**

After condensation begins, the temperature and the dew point are the same so

$T = T^d = \mathbf{15}\,^{\circ}\mathbf{C}$

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.12 The gas constant R has the value $2.87 \times 10^6\ cm^2/s^2{}^\circ K$ for dry air, when pressure is in mb. Using the ideal gas law $P = \rho RT$ find the density of dry air at 20°C with a pressure of 1013 mb. Find the density of moist air at the same pressure and temperature if the relative humidity is 65 percent.

ANSWER:

R = $2.87 \times 10^6\ cm^2/s^2{}^\circ K$

T = 20°C

P = 1013 mb

Note: 1 mb = 100 Pa = 100 Nt/m^2 = 100 kg/m·s^2

a) Rearrange for ρ gives

$$\rho = \frac{P}{RT} = \frac{1013mb \cdot \left(100\ {}^{Nt/m^2}/_{1mb}\right) \cdot \left({}^{1kg/m\ \cdot\ s^2}/_{1Nt/m^2}\right)}{2.87 \times 10^6 cm^2 \cdot s^{-2} \cdot K^{-1} \cdot (20 + 273.15)K} \cdot \left(\frac{100cm}{1m}\right)^2 = 1.20\ kg/m^3$$

b) The density of moist air can be found using the equation $\rho_m = \frac{P}{RT}(1 - 0.378e/P)$ Since we know the relative humidity, we can find e. (See Appendix C for values of e_s at 20° C (need to convert from kN/m^2 to mb)

At 20° C e_s = 23.4 mb

H = $100e/e_s$

65 = 100e/23.4

e = 15.21 mb

Substituting this into equation gives

$$\rho_m = \frac{P}{RT}(1 - 0.378e/P) = \rho_d\,(1 - 0.378e/P)$$

$$1.20\ \text{kg/m}^3 \left(1 - \frac{0.378 \cdot 15.21\ mb}{1013\ mb}\right) = \mathbf{1.19\ kg/\ m^3}$$

Moist air is lighter than dry air!

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.13 What are the three main mechanisms for generation of vertical air motion?

ANSWER:

The three mechanisms for the generation of vertical air motion are:

-convective: due to intense heating of air at the ground which leads to expansion and vertical rise of air

-cyclonic: associated with the movement of large air-mass systems, as in the case of warm or cold fronts

-orographic: due to mechanical lifting of moist air masses over the windward side of mountain ranges

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.14 Describe the naming system for describing basic clouds.

ANSWER:

The names of basic clouds have the following roots:

-cirrus: feathery or fibrous clouds

-stratus: layered clouds

-cumulus: towering, puffy clouds

-alto: middle-level clouds

-nimbus: rain clouds

The second aspect of cloud classification is by height. An example is “cumulonimbus.”

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.15 At a certain point in time the air temperature at a location is measured to be 110 kPa, the air temperature is 35˚ C and the dew point temperature is 25˚C. Determine

(a) vapor pressure
(b) saturation vapor pressure
(c) relative humidity
(d) specific humidity

ANSWER:

(a)
Use equation 1- 4 to find the vapor pressure:

$e=2.7489x10^8 \exp(-4278.6/(T+242.79))$
T=25
$e=2.7489x10^8 \exp(-4278.6/(25+242.79))$

e = 31.64 mb

(b)
$e_s=2.7489x10^8 \exp(-4278.6/(T+242.79))$
T=35
$e_s=2.7489x10^8 \exp(-4278.6/(35+242.79))$

e_s = 56.23 mb

(c)
Calculate the relative humidity:
$H=100*e/e_s=100*31.64/56.23$

H = 56%

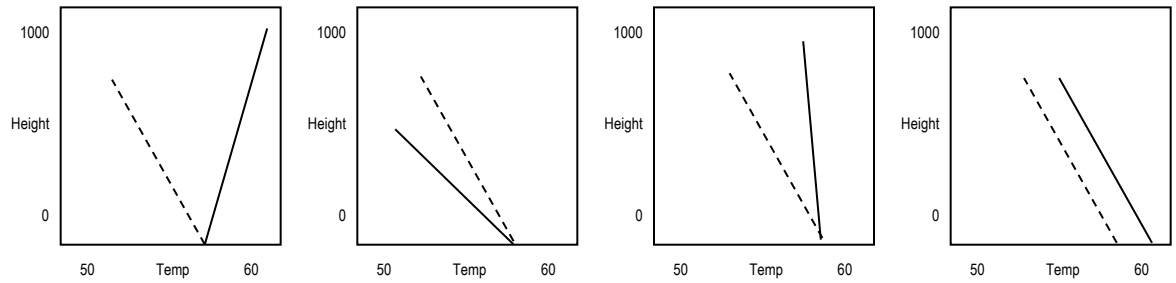
(d)
Use equation 1-3 to calculate the specific humidity
$q=\rho_w/\rho_m=(0.622*e)/(P-0.378e)$
P=110kPA=1100 mb
$q=\rho_w/\rho_m=(0.622*31.64)/(1100-0.37831.64)$

q = 0.018 kg water/kg moist air

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.16 Below are three different atmospheric systems. The dashed line represents the dry adiabatic lapse rate where as the solid line represents the dry ambient lapse rate. Label whether the atmosphere is stable, unstable, or neutral:

a. b. c. d.



ANSWER:

a. stable

b. unstable

c. stable

d. neutral

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.17 Hurricane Katrina was the most devastating hurricane in United States history. Referring to http://www.hpc.ncep.noaa.gov/. Find the information concerning total rainfall during Hurricane Katrina, answer the following questions:

(a) What category event was Hurricane Katrina when it made landfall?

(b) Which state experienced the most cumulative rainfall during Hurricane Katrina?

(b) What was the lowest central pressure recorded during the hurricane?

(c) What finally halted the path of the hurricane?

ANSWER:

a. Category 3
b. Florida received the greatest cumulative rainfall of 16.43 in.
c. The lowest central pressure was 902 mb.
d. It was absorbed into a developing extratropical cycle when it reached Pennsylvania. (Acceptable alternative: It transformed into extratropical low pressure as it moved eastward from the Great Lakes over the Tennessee Valley.)

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.18 A watershed of 2 km^2 with six rainfall gages can be divided into Thiessen polygons with areas listed in the table below.

(a) Using the rainfall measurements listed; find the average rainfall over the watershed in cm using the Thiessen calculation method.

