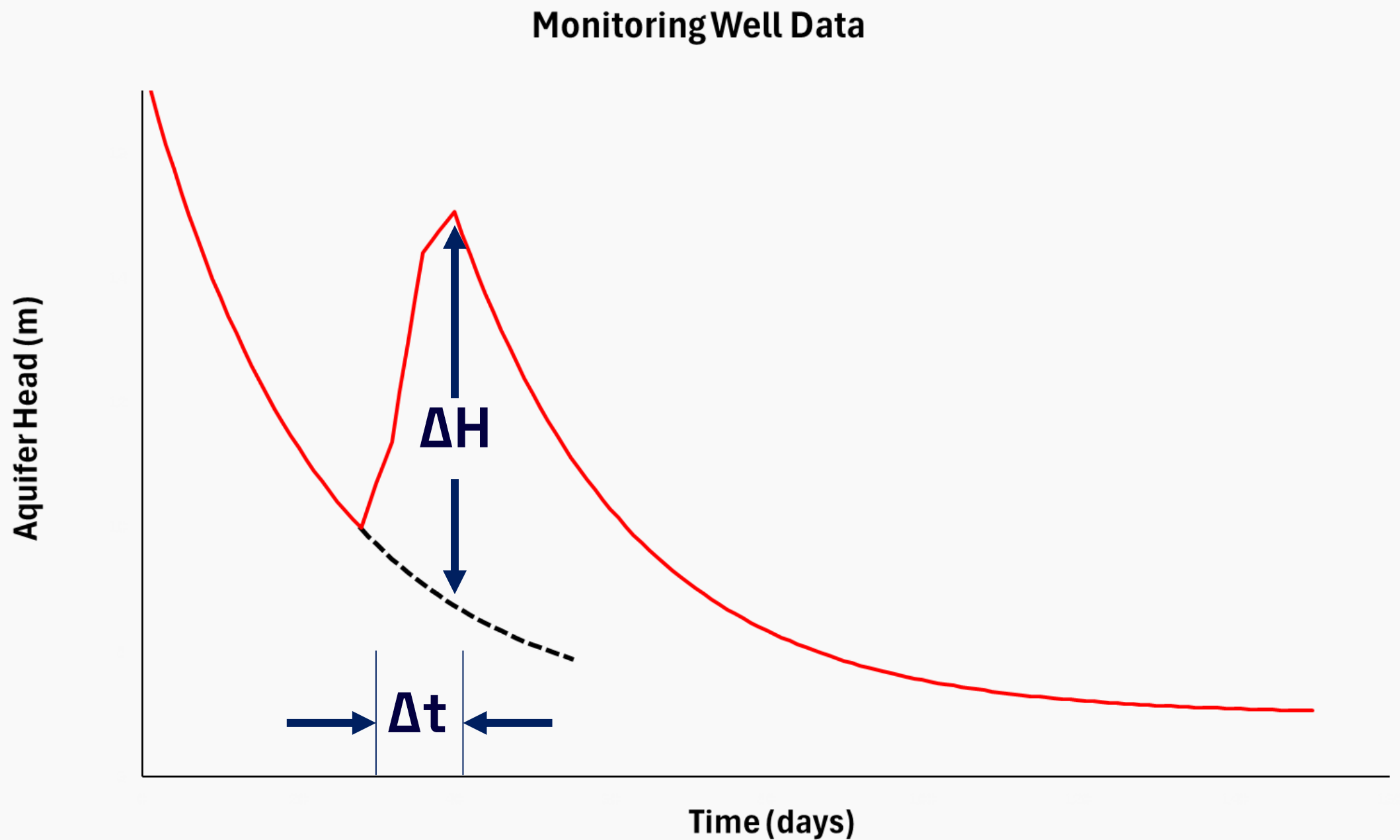


How to Estimate Unconfined Aquifer Recharge



Water Table Fluctuation Method:

$$\text{Aquifer Recharge} = S_y \frac{\Delta H}{\Delta t}$$

When to use this

Use this method when you need to estimate aquifer recharge and only have groundwater level data.

Why Recharge Is Hard to Estimate

Aquifer recharge is hard to estimate because it is not measured directly. Instead, it is inferred from indirect evidence, such as changes in groundwater level, which can be influenced by many other physical processes.

