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Evaluation of Chloride Soil-Groundwater Partitioning

Same Salt, Different Numbers



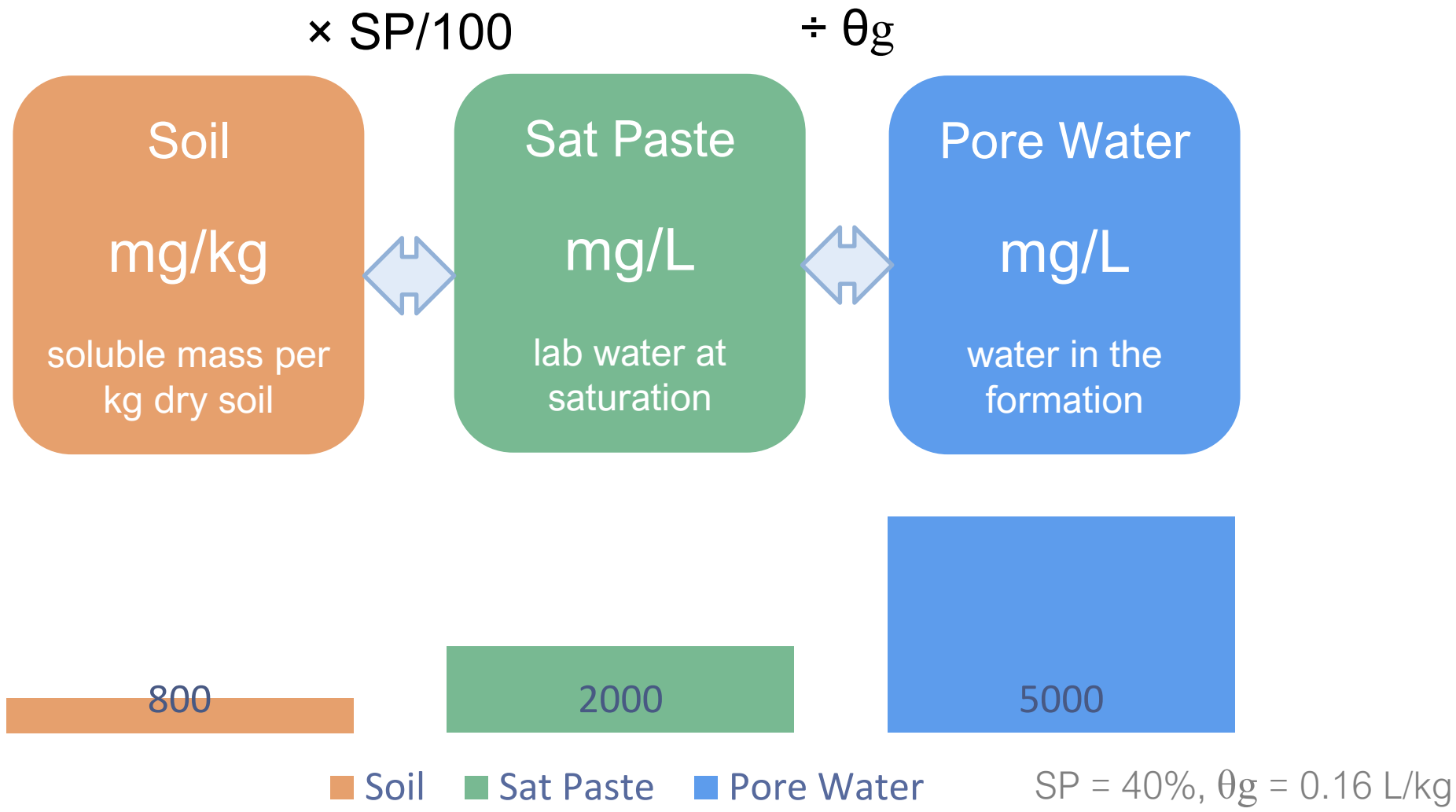
Daniel Pollard

RemTech 2026

October 15, 2026

For Planet & Progress

One Salt; Three Different Ways to Express It



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Regulatory Requirements

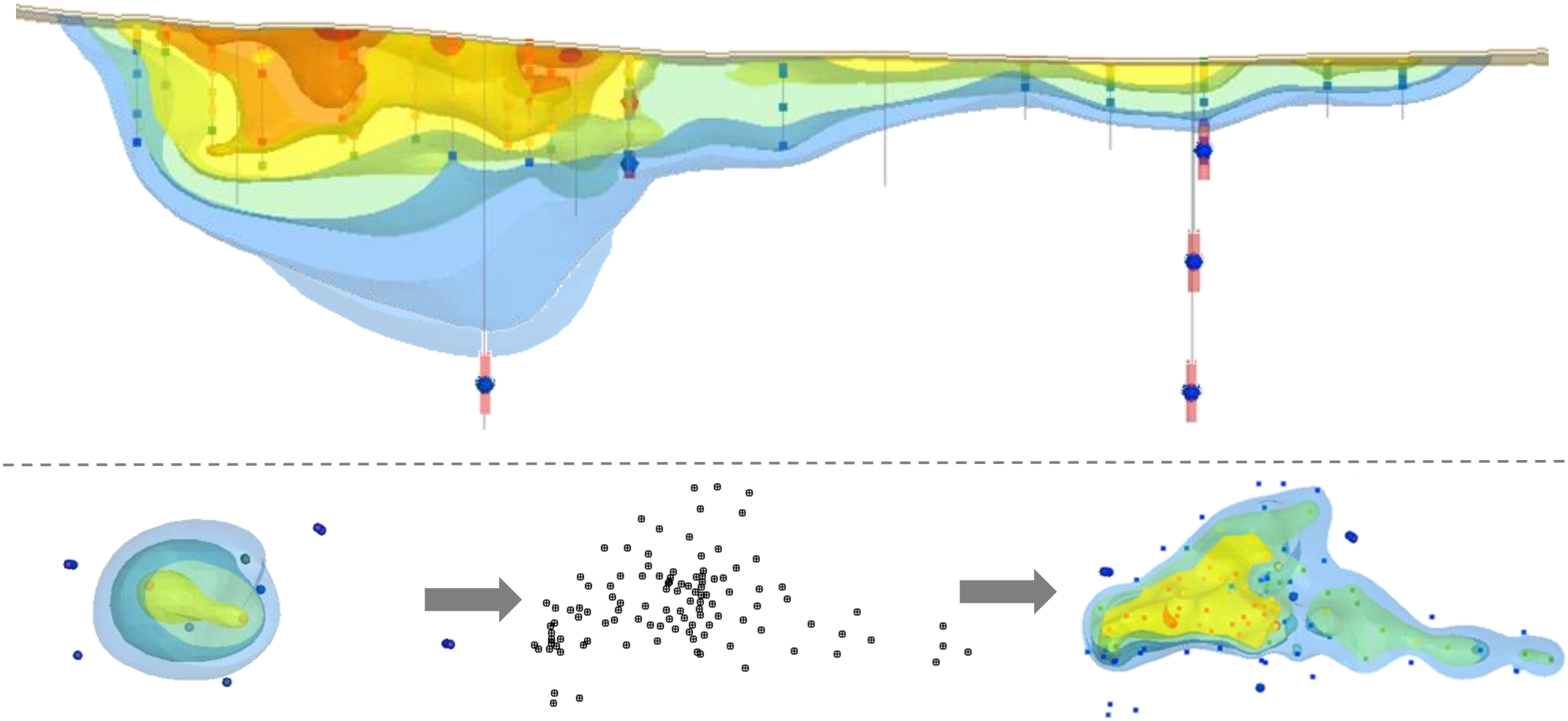
*"When delineating chloride-based **soil** salinity for comparison to Tier 1 soil salinity guidelines (Table 4), delineation must include the lateral and vertical extent of **chloride concentrations in saturated paste extracts (expressed as mg/L)** that exceed the **Tier 1 groundwater guideline**. The area and depth defined by soil chloride delineation requirements may extend beyond the area and depth of soil that exceeds Tier 1 soil salinity guidelines. In that case, soil remediation may be based on the Tier 1 soil salinity guidelines, but consideration must be given to the potential for **chloride contamination in groundwater**."*



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The Value of Extra Data



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Three ways a surface can hold a solute