(b) Calculate the average rainfall using the arithmetic mean method, and compare.

ANSWER:

(a)

Gage	Rainfall (cm)	Area (m^2)	Ai/A	P*(Ai/A)
A	5.59	383918	0.19	1.07
B	8.18	331309	0.17	1.36
C	1.8	88498	0.04	0.08
D	6.32	379872	0.19	1.20
E	2.24	675292	0.34	0.76
F	17.07	141111	0.07	1.20
		2,000,000	**1**	**5.67**

The average rainfall over the watershed is 5.67 cm using the Thiessen Method

(b)

Arithmetic mean:
(5.59+8.18+1.8+6.32+2.24+17.07)/6 = **6.87 cm**

The Average rainfall over the watershed is 6.87 cm using the arithmetic mean method
The arithmetic mean overestimates the average rainfall due to the most rainfall occurring over one of the smallest areas.

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.19 A small urban watershed has four rainfall gages as located in Fig. P1–19. Total rainfall recorded at each gage during a storm event is listed in the table below. Compute the mean areal rainfall for this storm using (a) arithmetic averaging and (b) the Thiessen method.

Gage	Rainfall (in.)
A	3.26
B	2.92
C	3.01
D	3.05

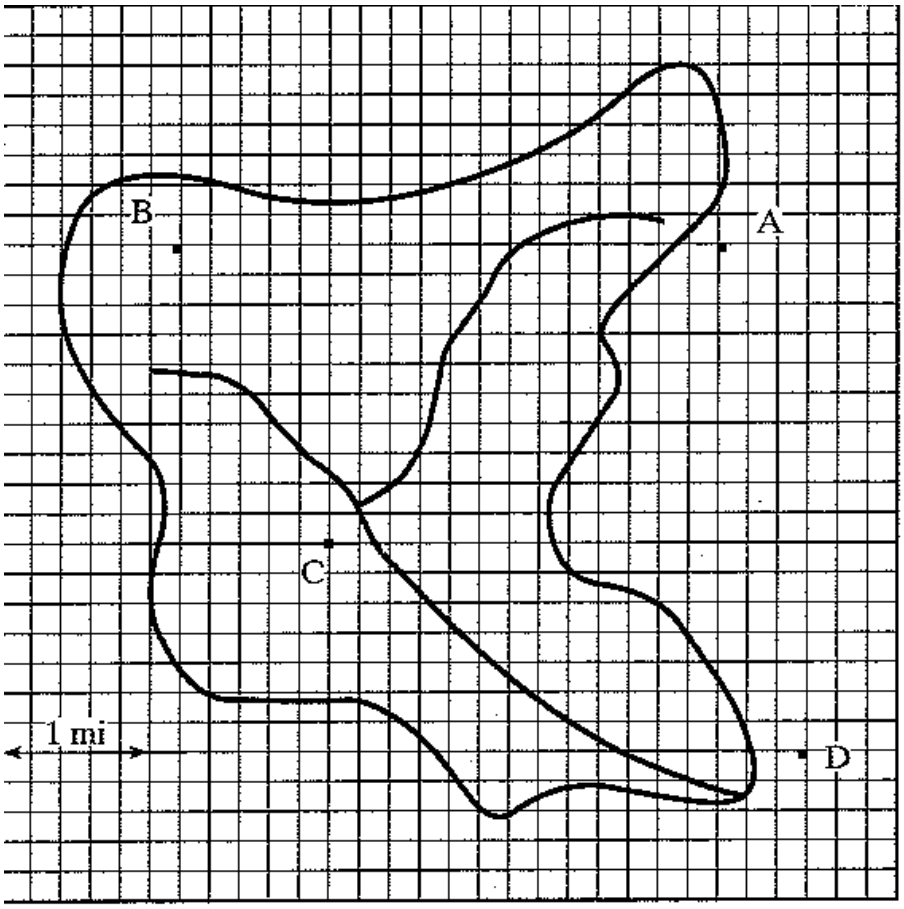


Fig. P1-19

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

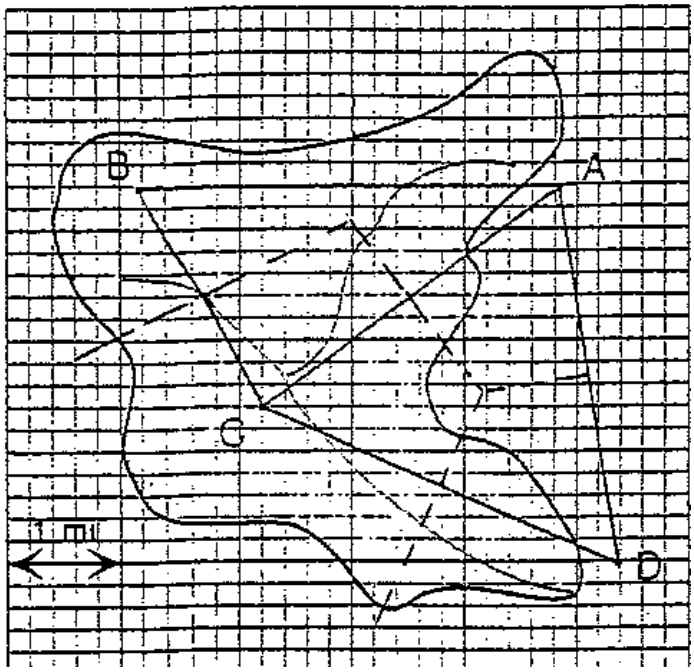
ANSWER:

a)

To calculate the arithmetic average only the gages that are present in the watershed boundary need to be taken into account which in this case are B and C:

Arithmetic Average: $\frac{2.92 + 3.01}{2}$ = **2.96 in.**

b)



25 squares = 1 mi^2

A = 64 squares = 2.56 mi^2

B = 78 squares = 3.12 mi^2

C = 148 squares = 5.92 mi^2

D = 36 squares = 1.44 mi^2

Area of watershed: (2.56 + 3.12 + 5.92 + 1.44) mi^2 = 13.04 mi^2

Gage	Area mi^2	Area %	Rainfall (in)	Weighted Rainfall (in)
A	2.56	19.6	3.26	0.639
B	3.12	23.9	2.92	0.698
C	5.92	45.4	3.01	1.336
D	1.44	11.1	3.05	0.338
SUM	**13.04**	**100**		**3.04**

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.19 cont'

Weighted Rainfall is calculated using: rainfall x area % (in decimals)

Rainfall = 3.04 in

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.20 Mud Creek has the watershed boundaries shown in Fig. P1–20. There are six rain gages in and near the watershed, and the amount of rainfall at each one during a storm is given in the accompanying table. Using the Thiessen method and a scale of 1 in. = 10 mi, determine the mean rainfall of the given storm.