Even so, simple methods are often necessary and can provide reasonable approximations.

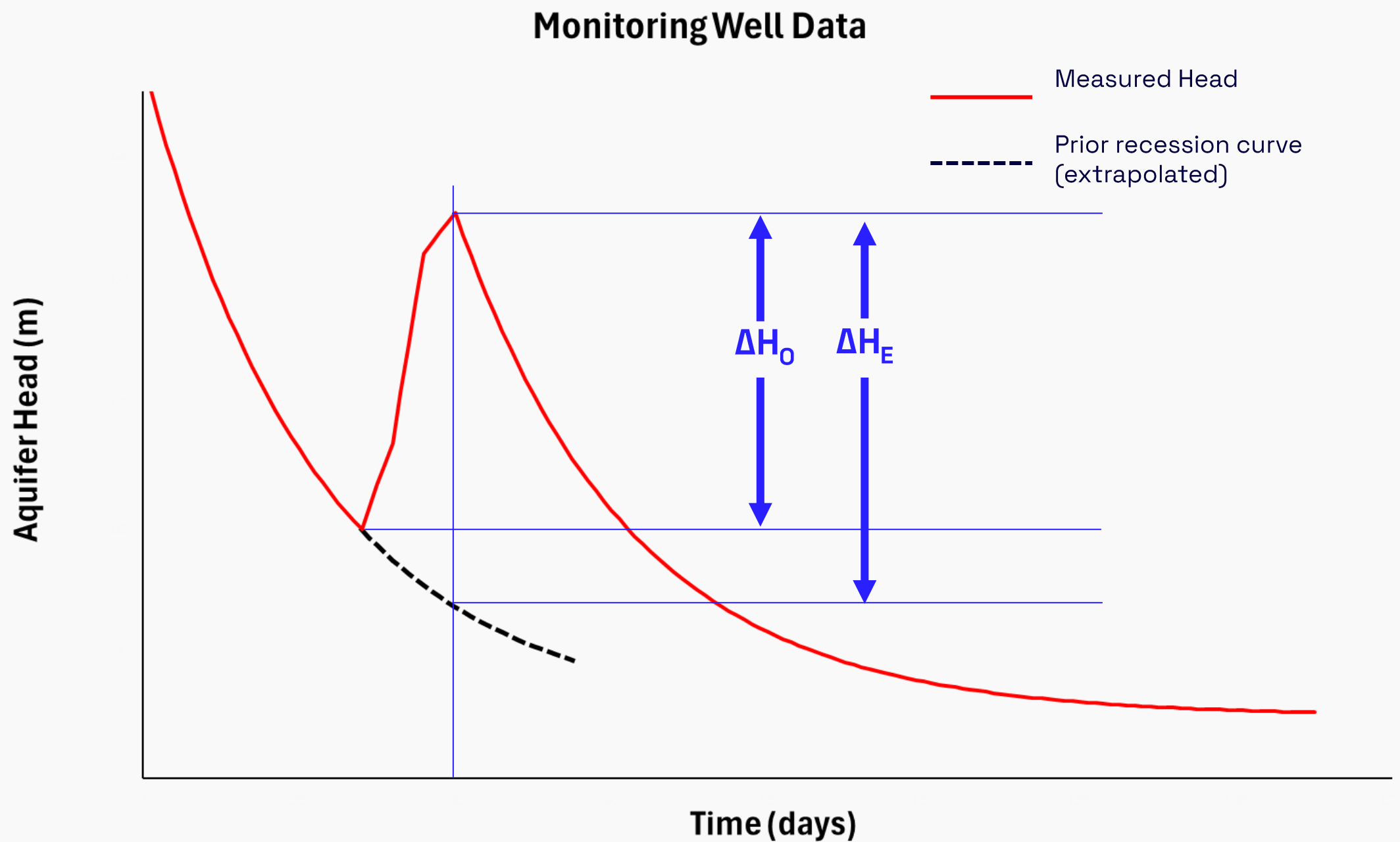
Common Applications

- Estimating recharge from storm or snowmelt events
- Interpreting water-table hydrographs
- Checking results from other recharge estimation methods
- Developing local empirical relationships between precipitation and recharge

Cautions & Limitations

- Requires a reasonable estimate of specific yield.
- Only applicable where groundwater levels show distinct recharge events.
- Other causes of groundwater-level rise, such as barometric pressure, can cause errors in the recharge calculations.

