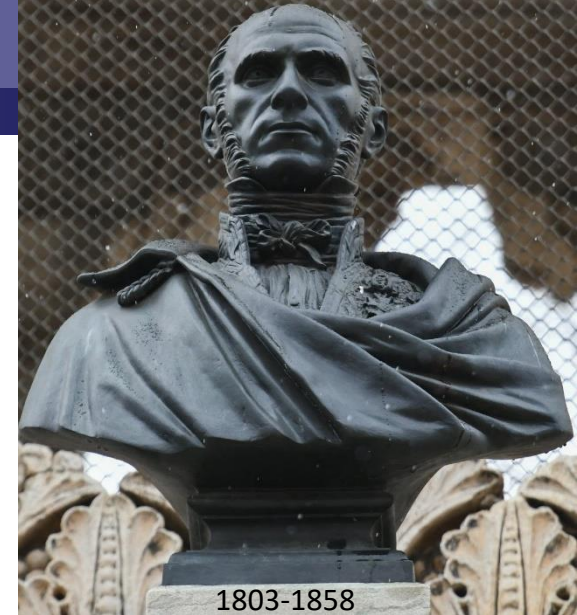


Groundwater with Darcy

<https://www.youtube.com/user/MartinRHendriks/videos>

French engineer Henry Darcy



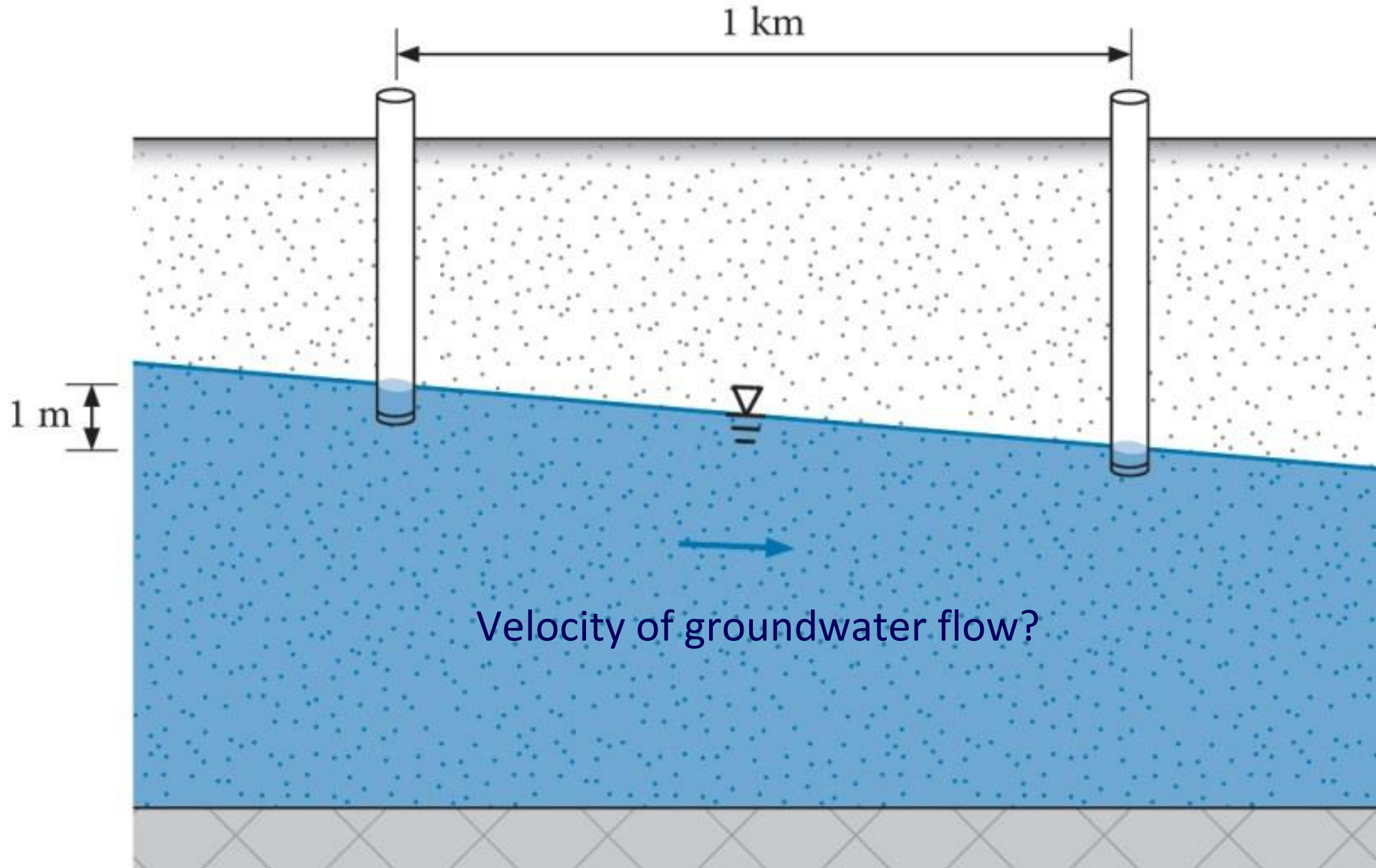
Source: Wikipedia

There is only one correct calculation method:

- A. Hydraulic conductivity = 1 cm day^{-1} , then groundwater travels 1 m in 100 days.
- B. Hydraulic conductivity = 1 cm day^{-1} and the porosity = 0.4, then groundwater travels 2.5 m in 100 days.
- C. Specific discharge = 1 cm day^{-1} , then groundwater travels 1 m in 100 days.
- D. Specific discharge = 1 cm day^{-1} and the porosity = 0.4, then groundwater travels 2.5 m in 100 days.

