EES 217 Physical and Chemical Hydrology
HW #2
Due: Wednesday Feb 13

Two multi-level samplers (MW-1 and MW-2), 1 kilometer apart, are installed in a 40 meter thick unconfined sand and gravel aquifer that has a point source of contamination from leaking detergent tanks. The ports (A,B,C) on the multi-level samplers are spaced at 10 meters apart with the first port (A) positioned at 10 meters below the water table. The results of the analysis are summarized below.

	MW-1	MW-2
Water level (Elevation in meters)	45.000	40.000
Land Surface (Elevation meters)	50.000	50.000
^{3}H values(TU)		
Port A	20	22
Port B	28	22
Port C	26	24
^{3}He/^{4}He Values (as R/R_{AIR})		
Port A	1.274	1.310
Port B	2.118	1.794
Port C	3.8	3.7
Detergent Concentration (ppm)		
Port A	10	0.1
Port B	100	20
Port C	5	100
Porosity	0.3	0.3

A) Determine the age of water at each sampling port and plot age versus depth below the water table. Why does the lower sampling port fall off a line drawn between the two upper sampling ports? Determine the vertical groundwater flow velocities from the upper two ports and determine the annual recharge rate from these two ports extrapolated to the water table. Use the equations in the Cape Cod paper to calculate V_o [Hint: If you rearrange the equation and plot the natural log of the depth (or B/B-z) vs. the age, then the slope of the line will be the recharge]. SHOW ALL WORK.

B) Using Calculations from the Vogel Model, calculate horizontal flow velocity(Vx) and horizontal hydraulic conductivity (Kx).

C) Calculate the V_X at the right hand boundary. Use the water balance (recharge in = flux out) to determine V_X. How does this V_X compare with the V_X from the Vogel Model?

Important constants:

$[^4He]$ in Water = 45μcc/kg
^3He(pcc/kg) x (10^{-6}) = ^3He (μcc/kg)
^3He(TU) = ^3He (pcc/kg) x 0.402

Age (years) = (1/ λ) * ln ((Daughter/Parent)+1) (Units of Parent and Daughter must be the same (ie, TU))

$\lambda = 0.0555$ years^{-1}

$R_{AIR} = 1.39 \times 10^{-6}$ $R_{SOL} = 0.985\ R_{AIR}$ pcc = 10^{-12} cc μcc = 10^{-6} cc

The Vogel Model:

recharge = V_z * Porosity $V_z = (B/t) * \ln[B/(B-z)]$ $\Delta X_f = \Delta X_1 / [([B - Z_1] * Z_2)/ [((B - Z_2) * Z_1) - 1]]$

$\Delta X_d = \Delta X_f * ((B - Z_1) / (Z_1))$ $Vx = (V_z * x) / B$ x = distance from flow divide

How to Calculate a $^3H/^3He$ age

In order to determine the age for the sample it is necessary to calculate the amount of tritiogenic ^3He (expressed as $^3He^*$) within the sample. The amount of ^3He within a sample can be shown as:

$$^3He_{tritium} = {}^3He_{total} - {}^3He_{SOL} = {}^4He_{MEASURED} * [(^3He/^4He)_{Total} - (^3He/^4He)_{SOL}]$$

This states that the total amount of ^3He within a sample is a result of the amount of ^3He contributed from solubility with air at the water table and the amount ^3He from tritium decay ($^3He_{tot} = {}^3He_{SOL} + {}^3He^*_{tritium}$ or $^3He^*_{tritium} = {}^3He_{tot} - {}^3He_{SOL}$). The amount contained of ^3He dissolved in the water will be a function of the solubility at a given temperature. In this exercise, the ^4He is at solubility equilibrium at 10°C (45 μcc/kg) for all samples.

To determine the amount of $^3He_{SOL}$ simply multiply the amount of 4He by the R_{sol}, this yields a number for $^3He_{sol}$ in units of μcc/kg).

We use the measured ratio normalized to the air value (1.39×10^{-6}) because air serves as the "standard gas". For the calculation you can use the "normalized ratio" (and then multiply by 1.39×10^{-6} as shown in the calculations) or convert all ratios to the absolute values by multiplying by the air ratio (e.g. 2.0 $R_{AIR} = 2.78 \times 10^{-6}$).