NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

HYDROLOGY AND CONTAMINANT PROCESSES
MAPH 6121
EXAMINATION

MSC GEOPHYSICS: JANUARY 2014 *DURATION: 4 HOURS*

ANSWER ALL QUESTIONS IN THIS PAPER. THE MAXIMUM POSSIBLE MARKS IS 120.

---

1. With the aid of a well labeled diagram, quantify the various components of a hydrologic cycle. [10]
2. Describe the vertical distribution of groundwater in the vadose zone and capillary fringe in unsaturated zone hydrology. [5]
3. (a) List any three forces which act on groundwater [3]
   (b) With the aid of well explained equations, distinguish between hydraulic head and pressure head for flow in the saturated zone. [5]
   (c) Draw a labeled section of a borehole showing the relation between pressure head, hydraulic head and elevation head for a well. [3]
4. With the aid of a single elaborative diagram, describe the geological setting and properties of the following aquifer formations:
   (a) Unconfined aquifer. [5]
   (b) Artesian aquifer. [4]
   (c) Perched aquifer. [3]

5. (a) With the aid of relevant equations, distinguish between specific yield and specific retention, for saturated flow. [4]
   (b) Estimate the average drawdown over an area where 25 million cubic meters of water has been pumped through a number of uniformly distributed wells. The area is 150 km^2 and the specific yield of the unconfined aquifer is 25 percent. [4]
6. (a) What do you understand by the terms aquifer storativity and transmissivity. Discuss the importance of these terms in aquifer characterization. [5]
   (b) A 1-m diameter well penetrates vertically through a confined aquifer 30 m thick. When the well is pumped at 113 m^3/hr, the drawdown in a well l5 m away is 1.8 m and in another well 50 m away, it is 0.5 m. Assume that the initial piezometric level is 40 m above the datum.
      (i) Calculate the approximate head in the pumped well for steady-state conditions and what is the approximate drawdown in the well. [4]
      (ii) Compute the transmissivity of the aquifer and the radius of influence of the pumping well. [4]

7. (a) State the Darcy equation for saturated groundwater flow, describing all symbols used. [2]

(b) A confined aquifer with a horizontal bed has a varying thickness as shown in Figure 1. The aquifer is inhomogeneous with K = 12 + 0.006x, where x = 0 at section (1), and the piezometric heads at sections (1) and (2) are 14.2 m and 18.8 m, respectively measured above the upper confining layer. Assuming the flow in the aquifer is essentially horizontal, determine the flow rate per unit width.

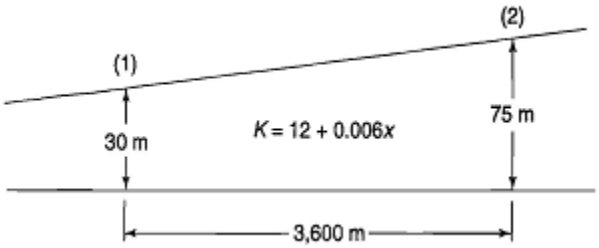


Figure 1. [4]

(c) Show that for unsaturated groundwater flow , Darcy's law can be modified to Richard's equation as:

$$\frac{\partial \theta}{\partial t} = -\frac{\partial q}{\partial z} = \frac{\partial}{\partial z}\left(D\frac{\partial \theta}{\partial z} + K(\theta) \right)$$

[7]

8. (a) Consider an unconfined aquifer between two rivers as shown in Figure 2 below with recharge rate of W. The flow is only in one direction so that the x-axis is aligned parallel to the flow.

