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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	GROUNDWATER ENGINEERING
COURSE CODE	:	BFW 40403
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	1.	ANSWER ALL QUESTIONS
	2.	THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **CLOSED BOOK.**
	3.	STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

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

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Q1 (a) With the aid of a sketch, describe on groundwater profile with details of the zones that occur.

(4 marks)

(b) Discuss **THREE (3)** points with examples for each point on principles of groundwater flow.

(6 marks)

(c) Ten wells are located in a valley setting. Glacial material underlies the land surface and a confined sandstone aquifer underlies the region. All wells are shown in **Figure Q1(c)** and **Table Q1(c).**

(i) Calculate head values and plot on the map the groundwater table contour lines.

(ii) Based on the plotting result from **Q1(c)(i)**, sketch the groundwater flow on the map.

(iii) If the confined aquifer water at the orange rectangle became contaminated with dissolved nitrate from downward leakage of water in the overlying unconfined aquifer, would any other monitoring wells become contaminated under steady-state flow conditions? Construct equipotential lines and flow lines to support your answer.

(15 marks)

Q2 (a) With the Wenner array, conduct and produce the result for the groundwater table survey.

(5 marks)

(b) Show with a sketch of groundwater and surface water interact by gaining and losing water level respectively. Briefly explain how surface-water and groundwater systems are connected in most landscapes.

(8 marks)

(c) List the governing equation that describes two-dimensional (x and y), steady-state flow in a confined anisotropic and homogenous aquifer.

(6 marks)

(d) In the accompanying **Figure Q2(d)**, flow lines (black lines) form two flow tubes, A and B. If conditions are isotropic and homogeneous and flow is at a steady-state, create equipotential lines under the following conditions and judge the condition occurs.

(i) For A, assume the aquifer thickness and hydraulic conductivities are constant.

(ii) For B, assume the thickness of the aquifer increases from left to right while all other conditions remain constant.

(6 marks)

Q3 (a) Describe the volume of the pumping rate.

(5 marks)

(b) Show by a derivation that the units of Ss are 1/L.

(5 marks)

(c) A fully penetrating well in a confined aquifer with 30 m thickness is pumped at a rate of 0.099 m^3/sec for 400 min. Drawdown measured at an observation well located 200 m away is given in **Table Q3(c(i))**. By using the Cooper-Jacob method, analyze:

(i) transmissivity, T (m^2/s)
(ii) hydraulic conductivity, K (m/s)
(iii) Storativity, S
(iv) Classify the type of soil (Refer to **Table Q3 c(ii)**).

(15 marks)

Q4 (a) Identify **THREE (3)** potential sources of groundwater contamination and give an example for each.

(6 marks)

(b) Groundwater flows in aquifer has a hydraulic conductivity of 2 x 10-5 m/s, a hydraulic gradient of 0.003 m/m, and effective porosity ne = 0.2 and an effective diffusion D = 0.5 x 10-9 m^2/s. A chloride solution with a concentration of 500 mg/L penetrates the aquifer along with a line source. Evaluate by appropriate equations for the chloride concentration at a distance of 20 m from the point of entry, after a period of 2 years.

(12 marks)

(c) A confined aquifer underlies a 10 km^2 area. The average water level in a number of wells penetrating the confined system rose 2.5 m from April through June. An overlying unconfined aquifer showed an average water table rise of 2.5 m over the same period of time. Assume the storativity for the confined system is 3.6×10^{-5}, and the specific yield is 0.12 for the unconfined system. Compare the amount of water (in m^3) recharged in each aquifer (confined and unconfined) based on the responses of each potentiometric surface.

(7 marks)

-END OF QUESTIONS-

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TABLES

Table Q1(c): Water level data

Well name	Total well depth (m)	Top of casing elevation (m)	Water level (m)
A	150	1105	57
B	160	1100	39
C	170	1108	76
D	150	1100	59
E	180	1098	67
F	160	1090	57
G	180	1080	53
H	170	1079	41
I	180	1070	50
J	170	1100	41

Data: All water levels (WL) are measured at depths below the top of casing (TOC) elevation. TD is the total well depth below the land surface. The head measurement is at the bottom of each well.

Table Q3(c(i)): 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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Table Q3 c(ii): Hydraulic conductivity values

Material	K (cm/sec)
Gravel	10^{-1} to 100
Clean sand	10^{-4} to 1
Silty sand	10^{-5} to 10^{-1}
Silt	10^{-7} to 10^{-3}
Glacial till	10^{-10} to 10^{-4}
Clay	10^{-10} to 10^{-6}
Limestone and dolomite	10^{-7} to 1
Fractured basalt	10^{-5} to 1
Sandstone	10^{-8} to 10^{-3}
Igneous and metamorphic rock	10^{-11} to 10^{-2}
Shale	10^{-14} to 10^{-8}

