

# Watershed Hydrology, Midterm 1, Fall 2022

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Please show all work associated with calculations and circle your answers. If I cannot read your handwriting, I cannot grade your exam, so please write as legibly as possible. The total number of points on this exam is 120.

## 1. For Question 1, answer the following questions (35 points total):

- A runoff event yielded 20,000 cubic meters of water from a 150 sq. kilometer watershed. Convert the runoff to mm. (5 points)
- If you measured 15 mm of rainfall for a storm with a 45 minute duration what is the rainfall intensity in mm/hr? (5 points)

```
Runoffm3 <- 20000 #m3
Area <- 150 #m2

Runoffmm <- Runoffm3/Area * 1000
```

```
## [1] a = The runoff is 133333.33 mm
```

```
#Rainfall Intensity
rainfall <- 15 #mm
duration <- 45 #minute
duration_h <- 45/60 #Convert minute to hour,

#If 15 mm fell in 0.75 how much mm would fell in 1 hour?
rainfall_h <- rainfall / duration_h
```

```
## [1] b = The rainfall instensity is 20 mm/hr
```

- What is albedo? Why is albedo important for estimating Net Radiation at the earth surface? (5 points)

*Albedo is the ratio of absorbtion versus reflectance in a surface, the higher the albedo the more the surface reflects. Albedo will let you know how much shortwave radiation is absorbed and how much longwave radiation is being re-release to the atmosphere*

- Describe and contrast the two types of methods for estimating watershed precipitation: 1) arithmetic average, 2) hypsometric method. (5 points)

*The hypsometric method uses the relationship of elevation and rainfall to estimate the value of rain, while the arithmetic average uses the mean between the gauges without weighting any other value. Rain in a watershed would most likely change according elevation, we can have better interpolations if we add the altitude of the gauges as a variable.*

- e. What are the three physical factors that drive the ET process? **(5 points)**

*For evaporation to happen, there must be unsaturated air around the source of water. Transpiration happens when the a plant release water to the atmospheres thur their photosynthetic organs. To keep this process going we need Wind, Radiation and a change in relative humidity.*

*Radiation as latent heat makes liquid water turn to gas, this gas enters into the atmosphere to find either more water molecules or less water molecules. The amount of water in the air measured in percentage is relative humidity. If the air is saturated with water, it means that ET would be limited, wind renews the air around the source, air that can be filled with more water, increasing ET.*

Wind must renew the air around the source so more water can leave. more radiation means more water transforming to vapor and more photosynthesis and more water consumption. The humidity in the air also plays a big factor in ET, if we have wind but is just saturated with water and the sun is high, we would reach a limit on the quantity of water this sources can give to the atmosphere\*

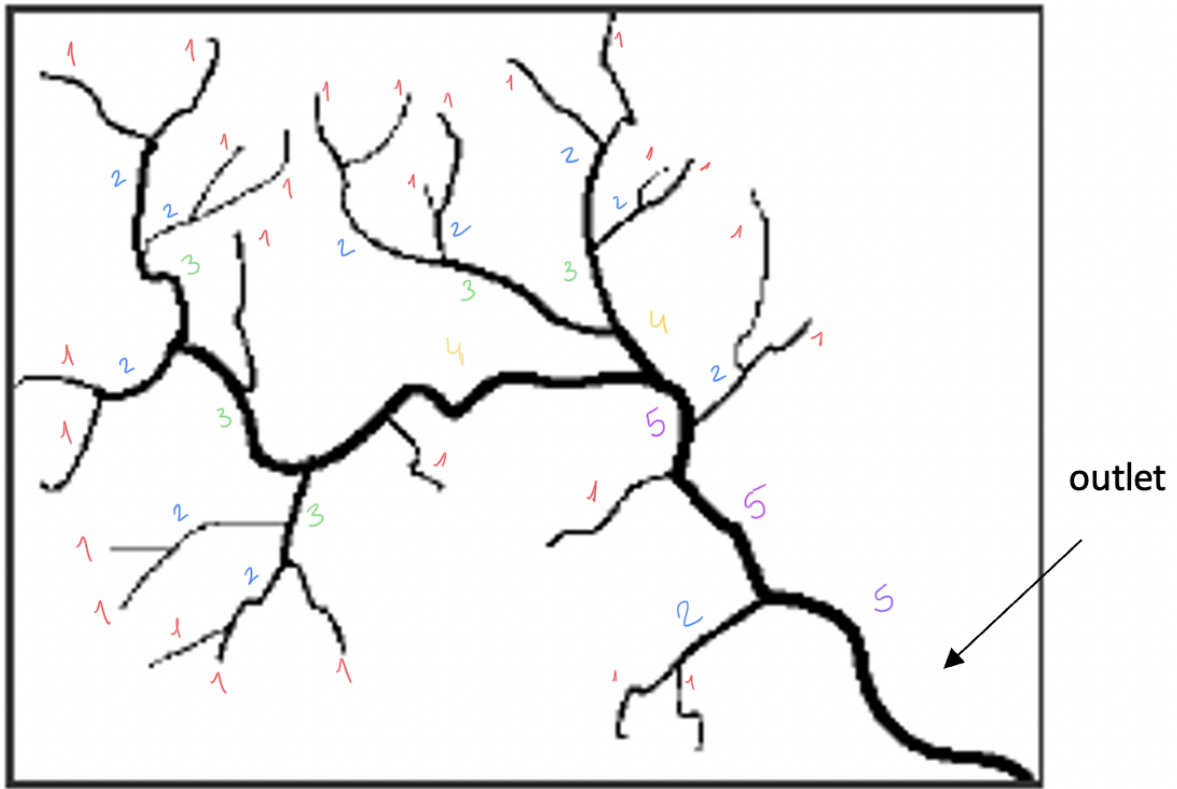
- f. What is a watershed? Identify three watershed characteristics. **(5 points)**

