Hidrogeológia BSc

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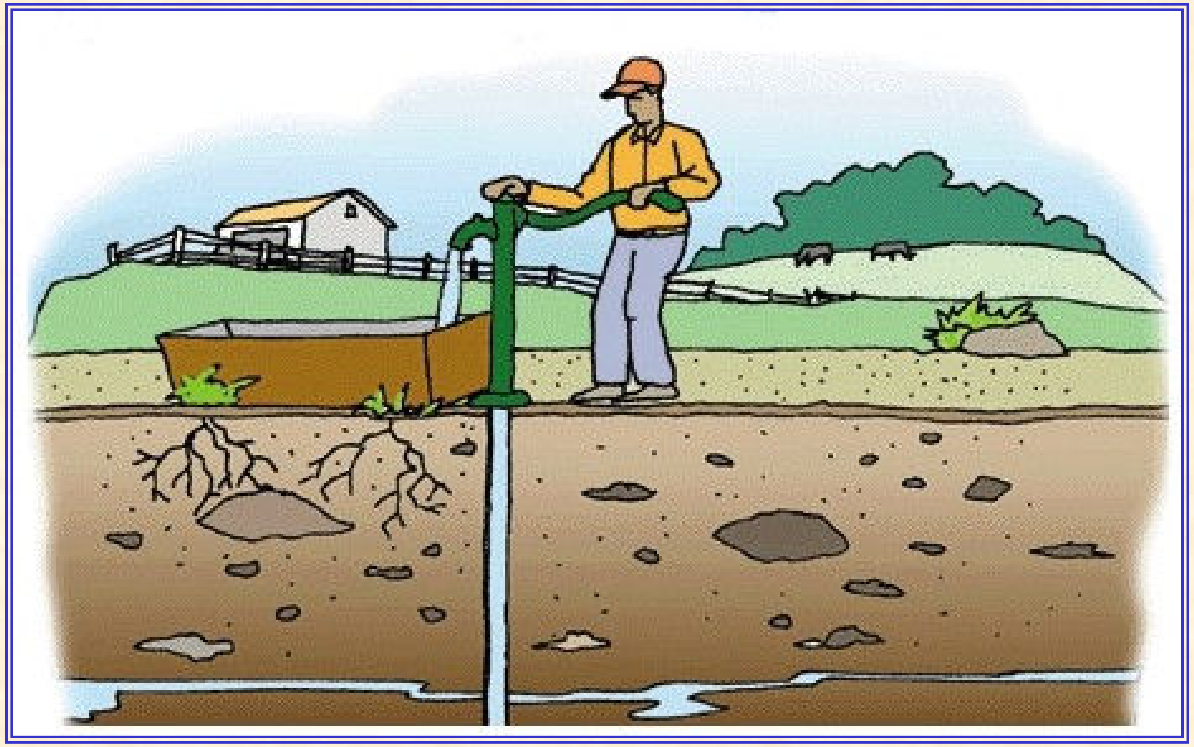
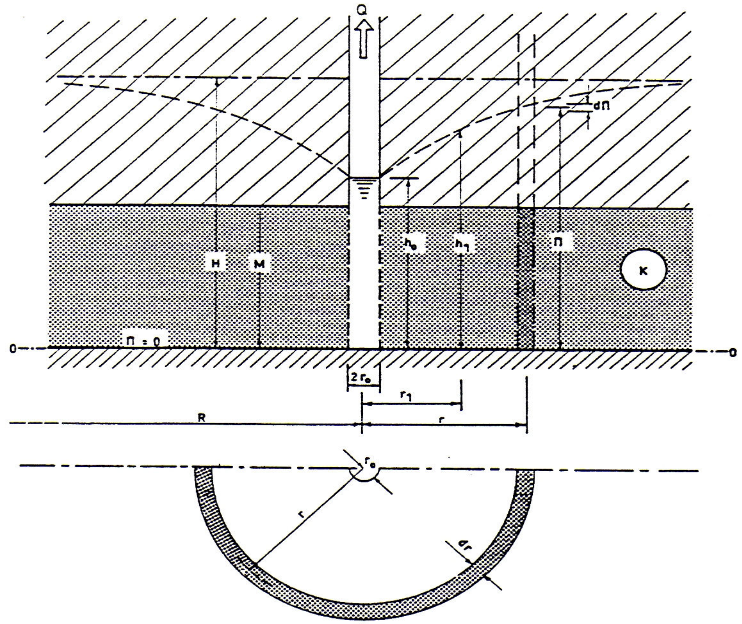
Hidrogeológiai – Mérnökgeológiai Tanszék

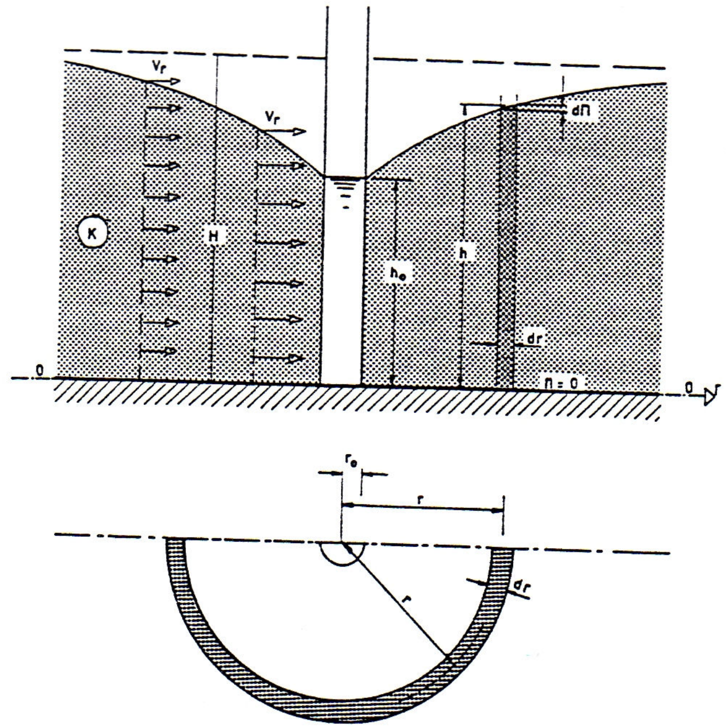
8. rész
Áramlástan, kúthidraulika



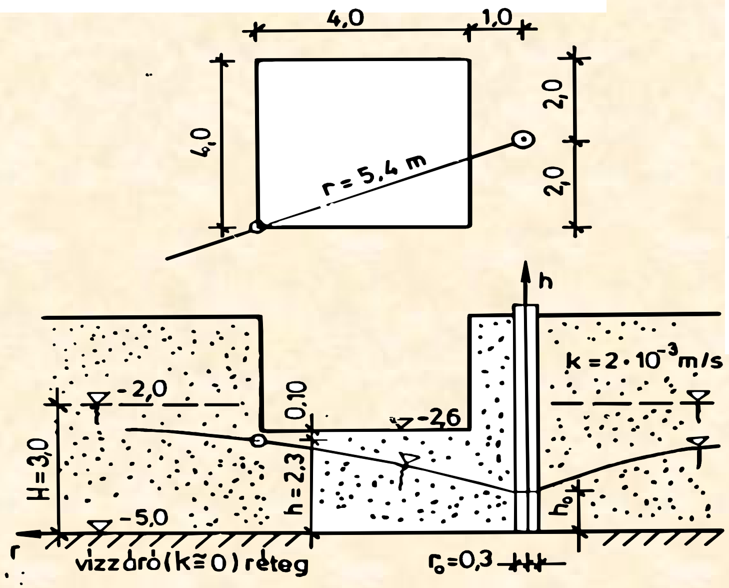
Áramlástan, kúthidraulika



Definition sketch for differential equation of steady-state flow to a well in a confined aquifer.

