Fundamental of Ground Water
Franklin W. Schwartz, Hubao Zhang, 2002

#1

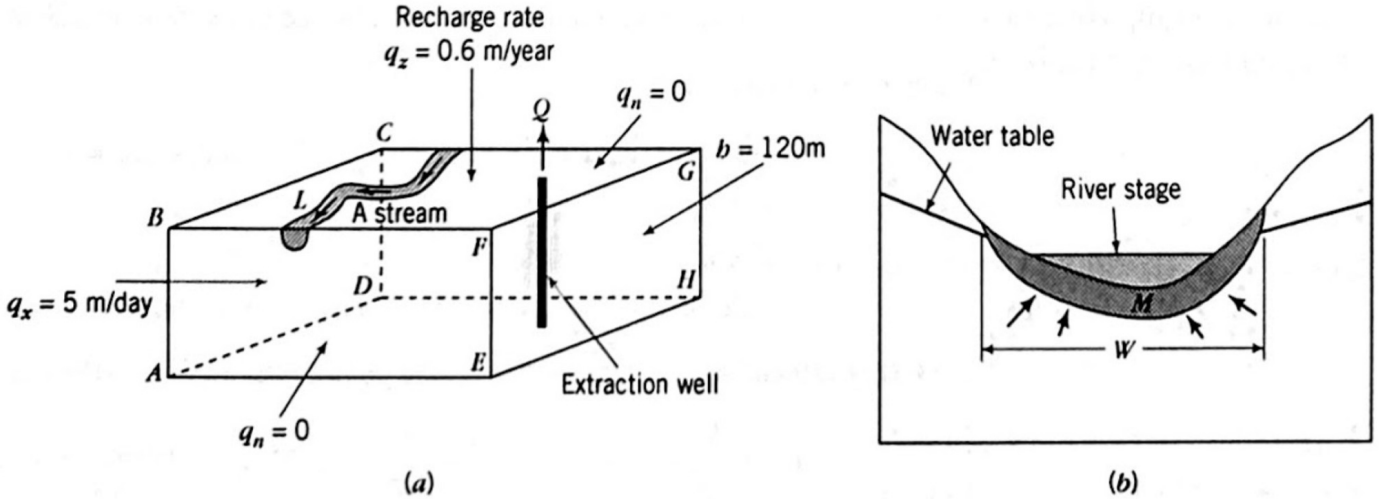


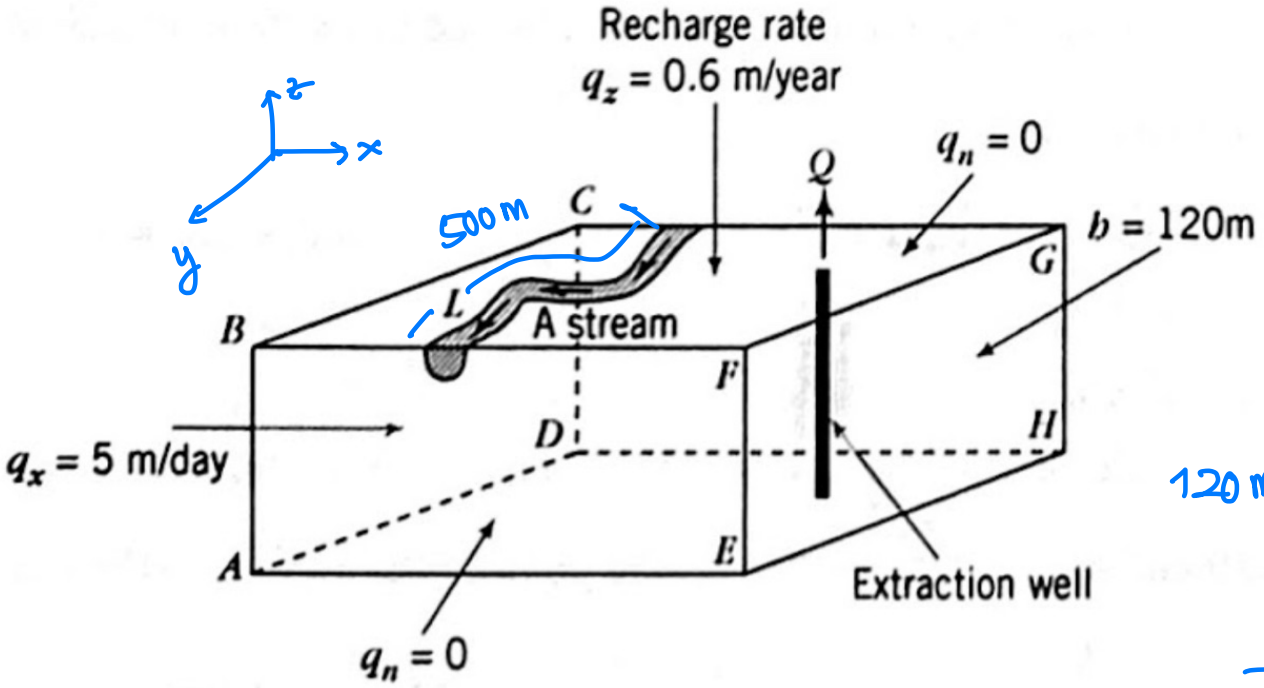
Figure 5.5 This figure illustrates how boundary conditions are applied at the sides and internal to the flow region. Panel (*a*) illustrates Dirichlet and Neumann conditions. Panel (*b*) illustrates a Cauchy boundary condition at the interface between ground-water and surface-water systems.