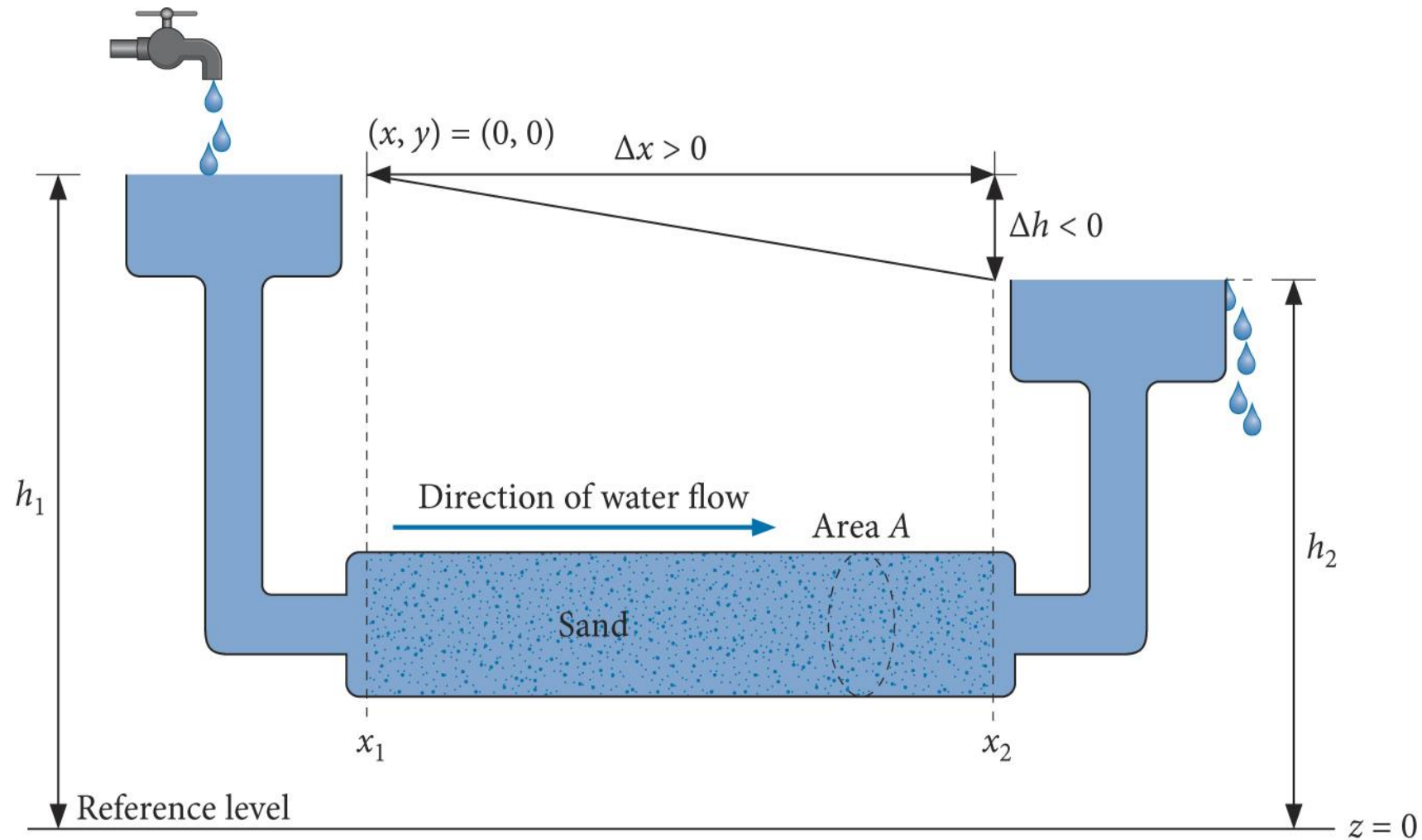
Cross-section of the subsurface

<https://www.youtube.com/user/MartinRHendriks/videos>



Experimental setup

<https://www.youtube.com/user/MartinRHendriks/videos>



