

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

SUMMER EXAMINATIONS 1999

THIRD SCIENCE EXAMINATION - HYDROLOGY AND HYDROGEOLOGY

Examiners: Professor P.E. O'Connell
 Professor C. Cunneane
 Mr. T. Henry

Time allowed is *three* hours.

Attempt *five* questions with at least two from each section.
 Use separate answer books for each section.
All questions carry equal marks.

SECTION A

1. Write notes on any *four* of the following:

- (a) The effect of afforestation/deforestation on catchment hydrology.
- (b) Climate change/and or El Nino.
- (c) Interception and infiltration.
- (d) Measurement of rainfall and its accuracy.
- (e) Chemical composition of rainfall.
- (f) River water quality in Ireland.

[5 marks each]

2. (a) What are the relative merits of river flow measurement by current meter and dilution gauging?

[12 marks]

- (b) A mass of 0.5kg of a conservative tracer was suddenly injected into the midpoint of a mountain stream. Samples were taken at six (6) minute intervals sufficiently far downstream to ensure that thorough transverse and vertical mixing of the tracer had taken place. Sampling was continued for 144 minutes. The concentrations of tracer measured in the samples are as shown in the table and diagram overleaf. Determine the flow rate (discharge) in the stream in m³/second, assuming that the background concentration of the tracer is negligible.

[8 marks]

Question Two contd. overleaf

Assuming zero (0) SMD for April, calculate SMD and actual evaporation for the months of May to October inclusive, and calculate areal values of these assuming that grassland and woodland occupy 60 percent and 20 percent respectively of the area and that the remainder is riparian. What is the total actual areal evaporation for these months as a percentage of total potential evaporation?

[12 marks]

4. Answer *all* parts of the question.

- (a) A location at 60° north has mean monthly wind speed of 0.8 m/s, mean monthly temperature of 14.6°C, and mean monthly vapour pressure of 1.1 kPa during a particular month of May. If the average number of hours of bright sunshine was 40 percent of the maximum possible calculate the average daily incoming radiation available at the Earth's surface assuming an albedo of $r = 0.20$.

[4 marks]

- (b) Calculate the average daily longwave or outward radiation of this month.

[4 marks]

- (c) Using the results of (a) and (b) calculate the average daily potential evaporation using the Penman equation.

[8 marks]

- (d) How does the Penman-Monteith equation differ from the original Penman equation?

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SECTION B

5. Answer *eight* of the following. Please keep your answers brief.

- (a) Is *specific discharge* (q) a microscopic or macroscopic concept? Briefly explain your answer.
 - (b) What is the difference between the *moisture content* and the *saturation* of a rock sample?
 - (c) Is hydraulic conductivity affected by a change in temperature of the fluid in a system? Briefly explain your answer.
 - (d) What is Hubbert's definition of potential?
 - (e) What is the difference between the *potentiometric surface* and the *water table*?
 - (f) What is the difference between *anisotropy* and *heterogeneity*?
 - (g) The drawdown at an observation well located some distance from a pumping well is a function of what *three* variables?
 - (h) The equation below describes two-dimensional flow through a homogeneous, anisotropic aquifer, including a source/sink term for recharge/leakage. Is the flow *transient* or *steady state*? Justify your answer.
- $$T_x \frac{d^2 h}{dx^2} + T_y \frac{d^2 h}{dy^2} + q_s(x, y, t) = S \frac{dh}{dt}$$
- (i) *Porosity* is a function of sorting, shape and size of particles. True or false? Briefly explain your answer.
 - (j) What is *Storativity*? How is it defined in an *unconfined* aquifer?

[2.5 marks each]

6. Answer either (a) or (b).

- (a) The quality and quantity of well water in East and South Galway is inextricably linked to the area's geology. Using specific examples, write an essay on the hydrogeology of the region. Your answer should include an explanation of the process of karstification.

[20 marks]

or

- (b) *Safe yield* is a concept that divides hydrogeologists. Write an essay on the subject. Your answer should include an explanation of the historical development of the term, as well as the conflicting definitions. Offer your own opinion of the concept, and suggest which definition is most workable, if at all.

[20 marks]

7. Answer *all* parts of the question.

- (a) What is an aquifer? There are three broad classes of aquifer; list them and write a *brief* note about each.

[6 marks]

- (b) What are the Dupuit assumptions in relation to steady flow in unconfined aquifers?

[3 marks]

- (c) Two rivers run parallel to each other, at a distance of 1000 metres. The rivers fully penetrate an unconfined (water-table) aquifer. The hydraulic conductivity of the aquifer is 0.5 m/day. Rainfall in the area averages 15 cm/year and evaporation averages 10 cm/year. The elevation of the water in River One is 20 metres above datum, and the elevation of the water in River Two is 18 metres above datum.

- (i) Determine the *location* of the water table divide. [2 marks]

- (ii) Determine the *elevation* of the water table divide (the maximum water table elevation). [4 marks]

- (iii) Determine the daily discharge per metre width into River Two.

[5 marks]

8. Answer (a) *and* (b). Both sections carry equal marks.

- (a) A well penetrating a confined aquifer is pumped at a constant rate of 0.2 m³/second. Drawdowns are measured in an observation well located 100 metres away. The results of the test are plotted on the attached graph.

- (i) Identify Δs and t_0 on the graph.

[2 marks]

- (ii) Calculate T and S, reporting T in m²/second.

[6 marks]

- (iii) Give two assumptions regarding the pumping well that are required for the analysis used in (i) and (ii) above.

[2 marks]

*Remember to write your name and examination number on the graph,
and to enclose the graph with your answer script.*

- (b) (i) There are two types of boundaries found in real aquifers. What are they? Briefly explain how they affect drawdowns in a well?

[4 marks]

- (ii) A well is installed in an aquifer and pumped at a rate of 1500 m³/day. The transmissivity of the aquifer is reported to be 95 m²/day and the storativity is 1×10^{-3} . A reservoir is located 350 metres from the pumping well. What would the drawdown be at a monitoring well located at the midpoint between the reservoir and the pumping well after 30 days of pumping?

[6 marks]