Linear

$q = K_d \cdot C$

Uniform affinity, no limit

q = 0.00

Freundlich

$q = K_F \cdot C^n$

Strong sites fill first

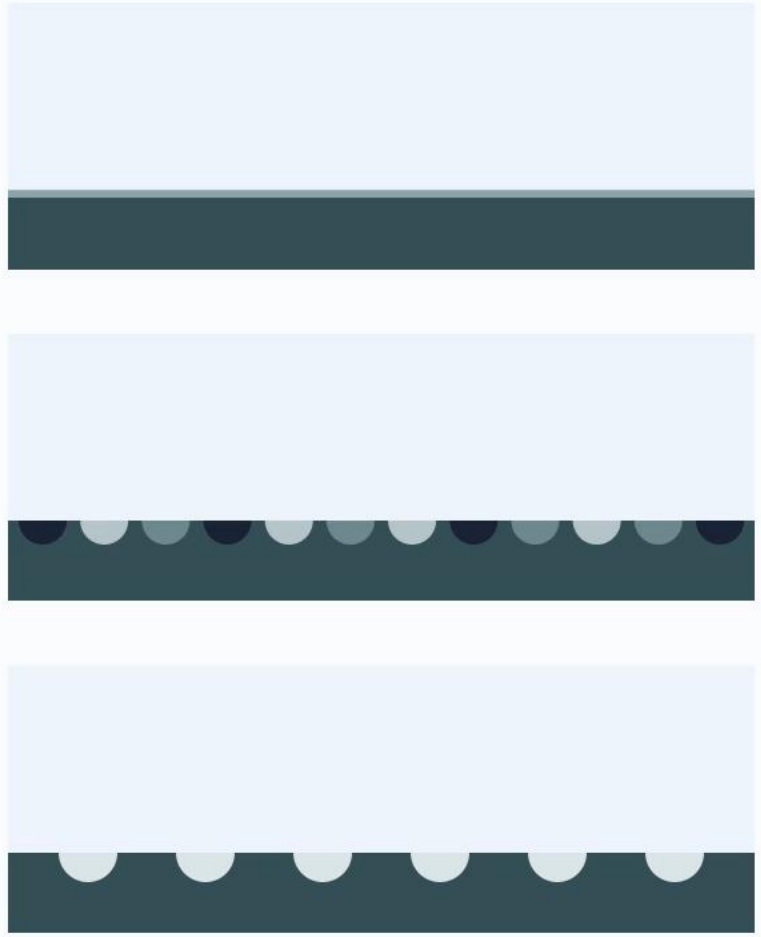
q = 0.00

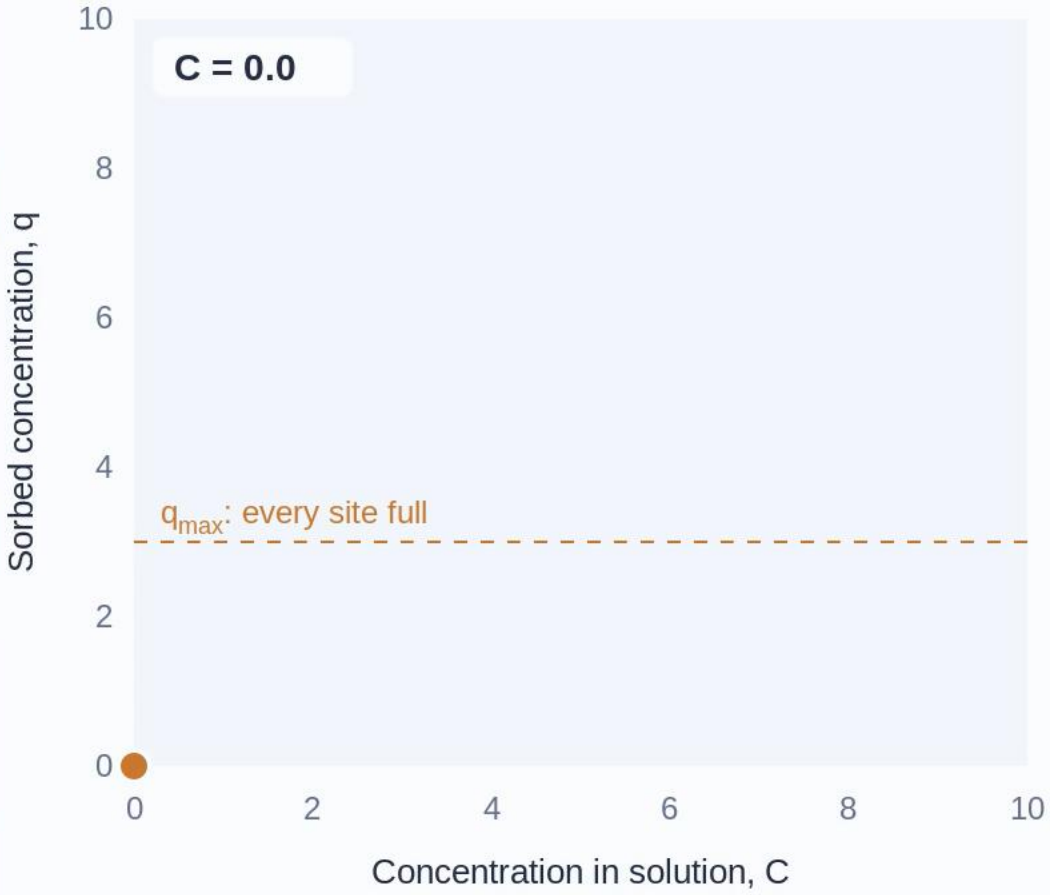
Langmuir

$q = q_{max} K_L C \div (1 + K_L C)$

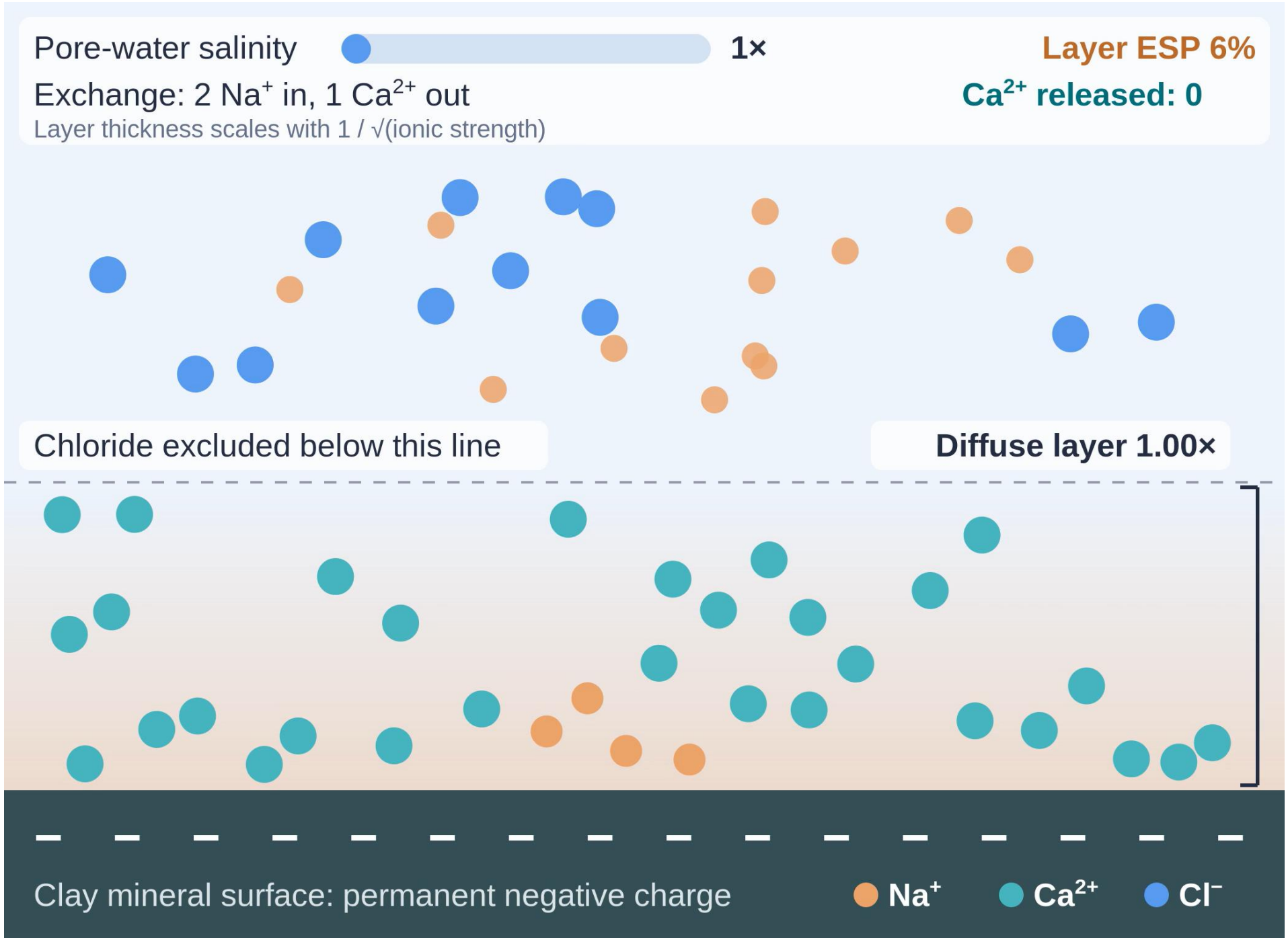
Finite sites: fills, then plateaus

q = 0.00



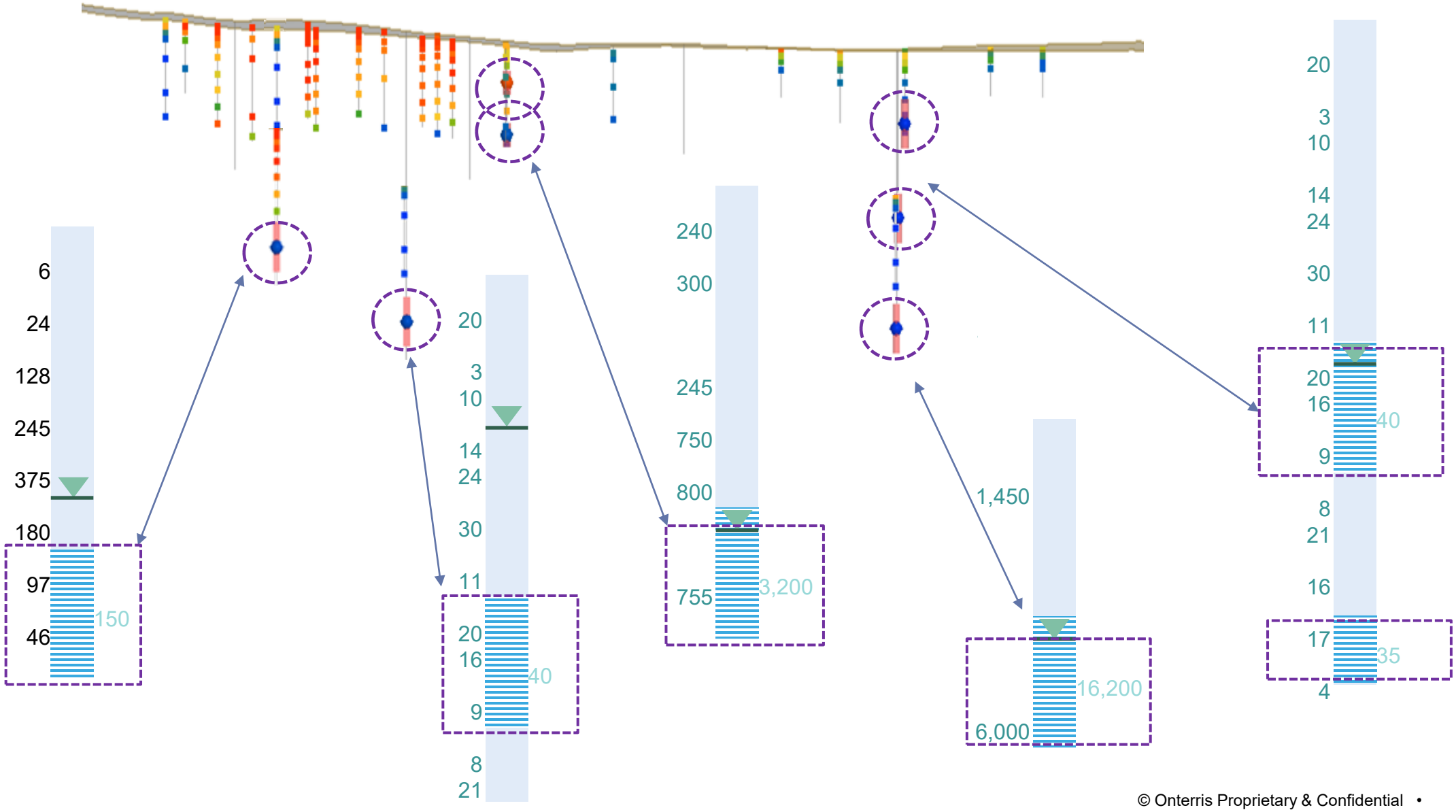


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Pore-water salinity
1×
Layer ESP 6%
Exchange: 2 Na+ in, 1 Ca2+ out
Ca2+ released: 0
Layer thickness scales with 1 / √(ionic strength)
Chloride excluded below this line
Diffuse layer 1.00×
Clay mineral surface: permanent negative charge
Na+
Ca2+
Cl−

