Best Available Science: Navigating Data Limitations Associated with Depletions

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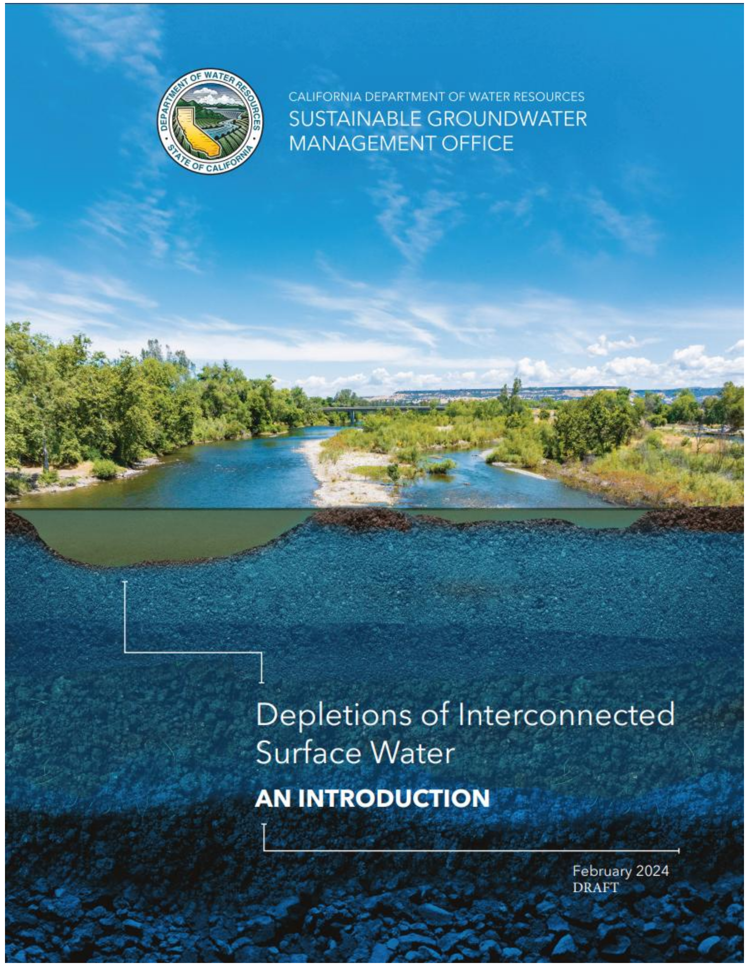
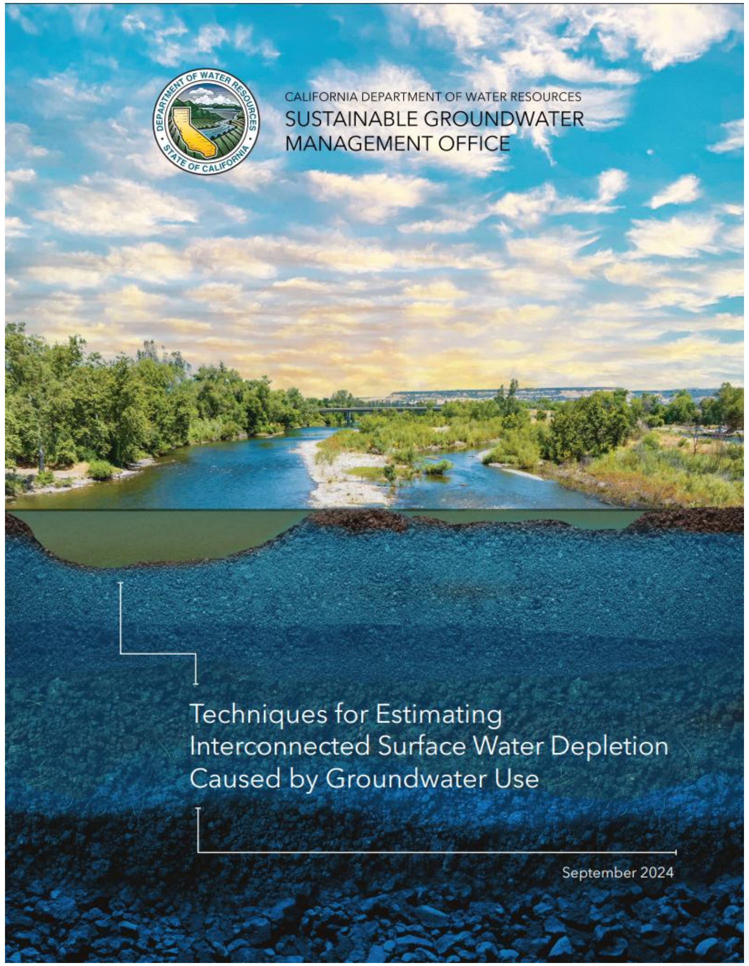
Woodard & Curran

