

Using water level measurements to define model layers: Status and plan

Stephen Hundt

TVHP Model Layering (Petrich, 2004)

Layer bottoms are planar, sloping from Boise to Snake

USBR model (Johnson, 2013) took similar approach in Payette Valley

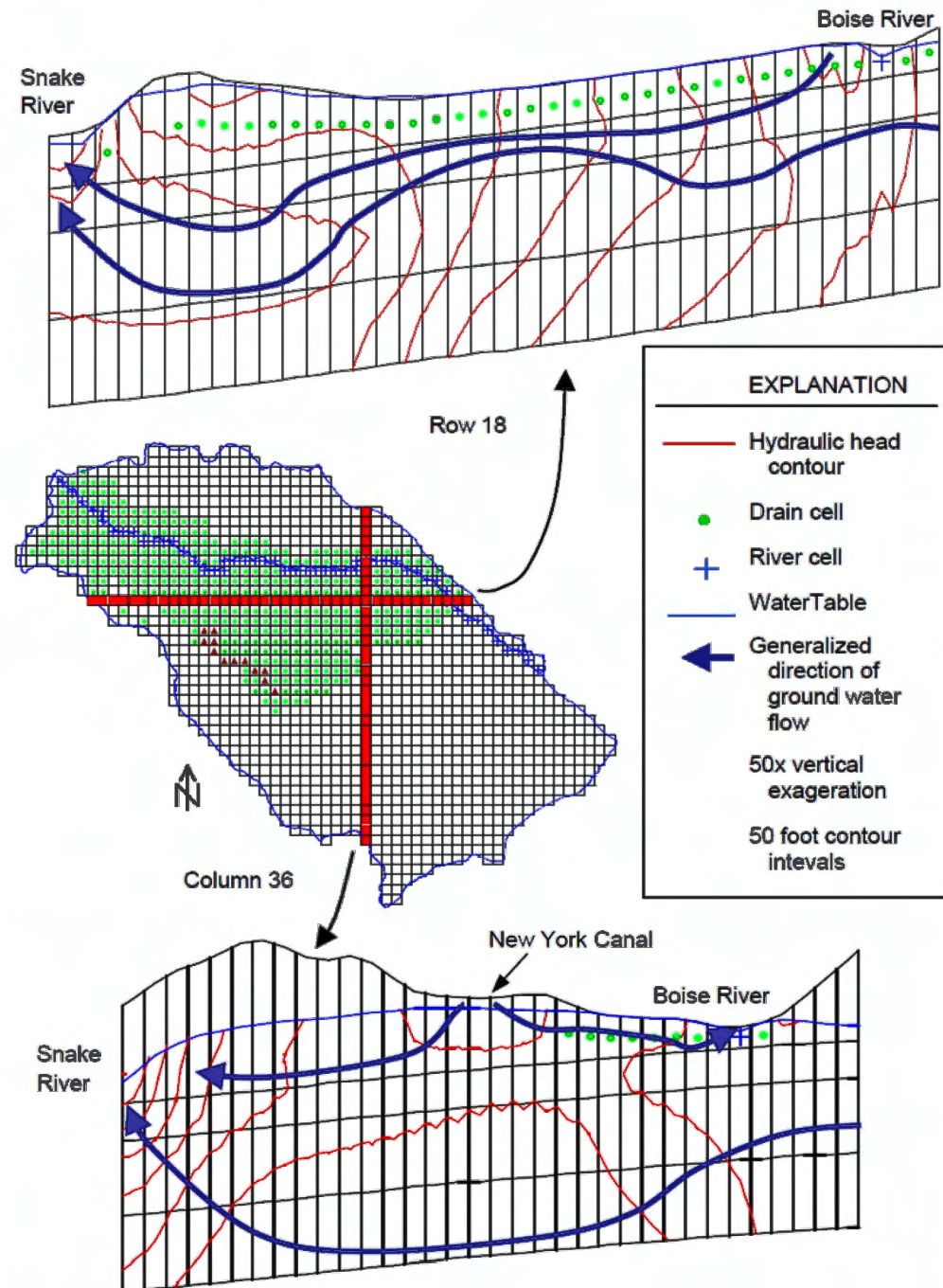
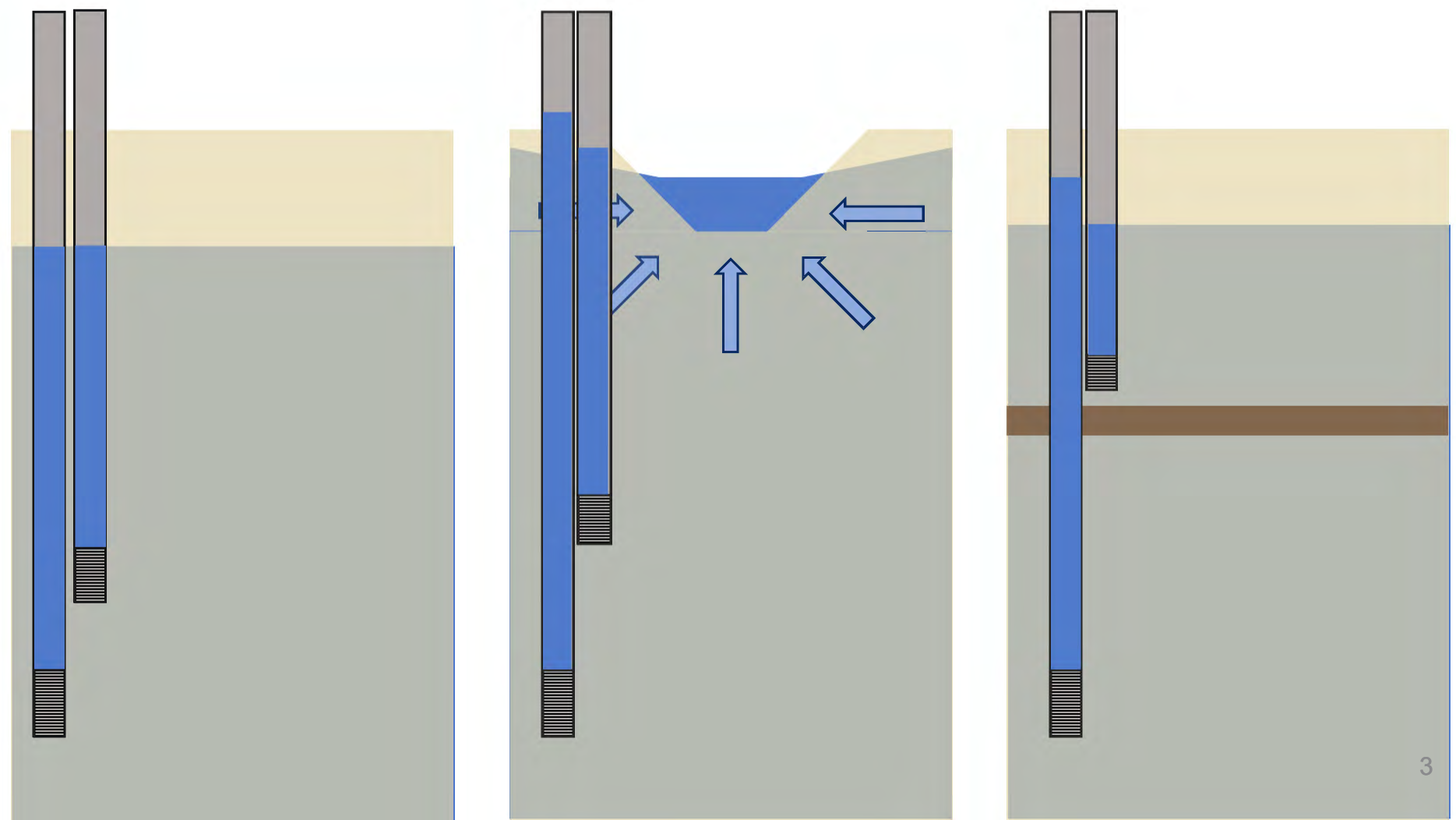
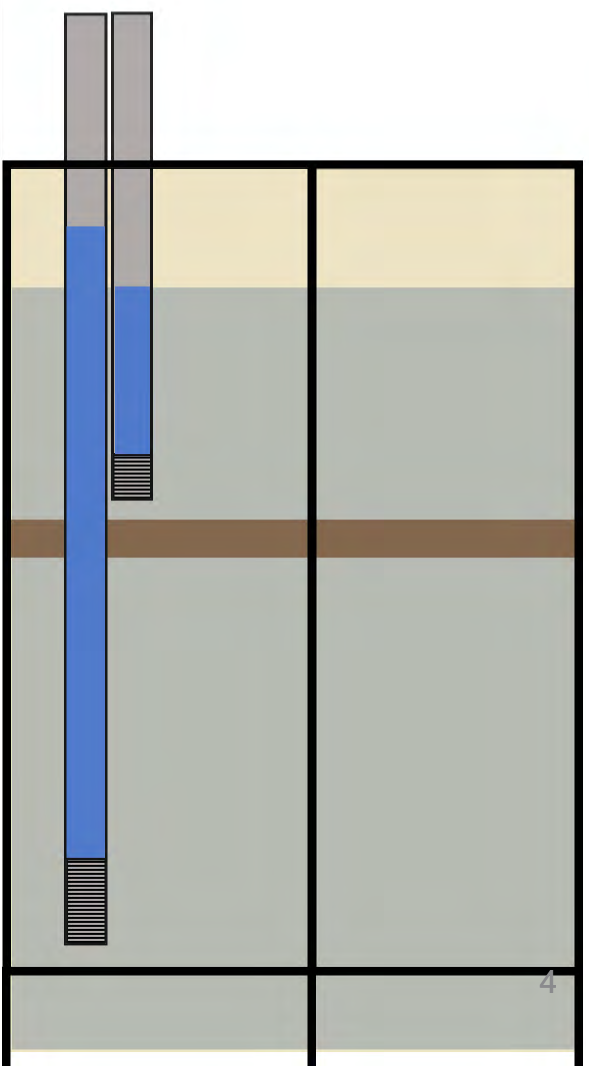


Figure from: Petrich, C. and Urban, S. (2004). Characterization of Ground Water Flow in the Lower Boise River basin. Idaho Water Resources Research Institute and the Idaho Department of Water Resources, Research Report IWRI-2004-01.

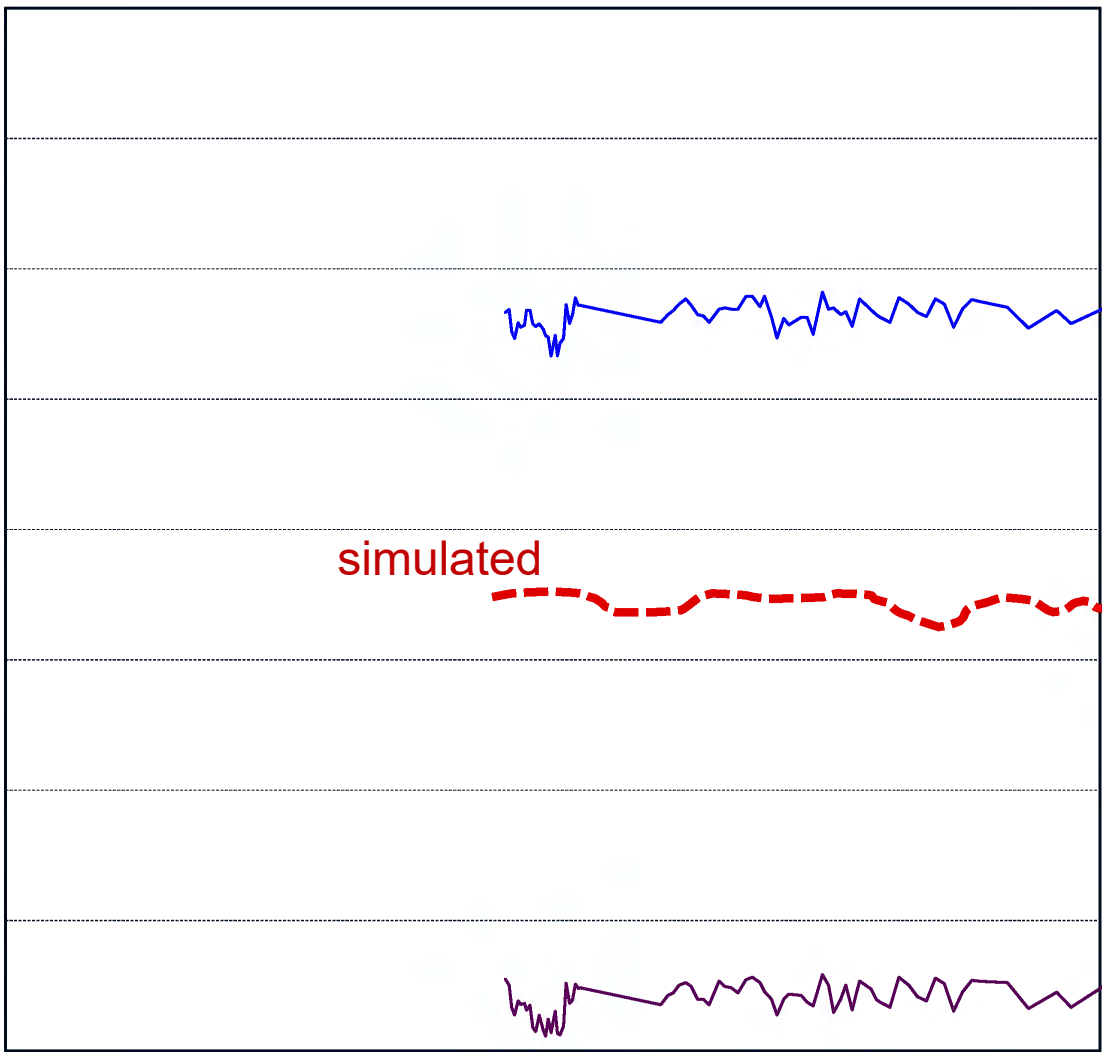
Multilevel wells



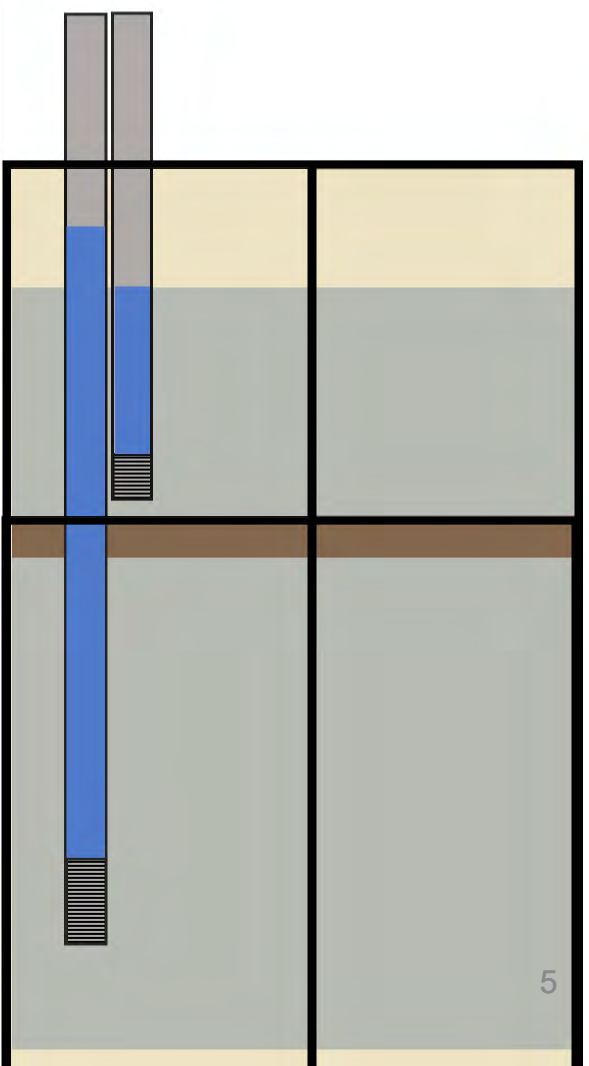
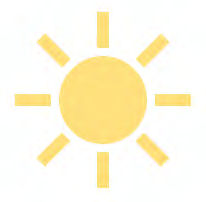
Multilevel wells



