1. **Program the attached chart in Excel for the analytical solution of the 1-D advection-dispersion equation.** The equation to create the chart is written on the top of the chart. You can use the built-in ERFC function in excel to program the equation. Print the chart and print the spreadsheet and submit it as part of your homework.

2. **Transit-time Design of Compacted Clay Liner**

Assume that you are a geoenvironmental engineering consultant who is an expert in landfill related projects. Your client, Allied Waste Services, has made a formal request to you to design a compacted clay liner (CCL) for a new cell of a hazardous waste landfill to be located north of Grand Rapids, Michigan.

Assume that the regulatory requirements for the liner are a compacted clay liner having hydraulic conductivity \( k \leq 5 \times 10^{-8} \text{ cm/s} \). The leachate collection system for the cell is designed such that the maximum leachate head on the liner is \( \leq 300 \text{ mm} \). Leachate that will be produced from the hazardous waste will contain these two key contaminants of concern: methylene chloride and toluene. Maximum concentrations of methylene chloride and toluene in the leachate are expected to be 8 mg/L and 35 \( \mu \)g/L, respectively. Assume that the design life of the cell is 50 years. Data from literature suggests that the effective diffusion coefficients for methylene chloride and toluene are \( 1.5 \times 10^{-6} \text{ and } 5 \times 10^{-6} \text{ cm}^2/\text{s} \), respectively. Assume the partition coefficient \( (K_d) \) for methylene chloride for the clay soil is 0.13 mL/kg and for toluene it is zero (non-sorptive). State and federal ground water standards require the flux of leachate from the cell not to exceed 0.4 kg/ha/yr for methylene chloride and 3 grams/ha/yr for toluene.

Spartan Soil Testing lab has measured these properties of the clay source which will be used to construct the CCL:

1. Specific gravity of clay solids = 2.7
2. Effective porosity of the compacted clay = 0.35
3. Clay can be compacted to achieve a saturated hydraulic conductivity of \( \leq 5 \times 10^{-8} \text{ cm/s} \)
4. The dry unit weight of the compacted clay to achieve the above \( k \) value is 15.8 kN/m\(^3\) when compacted to the wet of optimum water content.
\[
C/C_0 = 0.5 \left[ \text{erfc}\left(\frac{1-TR}{2(TR/P_L)^{0.5}}\right) + \exp(P_L) \text{erfc}\left(\frac{1+TR}{2(TR/P_L)^{0.5}}\right) \right]
\]