Best Available Science summarized by DWR…

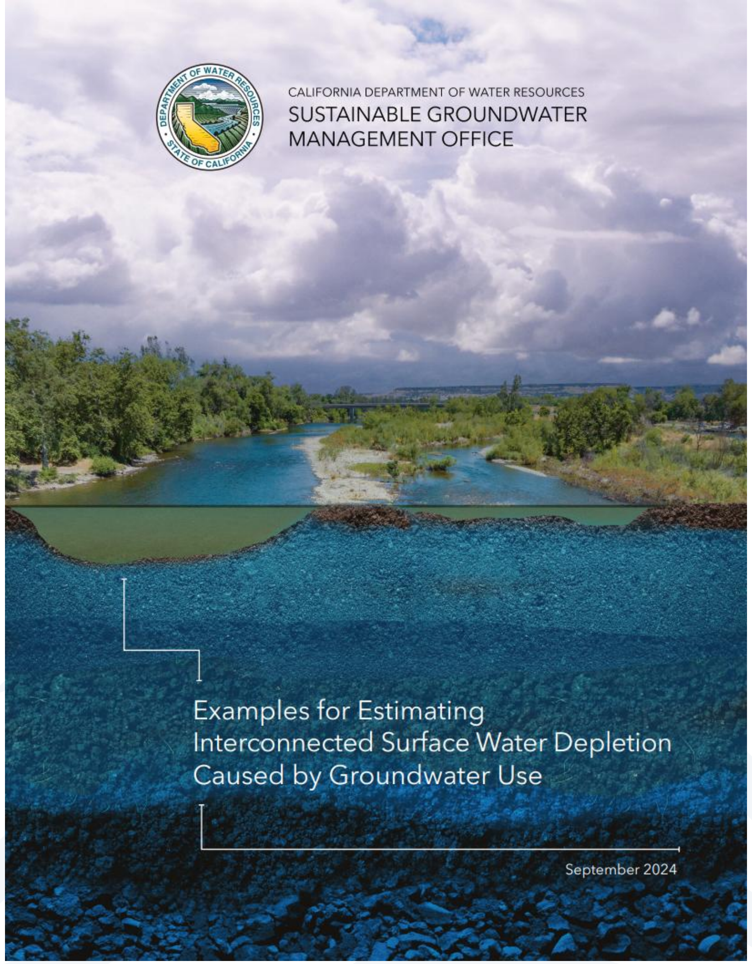
INTRODUCTION



TECHNIQUES



EXAMPLES



Most technically challenging of the six sustainability indicators

- Identify Interconnected Surface Waters
- Quantify the quantity, timing and location of depletions due to pumping
- Tie it to Sustainable Management Criteria (groundwater levels)