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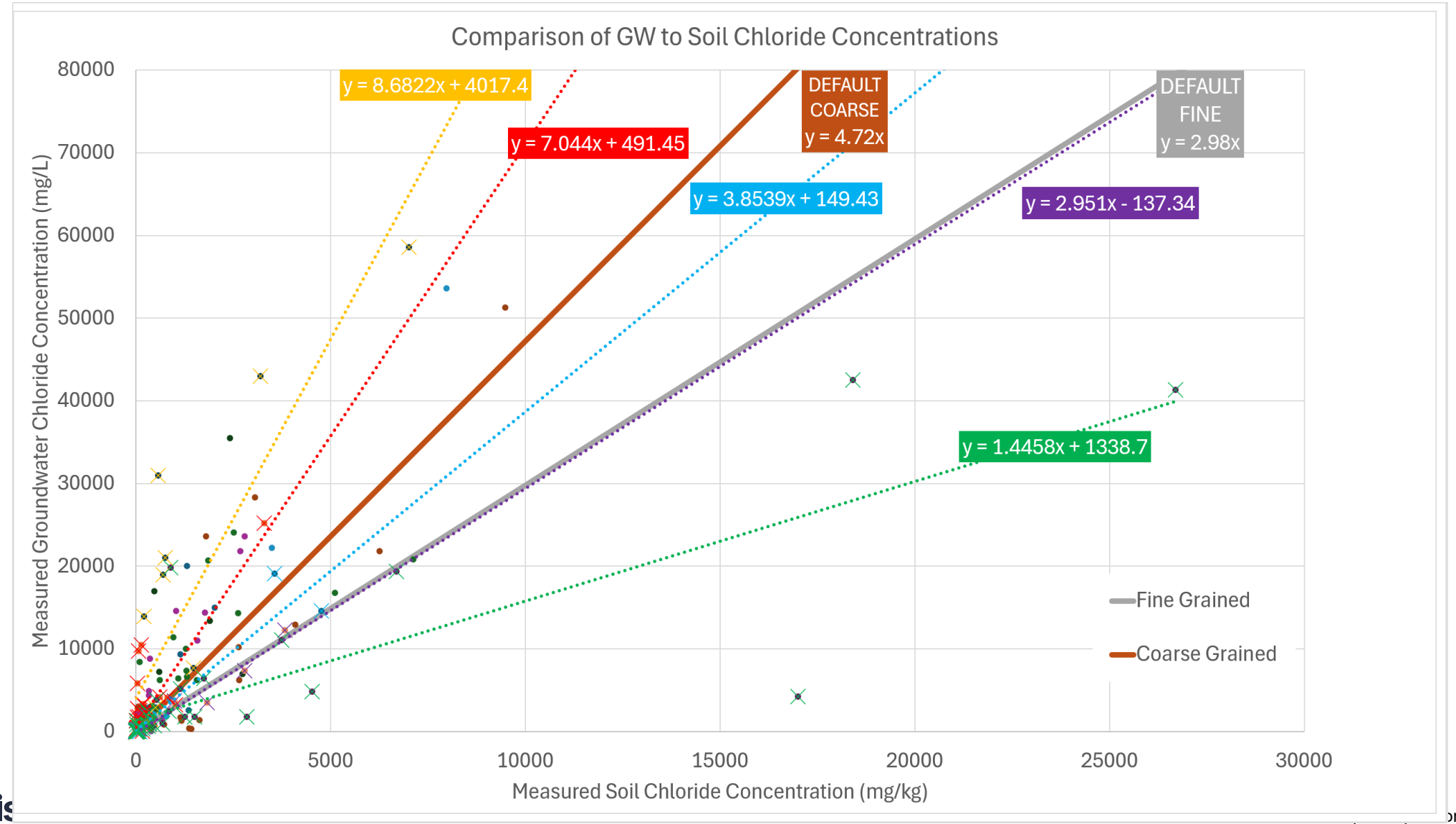
Testing the Relationship Between Soil and Groundwater Concentrations



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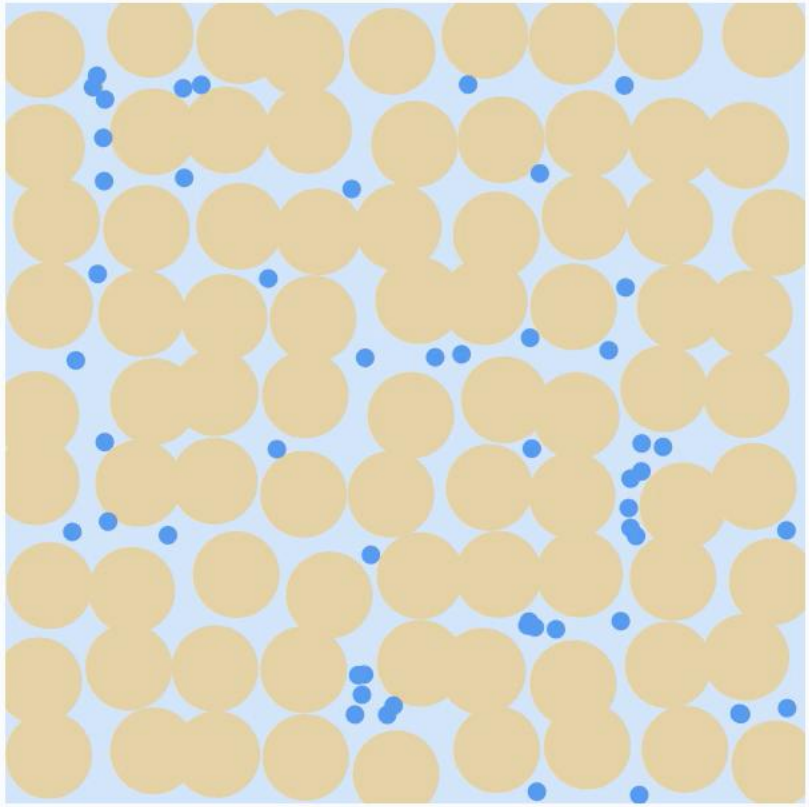
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Individual Site Correlation Comparison



Porosity and density set the groundwater multiplier

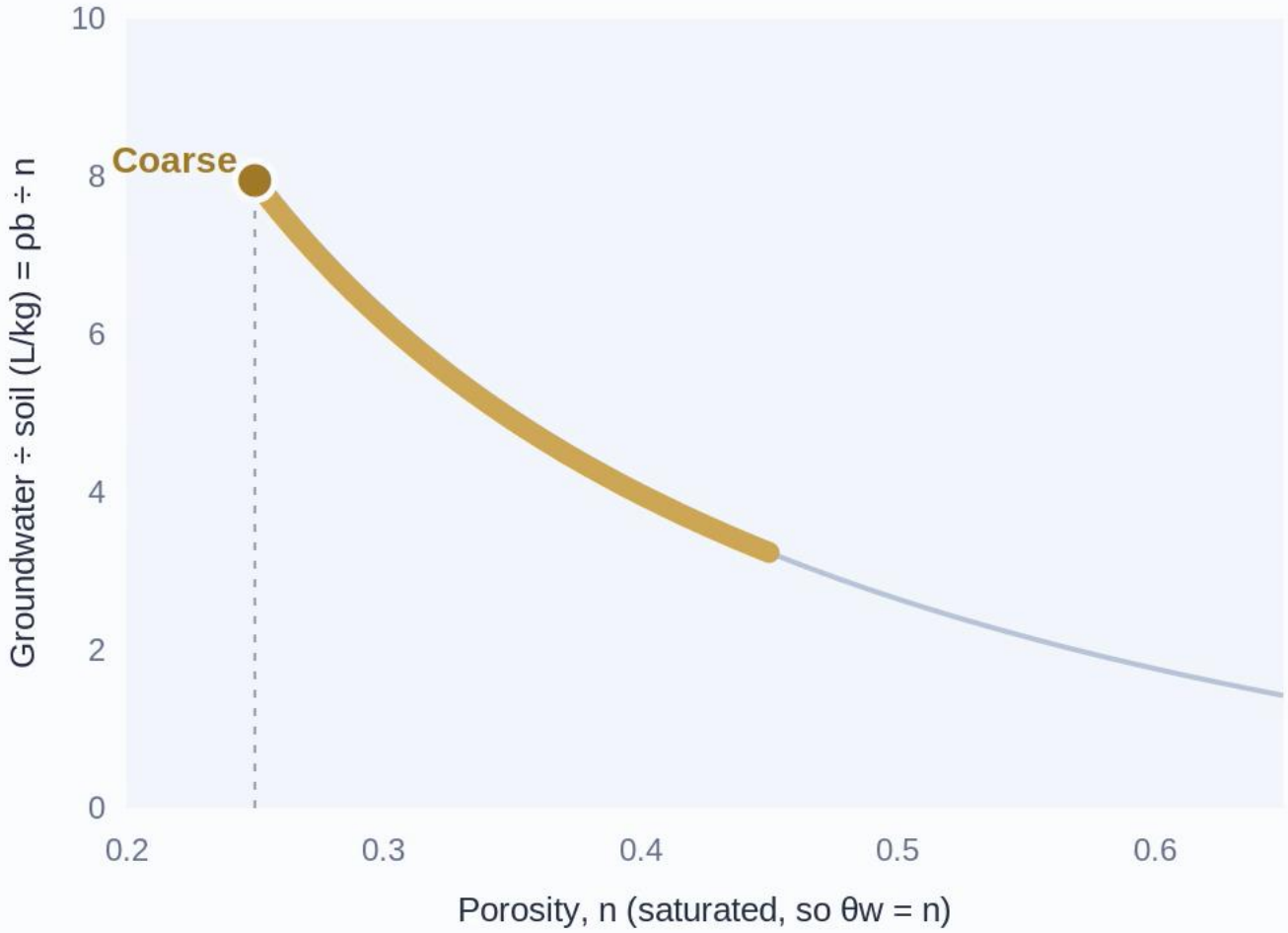
Coarse-grained (sand, gravel)



n = 0.25 ρb = 1.99 kg/L

Water per kg of soil: 0.13 L

7.9×



Saturated, no sorption (Cl Kd ≈ 0): Cw = Cs × ρb ÷ n, with ρb = 2.65 (1 − n)

