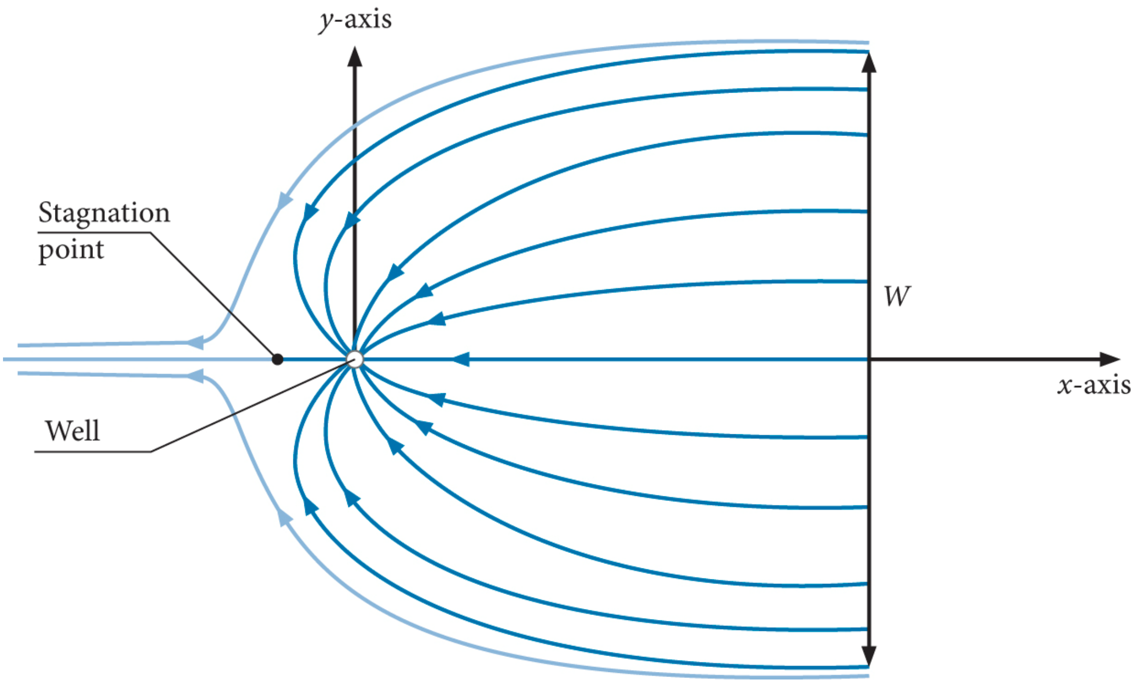
Groundwater hydraulics test

A summary sheet of equations is provided on the last page of this exam; if possible, provide answers to this exam working your way from one or more of these equations; write down all your calculation steps!

If you cannot solve a question, because you need the answer to another or earlier question, then choose a possible answer to this other/earlier question, clearly state on your exam paper what answer you have chosen and continue your calculations from there!

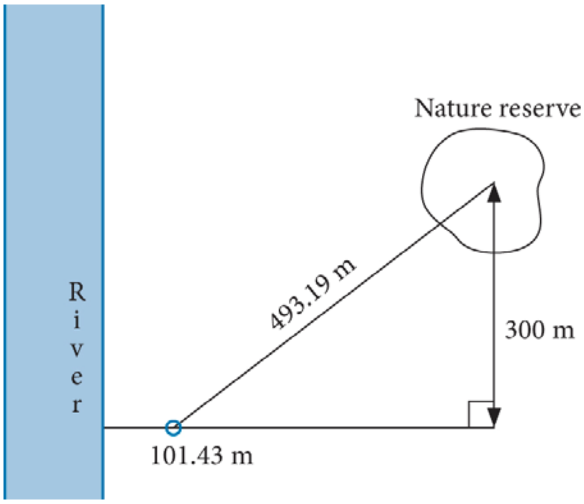
Exercise 1 (2 credits)



The above figure shows streamlines due to groundwater extraction by a pumping well in a regional flow field in plan view. As shown in the above figure a fully penetrating well (coordinates: 0,0) pumps water from a confined aquifer with a thickness of 50 m. Before pumping there existed a uniform groundwater flow parallel to the *x*-axis in a negative direction; the hydraulic gradient of this uniform flow field is 0.001. The aquifer has a hydraulic conductivity of 10 m day^{-1}. The well pumps water with a discharge or volume flux of 628.32 m^3 day^{-1}.

a. Determine the maximum width *W* of the area from which water is extracted by the well.
b. Determine the location of the stagnation point in the groundwater flow field.

