CEE 483, Winter 2009, HW#2

1. A retention pond for stormwater treatment has a volume of 15,000 m^3 and is full at the beginning of a 4-h storm. During the storm, 10,000 m^3 of water enters the pond, at a steady rate of 2,500 m^3/h. To be effectively treated, water must stay in the pond for at least a few days; the contaminants are barely removed at all if water enters the pond during the storm and exits before the storm ends. If the pond can be modeled as a CMR, what fraction of the 10,000 m^3 of water that enters during the storm is still there at the end of the storm, and what fraction has already exited? (Hint: assume that some tracer compound is absent from the pond at $t = 0$, but is present in the storm water at, say 10 mg/L, and determine the concentration of the tracer in the pond at the end of the dry period. Then use that result to answer the question posed above.)

2. An overflow at a pond holding an industrial waste has allowed a toxicant to enter a river steadily over a six-hour period, generating a constant concentration of 0.1 mg/L of the compound in the river water. Prior to the spill, the river water contained none of the contaminant. Downstream, this river is the source for a water treatment plant. The flow rate through the plant is 1 m^3/s.

   Laboratory tests have shown that the compound can be degraded by hydrogen peroxide (H_2O_2). For the H_2O_2 dose that would be reasonable to add, the reaction rate is first order with respect to the toxicant, with a rate expression given by $r_{\text{tox}} = -k_1 c_{\text{tox}}$, where $k_1 = 0.35\ h^{-1}$. The plant operator proposes to add the H_2O_2 to the rapid mix tank just upstream of the flocculation basin, so that the reaction occurs in the flocculation basin, which can be reasonably represented as a CMR with a 2-h hydraulic residence time.

   (a) If the H_2O_2 is *not* added, so that the toxicant does not undergo any reaction, what will its concentration be in the flocculation basin three hours after the spill arrives at the plant inlet?

   (b) What will the toxicant concentration be three hours after the contaminated water reaches the plant inlet, if the H_2O_2 is added continuously from the time when the toxicant first appears in the influent?

   (c) An additional measure that is being considered is turning off the paddle wheels in the flocculation basin, so that it approximates a PFR. Sketch on the graph provided below the effluent concentration vs. time that you would expect in this scenario for the period from $t = 0$ to 10 h, assuming that the H_2O_2 is dosed as in part *b*.

3. The raw water supply for a community contains 9 mg/L total particulate matter and is to be treated by addition of 30 mg alum ($Al_2(SO_4)_3 \cdot 14\ H_2O$) per liter of water. Essentially all of the added alum precipitates by the reaction shown below, generating a "sweep floc."

   $$Al_2(SO_4)_3 \cdot 14\ H_2O \rightarrow 2\ Al(OH)_3(s) + 3\ SO_4^{2-} + 6\ H^+ + 8\ H_2O$$

For a total flow of 7500 m^3/d, compute the daily alum requirement, the concentration of all solids entering the sedimentation basin (including both those initially present and those formed in the coagulation step), and the daily load of solids requiring disposal.