THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF MINERAL ENGINEERING
GEOEE 408 CHARACTERIZATION OF GROUNDWATER SYSTEMS

Final Examination
1 hour 50 minutes

Name: _____

SSN: _____

Question	Points	Score
1	100	
2	100	
3	100	
Total	100	

Question 1

Define the following terms, and identify the units [MLT] of the quantity, where relevant. Be as specific in your definitions as possible. Where relevant, include any equations or figures to explain the term.

1. Finite difference method.

2. Surfactant flooding.

3. Relative permeability, k_r, versus saturation, S, relations.

4. Gaseous retardation coefficient, R_a.

5. Mechanical dispersion.

6. Effective solubility.

7. Capillary rise and minimum ganglion height.

8. Advective velocity and travel time.

9. Rock coring and core retrieval.

10. Non-dimensional Henry's Law coefficient, H.

Question 2

Gasoline, both as free product and as BTEX components, has been found in the ground beneath and surrounding a service station site in New Hampshire. The geology comprises a thin covering of sandy soils, $0.5\ m$ in depth, underlain by fractured granite.

1. Describe an appropriate (direct) site investigation for this site to:

   (a) Evaluate geology and hydrogeology.

   (b) Determine the extent of NAPL (free product) and dissolved product contamination.

   (c) Determine the potential for continued migration of the aqueous plume.

   Use note form, if you wish, to itemize your choices and explain their relevance.

2. The water table is at a depth of $6\ m$. The hydraulic conductivity, measured in pump tests, is of the order of $10^{-4}\ cm/s$. The conductivity of the intact granite is of the order $10^{-10}\ cm/s$, with a porosity of 0.01%.

   Free product gasoline is present on the water table, covering an area of $400\ m^2$ below the station. The dissolved plume has reached at least $100\ m$ downgradient of the site.

   Identify, and describe the operating principles of three remedial techniques that may be applied to this site. For each of these three applicable techniques, identify three factors that make the technique particularly applicable to the site. Use note form to answer if you wish.

Question 3

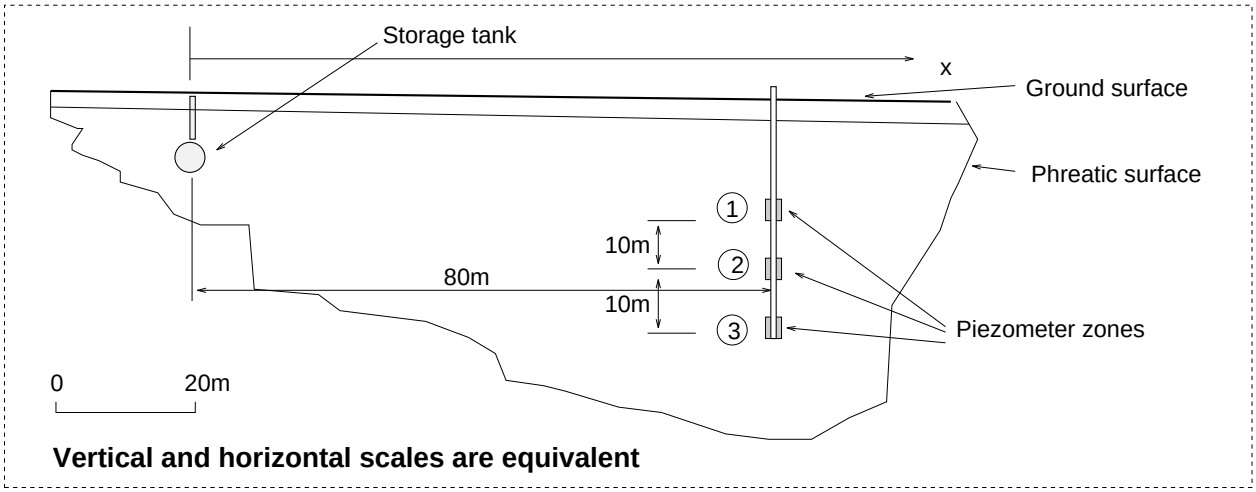
Inventory of water filling a disused underground storage tank, formerly filled with TCE, is known to have been lost. The water is suspected to carry ppm concentrations of TCE. The tank is located below the phreatic surface within an unconfined sandy aquifer. The regularly recorded inventory of the tank remained unchanged until December 1993 but had dropped significantly by May 1994, with no recorded withdrawals. On discovery of this, in May 1994, the remaining inventory was removed, and the tank interior grouted to surface.

