THE PENNSYLVANIA STATE UNIVERSITY
ENERGY AND MINERAL ENGINEERING
ENVSE 408 CONTAMINANT HYDROLOGY
ASSIGNMENT 3

Question 1

A core sample of sand, maintained fully water saturated, is placed within a Welge type apparatus. The solvent TCE is forced into the sample as water is forced out. From the following data, construct the capillary pressure –vs– saturation curve for TCE penetration.

Construct the capillary pressure –vs– saturation curve if the penetrating fluid is gasoline instead of TCE, and the properties of the fluid are as given.

Core Data

Core weight:	454.2 g (saturated)	415.0 g (dry)
Core dimensions:	5 cm (diameter)	10 cm (length).

Fluid Properties

	$\sigma\ (N/m)$	$\mu\ (N.s/m^2)$	$\gamma\ (kN/m^3)$
TCE	3.5×10^{-2} (TCE/water ($\theta = 0$))	$.96 \times 10^{-3}$	15.6
TCE	2.9×10^{-2} (TCE/air ($\theta = 0$))	—	—
Water	7.3×10^{-2} (Water/air ($\theta = 0$))	1.12×10^{-3}	9.8
Gasoline	2.6×10^{-2} (Gasoline/water ($\theta = 0$))	3.1×10^{-4}	6.7
Gasoline	2.2×10^{-2} (Gasoline/air ($\theta = 0$))	—	—

Note: $\nu = \mu/\rho$

At the site where the core is recovered, the uniform unconsolidated sand is present with the water table at the ground surface. If the source of the NAPL spills are 55 gallon drums present at the site, and punctured at their base, determine the following.

1. Determine the minimum height of TCE required within the leaking drum, resting on the ground surface, to initiate penetration of TCE into the aquifer.

2. Determine the minimum height of gasoline required within the leaking drum, resting on the ground surface, to initiate penetration of gasoline into the aquifer.

3. If possible, define the minimum or maximum saturation profiles with depth below the ground surface, for separate spills of TCE and gasoline. Assume that the initial critical height of NAPL above the ground surface is met/exceeded.

4. How will the field scale behavior, defined above, differ if a large volume of NAPL is available, versus as small volume?

Table 1: Fluid pressure applied to non-wetting NAPL (TCE) to expel a cumulative volume of the wetting fluid (water).

Fluid pressure (kN/m^2)	Cumulative volume expelled (ml)	Fluid pressure (kN/m^2)	Cumulative volume expelled (ml)
0.0	—	5.0	33.1
0.0	—	5.0	32.8
0.0	0.0	5.0	32.4
0.5	—	3.7	32.2
0.5	—	3.7	31.7
0.5	0.0	3.7	31.2
1.0	—	2.5	29.2
1.0	—	2.5	27.1
1.0	0.0	2.5	24.2
1.5	—	2.2	21.3
1.5	—	2.2	19.9
1.5	0.0	2.2	19.5
1.6	0.2	1.9	16.8
1.6	0.3	1.9	15.3
1.6	0.4	1.9	14.8
2.0	3.7	1.7	11.8
2.0	4.4	1.7	10.3
2.0	4.7	1.7	9.8
2.2	9.2	1.1	9.2
2.2	9.6	1.1	8.5
2.2	9.8	1.1	8.2
2.5	11.9	0.6	7.8
2.5	12.4	0.6	7.6
2.5	12.5	0.6	7.4
2.8	18.7	0.0	7.2
2.8	19.3	0.0	7.1
2.8	19.5	0.0	7.0
3.2	23.7		
3.2	24.1		
3.2	24.2		
4.0	28.8		
4.0	29.1		
4.0	29.2		
5.0	31.0		
5.0	31.1		
5.0	31.2		
7.0	32.9		
7.0	33.1		
7.0	33.2		

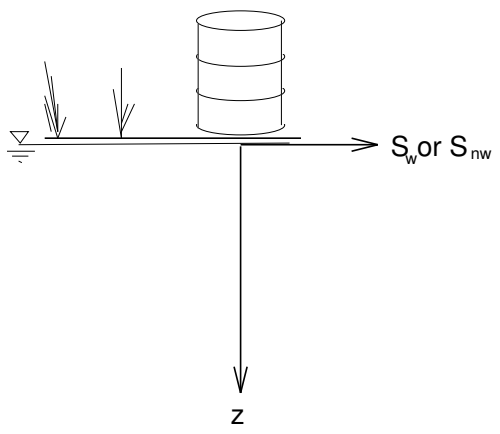
How will the behaviors differ in these two different situations, at field scale, if the spill location has a water table $1m$ below the surface?

