Hydrocycle - Chapter 1

Sample Problem Infiltration

$$f_p = f_c + (f_o - f_c)\, e^{-kt}$$
$$= 10 + 110\, e^{-t/2}$$

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

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

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

$$\therefore\ I = \int_0^4 P\, dt + \int_4^5 f_p\, dt$$

$$= \int_0^4 25\, dt + \int_4^5 10 + 110\, e^{-t/2} = 121.\cancel{7}\ mm$$

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

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

$$= \int_0^3 P\, dt + \int_3^5 f_p\, dt$$

$$= \int_0^1 25\, dt + \int_1^3 10\, dt + \int_3^5 10 + 110 e^{-t/2}\, dt$$

$$= 96 \text{ mm}$$

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 $\Rightarrow$

$$I = \int_0^{t_{end}} \min(P, f_p)\, dt = \int_0^5 P\, dt$$

$$= \int_0^1 50\, dt + \int_1^3 25\, dt + \int_3^5 10\, dt$$

$$= 120 \text{ mm}$$

Seasonal Baseflow Recession

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

Step 1 Find time t_1

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

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

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

Step 2 $$V_{tp}^{(1)} = \frac{Q_o^{(1)} t_1}{2.3} \doteq \frac{(1692)(4.5 \times 3600 \times 24 \times 30)}{2.3}$$

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

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

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

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

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

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

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

t is total length of recession in year 1

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

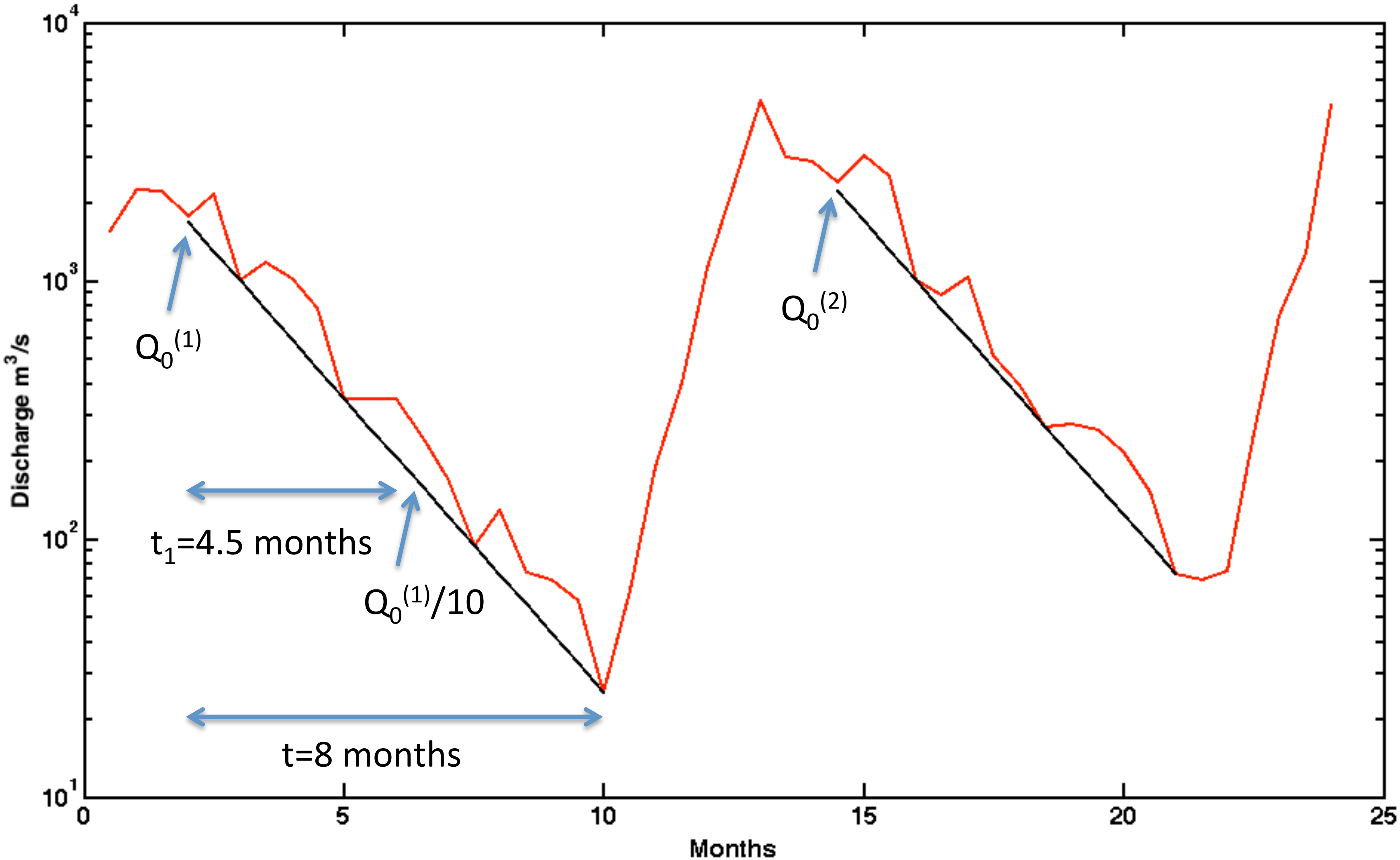
$$\therefore \quad V_t^{(1)} = \frac{1.97 \times 10^{10}}{10^{(8/4.5)}} = 3.2862 \times 10^8 \, m^3$$

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

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

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

because
$V_{tp}^{(1)} << V_t^{(2)}$



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 ~~gr~~ red lines (which are fit to the early and late parts of the data)

I will pick black line ~~#~~ and $Q = 683\ m^3/s$ on day 5

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

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

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

$Q = 466.5$ on day 9

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

$\Rightarrow t_1 = 33-9 = 24$ days $\Rightarrow$ Consistent!