*A watershed an ecology study area, where all the surface water that flows there end in the same point, that point would eventually end in a stream or the ocean.*

*We can characterize a watershed by looking at topography, understanding their climate, and analyzing their land use. Topography studies the elevation, how big is the slope, what is the shape of the catchment and where it ends up draining. Climate offer us a way to understand how much radiation would catchment receives and when, and how much precipitation can we can spec. Finally land use will give us clues about what kind of vegetation is on the ground and if we can foresee any land compaction or other human intervention like dams*

- g. What is the Strahler stream order at the outlet? **(10 points)**

**Its 5!**



**2. In the north central United States the forest industry is converting thousands of acres from red pine and spruce (both conifers) to aspen (a hardwood). Discuss the potential impact you could expect from this conversion on the hydrologic cycle, including changes in interception, evapotranspiration, and annual streamflow. (10 points)**

*Conifers are evergreen trees that have the same amount of foliage all year around. In a conifer forest ET might be bigger overall, being only limited by abiotic factors such as wind and radiation. The albedo would be low most time of the year, and in the winter this would make the snow pack to melt sooner, the forest will absorb more energy also augmenting ET. Interception will not change much between seasons.*

*Aspen trees are deciduous, the winter will find no interception of the canopy and the soil will have a greater snow pack than in the conifers. The high albedo of the watershed would reflect most of the radiation and the snow packs of ice will last longer. The ET would only start to increase as soon as leaves grow*

*The annual stream flow in a Conifers forest would be less erratic, while the Aspens will allow more snow accumulation and the stream flow will be bigger at the beginning of the spring, once the snow pack is gone the stream flow would be the same as a Conifer forest*