Ditanyakan:

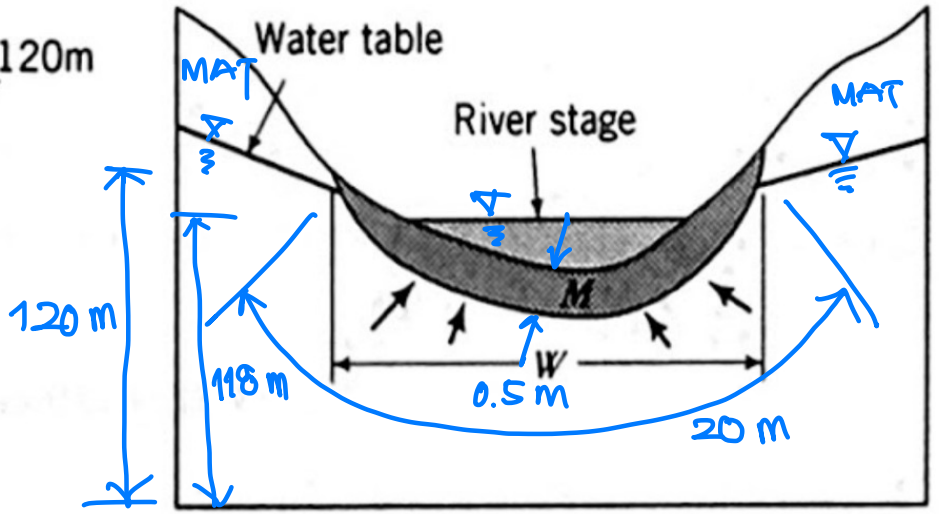
1. Arah aliran air tanah:
   akuifer → sungai
   akuifer ← sungai ?
2. Berapa kecepatan aliannya?
3. Berapa debitnya?

Diketahui,

- Panjang alur sungai L = 500 m
- Lebar dasar sungai W = 20 m
- Tebal lapis tanah dasar sungai M = 0.5 m
- Konduktivitas hidraulik dasar sungai K = 0.005 m/hari
- Tinggi (elevasi) muka air sungai, h_s = 118 m
- Tinggi (elevasi) muka air tanah, h_0 = 120 m



(a)



(b)

1. Arah aliran air tanah adalah dari akuifer ke sungai karena head di akuifer 120 m > head muka air sungai 118 m.

2. Kecepatan aliran air tanah di lapis tanah dasar sungai → kecepatan Darcy

$$q = -K\frac{\partial h}{\partial l} \approx -K\frac{\Delta h}{\Delta l} \Rightarrow q = -0.005 \times \frac{118-120}{0.5} = 0{,}02 \text{ m/hari}$$

3. Debit aliran air tanah dari akuifer ke sungai

$$Q = q.A \Rightarrow Q = 0.02 \times 500 \times 20 = 200 \text{ m}^3/\text{hari}$$