Gage Number	Rainfall (cm)
1	5.3
2	4.8
3	3.9
4	6.0
5	6.7
6	2.5

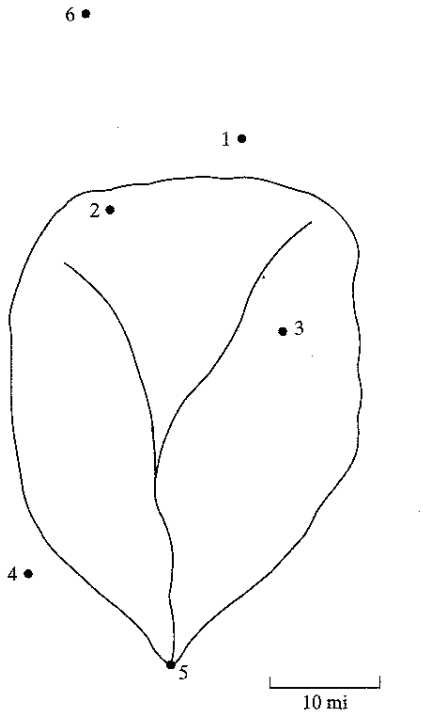
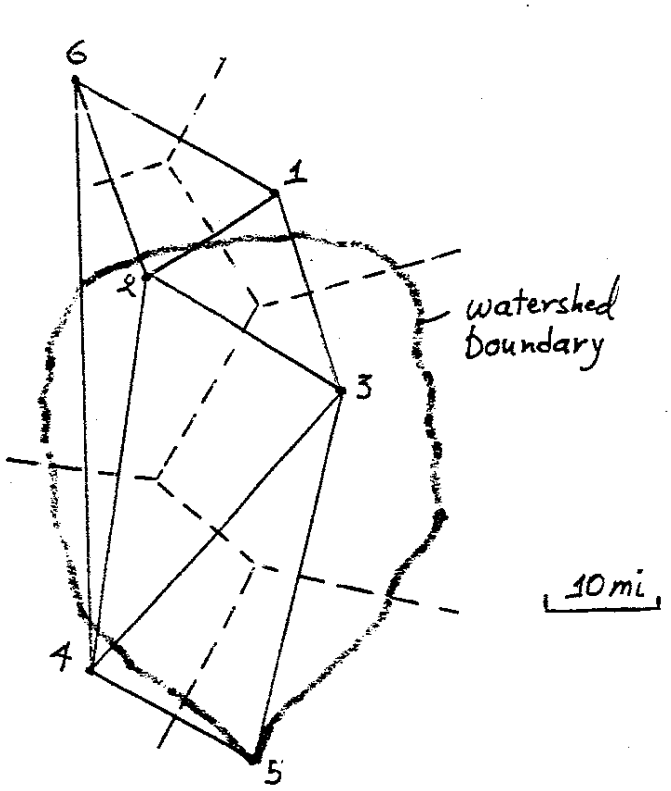


Fig. P1-20

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.20 cont'

ANSWER:



Gage	Area (sq mi)	Area (%)	Rainfall (cm)	Weighted Rainfall (cm)
1	55.6	5	5.3	0.265
2	266.7	23.5	4.8	1.128
3	466.7	41.2	3.9	1.607
4	200	17.6	6.0	1.056
5	144.4	12.7	6.7	0.851
6	0	0	2.5	0
SUM	**1133.4**	**100**		**4.907**

Answer: **4.96 cm**

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.21 Table P1–21 lists rainfall data recorded at a USGS gage for the storm of September 1, 1999. The basin area is 2050 acres. Using these data, develop a rainfall hyetograph (in./hr vs. *t*) in 15-min. intervals and determine the time period with the highest intensity rainfall.

Time (hr)	Accumulated Rainfall (in.)	Discharge (cfs)
0	0	0
.25	0.4	50
0.50	1.4	300
0.75	1.9	600
1	2.3	980
1.25	2.5	1380
1.50	2.6	1500
1.75		1340
2		1110
2.25		790
2.50		460
2.75		240
3		110
3.25		59
3.50		35
3.75		20
4		12
4.25		7
4.50		4
4.75		2

Table P1–21.

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.21 cont'

ANSWER:

The recorded rainfall was reported as cumulative volume. To develop a hyetograph, the change in volume is divided by the change in time. Referring to the table P1-21, it can be seen that rainfall was recorded in 15 min. intervals from time 1605 to 1750 so the hyetograph will have 15 min increments.

Initial i = 0 in./hr

i_1 = (0.4 in. - 0 in.) (60 min/hr) / (15min) = 1.6 in./hr

i_2 = (1.40 in. – 0.40 in.) (60 min./hr) / (15min) = 4.0 in./hr

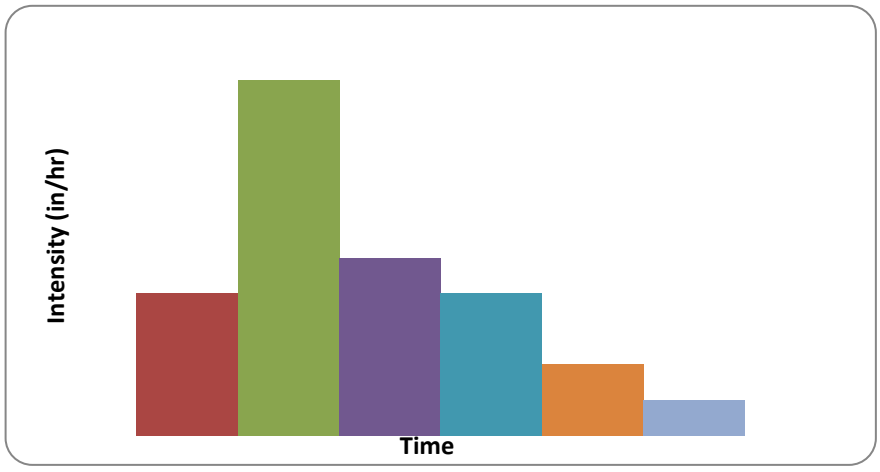
i_3 = (1.90 in. - 1.40 in.) (60 min/hr) / (15min) = 2.0 in./hr

i_4 = (2.30 in. - 1.90 in.) (60 min/hr) / (15min) = 1.6 in./hr

i_5 = (2.50 in. - 2.30 in.) (60 min/hr) / (15min) = 0.8 in./hr

i_6 = (2.60 in. - 2.50 in.) (60 min/hr) / (15min) = 0.4 in./hr

i_7 = rain ends = 0 in./hr



The period of highest intensity begins at 1635 with 4 in./hr.

