**Homework 4 Solution CE374K Hydrology Spring 2013**

Prepared by Gonzalo E. Espinoza

**Question 1.** **Rainfall-Runoff**

1. Subbasin BUT\_060 in Brushy Creek has an area of A = 0.78708 square miles and a lag time of tp = 35.2 mins. Construct an SCS triangular unit hydrograph unit hydrograph for this subbasin for a rainfall of 10 mins duration. Determine the peak flow (cfs), time to peak (min) and base time (min). Draw the unit hydrograph. What volume of water (ac-ft) is contained in this unit hydrograph? 1 square mile = 640 acres.
2. Prepare a table of unit hydrograph ordinates U (cfs) at 10 minute intervals starting at t = 0 for this unit hydrograph.
3. For a 10 inch storm on this subbasin, the total precipitation, losses and excess rainfall in the peak 40 mins of the storm are:

|  |  |  |  |
| --- | --- | --- | --- |
| Time (10 min incr.) | Total Precip (in) | Losses (in) | Excess Precip (In) |
| 1 | 0.55 | 0.15 | 0.40 |
| 2 | 1.15 | 0.26 | 0.90 |
| 3 | 1.15 | 0.20 | 0.95 |
| 4 | 0.55 | 0.08 | 0.47 |

Use the unit hydrograph table from (b) and the excess precipitation given in this table to compute the direct runoff hydrograph (cfs) in 10min intervals at the outlet of Subbasin BUT\_060 resulting from this rainfall. What is the total excess precipitation (in)? What is the volume of direct runoff (ac-ft)? What is the equivalent depth of direct runoff expressed in inches over the subbasin?

a.-

Time to peak: $T\_{p}=\frac{t\_{r}}{2}+t\_{p}=\frac{10}{2}+35.2=40.2min$

Base time: $t\_{b}=T\_{p}+1.67T\_{p}=40.2+1.67\left(40.2\right)=107.33min$

Peak Flow: $q\_{p}=\frac{CA}{T\_{p}}=\frac{483.4×0.78708}{{40.2}/{60}}=568cfs$



Volume:

$V=\frac{1}{2}\left(107.33min×\frac{60s}{1min}\right)\left(568cfs\right)\left(\frac{1acre}{43,560ft^{2}}\right)$

$V=42 acre-ft$

b.-

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| n [10 min] | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Q [cfs/in] | 141.26 | 282.52 | 423.79 | 565.05 | 484.97 | 400.38 | 315.79 | 231.19 | 146.60 | 62.01 |

c.-



Total Excess Precipitation:

 $P\_{e}=0.40+0.90+0.95+0.47=2.72in$

Volume of direct runoff:

 $V\_{dr}=114.40 acre-ft$

Equivalent depth of direct runoff:

 $d\_{e}=\frac{114.40 acre-ft}{0.78708mi^{2}}\left(\frac{1mi^{2}}{640 acres}\right)\left(\frac{12in}{1ft}\right)=2.72in$

**Question 2. Reservoir Routing**

1. For Dam 7, the elevation, storage and discharge characteristics are given in the table below. Discharge begins in the primary spillway at elevation 805 ft above datum and flow over the emergency spillway begins at elevation 829 ft above datum. Using this information, construct a table of 2S/t + Q (cfs) vs Q (cfs) for t = 3 hours.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
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|  |  |  |  |
| --- | --- | --- | --- |
| Elevation (ft) | Storage (Ac-ft) | Discharge (cfs) | 2S/∆t + Q (cfs) |
| 805 | 0.00 | 0.00 | 0.00 |
| 807 | 109.22 | 94.57 | 975.61 |
| 809 | 238.13 | 98.89 | 2,019.81 |
| 811 | 385.61 | 102.83 | 3,213.42 |
| 813 | 561.82 | 106.61 | 4,638.62 |
| 815 | 772.75 | 110.29 | 6,343.81 |
| 817 | 1,031.46 | 113.80 | 8,434.24 |
| 819 | 1,307.01 | 117.22 | 10,660.43 |
| 821 | 1,608.38 | 120.57 | 13,094.84 |
| 823 | 1,967.20 | 123.81 | 15,992.56 |
| 825 | 2,353.04 | 126.97 | 19,108.16 |
| 827 | 2,775.92 | 130.05 | 22,522.47 |
| 829 | 3,243.88 | 133.07 | 26,300.37 |
| 829.75 | 3,430.94 | 387.16 | 28,063.41 |
| 830.5 | 3,631.02 | 922.26 | 30,212.49 |
| 831.85 | 4,002.88 | 2,486.81 | 34,776.71 |
| 833.5 | 4,501.40 | 5,186.03 | 41,497.32 |
| 836.5 | 5,510.77 | 14,100.09 | 58,553.63 |
| 840.25 | 7,008.94 | 81,641.54 | 138,180.32 |
| 844 | 8,692.70 | 201,496.45 | 271,617.56 |

