Answer 9.4
Since Propane and TCE are both water-side controlled [H >> 0.01], from Chapter 9 we expect the rate constants describing their exchange with the atmosphere to have the following ratios:

Thin-Film Model, Water-Side Control

$$\frac{K_{TCE}}{K_{Propane}} = \frac{D_{wTCE}}{D_{wPropane}}$$

Surface Renewal Model, Water-Side Control

$$\frac{K_{TCE}}{K_{Propane}} = \sqrt{\frac{D_{wTCE}}{D_{wPropane}}}.$$

The channel Reynolds number based on hydraulic radius is Re_{RH}=13,000, indicating that the flow is turbulent. As described in the text, empirical evidence suggests that the surface renewal model is more appropriate for turbulent flows. Using this model, $K_{TCE} = 1.1 \times 10^{-4}\ s^{-1}$.

Given that the atmospheric concentration of TCE is negligible, the flux of TCE to the atmosphere can be represented by the first-order sink, $S = -K_{TCE}C$, in the mass balance equation for the stream. As a first guess, we assume that this is the only source/sink of TCE along the stream. Assume that the cross-section has uniform concentration, *i.e.* with rapid mixing, $\partial C/\partial y = \partial C/\partial z = 0$. Assume the system is at steady-state ($\partial C/\partial t = 0$). Then, the mass balance equation is $u\partial C/\partial x = -K_{TCE}C$. With an upstream boundary condition, $C = C_o = 10$ ppb at $x = 0$, the concentration downstream of the source will be

$C(x) = C_o \exp(-K_{TCE}x/u)$.

Evaluating this at x = 2000m,

$C(x = 2km) = 10ppb \exp(-(1.1 \times 10^{-4}\ s^{-1})(2000m)/(0.1ms^{-1})) = 1.1$ ppb.

The estimated concentration is much less than the measured concentration at this position (C = 5 ppb). This suggests that there is another source of TCE between x = 0 and 2 km.