$$Q = q.L.W$$

#2

sungai

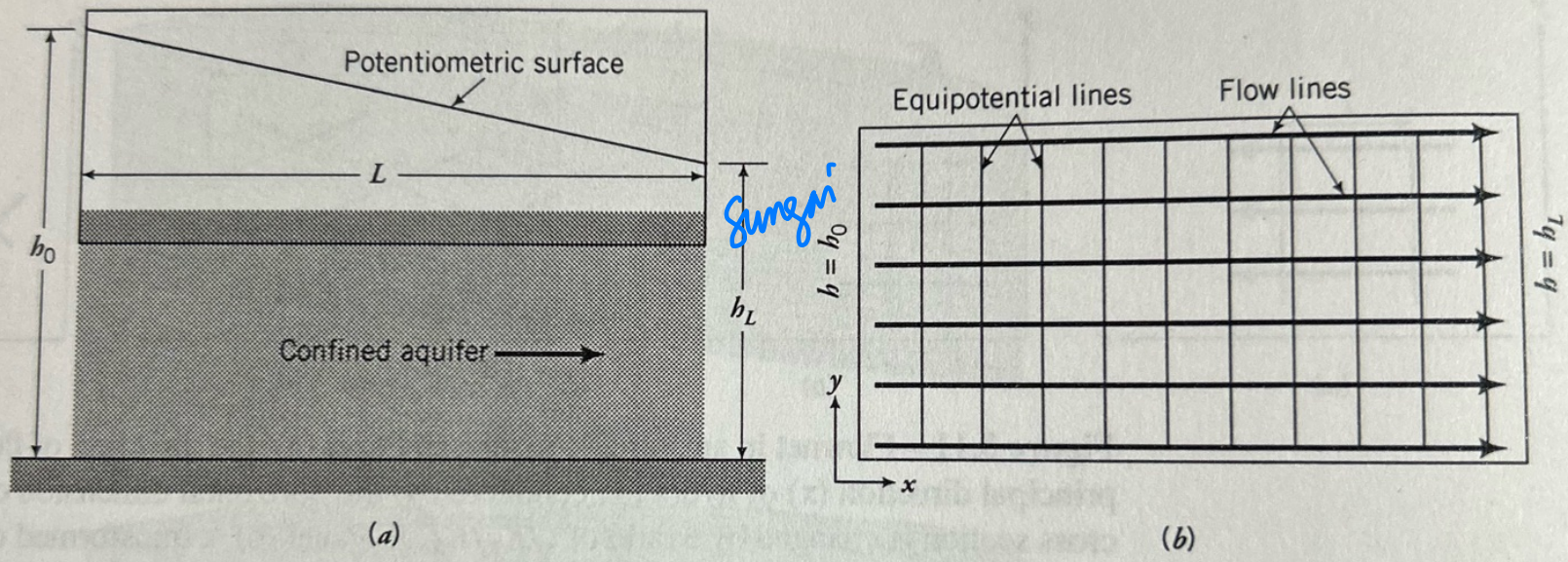
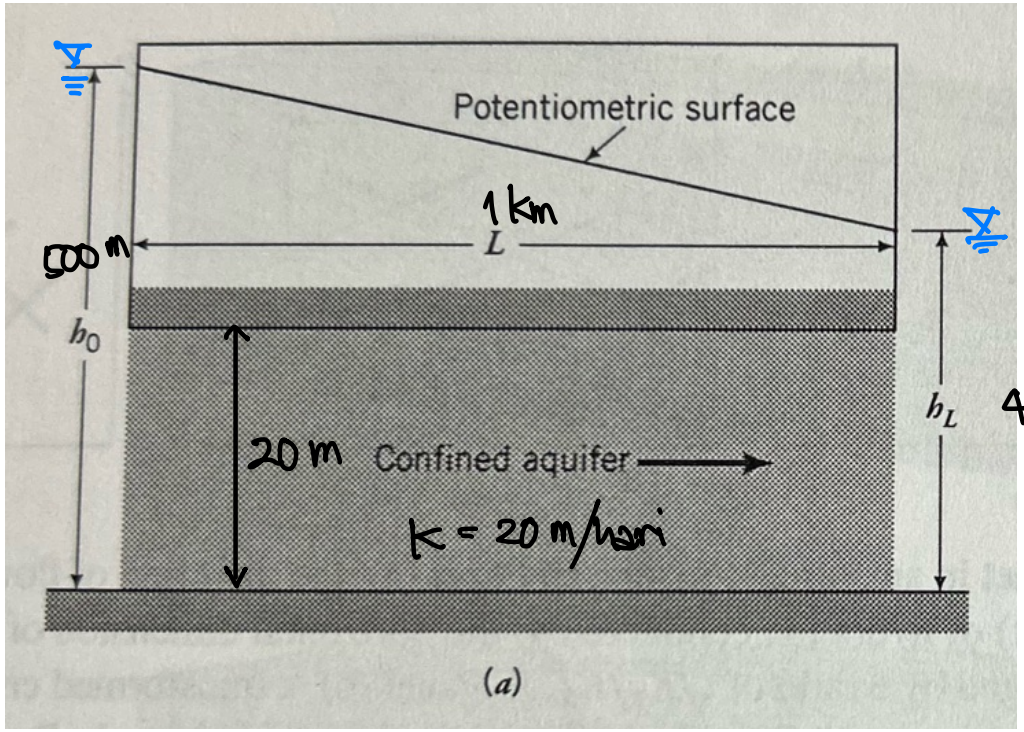
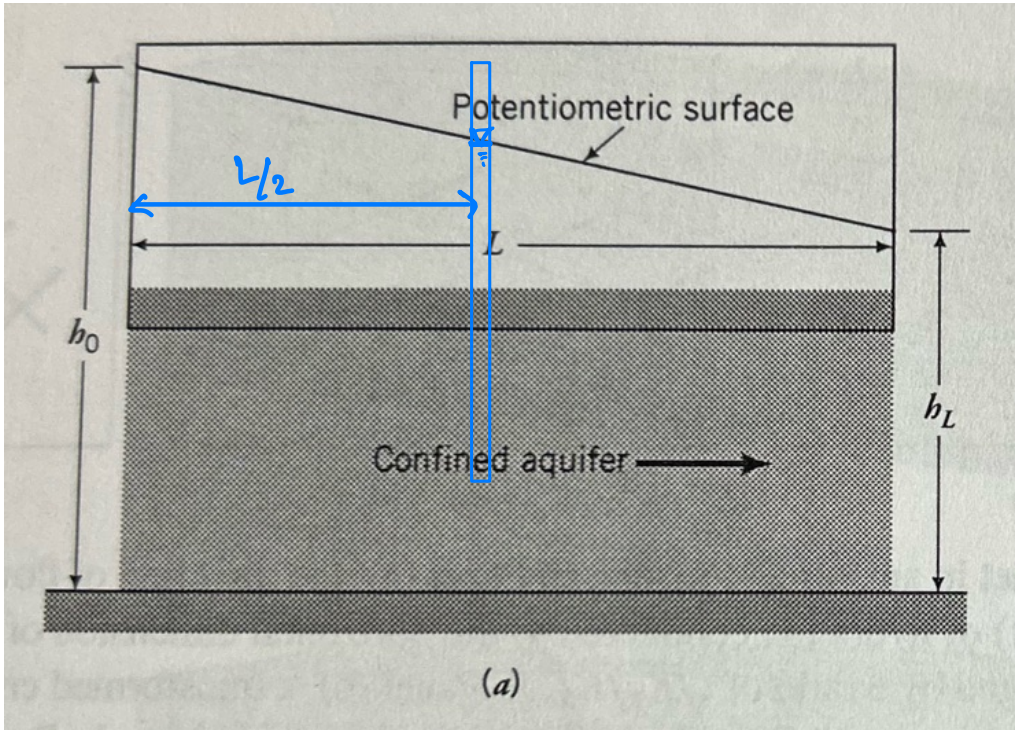