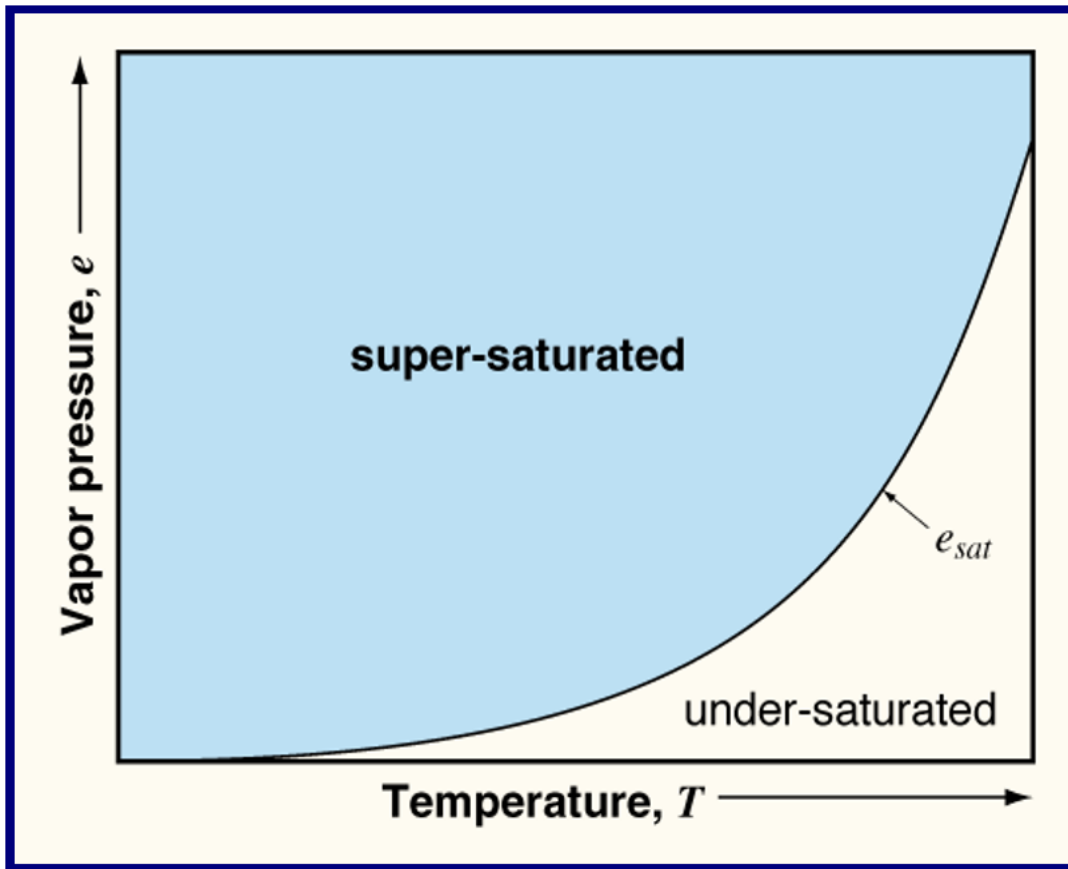
**3. On average, Tucson received roughly 500 mm of precipitation each year. (15 points total)**

- a) Using the water budget equation, along with your understanding of the hydrologic cycle in this area, describe and quantify to the best of knowledge, the fate of this precipitation input. For example, what percentage of total precipitation is lost through evapotranspiration, discharge (or streamflow), or storage? **(5 points)**
- b) Describe unique components, situations, or assumptions that might apply to Tucson in particular. Be thorough with your answer. **(5 points)**
- c) How might development of nearby natural landscapes into housing neighborhoods change how total precipitation is lost through ET, discharge, or storage? **(5 points)**

**4. Using this figure, explain what vapor pressure deficit (VPD) and dew point are, and how the two are different from one another. You can either use words or equations in your explanation. (10 points)**

*Vapor pressure deficit is the difference between the amount of moisture in the air and the amount of moisture the air can hold when saturated. When the air becomes saturated it will start to form fog, or dew, or just water in the surface of stuff. Temperature is the a big factor in water saturation, warm air can hold more water vapor than cold air (if we consider constant pressure). As the graph shows, changes in temperature can predict the saturation or not saturation of air. The temperature in which the air becomes saturated is the dew point.*

*VPD and DP are different because the first is a measure of pressure (unit kPA) and the second is a measure of Temperature (units C,K,F). VPD tells you how much pressure change you need for the air to saturate, while DP tells you the temperature of that saturation point.*



5. Using the IDF Curve below, determine the rainfall intensity (in/hr) and amount of rain (in) for a 20-min duration storm with 5-yr return period in Chicago. Do you think the return period for a 20-min duration storm with the same intensity would have a higher or lower return period in Tucson? Why? (10 points)

*In Chicago a rain as intense 3.5 in/hr for 20 min, might happen every 5 years. In Tucson, for a rain as intense with during that amount of time will happen very rarely with a return time of more than >500, so its extremely unlikely.*

*For a storm you need energy and water. Tucson has, most of the time, more energy from radiation than Chicago does, but it has less water available to complete such an intense discharge of water in that low amount of time. Chicago on the other hand is right next to the great lakes, giving the area a greater water source that can be use once the energy arrives.*