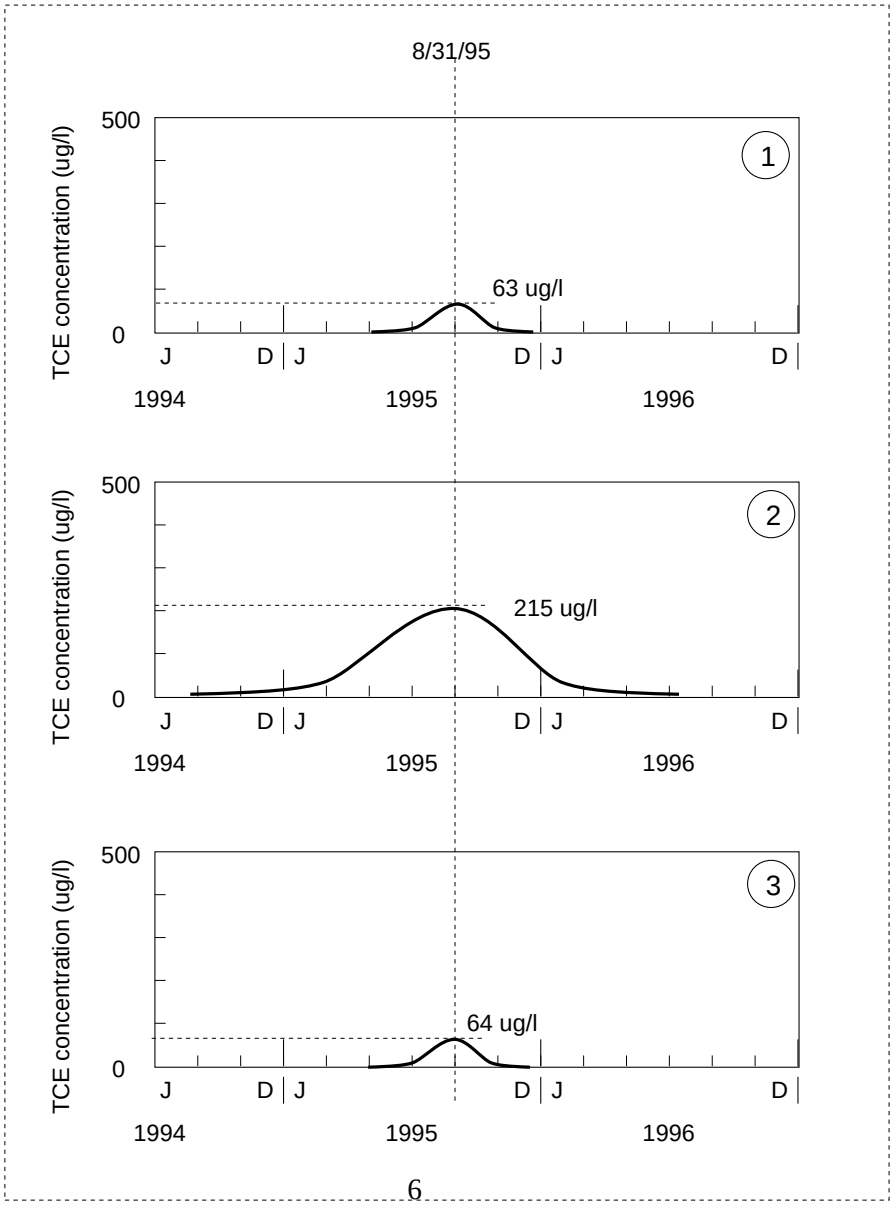
Piezometers were installed downgradient of the tank in July 1994, and monitored for TCE concentrations in the ground water. The approximate retardation coefficient for TCE in the clean sand is estimated at $R = 2$.

The results from a single multi-point piezometer array, recording the maximum change in concentration, and believed to intercept the plume center, are shown. The aquifer is laterally extensive and of a recorded saturated thickness greater than $100\ m$. The mean porosity of the aquifer is 27%.

Litigation between the tank owner and an adjacent landowner holds up remediation of the site until September 1996.

1. Evaluate the advective velocity (unretarded) within the aquifer.
2. If the slope of the water table is 1 vertical to 1000 horizontal, estimate the hydraulic conductivity of the sand aquifer.
3. Evaluate the longitudinal and lateral coefficients of hydrodynamic dispersion, D_L, D_T, for the aquifer.
4. Evaluate the dispersion coefficients, α_L, α_T, for the aquifer.
5. Determine the optimal location for the placement of a monitoring cluster of piezometers to detect the evolving plume? Define downgradient location and desired depth range below surface, if the earliest possible installation is September 1996.
6. Estimate the mass of TCE contained within the plume.


Storage tank
x
Ground surface
Phreatic surface
1
2
3
10m
80m
10m
Piezometer zones
0
20m
Vertical and horizontal scales are equivalent


8/31/95
TCE concentration (ug/l)
500
0
1
63 ug/l
J
D
J
D
J
D
1994
1995
1996
2
215 ug/l
3
64 ug/l