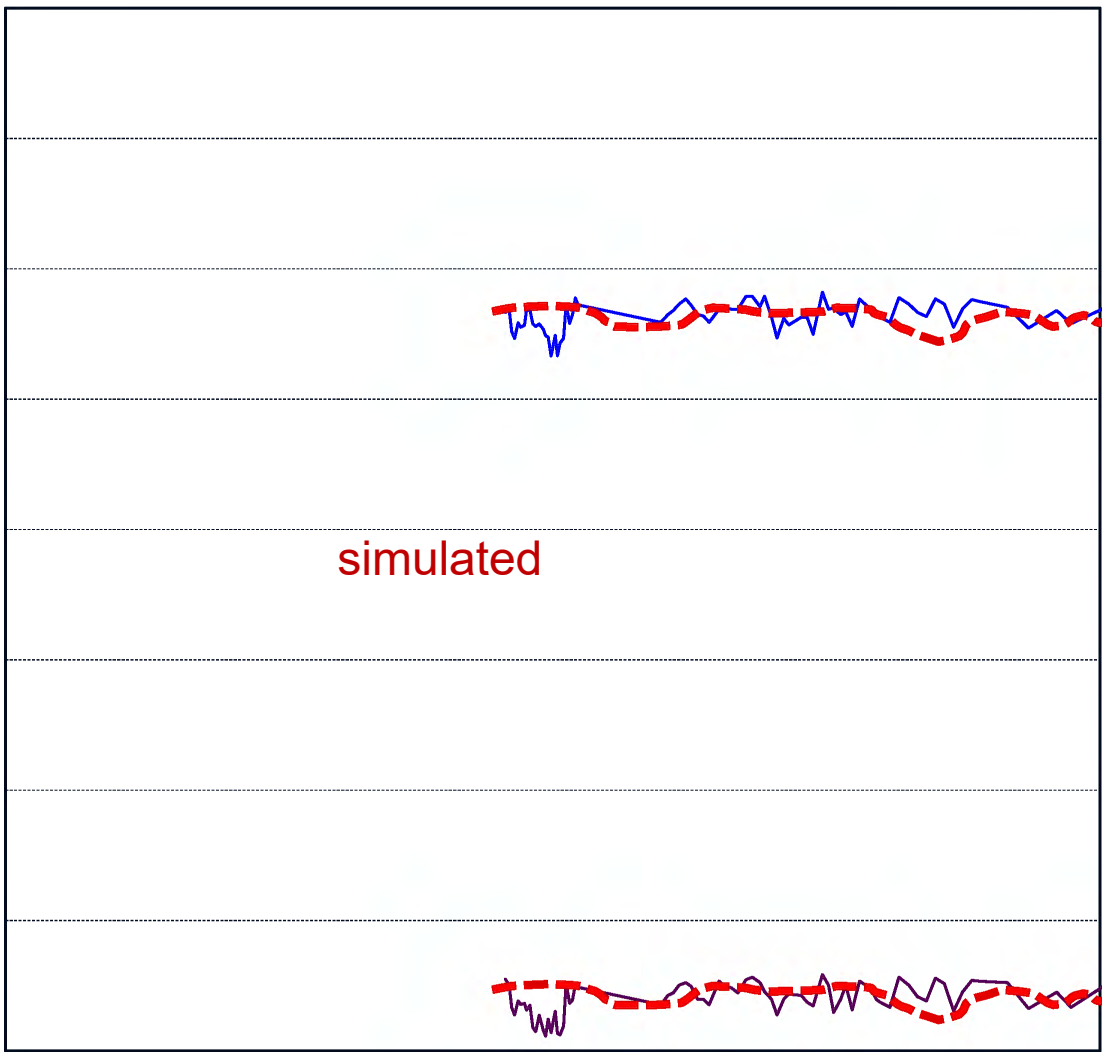
Water-level altitude, ft (NAVD88)



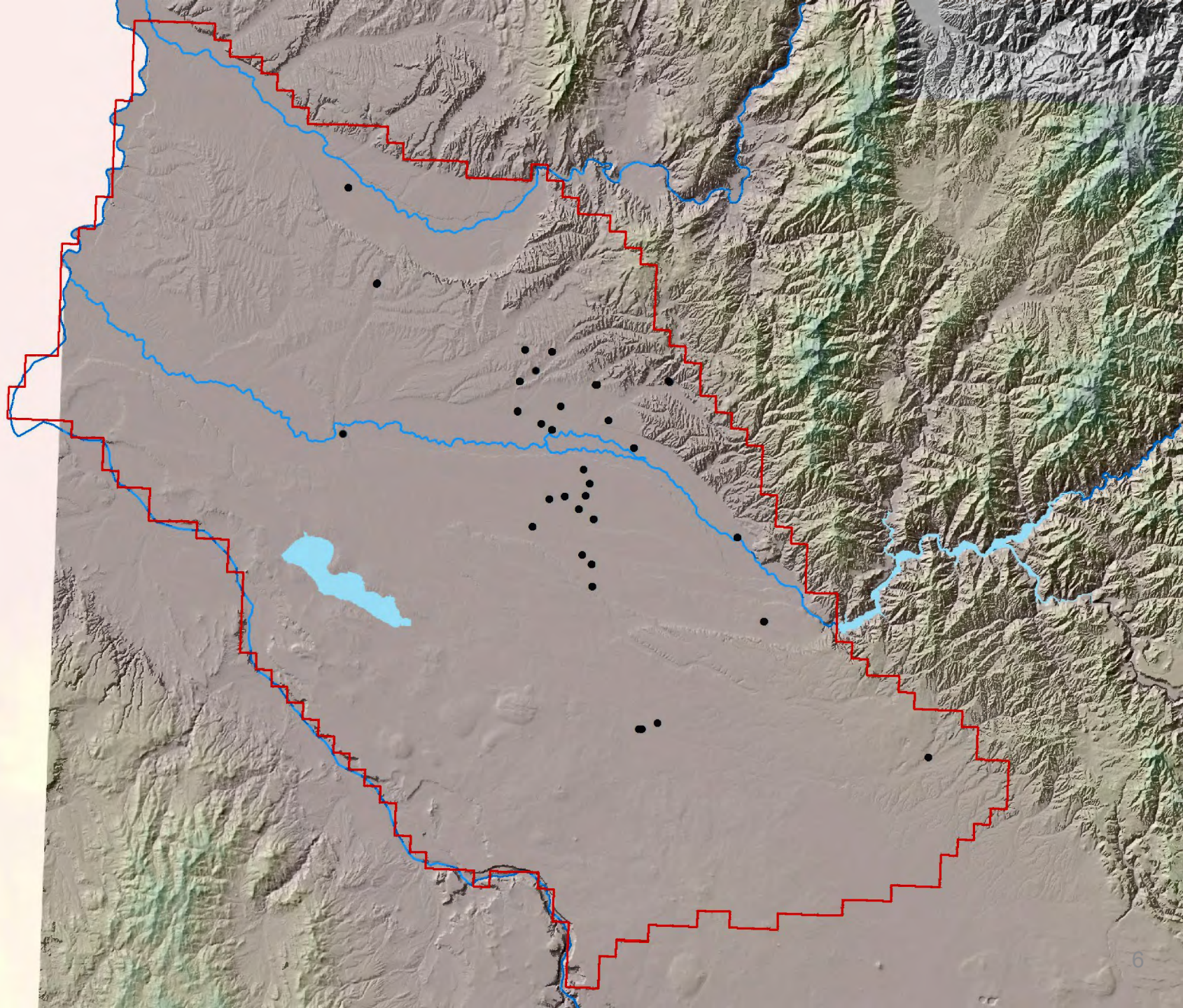
Multilevel wells



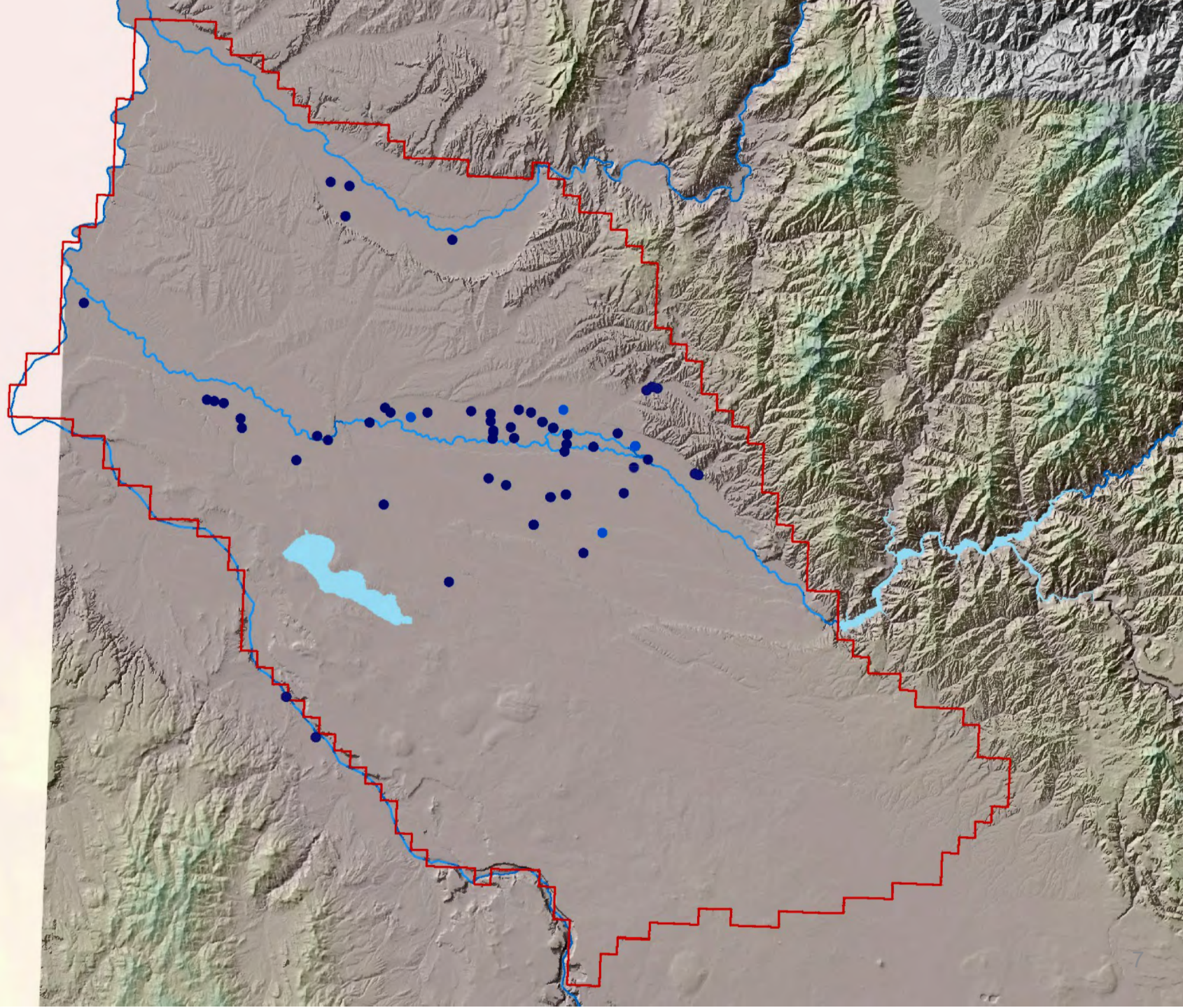
Water-level altitude, ft (NAVD88)



