THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF ENERGY AND GEO-ENVIRONMENTAL ENGINEERING
GEOEE 408 CHARACTERIZATION OF GROUNDWATER SYSTEMS

Mid-term Examination - Tuesday February 27th, 2001 - 75 minutes
Answer all three questions.

For water (in contact with air): $\sigma = 7.3 \times 10^{-2}\ N/m;\ \ \mu = 1.12 \times 10^{-3}\ N.s/m^2$
For TCE (in contact with water): $\sigma = 3.5 \times 10^{-2}\ N/m;\ \ \mu = 0.96 \times 10^{-3}\ N.s/m^2$

Name: _____

Include extra sheets, as needed, and return entire packet.

Question	Points	Score
1	100	
2	100	
3	100	
Total	300	

Question 1

Define the following terms, and identify the units [MLT] of the quantity, where relevant. Be as specific and as exhaustive in your definitions as possible.

1. Bubling pressure, p_{c_0}.

2. Coefficient of longitudinal dispersion, α_L.

3. Effective moisture content, θ_e.

4. Advection-dispersion equation, $\frac{\partial c}{\partial t} = D_L \frac{\partial^2 c}{\partial x^2} - v_x^a \frac{\partial c}{\partial x}$.

5. Breakthrough curves.

6. Minimum penetration pressure head, h_{min}.

7. Free-product.

8. Porosity, n.

9. Peclet number, Pe.

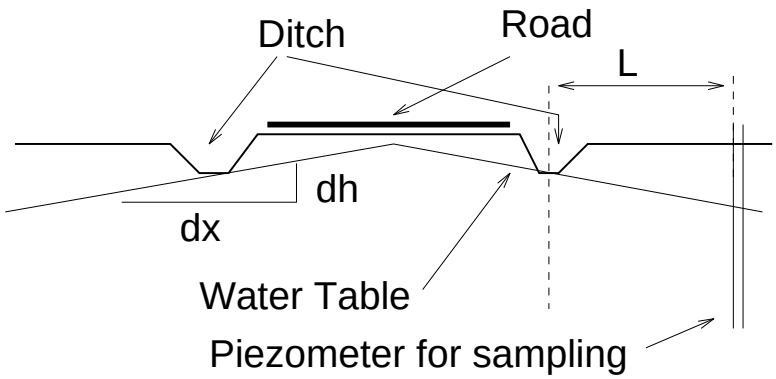
10. van Genuchten relations.

Question 2

The migration of contaminants at a site can be estimated by an analog with 1-D transport. The main component is sodium chloride that comes from the use of road salt. Road salt is applied, on average, over December, January and February, only, and is not applied for the remainder of the year. The solution lies within the roadside ditch, at concentration c_0, for these three months, and is able to pass through the groundwater system. This tracer is conservative.

The cross-section, representing migration from the ditch that parallels the road, is shown in the figure. The groundwater gradient ($\partial h/\partial x$)is 1:100, and the hydraulic conductivity of the sand comprising the phreatic aquifer is $4 \times 10^{-4} cm/s$, and the porosity 30%. The system flushes clean each year, in the time following the end of winter.

