Environmental Geology
Ground H2O Flow Problems — Answer Key

(1) $n_t = 0.436$ but 35% of pores are isolated

$n_y = 0.436 - 0.35 = 0.086 = 8.6\%$

(2) $n_y\% = \frac{V_{yield}}{V_{total}} \times 100\%$

(3) V = Ground H2O velocity $= \frac{d}{t} = \frac{5.60\text{ km}}{6.4\text{ yr}} = \left(0.875 \frac{\text{km}}{\text{yr}}\right)\left(\frac{1000\text{ m}}{\text{km}}\right) = \frac{875\text{ m}}{\text{yr}}$

$n_e = 0.350$

(A) $I = \frac{\Delta H}{\Delta L} = \frac{42\text{ m}}{5600\text{ m}} = 0.0075$

$V_d = n_e V = (0.350)\left(\frac{875\text{ m}}{\text{yr}}\right) = 306.25\text{ m/yr}$

$V_d = KI \Longrightarrow K = \frac{V_d}{I} = \frac{306.25\text{ m/yr}}{0.0075} = 40833\text{ m/yr}$

$K = 40{,}833\text{ m/yr} \cdot \frac{100\text{ cm}}{1\text{ m}} \cdot \frac{1\text{ yr}}{365\text{ day}} \cdot \frac{1\text{ day}}{24\text{ hr}} \cdot \frac{1\text{ hr}}{60\text{ min}} \cdot \frac{1\text{ min}}{60\text{ sec}} = 1.29 \times 10^{-1}\text{ cm/sec}$

$A = 93\text{ m} \times 7100\text{ m} = 660{,}300\text{ m}^2$

(3 B) $Q = KIA = \left(40833 \frac{\text{m}}{\text{yr}}\right)(0.0075)(660{,}300\text{ m}^2) = 2.02 \times 10^8 \frac{\text{m}^3}{\text{yr}}$

$\left(2.02 \times 10^8 \frac{\text{m}^3}{\text{yr}}\right)\left(\frac{1\text{ yr}}{365\text{ day}}\right)\left(\frac{1\text{ day}}{24\text{ hr}}\right)\left(\frac{1\text{ hr}}{60\text{ min}}\right)\left(\frac{1\text{ min}}{60\text{ sec}}\right) = 6.4\ \frac{\text{m}^3}{\text{sec}}$

72+
81

(4) $Q = KIA \longrightarrow I = \frac{Q}{KA}$

$I = \frac{8380 \; m^3/day}{\left(45.0 \frac{m}{day}\right)(211{,}700 \; m^2)} =$

$A = 73.0 \, m \times 2900 \, m = 211{,}700 \; m^2$

$I = 0.00088$

(5) — SKIP

(6) $V_0 = n_y V$ where $V = (3.4 \, V_0)$

$V_0 = n_y (3.4 V_0)$

$n_y = \frac{V_0}{3.4(V_0)} = \frac{1}{3.4} = 0.29$

$n_r = 0.233$

$n_{Total} = n_y + n_r = 0.233 + 0.29 = 0.523$

(7) Area $= 20 \, m \times 1700 \, m = 34{,}000 \; m^2$

$V_{ER} = \frac{2300 \, m}{2.5 \, yr} \left(\frac{1 \, yr}{365 \, day}\right) = 2.52 \; m/day$

$K = 31.0 \; m/day$

$I = \frac{\Delta H}{\Delta l} = \frac{26.0 \, m}{23..} = 0.011$

(A) $V_d = KI = \left(\frac{31.0 \, m}{day}\right) 0.011 = 0.341 \frac{m}{day}$

$V_0 = n_y V \Rightarrow n_y = \frac{V_0}{V} = \frac{0.341 \; m/day}{2.52 \; m/day} =$

$n_y = 0.14$

NEXT

(7B) $Q = KIA = \left(31.0 \frac{m}{DAY}\right)(0.011)(34{,}000\ m^2) = 11{,}594 \frac{m^3}{DAY}$

3 WEEKS VOLUME $= 11{,}594 \frac{m^3}{DAY} (14\ DAY) = 162{,}316\ m^3$

(7C) $n_y = 0.14$ VOLUME ABOVE WATER TABLE

$w = 1700\ m$

$t = 34.0\ m$

$L = 2300\ m$

$V_{OL} = w \times t \times L = 1700\ m \cdot 34\ m \cdot 2300\ m =$

VOLUME CONNECTED PORE SPACE = $1.33 \times 10^8\ m^3$

$$n_y \cdot V_{OL} = 0.14 \cdot 1.33 \times 10^8\ m^3 = 1.9 \times 10^7\ m^3$$

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(8) AREA = $830\ m \times 42\ m = 34{,}860\ m^2$

$K = 143\ m/d$ $I = \frac{\Delta H}{L} = 27.0\ m / 18200\ m = 0.015$

$n_y = 0.473$

$V_d = KI = 143\ m/d\ (0.015) = 2.145\ m/DAY$

$V_d = n_y V \Longrightarrow V = \frac{V_d}{n_y} = \frac{2.145\ m/DAY}{0.473} = 4.53 \frac{m}{DAY}$

