

Hydrocycle - Chapter 1

Sample Problem Infiltration

$$\begin{aligned} f_p &= f_c + (f_0 - f_c) e^{-kt} \\ &= 10 + 110 e^{-t/2} \end{aligned}$$

Now, create a plot of f_p vs time and P vs time for each of the three storms (see next page)

Storm 1 25 mm/hr for five hours

$$I = \int_0^{t_{\text{end}}} \min(P, f_p) dt$$

P and f_p intersect once at 4 hrs. Before this $P < f_p$
after $P > f_p$

$$\begin{aligned} \therefore I &= \int_0^4 P dt + \int_4^5 f_p dt \\ &= \int_0^4 25 dt + \int_4^5 10 + 110 e^{-t/2} = 121.7 \text{ mm} \end{aligned}$$

Storm 2

Hour 0-1	25 mm/hr
Hour 1-3	10 mm/hr
Hour 3-5	50 mm/hr

Again the curves intersect once ~ at 3 hours

$$\begin{aligned}
 I &= \int_0^{t_{\text{end}}} \min(P, S_p) dt \\
 &= \int_0^3 P dt + \int_3^5 S_p dt \\
 &= \int_0^1 25 dt + \int_1^3 10 dt + \int_3^5 10 + 10 e^{-t/2} dt \\
 &= 96 \text{ mm}
 \end{aligned}$$

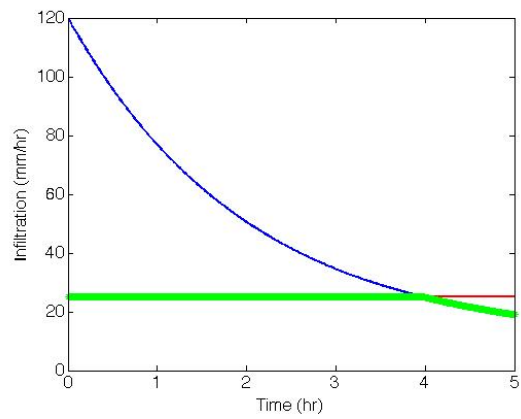
Storm 3

Hour 0-1	50 mm/hr
Hour 1-3	25 mm/hr
Hour 3-5	10 mm/hr

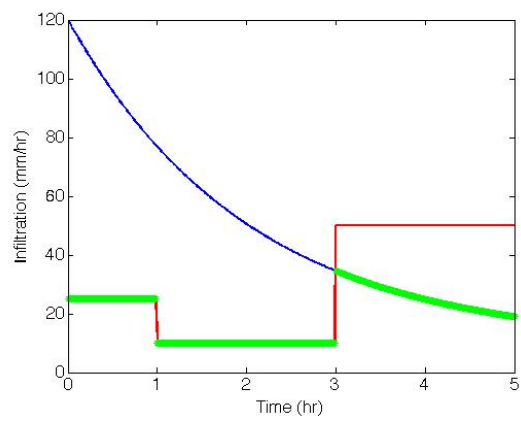
This time the curves never intersect $\Rightarrow$

$$\begin{aligned}
 I &= \int_0^{t_{\text{end}}} \min(P, S_p) dt = \int_0^5 P dt \\
 &= \int_0^1 50 dt + \int_1^3 25 dt + \int_3^5 10 dt \\
 &= 120 \text{ mm}
 \end{aligned}$$

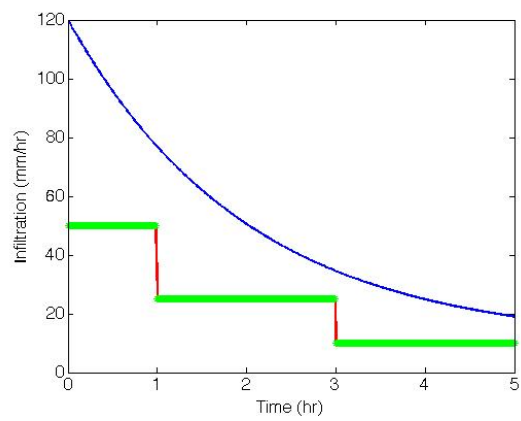
Storm 1



Storm 2



Storm 3



Seasonal Baseflow Recession

Use the figure provided (open in Matlab if helpful) and see next page also.