Thought experiment

<https://www.youtube.com/user/MartinRHendriks/videos>

$$(h_1 - h_2) \uparrow$$

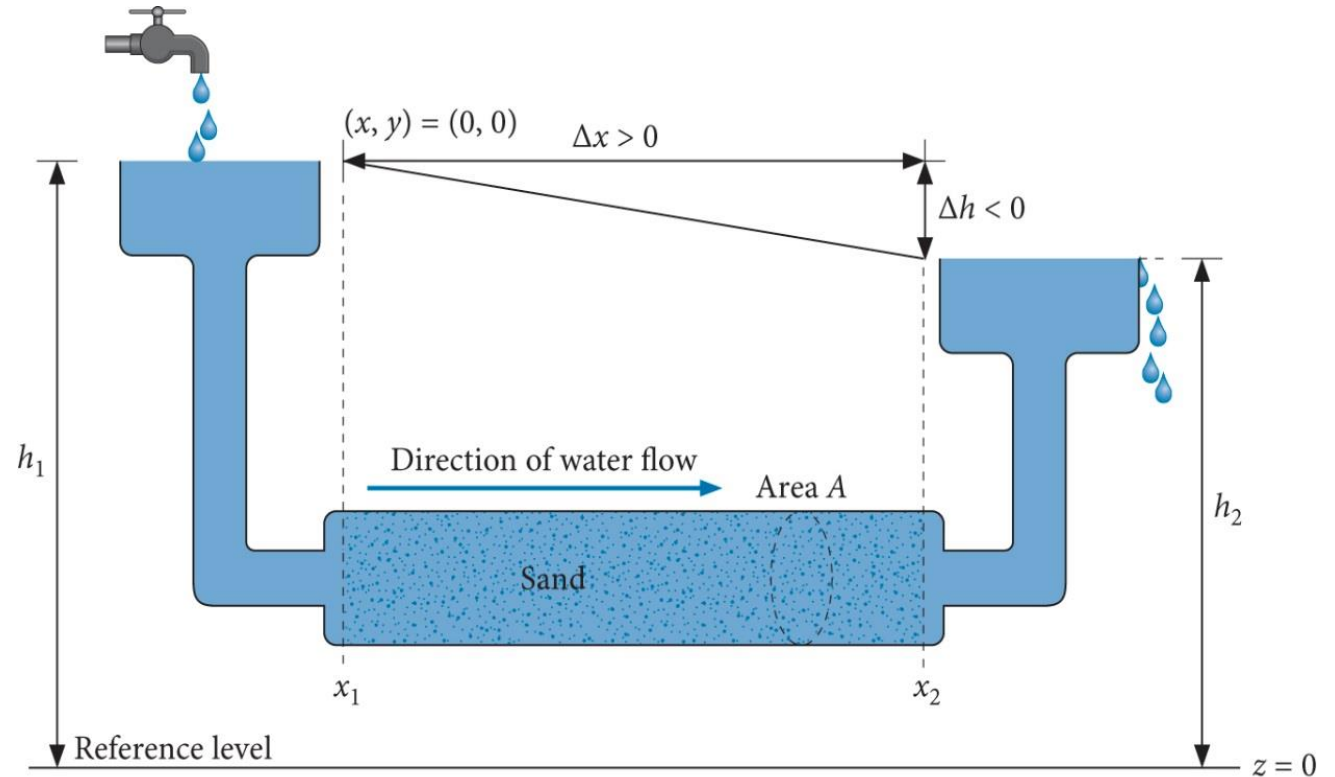
$$(h_1 - h_2) \uparrow \Rightarrow Q \uparrow$$