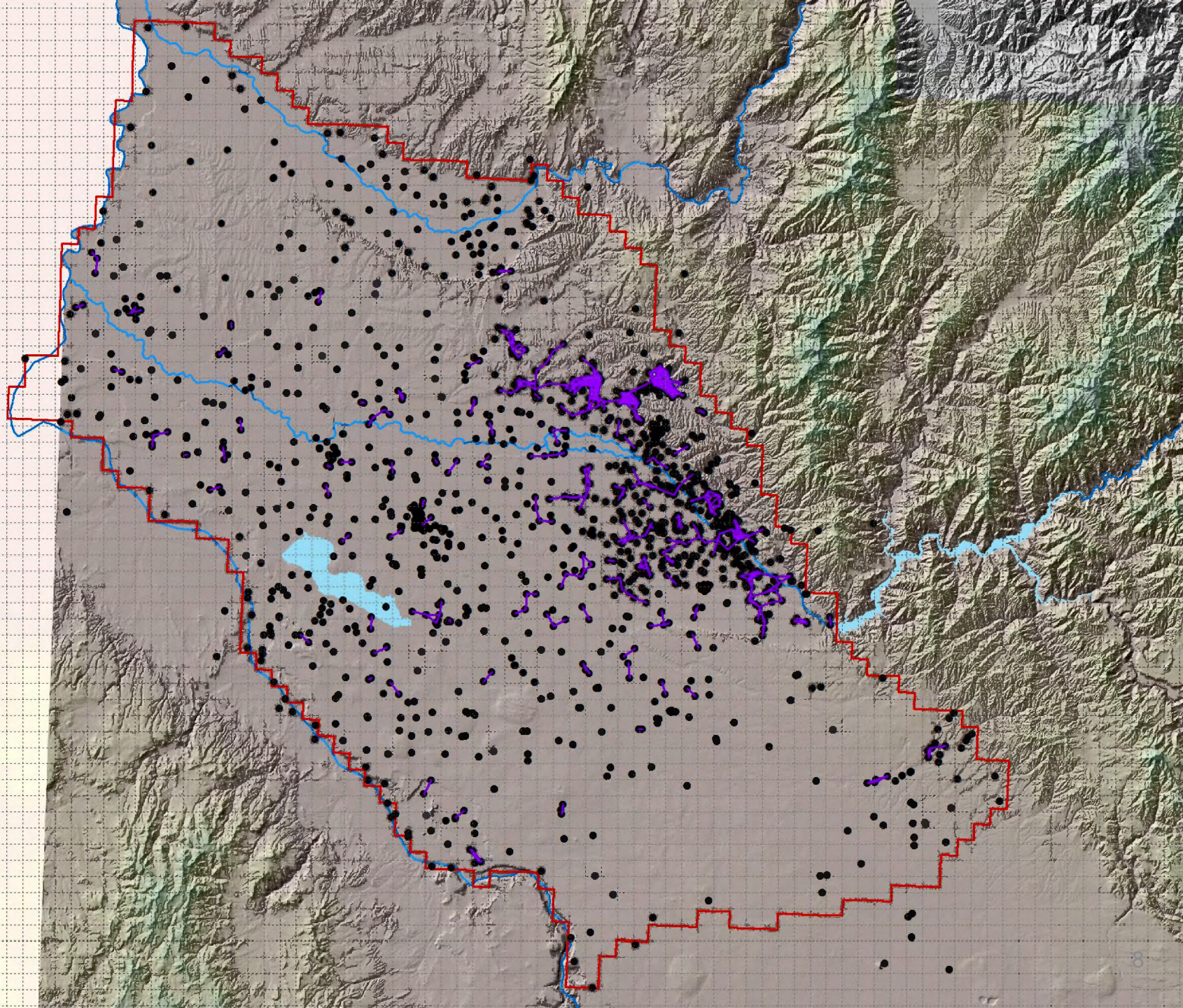
Multilevel wells



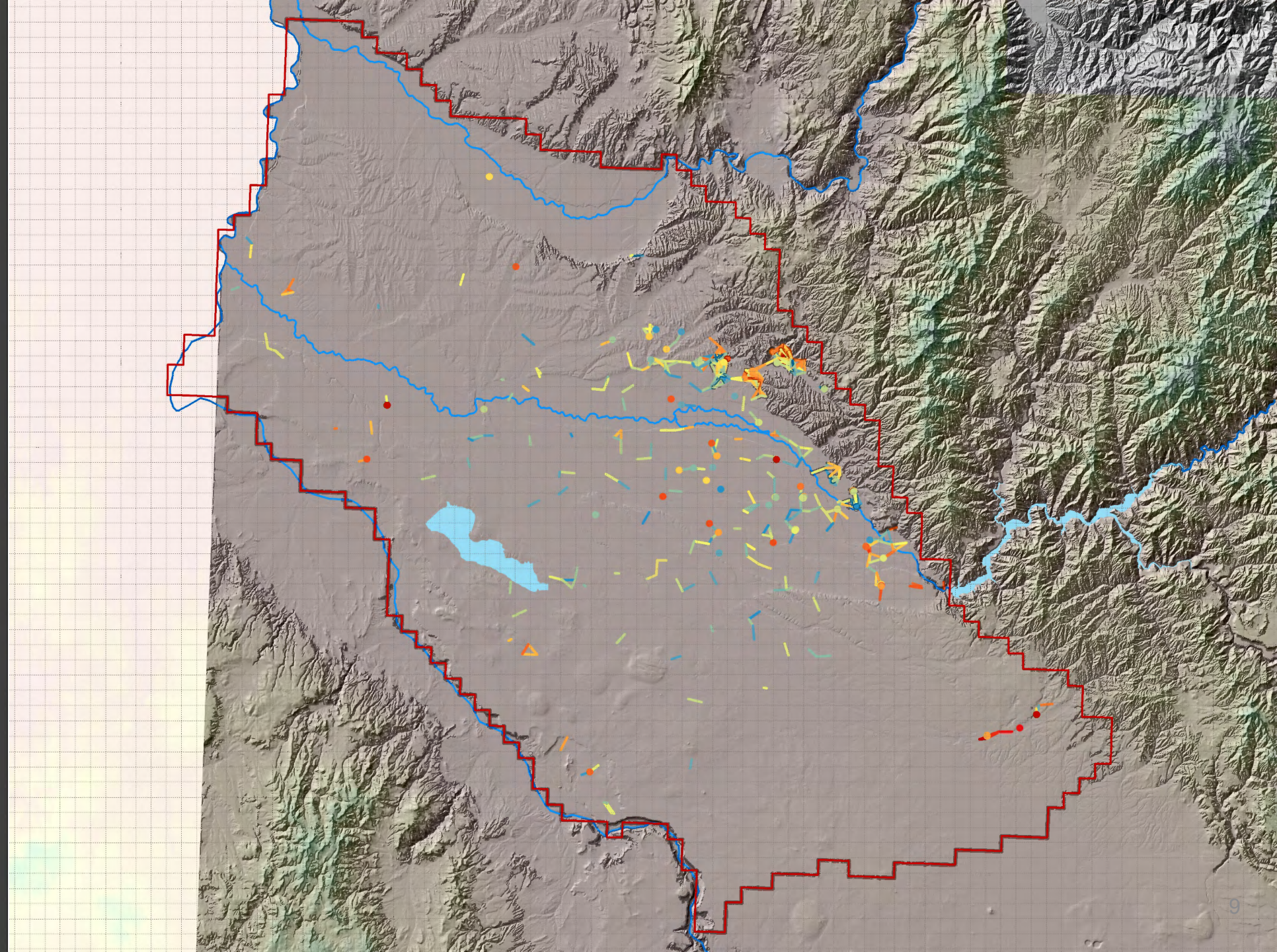
Artesian Wells



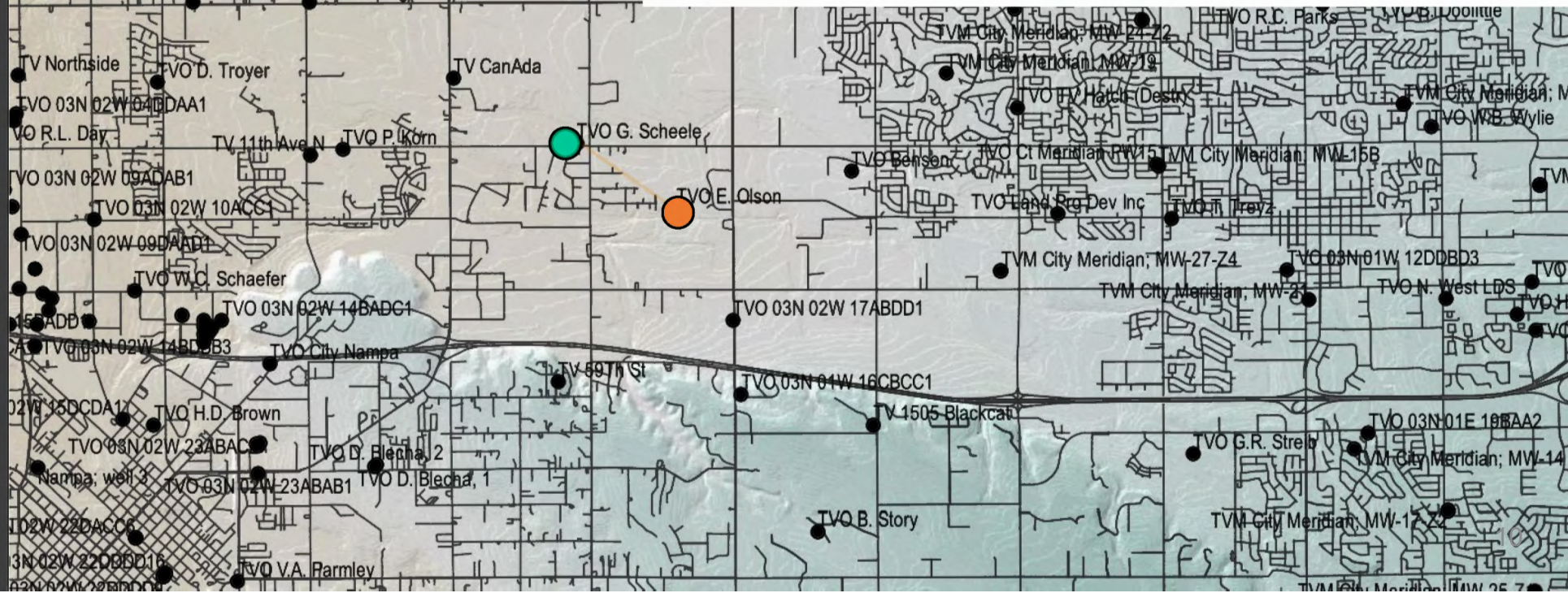
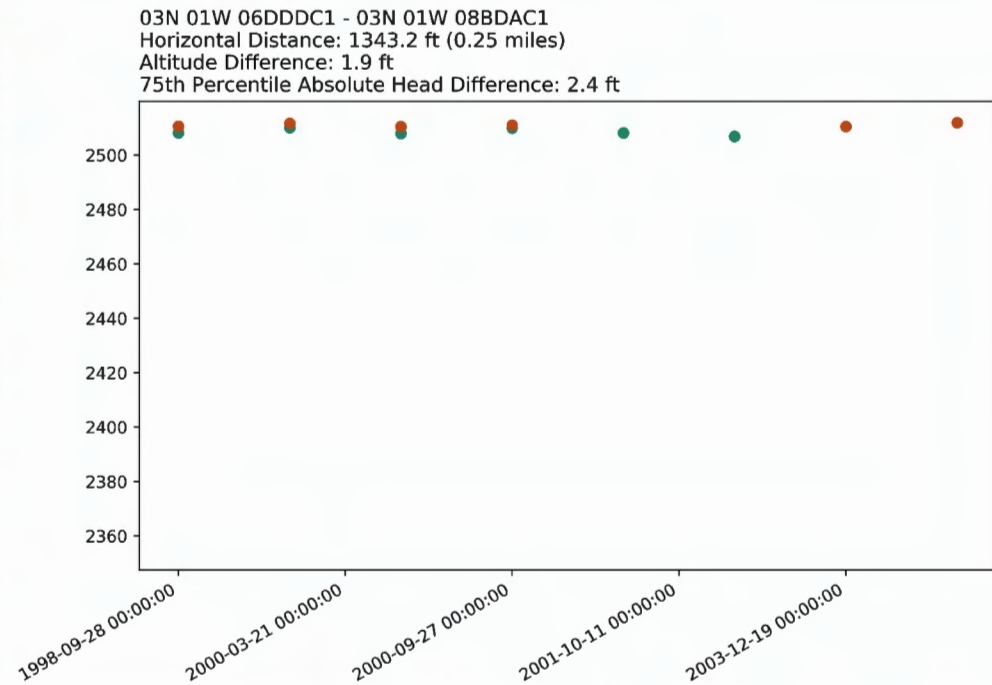
Well pairs within 1 mile