- Data and tool limitations
- Resources and complexity
- Realistic assumptions

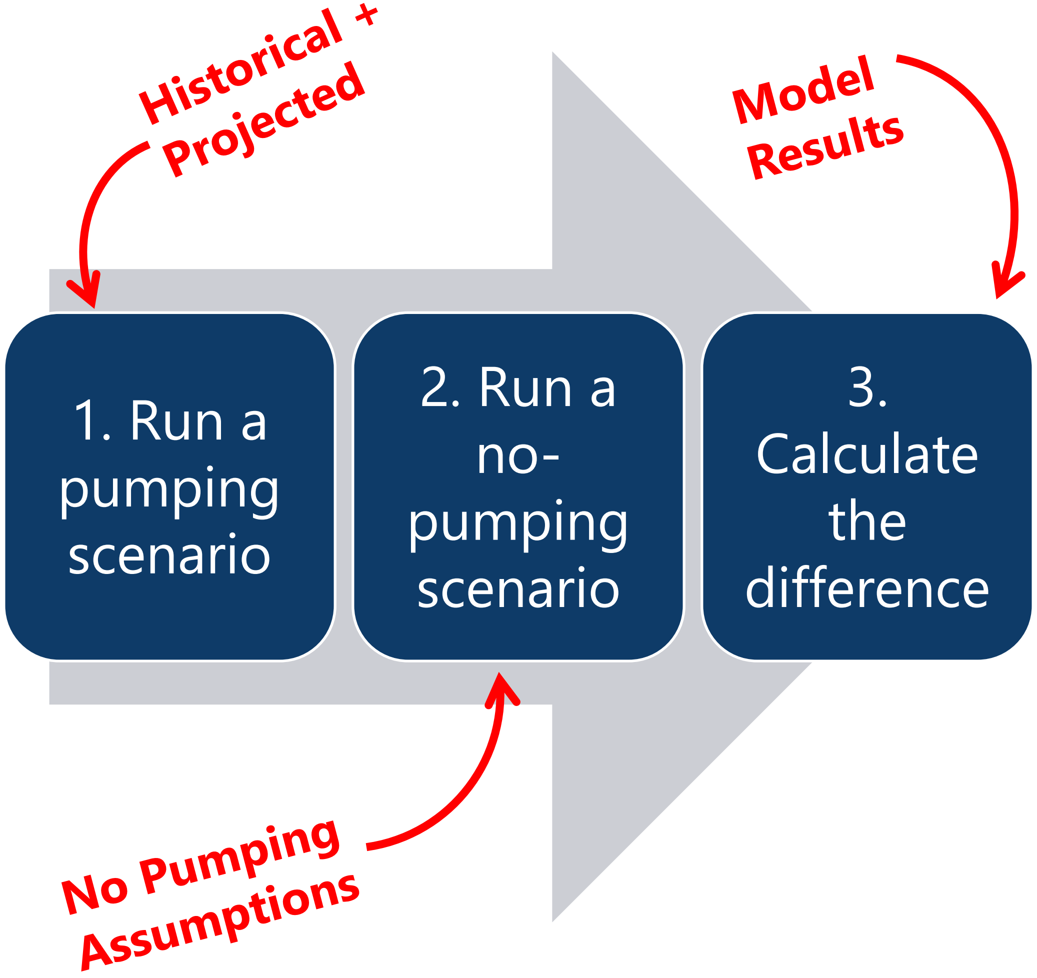
Outline

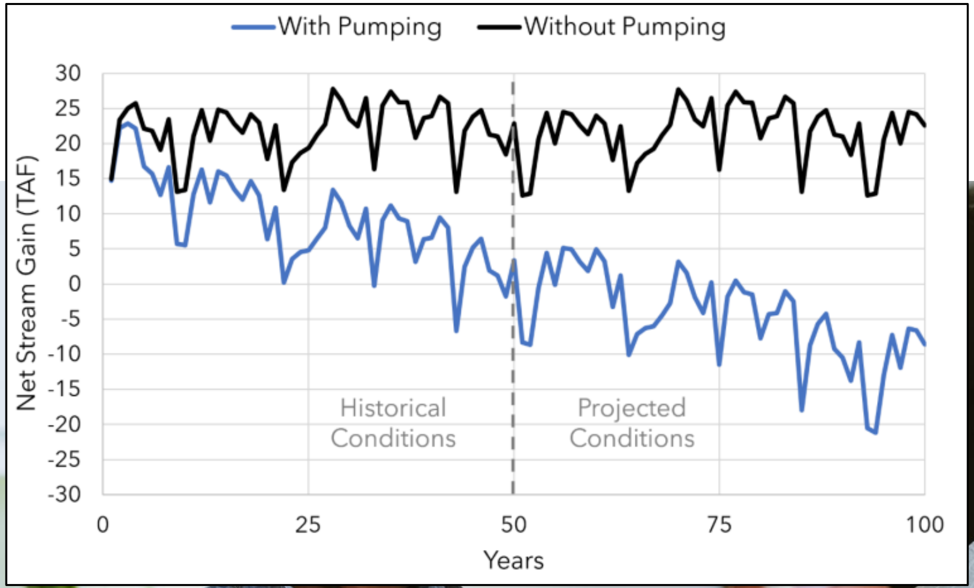
1. **Three hypothetical case studies**
   - <u>Subbasin A:</u> Small basin, 100% dependent on groundwater
   - <u>Subbasin B:</u> Medium sized sustainably managed basin, using surface water and groundwater conjunctively
   - <u>Subbasin C:</u> Large critically overdrafted basin, have limited surface water access, relies on groundwater for the rest

