AGRICULTURAL AND FOOD ENGINEERING DEPARTMENT
INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Mid-Spring Semester Examination 2003-2004

Program: M.Tech. (WRDM) & 4th Year Dual Degree **Full Marks: 30**

Subject: Advanced Groundwater Hydrology (AG60864/AG60044) ***Time: 2 hours***

Date of Examination: 28 February 2004 (AN) ***No. of Students: 15***

Instructions: *Answer **all** questions. Make reasonable assumptions wherever needed. Answer different parts of a question at one place.*

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1. (a) During a field investigation it was revealed that a slowly permeable soil layer of 0.5 m thickness (K = 1.5 cm/day) exists at a depth of 3.0 m. It is overlain by a silt loam layer having K = 15 cm/day and underlain by a sand and gravel layer having K= 90 m/day. A heavy rainfall storm causes a steady infiltration of 4 cm/day, which creates perched groundwater condition. After flowing through the slowly permeable layer, the water moves as unsaturated flow through the sand and gravel layer to an unconfined aquifer. What is the height of the perched water table from the top of the slowly permeable layer? *(4)*

   (b) A perennial stream passes by a groundwater basin in such a way that it constitutes basin's one boundary of length 6.5 km. The other side of the stream is dominated by rocks (almost impermeable). Field investigations indicated that the stream is in direct hydraulic connection with the basin up to 5 km from the stream. During dry periods, average daily streamflows at the upstream end (entry point) and downstream end (exit point) were observed to be 3.22 and 3.30 m^3/s, respectively. The distance between the two stream-gauging locations is 6 km and the average saturated thicknesses of the aquifer at 0.5, 1, 2, 5, 7 and 10 km from the stream are 60, 60, 58, 57, 45 and 40 m, respectively. During dry periods, the average water table elevation at 5 km away from the stream is 8.5 m (MSL) and that close to the stream is 7.25 m (MSL). **Calculate average hydraulic conductivity** of the portion of the groundwater basin, which is influenced by the stream. If the average water table elevations during wet periods are 12.5 m (MSL) near the stream and 9.2 m (MSL) at 5 km away from the stream, **estimate the return flow** in m^3/day. *(3+1)*

2. (a) During a tracer test in a groundwater basin, a non-radioactive tracer was injected as slug in an observation well having water table elevation 10.2 m (MSL) and the arrival time of the tracer was monitored in another observation well tapping the same aquifer (water table elevation = 3.1 m (MSL)) and located downstream at a distance of 250 m from the first observation well. It was found that the tracer reached the second observation well after 11.5 hours (since the tracer injection). If the area of the aquifer strip under investigation is 1.5 km^2 and the specific retention of the aquifer material is 0.88, **compute the aquifer hydraulic conductivity** and the **actual groundwater discharge** (in m^3/day) through the aquifer strip. Write the limitations of this field test. *(3)*

   (b) The streamflow data of a perennial river for two consecutive years were plotted with time on arithmetic scale and streamflow on logarithmic scale to construct annual streamflow hydrographs. Then the streamflows during the baseflow recession periods for first and second years were fitted separately to a straight line, which yielded the following baseflow recession models:

   First Year's recession: $Q = 750\ e^{-0.4187t}$; **Second Year's recession:** $Q = 1200\ e^{-0.3289t}$

   Where, Q = streamflow at time't' after the recession started (m^3/s) and t = time since the start of the recession (month). The periods of first and second years' baseflow recessions are 6.5 and 8.0 months,

respectively. Determine the groundwater recharge that occurs from the end of first year's baseflow recession to the start of second year's baseflow recession, if the evapotranspiration and groundwater pumping during the recharge period are 1.5×10^3 and 2.2×10^6 m^3, respectively. *(4)*

3. (a) Derive the expression for hydraulic conductivity ellipsoid for flow in the x-y plane in a homogeneous and anisotropic aquifer system. *(2.5)*

(b) A single-layer aquifer system has an area of 150 ha and a mean thickness of 70 m. Field investigation revealed that it has a mean transmissivity of 1500 m^2/day, specific yield of 15% and a storage coefficient of 5×10^{-5}. Determine the volume of groundwater recovered under the following field conditions: *(3.5)*

(i) The aquifer is unconfined and is completely drained.

(ii) The aquifer is confined and the piezometric head is lowered by 60 m, which drains half the thickness of the aquifer.

4. (a) Assuming that the principal directions of anisotropy coincide with x, y, and z directions of the coordinate axes, write the general three-dimensional equation of flow in the following types of confined aquifer systems: *(5)*

(i) Homogeneous and isotropic, **(ii)** Homogeneous and anisotropic, **(iii)** Heterogeneous and isotropic,

(iv) Transversely isotropic, and **(v)** Heterogeneous and anisotropic.

(b) Briefly explain the following terms: *(4)*

(i) Delayed yield phenomenon, **(ii)** Specific storage and Apparent specific yield, **(iii)** Barometric and tidal efficiencies of an aquifer system, and **(iv)** Hydraulic conductivity tensor and Hydrocompaction.

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Good Luck!