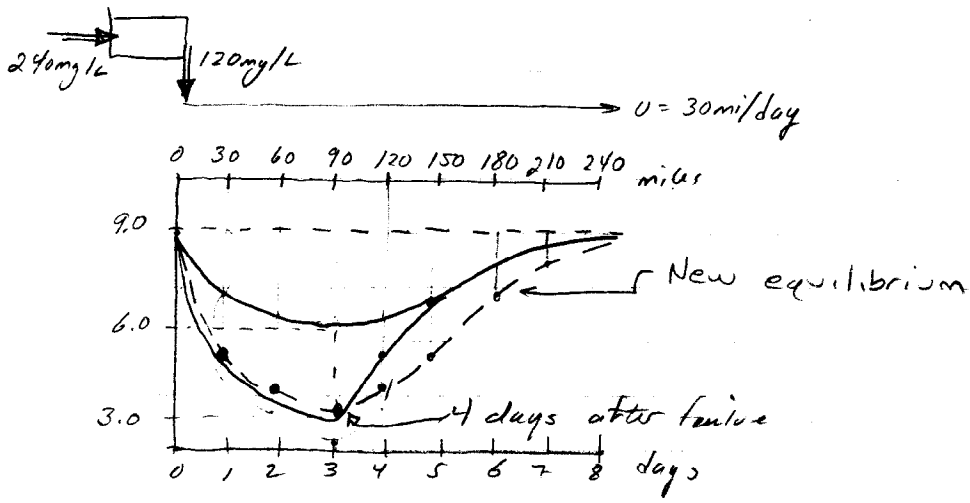
CIVE 3331 PROBLEM 5-26

Raw sewage BOD = 240 mg/L sent to plant that achieves 50% removal. Effluent produces Oxygen sag curve shown.



a) Assume plant fails, draw new DO sag curve after long time (equilibrium)

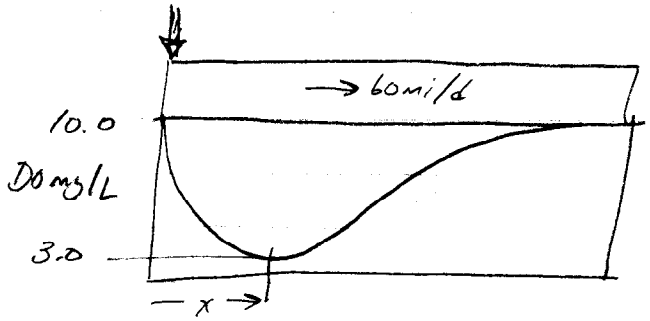
$$D(x) = \frac{k_d(L_0)}{k_r - k_d}\left(e^{-k_d x/u} - e^{-k_r x/u}\right) + D_0 e^{-k_r x/u}$$

Only change in equation is value of L_0, the ultimate BOD. It essentially doubles. Therefore $D(x)$ is doubled.

b) Sketch DO sag curve after only 4 days.
- day 5 & beyond no change (upset has not arrived yet)
- days 1 – 3 are probably near new equilibrium.
- day 4 is between old & new equilibrium.

CIVE 3331 Problem 5-27 1/2

Suppose only source of BOD is untreated waste from food processing plant. DO sag 3mg/L occurs downstream of plant as shown



$k_r = 0.8/d$ $k_d = 0.2/d$

a) by what % should BOD of wastes be reduced to achieve DO = 5.0 mg/L everywhere?

$$D = \frac{k_d L_o}{k_r - k_d}\left(e^{-k_d x/u} - e^{-k_r x/u}\right) + D_o e^{-k_r x/u}$$

from sketch we observe that $D_o = 0$

$$D = \frac{k_d L_o}{k_r - k_d}\left(e^{-k_d x/u} - e^{-k_r x/u}\right)$$

$$\frac{x_c}{u} = \frac{1}{k_r - k_d} \ln\left\{\frac{k_r}{k_d}\left(1 - \frac{D_o(k_r - k_d)}{k_d L_o}\right)\right\} = \frac{1}{0.8-0.2}\ln\left(\frac{0.8}{0.2}\right) = 2.31 \text{ day.}$$

($D_o = 0$)

$$D(x_c) = 7.0 \text{ mg/L} = \frac{(0.2)(L_o)}{(0.6)}\left(e^{-0.2(2.31)} - e^{-0.8(2.31)}\right)$$

$$7.0 \text{ mg/L} = 0.1575 L_o$$

$$L_o = \frac{7.0}{0.1575} = 44.4 \text{ mg/L}$$

Goal is to reduce $D(x_c)$ from 7.0 mg/L to 5.0 mg/L

$$L_o = \frac{5.0}{0.1575} = 31.7 \text{ mg/L}$$

$$\therefore \frac{44.4 - 31.7}{44.4} \times 100\% = 43.4 \text{ \% reduction required}$$

2/2

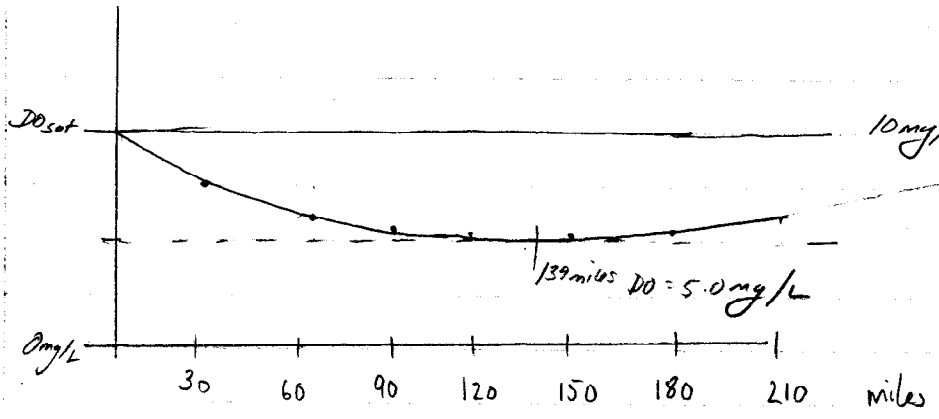
Will a primary plant achieve this reduction? Cannot answer based on information in text.

b) Where does lowest DO occur?