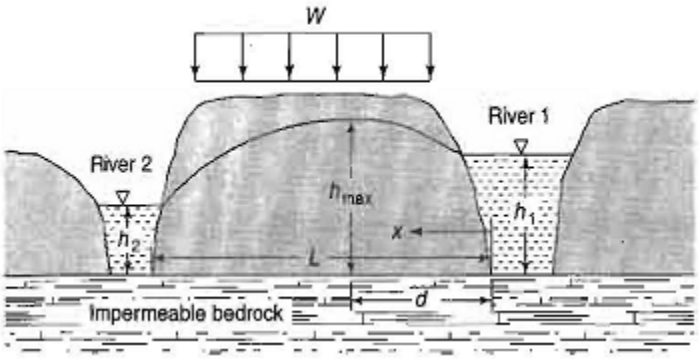


Figure 2.

Using flow considerations, obtain an expression for h_{max} the maximum elevation of the water table in the aquifer. [6]

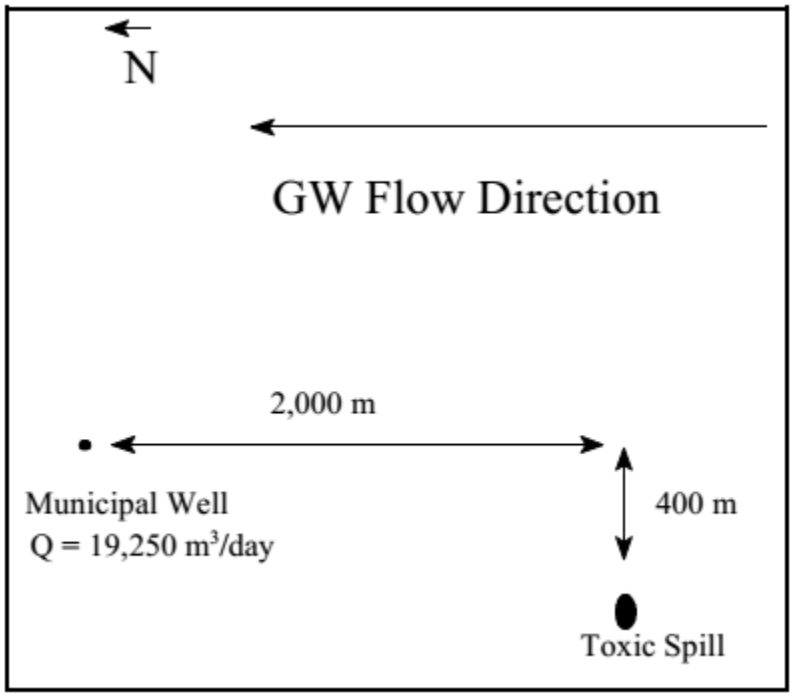
(b) An unconfined aquifer of clean sand and gravel is located between two fully penetrating rivers separated by 460m apart and has a hydraulic conductivity of K = 10^{-2} cm/sec. The aquifer is subject to a uniform recharge of 1.6 m/year. The water surface elevations in rivers A and B are 8.5 m and 10m, respectively, above the bottom. Estimate;

(i) the maximum elevation of the water table and the location of groundwater divide. [4]

(ii) the travel times from groundwater divide to both rivers (n, = 0.35). [6]

(iii) the daily discharge per kilometer from the aquifer into both rivers. [3]

9. The municipal well (which pumps at 19,250 m /day) is screened in a confined aquifer located 30 m to 80 m below the surface. Aquifer materials consist of coarse sands with a hydraulic conductivity of about 80 m/day. The well has been pumping for several years and conditions approach steady state. Groundwater flow in the aquifer trends toward the north. The potentiometric surface of the aquifer (measured before pumping commenced) drops approximately 1 m for every 200m. The location of the well relative to the toxic spill is illustrated by Figure 2. Estimate the spatial extent of the capture zone of the pumping well.



[8]

11. Discuss the role of advection and dispersion in contaminant transport. [6]

12. Discuss the vulnerability of karst aquifers to contaminant transport. [5]

13. Discuss of geoelectrical and electromagnetic geophysical methods may be useful in investigating potential contaminant transport at a landfill site. [10]

END OF PAPER