1. A watershed receives 1000 mm/yr precipitation and has an evapotranspiration rate of 600 mm/yr. If the watershed covers 10 ha, what is the total net input of water to the watershed in m³/yr?

\[ \text{Net Input} = P - ET = (1000 - 600) \text{mm/yr} = 400 \text{mm/yr} \]

\[ \text{Total Volumetric Input} = \left( 400 \text{ mm/yr} \right) \left( \frac{1 \text{ m}}{1000 \text{ mm}} \right) \left( 10 \text{ ha} \right) \left( \frac{10^4 \text{ m}^2}{1 \text{ ha}} \right) \]

\[ \text{Net Input Rate} \quad \text{Area} \]

\[ = \boxed{4 \times 10^4 \text{ m}^3/\text{yr}} \]

2. In the watershed above what is the heat loss associated with evaporation in units of W/m²?

\[ \text{ANS} \quad ET = 600 \text{ mm/yr} \]

In class we noted: \( 1 \text{ mm/yr} = 1 \frac{\text{kg-H}_2\text{O}}{\text{m}^2 \cdot \text{yr}} \)

\( \left( \frac{1 \text{ mm/yr}}{1 \text{ m}^2 \text{ yr}} \right) = 10^{-3} \text{ m}^3/\text{yr} \) \( \Rightarrow \left( \frac{1}{1 \text{ m}^2 \text{ yr}} \right) \left( \frac{1 \text{ kg}}{1 \text{ L}} \right) = \frac{1 \text{ kg/m}^2 \cdot \text{yr}}{1 \text{ m}^2 \text{ yr}} \)

\[ \text{Heat Loss} = \left[ \text{Evap Mass Flux, kg/m² yr} \right] \left[ \text{Latent Heat of Vaporization, J/kg} \right] \]

\[ H_e = 2400 \text{ J/g} \quad \text{near } 20^\circ\text{C} \Rightarrow H_e = 2.4 \times 10^6 \text{ J/kg} \]

\[ \phi_{\text{evap}} = \left( 600 \text{ mm/yr} \right) \left( \frac{1 \text{ Kg/m}^2 \text{ yr}}{1 \text{ mm/yr}} \right) \left( 2.4 \times 10^6 \frac{\text{ J}}{\text{ kg}} \right) \left( \frac{1 \text{ day}}{86400 \text{ s}} \right) \left( \frac{1 \text{ yr}}{365 \text{ days}} \right) \]

\[ \phi_{\text{evap}} = \boxed{46 \text{ W/m}^2} \]
3. A stream has a slope of 0.010 and a moderately rough bottom such that a Manning Coeff. of 0.040 is appropriate. The stream is 3.0 m wide and has an average depth of 0.50 m. Assume the stream is approximately rectangular in cross section.

What is the expected mean velocity? (m/s)

\[ v = \frac{R^{\frac{2}{3}} S^{\frac{1}{2}}}{n} \]

\[ R = \frac{A_{ws}}{b_{wet}} = \frac{(0.5 \text{ m})(3.0 \text{ m})}{2(0.5) + (3.0 \text{ m})} = 0.375 \text{ m} \]

\[ v = \frac{(0.375)^{\frac{2}{3}} (0.01)^{\frac{1}{2}}}{0.040} = 1.3 \text{ m/s} \]

ANS Use Manning Eqn

As noted in class.

4. A small pond has the following thermal properties:

\[ \dot{Q}_{s}^{in} = -300 \text{ W/m}^2 \]
\[ \dot{Q}_{s}^{out} = +360 \text{ W/m}^2 \]
\[ \dot{Q}_{e}^{in} = -200 \text{ W/m}^2 \]

Evaporation = 2.0 mm/day

What is the heat flux to/from the lake (\( \dot{Q}_{c} \)) in W/m^2? Be sure to specify if \( \dot{Q}_{c} \) is "in" (-) or "out" (+),
At steady state
\[ \phi_s + \phi_e + \phi_e^{\text{out}} + \phi_{\text{evap}} + \phi_c = 0 \]
\[ \phi_c = \phi_s + \phi_e^{\text{in}} + \phi_e^{\text{out}} + \phi_{\text{evap}} \]

Find \( \phi_c = [\text{Evap Rate}] \text{ m/s} \)
\[ = [2.0 \frac{\text{kg}}{\text{m}^2 \cdot \text{d}}] (2400 \frac{\text{kJ}}{\text{kg}}) \left( 10^3 \frac{\text{J}}{\text{kJ}} \right) \left( \frac{1 \frac{\text{d}}{\text{kg}}}{86400 \text{s}} \right) = 56 \frac{\text{W}}{\text{m}^2} \]

\[ \phi_c = (-300) + (-200) + (-360) + (+56) \frac{\text{W}}{\text{m}^2} \]
\[ \phi_c = 84 \frac{\text{W}}{\text{m}^2} \]

5. In problem 4, \( \phi_e^{\text{out}} \) is \( +360 \frac{\text{W}}{\text{m}^2} \).
What is the temperature of the lake? (°C)

Ans: \( \phi_e^{\text{out}} = \sigma T^4 \)
\[ (\varepsilon = 1.0 \text{ for H}_2\text{O}) \]
\[ T = \left( \frac{360 \frac{\text{W}}{\text{m}^2}}{5.7 \times 10^8 \frac{\text{W}}{\text{m}^2} \text{K}^4} \right)^{0.25} = 282 \text{ K} \]
\[ T = 9 \text{ °C} \]
Sounds reasonable (~48°F)

6. At Fred Meyer, potting soil bags are sold by volume (not weight). A large bag is 2.0 cu. feet. You are curious about the weight you bought & find the bag weighs 65 kg. What is the bulk density \( \rho_b \) of the potting soil? (Loose soil in bag)

\[ V = (2.0 \text{ cu. ft}) (0.0283 \frac{\text{m}^3}{\text{ft}^3}) = 0.057 \text{ m}^3 \]

\[ \rho_b = \frac{M_s}{V_T} = \frac{65 \text{ kg}}{57 \text{ L}} \]

(Loos for real soil) but this is bagged