$$(x_2 - x_1) \downarrow$$

$$(x_2 - x_1) \downarrow \Rightarrow Q \uparrow$$

$$A \uparrow$$

$$A \uparrow \Rightarrow Q \uparrow$$



$$Q \approx \frac{h_1 - h_2}{x_2 - x_1} A$$

Darcy's law

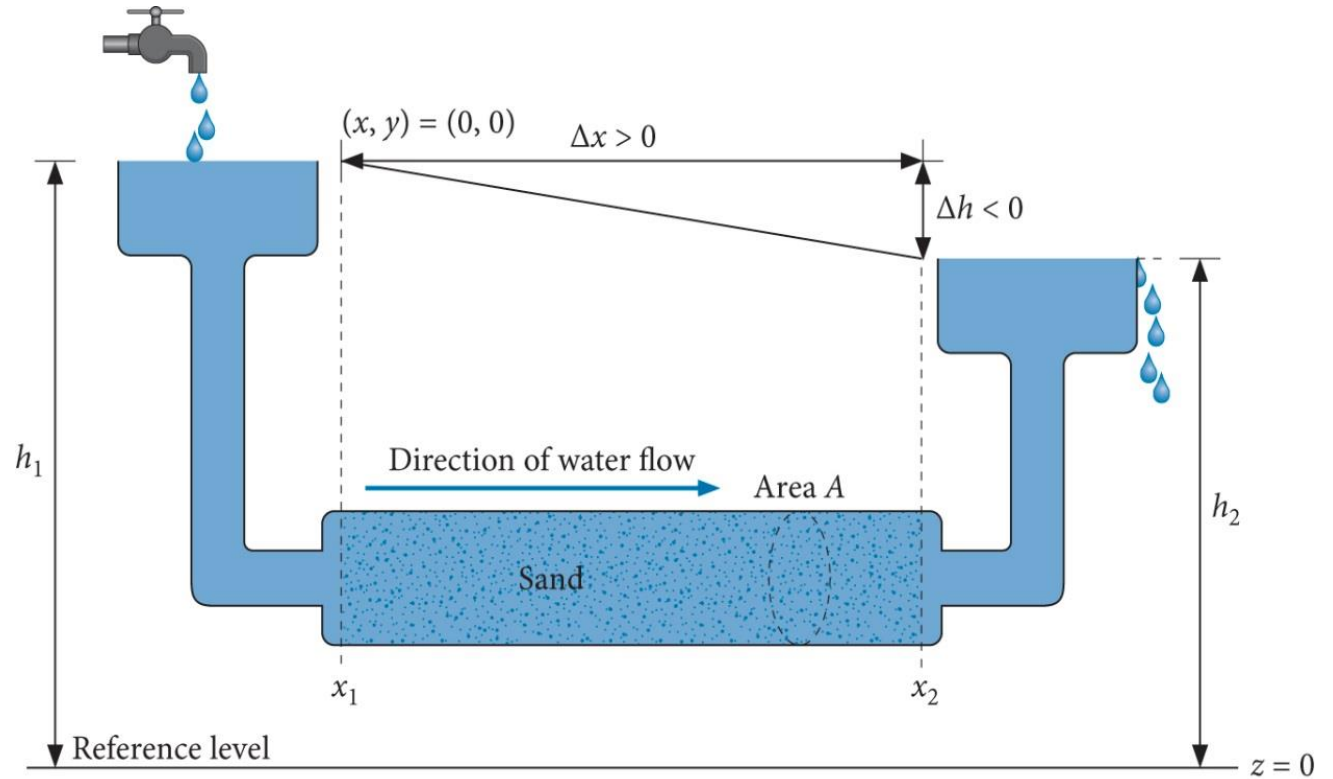
<https://www.youtube.com/user/MartinRHendriks/videos>

$$Q \approx \frac{h_1 - h_2}{x_2 - x_1} A$$

$$Q \approx -\frac{h_2 - h_1}{x_2 - x_1} A = -i A$$

$$Q = -K i A$$

$$q = \frac{Q}{A} = -K i$$



Hydraulic conductivity K (m day⁻¹)

