**2.3.2 The Precipitation and streamflow for the storm of May 12, 1980, on Shoal Creek at Northwest Park in Austin, Texas, are shown below. Calculate the time distribution of storage on the watershed assuming that the initial storage is 0. Compute the total depth of precipitation and the equivalent depth of streamflow which occurred during the 8-hour period. How much storage remained in the watershed at the end of the period? What percent of the precipitation appeared as streamflow during this period? What was the maximum storage? Plot the time distribution of incremental precipitation, streamflow, change in storage, and cumulative storage. The watershed area is 7.03mi2.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time (h) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 |   |
| Incremental Precipitation (in) |  | 0.18 | 0.42 | 0.21 | 0.16 |  |  |  |  |
| Instantaneous Streamflow (cfs) | 25 | 27 | 38 | 109 | 310 | 655 | 949 | 1060 |  |
|  |  |  |  |  |  |  |  |  |  |
| Time (h) | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 |
| Instantaneous Streamflow (cfs) | 968 | 1030 | 826 | 655 | 466 | 321 | 227 | 175 | 160 |

* Time Distribution

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Time Interval *j* | Time *t* (h) | Time Increment *Δt* (h) | Incremental Precipitation *Ij* (in) | Instantaneous Streamflow *Q(t)* (cfs) | Incremental streamflow *Qj* (in) | Incremental Storage *ΔSj* (in) | Cumulative Storage *Sj* (in) |
|   | 0.0 |   |   | 25 |   |   | 0.000 |
| 1 | 0.5 | 0.5 | 0.18 | 27 | 0.003 | 0.177 | 0.177 |
| 2 | 1.0 | 0.5 | 0.42 | 38 | 0.004 | 0.416 | 0.594 |
| 3 | 1.5 | 0.5 | 0.21 | 109 | 0.008 | 0.202 | 0.795 |
| 4 | 2.0 | 0.5 | 0.16 | 310 | 0.023 | 0.137 | 0.932 |
| 5 | 2.5 | 0.5 |   | 655 | 0.053 | -0.053 | 0.879 |
| 6 | 3.0 | 0.5 |   | 949 | 0.088 | -0.088 | 0.791 |
| 7 | 3.5 | 0.5 |   | 1060 | 0.111 | -0.111 | 0.680 |
| 8 | 4.0 | 0.5 |   | 968 | 0.112 | -0.112 | 0.568 |
| 9 | 4.5 | 0.5 |   | 1030 | 0.110 | -0.110 | 0.458 |
| 10 | 5.0 | 0.5 |   | 826 | 0.102 | -0.102 | 0.356 |
| 11 | 5.5 | 0.5 |   | 655 | 0.082 | -0.082 | 0.274 |
| 12 | 6.0 | 0.5 |   | 466 | 0.062 | -0.062 | 0.213 |
| 13 | 6.5 | 0.5 |   | 321 | 0.043 | -0.043 | 0.169 |
| 14 | 7.0 | 0.5 |   | 227 | 0.030 | -0.030 | 0.139 |
| 15 | 7.5 | 0.5 |   | 175 | 0.022 | -0.022 | 0.117 |
| 16 | 8.0 | 0.5 |   | 160 | 0.018 | -0.018 | 0.098 |
|  |  | ∑ | 0.97 |  | 0.87 |  |  |

* Total Depth of Precipitation

$$d=\sum\_{j=1}^{16}I\_{j}$$

$$d=0.97in$$

* Equivalent depth of Streamflow

$$d\_{e}=\sum\_{j=1}^{16}Q\_{j}$$

$$d\_{e}=0.87in$$

* Storage remained in the watershed at the end of the period

$$depth=0.098in$$

$$S=0.098in\left(7.03mi^{2}\right)\left(\frac{5280^{2}ft^{2}}{1mi^{2}}\frac{1ft}{12in}\right)$$

