Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2018/2019

| | | |
|---|---|---|
| COURSE NAME | : | GROUND WATER ENGINEERING |
| COURSE CODE | : | BFW40403 |
| PROGRAMME CODE | : | BFF |
| EXAMINATION DATE | : | DECEMBER 2018 / JANUARY 2019 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | ANSWER **FOUR (4)** QUESTIONS ONLY |



THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

**Q1** (a) Briefly define each of the followings :
(i) Saturated layer
(ii) Unconfined aquifer
(iii) Groundwater table

(3 marks)

(b) Briefly explain the **THREE (3)** occurrences of groundwater existence.

(6 marks)

(c) During one year, the water balance parameters for a lake include rainfall $P$ = 1145 mm/year, evaporation $E$ = 830 mm/year, surface inflow $I$ = 45 mm/year, surface outflow $O$ = 124 mm/year, and change in storage $\Delta S$ = 55 mm/year. Estimate the net groundwater flow for the lake.

(8 marks)

(d) If the water table drops 40 m, the change in intergranular pressure at the bottom of the sand layer would occurs. Consider a 60 m thick of sand layer and the water table is located at a depth of 10 m below the groundwater surface. Create groundwater profile for the new water table for these condition.

(8 marks)

**Q2** (a) State **THREE (3)** importances of groundwater level monitoring.

(3 marks)

(b) Describe **THREE (3)** techniques of resistivity application and their purposes.

(5 marks)

(c) A river and a canal run parallel to each other L= 500 m apart as shown in **Figure Q2(c)** containing a fully penetrate unconfined aquifer with a hydraulic conductivity of 0.3 m/day. The elevation of the water surface in the river is 1.25 m lower than in the canal where the depth is 5 m. Assumming no recharge, find
(i) the water table elevation midway between the river and the canal
(ii) the discharge into the river.

(9 marks)

(d) Surface water and groundwater systems are connected in most landscapes. Rewrite the conditions
(i) gaining and losing stream
(ii) sketch diagrams for both conditions

(8 Marks)

**Q3** (a) List **THREE (3)** groundwater flow characteristics in terms of groundwater movement.

(3 marks)

(b) A field sample of an unconfined aquifer is packed in a test cylinder. The length and the diameter of the cylinder are 1 m and 10 cm, respectively. The field sample is tested for a period of 15 min under a constant head difference of 16.7 cm. As a result, 65.8 $cm^3$ of water is collected at the outlet. Compute the hydraulic conductivity of the aquifer sample.

(6 marks)

(c) A stratum of clean sand and gravel between two channels has a hydraulic conductivity K = 0.1 cm/s, and is supplied by water from a ditch ($h_0$ = 6.5 m deep) that penetrates to the bottom of the stratum. If the water surface in the second channel is 4 m above the bottom of the stratum and its distance to the ditch is x = 150 m (which is also the thickness of the stratum), estimate the unit flow rate into the gallery.

(7 marks)

(d) Formulate **TWO (2)** relationships of the laboratory experiment as shown in **Figure Q3(d)** to Darcy's Law for hydraulic conductivity determination.

(9 marks)

**Q4** (a) Identify **THREE (3)** purposes of test pumping water well.

(3 marks)

(b) A well is being pumped at a constant rate of 0.004 $m^3/s$. Given that T = 0.0025 $m^2/s$, r = 100 meters and the storage coefficient = 0.00087. Given W(u) at 15 minutes = 0.23 and 20 hours = 8.49. Find the drawdown in the observation well for a time period of

(i) 15 minutes
(ii) 20 hours

(6 marks)

(c) A step test was carried out for 2h steps. The **Table Q4(c)** shows data were obtained for yield (Q) and corresponding drawdown ($s_w$) in the pumping well. Determine

(i) value of losses
(ii) percent of well efficiency drops

(7 marks)

(d) A fully penetrating well in a confined aquifer with 30 m thickness is pumped at rate of 0.099 $m^3$/sec for 400 min. Drawdown measured at an observation well located 200 m away is given in **Table Q4(d).** By using the Cooper-Jacob method, calculate

(i) transmissivity,
(ii) hydraulic conductivity,

(9 marks)

**Q5** (a) Briefly explain the terms of groundwater contamination.

(2 marks)

(b) Define **TWO (2)** categories of contamination sources and examples.

(4 marks)

(c) Groundwater remediation techniques are mainly divided into two technologies namely ex-situ and in-situ. Point out the technologies that involved within each of the technologies.

(9 marks)

(d) An aquifer has a hydraulic conductivity of $2 \times 10^{-5}$ m/s, a hydraulic gradient of 0.003 m/m, an effective porosity $n_e = 0.2$ and an effective diffusion $D = 0.5 \times 10^{-9}$ $m^2/s$. A chloride solution with a concentration of 500 mg/L penetrates in the aquifer along a line source. Compose by appropriate equations for the chloride concentration at a distance of 20 m from the point of entry, after a period of 2 years.

(10 marks)

**Q6** (a) List **THREE (3)** tips of daily activities to protect and conserve groundwater.

(3 marks)

(b) Formulate recharge equation based on water level fluctuation.

(4 marks)

(c) Relate the monitoring work and site remediation to groundwater protection and investigation in terms of groundwater flow and the transport of contaminants

(9 marks)

(d) Conclude the process of groundwater recharge on the vadose zone soil water budget into three distinct processes.