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|  |  |  |

1. The inflow hydrograph to Dam 7 is given below. Determine the resulting time distributions of the storage (ac-ft) and elevation (ft) in Dam 7 and discharge (cfs) from Dam 7 for time 0 to 36 hours. What is the peak elevation? What is the peak discharge? Does water flow over the emergency spillway?

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Time (hrs) | Inflow (cfs) | Ij+Ij+1 (cfs) | 2Sj/Δt -Qj | 2Sj+1/Δt +Qj+1 | Elevation (ft) | Outflow Q (cfs) |
| 0 | 0.0 |  | 0.0 |  | 805.00 | 0.00 |
| 3 | 123.2 | 123.2 | 99.3 | 123.2 | 805.25 | 11.94 |
| 6 | 230.3 | 353.5 | 365.0 | 452.8 | 805.93 | 43.89 |
| 9 | 485.9 | 716.2 | 891.2 | 1,081.2 | 807.20 | 95.01 |
| 12 | 3,534.3 | 4,020.2 | 4,697.0 | 4,911.4 | 813.32 | 107.20 |
| 15 | 4,914.9 | 8,449.2 | 12,905.0 | 13,146.2 | 821.04 | 120.63 |
| 18 | 1,742.6 | 6,657.5 | 19,307.7 | 19,562.5 | 825.27 | 127.38 |
| 21 | 1,270.1 | 3,012.7 | 22,060.7 | 22,320.4 | 826.88 | 129.87 |
| 24 | 1,048.1 | 2,318.2 | 24,115.8 | 24,378.9 | 827.98 | 131.53 |
| 27 | 506.5 | 1,554.6 | 25,405.3 | 25,670.4 | 828.67 | 132.57 |
| 30 | 239.3 | 745.8 | 25,885.2 | 26,151.1 | 828.92 | 132.95 |
| 33 | 148.8 | 388.1 | 26,007.2 | 26,273.3 | 828.99 | 133.05 |
| 36 | 102.4 | 251.2 | 25,992.3 | 26,258.4 | 828.98 | 133.04 |

Peak Elevation: 828.99 ft

Peak Discharge: 133.05 cfs

The water does not flow over the emergency spillway.

**Question 3. Channel Flow**

Reach SBR\_080 in Brushy Creek has a length of 1545 ft, a slope of 0.0008 ft/ft, a Manning’s “n” of 0.1 and a cross-section defined by the coordinates in the table below where Station means distance from the left hand side of the channel, looking downstream.

|  |  |
| --- | --- |
| Station(ft) | Elevation (ft) |
| 0.00 | 797.61 |
| 118.10 | 790.07 |
| 236.20 | 781.67 |
| 284.00 | 777.07 |
| 304.00 | 777.07 |
| 323.42 | 783.57 |
| 344.26 | 789.86 |
| 365.10 | 795.48 |

For elevations of h = 777, 780, 785, 790, 795 ft above datum, determine the corresponding water depth, y (ft), wetted perimeter, P (ft), cross-sectional area, A (ft2), hydraulic radius, R (ft), flow velocity V (ft/s), discharge Q (cfs), and kinematic wave celerity Ck (ft/s).

SUMMARY

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| --- | --- | --- |
|   |   | Case |
| Parameter | 777 ft | 780 ft | 785 ft | 790 ft | 795 ft |
| Water depth (ft): | 0.00 | 2.93 | 7.93 | 12.93 | 17.93 |
| Wetted perimeter (ft): | 0.00 | 87.53 | 227.54 | 249.50 | 368.33 |
| Cross-sectional area (ft^2): | 0.00 | 157.08 | 730.14 | 1,516.50 | 2,986.39 |
| Hydraulic radius (ft): | 0.00 | 1.79 | 3.21 | 6.08 | 8.11 |
| Flow velocity (ft/s): | 0.00 | 0.62 | 0.92 | 1.40 | 1.70 |
| Discharge (cfs): | 0.00 | 97.76 | 669.43 | 2,128.57 | 5,079.41 |
| Kinematic wave celerity (ft/s): | 0.00 | 1.04 | 1.53 | 2.34 | 2.83 |

