

CIVE520 PHYSICAL HYDROLOGY
FALL 2011

Homework No. 3

Assigned on: Friday, October 21, 2011
Due on: Monday, October 31, 2011

1. Two different soils are characterized by the following parameters:

	m	c	$K_z(\theta_s)$ cm/sec	$ \psi(\theta_s) $ cm	θ_o	θ_s
Fine Sand	1.36	4.22	1.0×10^{-3}	24	0.15	0.30
Light Clay	0.22	8.54	1.0×10^{-5}	26	0.24	0.48

For the two soils, and for the variable diffusivity case

- Compute the infiltration rate as a function of time for constant $\theta_l = \theta_s$ at the surface.
- Assuming a rainfall duration of 2 hours, calculate the maximum depth of penetration of an infiltration moisture wave for the two soils above.
- Compute the time to ponding, t_o , and volume of surface runoff, R_s for the following conditions:
 Fine Sand: Rain intensity: $i = 5$ cm/h, and rain duration, $t_r = 1.5$ h.
 Light Clay: Rain intensity: $i = 0.5$ cm/h, and rain duration, $t_r = 1.5$ h.

2. Assume that rainfalls are of constant intensity i_r and duration t_r . Infiltration capacity is given by Philip's equation evaluated at the initial soil moisture saturation before the storm, s_o . That is,

$$f_i^*(t) = \frac{1}{2} S_i t^{-1/2} + \frac{1}{2} K_z(\theta_s)(1 + s_o^c)$$

If no evaporation occurs during the storm, and neglecting capillary rise, show that the depth-averaged degree of soil moisture saturation at the end of the storm s_f can be approximated by,

$$s_f = s_o + [i_r t_r - K(1) s_o^c t_r] / n z \quad 0 \leq t_r \leq t_o$$

$$s_f = s_o + [i_r t_o + S_i (t_r^{1/2} - t_o^{1/2}) + A_o (t_r - t_o) - K(1) s_o^c t_r] / n z \quad t_r > t_o$$

where z is a characteristic soil depth over which the mass balance should be performed. A_o is the gravitational infiltration rate, n is the porosity, S_i is the sorptivity, t_o is the ponding time, $K(l)$ is the saturated hydraulic conductivity (that is, $K(l)$ is notation for $K_z(\theta_s)$), and c is the pore disconnectedness index. State all your assumptions.

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Use the expressions you derived and compute s_f for the two soils of Problem 1 and for two storms of intensity equal to 0.6 cm/h and whose durations are equal to $2t_o/3$ and $2t_o$. State all your assumptions. Assume that the depth of the soil column over which the water balance is to be performed is 1 m. Finally, if neither of the above two durations is applicable, assume a duration of 5 hours.

3. Calculate the soil moisture flux q_z (cm/day) between depths $z_1 = -0.8$ m and $z_2 = -1.8$ m in a soil column. The corresponding piezometric heads are $\phi_1 = -145$ cm and $\phi_2 = -230$ cm, respectively. For this soil the relationship between hydraulic conductivity and soil matric potential is given by,

$$K_z = 250(-\psi)^{-2.11}$$

where K_z is in cm/day and ψ is in cm. Note that a vertical coordinate positive in the upward direction is used.

The following equation may be useful,

$$\phi_i(m, s_o) = \frac{3\pi}{10(1-s_o)^2} \left[\frac{m}{1+4m} + \frac{m^2 s_o^{4+1/m}}{(1+4m)(1+3m)} - \frac{ms_o}{1+3m} \right]$$