# CE 3354 Engineering Hydrology
# Exercise Set 3

## Exercises

1. Estimate the monthly evapotranspiration depths for Dallas (Tarrant County), Houston (Harris County), and San Angelo (Concho County) area using the Blaney-Criddle method.[1]

[1] A Google search should get you sufficient guidance to perform this exercise.

2. Estimate the monthly evapotranspiration depths for the San Angelo (Concho County) area using the Thornwaithe method.[2]

[2] A Google search should get you sufficient guidance to perform this exercise.

3. Locate grid cells 506,410, and 812 at the TWDB lake evaporation database. Determine the long term monthly evaporation rates for the three cells. Compare these rates to the estimates you made above. These cells correspond approximately to

   - 506 == San Angelo
   - 410 == Dallas
   - 812 == Houston

4. A storm of moderate intensity strikes a semi-urban watershed with predominantly loamy soils. The storm begins at time $t = 0$ and lasts for **3 hours** with a constant rainfall intensity of **15 mm/h**.

   The watershed has the following properties:

   - Area: 2 hectares
   - Slope: gentle (assume negligible effect)
   - Vegetative cover: 50% grass, 50% compacted dirt
   - Antecedent moisture conditions: dry (unless otherwise specified)
   - Initial abstraction: assume 5 mm where applicable

   A prior study suggests the following Horton parameters:

$$\begin{aligned} f_0 &= 5 \text{ mm/h} \quad \text{(initial infiltration capacity)} \\ f_c &= 1 \text{ mm/h} \quad \text{(final infiltration capacity)} \\ k &= 2.0 \text{ h}^{-1} \quad \text{(decay constant)} \end{aligned}$$

   Determine:

   a) The infiltration rate function $f(t)$ over the 3-hour duration using Horton's exponential decay equation: $f(t) = f_c + (f_0 - f_c)e^{-kt}$

   b) The cumulative infiltration depth $F(t)$, by integrating the rate function over time.

   c) Plot the rate and cumulative infiltration depth for every 15-minutes for the 3 hour storm.

   d) Report the total runoff depth as: Runoff = Rainfall Depth $- F(3 \text{ h})$

5. A storm of moderate intensity strikes a semi-urban watershed with predominantly loamy soils. The storm begins at time $t = 0$ and lasts for **3 hours** with a constant rainfall intensity of **15 mm/h**.

   The watershed has the following properties:

   - Area: 2 hectares
   - Slope: gentle (assume negligible effect)
   - Vegetative cover: 50% grass, 50% compacted dirt
   - Antecedent moisture conditions: dry (unless otherwise specified)
   - Initial abstraction: assume 5 mm where applicable

   An prior study suggests the following Green-Ampt parameters for the watershed:

$$\begin{aligned} \Delta\theta &= 0.25 \quad \text{(initial moisture deficit)} \\ \psi &= 110 \text{ mm} \quad \text{(wetting front suction head)} \\ K_s &= 3 \text{ mm/h} \quad \text{(saturated hydraulic conductivity)} \end{aligned}$$

   Determine:

   a) Use the Green-Ampt equation to estimate cumulative infiltration:

$$F = K_s t + \psi\Delta\theta \ln\left(1 + \frac{F}{\psi\Delta\theta}\right)$$

   Solve this equation iteratively (numerically or in Excel/Python) for $t = 3$ hours.

   b) Plot the Green-Ampt cumulative infiltration for every 15-minutes for the 3 hour storm.

   c) Report the total runoff depth as: Runoff = Rainfall Depth − $F$(3 h)

6. A storm of moderate intensity strikes a semi-urban watershed with predominantly loamy soils. The storm begins at time $t = 0$ and lasts for **3 hours** with a constant rainfall intensity of **15 mm/h**.

   The watershed has the following properties:

   - Area: 2 hectares
   - Slope: gentle (assume negligible effect)
   - Vegetative cover: 50% grass, 50% compacted dirt
   - Antecedent moisture conditions: dry (unless otherwise specified)
   - Initial abstraction: assume 5 mm where applicable

   A prior study suggests the following NRCS CN parameters for the watershed:

   - Curve Number (CN): 75 (based on land use and hydrologic soil group B)
   - Total Rainfall: 45 mm over 3 hours

   Using the same watershed and storm conditions, Determine:

   a) Potential maximum retention:

   $$S = \frac{25400}{\text{CN}} - 254 \quad \text{(in mm)}$$

   b) Total runoff from the NRCS runoff equation:

   $$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \quad \text{for } P > 0.2S$$

   c) Total infiltration as:

   $$\text{Infiltration} = P - Q$$

7. Compare infiltration results among the three methods.
   a) What causes the differences?
   b) Which method is most sensitive to changes in soil properties?
   c) How would the results change under wet antecedent conditions?
   d) Suggest which model is most appropriate for:
      - Urban drainage design
      - Physically-based process modeling
      - Regional-scale hydrologic planning