Hyetograph can be plotted using a program such as Excel.

Problems 1.22 and 1.23 refer to the hydrologic data used in Problem 1.21.

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

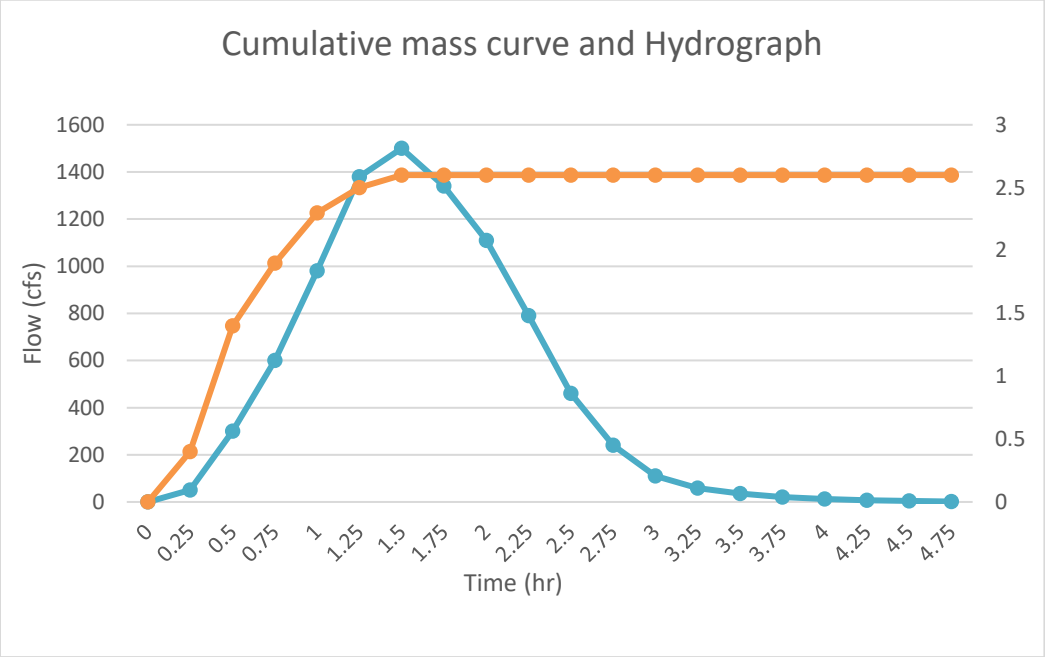
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.22 (a) Plot the cumulative mass curve for rainfall and the hydrograph (flow rate vs. time) on the same graph using two scales.

(b) Compute the volume of infiltration loss for the storm, neglecting ET by subtracting the volume of gross rainfall from the volume under the hydrograph.

ANSWER:

a) Cumulative mass curve and hydrograph.



The cumulative mass curve is the accumulated rainfall vs. time and the hydrograph is flow vs. time. All the information is available in the table P1-20.

The graphs can be created using a program such as Excel.

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

b) Volume of infiltration loss from the storm.

The total volume can be found using the flow. The flow multiplied by the time increment can give the volume in that increment in cfs-hr. These volumes can then be added up to give the total volume under the hydrograph.

Volume initial= 0 cfs-hr

$$\text{Volume}_1 = 50\ \text{cfs} \times 15\text{min}\frac{1\text{hr}}{60\,\text{min}} = 12.5\ \text{cfs-hr}$$

$$\text{Volume}_2 = 300\ \text{cfs} \times 15\text{min}\frac{1\text{hr}}{60\,\text{min}} = 75\ \text{cfs-hr}$$

$$\text{Volume}_5 = 600\ \text{cfs} \times 15\text{min}\frac{1\text{hr}}{60\,\text{min}} = 150\ \text{cfs-hr}$$

Time (hr)	Flow (cfs)	Volume Under Hydrograph (cfs-hr)
0	0	0
0.25	50	12.5
0.5	300	75
0.75	600	150
1	980	245
1.25	1380	345
1.5	1500	375
1.75	1340	335
2	1110	277.5
2.25	790	197.5
2.5	460	115
2.75	240	60
3	110	27.5
3.25	59	14.75
3.5	35	8.75
3.75	20	5
4	12	3
4.25	7	1.75
4.5	4	1
4.75	2	0.5
		2249.75

Total volume under hydrograph = 2249.75 cfs-hr.

Assume 1 cfs-hr $\approx$ 1 ac-in., so 2249.75 cfs-hr $\approx$ 2249.75 ac-in

To get the volume of runoff in inches, divide the volume by area 2249.75 ac-in. / 2050 ac = 1.097 in. = RF_N

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

To get the loss from infiltration, subtract the runoff from precipitation (RF_T = 2.6 in. from cumulative rainfall)

RF_T - RF_N = infiltration loss

2.60 in. - 1.097 in. = 1.50 in.

To obtain the value in ac-ft: $1.50\text{ in.} \cdot \frac{1\text{ft}}{12\text{in}} \cdot 2050\text{acres}$ = **256.69 ac-ft**

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.23 What is the runoff coefficient for the September 1, 1999 storm, where Coeff. = *R/P*?

ANSWER:

RF_N = 1.097 in

RF_T = 2.60 in

Runoff coefficient = $RF_N / RF_T = 1.097/2.6 = \mathbf{0.42}$

(Using RF_N = 1.19 in. gives same rounded answer.)

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.24 The following questions refer to Fig. 1–15, the IDF curve for Houston, Texas.

(a) What is the return period of a storm that recorded 3.0 in./hr for 2 hr in Houston?

(b) What amount of rain (in.) would have to fall in a 6-hr period to be considered a 10-yr storm in Houston?