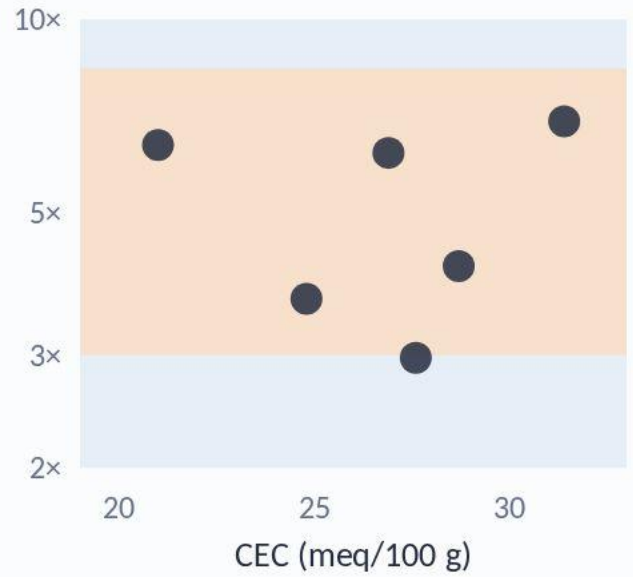
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No sign that CEC, pH or EC steer the ratio

Groundwater ÷ soil chloride (L/kg), 2025 well-screen composites

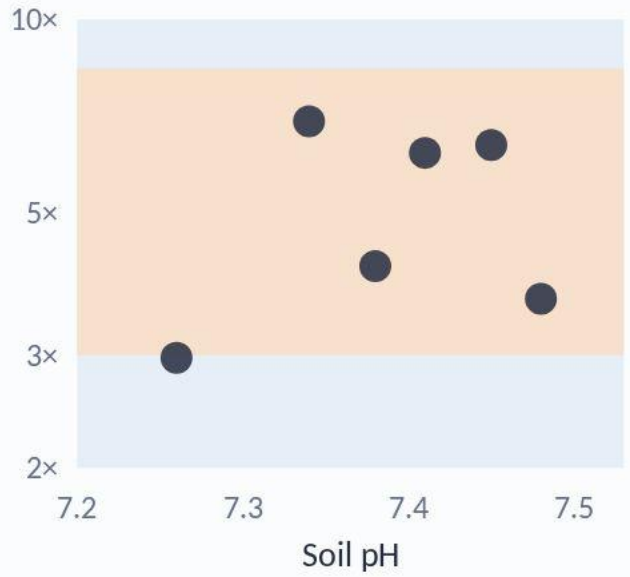
Typical: site averages 3.0–8.4×

Outside typical range



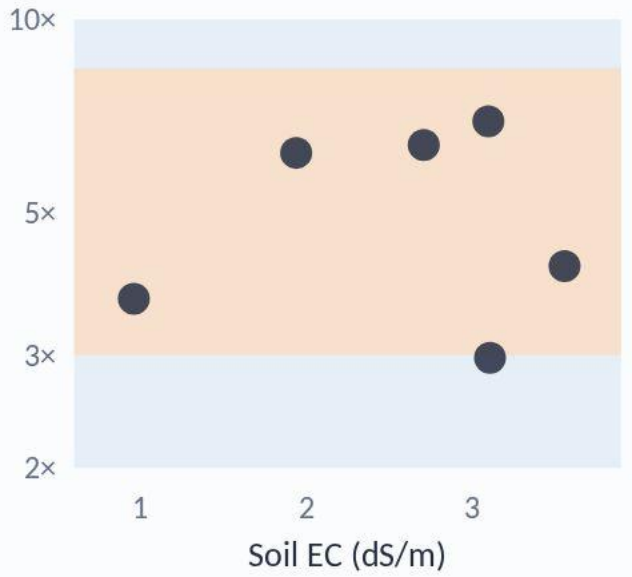
ρ = 0.14, p = 0.79

Spans 21 to 31 meq/100 g



ρ = 0.09, p = 0.87

Range only 7.3 to 7.5



ρ = −0.09, p = 0.87

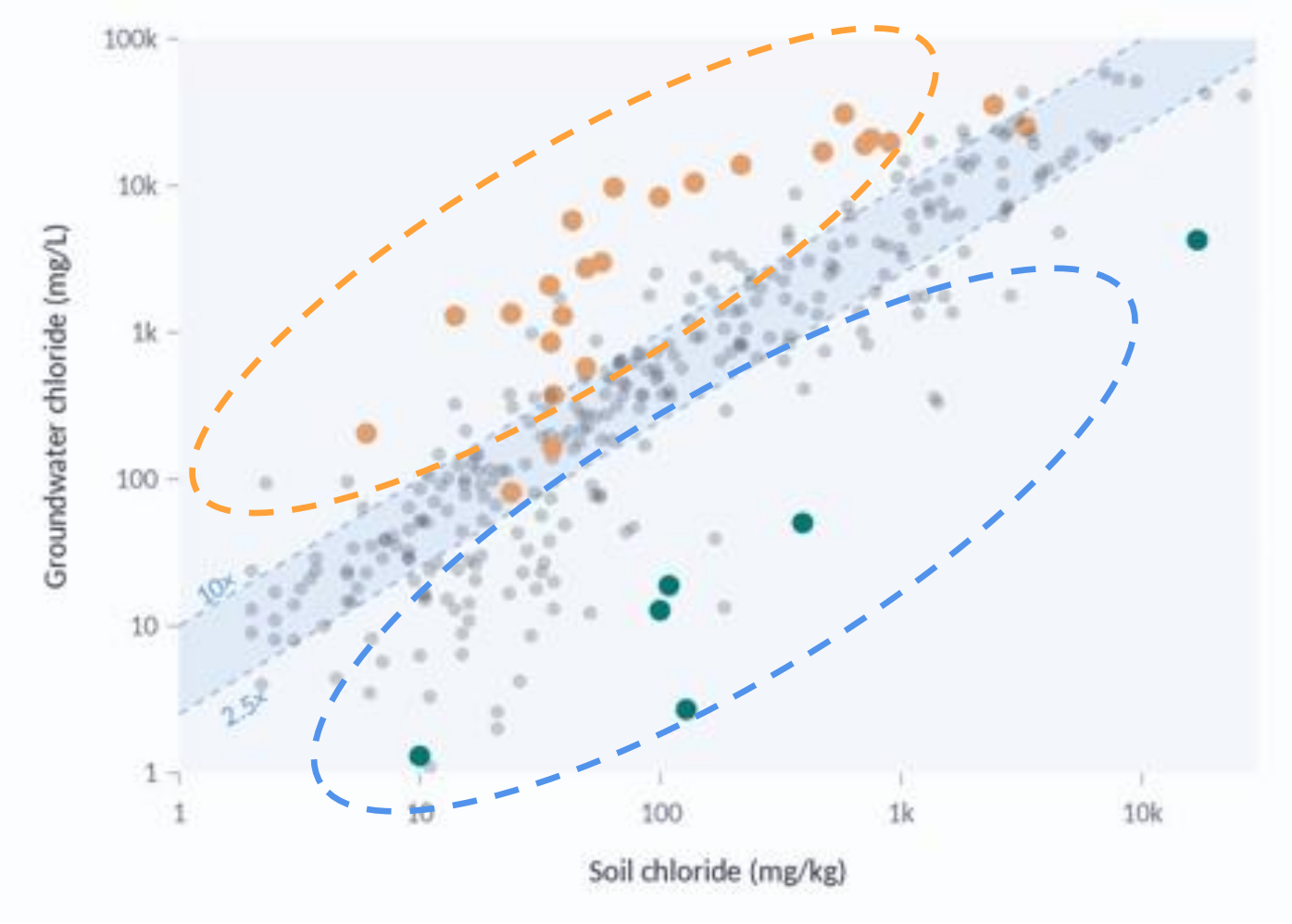
Cl dominates EC only at MW14A, MW15

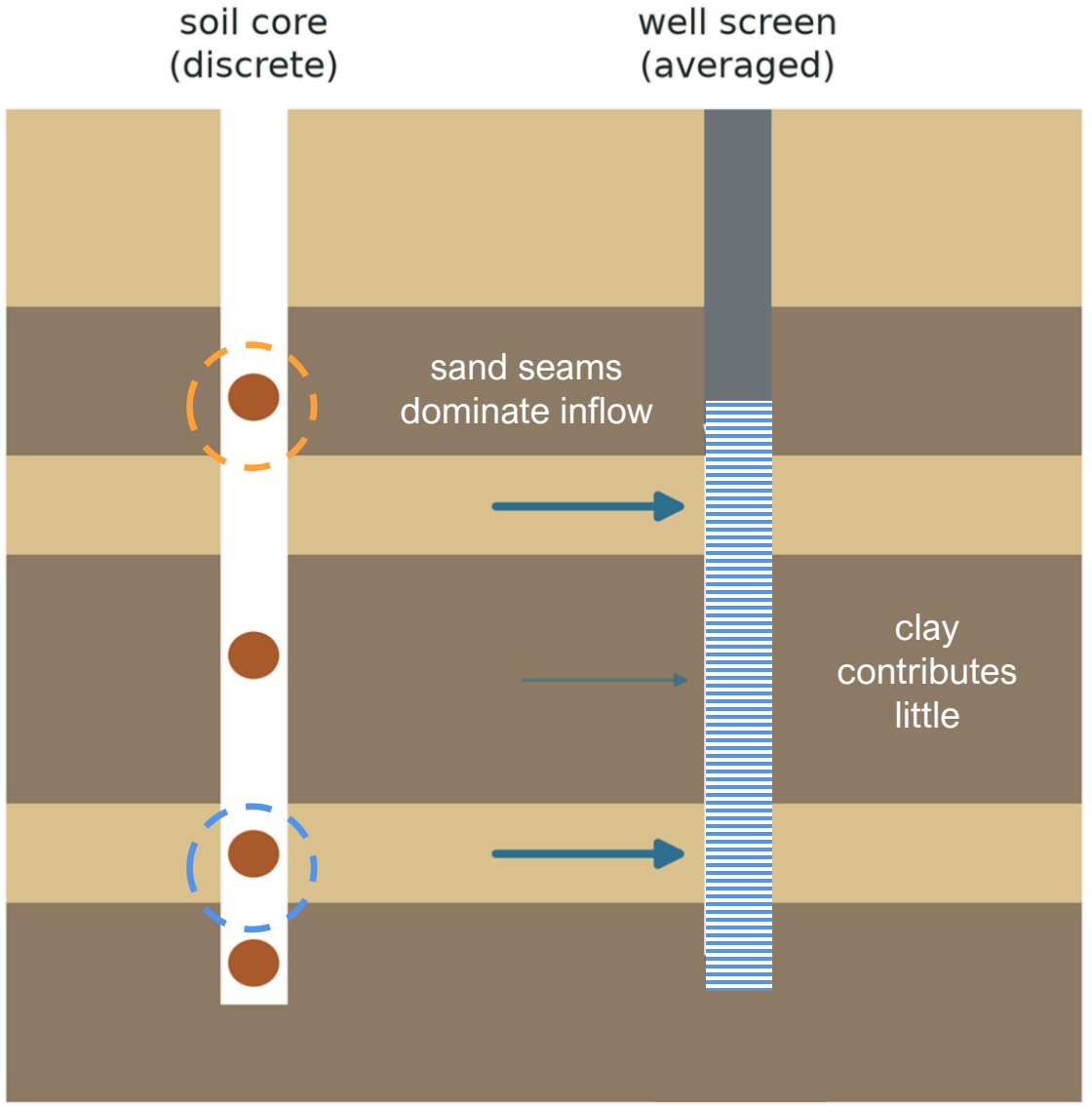
