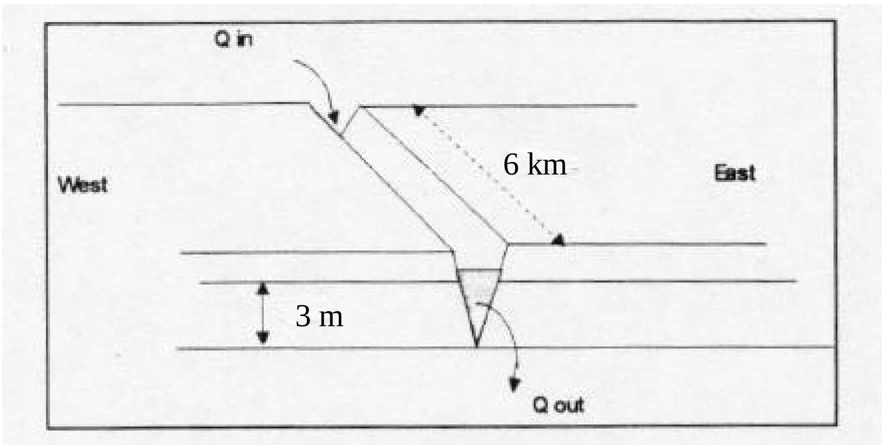
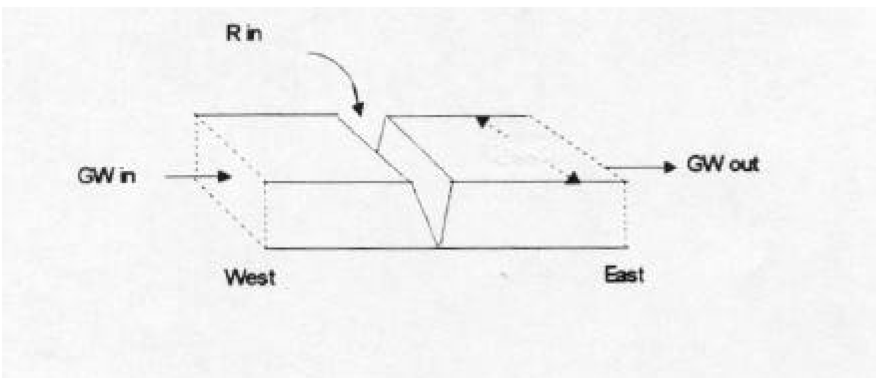
Problem #1 (Classical Water Balance Problem)

Dog Run Creek penetrates a confined aquifer 3 meters thick (Figure 3.1). During a long drought the flow in the creek decreases by 1.1 cubic meters per second between two gaging (flow measurement) stations along the creek located 6 kilometers apart. On the west side of the creek the hydraulic head contours run parallel to the bank of the creek and the contour levels decrease as one moves away from the creek at a rate of 0.0007 m/m. The head contours on the east side of the creek are also parallel to the creek and the levels decrease as one moves towards the creek at a rate of 0.0003 m/m.



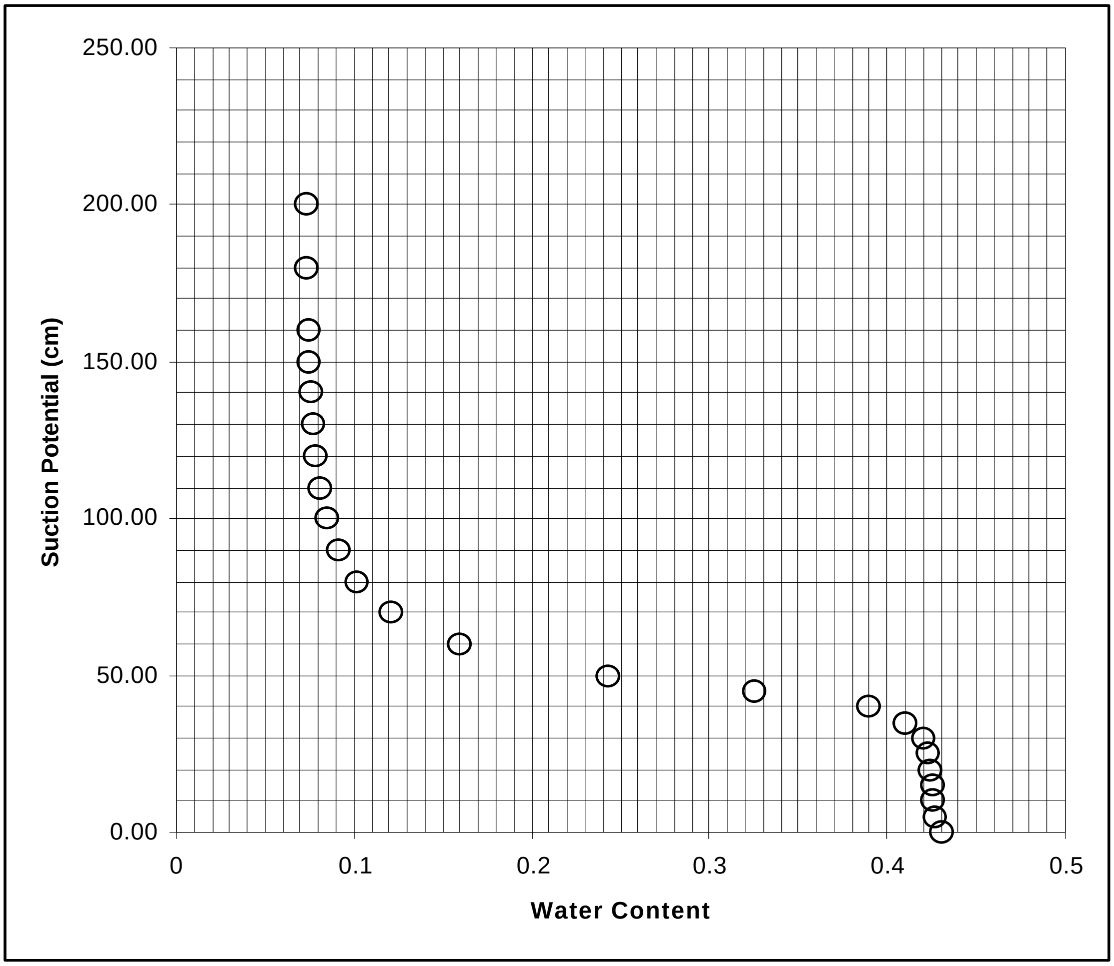
(a) Write a water balance for the aquifer in the 6 km section near the creek.