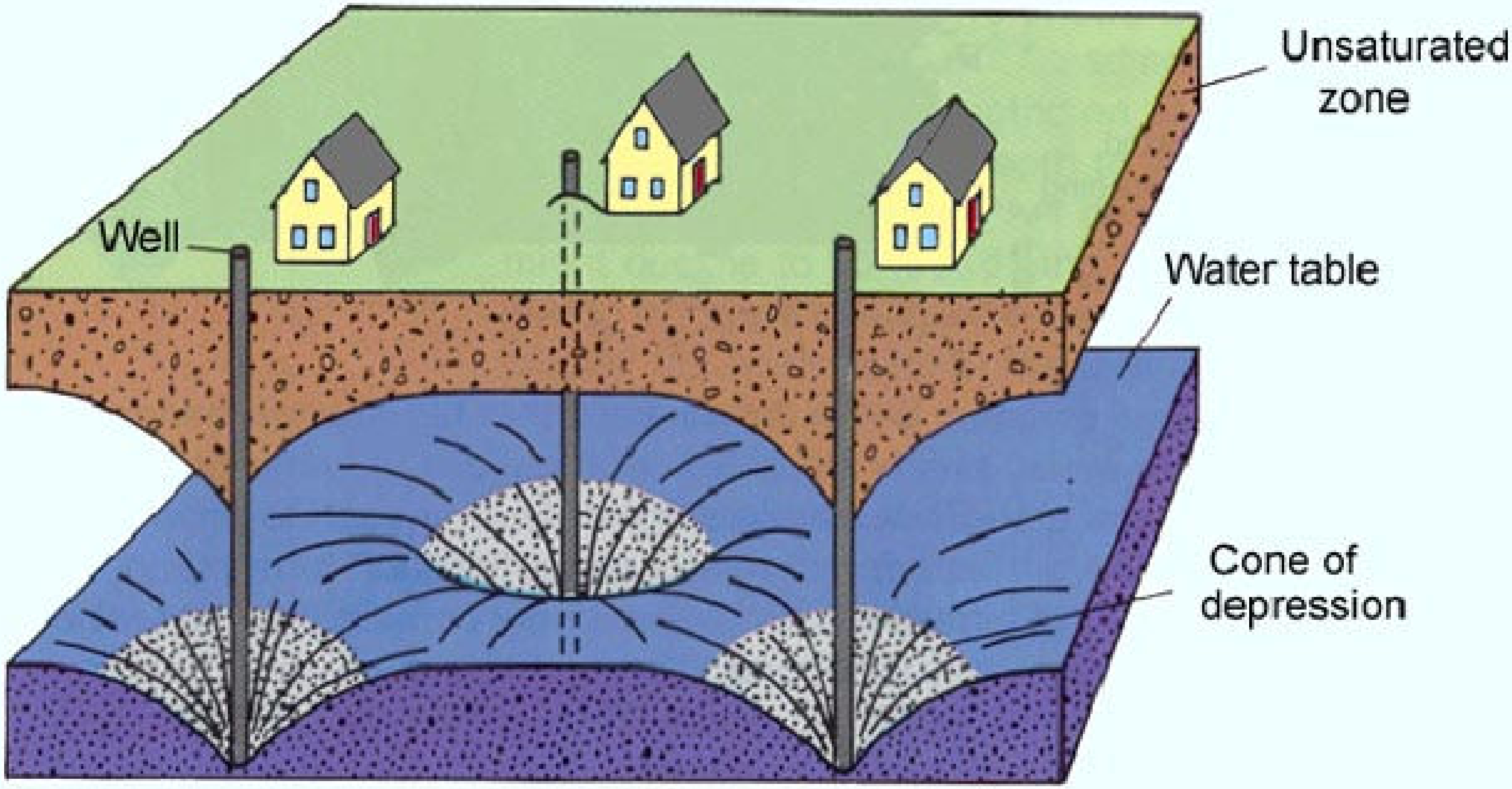


Definition sketch for deriving the differential equation of steady flow to a well in an unconfined aquifer.