- Across 285 compiled pairs, only the wettest soils (saturation > 70%) differ: **median 3.1×** vs ~5×.

n = 6 composites; MW13 excluded as a likely outlier (33×, soil Cl 11 mg/kg). ρ = Spearman rank correlation.

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Why The Data Can Disagree: Scale



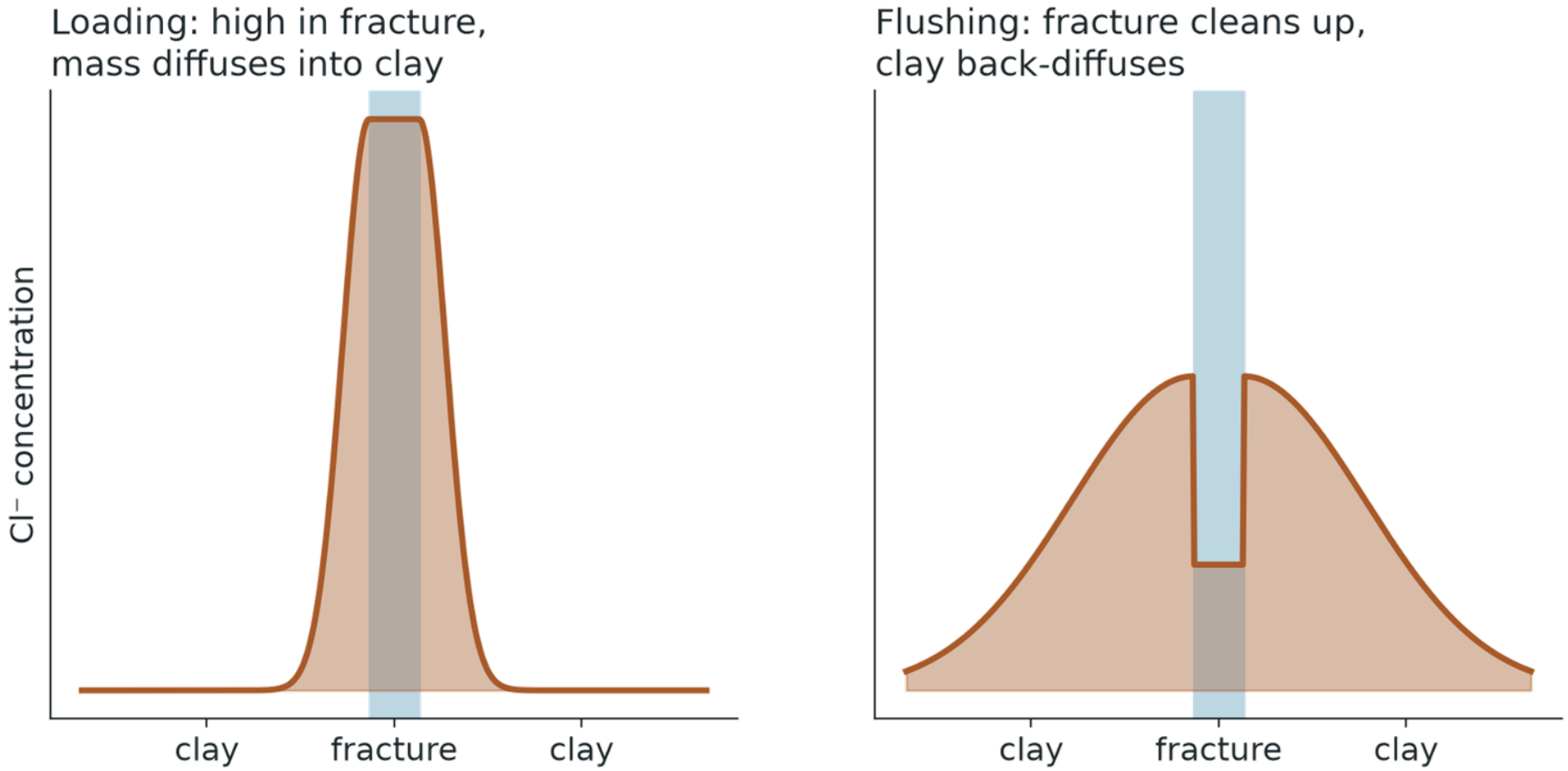


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Why The Data Can Disagree: Geology

Low K zones stores mass, then gives it back slowly



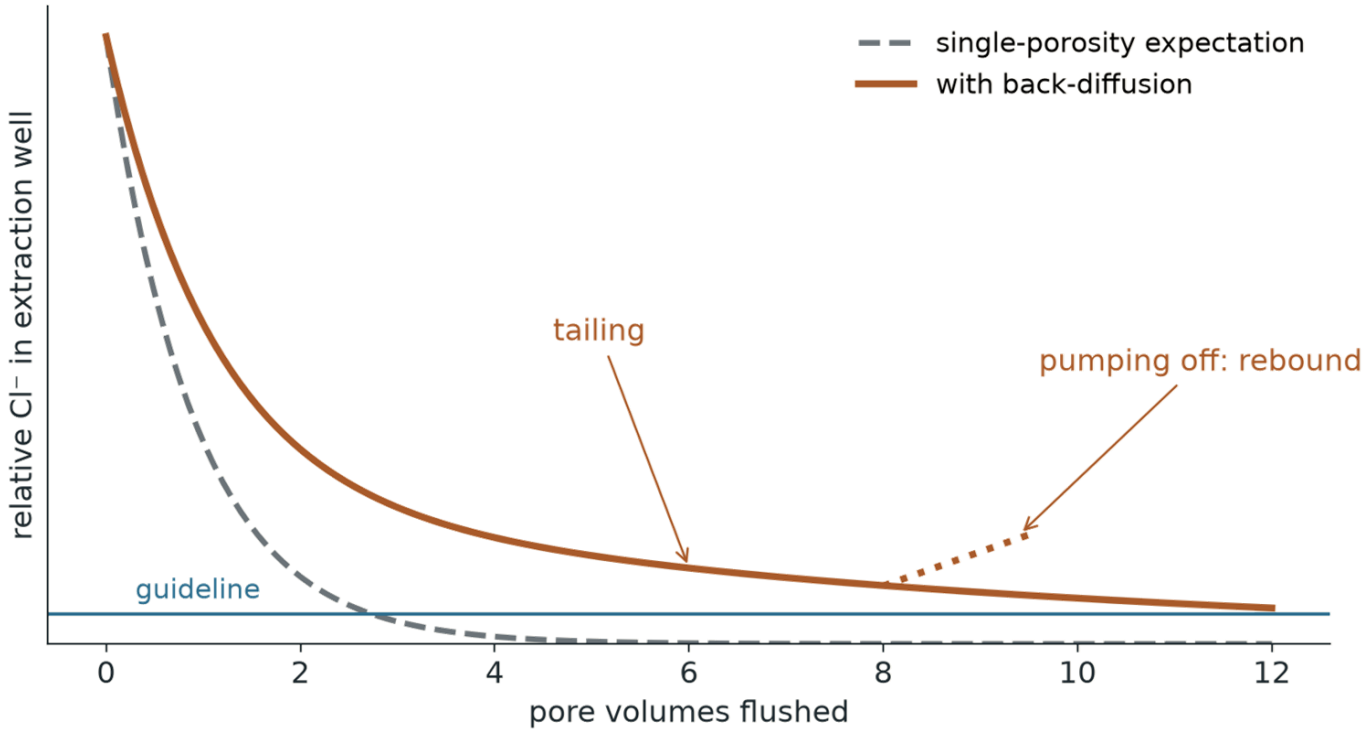
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Remediation Planning