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

Step 2 $\quad t_c = 0.2144\, t_1 = 5.14$ days

Step 3 $\quad$ Peak in data happens on day 13

$\therefore$ Go 5.14 days beyond this $\approx$ 18 days

Step 4 $\quad$ Measure Q_A and Q_B at this time

$$Q_B = 1978 \ m^3/s$$

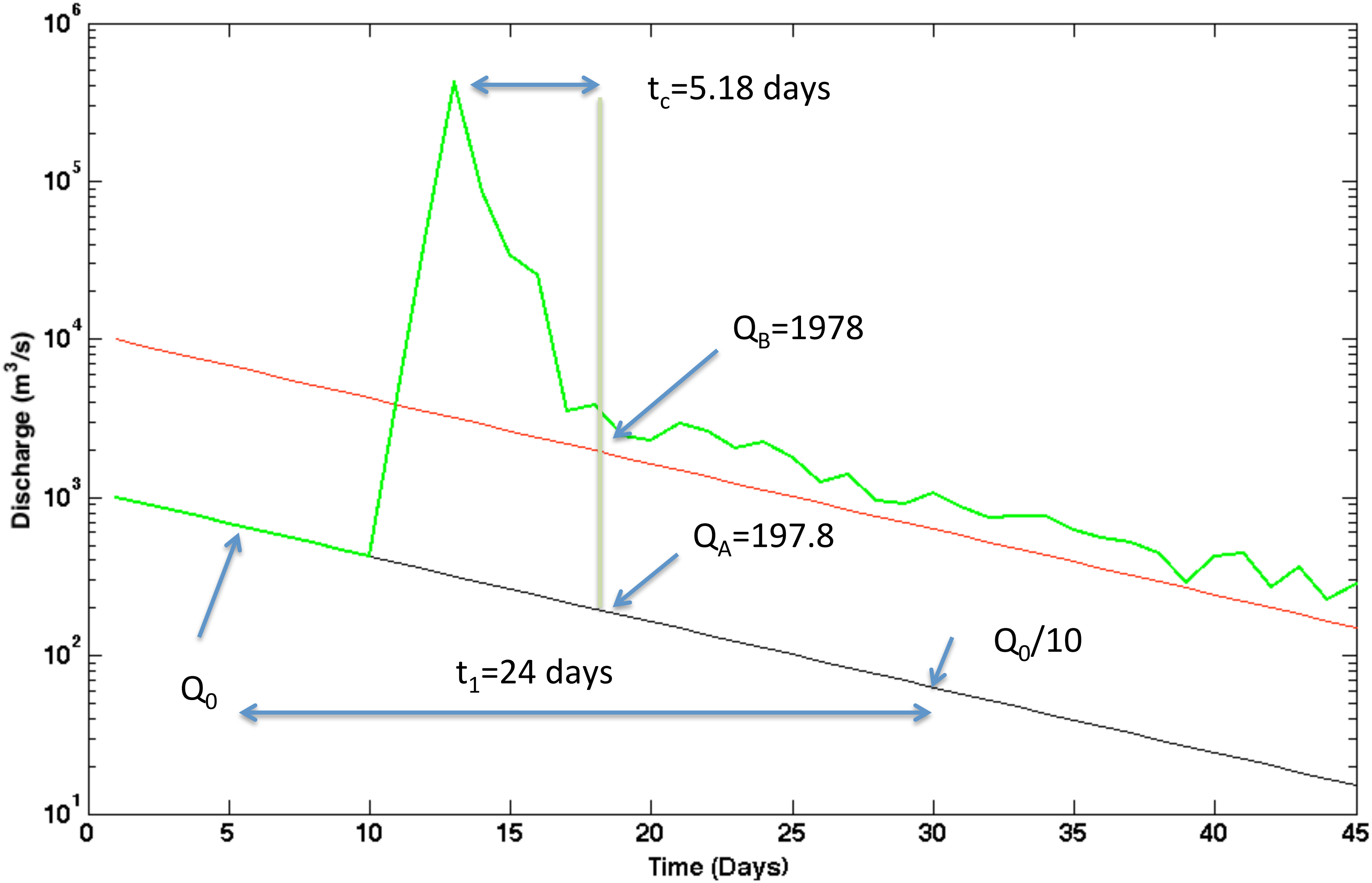
$$Q_A = 197.8 \ m^3/s$$

Step 5

$$G = \frac{2}{2.3}\left(Q_B - Q_A\right) t_1$$

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

$$= 3.2 \times 10^9 \ m^3$$



t_c=5.18 days
Q_B=1978
Q_A=197.8
Q_0/10
Q_0
t_1=24 days
Discharge (m^3/s)
10^6
10^5
10^4
10^3
10^2
10^1
0
5
10
15
20
25
30
35
40
45
Time (Days)

Manning Equation

$w = 0.5\,m$

$d = 0.2\,m$

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

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

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

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

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

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

$$= 0.2\ m^3/s$$