CEE 483, Winter 2009, HW#3

1. A suspension contains a total of 10 mg/L of non-flocculating particles that are characterized by the following distribution of sizes and densities.

Particle Type	Diameter (μm)	Density (g/cm^3)	Percentage of Particles (by weight)
A	3	1.60	10
B	10	2.65	10
C	20	1.10	70
D	50	1.85	10

(a) Assuming that the particles are approximately spherical, compute the particle number distribution (i.e., the percentage of all particles that is in each size range, based on particle numbers rather than particle mass).

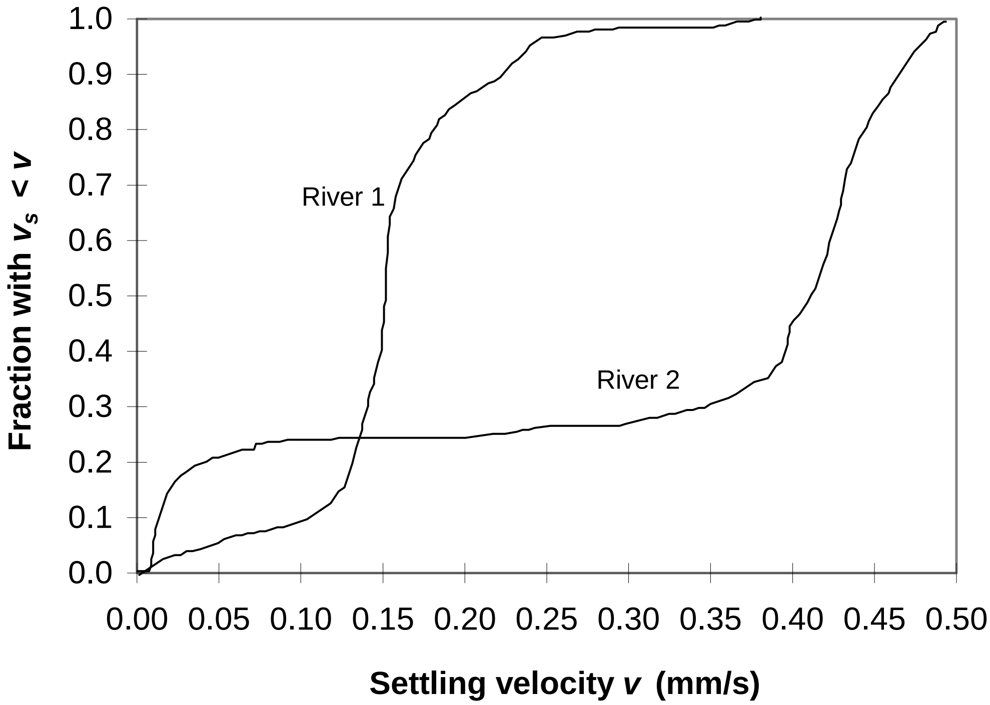
(b) Using a force balance, estimate the amount of time and the distance traveled for the 20-μm particles to reach a velocity equal to 90% of their terminal velocity in a solution at 25^{o}C. The calculations can be carried out using either an analytical approach (involving integration of the force balance) or numerically (in a spreadsheet).

(c) What would the particle concentration be in the effluent from a settling basin that received the given suspension as influent, if the hydraulic residence time was 3 hours and the effective settling depth was 2 m, assuming perfect plug flow through the tank?

2. Because of population growth in the service area, a water treatment plant is to be expanded to treat twice as much water as it currently does. The additional water is to be taken from a different source which has a total particle concentration 50% larger than the particle concentration in the current source water. The settling properties of the suspended sediments in the original supply (River 1) and in the new source (River 2) are shown in the following figure.

a. Which river has a larger fraction of particles which settle at a rate > 0.25 mm/s?

b. The waters are mixed in equal proportions, and the mixed suspension is then treated in a system designed for a critical velocity of 0.1 mm/s. Estimate the overall fractional particle removal that will be achieved.



3. A settling test on a suspension has yielded the following data for removal of particulate mass as a function of time and depth. Plot the data in two ways: as isopleths of constant fractional removal on a plot of depth versus time and as f (the fraction of the mass with average settling velocities less than v) versus v. On the latter plot, show curves for settling times of 30 and 60 minutes. Estimate the overall removal efficiency for particle mass in a basin that has an effective settling depth of 2.4 m and a hydraulic residence time of 60 minutes using both graphs.

	Depth (m)			
	0.6	1.2	1.8	2.4
Time (min)	Percentage removal of particles (based on mass)			
0	0	0	0	0
10	21	18	13	12
20	31	24	22	19
30	50	34	30	28
45	60	51	44	41
60	78	58	54	52
90	85	82	78	69

4. The raw water supply described in Problem #3 of HW2 has a pH of 7.3 and an alkalinity of 3×10^{-4} equiv/L. Estimate the pH after the alum addition, and the lime ($Ca(OH)_2$) dose, in mg/L, needed to yield a final pH of 8.0.

5. Write a brief critique (approx. 1 single-spaced page) of one of the three Opflow articles that have been assigned. Describe the problem that the article addresses, the solution that it advocates, and the benefits that are claimed. Also identify any shortcomings that you can find in the article, including errors (not typos, but conceptual errors) and/or missing information or explanations that you feel could have enhanced the article.