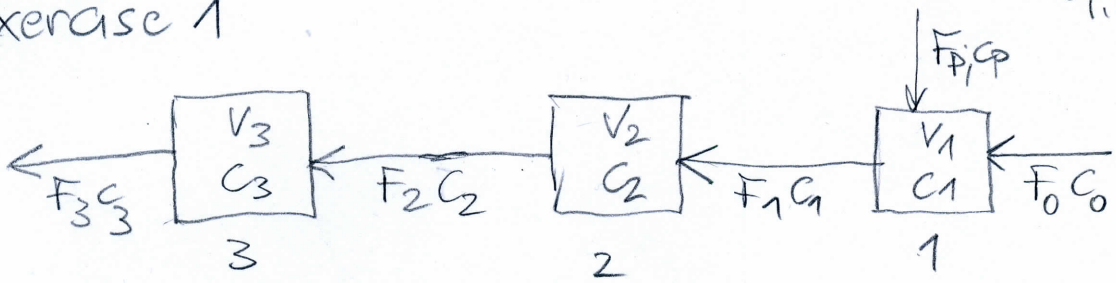
Exercise 1

9.2.1



Total mass balances with $dV_i = 0$, $d\rho = 0$

$$F_1 = F_p + F_0 \; ; \; F_2 = F_1 \; ; \; F_3 = F_2$$

Region 1

$$V_1 \frac{dC_1}{dt} = F_0 C_0 + F_{p,c_p} - F_1 C_1$$

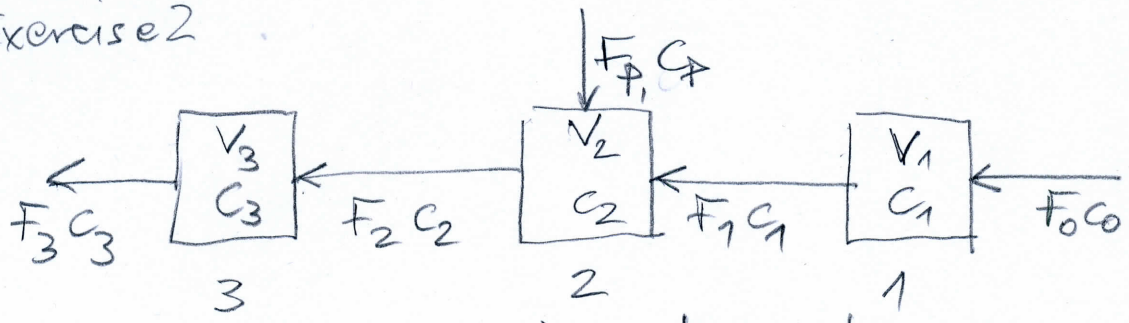
Region 2

$$V_2 \frac{dC_2}{dt} = F_1 C_1 - F_2 C_2$$

Region 3

$$V_3 \frac{dC_3}{dt} = F_2 C_2 - F_3 C_3$$

Exercise 2



Total mass balances with $dV=0$; $d\rho=0$

$$F_1 = F_0 \; ; \; F_2 = F_p + F_1 \; ; \; F_3 - F_2$$

Region 1 no pollutant → balance not needed

$$C_0 = 0$$

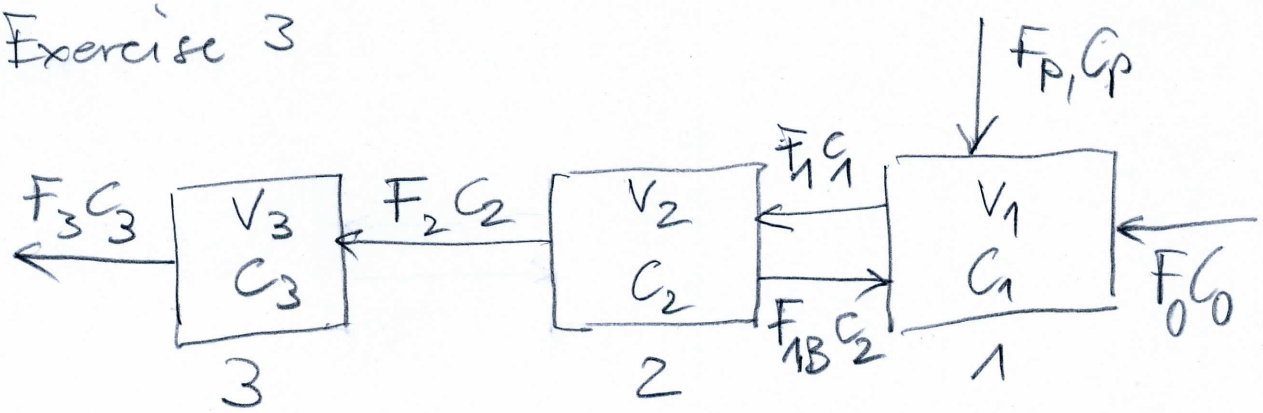
Region 2 $C_1 = 0$

$$V_2 \frac{dC_2}{dt} = F_p C_p$$

Region 3

$$V_3 \frac{dC_3}{dt} = F_2 C_2 - F_3 C_3$$

Exercise 3



Total mass balances with $dV=0$, $d\rho=0$

$$0 = F_P + F_0 + F_{1B} - F_1$$

$$0 = F_1 - F_2 - F_{1B}$$

$$0 = F_2 - F_3$$

Region 1:

$$V_1 \frac{dC_1}{dt} = F_0 C_0 + F_P C_P + F_{1B} C_2 - F_1 C_1$$

Region 2:

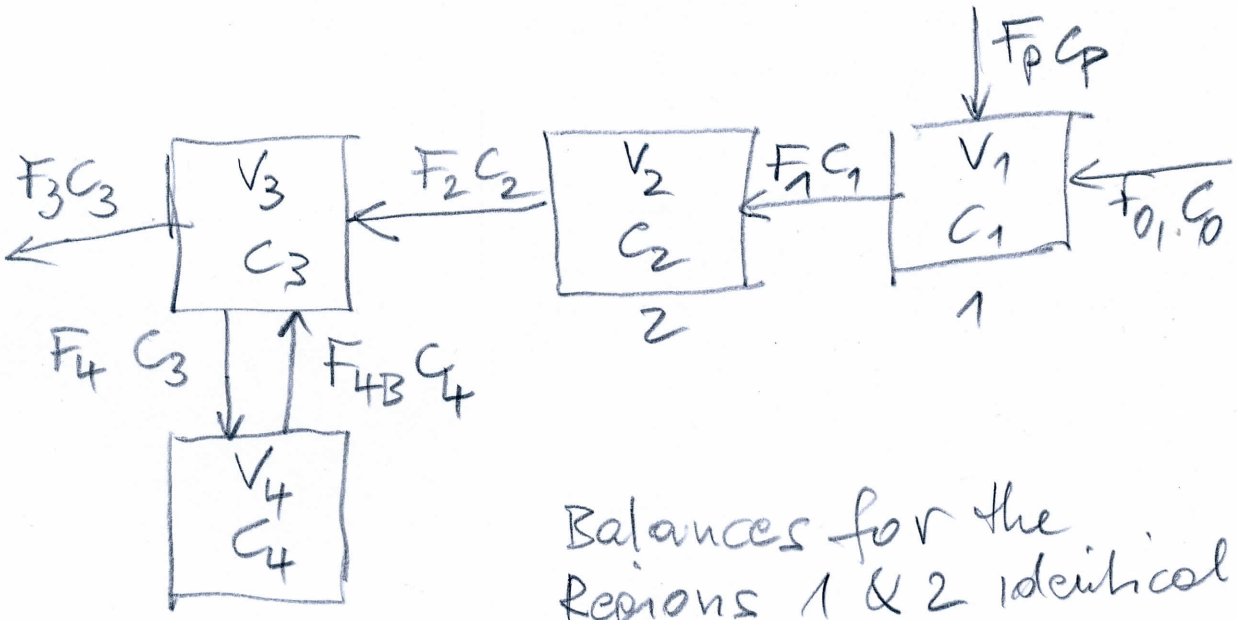
$$V_2 \frac{dC_2}{dt} = F_1 C_1 - F_2 C_2 - F_{1B} C_2$$

Region 3

$$V_3 \frac{dC_3}{dt} = F_2 C_2 - F_3 C_3$$

Exercise 4.

It could be that the actual 3D shape of the lake suggest the probable existence of dead zone, e.g. because of large depth in Region 3,



Balances for the Regions 1 & 2 identical to Exercise 1

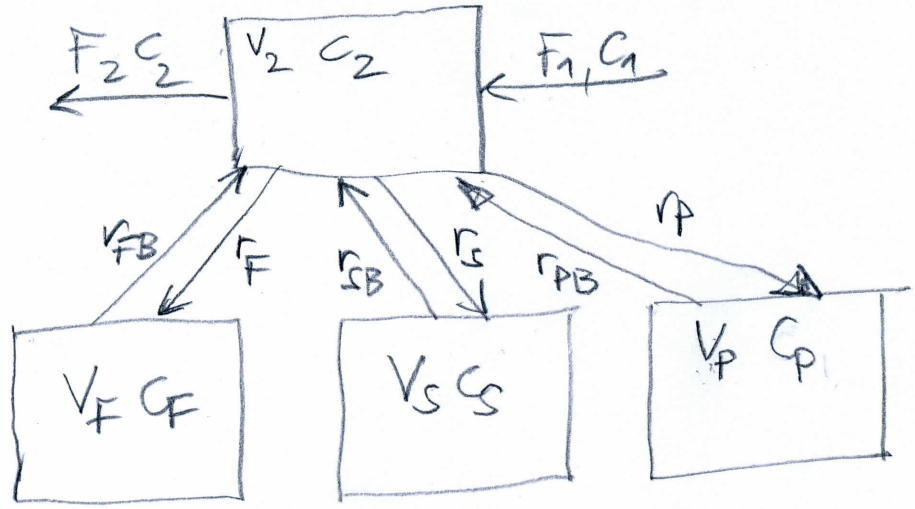
Region 3

$$V_3 \frac{dC_3}{dt} = F_2 C_2 - F_3 C_3 - F_4 C_3 + F_{4B} C_4$$

Region 4

$$V_4 \frac{dC_4}{dt} = F_4 C_3 - F_{4B} C_4$$

Exercise 5.
Consider only one lake region here



Define three new balance regions, one for plants (P), one for sediment (S) and one for fish (F) with volumes (V_i), forward rates (r_i) and backward rates (r_{iB}).