Question 2

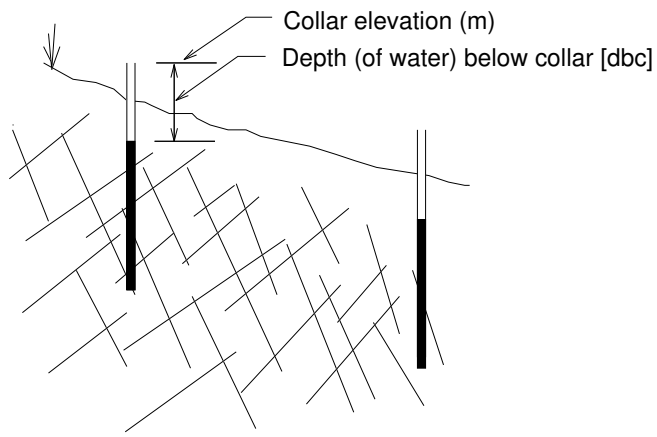
The site, shown in the attached figure, represents a shallow aquifer typical of New England and the Canadian Shield. A service station has leaked gasoline to the water table, and is acting as a source for dissolved BTEX degradation components.

Determine the rate at which hydrocarbons, dissolving at the water table, will migrate. Specifically, determine which of the well(s) may be affected, and the approximate travel times, given that retardation effects are ignored. Steady water levels are recorded within well(s) cased to uniform elevation below the ground surface, as given. Pumping tests reveal a hydraulic conductivity of $K = 2 \times 10^{-6} cm/s$ and core samples show an approximate spacing between the three sets of orthogonal fractures of $0.2m$. Matrix conductivities in the granite are of the order of $K = 10^{-12} cm/s$, with matrix porosities of the order of 0.01. What components of the gasoline would you expect to record in the contaminated well(s)?

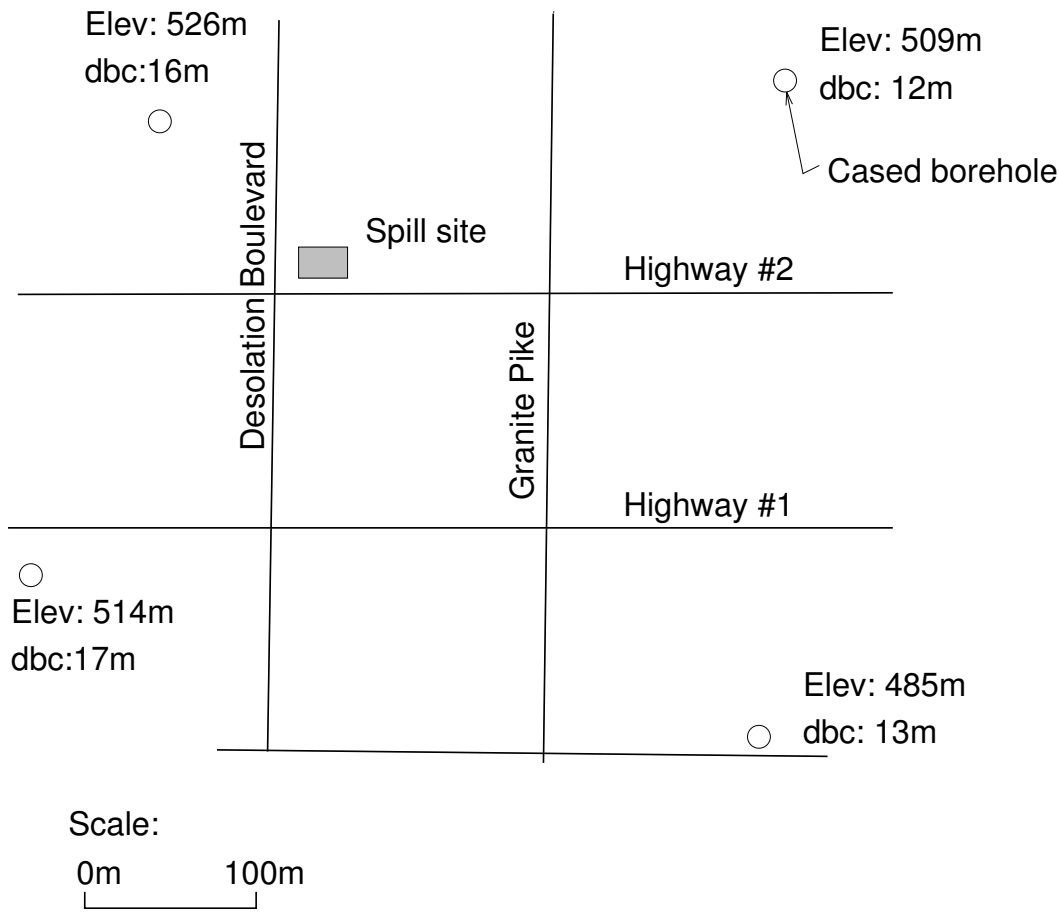
If the effective fracture spacing is $0.5m$, how will this affect the travel times and the components arriving at the well(s)?



Question 1



Question 2 (section)



Question 2 (plan)