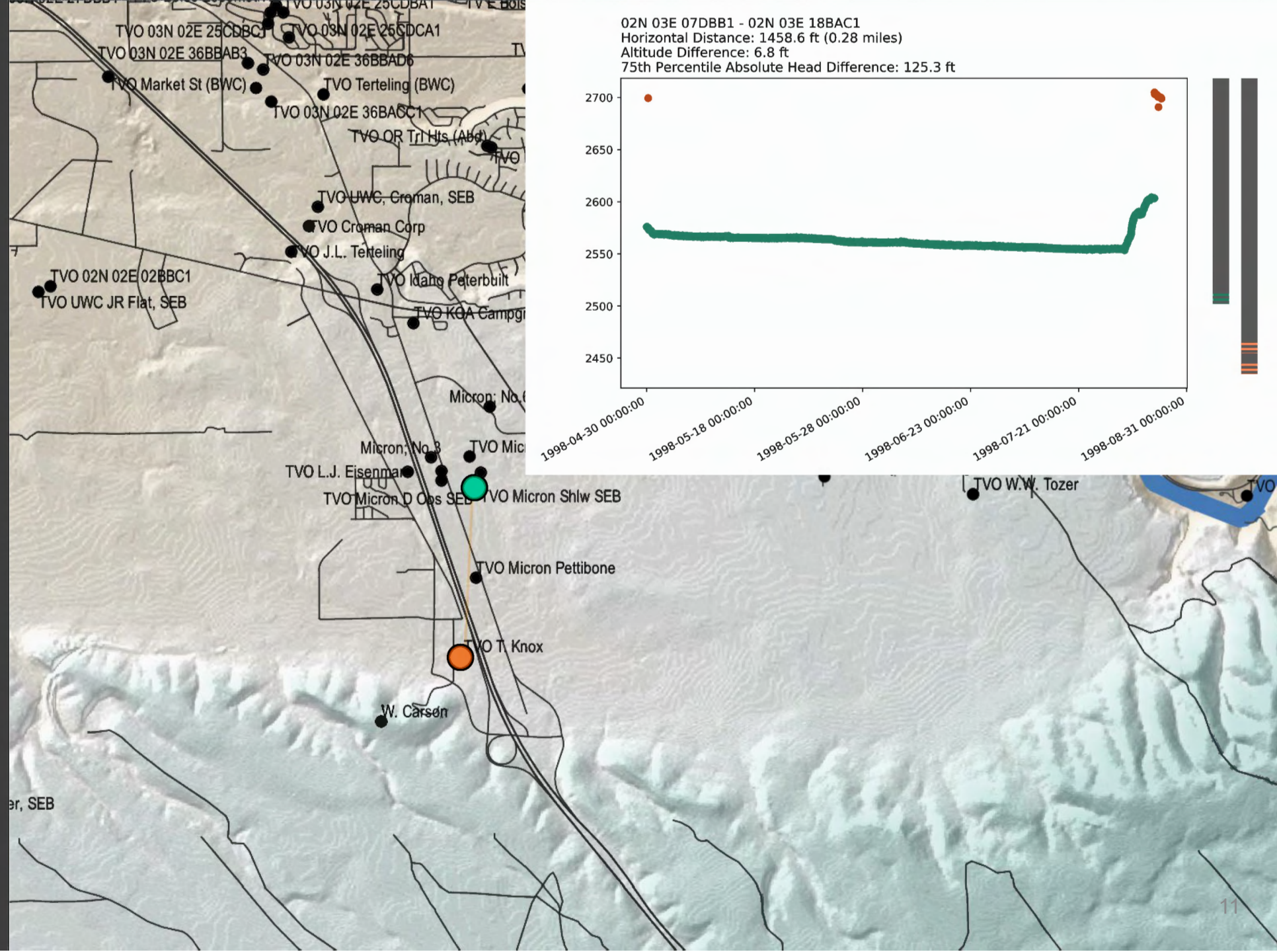
Water level comparison statistics



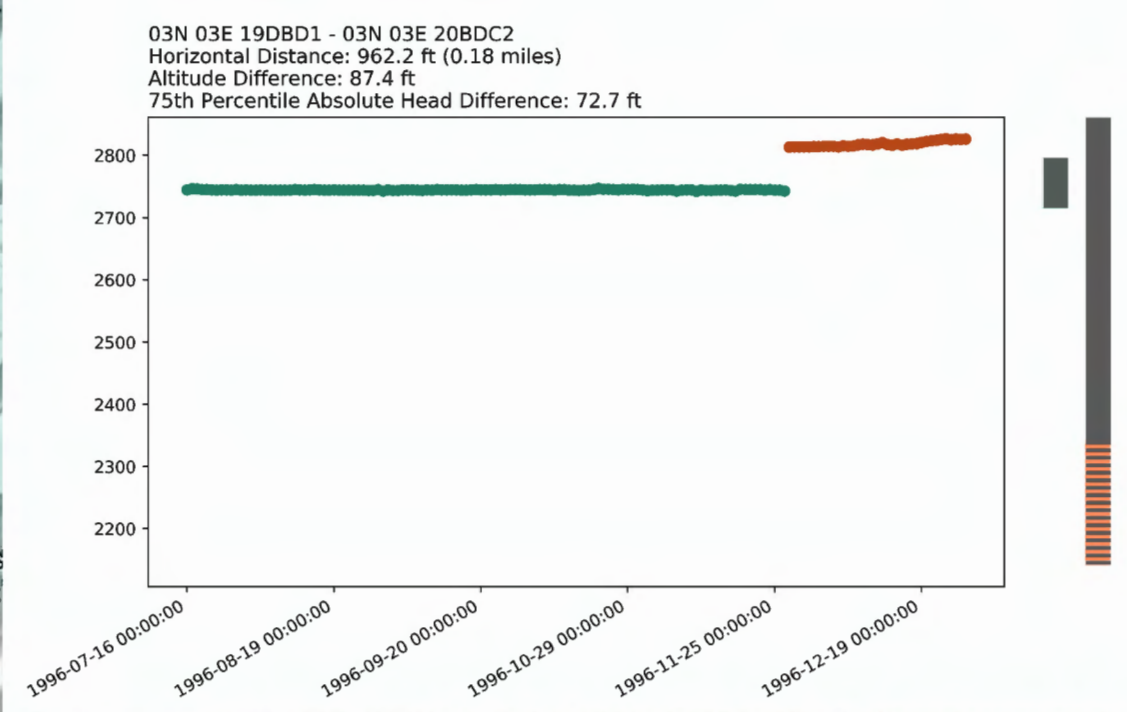
Classifying Water Level Pairs



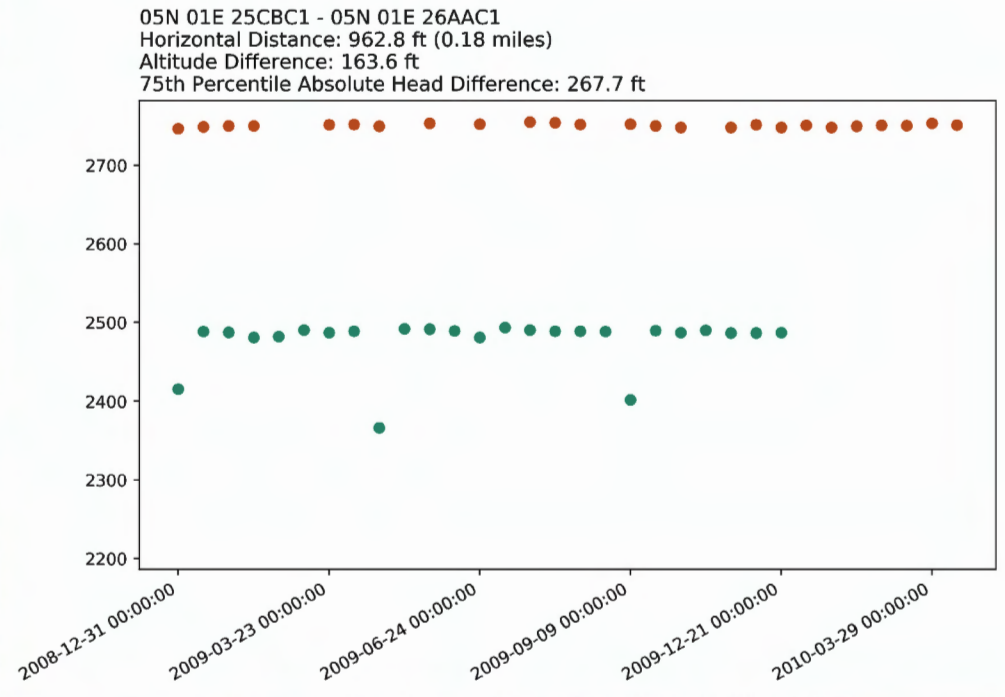
Classifying Water Level Pairs



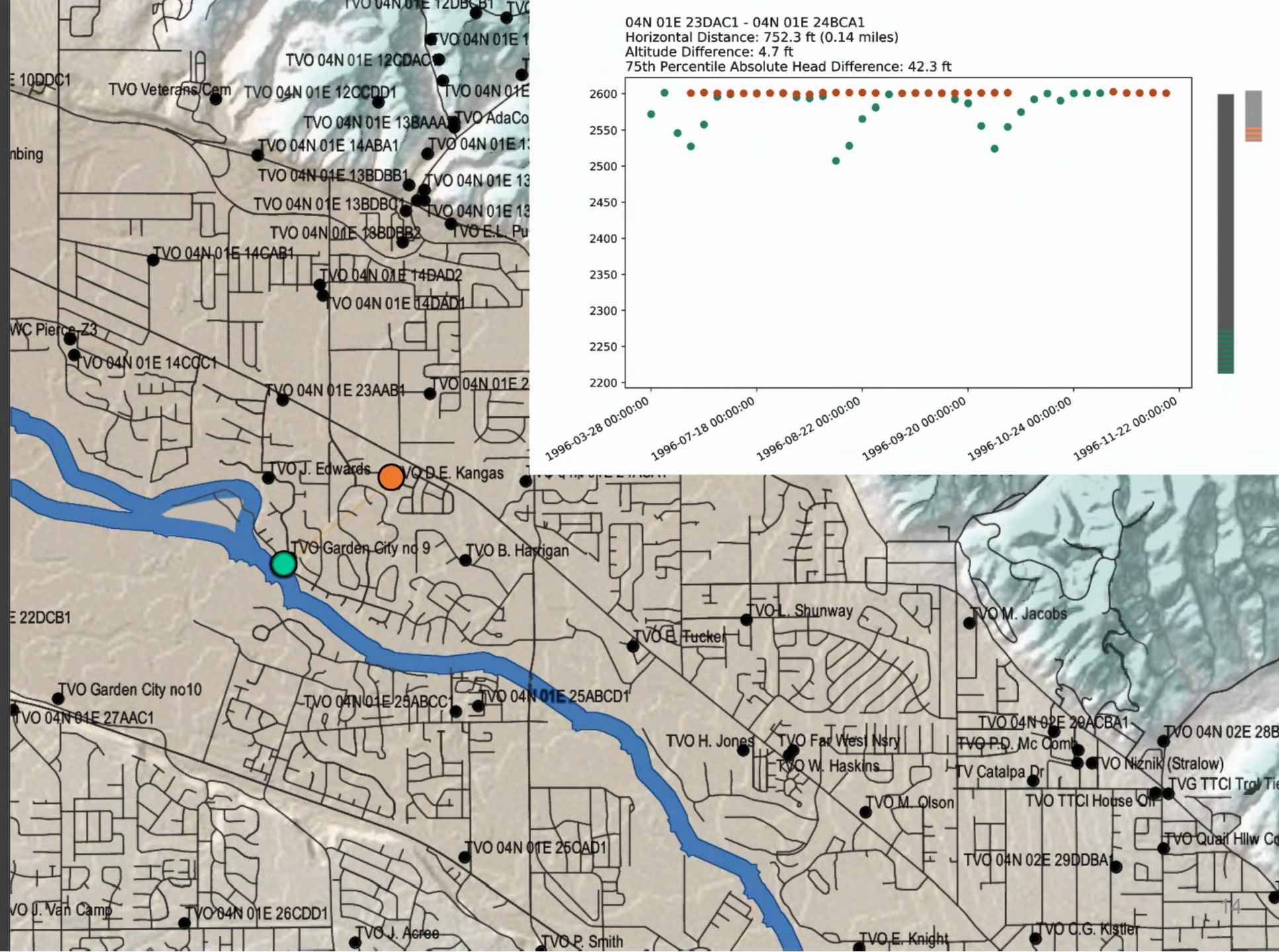
Classifying Water Level Pairs



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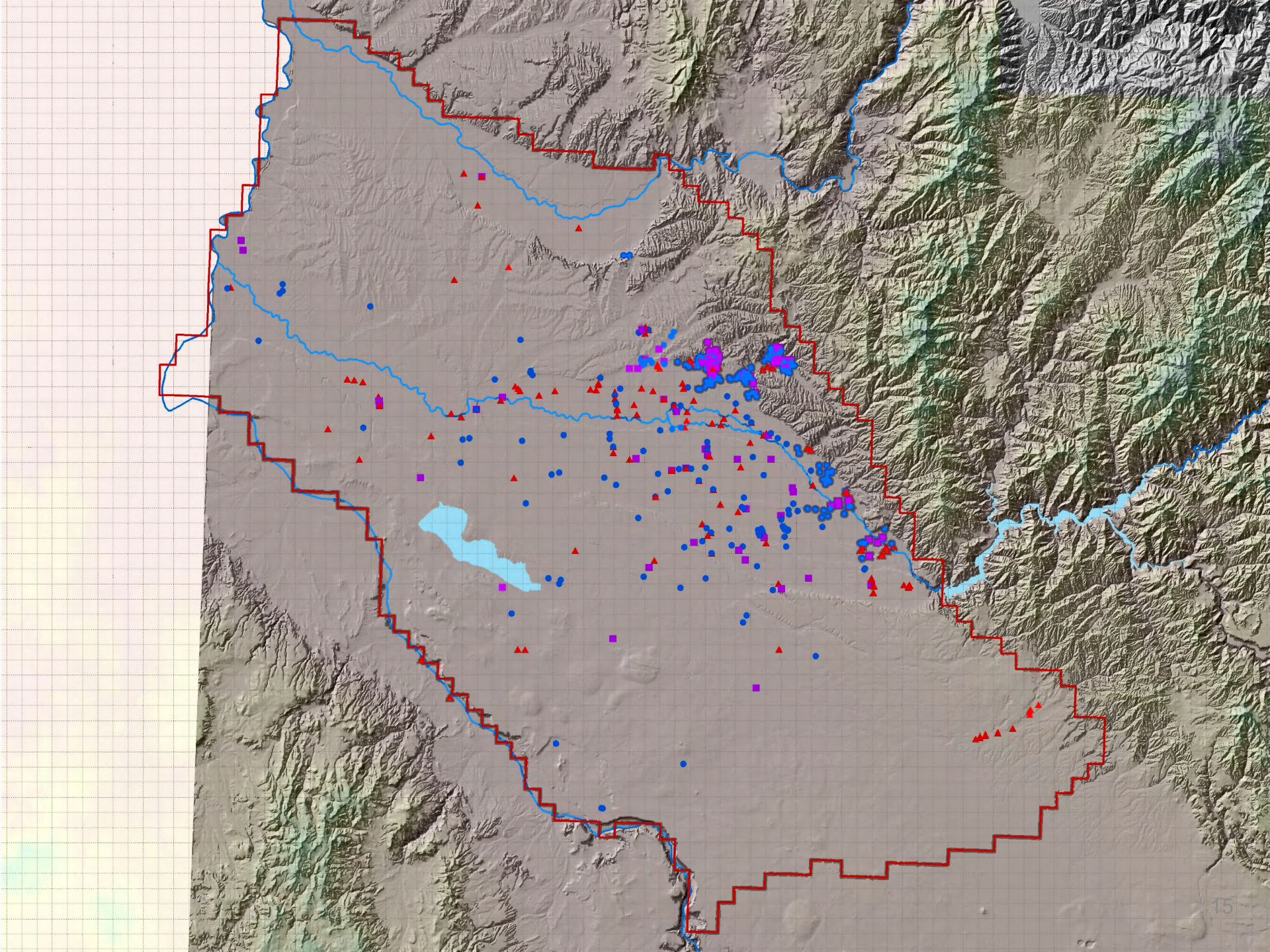


Classifying Water Level Pairs



Vertical split needed?

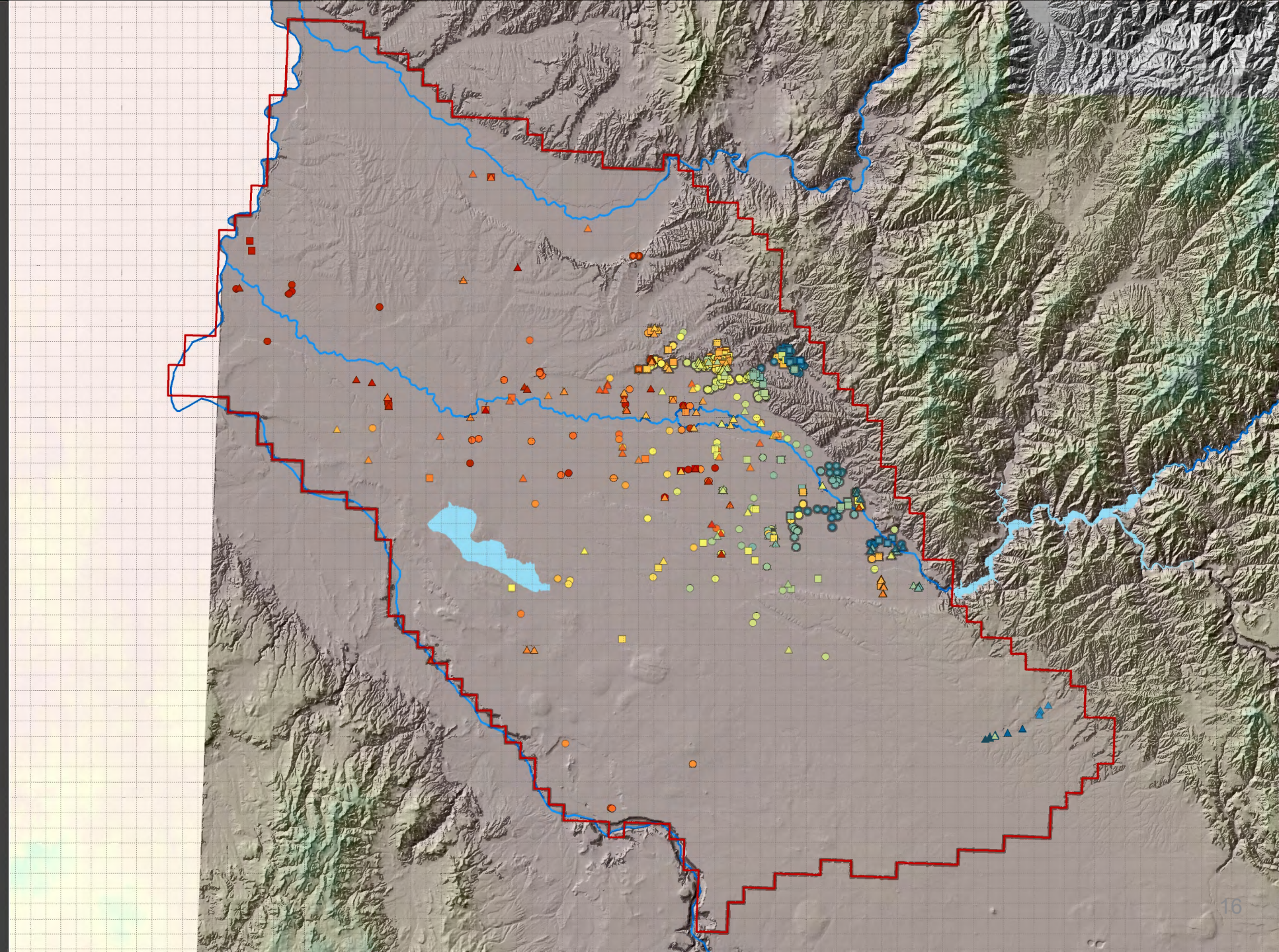
- ▲ YES
- MAYBE
- NO






Vertical split needed?

-  YES
-  MAYBE
-  NO

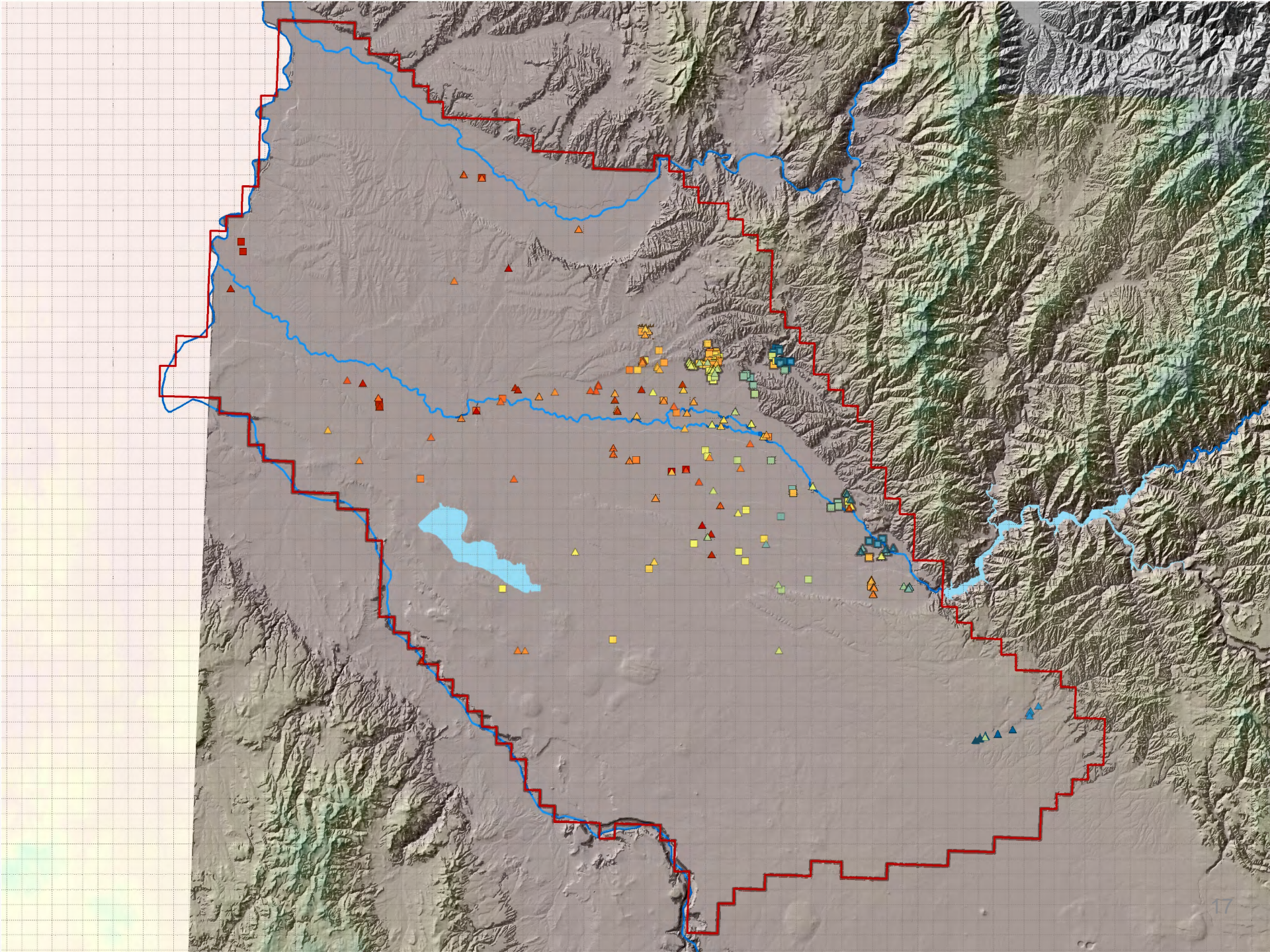
Altitude of Gap Center, ft



Vertical split needed?