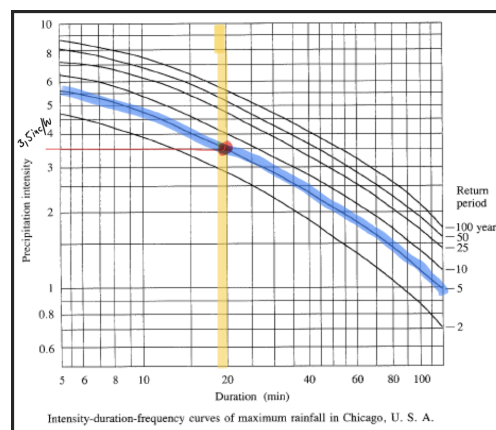


Figure 1: Chicago IDF Curve

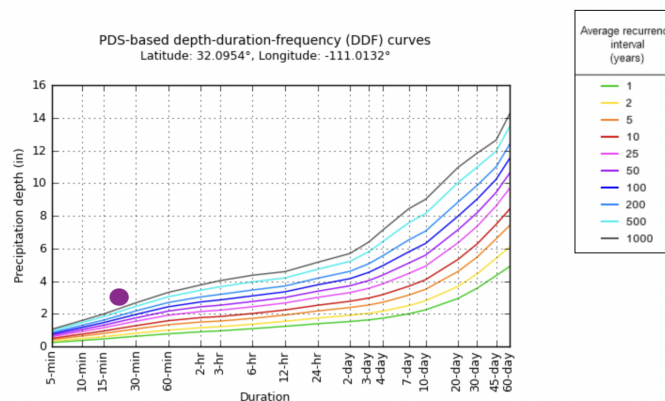


Figure 2: Tucson IDF Curve

6. On an average year, a small watershed (3.0 km<sup>2</sup>) receives 950 mm of precipitation. The watershed is drained by a stream (with continuous data) and discharge is  $1.1 \times 10^6$  m<sup>3</sup>. Assume groundwater recharge is negligible and storage is zero. (15 points total)

- What is the depth of water lost through evapotranspiration (in mm)? (5 points)
- What is the volume of water (in m<sup>3</sup>) lost through evapotranspiration for the year? (5 points)
- What is the runoff ratio (rout/p)? (5 points)

```
#Data
Area_6_km2 <- 3 #Km2
Prep_6_mm <- 950 #mm
Q_6_m3 <- 1.1e6 #m3

#1: Convert Area to m2
Area_6_m2 <- Area_6_km2 * 1e6

#2: Convert Runoff from m3 to mm
Q_6_mm <- Q_6_m3/Area_6_m2 * 1000

#3: Apply the formula  $p = et + q$   $et = p - q$ 
ET_6_mm <- Prep_6_mm - Q_6_mm
```

```
## [1] a = The evapotranspiration is 583.33 mm
```

```
#Find the Volume of ET
#1: Transform ET from mm to m and apply  $ET \times area\_m2$ 
ET_6_m3 = (ET_6_mm/1000)*Area_6_m2
```

```
## [1] b = The evapotranspiration is 1,749,990 m3
```

```
#Find the runoff ratio
#1: Apply  $rout/p$ 
Runoff_Ratio <- Q_6_mm / Prep_6_mm
```

```
## [1] c = The runoff ratio is 0.39
```

7. A lake with a surface area of 525 acres was monitored over a period of time. During a one-month period the inflow was 31 ft<sup>3</sup> s<sup>-1</sup>, the outflow was 28 ft<sup>3</sup> s<sup>-1</sup>, and a 1.5 – inch seepage loss (from the bottom of the lake) was measured. During the same month, the total precipitation was 4.25 in. Evaporation loss was estimated as 6.0 inches. (10 points total)

