Groundwater Hydraulics

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1d Solutions of groundwater flow

Exercise #7

An unconfined aquifer is bounded from the left by a mountain ridge. Due to precipitation in the mountains there is an unknown discharge q_0 from the mountains into the aquifer. On the right hand side, at a distance of 5000 m from the mountain ridge, the aquifer is bounded by a lake, which is separated from the surrounding area by a sheet pile wall. The bottom of the aquifer consists of an impermeable layer located 10 m above sea level. The bottom of the lake is at 15 m, the surface at 19 m above sea level. The bottom of the lake consists a layer of sediments (thickness = 0.5 m) which separates the underlying aquifer from the lake. The recharge rate (precipitation) in the area is $N = 2 \cdot 10^{-8}$ m/s. The hydraulic conductivity has been estimated from soil samples as $K = 2 * 10^{-3}$ m/s. One piezometer is located next to the sheet pile and a second one 2000 meters to its left. The piezometric head at the sheet pile is $h_1 = 21$ m. The piezometric head at the second piezometer is $h_2 = 28$ m.

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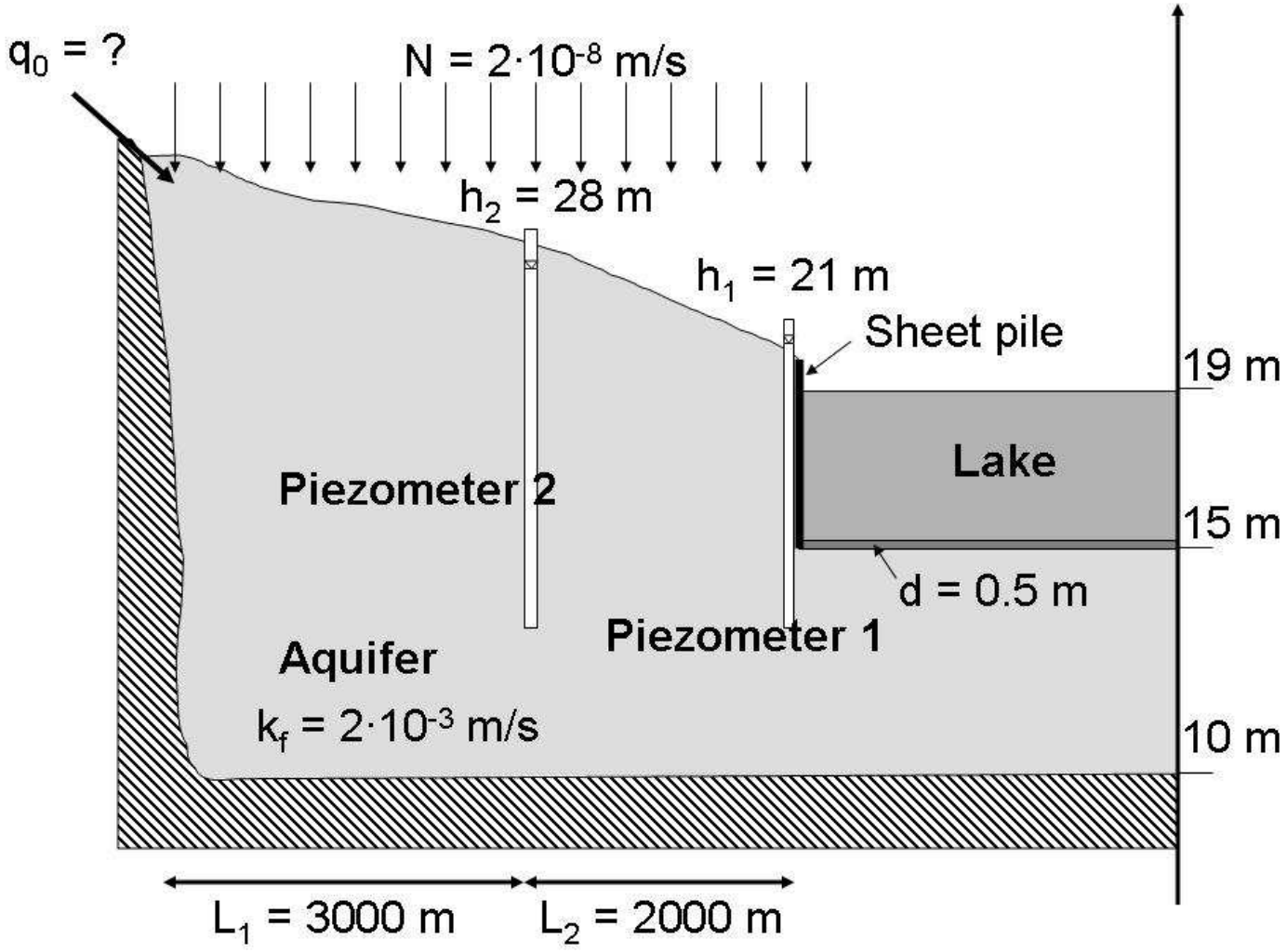

