Additional Problems

1. Lake Superior contains 10% of the Earth's freshwater. Lake Superior has a surface area of 8.21 x 10^{10} m^2, an average depth of 145 m, and an average water residence time of 112 years. Although Lake Superior is considered a pristine lake it is subject to atmospheric inputs of pollutants. Polychlorinated biphenyls (PCBs) have entered the lake primarily through atmospheric inputs and have resulted in an average water concentration of 2.2 ng/L. PCBs are considered to be resistant to degradation. (a) Prepare a plot of PCB concentration versus time (from 0 to 400 years) assuming that the major removal mechanism is washout in the St. Mary's River (the effluent river). (b) When will the PCB concentration in the lake be 0.05 ng/L?

2. Pine lake is a kettle lake located in upstate New York. The lake has a volume of 198100 m^3. The stream draining the lake has a average flow rate of 6603 m^3/day. If an instantaneous release of an insecticide is evenly distributed in the lake at a concentration of 1 mg/L, (a) how long will it take for the concentration to reduce to 1 mg/L?, (b) create a concentration versus time plot showing the change in concentration for a 1 year period, and (c) compare the concentration plot to one created without the first-order removal process. Assume that the insecticide degrades with a half-live of 24 days.

3. Lake Erie was severely contaminated from industrial activities prior to 1980. Since this time considerable effort has been made to remove or minimize these industrial inputs. For purposes of this section, say that the concentration of Toxin X in Lake Erie is 2.50 mg/L in the water. The lake has a hydraulic residence time of 3.00 years and Toxin X degrades at a rate of 1.39/yr. (a) When will the concentration of Toxin X be below 5 mg/L? (b) When would the concentration be below 5 mg/L if no degradation occurs?

4. A nuclear plant is located on a reservoir and accidentally releases 0.05 Curries of Cs-137. The Cs-137 has a half-life of 30.17 years. The reservoir has a surface area of 485000 m^2, an average depth of 85 m, and a hydraulic residence time of 1.8 years. Assume that the Cs is evenly spread over the volume of the lake. (a) What is the activity of Cs-137 in 5 years. (b) How long will it take for the Cs to reach an activity of 1 pCi/m^3?