-  YES
-  MAYBE
-  NO

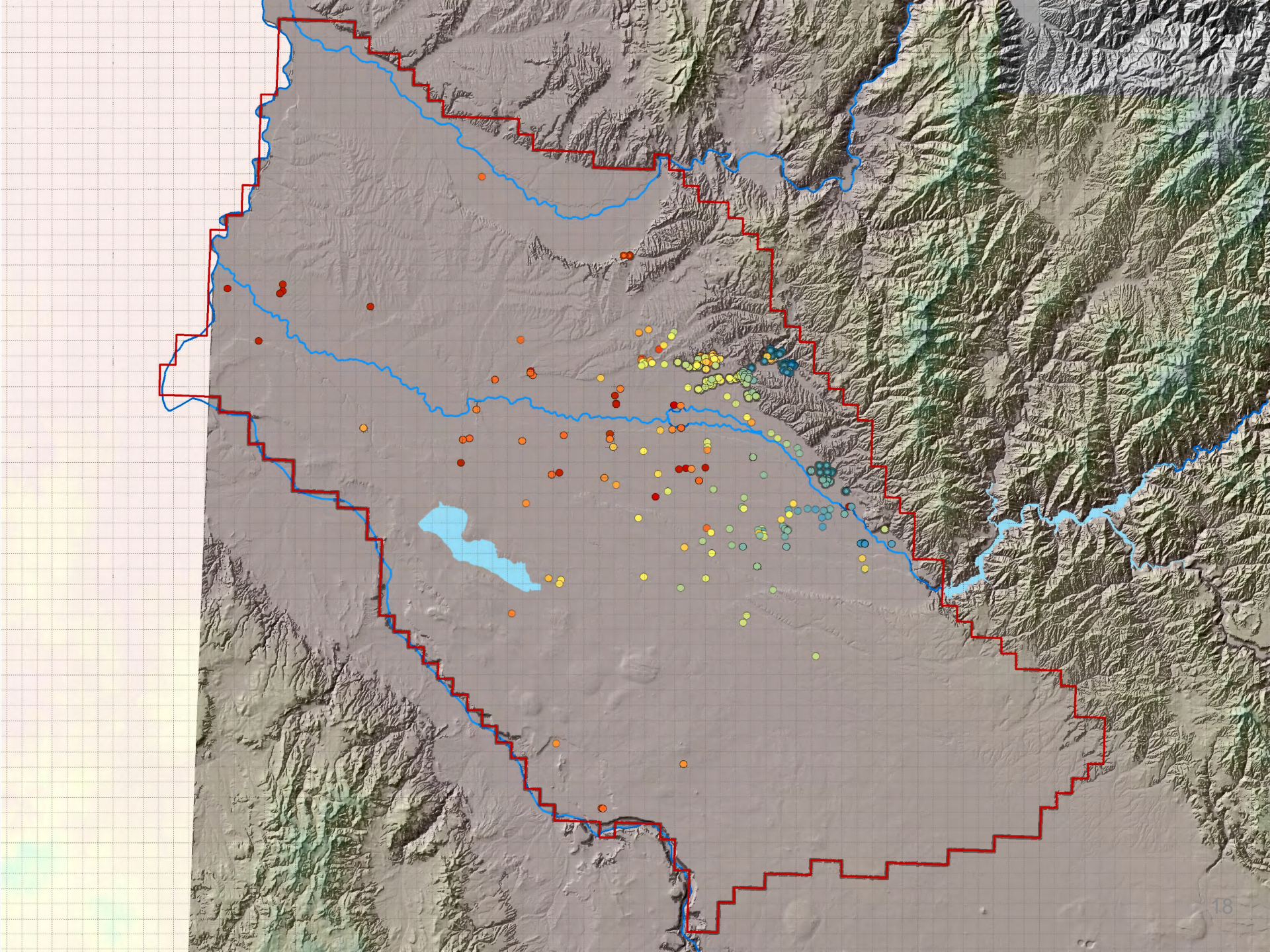
Altitude of Gap Center, ft



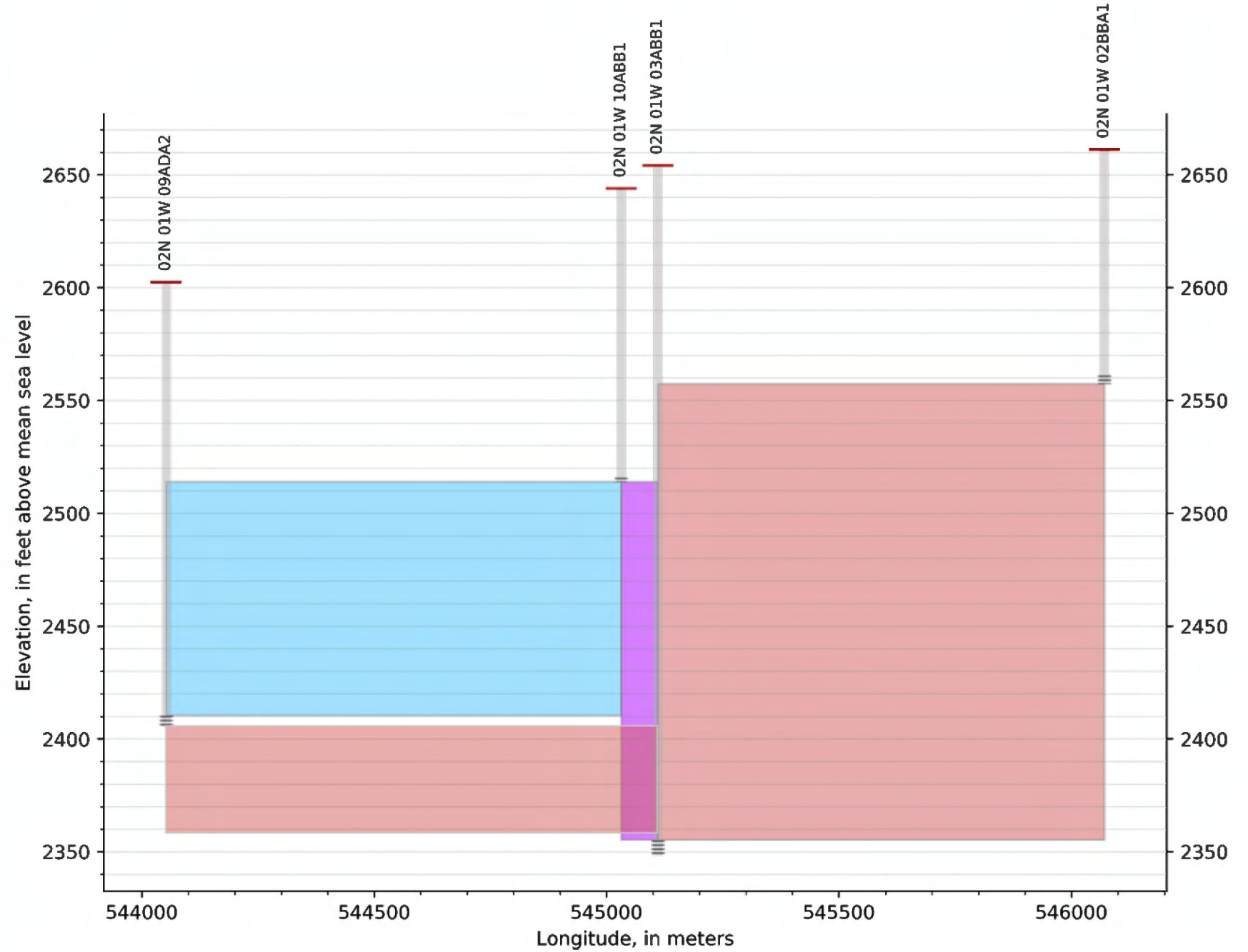
Vertical split needed?

- ▲ YES
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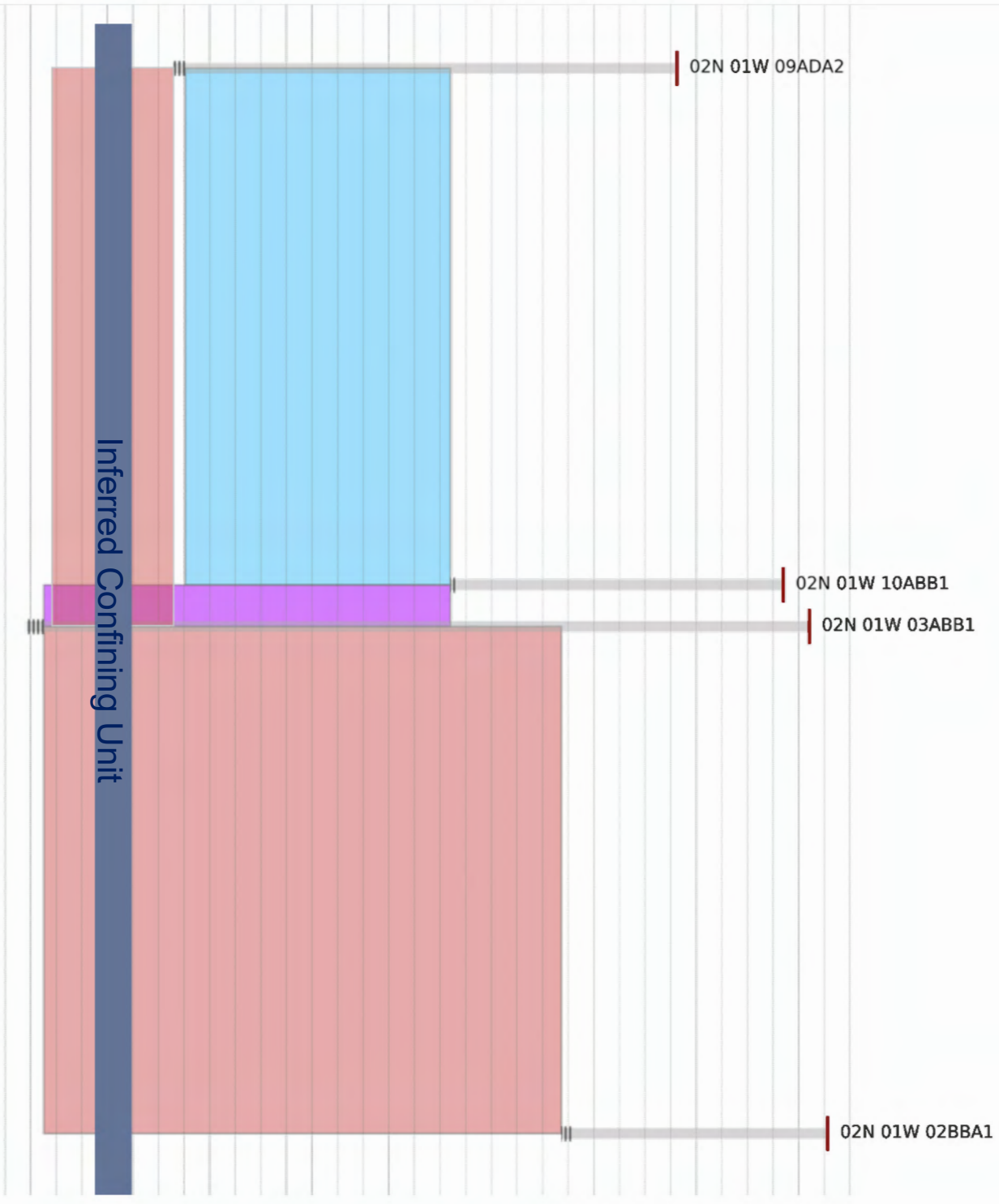
Altitude of Gap Center, ft



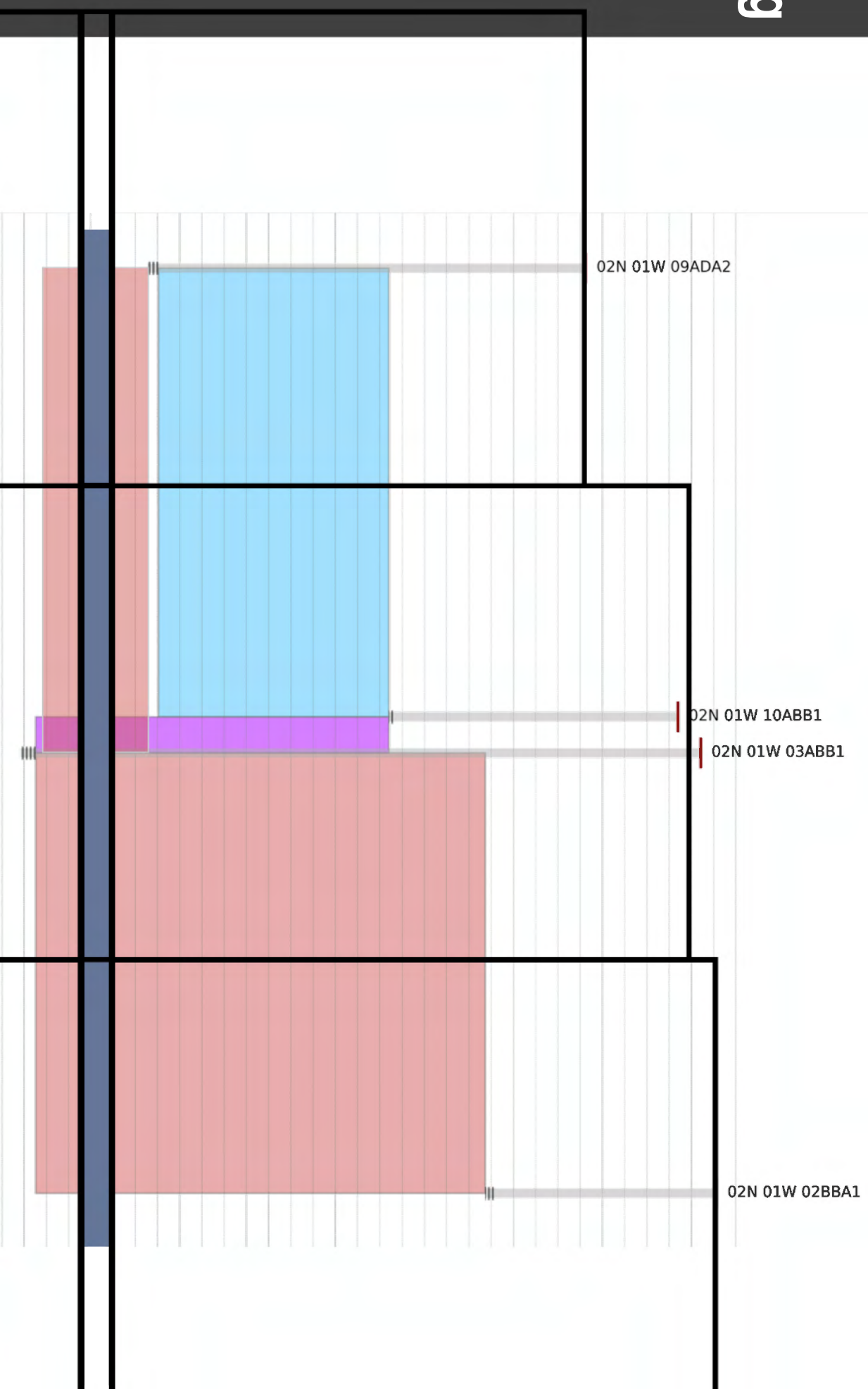
Dividing Layers



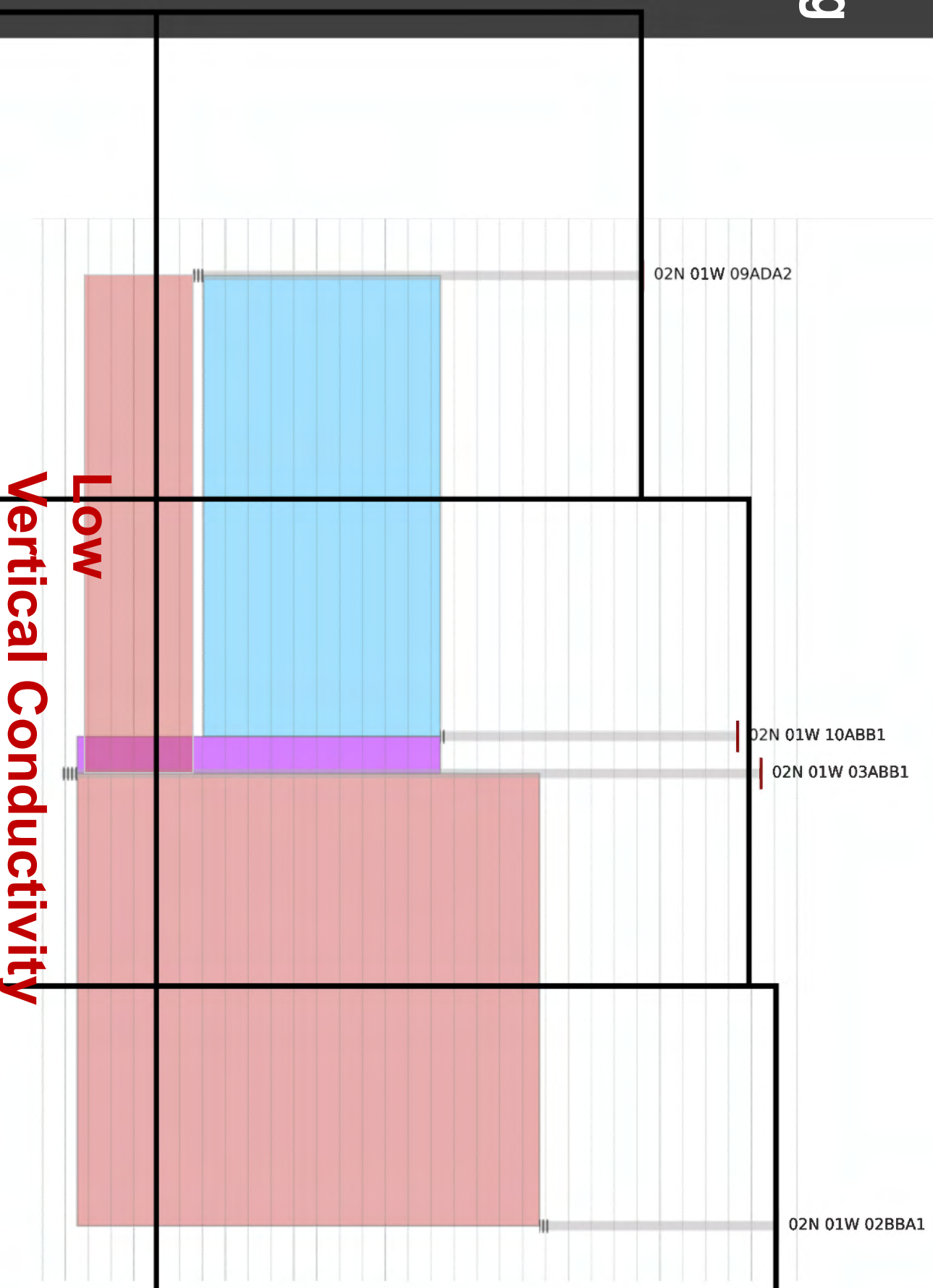
Dividing Layers



Representing inferred confining units?