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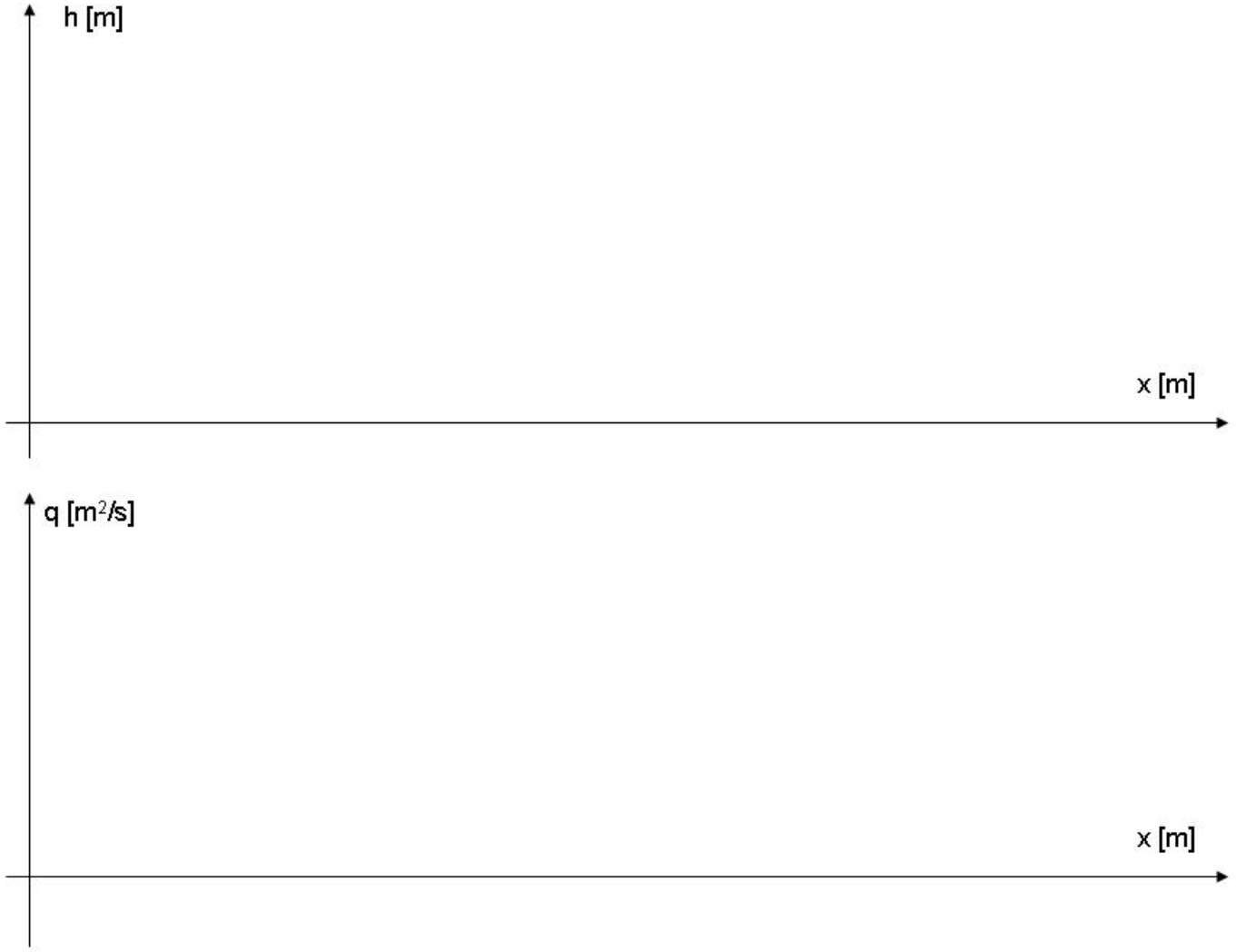