- Estimate the storage change in this lake during the month (answer in inches).
- Did the lake gain or lose water during the month?

```

#1: Look at the data for one month
Area_7_acres <- 525 #acres
inflow_7_ft3s <- 31 #ft3 s-1
outflow_7_ft3s <- 28 #ft3 s-1
seepage_in <- 1.5 #inches per month
Precip_7_in <- 4.25 #inches per month
ET_7_in <- 6 #inches per month

#2: Convert units/dimensions
Area_7_ft2 <- Area_7_acres * 43560
#Volume to area
inflow_7_ins <- inflow_7_ft3s/Area_7_ft2 * 12
outflow_7_ins <- outflow_7_ft3s/Area_7_ft2 * 12

#in second to in month
inflow_7_ft_inm <- inflow_7_ins * 2.628e6
outflow_7_inm <- outflow_7_ins * 2.628e6

#3: Water Balance
#p + rin = et + rout + s
IN_7_in <- Precip_7_in + inflow_7_ft_inm
OUT_7_in <- ET_7_in + outflow_7_inm + seepage_in

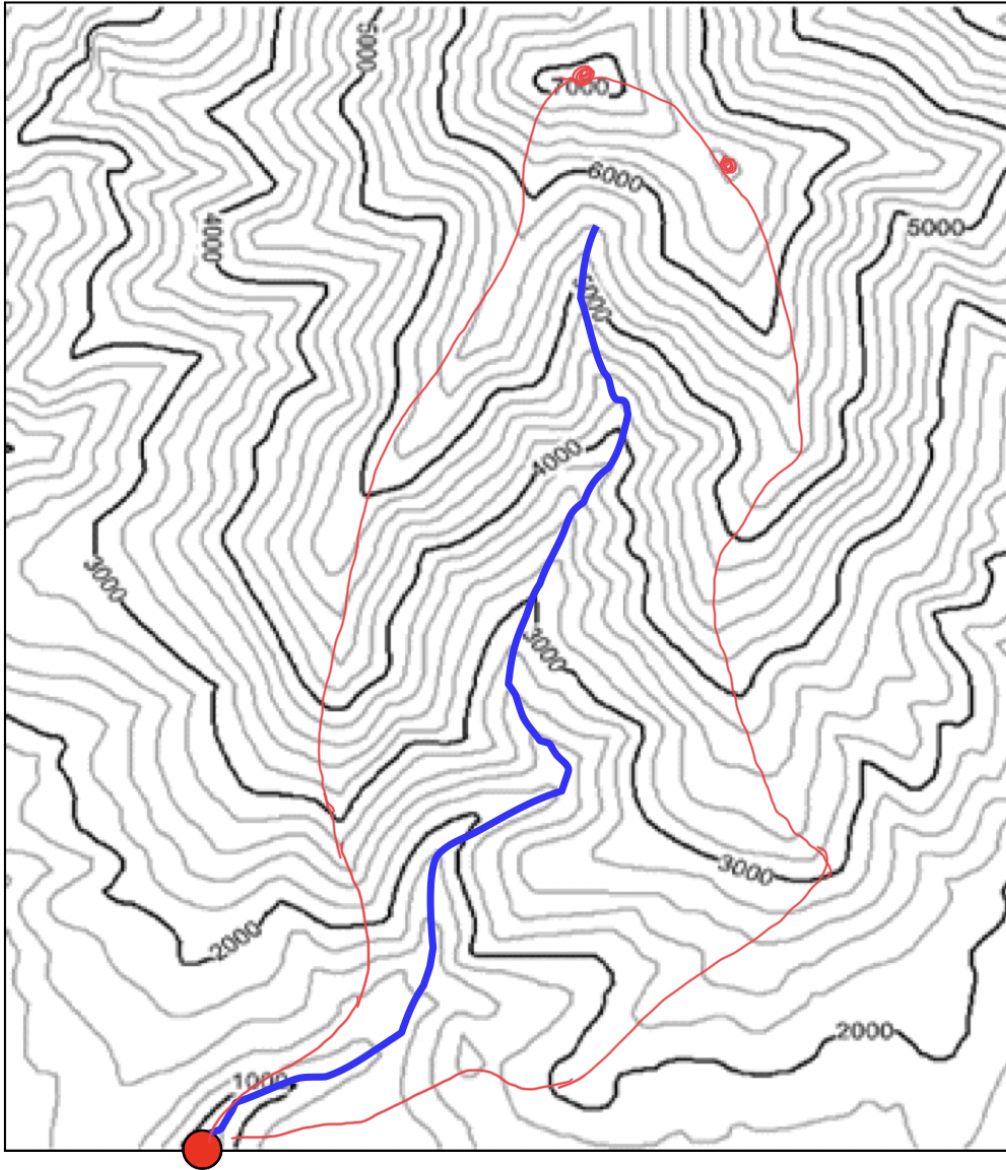
CHANGE_7_in <- IN_7_in - OUT_7_in

```

```
## [1] a = The storage change is 0.89 in per month
```



8. On the following image, delineate the watershed associated with the gauge point indicated with the dot at the bottom of the image. Briefly explain your method in the space below. (10 points)



*I look for the high points first, I could only find two high points and I drew a line that intersects both hills. Then I look for the slopes, there were two clear slopes around the river, I could identify them by seeing the U shape they form. With a line cut all the U in half, with that I had most of my catchment delimited. At the end I had to pay special attention to the flat part near the outpoint because the U where harder to identify.*

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