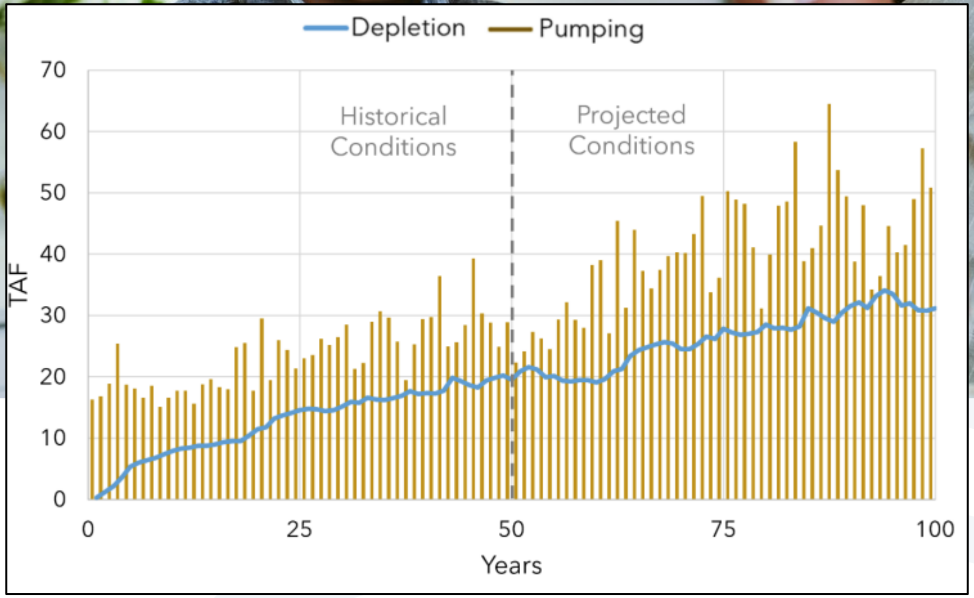
2. **Lessons Learned & Tips**

Once upon a time there were 3 subbasins…

Recipe for Quantifying Stream Depletion: 3-Step Approach







Subbasin A

- Small, mostly agricultural
- Critically overdrafted
- 100% dependent on GW with no surface water rights
- No urban use, some rural residential but negligible compared to agricultural use
- No neighboring subbasins
- No upstream watersheds
- Have to reduce GW production to reach sustainability