Darcy's law and effective velocity

<https://www.youtube.com/user/MartinRHendriks/videos>

$$Q = -K i A$$

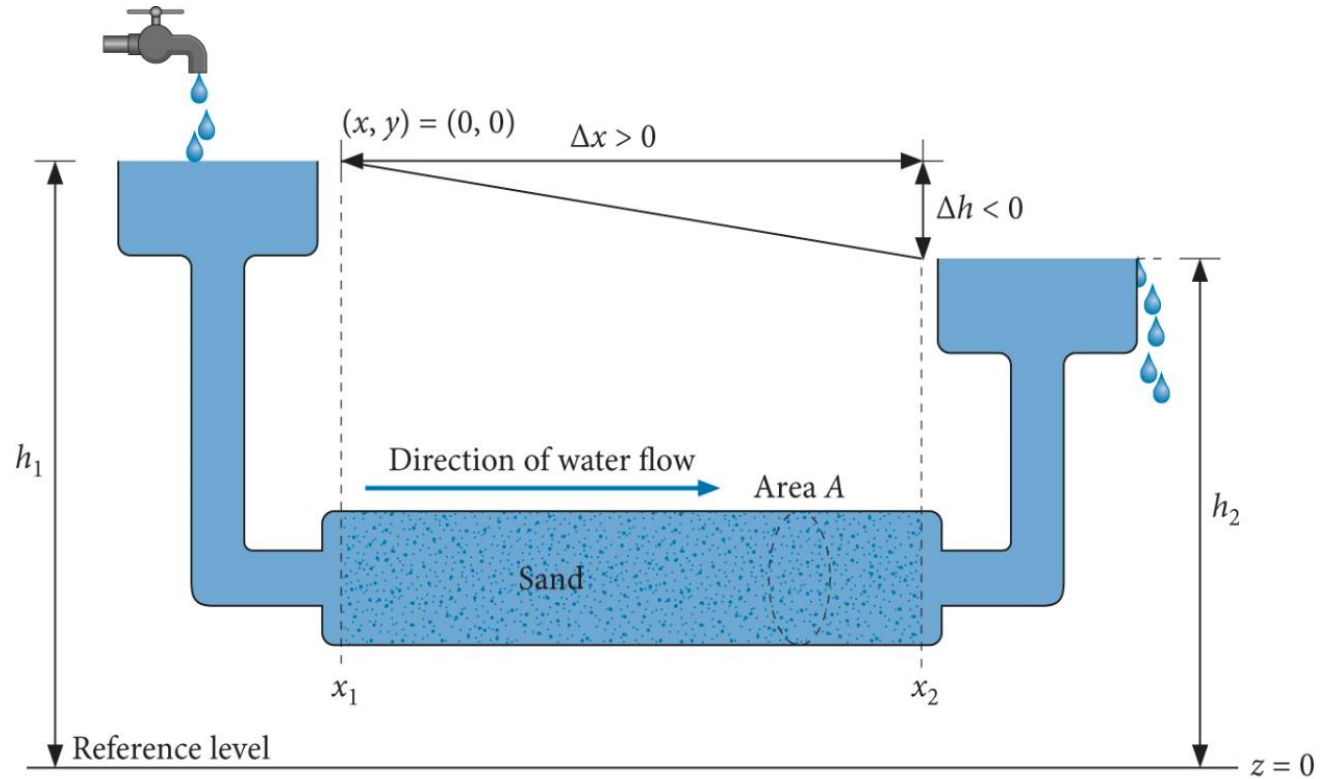
$$q = \frac{Q}{A} = -K i$$

Volume flux or discharge Q ($\text{m}^3 \text{ day}^{-1}$)