$$S=1,600,500ft^{3}$$

* Percent of Precipitation that appear as streamflow

$$\%P=100\left({0.87}/{0.97}\right)$$

$$\%P=90\%$$

* Maximum Storage

$$depth=0.932in$$

$$S=0.932in\left(7.03mi^{2}\right)\left(\frac{5280^{2}ft^{2}}{1mi^{2}}\frac{1ft}{12in}\right)$$

$$S=15,221,500ft^{3}$$

**2.5.1 Calculate the velocity and flow rate of a uniform flow 3 ft deep in a 100-ft-wide stream with approximately rectangular cross section, bed slope 1 percent, and Manning’s** $n$ **of 0.035. Check that the criterion for fully turbulent flow is satisfied.**

$$P=2\left(3ft\right)+100ft$$

$$P=106ft$$

$$A=3ft\left(100ft\right)$$

$$A=300ft^{2}$$

$$R={A}/{P}$$

$$R={300}/{106}$$

$$R=2.83ft$$

$$V=\frac{1.49}{n}R^{{2}/{3}}S\_{f}^{1/2}$$

$$V=\frac{1.49}{0.035}\left(2.83\right)^{{2}/{3}}\left(0.01\right)^{1/2}$$

$$V=8.5{ft}/{s}$$

$$Q=AV$$

$$Q=\left(300\right)\left(8.5\right)$$

$$Q=2,550{ft^{3}}/{s}$$

$$n^{6}\sqrt{RS\_{f}}$$

$$\left(0.035\right)^{6}\sqrt{\left(2.83\right)\left(0.01\right)}$$

$$3.09×10^{-10}>1.9×10^{-13}$$

(The criterion for fully turbulent flow is satisfied)

**2.8.5 The incoming radiation intensity on a lake is** $200{W}/{m^{2}}$**, Calculate the net radiation into the lake if the albedo is** $α=0.06$**, the surface temperature is 30°C, and the emissivity is 0.97.**

$$T=30+273=303K$$

$$R\_{e}=eσT^{4}$$

$$R\_{e}=0.97\left(5.67×10^{-8}\right)\left(303\right)^{4}$$

$$R\_{e}=463.58{W}/{m^{2}}$$

$$R\_{n}=R\_{i}\left(1-α\right)-R\_{e}$$

$$R\_{n}=200\left(1-0.06\right)-463.58$$

$$R\_{n}=-276{W}/{m^{2}}$$

**3.2.1 At a climate station, the following measurements are made: air pressure = 101.1kPa, air temperature = 25°C, and dew point temperature =20°C. Calculate the corresponding vapor pressure, relative humidity, specific humidity, and air density.**

* Vapor Pressure

$$e=611exp\left(\frac{17.27T\_{d}}{237.3+T\_{d}}\right)$$

$$e=611exp\left(\frac{17.27\left(20\right)}{237.3+20}\right)$$

$$e=2,339Pa$$

* + Saturation Vapor Pressure

$$e\_{s}=611exp\left(\frac{17.27T}{237.3+T}\right)$$

$$e\_{s}=611exp\left(\frac{17.27\left(25\right)}{237.3+25}\right)$$

$$e\_{s}=3,169Pa$$

* Relative Humidity

$$R\_{h}=\frac{e}{e\_{s}}$$

$$R\_{h}=\frac{2,339}{3,169}$$

$$R\_{h}=0.74=74\%$$

* Specific Humidity

$$q\_{v}=0.622\frac{e}{p}$$

$$q\_{v}=0.622\frac{2,339}{101,100}$$

$$q\_{v}=0.0144$$

(kg water/kg most air)

* Air Density

$$T=25+273=298K$$

$$R\_{a}=287\left(1+0.608q\_{v}\right)$$

$$R\_{a}=287\left(1+0.608\left(0.0144\right)\right)$$

$$R\_{a}=289.51{J}/{kg}K$$

$$ρ\_{a}=\frac{p}{R\_{a}T}$$

$$ρ\_{a}=\frac{101,100}{289.51\left(298\right)}$$

$$ρ\_{a}=1.17{kg}/{m^{3}}$$