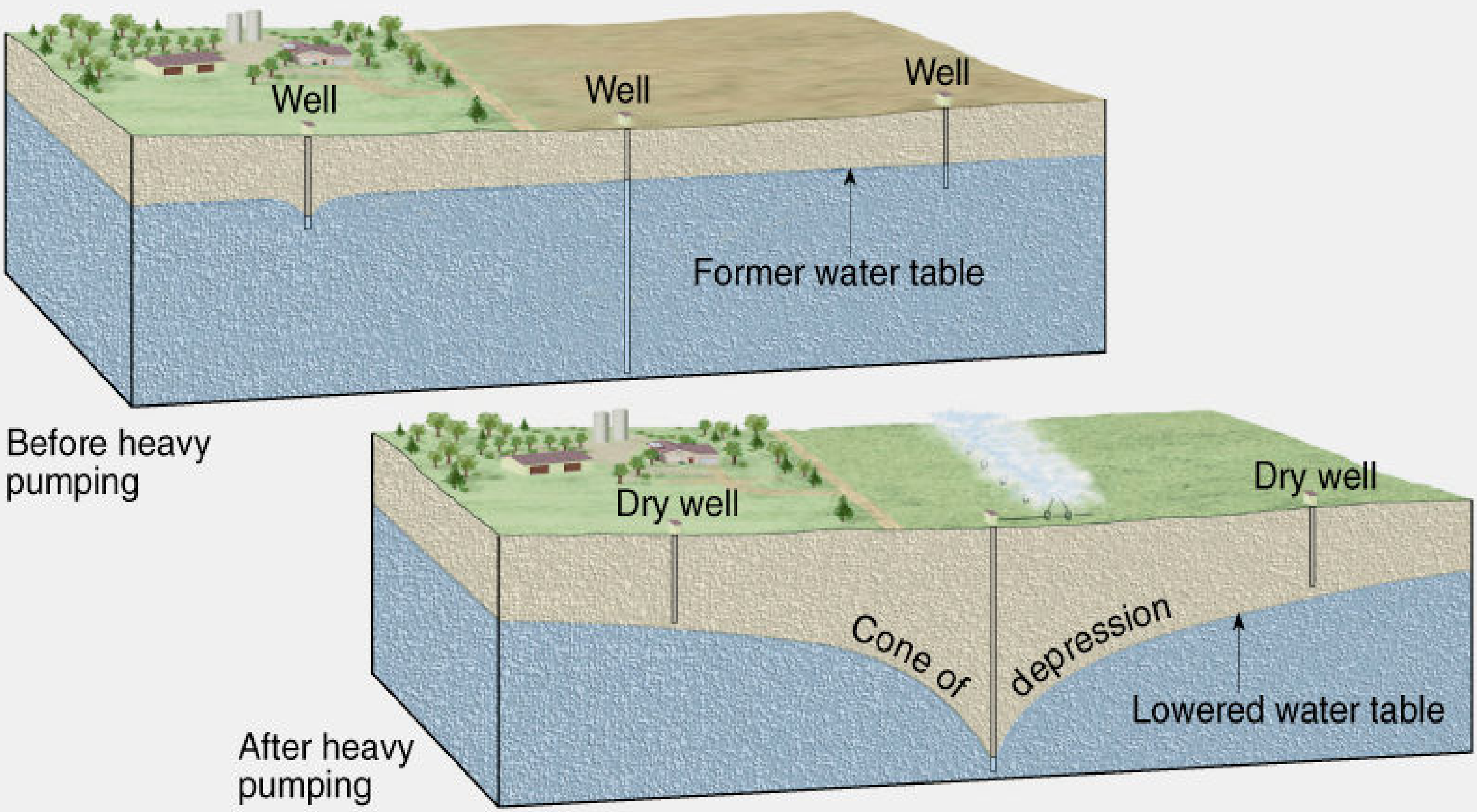


Vízművek termelő kútjai, víztelenítési feladatok

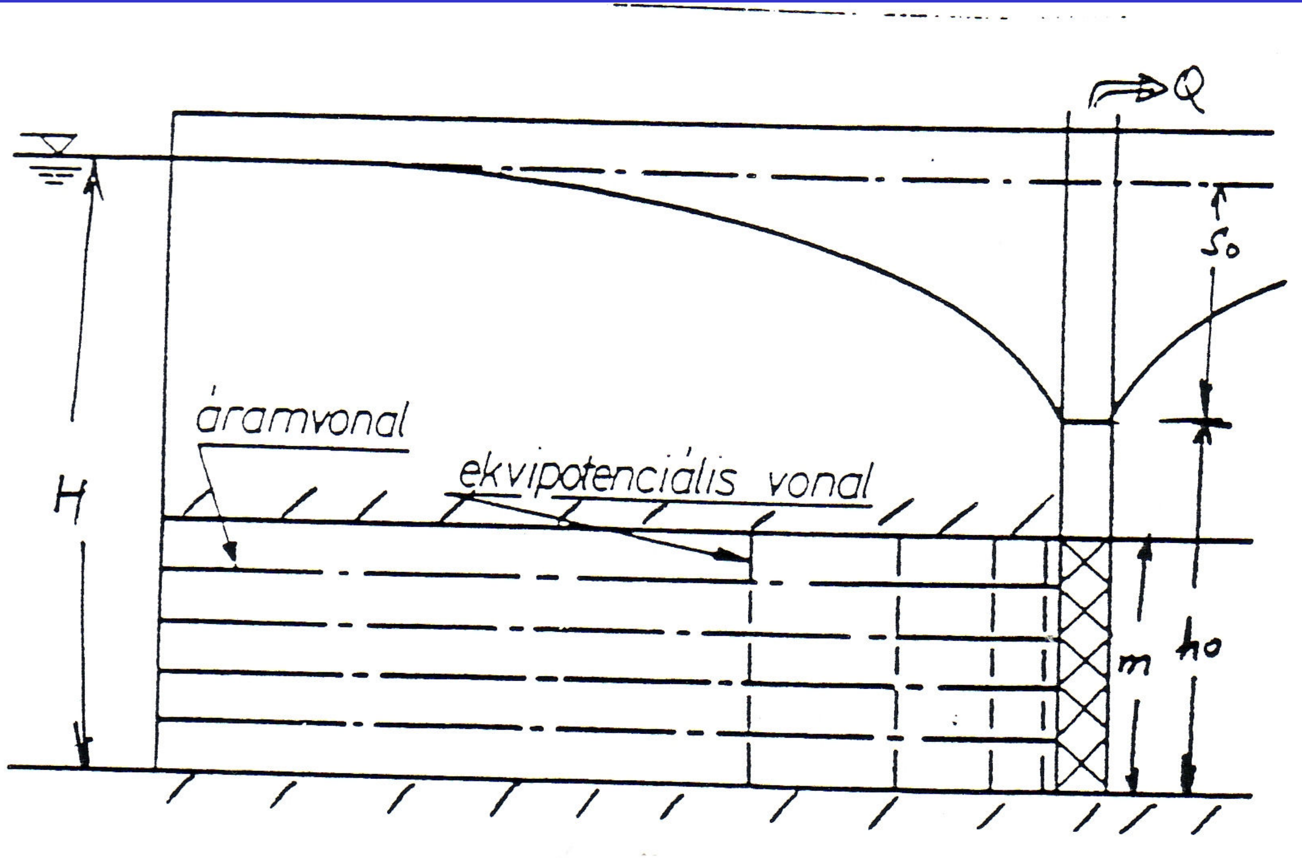
CONES OF DEPRESSION



Shallow wells go dry due to excessive pumping



Teljes kút, nyomás alatti rendszer, oldalsó utánpótlódás



Teljes kut nyomás alatti rétegben kialakult áramképe

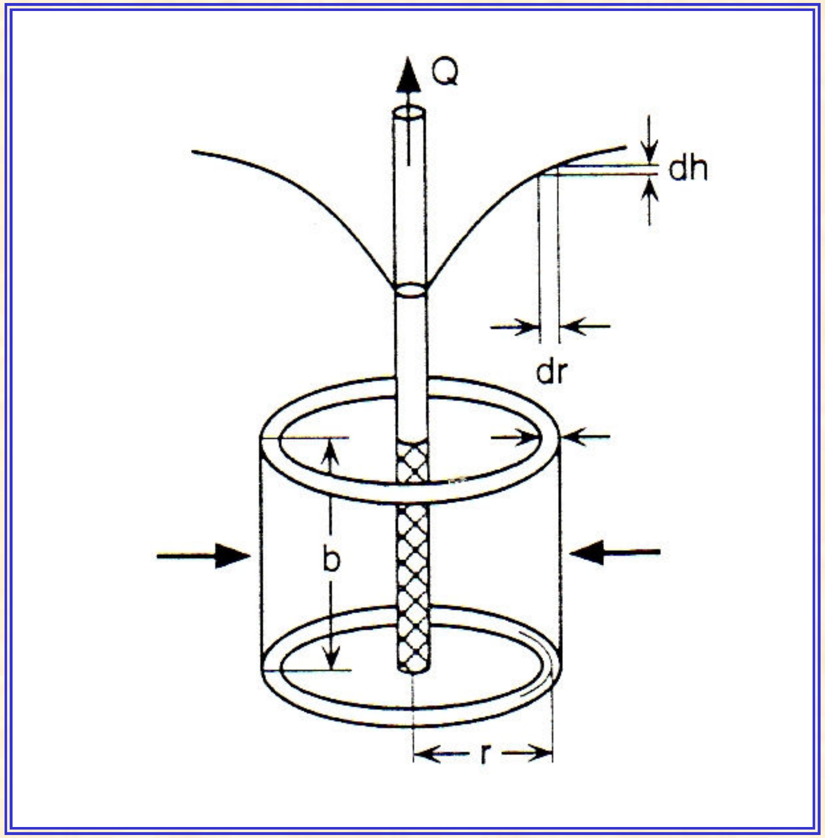
Q $\left[\frac{m^3}{s}\right]$

h $[m]$

v $\left[\frac{m}{s}\right]$

- hozam, Q
- depressziós görbe, h
- sebesség, v

Teljes kút, nyomás alatti rendszer, oldalsó utánpótlódás



$$Q = F \cdot v \qquad \left[\frac{m^3}{s}\right]$$

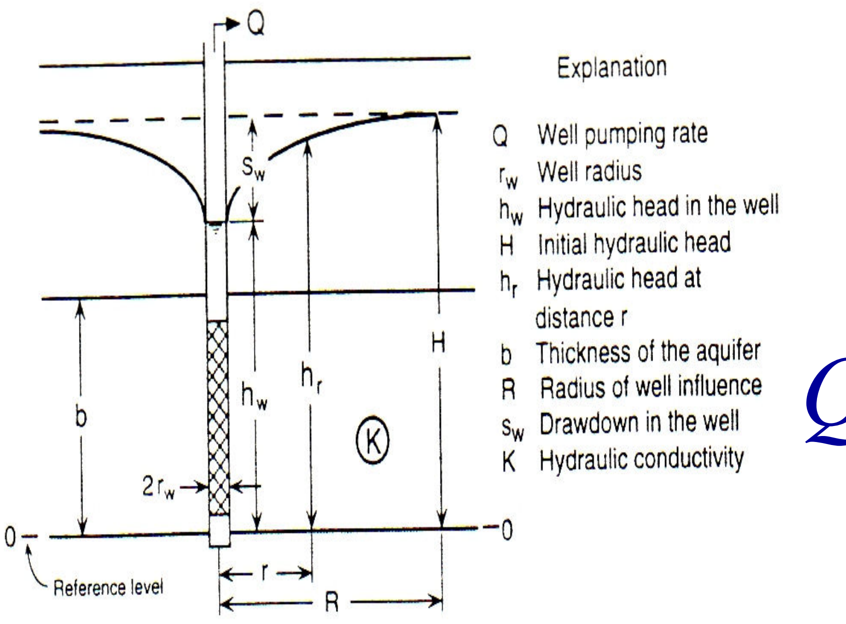