(c) What is the return period of a storm that lasts 1 hr and records 3.5 in. of rainfall?

(d) Develop and plot a 6-hr, 10-yr storm design rainfall using 1-hr time steps (see Fig. 1–15). Assume the maximum hourly value occurs between hours 3 and 4.

(i) Find the rainfall intensity for a 1-hr duration and plot the rainfall intensity in in./hr between the hours of 3 and 4 on a bar graph.

(ii) Then, find the rainfall intensity for a 2-hr duration; multiply the intensity by the duration of rain to get the volume. Plot the difference between the 2-hr duration volume and the 1-hr duration volume for hour 2 to 3 on a bar graph.

(iii) Continue in the same way for the 3-hr duration, plotting the new intensity to the right of the maximum (hour between 4–5). (Find the 3-hr volume and subtract the 2-hr volume.)

(iv) Then, find the rainfall intensity for a 6-hr duration and the respective volume. Plot the remaining volume (6-hr minus 3-hr) over the 3 hours, assuming equal distribution between them, with two bars to the left and one to the right of the maximum (time intervals 0–1, 1–2, and 5–6).

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.24 cont'

ANSWER:

a. More than 10 yr storm

b. 0.86 in/hr $\cdot$ 6 hr = 5.16 in.

c. $\approx$25 yr. storm

d. (i) - (iv) the rainfall intensities can be found using the IDF curve (Fig 1-15) for the following times (1,2,3,6). To find the volume you multiply by the hour. All the parts have been plotted on one graph.

(i) Interval 3-4

1 hr duration: 1hr $\cdot$ 3.1 in./ hr = 3.1 in.

Rainfall intensity between hours three and four for an one hour duration is 3.1 in./hr so 3.1 inches is the maximum volume for the 6hr 10 yr storm.

(ii) Interval 2-3

2 hr duration: 2hr $\cdot$ 2.0 in./ hr = 4.0 in.

4.0 – 3.1 = 0.9 in.

(iii) Interval 4-5

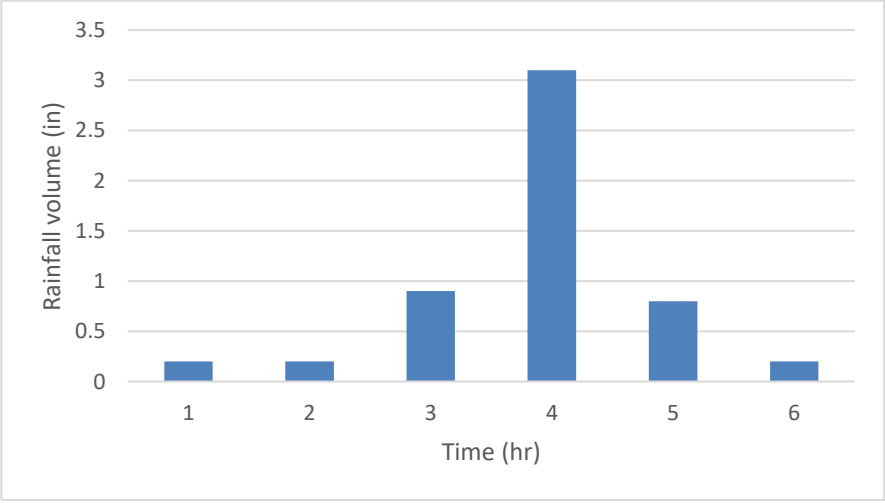
3 hr duration: 3hr $\cdot$ 1.6 in./ hr = 4.8 in.

4.8 – 4.0 = 0.8 in

(iv) Intervals 0-1, 1-2, and 5-6

6 hr duration: 6hr $\cdot$ 0.9 in./ hr = 5.4 in.

(5.4-4.8)/3 = 0.2



The graph can be created using programs such as Excel

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.25 Given the stream section shown in Fig. P1-25 and the following measurements, calculate the total discharge throughout the section (Table P1-25).

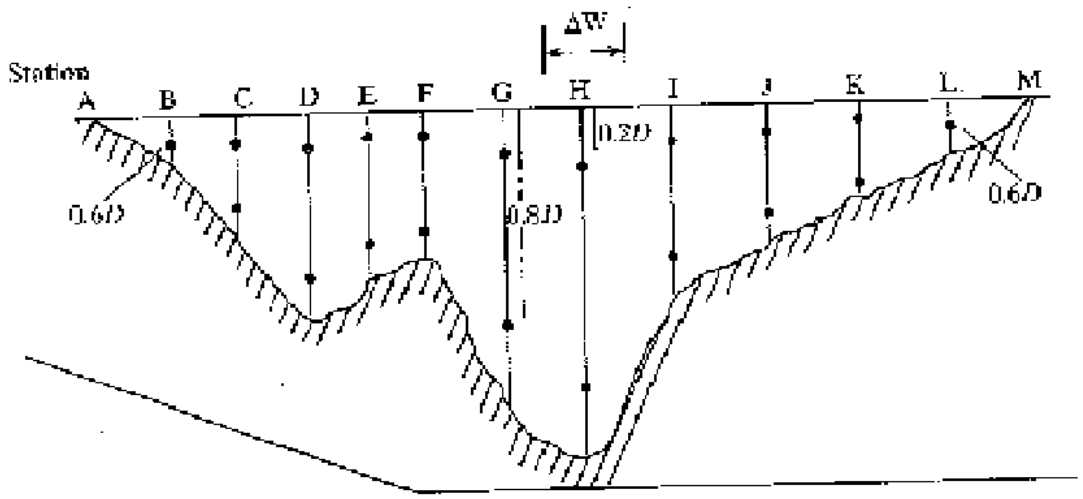


Fig P1-25

Measurement Station	Distance Across Stream (ft)	Depth D (ft)	Mean Velocity v (ft/sec)
A	0	0	0
B	14	1.1	0.43
C	26	2.6	0.61
D	38	3.5	1.54
E	49	3.2	1.21
F	61	3.1	1.13
G	78	3.9	1.52
H	95	4.2	2.34
I	114	3.3	1.42
J	133	2.9	1.34
K	152	2.1	1.23
L	171	1.4	0.53
M	190	0	0

Table P1-25

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

ANSWER:

The distance represents the distance along the top of the stream. The depth and the velocity are measured directly in the field.