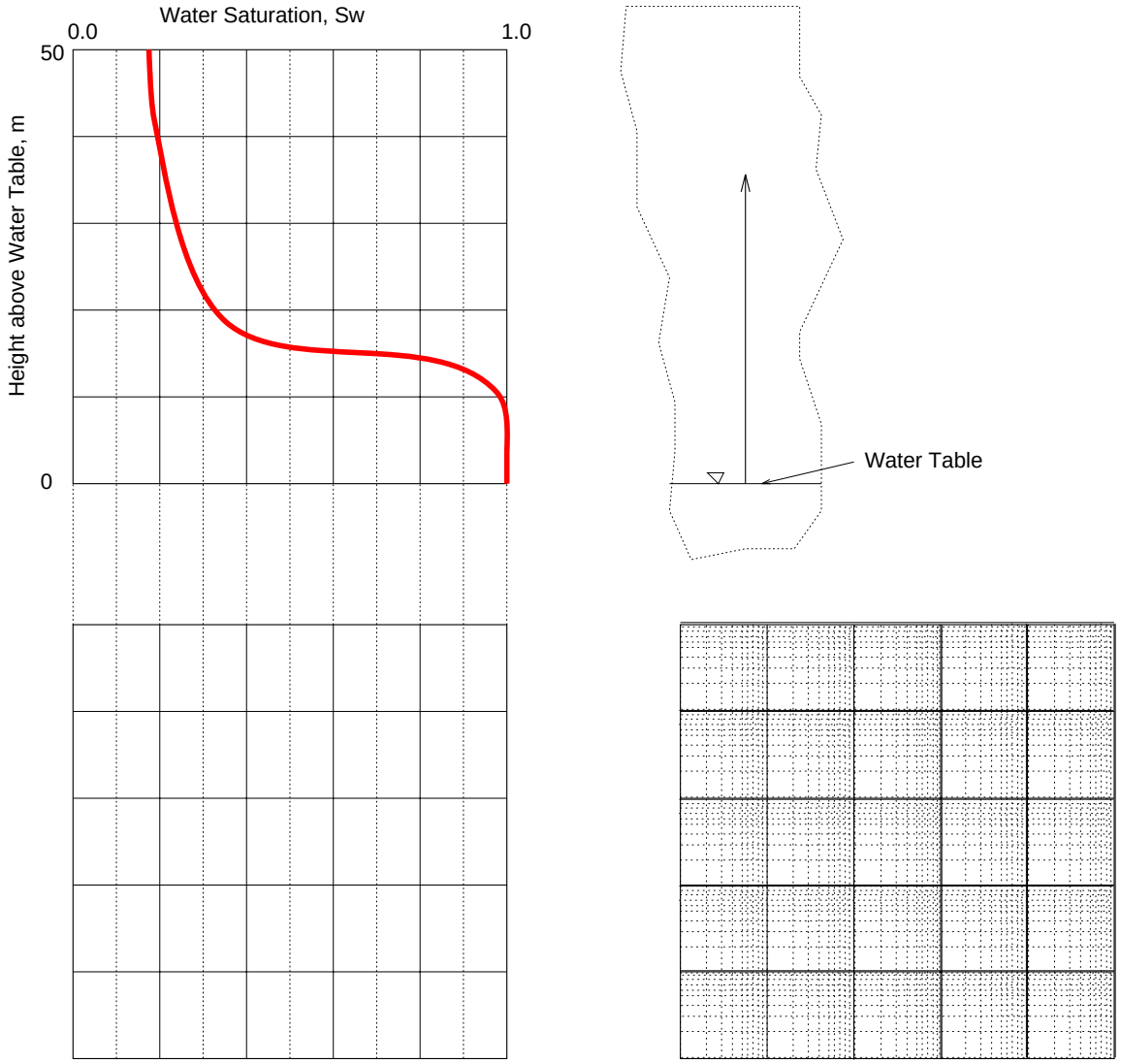
Evaluate the following:



1. Determine the Darcy velocity of the flowfield.
2. Determine the advective velocity of the flowfield.
3. Estimate the dispersion coefficient, D_L, for the sandy aquifer. The coefficient of molecular diffusion of salt in the saturated aquifer is $D* = 2 \times 10^{-9} m^2/s$.
4. Determine the Peclet number of the flow.
5. Determine how long it takes following the first application of salt for breakthrough to occur at the sampling location $L = 20\ m$ out from the ditch.
6. Sketch the breakthrough curve for a five year period, annotating important features.

Question 3

The distribution of water saturation, with height above the water table, is given in the figure below. The second fluid is air. Determine the following:



1. Construct the curve of capillary pressure versus saturation, and identify important characteristics of this curve.
2. Determine the two parameters (p_b, λ) that define the Brooks-Corey representation of this curve.
3. Determine the pressure required to force air into the water-saturated soil (see the fluid parameters on page 1, as needed).
4. Determine the pressure required to force TCE into the water-saturated soil.