Subbasin A

1. Run a pumping scenario
2. Run a no-pumping scenario
3. Calculate the difference

Scenario 1:

- Historical + Projected

Scenario 2:

- Historical + Projected w/ pumping reductions

- Ignore negligible residential pumping
- Convert ag. lands to native vegetation (NV)

Pumping impacts are on:

1. Stream-GW interaction
2. Groundwater storage
3. Deep Percolation

Rainfall-Runoff and Actual ET dynamics change with NV conversion

Subbasin B

- Medium sized, mostly agricultural with some urban
- Sustainably managed
- Conjunctive use of SW and GW for ag.
- Urban & residential use are not negligible but depend on GW
- Has neighboring subbasins
- Has an upstream watershed with a reservoir

Subbasin B

1. Run a pumping scenario → 2. Run a no-pumping scenario → 3. Calculate the difference

Scenario:
- Historical + Projected

- Convert GW only ag. lands to NV
- Convert urban areas to NV
- Supply additional SW to replace GW use in remaining ag. lands

Pumping impacts are on:
1. Stream-GW interaction
2. Groundwater storage
3. Deep Percolation (Runoff & Actual ET)
4. Boundary flows
5. Canal Recharge

Additional considerations:
- Minimum flow requirements
- Streams used for irrigation conveyance
- Conditions in neighbors

Subbasin C

- Large sized, with significant agricultural and urban water use
- Critically overdrafted
- Conjunctive use of SW and GW for ag. and urban
- Has neighboring subbasins
- Has access to more SW, but it is limited

Subbasin C

Reduced pumping

1. Run a pumping scenario

2. Run a ~~no-pumping~~ scenario

3. Calculate the difference

Scenario:

- Historical + Projected

- No pumping scenario doesn't stabilize throughout the simulation time
- Meet urban demand by additional SW
- Supply remaining SW to ag. to reduce GW until levels stabilize around SMCs

Pumping impacts are on:

1. Stream-GW interaction
2. Groundwater storage
3. Deep Percolation (Runoff & Actual ET)
4. Boundary flows
5. Canal Recharge

Takeaways

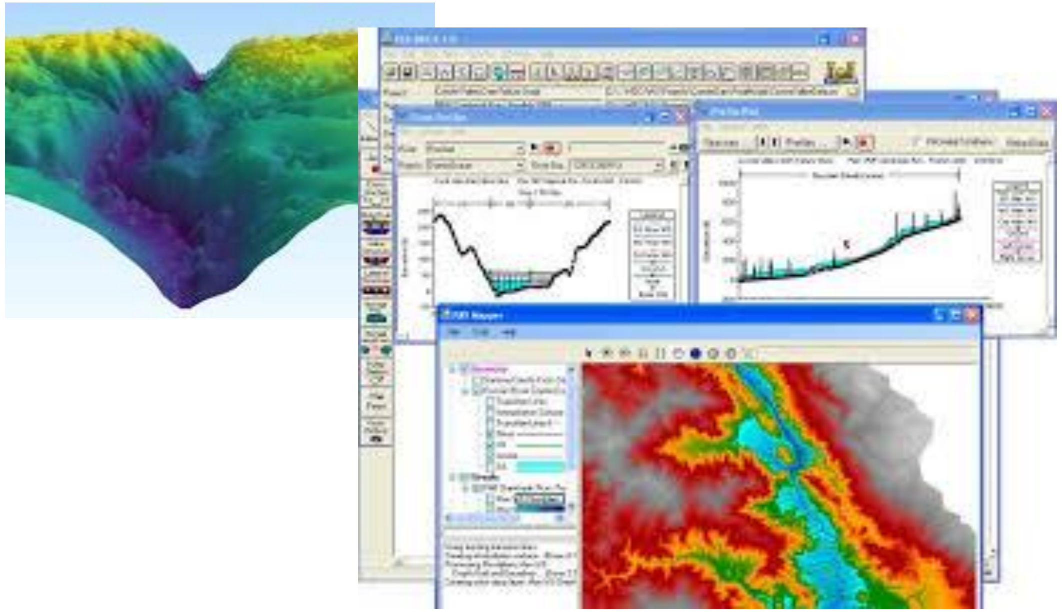
- Path to sustainability is an iterative process.
  - Use the best available tools and data, not necessarily the best "possible"
  - Make reasonable assumptions
  - Acknowledge data gaps & limitations
  - Leave the door open for iterations & updates
- Integrated numerical models are the best available tools.
- The modeling process is straightforward once assumptions are made for the no-pumping scenario.
- Remember that there may be impacts to other GW budget components