To find the discharge the width needs to be found:

The distance points mark the middle of each width division across the stream; accordingly, the width is measured as halfway to the next and halfway back to the previous station.

For example station F:

$$\Delta W = 0.5\times(61-49)+0.5(78-61)=14.5$$

The discharge is calculated as the depth times the width mean velocity summed across the stream: $Q_1 = \sum_{i=1}^{n}(\Delta W_i \cdot D_i \cdot v_i)$

The calculations are summarized in the following table

Station	Distance Across Stream (ft)	Depth D (ft)	Mean Velocity v (ft/sec)	Width ΔW(ft)	Area ΔW×D(ft^2)	DischageQ (cfs)
A	0	0	0	7	0	0.00
B	14	1.1	0.43	13	14.3	6.15
C	26	2.6	0.61	12	31.2	19.03
D	38	3.5	1.54	11.5	40.25	61.99
E	49	3.2	1.21	11.5	36.8	44.53
F	61	3.1	1.13	14.5	44.95	50.79
G	78	3.9	1.52	17	66.3	100.78
H	95	4.2	2.34	18	75.6	176.90
I	114	3.3	1.42	19	62.7	89.03
J	133	2.9	1.34	19	55.1	73.83
K	152	2.1	1.23	19	39.9	49.08
L	171	1.4	0.53	19	26.6	14.10
M	190	0	0	0	0	0.00

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.26 Assume that stations B through L in problem 1–25 have all become 0.2 ft deeper. In addition, a tributary has joined the stream and added approximately 500 cfs to the flow in the channel. Calculate the new discharge amounts for each station by altering the depths and adding the tributary's contribution across the channel in proportion to the modified discharge distribution. Assume velocity distribution remains unchanged.

ANSWER:

Station	Dist. Across stream (ft)	Width ΔW(ft)	Old Depth D (ft)	New depth D2 (ft)	Mean vel., v (ft/sec)	New Area (ft^2) (ΔW* D2)	New Q without tributary (cfs)	%Q	%Q*500 (cfs)	Total Q (cfs)
A	0	7	0	0.0	0	0	0.0	0	0	0
B	14	13	1.1	1.3	0.43	16.9	7.3	0.01	5	12.3
C	26	12	2.6	2.8	0.61	33.6	20.5	0.028	14	34.5
D	38	11.5	3.5	3.7	1.54	42.6	65.5	0.09	45	110.5
E	49	11.5	3.2	3.4	1.21	39.1	47.3	0.065	32.5	79.8
F	61	14.5	3.1	3.3	1.13	47.9	54.1	0.074	37	91.1
G	78	17	3.9	4.1	1.52	69.7	106.0	0.145	72.5	178.5
H	95	18	4.2	4.4	2.34	79.2	185.5	0.254	127	312.3
I	114	19	3.3	3.5	1.42	66.5	94.3	0.13	65	159.4
J	133	19	2.9	3.1	1.34	58.9	79.0	0.108	54	133
K	152	19	2.1	2.3	1.23	43.7	53.8	0.074	37	90.8
L	171	19	1.4	1.6	0.53	30.4	16.1	0.022	11	27.1
M	190	19	0	0.0	0	0	0.0	0	0	0
SUM							**729.1625**	**1**	**500**	**1229.16**

The new flow rate (without tributary) is found using this equation:

$$Q_i = \sum_{i=1}^{n} (\Delta W_i \cdot D2_i \cdot v_i)$$

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.27 The incremental rainfall data in the table below were recorded in a 2-acre dirt lot. Be careful to use a 0.5-hr time step and record intensity in cm/hr.

(a) Plot the rainfall hyetograph

(b) Determine the total storm rainfall depth in inches.

(c) If the runoff coefficient for the lot is 0.7 and the time base of a triangular hydrograph (flow rate vs. time) is 3 hr, find the peak flow of the hydrograph in cfs.

Time (hr)	Rainfall (cm)
0	0
0.5	2
1	2.5
1.5	6
2	7
2.5	8
3	5
3.5	4.5
4	3
4.5	0

Hint: First find the volume of rainfall, then equate it to the area under the hydrograph.

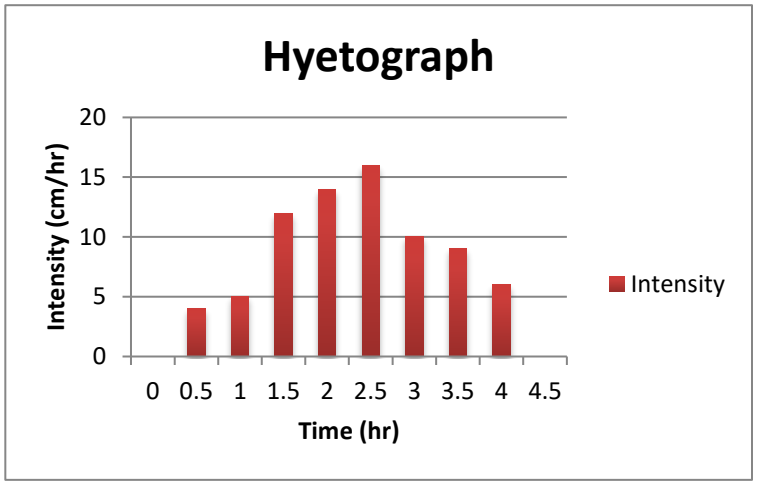
© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

ANSWER:

a. The rainfall table that we are given provides us with the gross rainfall values. In order to develop the hyetograph we need to divide each of these rainfall values by the time step to get the rainfall intensity in cm/hr.

Time (hr)	Intensity (cm/hr)
0	0
0.5	4
1	5
1.5	12
2	14
2.5	16
3	10
3.5	9
4	6
4.5	0



b. The total storm rainfall depth is the sum of all the gross rainfall measurements.

0+2+2.5+6+7+8+5+4.5+3+0=38 cm
(38 cm)(2 in/2.54 cm)=**14.96 in.**

The total storm rainfall depth is 38 cm or 14.96 in

c. We will use the rational method to solve this problem.

R/P=0.7
R=0.7*P=0.7*14.96 in = 10.47 in --> 20.94 ac-in

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

This volume represents the area under the hydrograph. Since the hydrograph is triangular the area calculation is easy. Using the "area" we calculated and a base of 3 hrs we can calculate the "height" of the triangle, which corresponds to the value of peak flow.