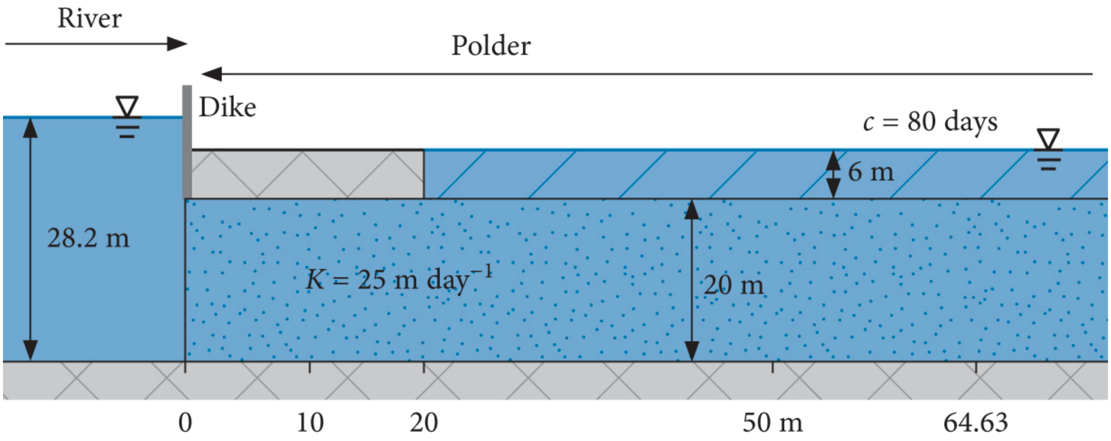
Exercise 2 (2 credits)



On behalf of the drinking water supply, groundwater is pumped from a confined aquifer. The pumping discharge is 314.16 m^3 day^{-1}. At a radial distance of 2000 m from the well there is no lowering of the hydraulic head due to pumping. The saturated depth of the aquifer is 50 m; the hydraulic conductivity of the aquifer equals 10 m day^{-1}. A river is located at a distance of 101.43 m of the pumping well, and the midpoint of a nature reserve is located at a distance of 493.19 m from the pumping well, both as shown in the above figure.

Determine the lowering of the hydraulic head in the midpoint of the nature reserve given the above setup.

Exercise 3 (6 credits)



The above figure shows a typically Dutch inverse landscape profile ('Hollands profiel') with a high river, dike and low polder acting as a leaky confining layer. The water level of the fully penetrating river is situated 28.2 m above an impermeable layer. The aquifer overlies an impermeable layer, has a thickness of 20 m and a hydraulic conductivity of 25 m day^{-1}. The leaky confining layer has a thickness of 6 m and a hydraulic resistance to vertical groundwater flow *c* of 80 days. From *x* = 0 to 20 m behind the dike the leaky confining layer has been made impermeable by sealing with clay. From *x* = 20 m onwards the water table in the polder may be taken at surface level. All layers and aquifers are homogeneous and isotropic. Steady groundwater flow occurs in the *x* and vertical (*z*) direction only.

Preferably use the storage function of your scientific calculator or else use sufficient figures/numbers after the decimal point in your calculations.

Determine the seepage into the polder between *x* = 20 and 64.63 m in m^2 day^{-1} using two methods, the 'horizontal-' as well as the 'vertical method'.

Summary sheet groundwater hydraulics

One-dimensional steady groundwater flow

Confined $h = C_1 x + C_2$

Unconfined $h^2 = C_1 x + C_2$

Leaky $h = h_a + C_1 e^{\frac{x}{\lambda}} + C_2 e^{\frac{-x}{\lambda}}$ with $\lambda = \sqrt{KDc}$

Recharge; equal water levels $h^2 = -\frac{N}{K} x^2 + C$

Recharge; different water levels $h^2 = -\frac{N}{K} x^2 + C_1 x + C_2$

Radial-symmetric steady groundwater flow

Confined $h = h_R + \frac{Q_0}{2\pi KD} \ln \frac{r}{R}$ for $r_w \le r \le R$

Unconfined $h^2 = h_R^2 + \frac{Q_0}{\pi K} \ln \frac{r}{R}$ for $r_w \le r \le R$