Review Sheet for Geology 627 Midterm 1, Fall 2004

Terms to review: For the following terms you should be familiar with definitions, common abbreviations, dimensions (units) associated with parameter, relations among relevant parameters.

Ground water (can be spelled with one or two words), conservation equation, recharge, evaporation, evapotranspiration, potential evapostranspiration, porosity (usually refers to total porosity), primary porosity, secondary porosity, effective porosity, void ratio, bulk density, wet bulk density, solids density, gravitational constant, specific weight, hydraulic head, elevation head, pressure head, fluid (or pore) pressure, velocity head, Hubbert's potential, hydraulic conductivity, hydraulic gradient, specific discharge (also referred to as Darcy velocity or Darcy flux), linear velocity (also referred to as pore velocity), volumetric flux (Q), water table, potentiometric surface, piezometer, piezometer nest, intrinsic permeability (sometimes just called permeability), viscosity, isotropy, anisotropy, arithmetic mean, harmonic mean, geometric mean, homogeneous, heterogeneous, equipotential, streamline (flowline), transmissivity, specific yield, specific retention, specific (elastic) storage, aquifer storativity (also referred to as the aquifer storage coefficient), (coefficient of) compressibility of water, (coefficient of) vertical compressibility of pores (or of the aquifer matrix), total (vertical) stress, effective (vertical) stress, aquifer, confining unit, aquitard, hydrostratigraphic unit, REV, governing equation, boundary conditions, initial conditions, dependent variable, independent variables, 1st type (Dirichlet) b.c., 2nd type (Neumann) b.c., 3rd type (Cauchy) b.c.

Sample questions. Note that these are intended to give you an idea of the *style and level of complexity* of the questions that will appear on the exam. They are *not* intended to provide exhaustive coverage of the factual, mathematical, and conceptual content of the exam. The exam will include material covered in lectures through October 13 (solutions to the gw flow equation), assigned readings (through Chapter 5, excluding section 5.4 on flow nets), Problem Sets 1 and 2, and Labs 1-4.

Multiple Guess - Mark all answers that are correct. There may be more than one correct answer for some questions.

1. As written, the equation $\frac{\partial}{\partial x}\left(b\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(b\frac{\partial h}{\partial y}\right)=\frac{S}{K}\frac{\partial h}{\partial t}$ ***best*** describes flow in a confined aquifer that (mark all that apply)
   ____ a) is at steady state
   ____ b) is under transient flow conditions
   ____ c) has a homogenous distribution of transmissivity
   ____ d) has a heterogeneous distribution of transmissivity
   ____ e) has a uniform thickness
   ____ f) has a nonuniform thickness
   ____ g) is isotropic
   ____ h) is anisotropic

2. The water balance method applied in the first lab accounts for
   ____ a) depletion and replenishment of water held in the soil
   ____ b) surface runoff
   ____ c) enhanced recharge during snowmelt
   ____ d) seasonal differences in potential evapotranspiration due to seasonal variations in temperature and daylight hours

3. The head measured in a water table well is 99.6 m while the head measured in an adjacent piezometer open at an elevation of 40.0 m (measured relative to the same datum) is 98.6 m. At this site
   ____ a) the vertical component of flow is upwards
   ____ b) the vertical hydraulic gradient is computed as $\frac{99.6m - 40.0m}{99.6m - 98.6m}$
   ____ c) the hydraulic gradient is positive
   ____ d) the vertical specific discharge is negative

4. The equation $\frac{\partial^2(h^2)}{\partial x^2} + \frac{\partial^2(h^2)}{\partial y^2} = \frac{S}{T}\frac{\partial(h^2)}{\partial t}$
   ____ a) describes steady state flow in a confined aquifer
   ____ b) describes transient flow in an unconfined aquifer
   ____ c) is based on an assumption that the aquifer is homogeneous but anisotropic
   ____ d) will use the specific yield as the aquifer storage coefficient S

5. Which of the following rock types is most likely to have high porosity but low hydraulic conductivity?
   ____ a) Shale
   ____ b) Granite
   ____ c) Sandstone
   ____ d) Gravel