Back-diffusion stretches every cleanup

- Mass sets pore volumes and disposal
- Expect tailing and rebound
- Set realistic endpoints
- Track mass removed, not just trends



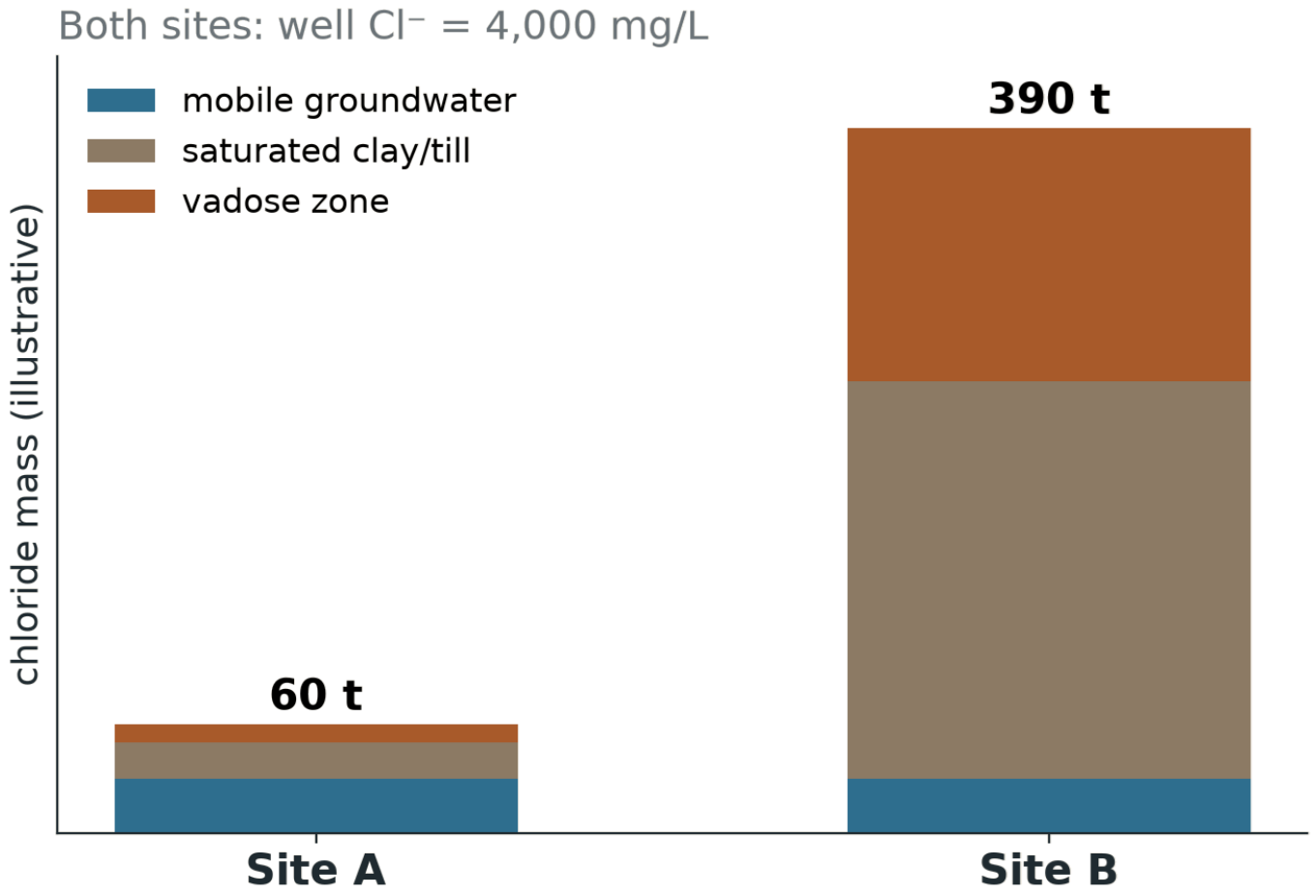
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Concentration isn’t Enough

Same well data, 6× the mass

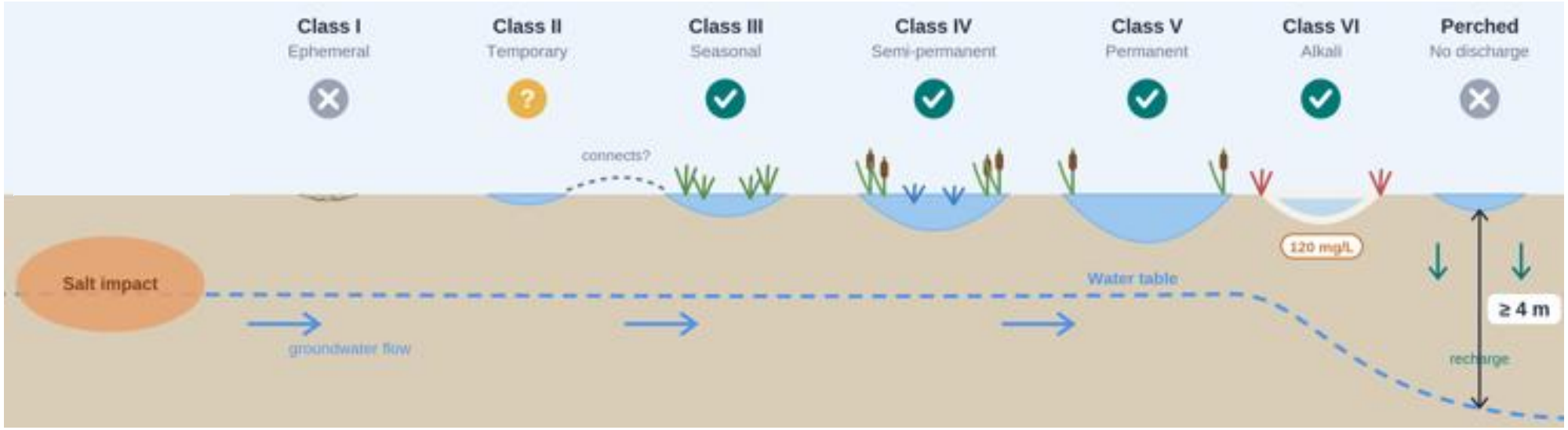
- Wells see the mobile phase
- Most mass hides in matrix and vadose
- Equal concentrations, unequal risk



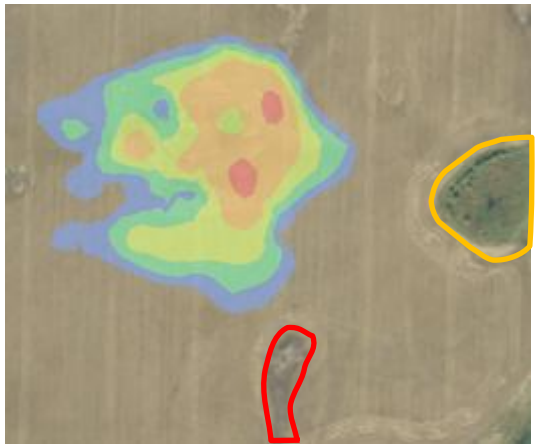
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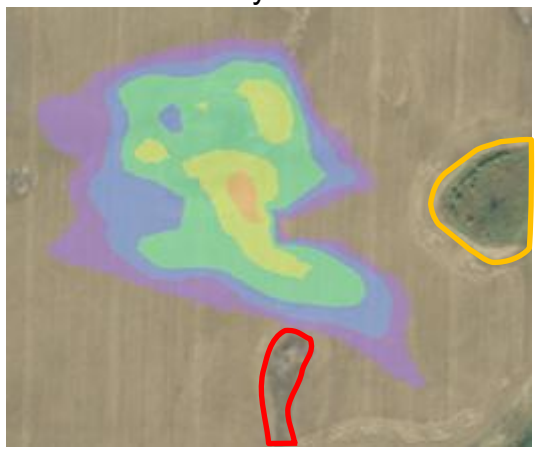
Challenges & Uncertainties - Fate & Transport