$$F = 2 \cdot \pi \cdot r \cdot m \qquad \left[m^2\right]$$

$$v = k \cdot I = k \cdot \frac{dh}{dr} \qquad \left[\frac{m}{s}\right]$$

$$Q = 2 \cdot \pi \cdot r \cdot m \cdot k \cdot \frac{dh}{dr}$$

$$Q\frac{dr}{r} = 2\pi mkdh$$

Teljes kút, nyomás alatti rendszer, oldalsó utánpótlódás



Elements of groundwater flow toward a fully penetrating well in a confined aquifer.

$$Q\int_{r_0}^{R}\frac{dr}{r} = 2\pi mk\int_{h_0}^{H} dh$$

$$Q\ln\frac{R}{r_0} = 2\pi mk(H - h_0)$$

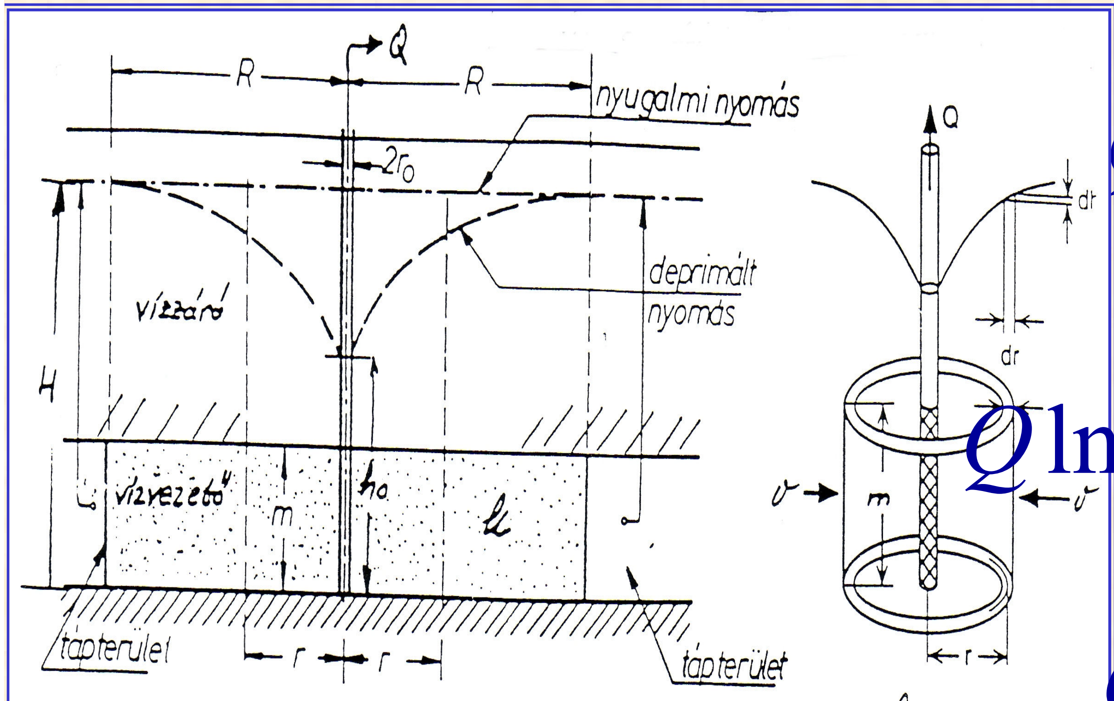
$$Q = 2\pi mk\frac{(H - h_0)}{\ln\frac{R}{r_0}}\left[\frac{m^3}{s}\right]$$