5 tips that can make your life easier

Tip #1: Suggest prioritizing the stream and aquifer characterization

Rating table data is limited, or is focused on flood flows

- Use LiDAR survey + hydraulic model to create rating tables



Point aquifer data may not represent the entire reach

- Use geophysics: tTEM / FloaTEM and inform the numerical model

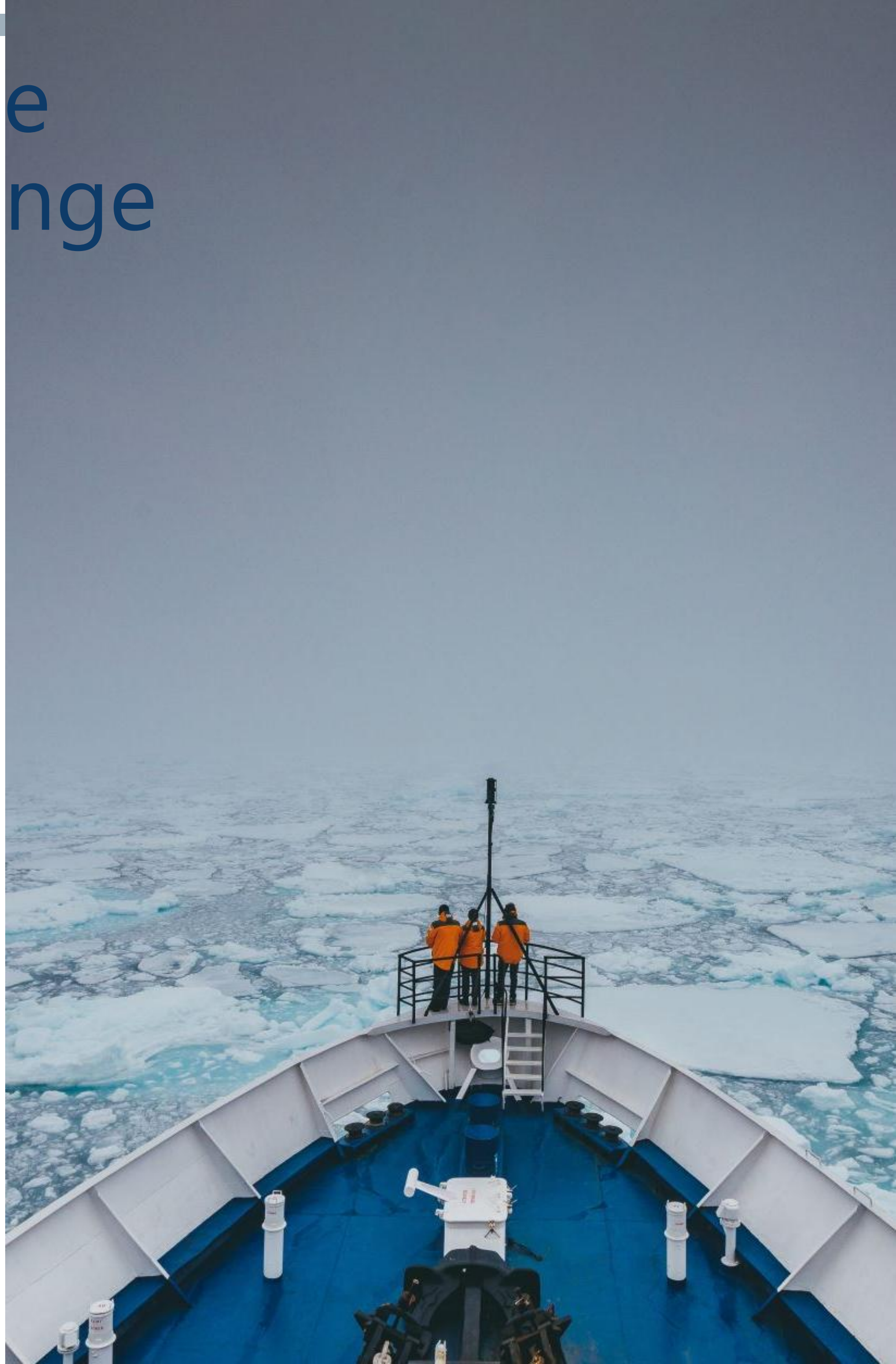
Tip #2: Consider using superposition

- Stream-aquifer connection/disconnection is a non-linear process.
- When a simplifying assumption is needed, superposition can be a useful tool, assuming linearity:

1. Make the 3-step analysis for a single year of pumping, with a reasonable rate for your subbasin.
2. Record the impact by stream reach and by month following the start of pumping as a percentage of pumping, use as a "Unit Response Curve".
3. To quantify the cumulative impacts of multiple years of pumping with changing rates, scale and superimpose the "Unit Response Curve".

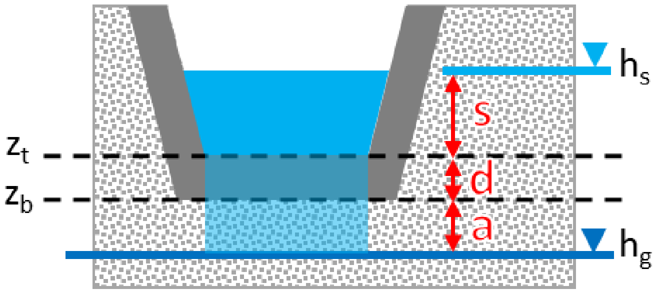
Tip #3: Be cautious when using the models outside their calibrated range