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1. Qualitatively draw the piezometric head distribution and the discharge (units: m^2 / s) in the aquifer into the sketch given below (Figure 2).
2. Determine the recharge q_0 from the mountain ridge into the aquifer.
3. What is the total discharge from the aquifer into the lake?
4. Based on this discharge, calculate the hydraulic conductivity of the sediment layer. In case you did not solve part 3), you may assume that the total discharge is $Q = 1.5 \cdot 10^{-4}$ m^2/s.
5. After some years the sediment layer has increased to a thickness of d = 1 m. Its hydraulic conductivity remains unchanged. Qualitatively draw into the sketch from part 1) the new piezometric head distribution

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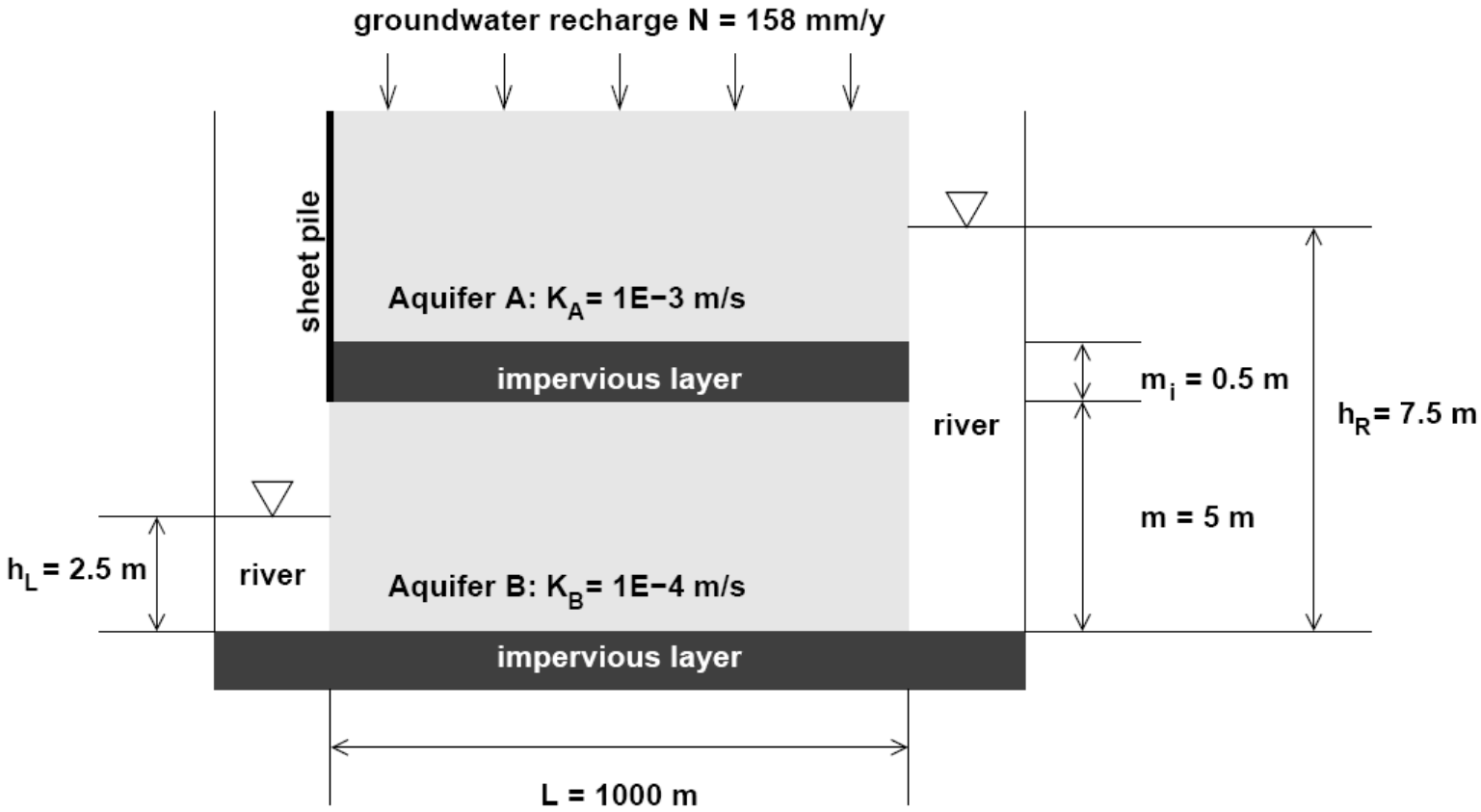
Exercise #9