1 metric TON = 1000 kg

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(8b) $150{,}000 \text{ metric ton} \cdot \frac{1000 \text{ kg}}{1 \text{ metric ton}} = 1.5 \times 10^8 \text{ kg}$

Density water $= \frac{1 g}{cm^3} \cdot \frac{1 kg}{1000 g} \cdot \frac{100 cm}{m} \cdot \frac{100 cm}{m} \cdot \frac{100 cm}{m} = 1000 \frac{kg}{m^3}$

Volume $H_2O = 1.5 \times 10^8 \text{ kg} \cdot \frac{1 m^3}{1000 kg} = 150{,}000 = 1.5 \times 10^5 m^3$

$Q = KIA = \left(143 \frac{m}{day}\right)(0.015)(34{,}860 m^2) = 74774.7 \frac{m^3}{day}$

$\text{TIME} = \left(\frac{1 \text{ DAY}}{74774.7 m^3}\right)(1.5 \times 10^5 m^3) = \boxed{2 \text{ DAYS}}$

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(10) Density of water $= \left(1 g/ml\right)\left(\frac{1000 ml}{L}\right)\left(\frac{1 kg}{1000 g}\right) = 1 kg/L$

$1 L \; H_2O = 1 kg \; H_2O$

$1 kg = 1 \times 10^6 mg$

$1 ppm = \frac{1 mg}{L} = \frac{1 mg}{kg}$ ([illegible]

$\frac{1 mg}{1 \times 10^6 mg} = 1 ppm$

(11)

GIVEN:

$V_d = KI$ and $V_d = n_y V$

$V = L/t$ $\qquad I = \Delta H / L \qquad K = L/t$

SUBSTITUTE & REARRANGE EQUATION

$(n_y \cdot V) = KI = (K)\left(\frac{H}{L}\right)$

$n_y \cdot \frac{L}{t} = K \frac{H}{L}$

$\frac{t}{n_y \cdot L} = \frac{L}{KH}$

$t = \frac{n_y L \cdot L}{KH} = \frac{n_y L^2}{KH}$

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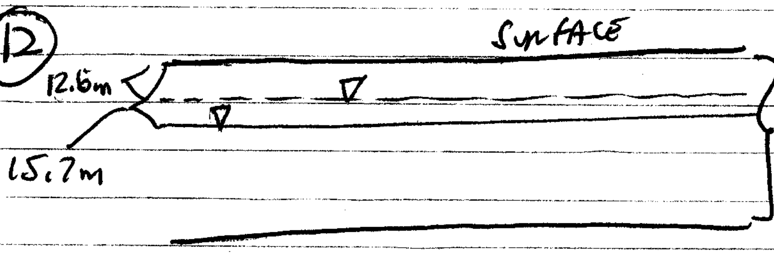
(12)



AQUIFER THICKNESS = 73m

BASIN AREA = 6.82 ha $\frac{1 \times 10^4 m^2}{1 \text{ ha}}$ = $6.82 \times 10^4 m^2$

$n_e = 0.472$

Δ HEAD = 15.7m − 12.6m = 3.1m

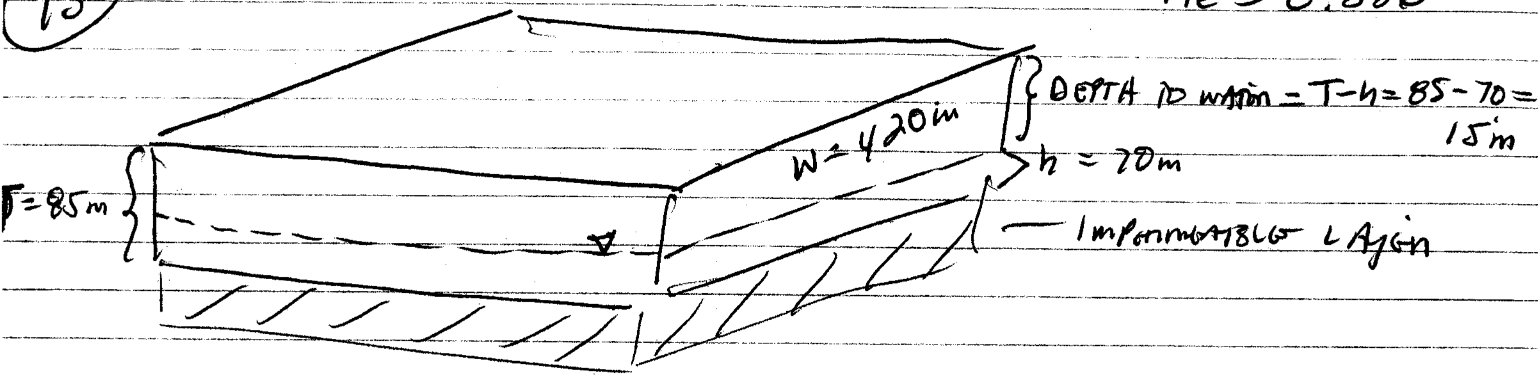
EFFECTIVE AQUIFER VOLUME = $n_e \cdot$ AREA $\cdot$ Δ HEAD =