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| --- | --- | --- | --- | --- | --- | --- |
| Case: 777 ft |  |  |  |  |  |  |
| Station(ft) | Elevation (ft) | Water depth (ft) | Width (ft) | Mean Water depth (ft) | Area (ft^2) | Wet Perimeter (ft) |
| 0.00 | 797.61 | 0.00 |  |  |  |  |
| 118.10 | 790.07 | 0.00 | 118.10 | 0.00 | 0.00 | 0.00 |
| 236.20 | 781.67 | 0.00 | 118.10 | 0.00 | 0.00 | 0.00 |
| 284.00 | 777.07 | 0.00 | 47.80 | 0.00 | 0.00 | 0.00 |
| 304.00 | 777.07 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 |
| 323.42 | 783.57 | 0.00 | 19.42 | 0.00 | 0.00 | 0.00 |
| 344.26 | 789.86 | 0.00 | 20.84 | 0.00 | 0.00 | 0.00 |
| 365.10 | 795.48 | 0.00 | 20.84 | 0.00 | 0.00 | 0.00 |
|  |  |  |  | ∑ | 0.00 | 0.00 |
|  |  |  |  |  |  |  |
|  |  |  |  | Water depth (ft): | 0.00 |
|  |  |  |  | Wetted perimeter (ft): | 0.00 |
|  |  |  |  | Cross-sectional area (ft^2): | 0.00 |
|  |  |  |  | Hydraulic radius (ft): | 0.00 |
|  |  |  |  | Flow velocity (ft/s): | 0.00 |
|  |  |  |  | Discharge (cfs): | 0.00 |
|  |  |  |  | Kinematic wave celerity (ft/s): | 0.00 |

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| --- | --- | --- | --- | --- | --- | --- |
| Case: 780 ft |  |  |  |  |  |  |
| Station(ft) | Elevation (ft) | Water depth (ft) | Width (ft) | Mean Water depth (ft) | Area (ft^2) | Wet Perimeter (ft) |
| 0.00 | 797.61 | 0.00 |  |  |  |  |
| 118.10 | 790.07 | 0.00 | 118.10 | 0.00 | 0.00 | 0.00 |
| 236.20 | 781.67 | 0.00 | 118.10 | 0.00 | 0.00 | 0.00 |
| 284.00 | 777.07 | 2.93 | 47.80 | 1.46 | 70.03 | 47.89 |
| 304.00 | 777.07 | 2.93 | 20.00 | 2.93 | 58.60 | 20.00 |
| 323.42 | 783.57 | 0.00 | 19.42 | 1.46 | 28.45 | 19.64 |
| 344.26 | 789.86 | 0.00 | 20.84 | 0.00 | 0.00 | 0.00 |
| 365.10 | 795.48 | 0.00 | 20.84 | 0.00 | 0.00 | 0.00 |
|  |  |  |  | ∑ | 157.08 | 87.53 |
|  |  |  |  |  |  |  |
|  |  |  |  | Water depth (ft): | 2.93 |
|  |  |  |  | Wetted perimeter (ft): | 87.53 |
|  |  |  |  | Cross-sectional area (ft^2): | 157.08 |
|  |  |  |  | Hydraulic radius (ft): | 1.79 |
|  |  |  |  | Flow velocity (ft/s): | 0.62 |
|  |  |  |  | Discharge (cfs): | 97.76 |
|  |  |  |  | Kinematic wave celerity (ft/s): | 1.04 |