Step 1 Find time t_1

$$Q_0 \text{ for season 1} = 1692 \text{ m}^3/\text{s} \quad @ \text{ month 2}$$

$$Q_0 \approx 169.2 \text{ m}^3/\text{s} \quad @ \text{ month 6.5}$$

$$\therefore t_1 = (6.5 - 2) = 4.5 \text{ months}$$

Step 2

$$V_{tp}^{(1)} = \frac{Q_0^{(1)} t_1}{2.3} = \frac{(1692)(4.5 \times 3600 \times 24 \times 30)}{2.3}$$

$$= 1.97 \times 10^{10} \text{ m}^3$$

$$V_{tp}^{(2)} = \frac{Q_0^{(2)} t_2}{2.3}$$

$Q_0^{(2)}$ is Q at beginning of 2nd year recession

$$Q_0^{(2)} = 2218$$

$$\therefore V_{tp}^{(2)} = \frac{(2218)(4.5 \times 3600 \times 24 \times 30)}{2.3}$$

$$= 2.58 \times 10^{10} \text{ m}^3$$

Step 3 Calculate $V_t^{(1)} = \frac{V_{tp}^{(1)}}{10^{t/t_1}}$

t is total length of recession in year 1

Recession starts @ month 2 } $\Rightarrow t = 10 - 2 = 8$
ends @ month 10

$$\therefore V_t^{(1)} = \frac{1.97 \times 10^{10}}{10^{(8/4.5)}} = 3.2862 \times 10^8 \text{ m}^3$$

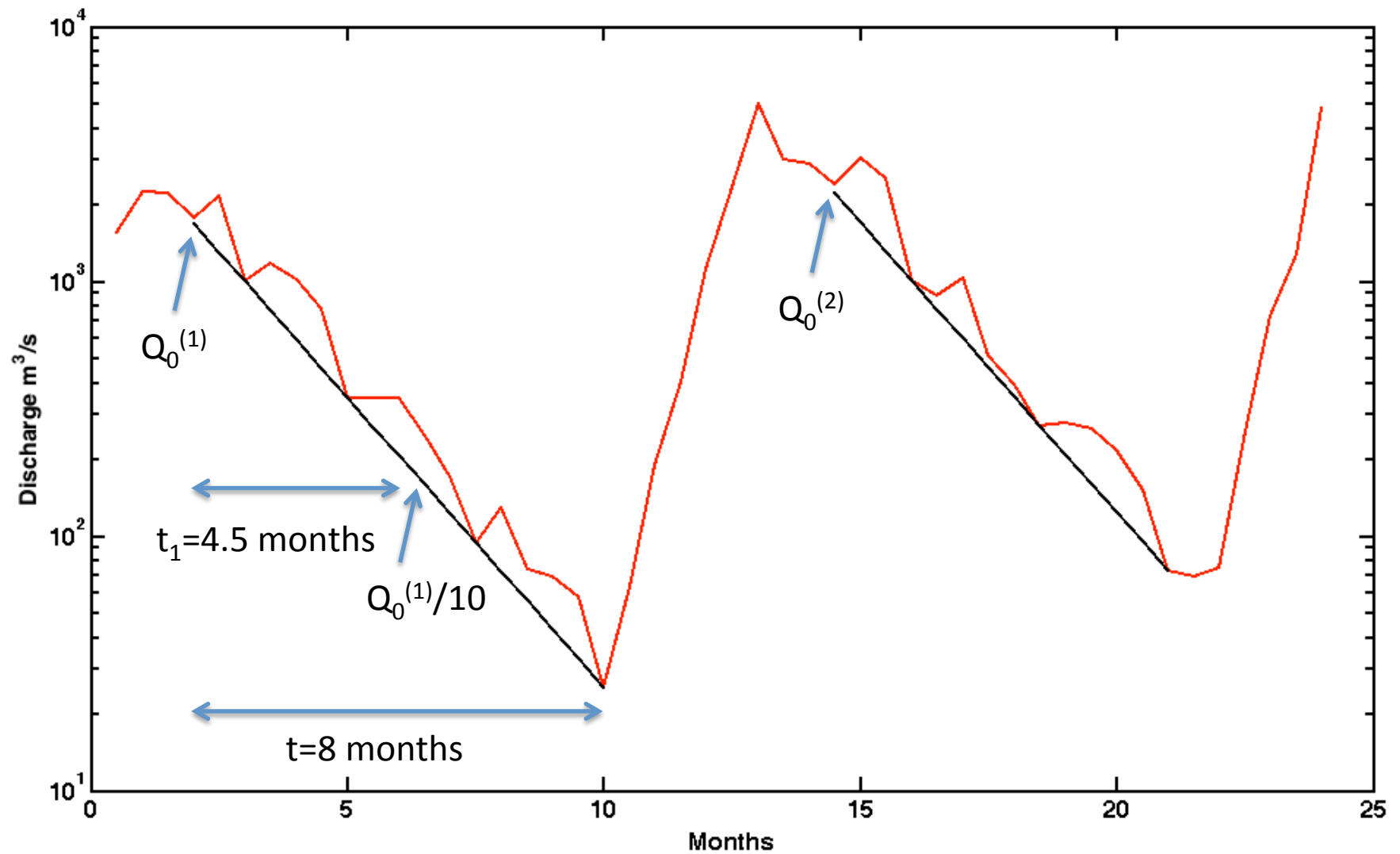
$$\text{Recharge} = V_t^{(2)} - V_{tp}^{(1)}$$