$(0.472)(6.82 \times 10^4 m^2)(3.1 m) =$

$9.98 \times 10^4 m^3$

(13)

$n_e = 0.536$



$V = 1.27 \frac{m}{day}$

$$Q = 2\times10^7 \frac{L}{day}\left(\frac{1\,m^3}{1000\,L}\right) = 2\times10^4\, m^3/DAY$$

$$Q = n_e V A = n_e V(w \cdot h)$$

$\Downarrow$

$$h = \frac{Q}{n_e V w} = \frac{2\times10^4\, m^3/day}{(0.536)\left(1.27\frac{m}{day}\right)(420m)} =$$

$$h = \frac{2\times10^4\, m^3/day}{286\, m^2/day} = 70m$$

DEPTH TO WATER = 85m − 70m = 15m

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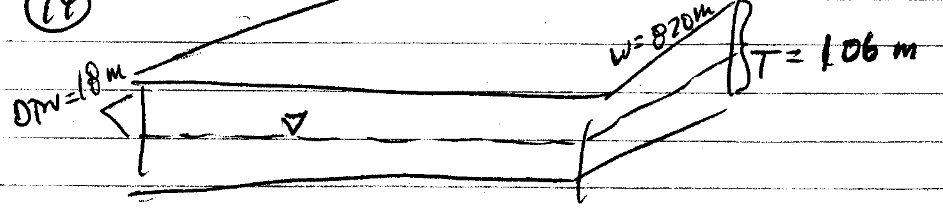
(14)



$Q = 2.19\, m^3/sec$

$Q = KIA$ $\quad V_d = KI$

$Q/A = KI$

$$V_d = KI = \frac{Q}{A} = \left(2.19\frac{m^3}{sec}\right) / \left[(820m)(106m - 18m)\right] = 3\times10^{-5}\frac{m}{sec} =$$

$= 2.62\, m/DAY$

$902 \frac{m}{yr} \cdot \frac{1\,yr}{365\,day} =$

(15)

$$I = \frac{\Delta H}{\Delta L} = \frac{41.5\,m}{2870\,m} = 0.014$$

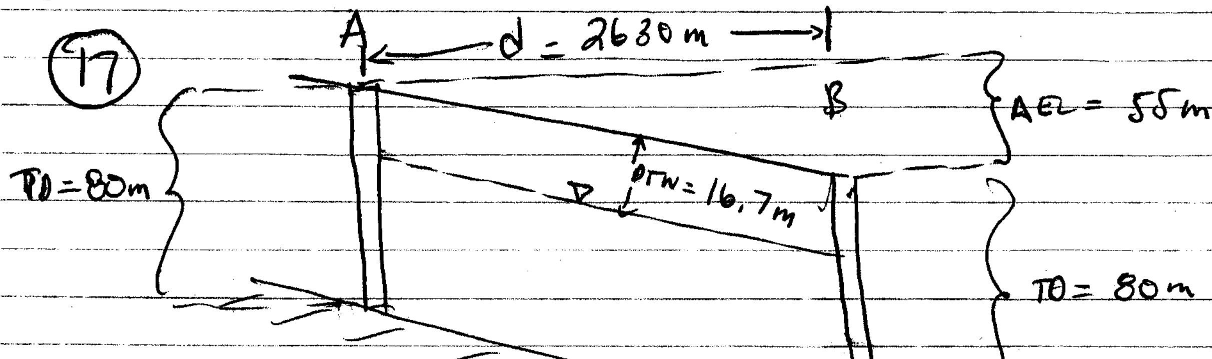
$$V = d/t = \left(2870\,m / 3.18\,year\right)\left(\frac{1\,yr}{365\,DAY}\right) = 2.47\,\frac{m}{DAY}$$

$$n_e = 0.640 \qquad A = 1.8\,ha\left(\frac{1\times10^4\,m^2}{ha}\right) = 1.8\times10^4\,m^2$$

$$V_D = n_y V = (0.640)\left(2.47\,\frac{m}{DAY}\right) = 1.58\,m/DAY$$

$$V_D = KI \rightarrow K = \frac{V_D}{I} = \frac{1.58\,m/DAY}{0.014} = 112.9\,\frac{m}{DAY}$$

(17)



Aquifer width = 1650 m

$$I = \frac{\Delta H}{L} = \frac{55\,m}{2630\,m} = 0.021$$

$n_y = 0.364$

$K = 24.0\,m/day$

$$V_d = KI = \left(24.0\,\frac{m}{DAY}\right)(0.021) = 0.50\,\frac{m}{DAY}$$

$$V = \frac{V_D}{n_y} = \frac{0.50\,m/day}{0.364} = 1.38\,m/DAY$$

$$V = \frac{d}{t} \rightarrow t = \frac{d}{V}$$

$$t = 2630\,m / 1.38\,m/DAY \Rightarrow$$

1906 DAYS = 5.2 yrs