- Models can behave strangely when scenarios take them to uncharted waters:
  - Too much/too little pumping
  - Too high/too low groundwater levels
  - Too much stream flow
- Use your judgement to validate the results, do not believe just because the model says so.



Tip #4: Consider this condition while identifying ISWs

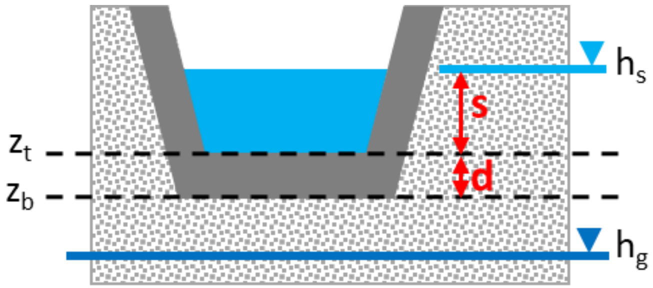
Losing & Connected Stream



$$K_{bed} > K_{aq}\left(\frac{d}{d+s}\right)$$

Soil column beneath the streambed layer will never desaturate, and the pressure below the streambed layer will remain positive. Stream will remain connected.

Losing & Disconnected Stream



$$K_{bed} \leq K_{aq}\left(\frac{d}{d+s}\right)$$

System is gravity flow through streambed and the stream is disconnected. The flow rate can be calculated by the equation for disconnected streams.

Woodard & Curran

Brunner et.al., 2009. Hydrogeologic controls on disconnection between surface water and groundwater: 4.1. Condition for Disconnection, Eq.5

Tip #5: Let's talk if you have any questions