Watershed Hydrology - WSM560

Final Exam - Fall 2022

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1. A standard Class A Evaporation Pan (diameter 47.5 inches) begins the month of June with 10 inches of water in it. At the end of June, the pan only has 5 inches in it. Note that it also rained 2 inches in June. Knowing the density of water is 1000 kg/m3, what would you say is the closest estimate for the mass of water lost from the pan in the month of June? 5 points

```
diam_1 <- 41.5 #inches
JuneA_1 <- 10 #inches, begging of month
JuneZ_1 <- 5 #inches, end of month
JunePrecip_1 <- 2 #inches, june precipitation
Wden_1 <- 1000 #kg/m3, water density

#Find the EV in inches
EV_1 <- JuneA_1 - JuneZ_1 + JunePrecip_1

#Find Water Volume at the end of June
Vol_in3_1 <- 3.14 * (diam_1/2)^2 * EV_1 #in3, Volume of cylinder = Pi * r2 * h

#Transform cubic inches to cubic meters
Vol_m3_1 <- Vol_in3_1/61020

#How much in Kg?
Mass_kg_1 <- Vol_m3_1*1000 #Density = mass/volume
```

```
## [1] The water mass lost in June is 155.09 kg
```

2. A watershed has an area of 25 miles2. A rain event of 0.25 inch falls on that watershed. One-third of that rain infiltrates into the ground, and the rest becomes runoff. 15 points

a. What is the total **volume** of rain over the watershed? (Report your answer in acre-ft.)

b. What is the total **volume** of runoff from the watershed? (Report your answer in acre-ft.)

```
Area_2 <- 25 #miles2
Prepipitation_2 <- 0.25 #inch
Infiltration_2 <- Prepipitation_2*(1/3) #inch
```

```r
RunOff_2 <- Prepipitation_2 - Infiltration_2 #inch

#B = Total volume of Rain Over Watershed, transform inches to miles
Precipitation_miles3_2 <- (Prepipitation_2/63360) * Area_2

#Transform cubic miles to Acre-ft
Precipitation_acreft_2 <- Precipitation_miles3_2*3.379e+6

# A = Total volume runoff from the watershed, transform inches to miles
RunOff_miles3_2 <- (RunOff_2/63360) * Area_2

#Transform runoff to Acre-ft
RunOff_acreft_2 <- RunOff_miles3_2*3.379e+6
```

```
## [1] a = The volume of rain over the watershed is 333.3 acre-f
```

```
## [1] b = The volume of runoff over the watershed is 222.2 acre-f
```

c. If some of the native vegetation in the watershed is removed and replaced with a new housing development, would you expect the runoff to increase or decrease? Explain your answer using specific examples

If we model that there is no difference in the precipitation after the land use change, evapotranspiration is unknown, and there is no management strategies that would keep infiltration at a similar rate, the run off will increase. When deep rotted vegetation is replaced by shallow turf and miles of concrete and roofs, rain will inevitably pour thru the streets at higher rates.

3. In the space below, describe the hydrologic cycle and all its components in 3-4 sentences. Then, in the following image, label the arrows showing the hydrologic fluxes using the letter in the key provided. 20 points

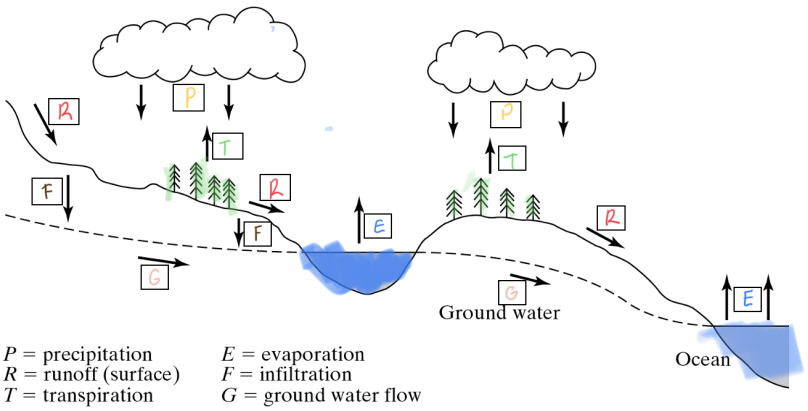

Figure 1: Hidrologic Fluxes

Precipitation:

1.