Figure 5.12 Unidirectional flow in a confined aquifer. Panel (*a*) is a cross section showing the region of interest, the aquifer, and the potentiometric surface. Panel (*b*) is a plan view showing the flownet.

- Jarak antar sungai 1 km
- Tebal akuifer 20 m
- Konduktivitas hidraulik 20 m/hari
- Elevasi muka air di sungai +500 m dan +495 m
- Panjang sungai (tegak lurus bidang gambar) 600 m

1. Berapa kecepatan dan debit aliran air tanah antar kedua sungai?
2. Jika sebuah sumur ditempatkan di tengah-tengah kedua sungai, berapa head di sumur sebelum pemompaan?





1. Kecepatan Darcy

$$q = -k\frac{\Delta h}{\Delta L}$$

$$= -20 \times \frac{495-500}{1000}$$

$$= 0.1 \text{ m/hari}$$

Debit aliran dari sungai kiri ke sungai kanan

$$Q = q \cdot A$$

$$= 0.1 \times 20 \times 600$$

$$= 1200 \text{ m}^3/\text{hari}$$

2. Aliran permanen di akuifer homogen-isotropis

$$\frac{\partial^2 h}{\partial x^2} = 0$$

Syarat batas: $x = 0 \Rightarrow h = h_0$

$x = L \Rightarrow h = h_L$

$$\Rightarrow h(x) = h_0 + \frac{h_L - h_0}{L} x$$

$$x = \tfrac{1}{2}L \Rightarrow h(x) = 500 + \frac{495-500}{1000} \times 500$$

$$= 497.5 \text{ m}$$

#3

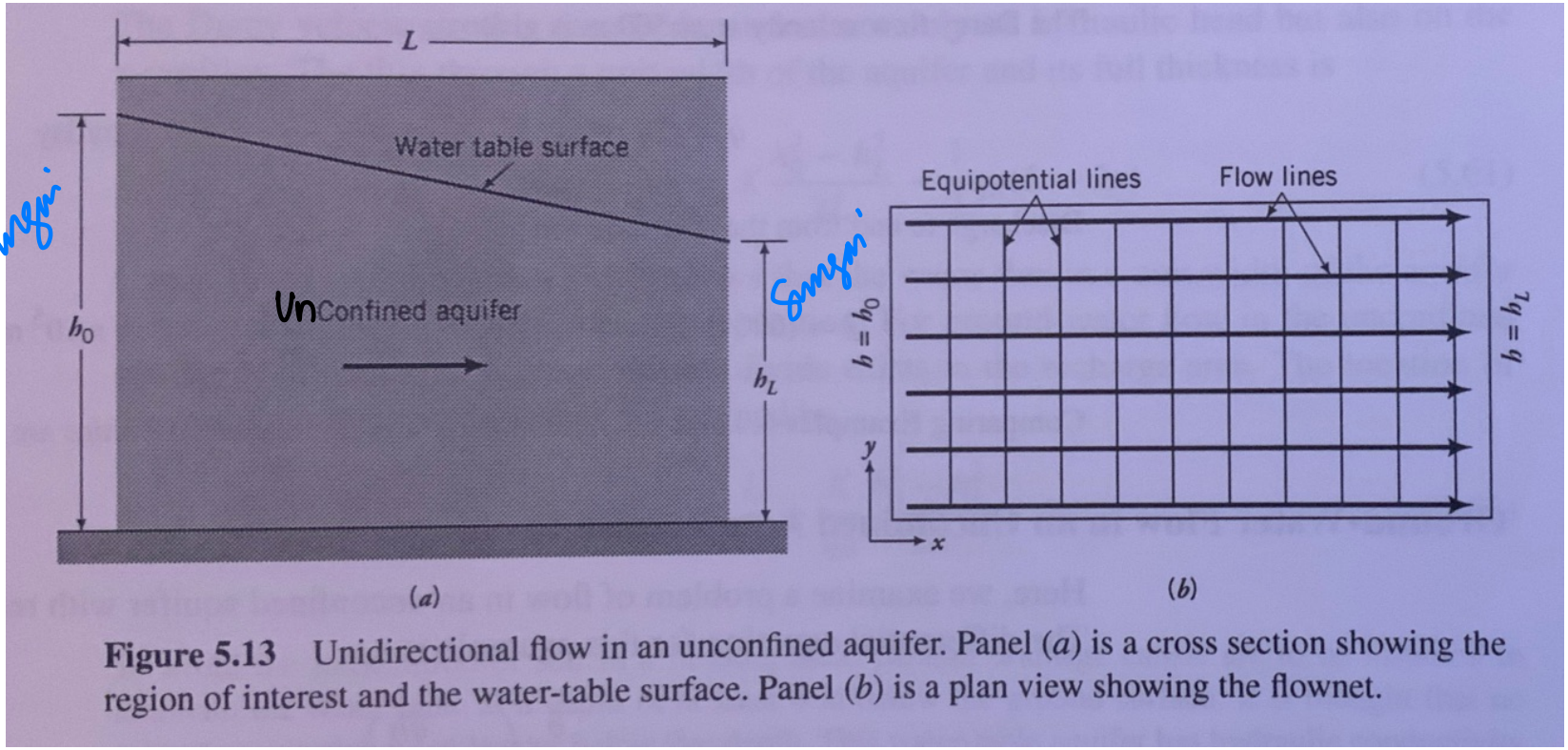
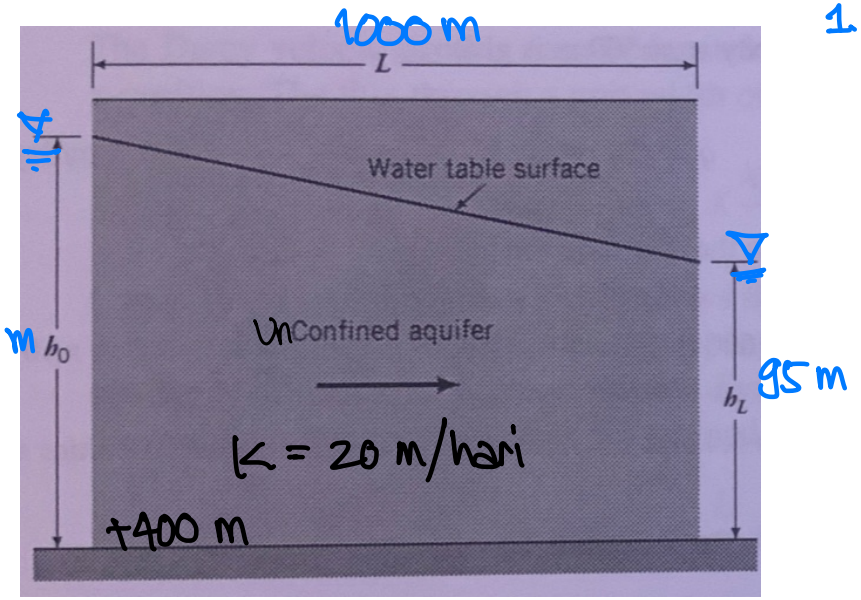