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| --- | --- | --- | --- | --- | --- | --- |
| Case: 785 ft |  |  |  |  |  |  |
| Station(ft) | Elevation (ft) | Water depth (ft) | Width (ft) | Mean Water depth (ft) | Area (ft^2) | Wet Perimeter (ft) |
| 0.00 | 797.61 | 0.00 |  |  |  |  |
| 118.10 | 790.07 | 0.00 | 118.10 | 0.00 | 0.00 | 0.00 |
| 236.20 | 781.67 | 3.33 | 118.10 | 1.67 | 196.64 | 118.15 |
| 284.00 | 777.07 | 7.93 | 47.80 | 5.63 | 269.11 | 48.02 |
| 304.00 | 777.07 | 7.93 | 20.00 | 7.93 | 158.60 | 20.00 |
| 323.42 | 783.57 | 1.43 | 19.42 | 4.68 | 90.89 | 20.48 |
| 344.26 | 789.86 | 0.00 | 20.84 | 0.71 | 14.90 | 20.89 |
| 365.10 | 795.48 | 0.00 | 20.84 | 0.00 | 0.00 | 0.00 |
|  |  |  |  | ∑ | 730.14 | 227.54 |
|  |  |  |  |  |  |  |
|  |  |  |  | Water depth (ft): | 7.93 |
|  |  |  |  | Wetted perimeter (ft): | 227.54 |
|  |  |  |  | Cross-sectional area (ft^2): | 730.14 |
|  |  |  |  | Hydraulic radius (ft): | 3.21 |
|  |  |  |  | Flow velocity (ft/s): | 0.92 |
|  |  |  |  | Discharge (cfs): | 669.43 |
|  |  |  |  | Kinematic wave celerity (ft/s): | 1.53 |

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| --- | --- | --- | --- | --- | --- | --- |
| Case: 790 ft |  |  |  |  |  |  |
| Station(ft) | Elevation (ft) | Water depth (ft) | Width (ft) | Mean Water depth (ft) | Area (ft^2) | Wet Perimeter (ft) |
| 0.00 | 797.61 | 0.00 |  |  |  |  |
| 118.10 | 790.07 | 0.00 | 118.10 | 0.00 | 0.00 | 0.00 |
| 236.20 | 781.67 | 8.33 | 118.10 | 4.17 | 491.89 | 118.39 |
| 284.00 | 777.07 | 12.93 | 47.80 | 10.63 | 508.11 | 48.02 |
| 304.00 | 777.07 | 12.93 | 20.00 | 12.93 | 258.60 | 20.00 |
| 323.42 | 783.57 | 6.43 | 19.42 | 9.68 | 187.99 | 20.48 |
| 344.26 | 789.86 | 0.14 | 20.84 | 3.28 | 68.46 | 21.77 |
| 365.10 | 795.48 | 0.00 | 20.84 | 0.07 | 1.46 | 20.84 |
|  |  |  |  | ∑ | 1,516.50 | 249.50 |
|  |  |  |  |  |  |  |
|  |  |  |  | Water depth (ft): | 12.93 |
|  |  |  |  | Wetted perimeter (ft): | 249.50 |
|  |  |  |  | Cross-sectional area (ft^2): | 1,516.50 |
|  |  |  |  | Hydraulic radius (ft): | 6.08 |
|  |  |  |  | Flow velocity (ft/s): | 1.40 |
|  |  |  |  | Discharge (cfs): | 2,128.57 |
|  |  |  |  | Kinematic wave celerity (ft/s): | 2.34 |

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| --- | --- | --- | --- | --- | --- | --- |
| Case: 795 ft |  |  |  |  |  |  |
| Station(ft) | Elevation (ft) | Water depth (ft) | Width (ft) | Mean Water depth (ft) | Area (ft^2) | Wet Perimeter (ft) |
| 0.00 | 797.61 | 0.00 |  |  |  |  |
| 118.10 | 790.07 | 4.93 | 118.10 | 2.46 | 291.12 | 118.20 |
| 236.20 | 781.67 | 13.33 | 118.10 | 9.13 | 1,078.25 | 118.40 |
| 284.00 | 777.07 | 17.93 | 47.80 | 15.63 | 747.11 | 48.02 |
| 304.00 | 777.07 | 17.93 | 20.00 | 17.93 | 358.60 | 20.00 |
| 323.42 | 783.57 | 11.43 | 19.42 | 14.68 | 285.09 | 20.48 |
| 344.26 | 789.86 | 5.14 | 20.84 | 8.28 | 172.66 | 21.77 |
| 365.10 | 795.48 | 0.00 | 20.84 | 2.57 | 53.56 | 21.46 |
|  |  |  |  | ∑ | 2,986.39 | 368.33 |
|  |  |  |  |  |  |  |
|  |  |  |  | Water depth (ft): | 17.93 |
|  |  |  |  | Wetted perimeter (ft): | 368.33 |
|  |  |  |  | Cross-sectional area (ft^2): | 2,986.39 |
|  |  |  |  | Hydraulic radius (ft): | 8.11 |
|  |  |  |  | Flow velocity (ft/s): | 1.70 |
|  |  |  |  | Discharge (cfs): | 5,079.41 |
|  |  |  |  | Kinematic wave celerity (ft/s): | 2.83 |