$$Q = 2\pi mk\frac{s_0}{\ln\frac{R}{r_0}}\left[\frac{m^3}{s}\right]$$

$$R = 5000\cdot s_0\cdot\sqrt{k}\,[m]$$

Sichard

Teljes kút, nyomás alatti rendszer, oldalsó utánpótlódás



Teljes kut nyomás alatti rétegben

$$Q\int_{r_0}^{r}\frac{dr}{r} = 2\pi mk\int_{h_0}^{h} dh$$

$$Q\ln\frac{r}{r_0} = 2\pi mk(h - h_0)$$

$$h = \frac{Q}{2\pi mk}\ln\frac{r}{r_0} + h_0 \qquad [m]$$

$$h = \frac{H - h_0}{\ln\frac{R}{r_0}}\ln\frac{r}{r_0} + h_0 \qquad [m]$$

Teljes kút, nyomás alatti rendszer, oldalsó utánpótlódás

$$v_t = \frac{v}{n_e} \quad \left[\frac{m}{s}\right]$$

$$v = \frac{Q}{2\pi r m} \quad \left[\frac{m}{s}\right]$$

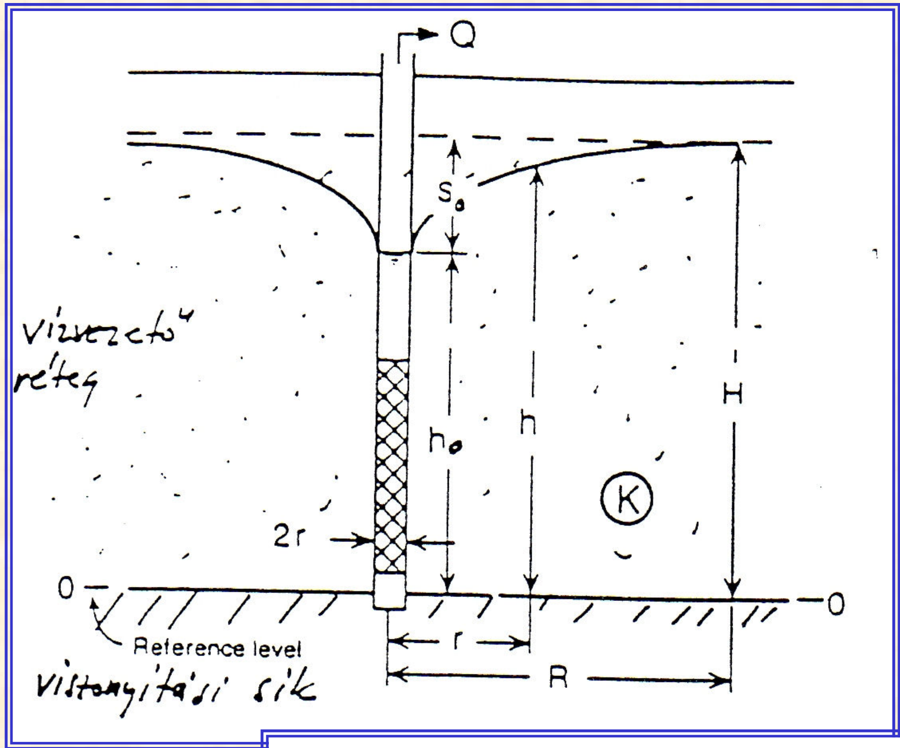
$$v = k\frac{(H - h_0)}{\ln\frac{R}{r_0}}\frac{1}{r} \quad \left[\frac{m}{s}\right]$$

$$v_{max} \leq \frac{\sqrt{k}}{15} \quad \left[\frac{m}{s}\right]$$

$$v_{max} = k\frac{(H - h_0)}{\ln\frac{R}{r_0}}\frac{1}{r_0} \quad \left[\frac{m}{s}\right]$$

Sichard-féle kritikus sebesség: $\frac{\sqrt{k}}{15}$

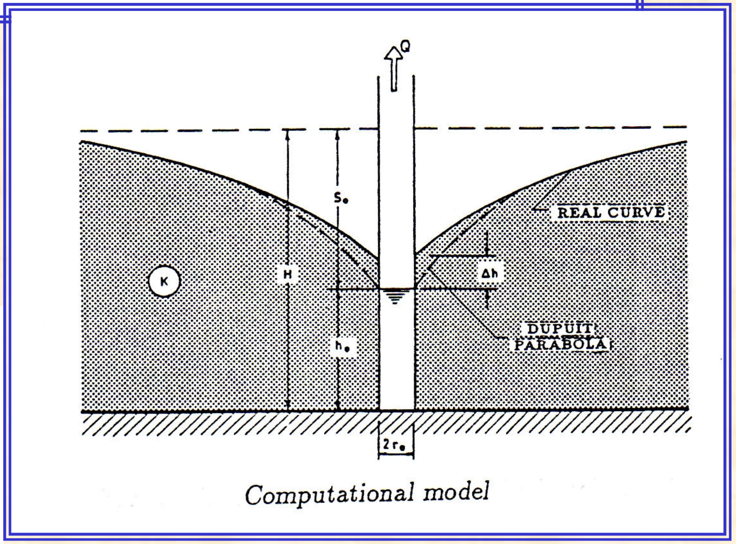
Teljes kút, nyílt tükrű rendszer, oldalsó utánpótlódás