Figure 5.13 Unidirectional flow in an unconfined aquifer. Panel (*a*) is a cross section showing the region of interest and the water-table surface. Panel (*b*) is a plan view showing the flownet.

- Jarak antar sungai 1 km
- Elevasi lapis aquitard +400 m
- Konduktivitas hidraulik 20 m/hari
- Elevasi muka air di sungai +500 m dan +495 m
- Panjang sungai (tegak lurus bidang gambar) 600 m

1. Berapa kecepatan dan debit aliran air tanah antar kedua sungai?
2. Jika sebuah sumur ditempatkan di tengah-tengah kedua sungai, berapa head di sumur sebelum pemompaan?



1. Aliran air tanah di akuifer muka air bebas, aliran permanen, satu arah (1D)

$$\frac{\partial}{\partial x} h \frac{\partial h}{\partial x} = 0$$

Syarat batas: $x = 0 \Rightarrow h = h_0$

$x = L \Rightarrow h = h_L$

$$\Rightarrow h(x) = \sqrt{h_0^2 + \frac{(h_L^2 - h_0^2)}{L} x}$$

Kecepatan Darcy

$$q = -K \frac{h_L^2 - h_0^2}{2L h(x)}$$

2. Di tengah-tengah lebar sungai, $x = L/2 = 500$ m

$$h(x=500) = \sqrt{100^2 + \frac{(95^2 - 100^2)}{1000} \times 500} = 97.53 \text{ m} \leftarrow \text{head di } x = L/2 = 500 \text{ m}$$

$$q = -K \frac{h_L^2 - h_0^2}{2Lh} = -20 \times \frac{95^2 - 100^2}{2 \times 1000 \times 97.53} = 0.1 \text{ m/hari}$$

