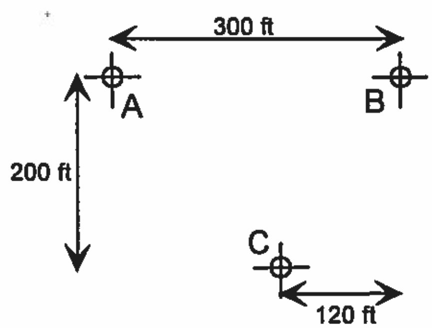
CE 4363/5363 Groundwater Hydrology

Homework #2

1. Problem 4.6.
2. Problem 4.8.
3. Problem 4.10.
4. Problem 4.13.
5. Three monitoring wells exist in an aquifer as shown below. North is upward (toward the top of the page). The land surface elevations and depths to water are shown below. Find the magnitude and direction of the head gradient.

Well	Land Surface Elevation (ft)	Depth to Water (ft)
A	3138.5	42.1
B	3139.2	43.3
C	3140.0	45.0



6. Page 109, Analysis B.

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4.6 Given: Fluid pressure at piezometer screen = 7.688×10^5 N/m²
$\rho_f = 1055$ kg/m³ $T = 14°C$ $z = 45.9$ msl

Find: [a] porewater pressure head
[b] freshwater pressure head
[c] total freshwater head

[a] $$\frac{P}{\gamma_f} = \frac{P}{\rho_f g} = \frac{7.688 \times 10^5 \text{ N/m}^2}{(1055 \text{ kg/m}^3)(9.81 \text{ m/s}^2)\frac{1\text{ N}}{1 \text{ kg m/s}^2}}$$

$$\boxed{\frac{P}{\gamma_f} = 74.28 \text{ m}}$$

[b] $$\frac{P}{\gamma_w} = \frac{P}{\gamma_f}\frac{\gamma_f}{\gamma_w}$$ @ 14°C $\rho_w = 999.244$ kg/m³

$$= \frac{P}{\gamma_f}\frac{\rho_f}{\rho_w} = (74.28 \text{ m})\frac{1055 \text{ kg/m}^3}{999.244 \text{ kg/m}^3}$$

$$\boxed{\frac{P}{\gamma_w} = 78.42 \text{ m}}$$

[c] $$\frac{P}{\gamma_w} + z = 78.42 \text{ m} + 45.9 \text{ m}$$

$$= \underline{124.3 \text{ m}}$$

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4.6 Given: Aquifer $K = 12\,ft/d$, $n_e = 0.17$ $\frac{dh}{dl} = 0.0055$

Find: (a) Specific discharge

(b) average linear velocity

(c) $T = 14°C$ $d_{50} = 0.33\,mm$, Is Darcy's Law permissible?

(a) $v = K\frac{dh}{dl}$

[3] $v = (12\,ft/d)(0.0055)$

$\boxed{v = 0.066\,ft/d}$

(b) $v_x = \frac{K}{n_e}\frac{dh}{dl}$

$= \frac{12\,ft/d}{0.17}(0.0055)$

[3] $\boxed{v_x = 0.39\,ft/d}$

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(c) $\mathbb{R} = \frac{\rho q d}{\mu}$ $q = v_x$

$T = 14°C$ $\rho = 0.999244\,g/cm^3$ $\mu = 0.011709\,\frac{g}{s\,cm}$

[4] $\mathbb{R} = \frac{(0.999244\,\frac{g}{cm^3})(0.39\,ft/d)(0.033\,cm)\left(\frac{30.5\,cm}{ft}\right)\left(\frac{1\,d}{86400\,sec}\right)}{(0.011709\,g/sec\,cm)}$

$\mathbb{R} = 3.9 \times 10^{-4}$ < 1 OK for Darcy's Law

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4-10 Given: Confined aquifer $b = 18.5m$ $\Delta h = 1.99m$ over $L = 823m$
$K = 4.35\ m/d$

Find: $\frac{Q}{width}$ in $m^3/m\,d$

$$Q = KA\frac{\Delta h}{L}$$

(width) b

$$\frac{Q}{width} = Kb\frac{\Delta h}{L}$$

$$= (4.35\ m/d)(18.5m)\frac{(1.99m)}{823m}$$

$$\boxed{\frac{Q}{width} = 0.195\ m^3/m\,d}$$ or m^2/d

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4.13 | Given: Fig. 4.19 Unconfined aquifer. 1-D flow

$K = 14.5$ m/d
$h_1 = 17.6$ m $\quad h_2 = 15.3$ m
$L = 525$ m $\quad w = 0.007$ m/d

Find: (a) $q\ (x=0)$
(b) $q\ (x = 525\text{ m})$
(c) Location of water table divide
(d) h @ divide