$$Q = F \cdot v \quad \left[\frac{m^3}{s}\right]$$

$$F = 2 \cdot \pi \cdot r \cdot h \quad \left[m^2\right]$$

$$v = k \cdot I = k \cdot \frac{dh}{dr} \quad \left[\frac{m}{s}\right]$$

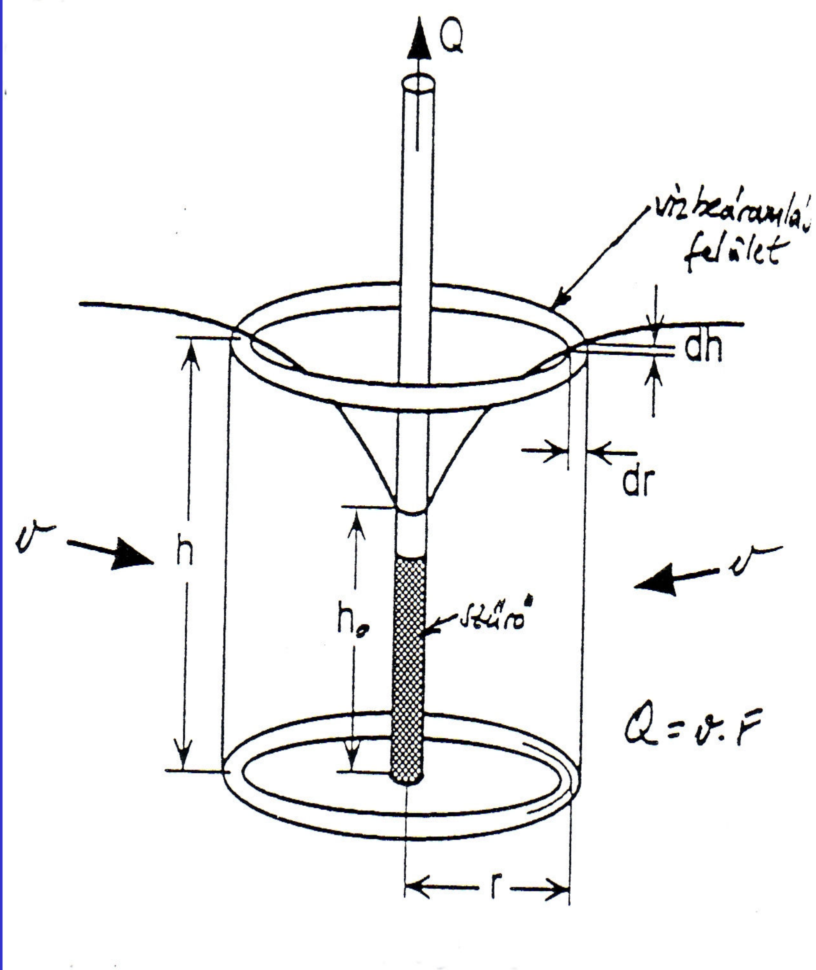


Computational model

$$Q = 2 \cdot \pi \cdot r \cdot h \cdot k \cdot \frac{dh}{dr}$$

$$Q\frac{dr}{r} = 2\pi khdh$$

Teljes kút, nyílt tükrű rendszer, oldalsó utánpótlódás



$$Q\int_{r_0}^{R}\frac{dr}{r} = 2\pi k\int_{h_0}^{H} h\,dh$$

$$Q\ln\frac{R}{r_0} = \pi k(H^2 - h_0^2)$$

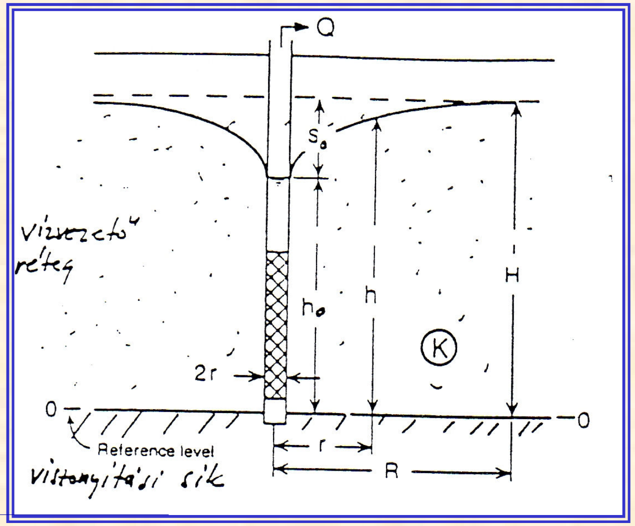
$$Q = \pi k\frac{(H^2 - h_0^2)}{\ln\frac{R}{r_0}} \quad \left[\frac{m^3}{s}\right]$$

$$R = 3000\cdot s_0\cdot\sqrt{k} \quad [m]$$

Sichard

Teljes kút, nyílt tükrű rendszer, oldalsó utánpótlódás

$$Q\int_{r_0}^{r}\frac{dr}{r}=2\pi k\int_{h_0}^{h}h\,dh \qquad Q\ln\frac{r}{r_0}=\pi k(h^2-h_0^2)$$



$$h=\sqrt{\left(\frac{Q}{\pi k}\ln\frac{r}{r_0}+h_0^2\right)}\quad [m]$$

$$h=\sqrt{\left(\frac{H^2-h_0^2}{\ln\frac{R}{r_0}}\ln\frac{r}{r_0}+h_0^2\right)}\quad [m]$$

Teljes kút, nyílt tükrű rendszer, oldalsó utánpótlódás

$$v = \frac{Q}{2\pi r h} \quad \left[\frac{m}{s}\right]$$

$$v = \frac{k}{2r} \frac{\dfrac{H^2 - h_0^2}{\ln\dfrac{R}{r_0}}}{\sqrt{\left(\dfrac{H^2 - h_0^2}{\ln\dfrac{R}{r_0}} \ln\dfrac{r}{r_0} + h_0^2\right)}} \quad \left[\frac{m}{s}\right]$$

$$v_t = \frac{v}{n_e} \quad \left[\frac{m}{s}\right]$$

$$v_{max} = \frac{k}{2r_0} \frac{\dfrac{H^2 - h_0^2}{\ln\dfrac{R}{r_0}}}{h_0} \left[\frac{m}{s}\right]$$

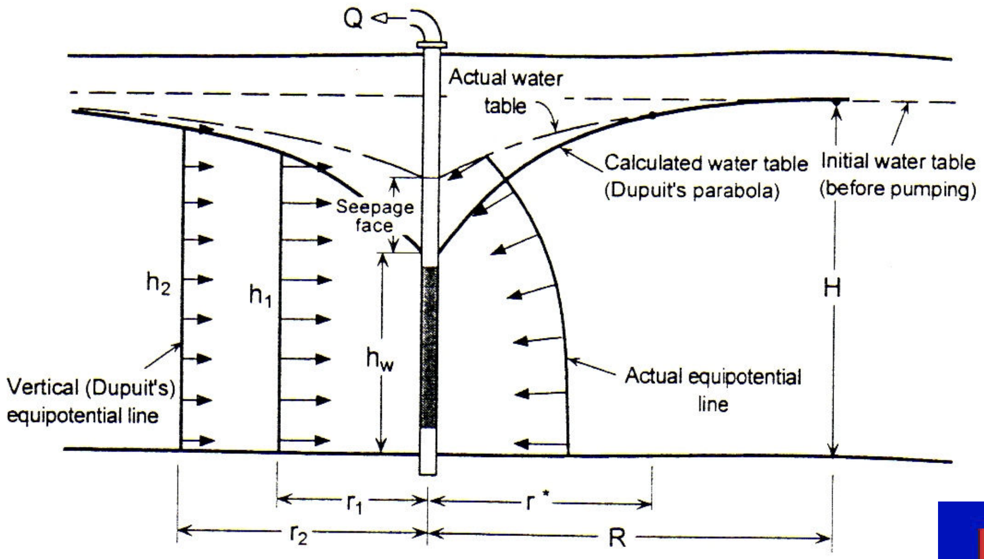
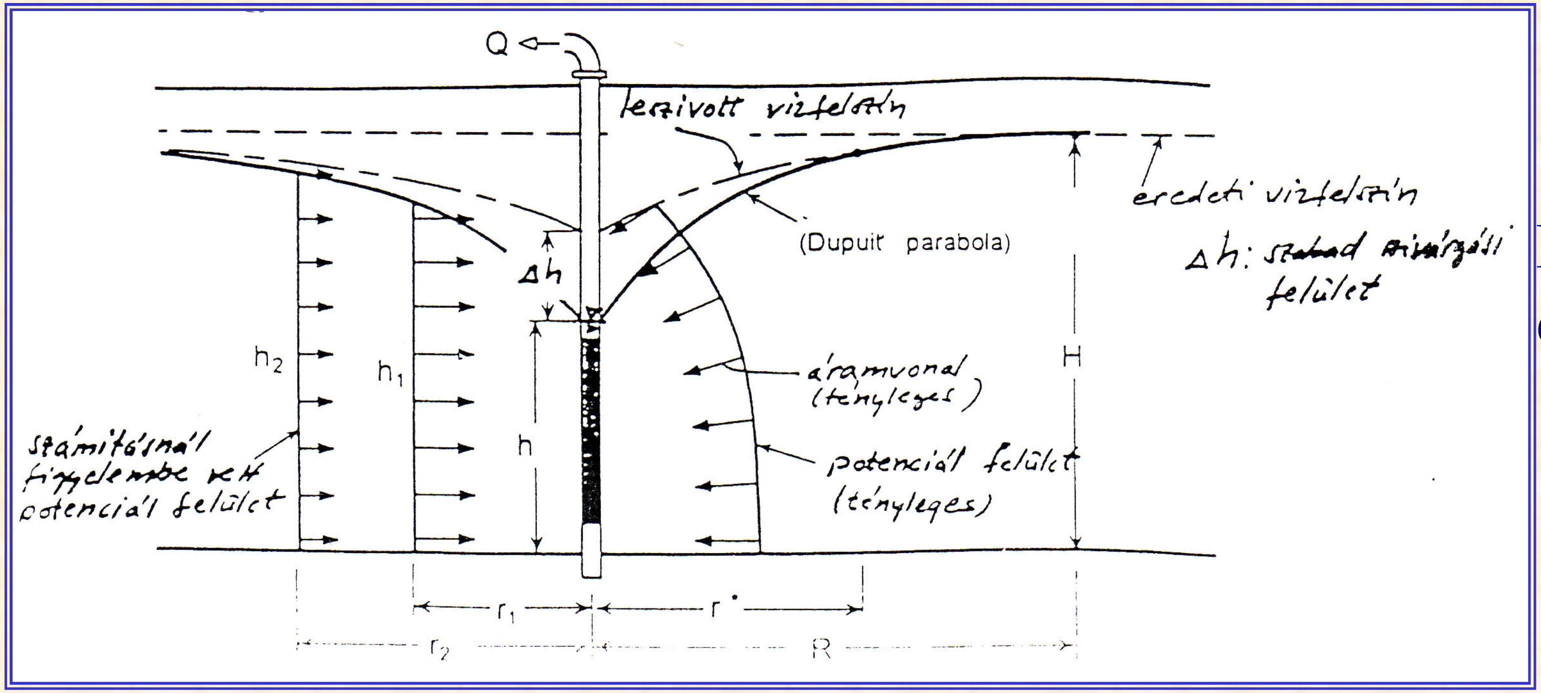


