CEE6400 Physical Hydrology

Infiltration example problem

Consider a soil of given type (e.g. **silty clay loam**) and given an input rainfall hyetograph, calculate the infiltration and the runoff. Initial soil moisture content 0.3. Rainfall rate 2 cm/hr, for 3 hours.

This is an event based calculation of runoff

Solution outline

1. Determine soil properties from texture (Table 1 p 4:18)

   These are the parameters of the problem (time invariant quantities that describe behavior in a particular situation).

K_{sat}	
n	
ψ_a	
b	

2. System state described by initial condition and the depth of water that has infiltrated up to any point in time

$\theta_o = 0.3$	F = 0 cm at t=0 cm (will change during course of the event)

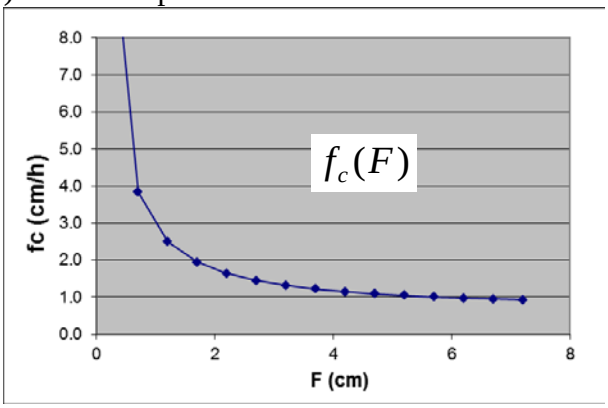
3. Establish Infiltrability – Depth approximation. In Green-Ampt approach this is based on hydraulic gradient over the depth of penetration of wetting front, Darcy's equation and suction in advance of a wetting front (Infiltration18.pptx, slide 13)

$$f_c = K_{sat}\left(1+\frac{|\psi_f|\Delta\theta}{F}\right) = K_{sat}\left(1+\frac{P}{F}\right)$$

$\|\psi_f\| = \frac{2b+3}{2b+6}\|\psi_a\|$ equation 44	
$\Delta\theta = n-\theta_o$	
P	

F cm				
f_c cm/h				

f_c(F) relationship serves as foundation for calculations that follow



4. Ponding (saturation at the surface) first occurs when f_c=W (water input rate or rainfall rate) This idea lets you solve for the depth of water that has to infiltrate before ponding occurs, F_p, and the time to ponding t_p for a particular input rate W.

F_p cm	
t_p h	

5. After ponding the rate of increase in F (remember, this is a state variable describing the state of the system) is limited by the infiltration capacity

$$\frac{dF}{dt} = f_c(F) = K_{sat}\left(1+\frac{P}{F}\right)$$

Solving this gives an equation relating F and t for ponded conditions