(b) Use Darcy's Law and the water balance to estimate the hydraulic conductivity of the aquifer.

Problem #2

A fine sand soil has the following soil-water characteristic curve. From this curve estimate the soil porosity, *n*, irreducible water content, q_{wr}, the irreducible saturation, S_{wr}, and the bubbling pressure, Ψ_b.



If you can, also estimate the Brooks and Corey exponent, l, for this soil.

Problem #3 (Classical linear-isotherm/retardation problem)

In a plan view of a contaminant plume you observe that a conservative constituent (e.g. chloride) has moved about 1500 meters while a reactive constituent (e.g. chromium) has moved only 400 meters. Assuming both species were released at the same time, estimate the distribution coefficient of the reactive species if the porosity is 0.35 and the solids density is 2.22 g/mL.

Problem #4 (Simple NAPL leaching problem – you do not need to do any compositional modeling, the source concentration is given)

Dissolution of constituents from a residual NAPL source results in a contaminant plume whose maximum length is determined by the balance between advection and decay. Develop an expression for the maximum plume length if the constituent source-term concentration is C_o. Apply the expression to estimate the maximum length of a benzene plume whose equilibrium concentration in water at the source is 2.4 mg/L and whose MCL is 0.005mg/L. Assume that the pore velocity is 0.35 m/d and the half-life of the benzene in a first order decay model is 60 days. Assume that the retardation coefficient for benzene in the aquifer is 2.

Problem #5 (Classical simple dissolution problem; Again no compositional model required)

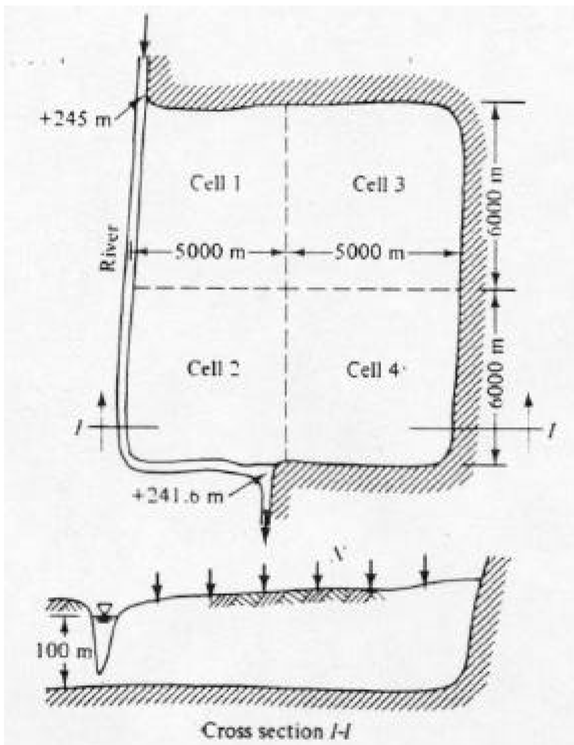
A cubic meter of sand-gravel aquifer is contaminated with 20 L of tetrachloroethylene (PCE). The aquifer has porosity of 20% and hydraulic conductivity of 410 m/d. You may assume that the air content is negligible.

a) What is the equilibrium concentration of PCE in the water phase?
b) What is the mass PCE in the water phase?
c) What is the mass PCE in the NAPL phase?
d) If the aquifer gradient is 0.001 estimate how long it would take to completely dissolve and flush the PCE from the cubic-meter source zone.

Problem #6 (Simple modeling problem – an expansion of the ideas in the numerical generation of flow nets; the solution will probably use a few sheets of paper, so don't try to fit it onto a single page)

Given the four-cell conceptualization of an aquifer with the properties listed below determine:

a) Write the **steady-flow** balance equations for average water levels in the four cells
b) Solve these equations to determine if the aquifer is a net supplier of water to the river or if the river is a supplier of water to the aquifer.
c) Write the **steady-state** balance equations for average concentration of a conservative tracer in the four cells.
d) If the river concentration of this tracer is 1,000 mg/L, calculate the steady-state concentrations in the four cells.



Pumping (10^6 m^3/yr)		Recharge (mm/yr)	K (m/day)
Cell 1	17.8	200	40
Cell 2	0	420	40
Cell 3	6.3	300	30
Cell 4	2.7	300	30