$$= 2.58 \times 10^{10} - 3.2862 \times 10^8$$

$$= 2.547 \times 10^{10} \text{ m}^3 \approx V_t^{(2)}$$

because

$$V_{tp}^{(1)} \ll V_t^{(2)}$$



Note – to read off the actual data you can open the Matlab figure (download from website)

Recession Curve Displacement

See attached figure

Step 1 ~ Calculate t_1

t_1 is the time it takes for Q to drop to $\frac{Q}{10}$.

Pick any point on either the black or ~~red~~ lines
(which are fit to the early and late parts
of the data)

I will pick black line and $Q = 683 \text{ m}^3/\text{s}$ on day 5

When is $Q = \frac{683}{10} \approx 68.3 \Rightarrow \approx \text{day } 29$

$$\therefore t_1 = (29 - 5) = 24 \text{ days}$$

[Aside ~ for the sake of argument say I had picked

$Q = 466.5$ on day 9

$\frac{466.5}{10} \approx 46.65$ happens around day 33

$\Rightarrow t_1 = 33 - 9 = 24 \text{ days} \Rightarrow \text{Consistent!}^+$

It does not matter where I pick Q
as long as I stay on the same line

Step 2 $t_c = 0.2144 t_1 = 5.14 \text{ days}$

Step 3 Peak in data happens on day 13

$\therefore$ Go 5.14 days beyond this $\approx 18 \text{ days}$

Step 4 Measure Q_A and Q_B at this time

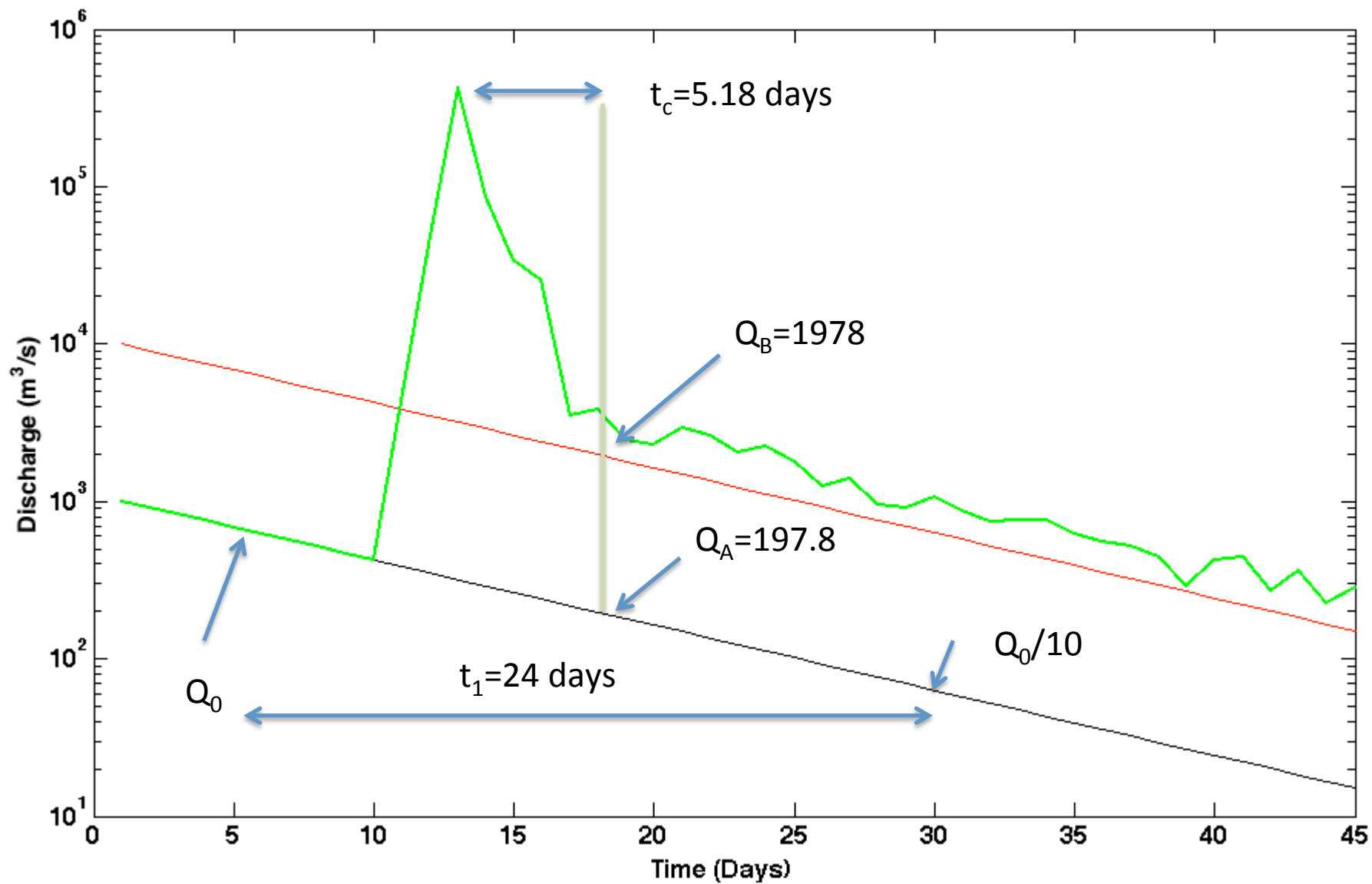
$$Q_B = 1978 \text{ m}^3/\text{s}$$

$$Q_A = 197.8 \text{ m}^3/\text{s}$$

Step 5 $G = \frac{2}{2.3} (Q_B - Q_A) t_1$

$$= \frac{2}{2.3} (1978 - 197.8) (24 \times 3600 \times 24)$$

$$= 3.2 \times 10^7 \text{ m}^3$$



Manning Equation

$$w = 0.5 \text{ m}$$

$$d = 0.2 \text{ m}$$

Mountain stream with rocky bed $\Rightarrow n = 0.05$

$$S = \frac{2}{10} = 0.2$$

$$R = \frac{A_c}{P_{\text{wetted}}} = \frac{\cancel{wd} \quad wd}{w + 2d}$$

$$Q = v A_c = \left(\frac{R^{2/3} S^{1/2}}{n} \right) (wd)$$

$$= \left(\frac{\left(\frac{wd}{w + 2d} \right)^{2/3} (S^{1/2})}{n} \right) (wd)$$

$$= \left(\frac{\left(\frac{(0.5)(0.2)}{0.5 + 0.4} \right)^{2/3} (0.2)^{1/2}}{0.05} \right) (0.5)(0.2)$$

$$= 0.2 \text{ m}^3/\text{s}$$