Equations



$$\text{Average Daily Recharge (per unit time)} = S_y \frac{\Delta H_E}{\Delta t}$$

$$\text{Total Recharge (total per event)} = S_y \Delta H_E$$

Variables

Symbol	Units	Description
R	L/T	Aquifer recharge
ΔH_E	L	Effective change in aquifer level (head). This is the rise in groundwater level measured from the prior recession curve (extrapolated) to the peak.
ΔH_0	L	Observed change in aquifer level (head)
Δt	T	The time between the beginning and end of the recharge event
S_y	L	Specific yield of the aquifer

Note:

For this calculation you should use ΔH_E because it accounts for the groundwater decline that would have continued without the recharge event.

However, to estimate ΔH_E , you must extrapolate the prior recession curve to the time of the peak and measure the rise from that extrapolated curve to the peak groundwater level. Your extrapolation of the prior recession curve will be subjective and can introduce error in your estimate of ΔH_E .

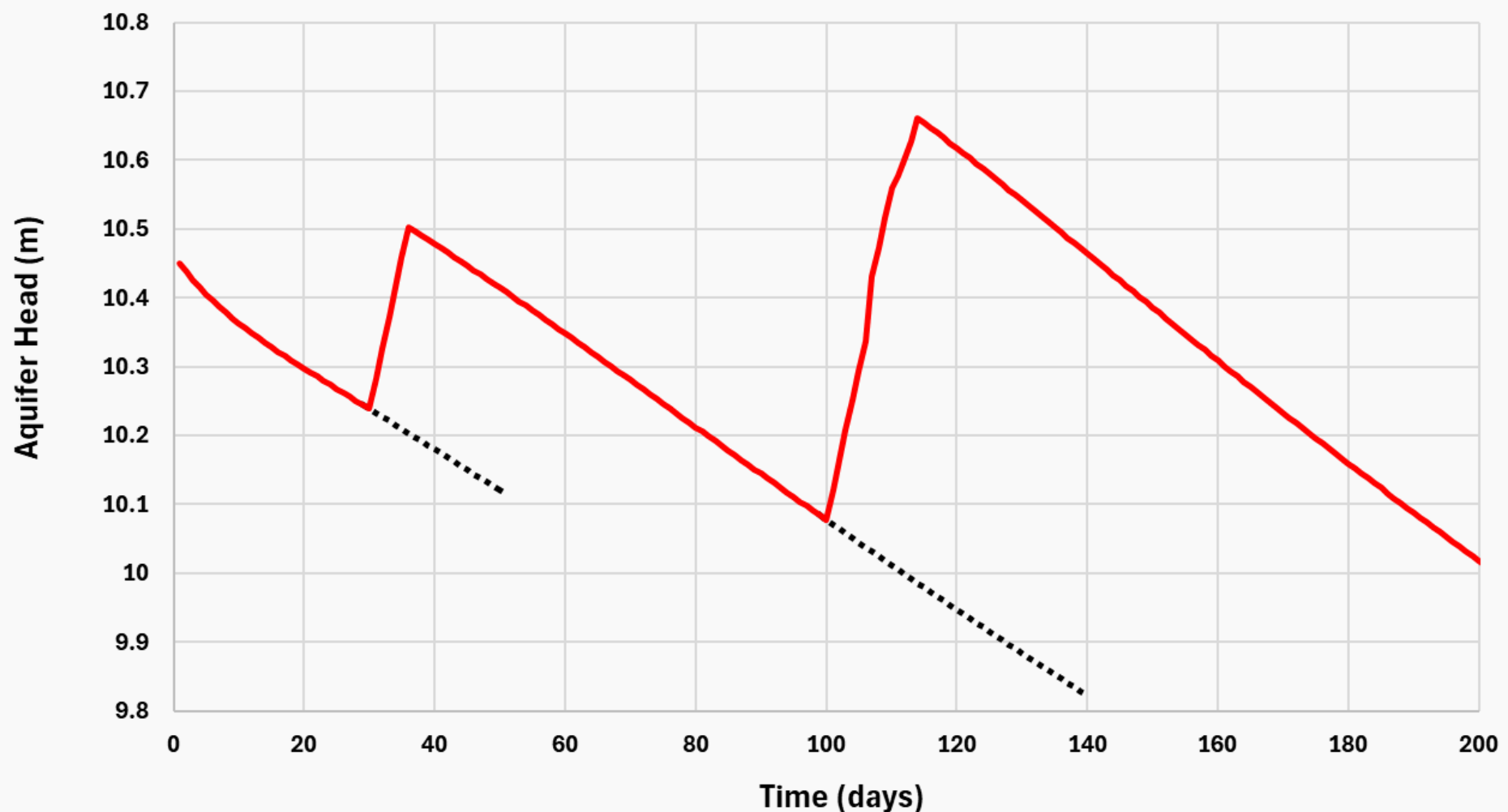
Also note that if the prior recession curve is relatively flat, then ΔH_0 and ΔH_E will be similar, and ΔH_0 may be a reasonable approximation.