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FIGURE

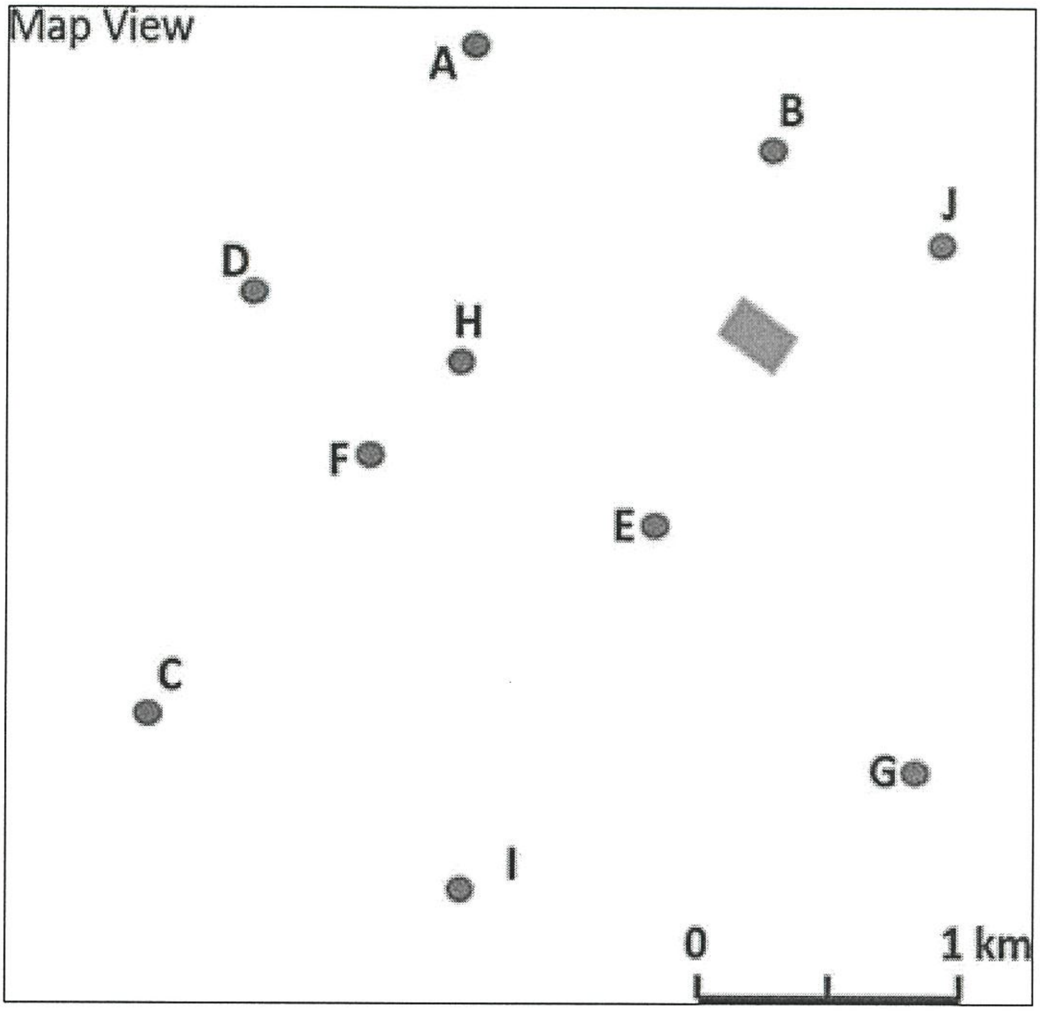

Figure Q1(c): Map view for the study area

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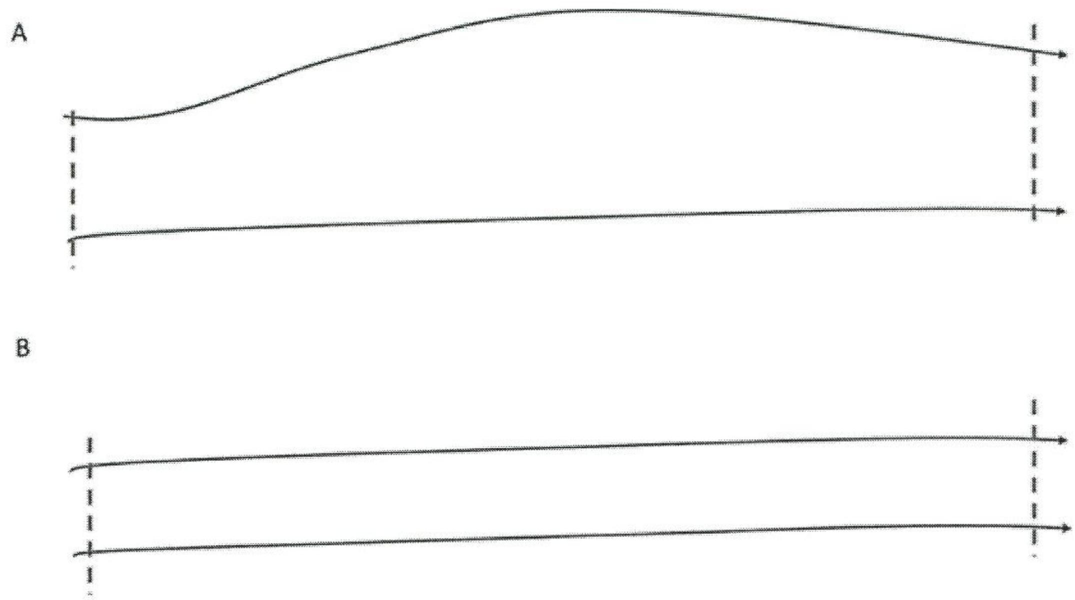

Figure Q2(d): Cross-section of groundwater flow

EQUATIONS

$$v = \frac{K}{n_e} dh / dx \qquad P_e = vL / D_L \qquad T = \frac{(2.30Q)}{4\pi\Delta s'}$$

$$S = \frac{2.25Tt_0}{r^2} \qquad S_s\frac{\partial h}{\partial t} = K_x\frac{\partial^2 h}{\partial x^2} + K_y\frac{\partial^2 h}{\partial y^2} + K_z\frac{\partial^2 h}{\partial z^2}$$

$$Ss = \rho g\ (\alpha + ne\beta) \qquad T = Kb$$