A double-layered aquifer system is located between two rivers. The aquifer layers are separated by an impervious layer. Both aquifers are in perfect contact with the right-hand side river.

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Situation with Sheet Pile

The lower aquifer is in perfect hydraulic contact with the left-hand side river, whereas the upper aquifer is sealed off by a sheet pile.

- Characterize the two aquifers (subdivide them into different zones if appropriate).
- Draw qualitatively into the figures the profiles of hydraulic head in both aquifers.
- Give an analytical expression for the total discharge per unit width (specific discharge times thickness of the aquifer) as a function of space in the upper aquifer.
- Calculate the hydraulic head in the upper aquifer at the sheet pile.
- Calculate the exfilitration respectively infiltration rates (total discharge per width in $m^3/s/m$) of both aquifers at the right-hand side river. How much water flows from the right river to the left river when the length of the rivers is 10km?

Situation without Sheet Pile

The sheet pile has been removed so that the upper aquifer is open to both sides.

- Draw qualitatively into the figures the new profiles of the hydraulic heads.
- Re-evaluate how much water flows into the left river when the length of the rivers is 10km.
- Discuss the assumptions you have made in your evaluations.

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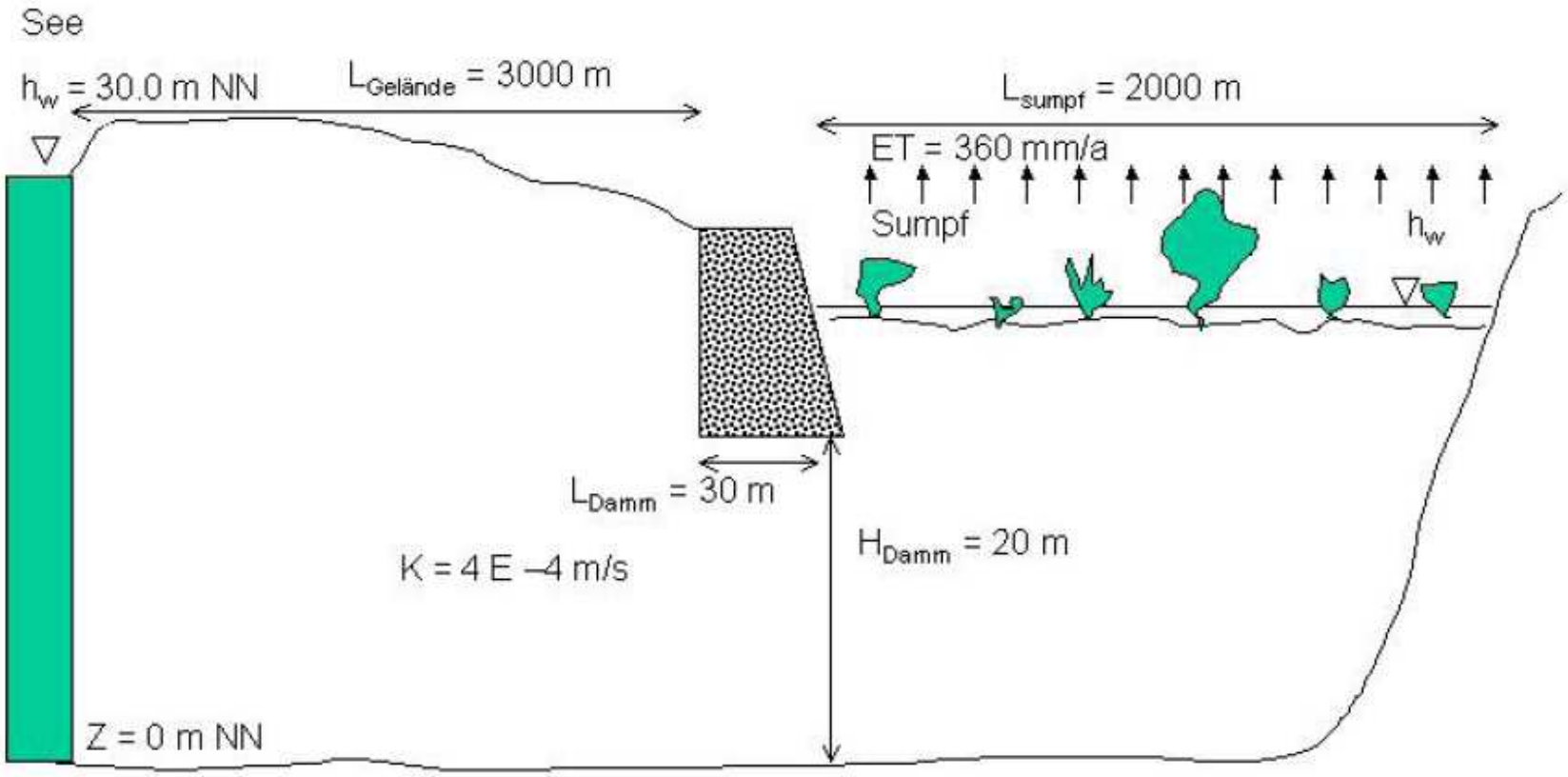
Exercise #10



1d Solutions of groundwater flow

Exercise #10

A swamp is separated from a neighbouring area by an impermeable dam. On the right hand side the swamp is bounded by a mountain ridge. The underground underneath the dam is completely saturated with water. The terrain to the left of the dam is bounded to the left by a lake, which is in contact to the aquifer over the whole depth. The parameters for the soil and the spatial dimensions can be found in the figure. The swamp is in a warm climate zone with a constant netto evapotranspiration of 360 mm/year.

1. Name the aquifer types in the different fragments and the boundary conditions. Sketch the piezometric head in the area and the discharge (in 2d, units m^2/s). In which direction does the water flow?
2. Calculate the Darcy velocity vf at the right boundary of the dam. Hint: A water balance might help.
3. Calculate the piezometric head at the right hand side of the dam. Hint: You need to consider the left part of the aquifer.
4. Make a qualitative sketch of the piezometric head and the discharge for the case that you have a netto recharge of 100 mm/year in the area left of the dam.