

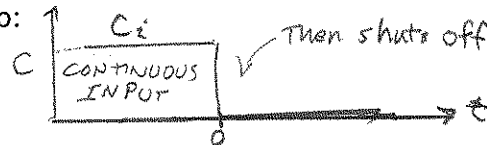
**CEE/ESM 479/579**  
**Fate and Transport**  
**Problem Set 2 - 2016**

1. In class we showed the results of introducing an instantaneous pulse of contaminant into a completely-mixed reservoir with a steady inflow of uncontaminated water and an equal outflow of reservoir water: Instantaneous increase to  $C = C_0$ , followed by exponential decrease of the form  $C = C_0 \exp(-t/\tau_r)$ . Consider a different situation. Suppose the reservoir for a long time has been receiving a steady and continuous input of contaminant such that:

At  $t < 0$ ,  $C_i = C_0$

(Neglect any decay). But then we get our clean-up act together, and we eliminate the input as a step function, from  $C_0$  to down to zero:

At  $t > 0$ ,  $C_i = 0$



What would be the response in concentration  $C$  in the reservoir after  $t = 0$ ? In other words what would the concentration in the outflow (= reservoir itself, of course) look like as a function of time? Show the relevant governing equation, your solution, and a graph of  $C$  vs.  $t$ . [Hint: This is not very hard. If it seems hard, just stop and think about it.]

2. Suppose we have a reservoir of the type in Part 1 above: constant volume, steady inflow of water that equals the outflow. We would like to know the hydraulic residence time of the reservoir, but unfortunately we don't have accurate data for the flows or the reservoir volume, and we have a very tight budget. Design a simple experiment we could run that would give us an estimate of  $\tau_r$  without actually measuring  $Q$  or  $V$ .
3. We are interested in determining the longitudinal dispersion coefficients for a small stream. To measure this, we inject a pulse of fluorescent rhodamine dye, which is a conservative tracer that can be easily and sensitively measured using a fluorometer, a portable device that measures the relative fluorescence in the water. In our case, we have access to a downstream array of in situ fluorometric probes (see: <http://www.fondriest.com/news/rhodaminedyetracersystem.htm>) which enables us to get a "snapshot" of the spatial distribution of dye concentrations, expressed in "relative fluorescence units" or RFU. Smoothed data sets for two such snapshot distributions,

one at 500 s after release and one at 750 s after release, are shown on the last page. Use these graphs to answer the following questions:

- a. What is the velocity of the stream and does it appear to be steady over this reach?
  - b. What is the longitudinal dispersion coefficient at  $t_1$  and at  $t_2$ ?
  - c. Is the dispersion coefficient steady throughout this reach of the stream? If not, what could explain the variation?
4. For the study area of the stream above, the mean depth is 0.8 m and the average slope of the streambed is  $S = 5 \times 10^{-4}$ .
- a. Calculate an estimate of the *transverse* dispersion coefficient  $D_t$ .
  - b. How does the magnitude of transverse dispersive transport compare to that of longitudinal dispersive transport?
  - c. How does your calculated value compare to reported coefficients presented in the text reading?