20

5

(a) $$q'_x = \frac{K(h_1^2 - h_2^2)}{2L} - w\left(\frac{L}{2} - x\right)$$

$$= \frac{(14.5\text{ m/d})\left[(17.6\text{ m})^2 - (15.3\text{ m})^2\right]}{2(525\text{ m})} - 0.007\frac{\text{m}}{\text{d}}\left(\frac{525\text{ m}}{2} - \cancel{x}^{\,0}\right)$$

$$= 1.04\frac{\text{m}^2}{\text{d}} - 1.84\frac{\text{m}^2}{\text{d}}$$

$$\boxed{q'_x = -0.80\ \text{m}^2/\text{d} \quad @\ x = 0}$$

5

(b) $$q'_x\,(525\text{ m}) = 1.04\frac{\text{m}^2}{\text{d}} - 0.007\frac{\text{m}}{\text{d}}\left(\frac{525\text{ m}}{2} - 525\text{ m}\right)$$

$$= 1.04\frac{\text{m}^2}{\text{d}} + 1.84\ \text{m}^2/\text{d}$$

$$\boxed{q'_x = 2.88\ \text{m}^2/\text{d}} \quad @\ x = L$$

5

(c) Yes There is a divide

$$d = \frac{L}{2} - \frac{K}{w}\,\frac{(h_1^2 - h_2^2)}{2L}$$

$$= \frac{525\text{ m}}{2} - \frac{14.5\text{ m/d}}{0.007\text{ m/d}}\ \frac{\left[(17.6\text{ m})^2 - (15.3\text{ m})^2\right]}{2(525\text{ m})}$$

$$= 262.5\text{ m} - 179.3\text{ m}$$

$$\boxed{d = 113\text{ m}}$$

5

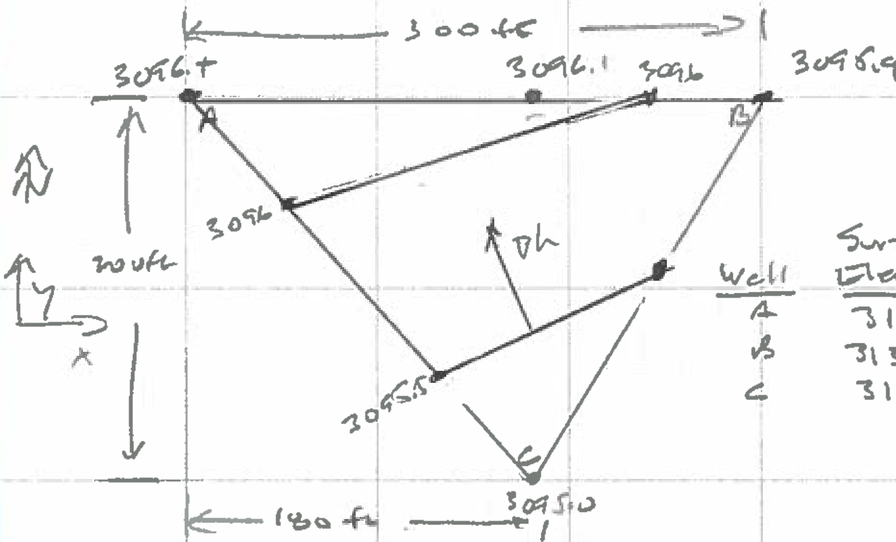
(d) $$h_{max} = \left[h_1^2 - \frac{(h_1^2 - h_2^2)d}{L} + \frac{w}{K}(L-d)d\right]^{1/2}$$

$$= \left[(17.6\text{ m})^2 - \frac{\left[(17.6\text{ m})^2 - (15.3\text{ m})^2\right](113\text{ m})}{525\text{ m}} + \frac{0.007\frac{\text{m}}{\text{d}}}{14.5\text{ m/d}}(525\text{ m} - 113\text{ m})(113\text{ m})\right]^{1/2}$$

$$= \left[309.8\text{ m}^2 - 16.3\text{ m}^2 + 22.5\text{ m}^2\right]^{1/2}$$

$$\boxed{h_{max} = 17.8\text{ m}}$$

6) Given: 3 observation wells in figure below
Find: Magnitude & direction of head gradient



Well	Surface Elev (ft)	Depth to Water (ft)	h (ft)
A	3138.5	42.1	3096.4
B	3139.2	43.3	3095.9
C	3140.0	45.0	3095.0

6

In x-direction

5

$$\frac{\partial h}{\partial x} = \frac{h_B - h_A}{300\text{ ft}} = \frac{3095.9\text{ ft} - 3096.4\text{ ft}}{300\text{ ft}} = \underline{-0.0017}$$

20 total

In y-direction

$$h_D = \frac{\partial h}{\partial x}(x_D - x_A) + h_A = (-0.0017)(180\text{ ft}) + 3096.4 = 3096.1\text{ ft}$$

5

$$\frac{\partial h}{\partial y} = \frac{h_D - h_C}{200\text{ ft}} = \frac{3096.1\text{ ft} - 3095\text{ ft}}{200\text{ ft}} = \underline{+0.0055}$$