6. When mapping the potentiometric surface for a confined aquifer, it is acceptable to use wells that are open at different depths below the land surface as long as
   ____ a) the equipotentials in the aquifer are approximately horizontal
   ____ b) the direction of flow in the aquifer is approximately horizontal
   ____ c) the well screens are very short
   ____ d) the well screens are located at the same elevation relative to sea level

7. (Fill in the blanks) The dry bulk density of a sandstone is 1.80 g/cm^3. Assuming that the sandstone is composed entirely of quartz with a density of 2.65 g/cm^3, the porosity of the sandstone is _____ and the wet bulk density of the sandstone is _____.

8. (Fill in the blanks) The total porosity of an unconfined aquifer that underlies an area of 2.0 x 10^9 ft^2 is 26% and the specific yield is 20%. The specific retention of this aquifer is _____. Following an extended drought, the water table drops by 3.5 feet. This decline in the water table corresponds to a loss of water from storage of _____ ft^3.

Short answer problems

1. A series of falling head permeameter experiments are conducted using a sediment-filled column with a length of 30.0 cm and a cross-sectional area of 10.0 cm^2. The column outlet port is at an elevation of 35.0 cm above the reference datum. For the first experiment, the timer was started at t_0 when the water level in the burette was at an elevation of 80.0 cm above the datum and was stopped at t_1 when the water level in the burette was 50.0 cm above the datum. The elapsed time, t_1-t_0, for the experiment was 45 seconds and the volume of water that flowed through the column during this time was 30.0 ml.
a) Determine the hydraulic conductivity of the sediment.
b) Based on the value of K determined in part a) the sediment is most likely to be (circle one answer below)

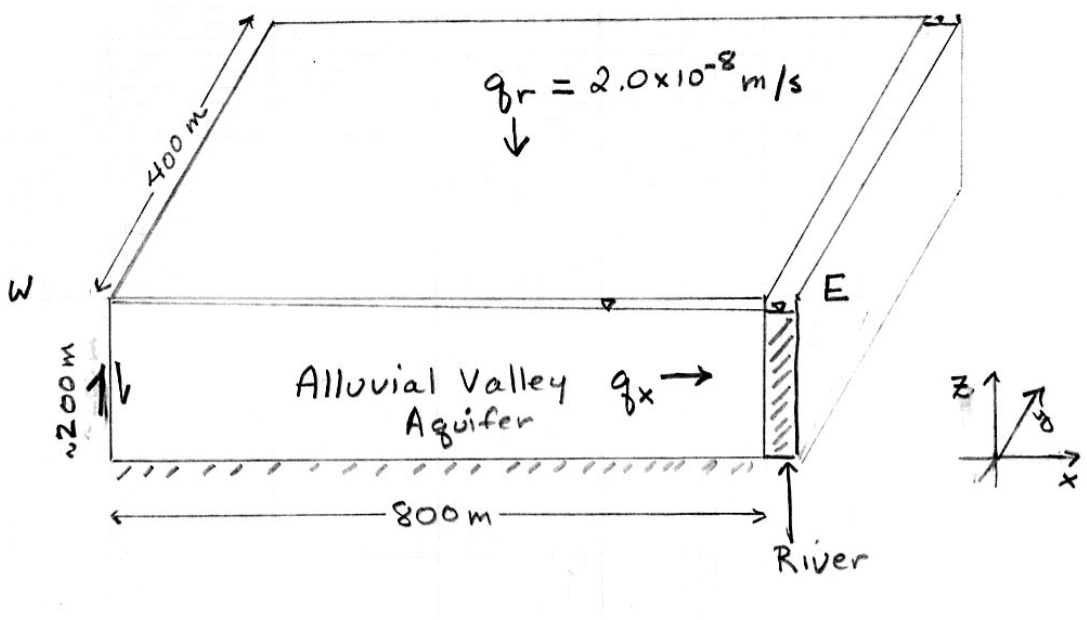
gravel fine sand silt

c) During the second experiment, the timer was started when the water level in the burette was at an elevation of 70.0 cm above the datum and was stopped when the water level in the burette was at an elevation of 40.0 cm above the datum. Assuming that the burette has a uniform cross-sectional area, what was the volume of flow through the column during the elapsed time of this experiment?
d) What was the elapsed time, t_1-t_0, for this second experiment?

