



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL AND WATER ENGINEERING

GROUNDWATER HYDRAULICS AND MODELLING

ECW 5001

Main Examination Paper

DECEMBER 2024

This examination paper consists of 3 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: NONE

Examiner's Name: ELLEN NDUNA

INSTRUCTIONS

1. Answer ANY FOUR (4) questions
2. Each question carries 25 marks
3. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	25
2.	25
3.	25
4.	25
5.	25
TOTAL	100

QUESTION 1

a. What do you understand by the following terms as used in hydrogeology

i. perched water table

ii. hydraulic conductivity

iii. cone of depression

iv. aquitard

v. baseflow

(10 marks)

b. An unconfined aquifer is located between 2 fully penetrating rivers and has a hydraulic conductivity of $K = 10^{-2}$ cm/s. The aquifer is subject to a uniform recharge of 1.6 m/year. The water surface elevation in the first river is 8.5 m and 10 m in the second river. Estimate:

i. the maximum elevation of the water table and the location of groundwater divide.

ii. the travel time from the groundwater divide to both rivers

iii. the daily discharge per kilometer from the aquifer into both rivers.

Take effective porosity = 0.35

(15 marks)

[25 marks]

QUESTION 2

a. What are the water quality factors that affect groundwater use and sustainability

(10 marks)

b. Outline the geological occurrence of groundwater in ONE aquifer (of your choice), possible groundwater quality and groundwater abstraction problems in Zimbabwe.

(15 marks)

[25 marks]

QUESTION 3

a. Near steady-state conditions, explain how the hydraulic gradient changes in the flow direction in: i. confined ii. unconfined aquifer

(5 marks)

b. Three pumping wells located along a straight line are spaced at 200 m apart. What should be the steady-state pumping rate from each well so that the near steady-state drawdown in each well will not exceed 2 m? The transmissivity of the confined aquifer, which all the wells fully penetrate, is $2400 \text{ m}^2/\text{day}$ and all the wells are 40 cm in diameter. The thickness of the aquifer is 40 m and the radius of influence of each well is 800 m.

(15 marks)

c. A confined aquifer is 18.5 m thick. The potentiometric surface elevations at 2 observation wells 822 m apart are 25.96 m and 24.62 m. If the hydraulic conductivity of the aquifer is 25 m/day, determine the flow rate per unit width of the aquifer, specific discharge and average linear velocity of the flow assuming steady unidirectional flow.

(5 marks)

[25 marks]

QUESTION 4

a. A 0.5 m diameter well, 200 m from a river is pumping at an unknown rate from a confined aquifer. The aquifer properties are $T = 432 \text{ m}^2/\text{day}$ and $S = 4.0 \times 10^{-4}$. After 8 hours of pumping, the drawdown in the observation well (60 m from the river) is 0.8 m. Compute the rate of pumping and the drawdown in the pumped well. What is the effect of the river on drawdown in the observation well and in the pumped? (15 marks)

b. A well is pumping near a barrier boundary at a rate of $0.03 \text{ m}^3/\text{s}$ from a confined aquifer 20 m thick. The hydraulic conductivity of the aquifer is 27.65 m/day and its storativity is 3×10^{-5} . Determine the drawdown in the observation well after 10 hours of continuous pumping. What is the fraction of the drawdown attributable to the barrier boundary? (10 marks)

[25 marks]

QUESTION 5

- a. Describe the 4 general steps of the finite difference method in groundwater modelling. (10 marks)
- b. State and explain any 2 conditions in which to apply the finite difference method (5 marks)
- c. Derive the equation for 1-dimensional flow through a porous media (10 marks)

[25 marks]