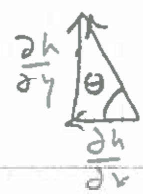
$$|\nabla h| = \sqrt{\left(\frac{\partial h}{\partial x}\right)^2 + \left(\frac{\partial h}{\partial y}\right)^2} = \left[(-0.0017)^2 + (0.0055)^2\right]^{1/2}$$

5

$$\boxed{|\nabla h| = 0.0057}$$

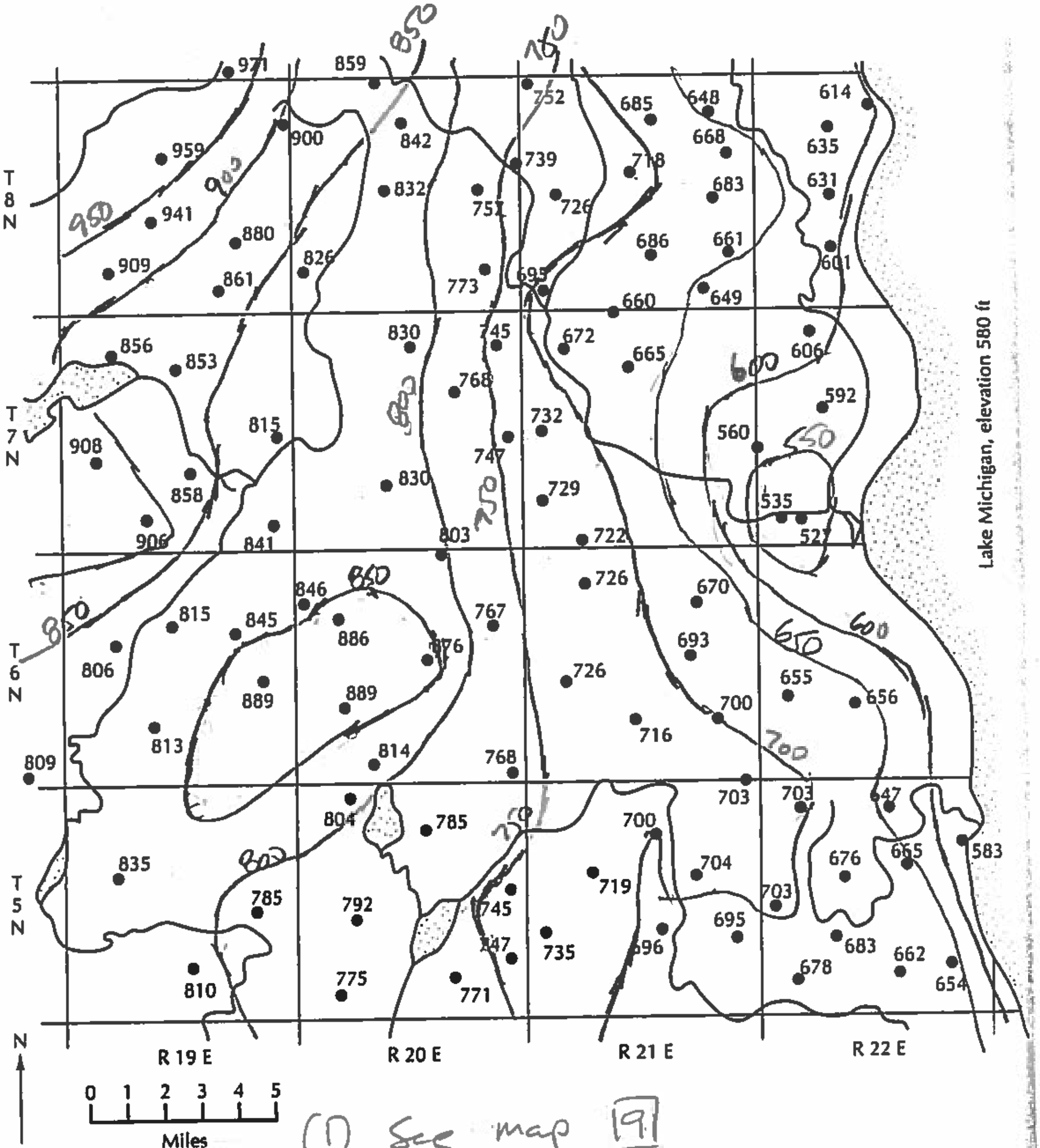
$$\theta = \tan^{-1}\frac{\partial h/\partial y}{\partial h/\partial x} = \tan^{-1}\left(\frac{+0.0055}{-0.0017}\right)$$

$$\boxed{\theta = 72.8^\circ}$$ north of west



flow is opposite direction

10 Total



▲ FIGURE 3.32
Base map for Analysis B.

(1) See map [9]

(2) Must be pumping wells at low head values < 580ft [1]