Representing inferred confining units?



Vertical Hydraulic Anisotropy

Steady state flow **parallel to bedding**:

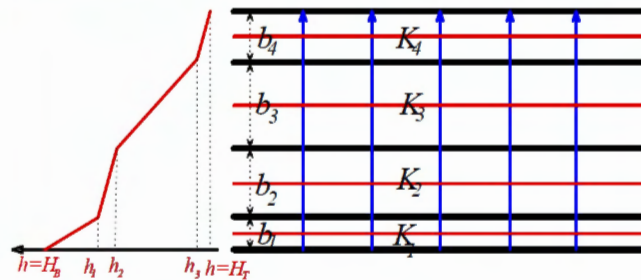


$$K_a = \frac{(K_1 b_1 + K_2 b_2 + K_3 b_3 + K_4 b_4)}{(b_1 + b_2 + b_3 + b_4)}$$

or, for N layers,

$$K_a = \frac{\sum_{n=1}^N K_n b_n}{\sum_{n=1}^N b_n}$$

Steady state flow **normal to bedding**:



yielding a **weighted harmonic average**

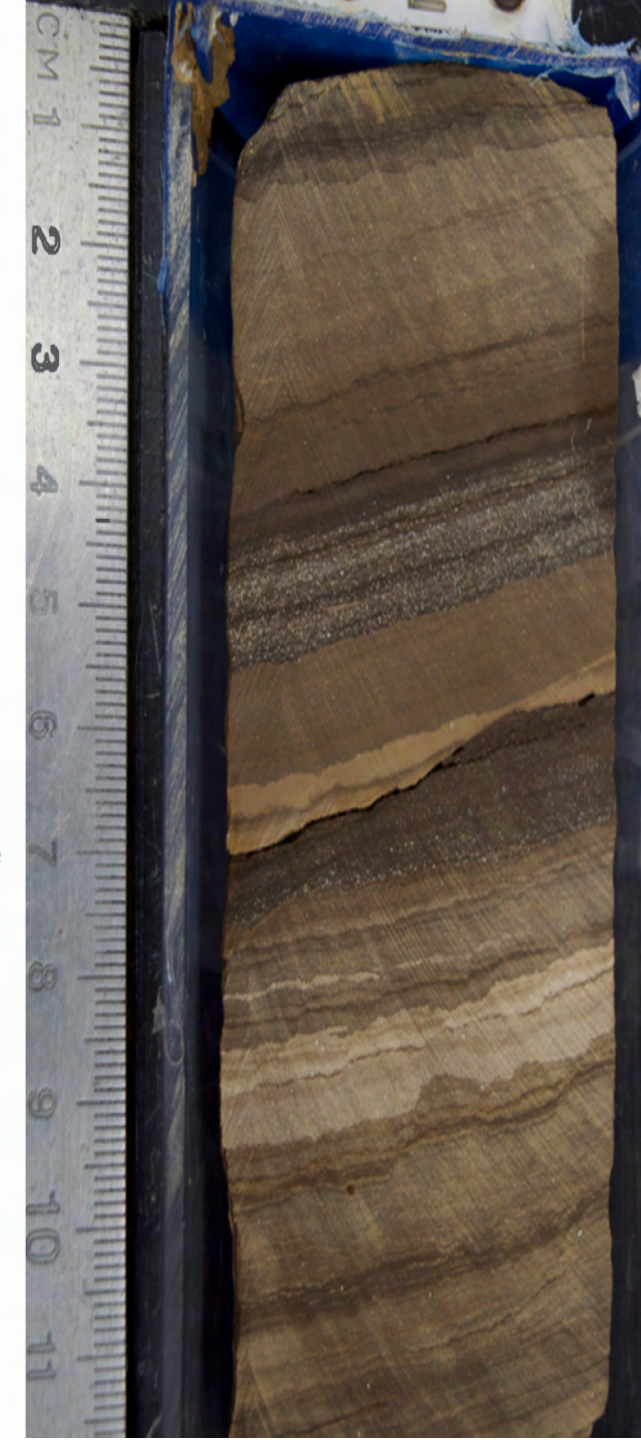
$$= \frac{b_1 + b_2 + b_3 + b_4}{b_1 / K_1 + b_2 / K_2 + b_3 / K_3 + b_4 / K_4}$$

For N layers in series

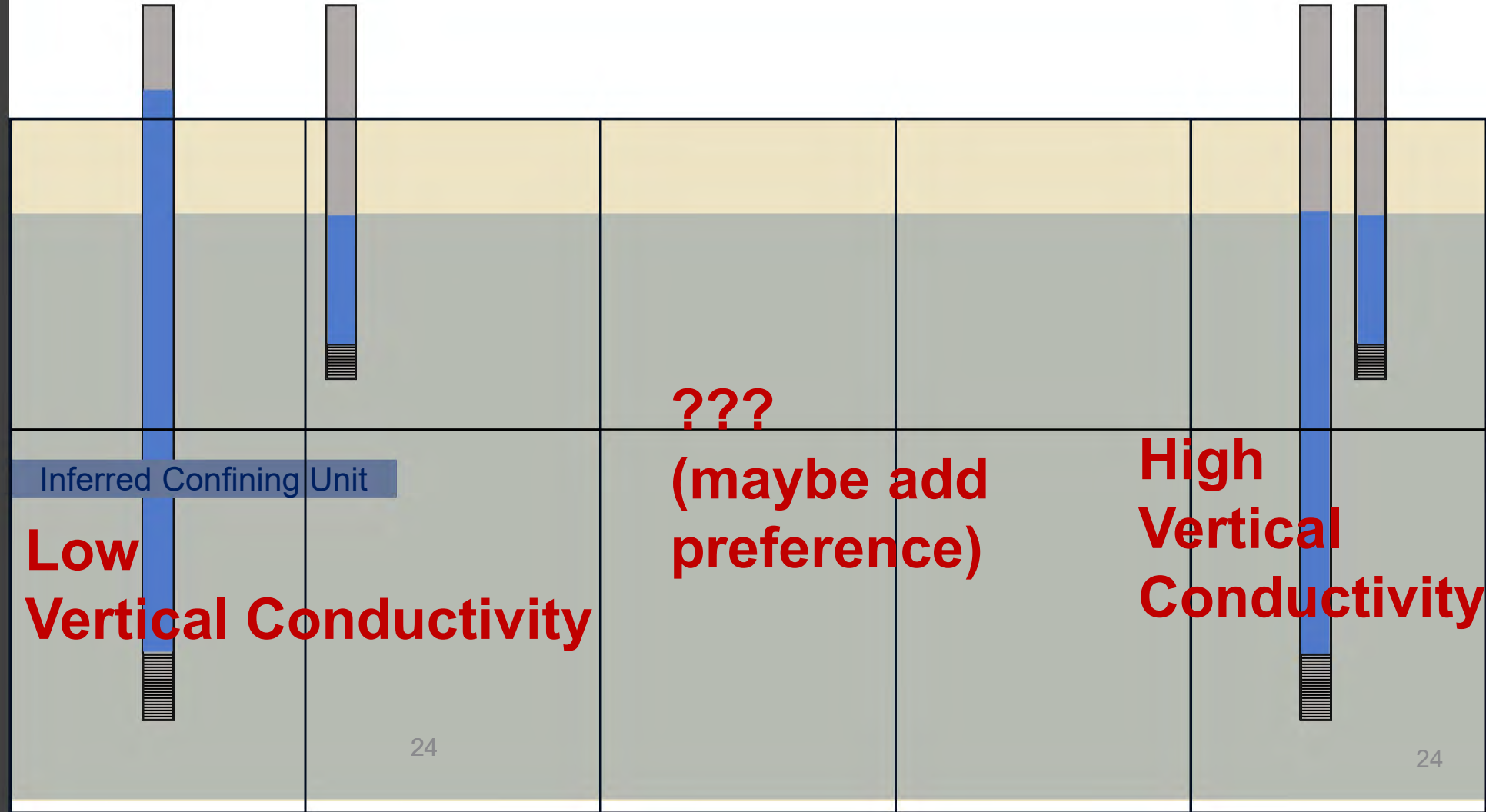
$$K_h = \frac{\sum_{n=1}^N b_n}{\sum_{n=1}^N \frac{b_n}{K_n}}$$