A=1/2*b*h
20.94 acre-in = ½*3*h
13.96=h acre-in/hr = **13.96 cfs**

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.28

a) Determine the rainfall intensity at each time step from the rainfall gage data below and create a hyetograph of the storm event. What is the maximum rainfall intensity? What is the average rainfall intensity?
b) How do the maximum and average values compare to a 6 hour 2 year storm? To a 6 hour 5 year storm? (See Figure 1-15.)
c) Plot a cumulative mass curve. How does this compare to the hyetograph?

Time (hr)	**Cumulative Rainfall (in.)**
0	0
0.25	0.05
0.5	0.12
0.75	0.3
1	0.5
1.25	0.9
1.5	1.4
1.75	1.8
2	2.2
2.25	2.4
2.5	2.5
2.75	2.6
3	2.68
3.25	2.75
3.5	2.8
3.75	2.9
4	3.1
4.25	3.4
4.5	3.75
4.75	4
5	4.2
5.25	4.3
5.5	4.35
5.75	4.4
6	4.42

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

ANSWER:

a. In order to determine the rainfall intensity you need to get the gross rainfall values for each of the time steps and then divide them by the value of your time step to get figure in in/hr. For this case we will divide each of the gross rainfall values by 0.25, or you can just multiply them by 4.

Time (hr)	Cumulative Rainfall (in.)	Gross Rainfall (in.)	Rainfall Intensity (in/hr)
0	0	0	0
0.25	0.05	0.05	0.2
0.5	0.12	0.07	0.28
0.75	0.3	0.18	0.72
1	0.5	0.2	0.8
1.25	0.9	0.4	1.6
1.5	1.4	0.5	2
1.75	1.8	0.4	1.6
2	2.2	0.4	1.6
2.25	2.4	0.2	0.8
2.5	2.5	0.1	0.4
2.75	2.6	0.1	0.4
3	2.68	0.08	0.32
3.25	2.75	0.07	0.28
3.5	2.8	0.05	0.2
3.75	2.9	0.1	0.4
4	3.1	0.2	0.8
4.25	3.4	0.3	1.2
4.5	3.75	0.35	1.4
4.75	4	0.25	1
5	4.2	0.2	0.8
5.25	4.3	0.1	0.4
5.5	4.35	0.05	0.2
5.75	4.4	0.05	0.2
6	4.42	0.02	0.08

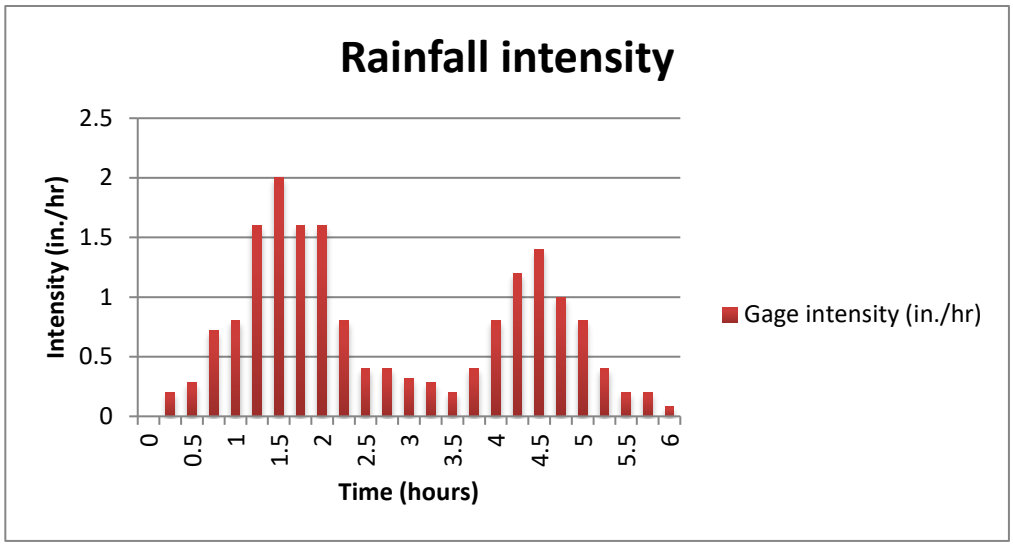
Maximum Rainfall Intensity = 2.00 in/hr

Average Rainfall Intensity = 0.74 in/hr

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

Hyetograph:



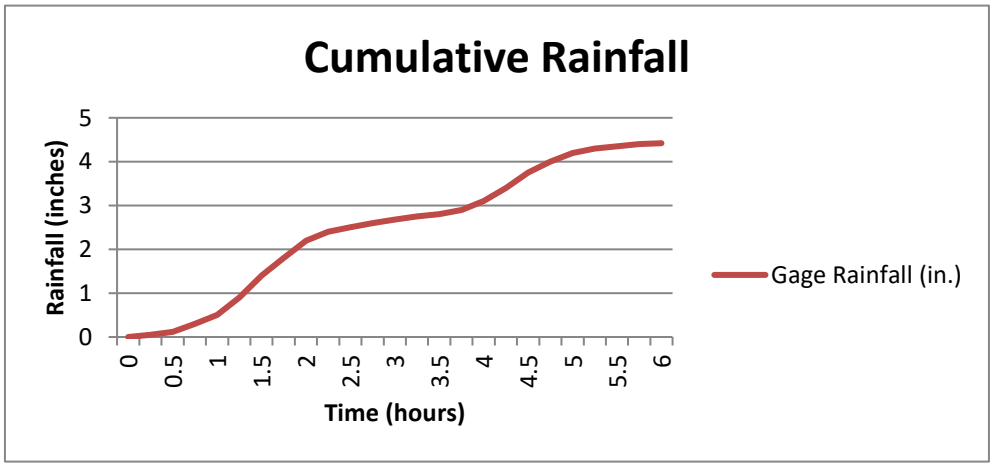
b. From Figure 1-15 (page 32)

6-hr 2-yr storm: i = 0.55 in./hr

6-hr 5-yr storm: i = 0.75 in./hr

The maximum rainfall intensity for this storm is greater than the rainfall intensities for both a 6-hr 2-yr and a 6-hr 5-yr storm. The average rainfall intensity of 0.74 makes this more than a 2-yr storm and would probably be considered a 5-yr storm event based on the average rainfall intensity.

c. The steepest slopes on the cumulative rainfall curve correspond to the peaks of the hyetograph.



© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.

Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

1.29 Rework Example 1–6 using Horton's equation [Eq. (2–42)] for infiltration rather than the ϕmethod to determine the net rainfall hyetograph. Then, determine the total volume of runoff and the watershed area. Horton's equation [Eq (2–42)] is described in detail in Chapter 2, and can be written as: $f = f_c + (f_0 - f_c)e^{-kt}$. For this problem, use the following parameters:

f_0 (Initial Infiltration Capacity)	1 in./hr
f_c (Final Capacity)	0.3 in./hr
k (Empirical Constant)	0.35 hr^{-1}

ANSWER:

$f_0 = 1$ in./hr

$f_c = 0.3$ in./hr

$k = 0.35\ hr^{-1}$

First, calculate infiltration capacity, with $f = f_c + (f_0 - f_c)e^{-kt}$

$f = 0.3 + (1 - 0.3)e^{-0.35t}$ (1)

To have Horton infiltration we need to get the average between every two f. Name it f_L.

Time (hr)	i_T (in/hr)	f (in/hr)	f_L(in/hr)	i_N (in/hr)
0	0	1.00	/	0
1	1.00	0.79	(1+0.79)/2 = 0.895	0.105
2	1.00	0.65	(0.79+0.65)/2 = 0.72	0.28
3	2.00	0.54	(0.65+0.54)/2 = 0.595	1.405
4	1.50	0.47	(0.54+0.47)/2 = 0.505	0.995
5	0.50	0.42	(0.47+0.42)/2 = 0.445	0.055

table P1-29-a

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

Then, we use the third column of table P1-29-a, calculated from the Horton's equation, to determine the net rainfall, the fourth column in table P1-29-a. Next, draw the hyetograph based on the net rainfall. (Figure P1-29-b)

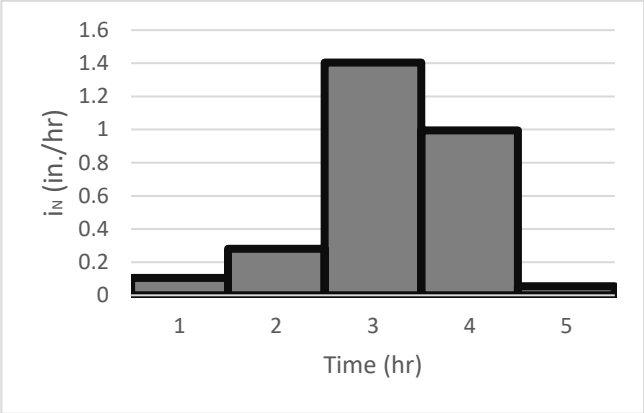


Figure P1-29-b

Finally, add this to the hydrograph plot in the upper left corner of Figure Figure E1-6a.

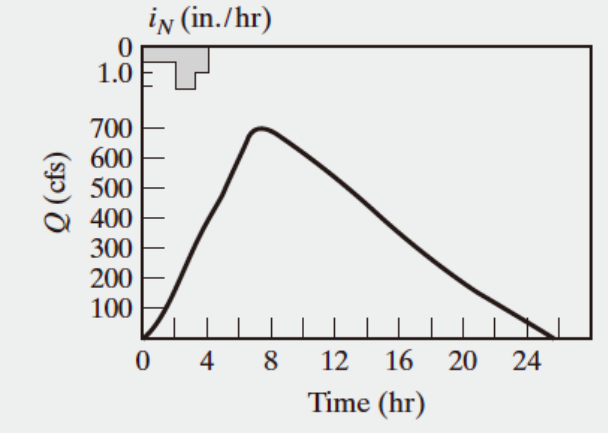


Figure P1-29-c

The volume of runoff is equal to the area under the hydrograph. To determine the volume of runoff, we can use $\sum \vec{Q} dt$. This estimates the volume as the bar graph shown in Figure P1-29-

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual

e. Calculations are tabulated in the accompanying table P1-29-d.

Time	$\bar{Q}$ (cfs)	Volume (cfs-hr)
0-2	100	200
2-4	300	600
4-6	500	1000
6-8	700	1400
8-10	650	1300
10-12	600	1200
12-14	500	1000
14-16	400	800
16-18	300	600
18-20	200	400
20-22	150	300
22-24	100	200
24-26	50	100

Table P1-29-d

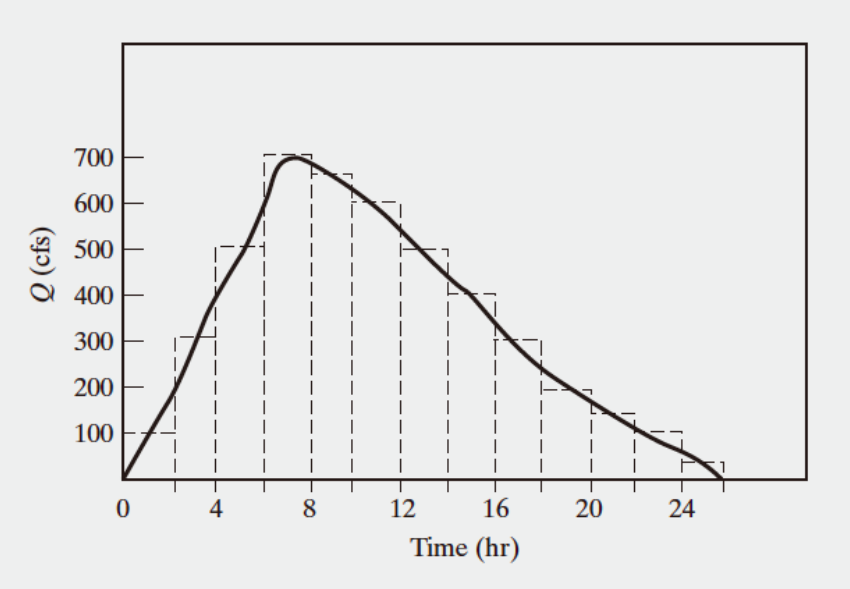


Figure P1-29-e

Estimation runoff volume $\sum \vec{Q} dt$ resulting bargraph

© 2019 Pearson Education, Inc., Hoboken, NJ. All rights reserved.
Hydrology and Floodplain Analysis 6th edition Bedient Solutions Manual