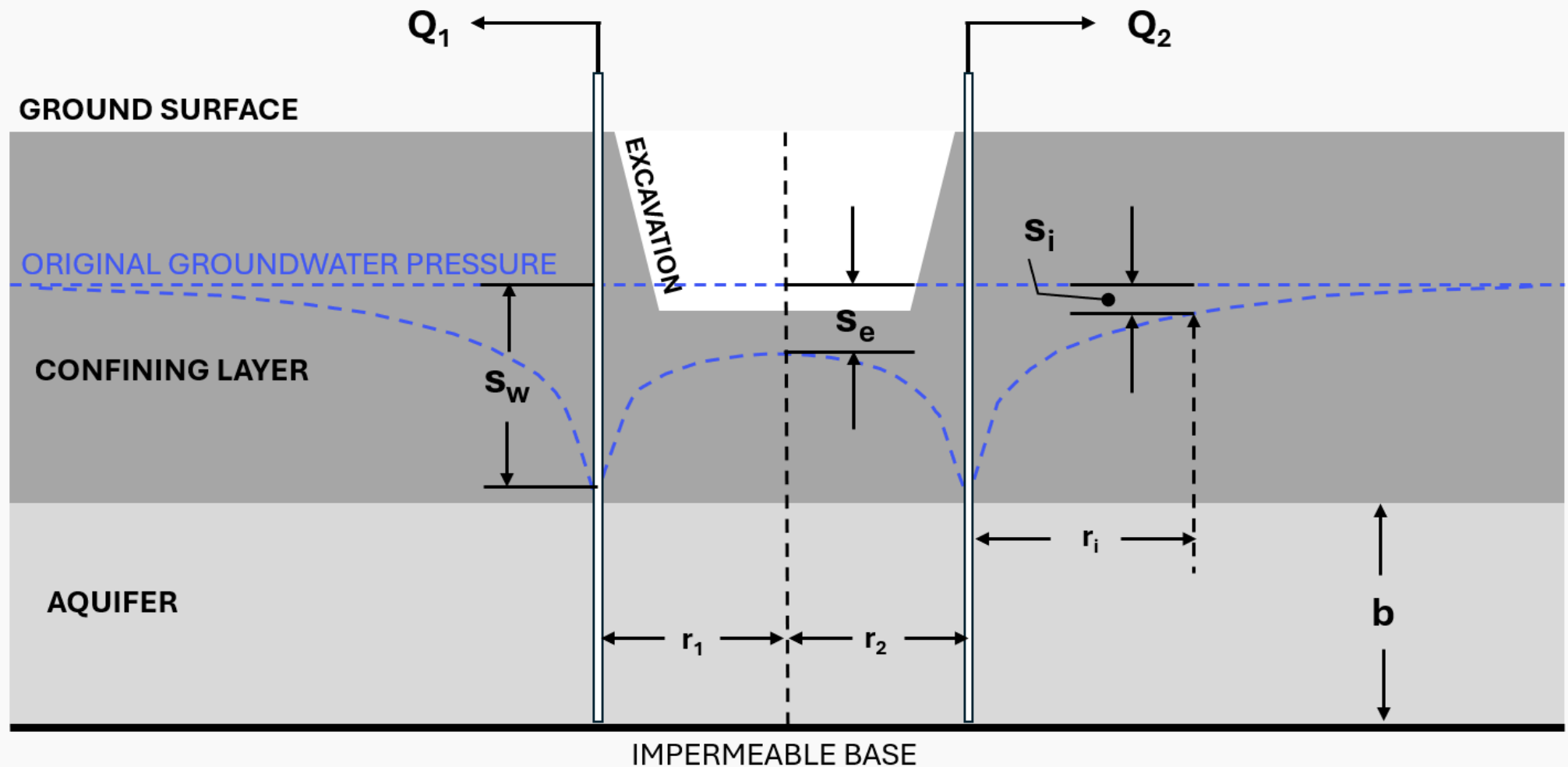


Aquifer Depressurization Model by Superposition

Application: Confined Aquifer



$$Q_i \approx \frac{4\pi K b s_w}{2.3 \log_{10} \left(\frac{2.25 K b t}{r_w^2 S} \right)}$$



Flow Rate per well

Groundwater Drawdown



$$s_i(r_i, t) \approx \frac{2.3 Q_i}{4\pi K b} \log_{10} \left(\frac{2.25 K b t}{r_i^2 S} \right)$$

Superposition Method

This method uses the Cooper-Jacob equation to estimate drawdown from each pumping well, then adds those drawdown contributions at the point of interest.

When to use it

Use this method when a simple equivalent well or slot equation does not fit the problem well.

It is useful for excavations, pits, and quarries with more complex shapes, multiple wells, or nearby boundaries such as streams, recharge zones, or no-flow limits.

Unlike the other simplified equations, it can also estimate drawdown at points inside the excavation.

What you need

- Aquifer K , b , and s
- Well locations and effective radius
- Target drawdown at the point of interest
- Time since pumping began
- Distance from each well to the point of interest

Limitations

- Best suited to confined aquifers or modest unconfined drawdown (10-15% of saturated aquifer thickness).
- Assumes uniform aquifer properties.
- Does not include well losses or partial penetration effects.
- Boundary effects must be added separately.
- May require iteration to match the target drawdown.

Model Equations

$$Q_i \approx \frac{4\pi K b s_w}{2.3 \log_{10} \left(\frac{2.25 K b t}{r_w^2 S} \right)}$$

Flow Rate (Q)

Estimate the pumping rate from each well based on assigned drawdown at the well.

$$s_i(r_i, t) \approx \frac{2.3 Q_i}{4\pi K b} \log_{10} \left(\frac{2.25 K b t}{r_i^2 S} \right)$$

Groundwater Drawdown

Approximate the drawdown contribution from each well at the point of interest.

$$s_e = \sum_i s_i(r_i, t)$$

Total Drawdown Effect from all wells

Add the drawdown contribution from each well to estimate the total drawdown at the point of interest.

$$Q_{\text{total}} = \sum_i Q_i$$

Total Well Discharge

Add the pumping rates from each well to estimate the total pumping rate required for the well system.

$$s_c = s - \frac{s^2}{2b}$$

Unconfined Drawdown Correction*

Adjust the summed Cooper-Jacob drawdown to estimate the larger drawdown expected under unconfined conditions.

*Apply the s_c correction only after superposition is complete, so the correction is applied once to the total drawdown.

Model Variables

Symbol	Units	Description
Q_i	L^3/T	Pumping rate from well i
Q_{total}	L^3/T	Total pumping rate from all wells
s_i	L	Drawdown contribution from well i
s_e	L	Total drawdown at the point of interest
s_w	L	Assigned drawdown at well i
s_c	L	Corrected drawdown for unconfined conditions
r_i	L	Distance from well i to the point of interest
r_w	L	Effective well radius
K	L/T	Hydraulic conductivity
S	-	Storativity (use specific yield for unconfined aquifers)
b	L	Aquifer thickness
t	T	Time since pumping began
i	-	Well index

Notes

The calculation is straightforward for a small number of wells, but it can become difficult to track as more wells and image wells are added. For larger systems, the method is best handled with an efficient calculation setup, such as a spreadsheet or scripting language.