Note: Generally

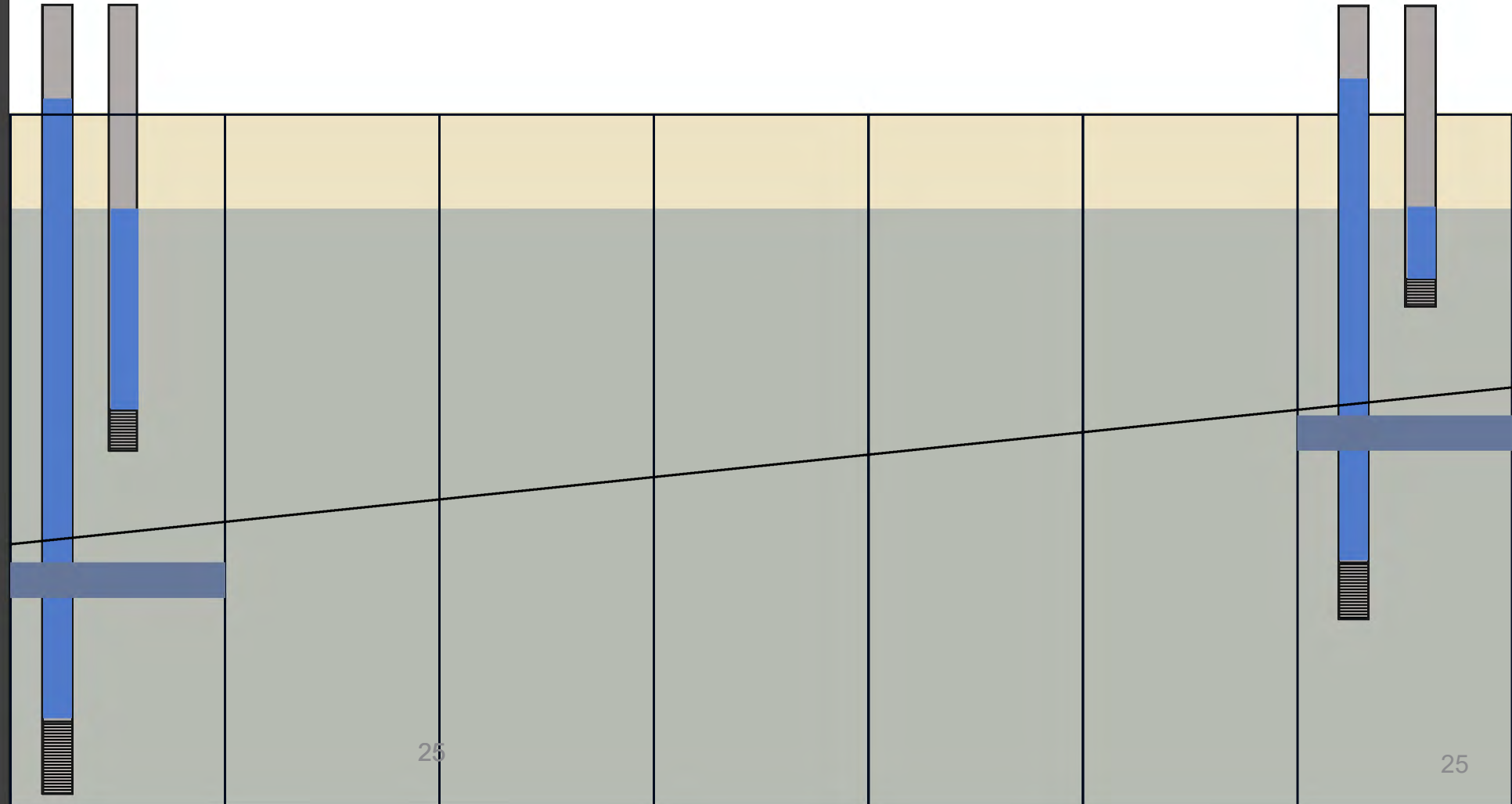
$$K_h \ll K_a$$



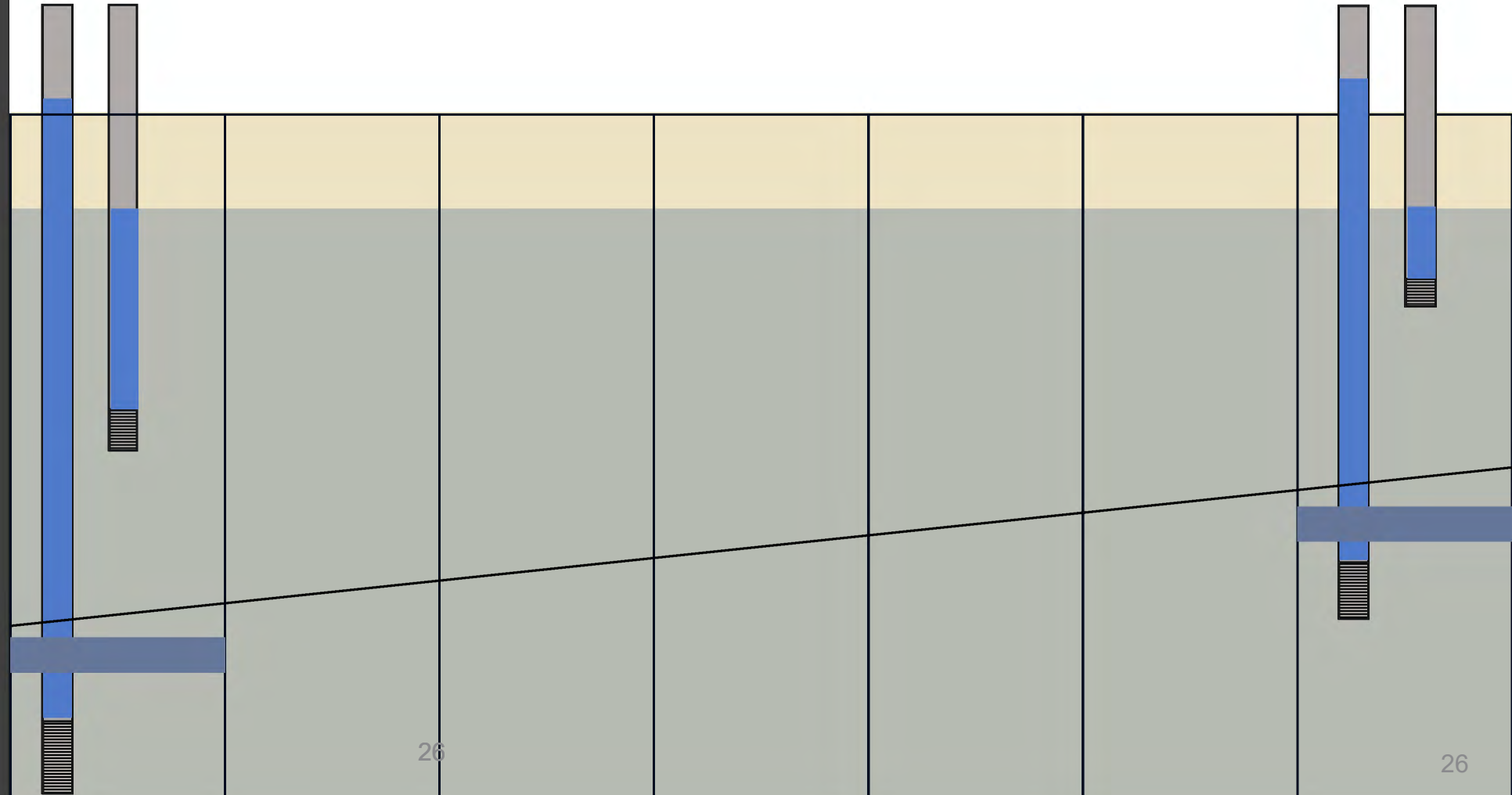
Layering to provide flexibility



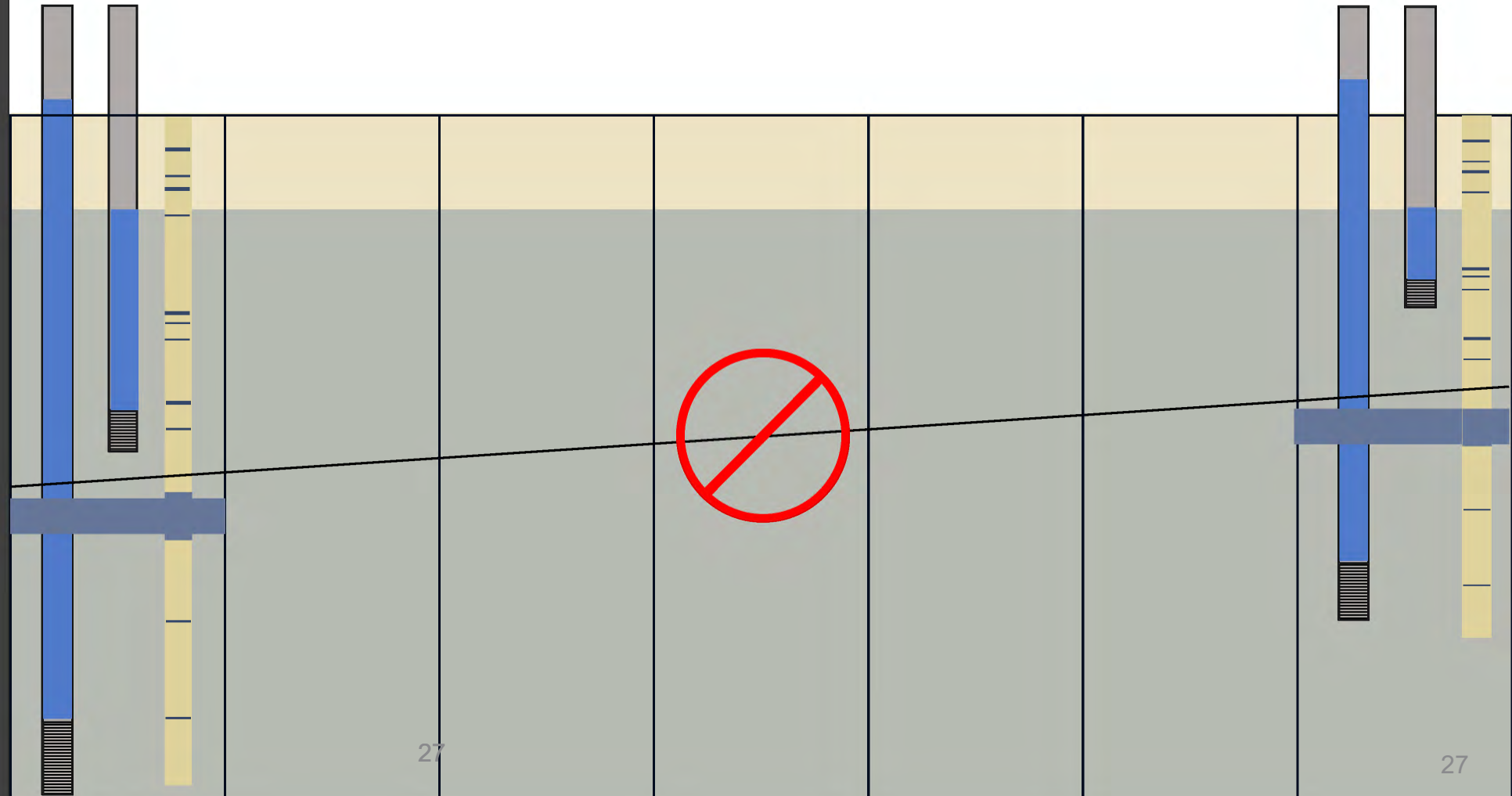
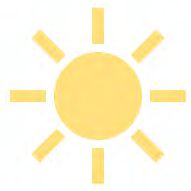
Where to divide?



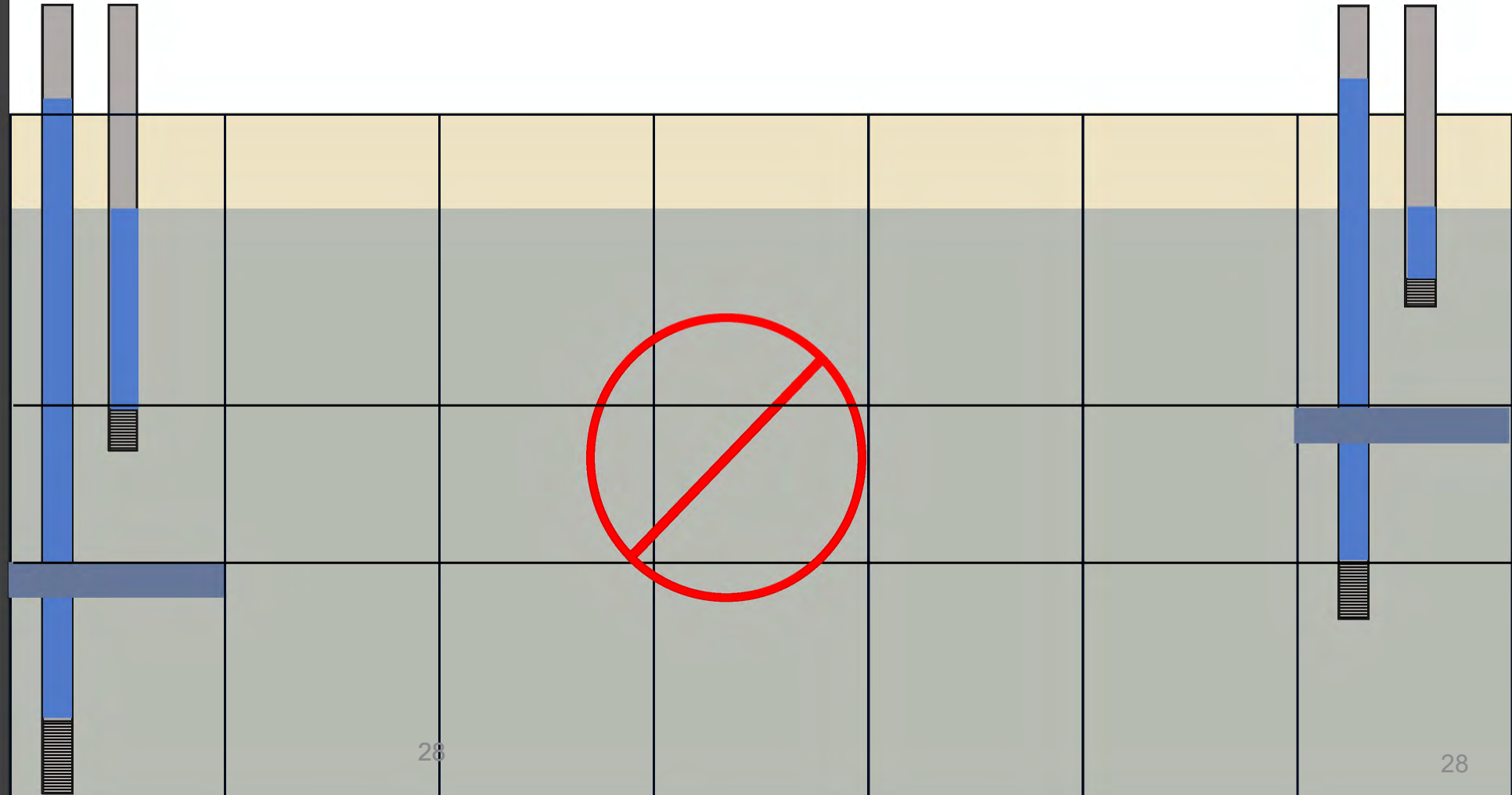
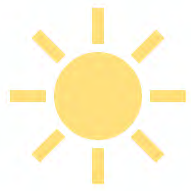
Where to divide?



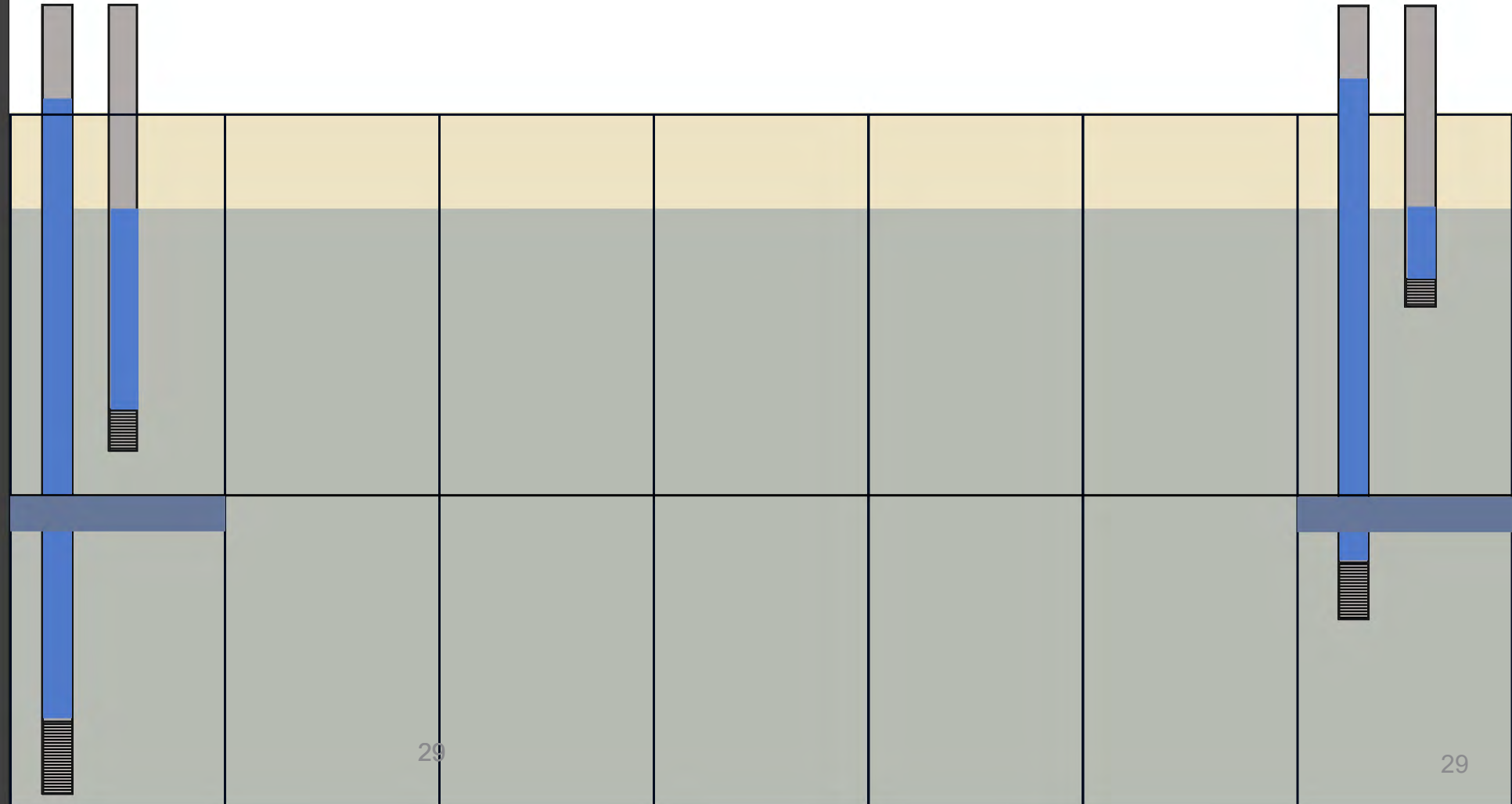
Where to divide?



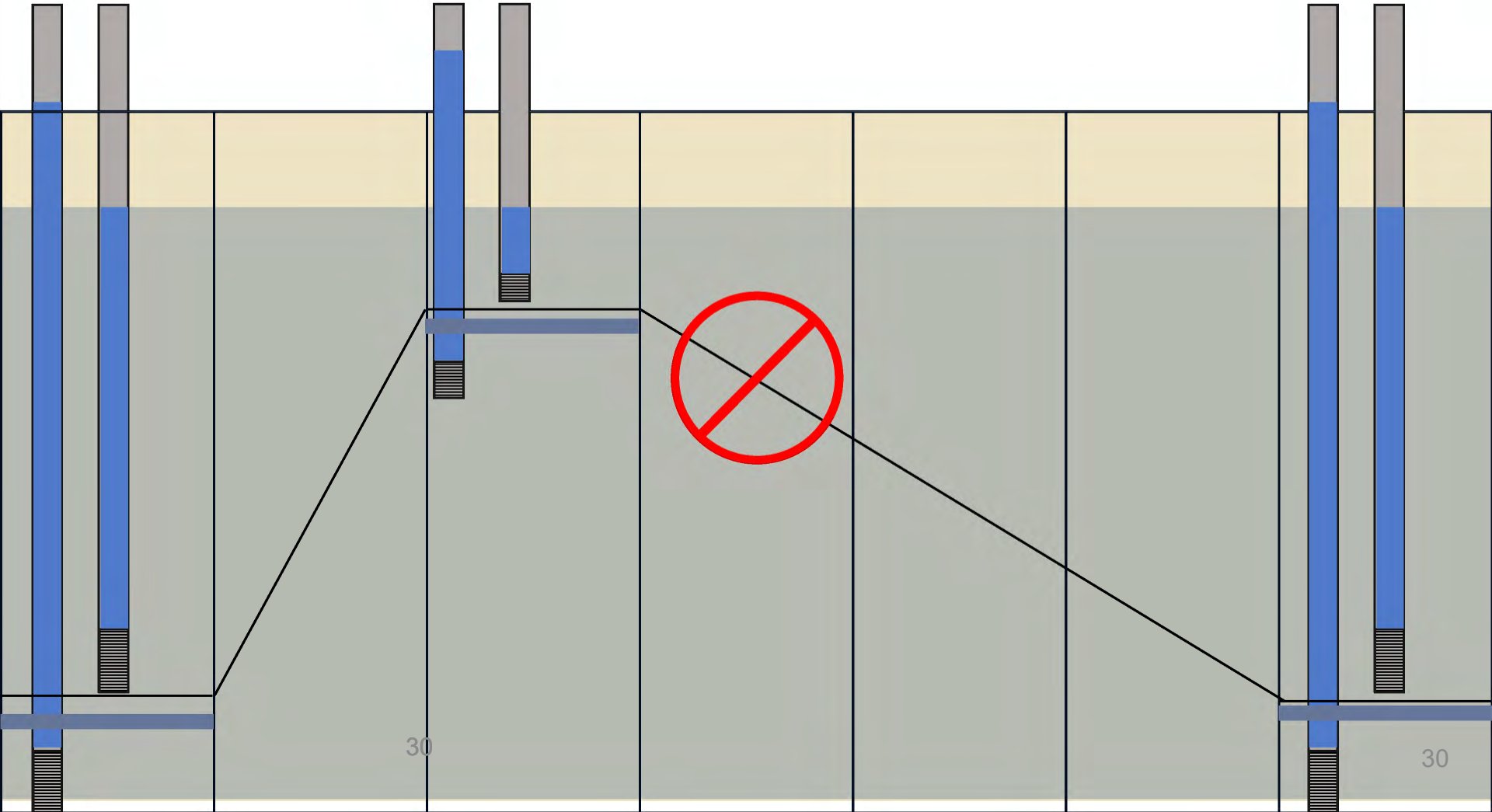
Where to divide?