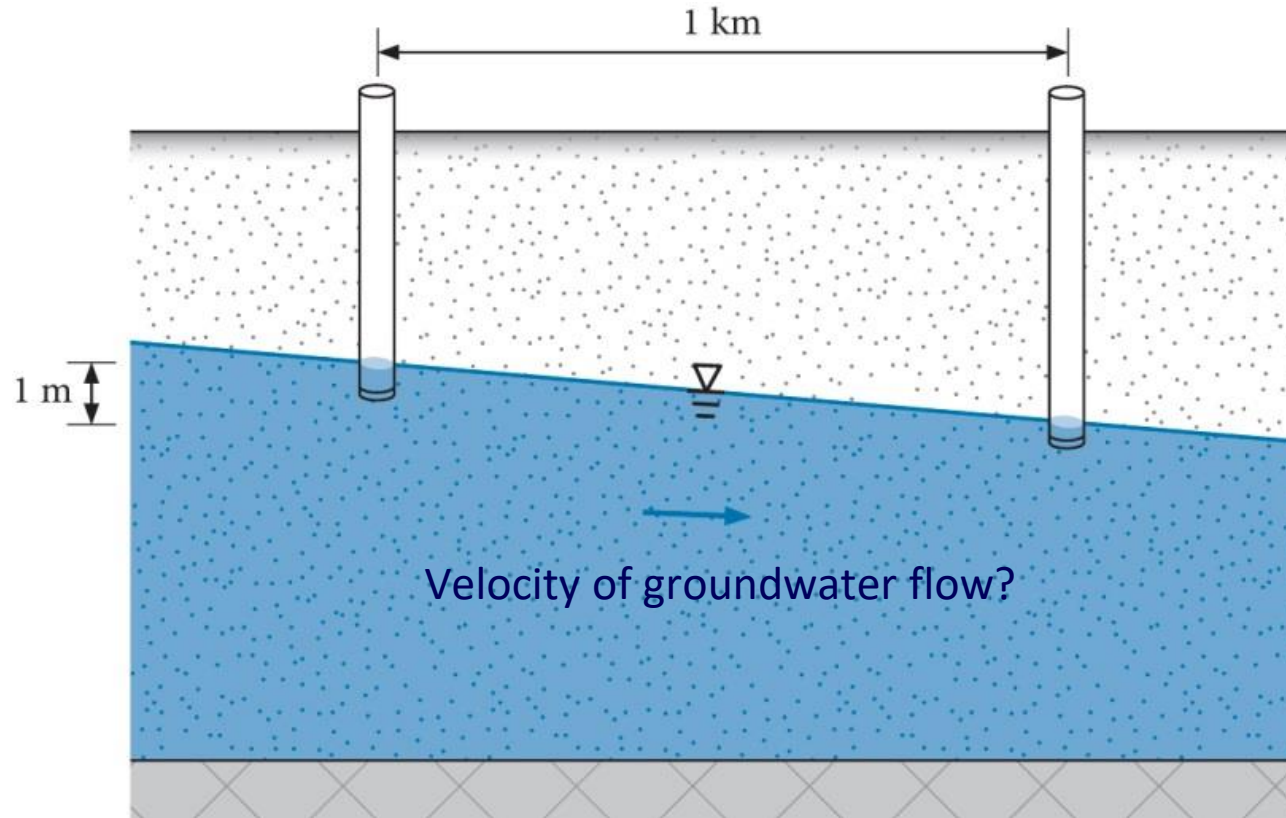
Volume flux density or specific discharge q (m day^{-1})

$$v_e = \frac{q}{n_e}$$

Effective groundwater velocity v_e (m day^{-1})



Velocity of groundwater flow



$$q = -K i = -10 \times -10^{-3} = 10^{-2} \text{ m day}^{-1}$$

$$v_e = \frac{q}{n_e} = \frac{10^{-2}}{0.4} = 2.5 \times 10^{-2} \text{ m day}^{-1} = 2.5 \text{ cm day}^{-1}$$

2.5 m in 100 days (answer D)

9 m year⁻¹

less than 1 km century⁻¹

a mere stretch of 10 km in 1100 years

Groundwater generally flows very slowly!



Take home messages

<https://www.youtube.com/user/MartinRHendriks/videos>

Unconfined groundwater can flow along curved pathways.

Groundwater flows in the direction of a lower hydraulic head.

Groundwater generally flows very slowly.

The minus sign in Darcy's law and the differences between specific discharge = volume flux density, hydraulic conductivity and effective velocity (all in m day^{-1}) have been explained.

Exercises

<https://www.youtube.com/user/MartinRHendriks/videos>



Introduction to Physical Hydrology (Oxford University Press)
<http://ukcatalogue.oup.com/product/9780199296842.do>