Illustration of Dupuit's hypothesis (left) and the actual flow (right) toward a fully penetrating well in an unconfined aquifer. Note that the actual equipotential line is curvilinear, and that the velocity vector has both horizontal and vertical components.

Teljes kút, nyílt tükrű rendszer, oldalsó utánpótlódás



Δh_1

Hidraulikai ellenállás

$[m]$

Ehrenburger: $$\Delta h_1 = C\frac{(H-h_0)^2}{H} \quad [m]$$

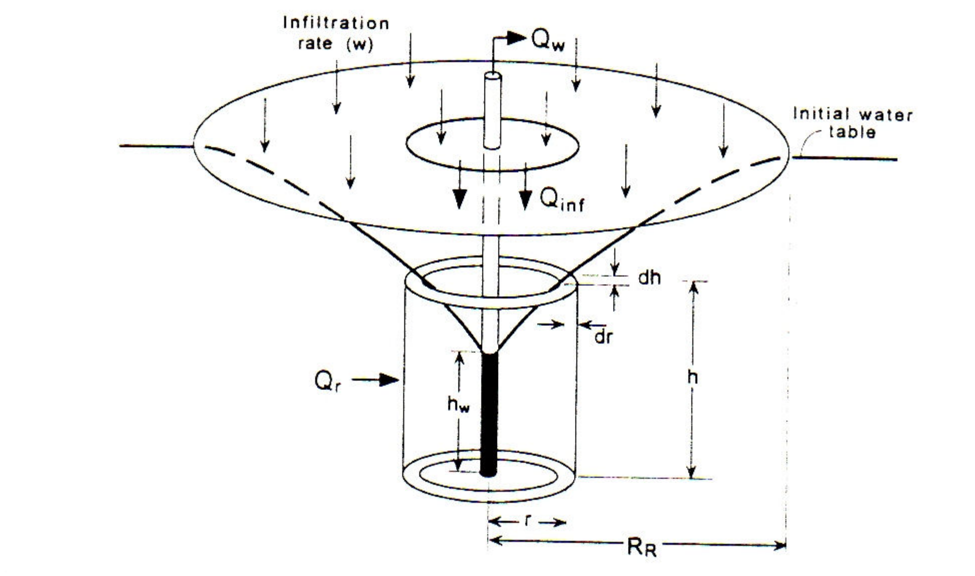
Öllös G.:

$$\Delta h_1 = 0.228\sqrt[3]{\frac{H}{r_0}}\frac{(H-h_0)^2}{H} \quad [m]$$

Hall:

$$\Delta h_1 = \frac{s_0\left(1-\left(\frac{h_0}{H}\right)^{2.4}\right)}{\left[1-0.02\ln\frac{R}{r_0}\right]\left[1+5\frac{r_0}{R}\right]} \quad [m]$$

Teljes kút, nyílt tükrű rendszer, felső utánpótlódás



Scheme for deriving the differential equation of groundwater flow toward a fully penetrating well in an unconfined aquifer under the influence of infiltration.

$i\left[\frac{m}{s}\right]$ Utánpótlódás mértéke

$$Q = 2 \cdot \pi \cdot r \cdot h \cdot k \cdot \frac{dh}{dr}$$

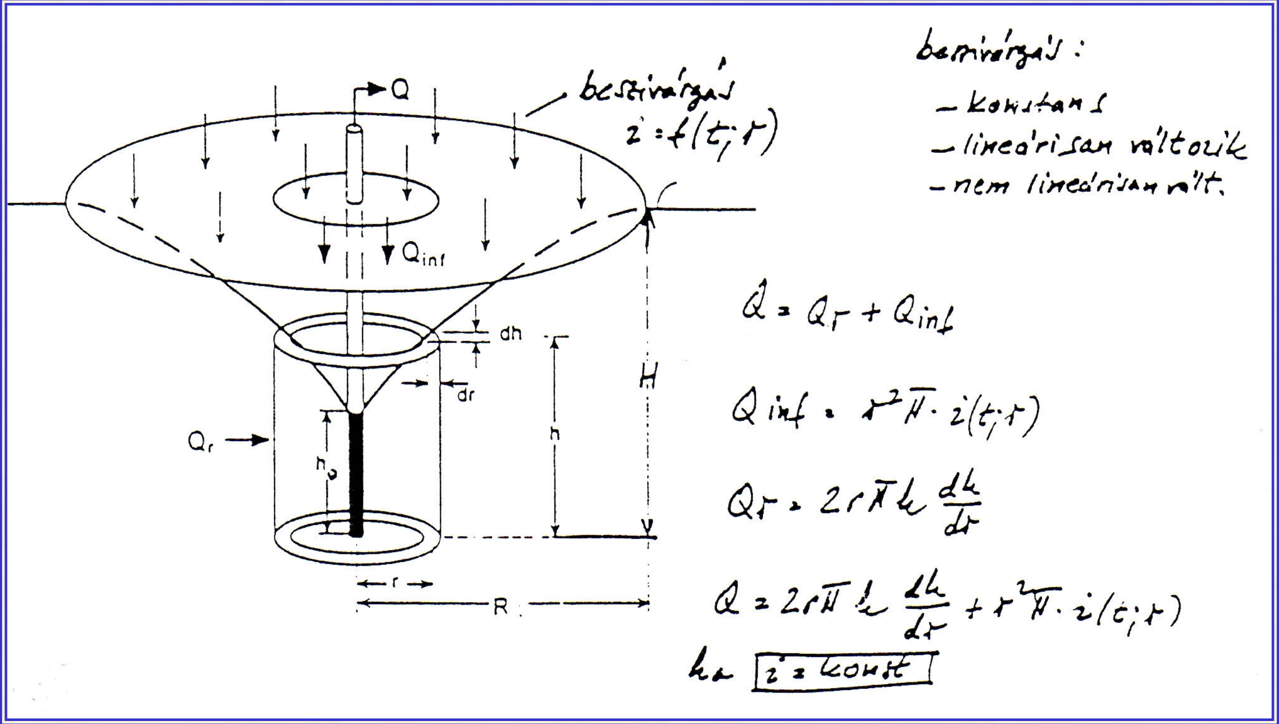
$$Q = \pi \cdot (R^2 - r^2) \cdot i$$

$$\pi \cdot (R^2 - r^2) \cdot i = 2 \cdot \pi \cdot r \cdot h \cdot k \cdot \frac{dh}{dr}$$