2. The horizontal specific discharge, **q**, in a confined aquifer has a magnitude of 5.6×10^{-7} m/s and a direction of $S35^0W$ (35^0 west of south). The aquifer is anisotropic, with the principal axes of anisotropy oriented in the N-S and E-W directions. The hydraulic gradient, dh/dl, has a magnitude of 2.8×10^{-3} and a direction of $N20^0E$ (20^0 east of north). You may find it helpful to sketch this situation before attempting to answer the questions below.

a) Determine the magnitudes of the specific discharge vectors $\mathbf{q_X}$ and $\mathbf{q_Y}$ where the x-axis corresponds to the E-W direction and the y-axis corresponds to the N-S direction.
b) Determine the magnitudes of the hydraulic conductivities K_x and K_y in the E-W and N-S directions.
c) If the head at a point A is 100.00 m above sea level, what is the head at a point B located 500 m due west of A?

3. Consider the diagram shown below, which represents a homogeneous, isotropic, unconfined aquifer in a river valley. The aquifer if approximately 200 m thick and is underlain by low permeability clay. It is bounded to the west by an impermeable fault and to the east by a river that penetrates the entire thickness of the aquifer. The aquifer receives recharge over its entire area at a rate of 2.0 x 10^{-8} m/s. this is the only source of water to the aquifer. Discharge occurs to the river, and the river is the only place at which water can exit the aquifer.



a) Assuming that the flow system is at steady state, how much water (in m^3/s) does the river gain over the 400 m reach shown in the figure?
b) If the hydraulic conductivity of the aquifer is 4.0 x 10^{-4} m/s and the water level in the river is 198.0 m above the base of the aquifer, what is the horizontal gradient in the aquifer at the edge of the river?
c) Assuming that the flow field in the aquifer is steady and that flow is strictly horizontal from west to east, list the simplest governing equation that could be used to compute heads in the aquifer. (Note that the east-west direction corresponds to the x-axis on the diagram.)
d) Specify the two boundary conditions that you would use at the river and along the western boundary of the aquifer to obtain a solution to the governing equation for this aquifer.

4. A field sample of sandstone is collected from below the water table in a sealed container whose volume is 0.0004 cubic meters. After accounting for the weight of the container, the sample is found to weigh 1.567 kg. A small valve is opened at the bottom of the container and the sample is drains for a week after which time it weighs 1.423 kg. The sample is then oven dried after which it weighs 1.407 kg. What are the **wet bulk density, the dry bulk density, the specific yield, the specific retention, and the porosity** of the sample?

5. The thicknesses and lithologies of sedimentary rocks in the San Juan Basin of northwestern New Mexico are described in the table below (modified from a USGS professional paper). Formations are listed from shallowest to deepest (top to bottom).

Geologic Unit	Description and Thickness (ft)
Ojo Alamo Sandstone	Chiefly sandstone and conglomerate, 50-200
Kirtland Shale	Chiefly mudstone, siltstone and silty sandstone, 700
Fruitland Formation	Chiefly mudstone, siltstone, coal and silty sandstone, 700
Pictured Cliffs Sandstone	Chiefly sandstone, 100-400
Lewis Shale	Chiefly claystone to siltstone, 0-400
Cliff House Sandstone	Sandstone, 200-800
Menefee Formation	Alternating siltstone, coal and sandstone beds, 1,100-2,200
Point Lookout Sandstone	Chiefly sandstone, 0-300
Crevasse Canyon Formation	Alternating siltstone, coal and sandstone beds, 700-900
Gallup Sandstone	Chiefly sandstone, 0-300

a) List the formations(s) that would be part of an unconfined aquifer, assuming that the water table occurs within 30 ft of the land surface.
b) Which geologic formations contain more than one hydrostratigraphic unit?
c) List two formations that could act as a single aquifer in at least some portions of the basin.