Worked Example using a Synthetic Case Study

This worked example uses a simple groundwater flow model that includes two distinct recharge events. The graph of the model results is presented below, and the calculations are provided on the next two cards.

A key advantage of using a model for this example is that the applied recharge is known exactly, and the prior recession curve can be projected exactly as it would have occurred without recharge. This makes it possible to calculate recharge using both ΔH_E and ΔH_O and to compare the results directly with each other and with the “true” simulated recharge. This allows us to see how the Water Table Fluctuation equation performs in a controlled, albeit synthetic, groundwater flow system.

Synthetic Case Study - Well Hydrograph



Example Calculation - Recharge Event #1

Note: The simulation applied a uniform recharge of 0.012 m/d during Event #1

Data

S_y : 0.2

Start: Day 30

End: Day 35

ΔH_0 : 0.26 m

ΔH_E : 0.30 m

Calculation 1: Total Recharge During Event

$$\text{Total Recharge} = S_y \Delta H$$

Total Recharge by ΔH_0 :	0.05 m
Total Recharge by ΔH_E :	0.06 m
“True” Simulated Recharge:	0.06 m

Calculation 2: Average Daily Aquifer Recharge

$$\text{Average Daily Recharge} = S_y \Delta H / \Delta t$$

Recharge per day by ΔH_0 :	0.011 m/d
Recharge per day by ΔH_E :	0.012 m/d
“True” Simulated Recharge:	0.012 m/d

Example Calculation - Recharge Event #2

Note: The simulation applied a non-uniform recharge rates ranging between 0.005 m/d and 0.02 m/d during Event #2

Data

S_y : 0.2

Start: Day 100

End: Day 113

ΔH_0 : 0.58 m

ΔH_E : 0.68 m

Calculation 1: Total Recharge During Event

$$\text{Total Recharge} = S_y \Delta H$$

Total Recharge by ΔH_0 :	0.12m
Total Recharge by ΔH_E :	0.14m
“True” Simulated Recharge:	0.14m

Calculation 2: Average Daily Aquifer Recharge

$$\text{Average Daily Recharge} = S_y \Delta H / \Delta t$$

Recharge per day by ΔH_0 :	0.009m/d
Recharge per day by ΔH_E :	0.010m/d
“True” Simulated Recharge:	0.010m/d

Discussion

This synthetic example shows that the WTF method can perform very well when the groundwater-level record is clear and the prior recession curve can be reasonably defined.

In both recharge events, ΔH_E matched the “true” simulated recharge, while ΔH_O gave a slightly lower but still similar result.

Further Reading

Healy, R.W., Cook, P.G. Using groundwater levels to estimate recharge. *Hydrogeology Journal* 10, 91–109 (2002). <https://doi.org/10.1007/s10040-001-0178-0>

Delottier, H., Pryet, A., Lemieux, J.M. et al. Estimating groundwater recharge uncertainty from joint application of an aquifer test and the water-table fluctuation method. *Hydrogeol J* 26, 2495–2505 (2018). <https://doi.org/10.1007/s10040-018-1790-6>