Első lépés:
a távolhatás (R)
meghatározása

$$R = \sqrt{\frac{\frac{k}{i}(H^2 - h_0^2) - r_0^2}{\ln\frac{R}{r_0} - \frac{1}{2}}} \quad [m]$$

Teljes kút, nyílt tükrű rendszer, felső utánpótlódás



A hozam:

$$Q_{kút} = \pi \cdot (R^2 - r_0^{\ 2}) \cdot i$$

$$\left[\frac{m^3}{s} \right]$$

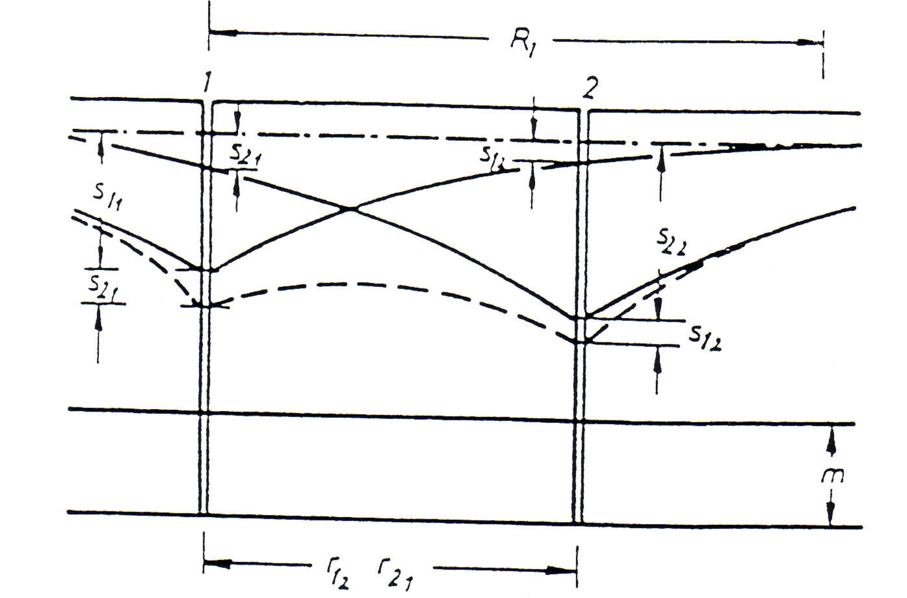
Depressziós görbe:

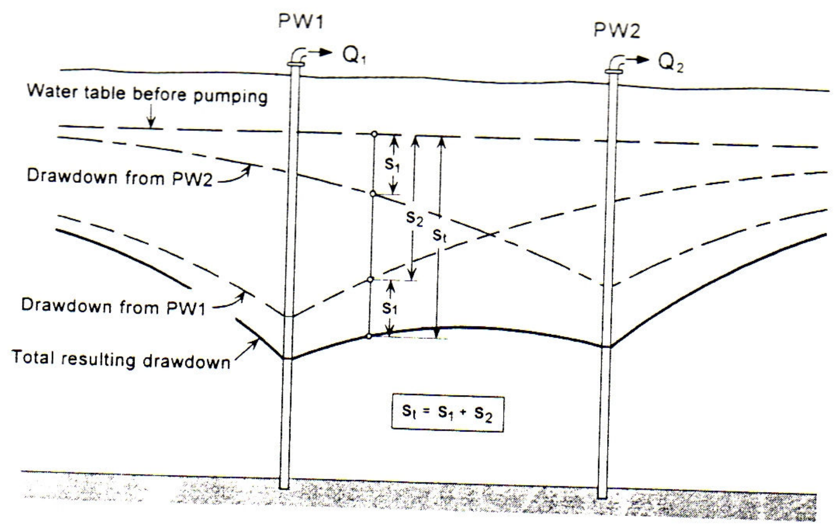
$$h = \sqrt{\frac{i}{k} (R^2 \ln \frac{r}{r_0} - \frac{r^2}{2} + \frac{r_0^2}{2}) + h_0^2 } \quad [m]$$

A sebesség:

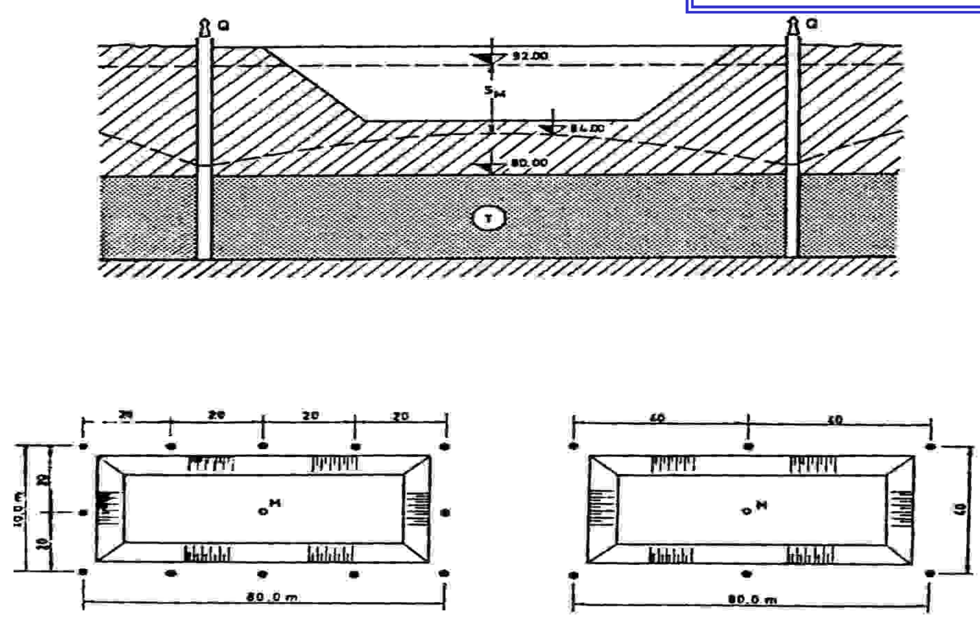
$$v(r) = \frac{\pi \cdot (R^2 - r^2) \cdot i}{2 \cdot \pi \cdot r \cdot h} \quad \left[\frac{m}{s} \right]$$

Kútcsoportok, kutak egymásra hatása





Superposition of flows toward two pumping wells. The resulting drawdown is the algebraic sum of the drawdowns caused by individual wells.



Bányászati vízvédelem

Munkaterek víztelenítése