**Study guide for groundwater and surface-subsurface exchange.**

**Vocabulary:**

Water content ($θ$), porosity ($ϕ$), water table, capillary fringe, well casing, well screening, aquifer, aquitard, unconfined aquifer, storativity (or storage coefficient), specific yield, confined aquifer, potentiometric or piezometric surface, specific storage, hydraulic head, elevation head, pressure head ($ψ$), Darcy’s law, hydraulic conductivity, permeability, hydraulic gradient, flow lines, equipotential lines, flow net, recharge (to an aquifer), discharge (from an aquifer), local flow path (in a local aquifer), intermediate flow path (in an intermediate aquifer), regional flow path (in a regional aquifer), net gain (for a river), net loss (for a river), piezometer, drawdown curve, cone of depression, Darcy flux, dispersion, transient storage, turnover

**Concepts:**

Understand the formal definition of the water table and the nature of pressure head above and below the water table. Understand where sediments are saturated and unsaturated relative to the water table and the capillary fringe. Understand that the capillary fringe is where pore space is saturated but the pressure head is still negative.

Understand the nature of a well and where the water level will be in a well after it is driven into a confined (water table) and unconfined (piezometric surface) aquifer.

Understand the two mechanisms behind storativity: specific yield and specific storage. Understand how specific yield is the dominant mechanism of storage in unconfined aquifers and how specific storage is the dominant mechanism of storage in confined aquifers. Understand the reasons that specific yield produces much more water volume than specific storage, for a given change in head after withdrawal.

Understand how to interpret a groundwater flow net to know where hydraulic head is relatively high or low and which direction water is flowing. Understand the relative roles of elevation and pressure head below the water table. Understand that flow lines are always perpendicular to equipotential lines, and that equipotential lines are always perpendicular to no-flow boundaries.

Understand how configurations of no-flow boundaries (like the Nyack Floodplain example), variation in surface topography (like Figure 9-7 in Dingman), and variation in subsurface hydraulic conductivity (like Figure 9-22 in Dingman) can influence the configuration of groundwater flow nets. Understand how the configuration of groundwater flow nets may influence watershed water balances.

Understand how to interpret the intersection of flow nets with rivers to determine gains and losses from the river and recharge or discharge to the aquifer. Understand how water levels in wells and piezometers can be compared to water level in the river to determine potential for exchange between river and groundwater.

Understand how a drawdown curve or cone of depression forms when pumping a well in an unconfined aquifer, and understand how intersection of the drawdown with a river may alter surface-subsurface interaction.

Understand the difference between calculating a Darcy Flux and an average water velocity in a saturated aquifer.

Understand the different scales of stream subsurface exchange, and understand the effect of these exchanges on transient storage of stream water and stream water turnover.

**Useful equations:**

Storativity ($S$) of an aquifer

$$S=\frac{∆V\_{W}}{A\_{A}∆h}$$

where $∆V\_{W}$ is the change in volume of water in the aquifer (or the amount pumped in or out), $A\_{A}$ is the surface area of the aquifer, and $∆h$ is the change in hydraulic head that is associated with the change in volume of water.

The two components of storativity

$$S=HS\_{s}+S\_{y}$$

where $S\_{s}$ is specific storage (water produced by change in pressure but no change in saturation), $H$ is the depth of the aquifer, and $S\_{y}$ is specific yield (water produced by draining of water in the pore space leading to lowering of the water table in unconfined aquifers).

Storativity in an unconfined aquifer

$$S≈S\_{y}$$

where specific yield dominates because for the same change in head, it produces much more water than the specific storage.

Specific yield defined by water content

$$S\_{y}=ϕ-θ\_{fc}$$

where $ϕ$ is porosity and $θ\_{fc}$ is water content at field capacity.

Hydraulic head (review from previous notes)

$$h=z+ψ=z+\frac{p}{γ\_{W}}$$

Darcy’s Law (review from previous notes) for calculating a Darcy flux ($\frac{Q}{A}$) in a porous medium.

$$\frac{Q}{A}=-K\frac{Δh}{Δl}=-K\frac{Δ\left(z+ψ\right)}{Δl}$$

Average velocity ($\overbar{U}$) of water (or solutes in water) in a porous medium based on Darcy’s Law

$$\overbar{U}=\frac{Q}{Aϕ}=-\frac{1}{ϕ}K\frac{Δh}{Δl}$$