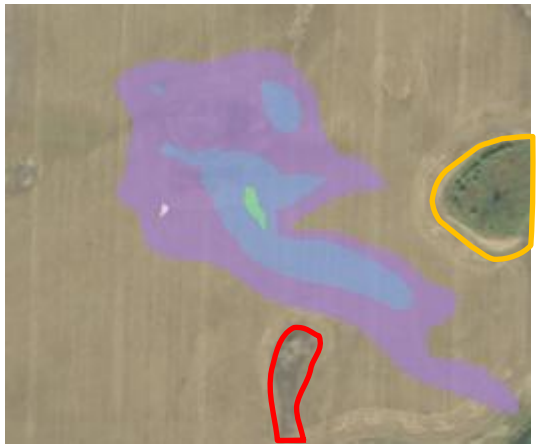
Present



50 years



100 years



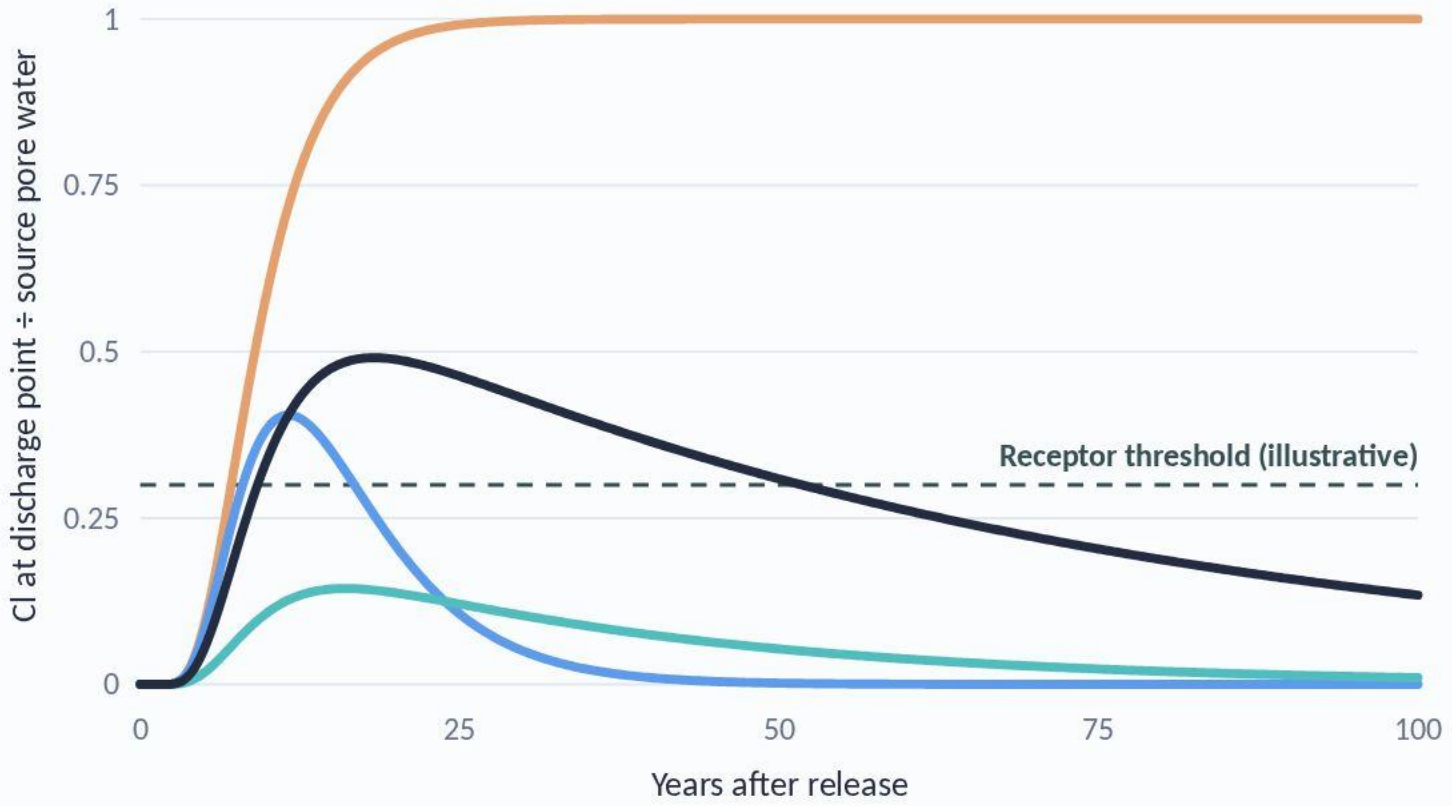
150 years

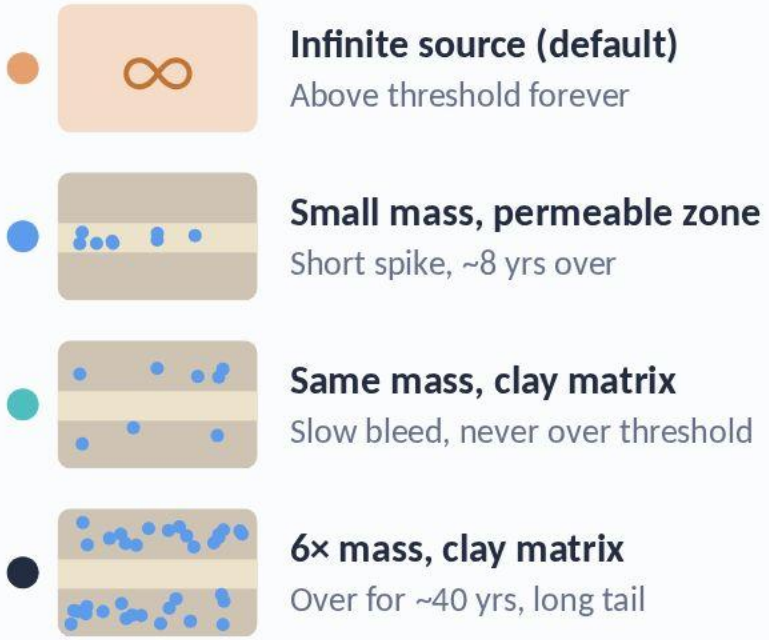


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How much salt, and where it sits, sets the creek's future





Infinite source (default)
Above threshold forever

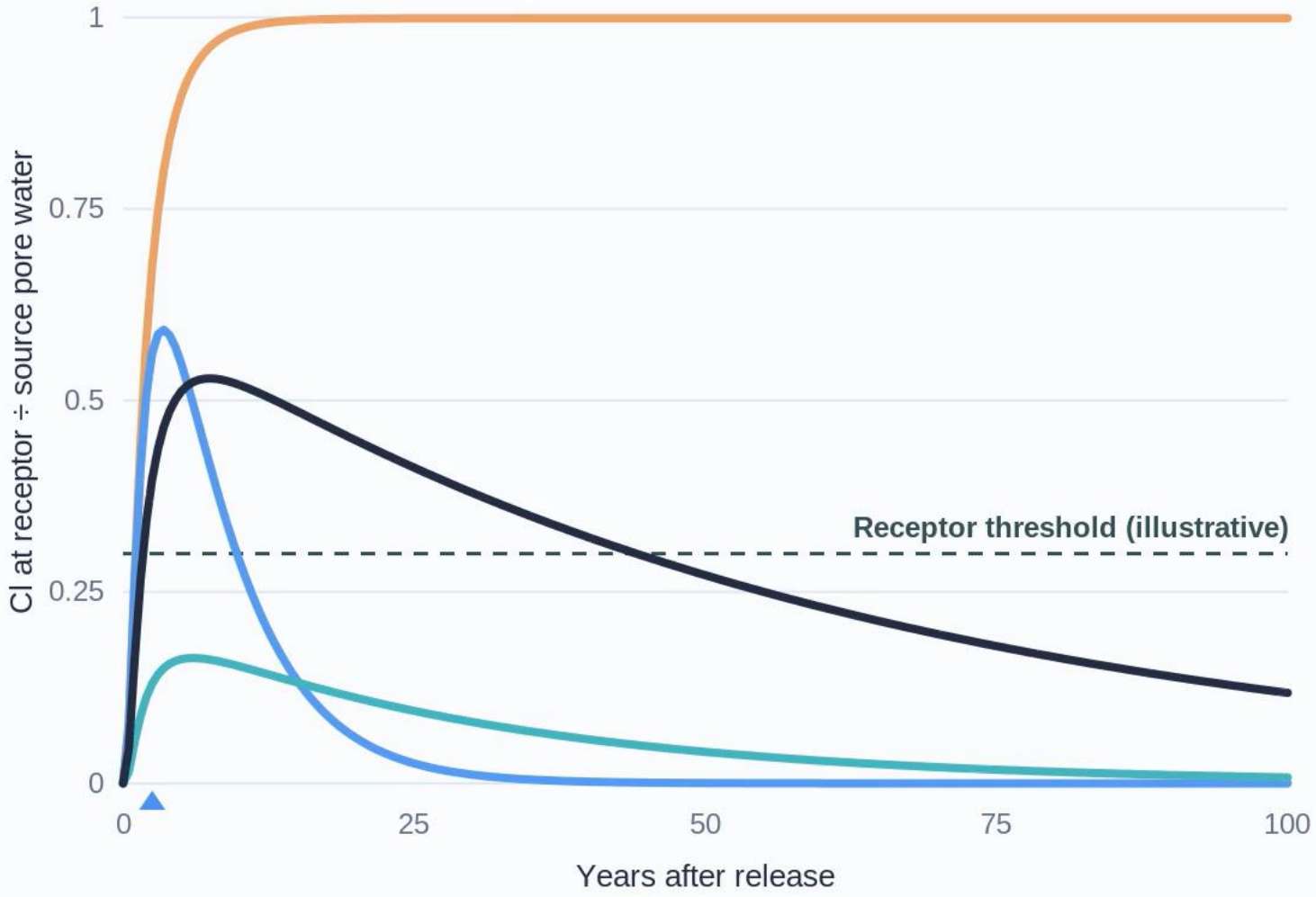
Small mass, permeable zone
Short spike, ~8 yrs over

Same mass, clay matrix
Slow bleed, never over threshold

6× mass, clay matrix
Over for ~40 yrs, long tail

Illustrative: 200 m to discharge, v 20 m/yr, α_L 20 m; source depletion 6 / 30 / 60 yrs. Soil gives mass and location; groundwater gives the release rate.

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50 m to the creek

▲ Plume arrives ~2 yrs

α_T 0.5 m · lateral dilution ×1.00

Source — 1 km

Infinite source (default)
Plateau 1.00, over from year ~1

Small mass, permeable zone
Peak 0.59, ~9 yrs over

Same mass, clay matrix
Peak 0.16, never over

6× mass, clay matrix
Peak 0.53, ~42 yrs over

Illustrative: v 20 m/yr, α_L 20 m, α_T = 0.01 × distance, 50 m wide source, plume centreline, no vertical spreading.

How Should We Use the Data We Have?

Is the plume reaching a receptor?

Groundwater

How much salt is stored in the clay?

Soil

Is the root zone recovering?

Soil

Is the plume stable or shrinking?

Groundwater

Where's the edge in tight till?

Soil

How long will the source last?