4. In one of the first lectures from class, we discussed the 21 major watersheds within the United States. Furthermore, we discussed the standardized method in which 'Hydrologic Units Codes' are used to represent the scale of these different watersheds. What is the 6-digit Hydrologic Unit Code for the Santa Cruz River Basin near Tucson? Please provide the website link in which you found this information. 5 points

5. A soil retention curve examines the relationship between soil water content and soil water potential. Explain why the curve is different for when soils become more wet (wetting) compared to when they dry (drying). 10 points

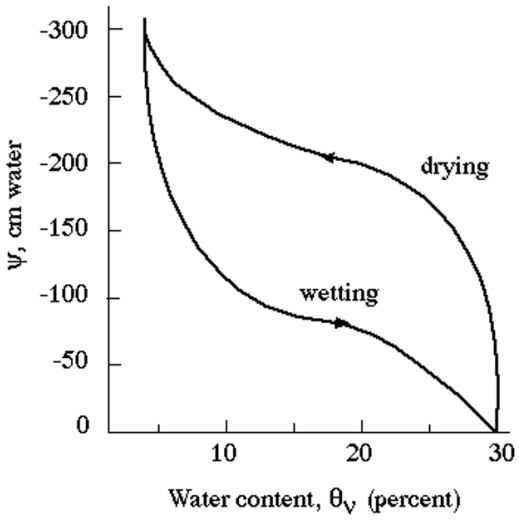

Figure 2: Soil Retention Curve

6. In class, we have often used publicly available data from the US Geological Society (USGS) in our labs and problem sets. You have learned how to navigate the USGS website and to access data. For this assignment, please use the USGS website to answer the following questions (you must find the website yourself). 25 points

a) For the San Pedro River near Tombstone, AZ (USGS gage 09471550), download the peak stream discharge data for the time period available (1967-2015). Using this dataset, construct a Probability of Exceedance Plot in Excel and **insert the figure in your answer**. You may recall that the plot has the "Annual Exceedance Probability (expressed as %) on the x-axis and "Annual Peak Discharge" (expressed as CFS) on the y-axis. Also, remember to express both your x- and y-axis in log scale so that your relationship is relatively linear. Please label your axis clearly. **(15 pts)**

b) What is the return period of a 10,000 cfs flood? **(5pts)**

c) Estimate the magnitude (expressed as cfs) of a 50 year flood. **(5pts)**

7. You have been working with a contractor that needs to help a developer planning to build a residential neighborhood in Sahuarita that is concerned about overland flow. Your job is to get a handle on the infiltration capacity of the soil. Your field work has resulted in the table below. You also have estimated an average initial rate of infiltration at 0.7 cm hr-1 with an average final capacity of 0.5 cm hr-1. Use Horton's equation (with an empirical constant of 0.1 hr-1) to estimate the infiltration capacity at t = 30 min, 1 hr, 1.5 hr, 2 hr, and 2.5 hr, 3 hr, and 3.5 hr as in the table below. With this information, determine the excess of rainfall (runoff) in cm hr-1. What is the average ratio of runoff to rainfall for the storm that you used in your fieldwork? Should the developer be concerned? Explain why or why not. 20 points

Time (hr)	Rainfall Intensity (cm hr-1)	Infiltration (cm hr-1)	Runoff (cm hr-1)
0 - 0.5	1.0	NA	NA
0.5 – 1	0.7	NA	NA
1 – 1.5	2.0	NA	NA
1.5 – 2	2.5	NA	NA
2 – 2.5	2.8	NA	NA
2.5 – 3	1.5	NA	NA
3 – 3.5	0.5	NA	NA
Total	11.0	-	-

8. Two tensiometers are installed into unsaturated soil to determine the direction of unsaturated water flow. Tensiometer A measures pressure head PhiA at a depth of 20 cm, and tensiometer B measures pressure head PhiB at a depth of 60 cm. The following results are obtained for three different treatments (1 through 3). 20 points

Treatment	PhiA(cm)	PhiB(cm)	Flow Direction
1	-123	NA	NA
2	-211	NA	NA
3	-9	NA	NA
Total	-343	-	-

Briefly describe a tensiometer. Draw these scenarios in the space below, **including your reference point**. Determine the flow direction under each treatment (A to B or B to A).

I promise that I have not asked nor received help from anyone on this final. _____