$\frac{X_c}{U} = 2.31 \text{ days}$ $X_c = U \cdot 2.31 \text{ day} = 60 \text{ mi/l} \; 2.31 \text{ day} = 138.6 \text{ miles}$

c) Already calculated $L_o = 31.7 \text{ mg/L}$ for 5.0 mg/L DO.

d) Sketch the DO curve



CIVE 3331 PROBLEM 5.31

Find min DO expected

	Waste	River	
Q	0.3	0.9	m^3/s
L_o	6.4	7.0	mg/L
DO_o	1.0	6.0	mg/L
k_d		0.2	day^{-1}
k_r		0.37	day^{-1}
U		0.65	m/s
DO_{sat}	8.0	8.0	

$$D = \frac{k_d L_o}{k_r - k_d}\left(e^{-k_d x/U} - e^{-k_r x/U}\right) + D_o e^{-k_r x/U}$$

Need L_o of mixture

$$L_o = \frac{Q_W L_W + Q_R L_R}{Q_W + Q_R} = \frac{(0.3)(6.4) + (0.9)(7.0)}{1.2} = 6.85 \text{ mg/L}$$

Need D_o (initial deficit) of mixture

$$D_o = DO_{sat} - \frac{Q_W DO_W + Q_R DO_R}{Q_W + Q_R} = 8.0 - \frac{(0.3)(1.0) + (0.9)(6.0)}{1.2} = 3.25 \text{ mg}$$

Now find $\frac{X_c}{U}$ from

$$\frac{X_c}{U} = \frac{1}{k_r - k_2} \ln\left(\frac{k_r}{k_d}\left(1 - \frac{D_o(k_r - k_d)}{k_d L_o}\right)\right)$$

$$= \frac{1}{(0.37 - 0.2)} \ln\left(\frac{0.37}{0.2}\left(1 - \frac{3.25(0.37 - 0.2)}{0.2(6.85)}\right)\right) = 0.581 \text{ days}$$

$$X_c = (0.65 m/s)(86400 s/d)(0.581 day) = 32\,662 \text{ meters} = 32.6 \text{ km}$$

Now find $D(X_c) = \frac{(0.2)(6.85)}{(0.17)}\left[e^{-0.2(0.581d)} - e^{-0.37(0.581day)}\right] + 3.25\, e^{-(0.37)(0.581)}$

$$= 3.29 \text{ mg/L}$$

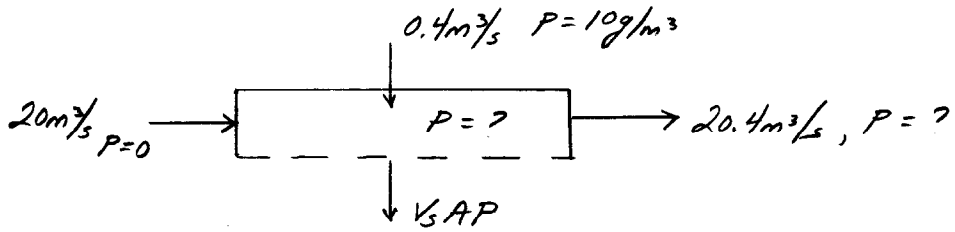
LAKE S.A. = $100 \cdot 10^6 m^2$

P SOURCE IS $0.4 m^3/s$ @ 10mg/L ($10 g/m^3$)

STREAM FLOW IN = $20 m^3/s$, P = 0.

V_s = 10m/yr.

ESTIMATE P CONC.



INFLOW	OUTFLOW	ACCUMULATION
$20(0) + 0.4(10)$	$-(10)(100 \cdot 10^6)P$	$= 0$
	$(20.4)P$	

$$4 g/sec - (10 m/yr)\left(\frac{1 yr}{365 d}\right)\left(\frac{1 d}{86400 sec}\right)(100 \cdot 10^6 m^2)P - 20.4P = 0$$

$$4 g/sec - 31.7 \frac{m^3}{sec} P - 20.4 \frac{m^3}{sec} P = 0$$

Solve for P $\quad P = \dfrac{4 g/sec}{52.1 m^3/sec} = 0.0767 g/m^3$

$$0.0767 g/m^3 = \frac{76.7 mg}{m^3} \cdot \frac{1 m^3}{1000 L} = \underline{\underline{0.0767 mg/L}}$$ ←

HOW MUCH TREATMENT TO GET P = 0.01 mg/L?

$\dfrac{x}{52.1} = 0.01 \quad \therefore x = 0.521$

$0.4(y) = 0.521 \quad y = 1.302 g/m^3$

% removal: $\dfrac{10 - 1.302}{10} \times 100 = 87\%$ ←