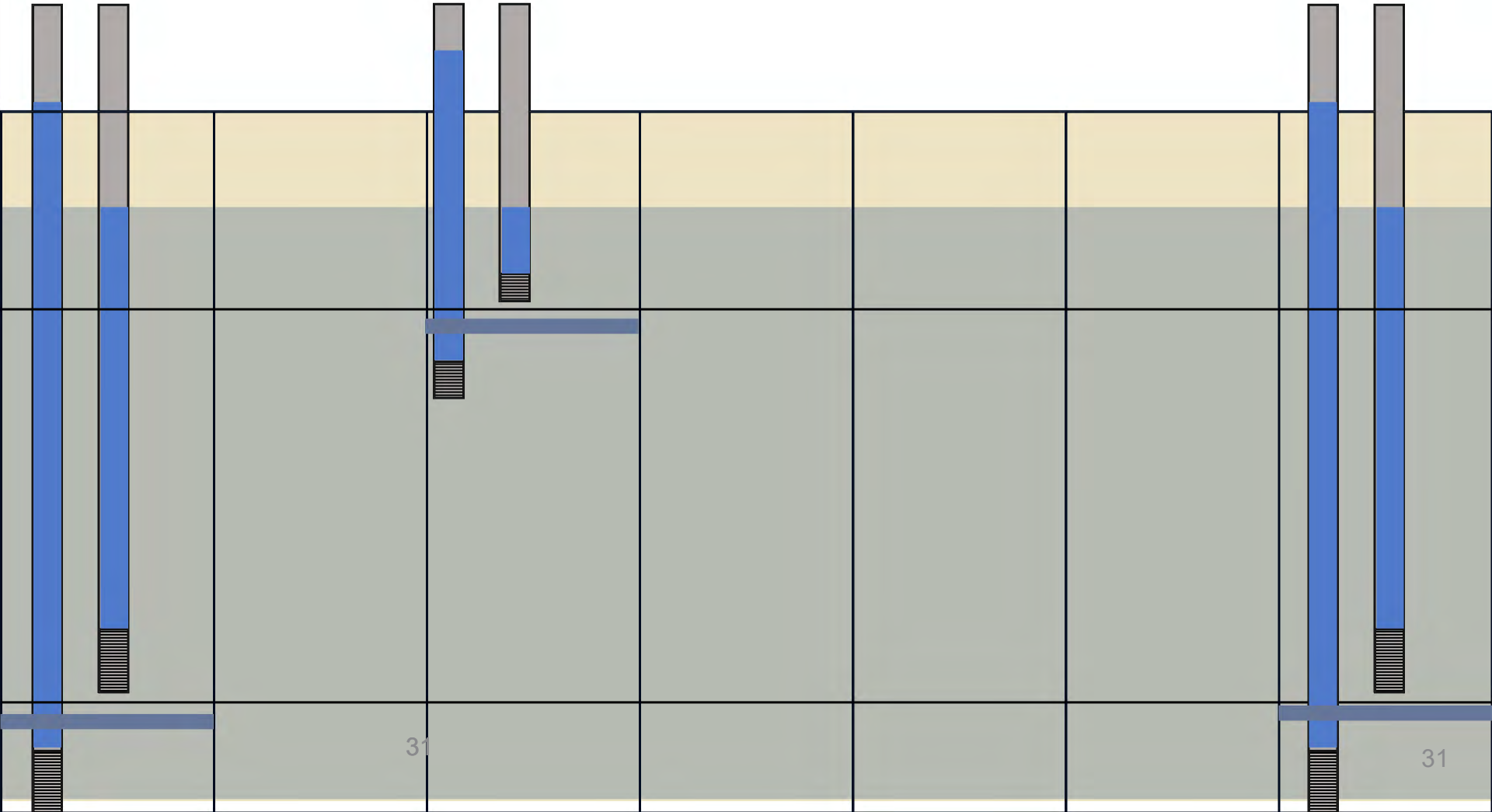
Where to divide?



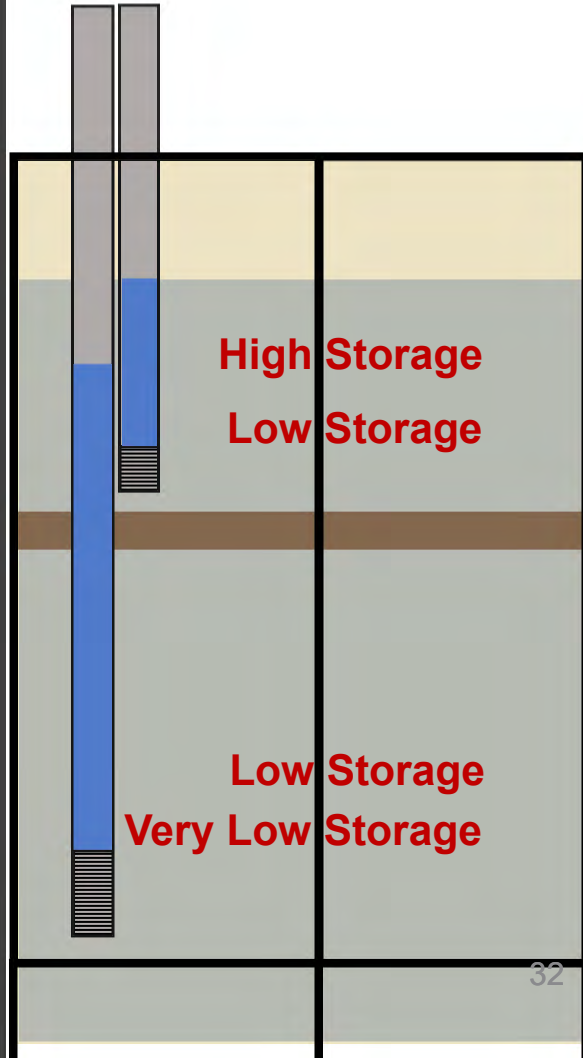
Interpolating Layer Altitudes



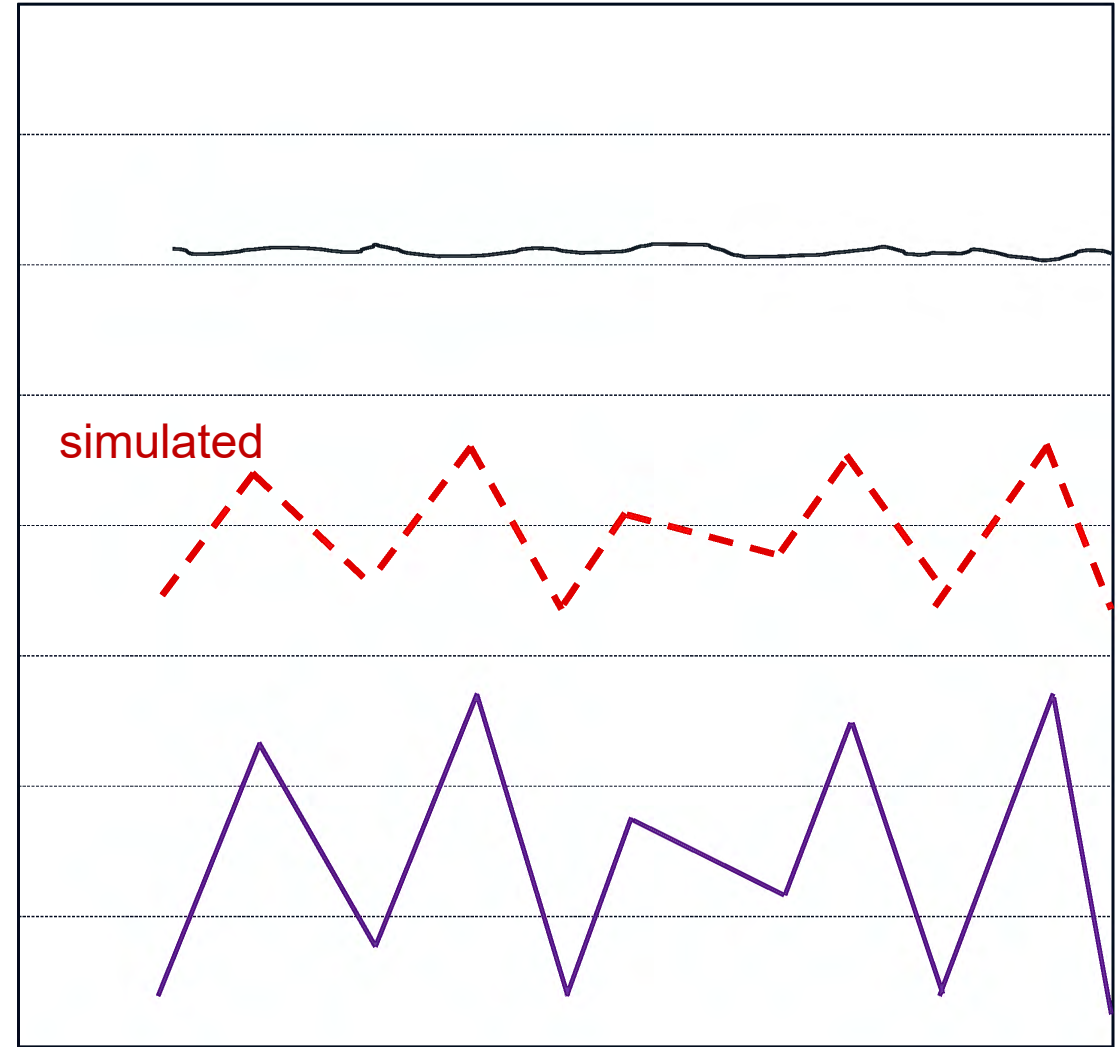
Interpolating Layer Altitudes



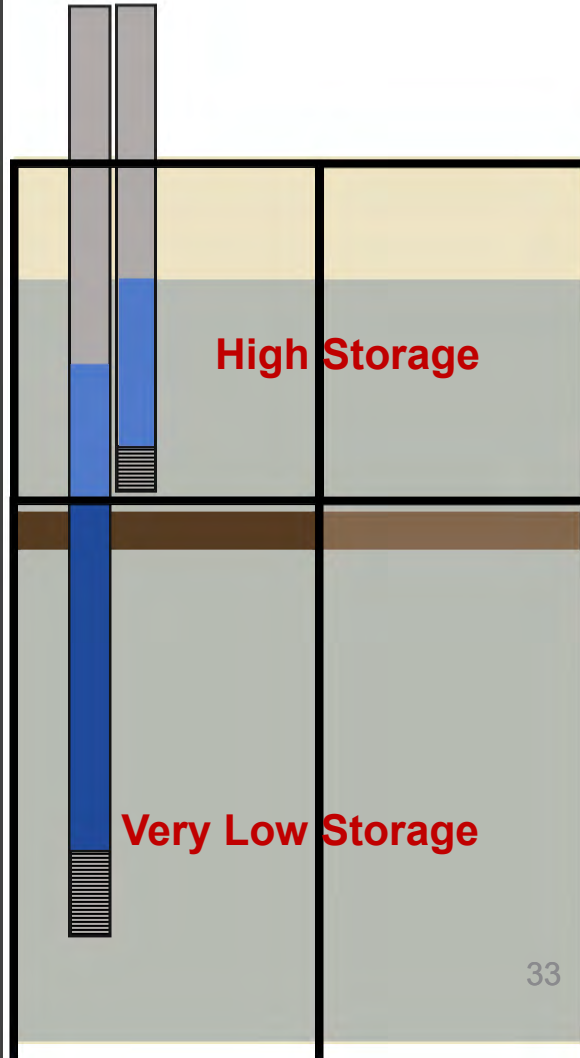
Does this matter?



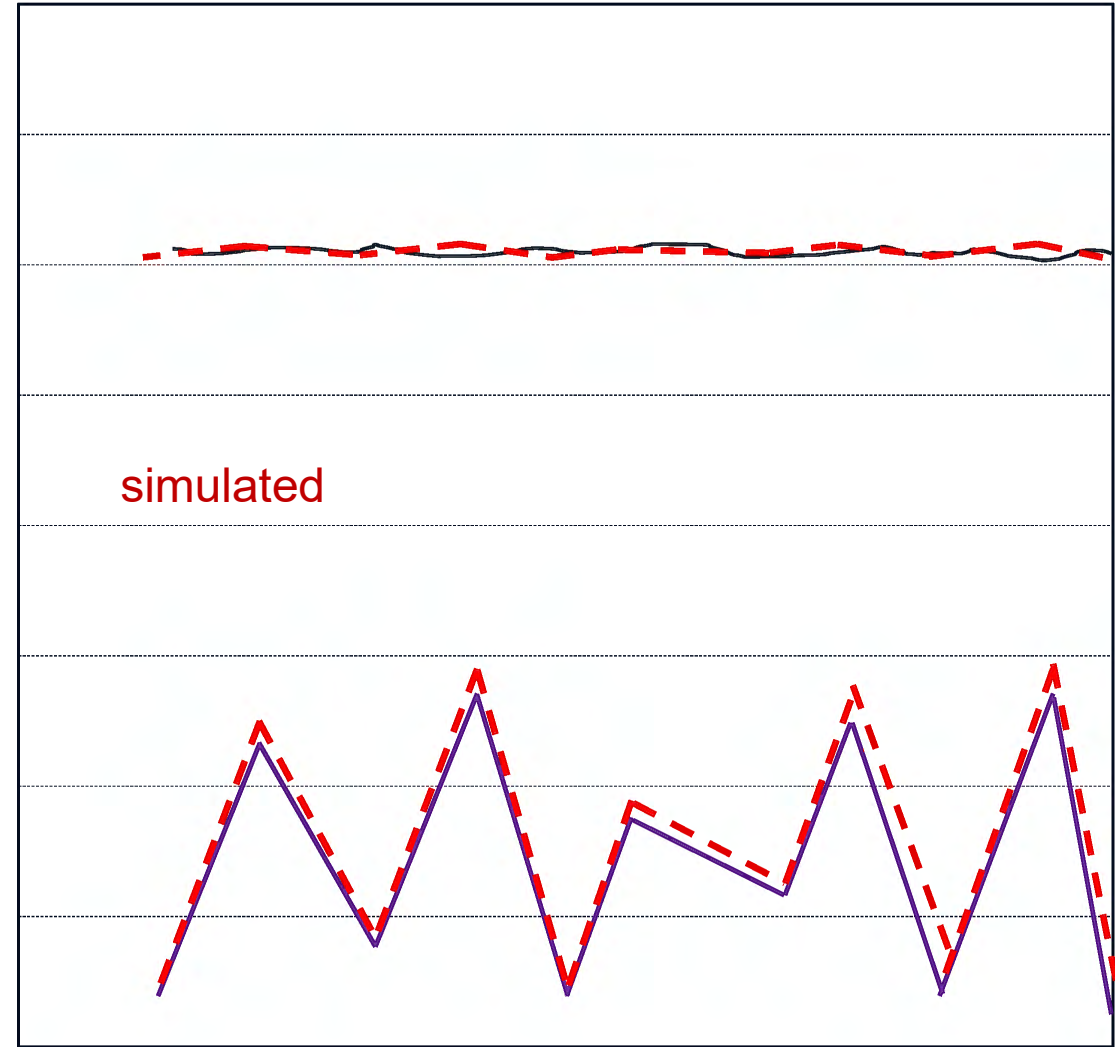
Water-level altitude, ft (NAVD88)



Does this matter?



Water-level altitude, ft (NAVD88)



Questions?
Comments?

Brief update on Modflow 6 and associated programs

Stephen Hundt

Modflow 6 and Associated Programs

- **Is being used by for large regional models**
- **MT3D-USGS coming soon**
- **MF6 transport code also upcoming**
- **Flopy python interface is updated for MF6**
- **PEST++ (USGS PEST) development ongoing**
- **Iterative Ensemble Smoother:
Jacobian with *runs* \ll *npar*
(<https://doi.org/10.1016/j.envsoft.2018.06.009>)**

Thanks for listening!