$$Q = q \cdot A = 0.1 \times 97.53 \times 600 = 5850 \text{ m}^3/\text{hari}$$

#4

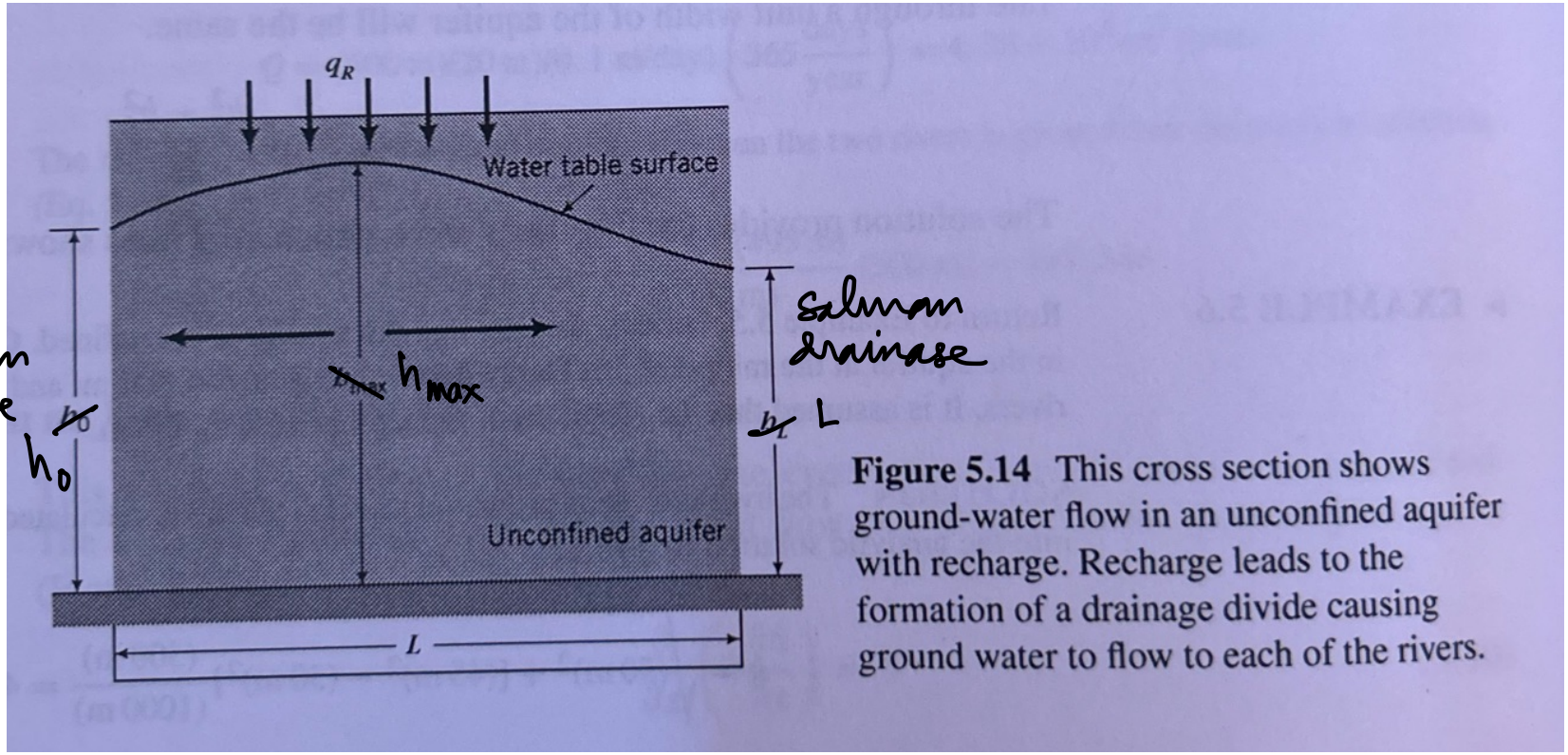
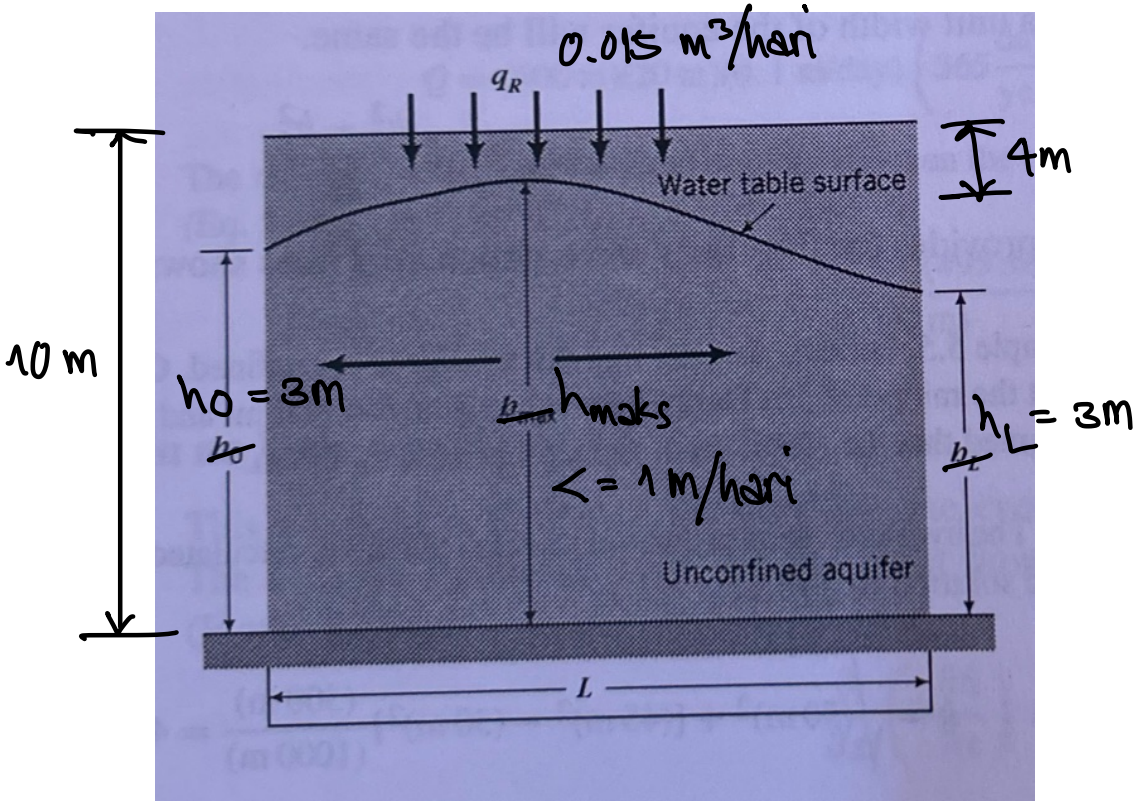