Both

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Acknowledgements

This presentation was based on work conducted for PTAC

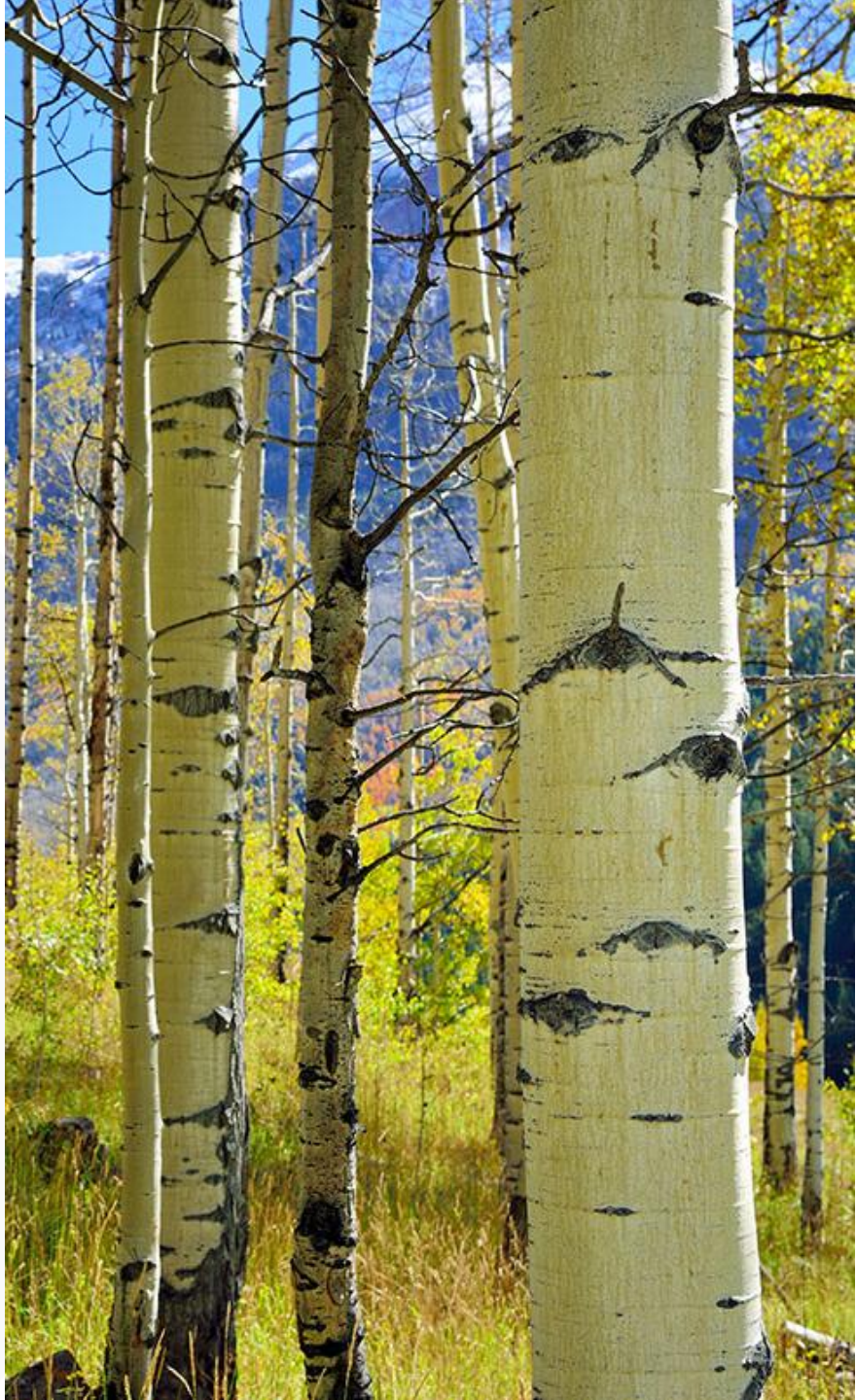
AGAT Laboratories

Contributors:

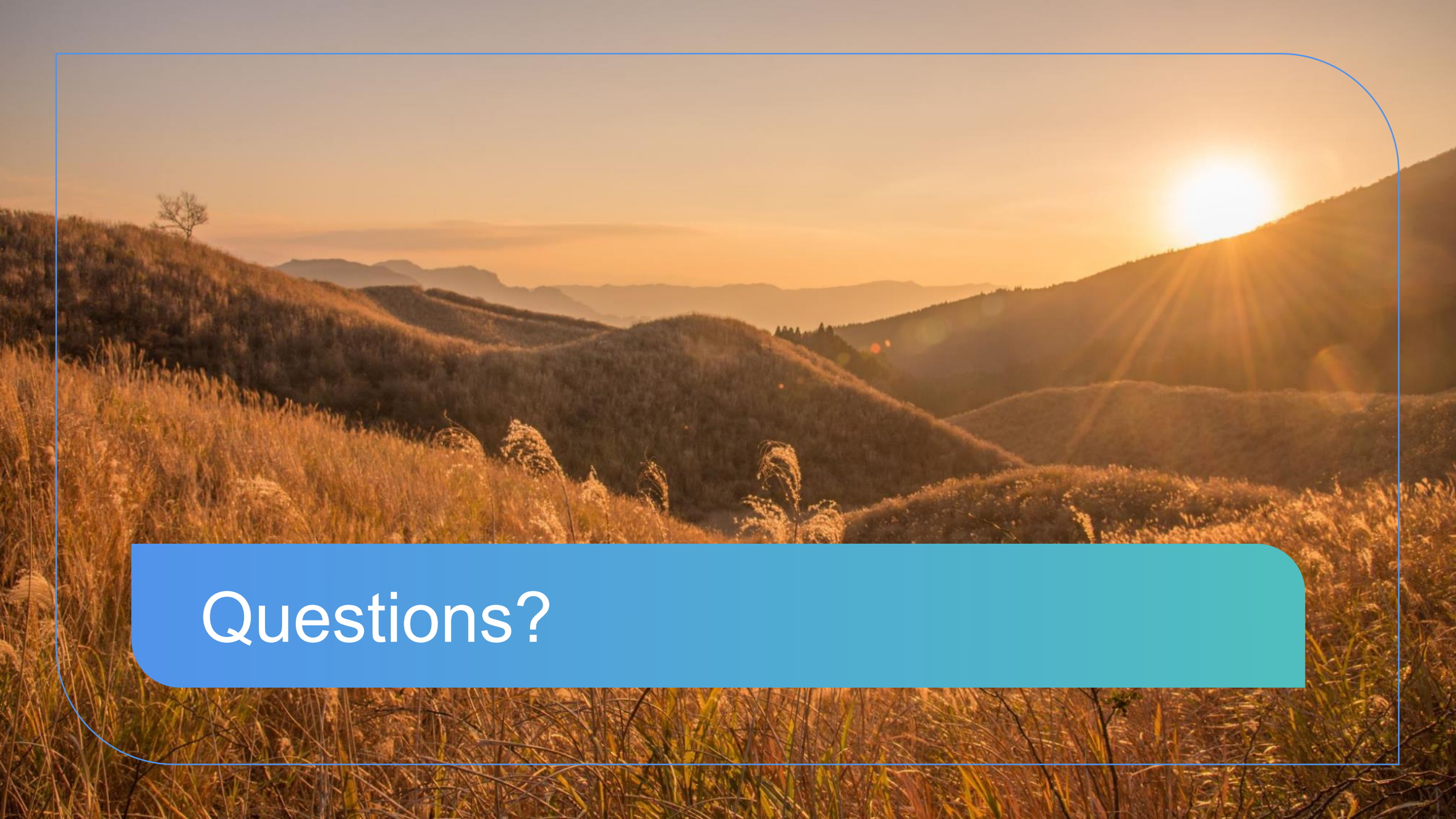
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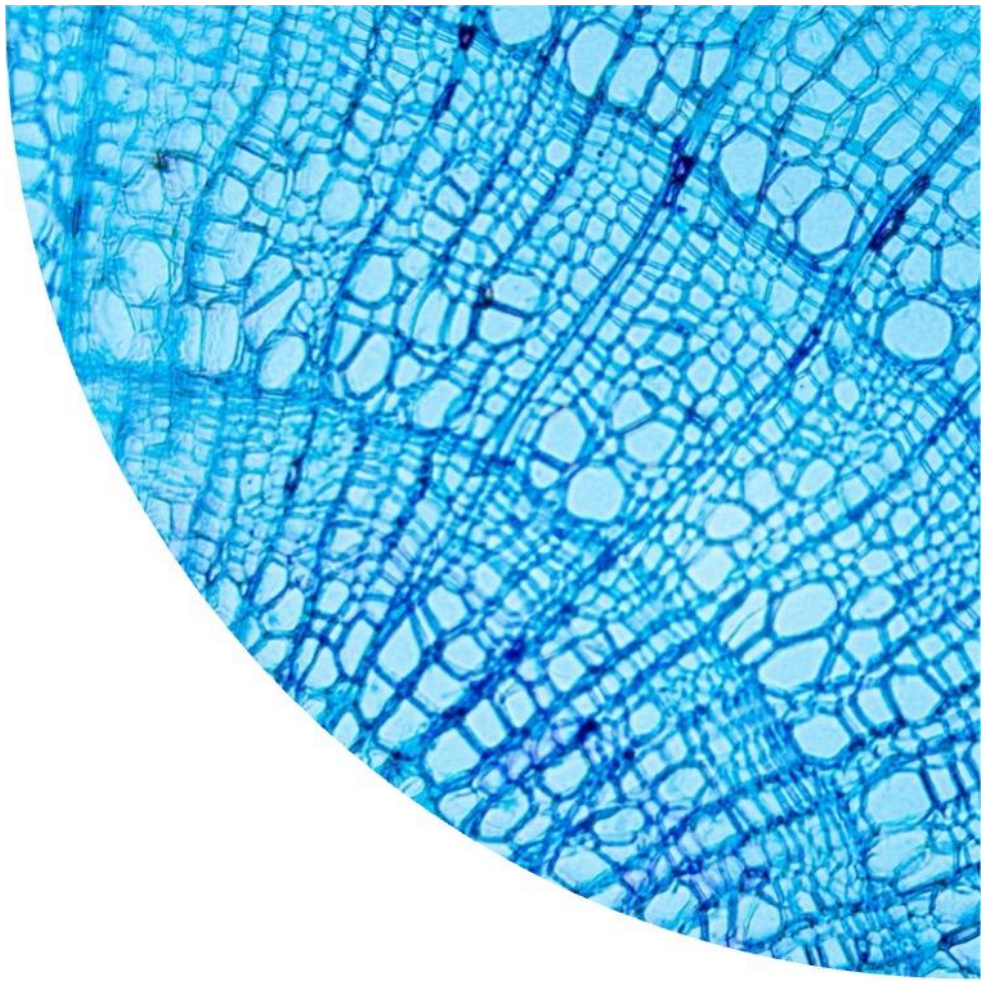
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Questions?

Thank You

Evaluation of Chloride Soil-Groundwater Partitioning

Same Salt, Different Numbers



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