(9 marks)

**–END OF QUESTIONS–**

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## FIGURES

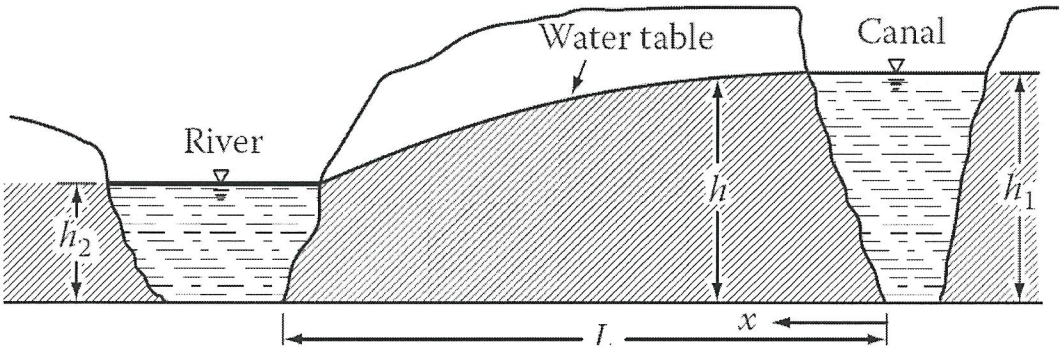


**FIGURE Q2(c):** Open channel cross section

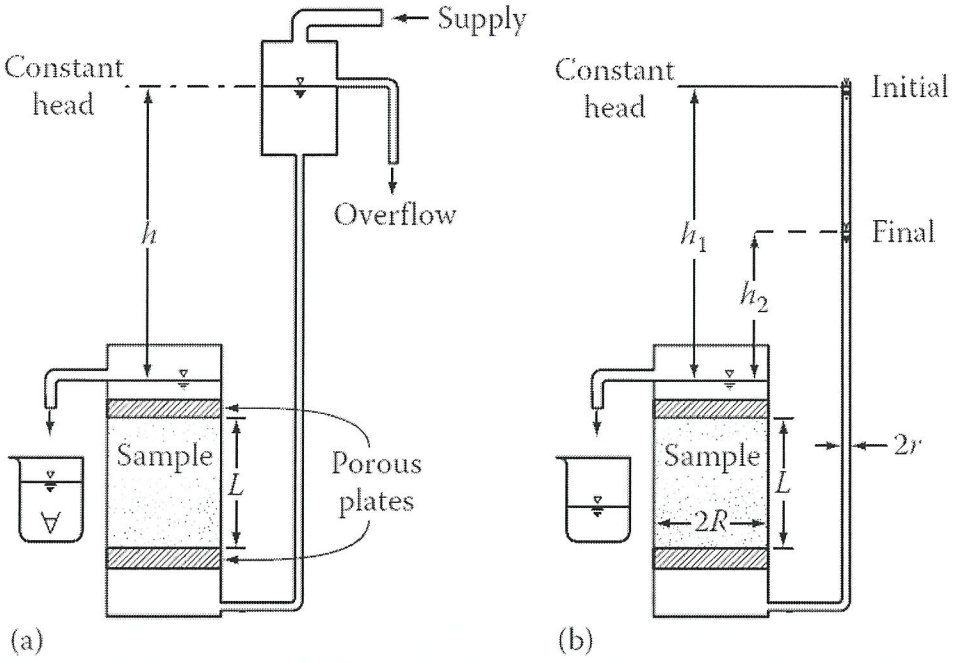


**FIGURE Q3(d):** Experimental samples

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## TABLES

**Table Q4(c):** Pumping test

| Step | Q (l/s) | $s_w$ (m) | $Q/s_w$ ($m^2$/day) |
|---|---|---|---|
| Rest | 0 | 0 | 0 |
| 1 | 14.7 | 1.43 | 888 |
| 2 | 31.5 | 3.46 | 787 |
| 3 | 44.4 | 5.41 | 709 |
| 4 | 57.6 | 8.90 | 559 |

**Table Q4(d):** Drawdown data

| Elapsed Time (min) | Drawdown (m) | Elapsed Time (min) | Drawdown (m) |
|---|---|---|---|
| 1 | 0.158 | 30 | 0.505 |
| 2 | 0.205 | 40 | 0.536 |
| 3 | 0.268 | 50 | 0.536 |
| 4 | 0.282 | 60 | 0.568 |
| 5 | 0.315 | 70 | 0.568 |
| 6 | 0.347 | 80 | 0.583 |
| 7 | 0.347 | 90 | 0.583 |
| 8 | 0.363 | 100 | 0.599 |
| 9 | 0.378 | 200 | 0.646 |
| 10 | 0.394 | 300 | 0.678 |
| 20 | 0.473 | 400 | 0.710 |

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## EQUATIONS

$$d^2(h^2)/dx^2 = 0$$

$$h^2 = c_1x + c_2$$

$$q = -Kh\left(\frac{dh}{dx}\right) = K(h_1^2 - h_2^2)/2L$$

$$K = \frac{\forall L}{Ath} \qquad K = \frac{r^2 L}{R^2 t}\ln\frac{h_1}{h_2}$$

$$u = \frac{r^2 S}{4tT} \qquad q = \frac{K}{2x}(h_o^2 - h^2) \qquad s = \frac{QW(u)}{4\pi t}$$

$$T = \frac{2.3Q}{4\pi\Delta s'} \qquad T = K \qquad S = \frac{2.25Tt_0}{r^2}$$

$$v = \frac{K}{n_e}dh/dx \qquad A = \pi r^2 \qquad Q_s = -K_s\frac{dh}{dx}A$$

$$\alpha_L \approx 0.0175L^{1.46} \qquad p_e = vL/D_L \qquad D_L = \alpha_L v + D^*$$

$$C(x,t) = \frac{C_0}{2}\left[erfc\left(\frac{x-vt}{2\sqrt{D_L t}}\right) + \exp\left(\frac{vx}{D_L}\right)erfc\left(\frac{x+vt}{2\sqrt{D_L t}}\right)\right]$$