Figure 5.14 This cross section shows ground-water flow in an unconfined aquifer with recharge. Recharge leads to the formation of a drainage divide causing ground water to flow to each of the rivers.

- Kedalaman saluran drainase 10 m
- Kedalaman air di kedua saluran 3 m
- Konduktivitas hidraulik 1 m/hari
- Recharge (imbuhan) air tanah dari muka tanah (hujan, irigasi) 0.05 m/hari
- Berapa jarak antar kanal jika diinginkan muka air tanah berada 4 m di bawah muka tanah?



q_R → imbuhan, recharge

Persamaan aliran

$$\frac{\partial}{\partial x}\left(K_x h \frac{\partial h}{\partial x}\right) + q_R = 0$$

Syarat batas: $x = 0 \Rightarrow h = h_0$

$x = L \Rightarrow h = h_L$

Penyelesaian persamaan dengan menerapkan asumsi Dupuit-Forcheimer adalah

$$h(x) = \sqrt{h_0^2 + \frac{h_L^2 - h_0^2}{L} x + \frac{q_R}{K_x}(L - x)\, x}$$

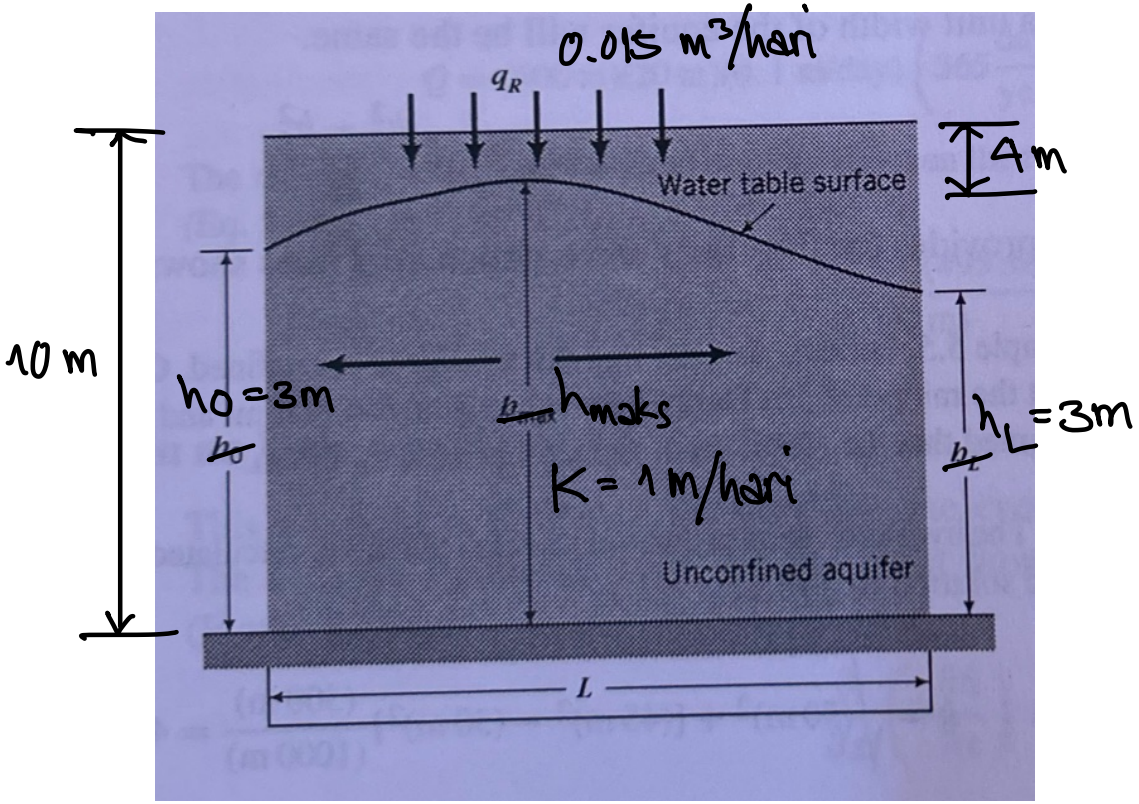
Kecepatan Darcy

$$q_x = -K_x \frac{h_L^2 - h_0^2}{2Lh} - \frac{1}{2} q_R \frac{L - 2x}{h}$$

Debit aliran

$$Q_x = -K_x \frac{h_L^2 - h_0^2}{2Lh} Bh - \frac{1}{2} q_R \frac{L - 2x}{h} Bh$$

← B = lebar akuifer tegak lurus bidang gambar



$$\Rightarrow x_d = \frac{L}{2} + \frac{K_x}{q_R}\frac{h_L^2 - h_0^2}{2L}$$

↑ lokasi muka air tanah tertinggi

jika $h_0 = h_L = 3$ m, maka

$x_d = \frac{L}{2}$

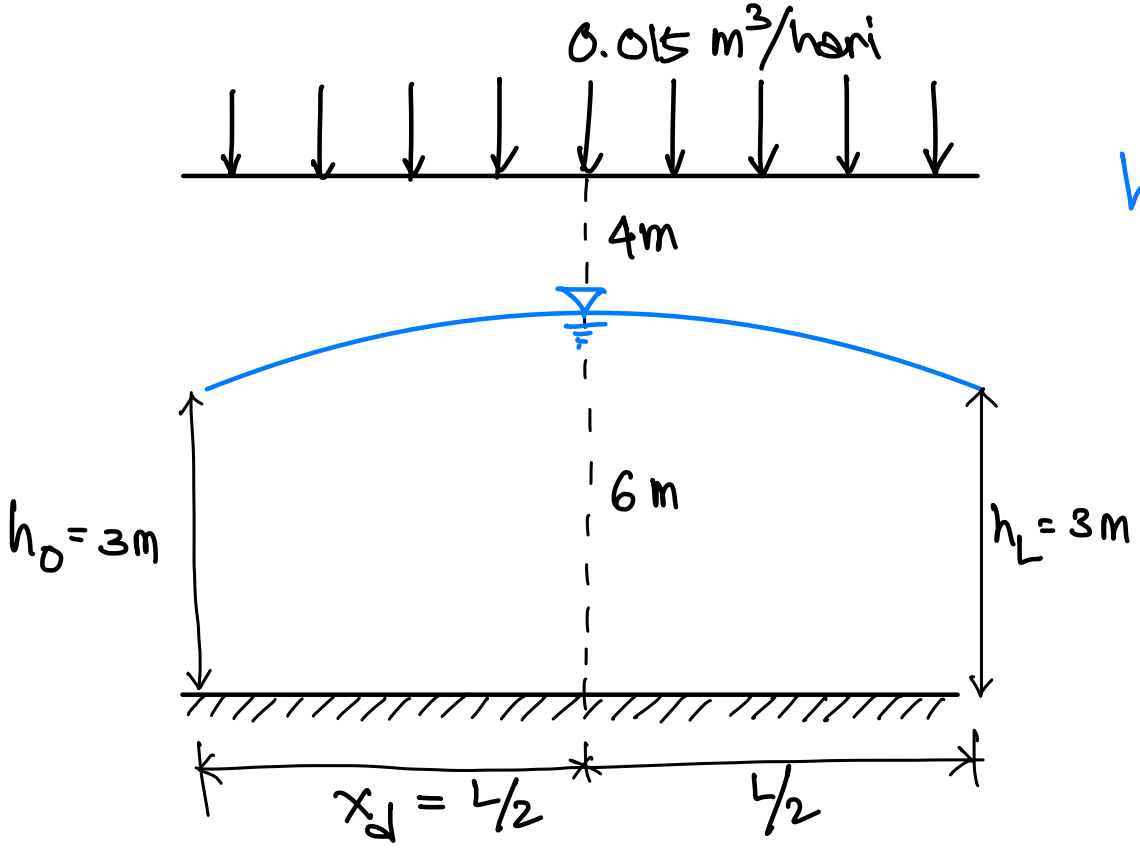
$h(x_d) = 10 - 4 = 6$ m

$$Q_x = -K_x \frac{h_L^2 - h_0^2}{2Lh} Bh - \frac{1}{2} q_R \frac{L-2x}{h} Bh$$

Air tanah mengalir ke kanan-kiri.

Di atas, $Q_x = 0 \Rightarrow x = x_d$

$$\Rightarrow -K_x \frac{h_L^2 - h_0^2}{2Lh} Bh = \frac{1}{2} q_R \frac{L-2x_d}{h} Bh$$



$$h(x)=\sqrt{h_0^2+\frac{h_L^2-h_0^2}{L}x+\frac{qR}{K_x}(L-x)x}$$

$$x=\frac{L}{2}$$

$$6=\sqrt{3^2+\frac{3^2-3^2}{L}\frac{L}{2}+\frac{0.015}{1}\left(L-\frac{L}{2}\right)\frac{L}{2}}$$

$$6=\sqrt{9+0+\frac{0.015}{4}L^2}$$

$$36=9+\frac{0.015}{4}L^2$$

$$L^2=\frac{4\times(36-9)}{0.015}$$

$$L=84.85\ m$$

$$L\simeq 85\ m$$

Jadi jarak antara kedua saluran drainase adalah 85 m.