

Brine Reinjection: Strategies and Technologies to make it a sustainable reality.

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CTO Eramine

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Brine Reinjection: Strategies and Technologies to Make It a Sustainable Reality.

Centenario – Ratonés Location

- The province of Salta, in northwestern Argentina (NOA), with about 1,200,000 inhabitants, is one of the provinces that are part of the "Lithium Triangle".
- The region where the Salar Centenario-Ratonés is located is known as the Puna. It is characterized by an arid climate, strong gusts of wind and extreme temperatures (-15°C to 25°C).
- Santa Rosa de los Pastos Grandes is the closest community and belongs to the Kolla Andina people. It is located 74 kilometers from the Production Plant and has approximately 260 inhabitants.
- In addition, there are 7 semi-nomadic families near the camp, whose main livelihood is livestock (llamas, goats).
- In February 2020, the community expressed their support for our project during the Free, Prior and Informed Consultation process (ILO Convention 169).

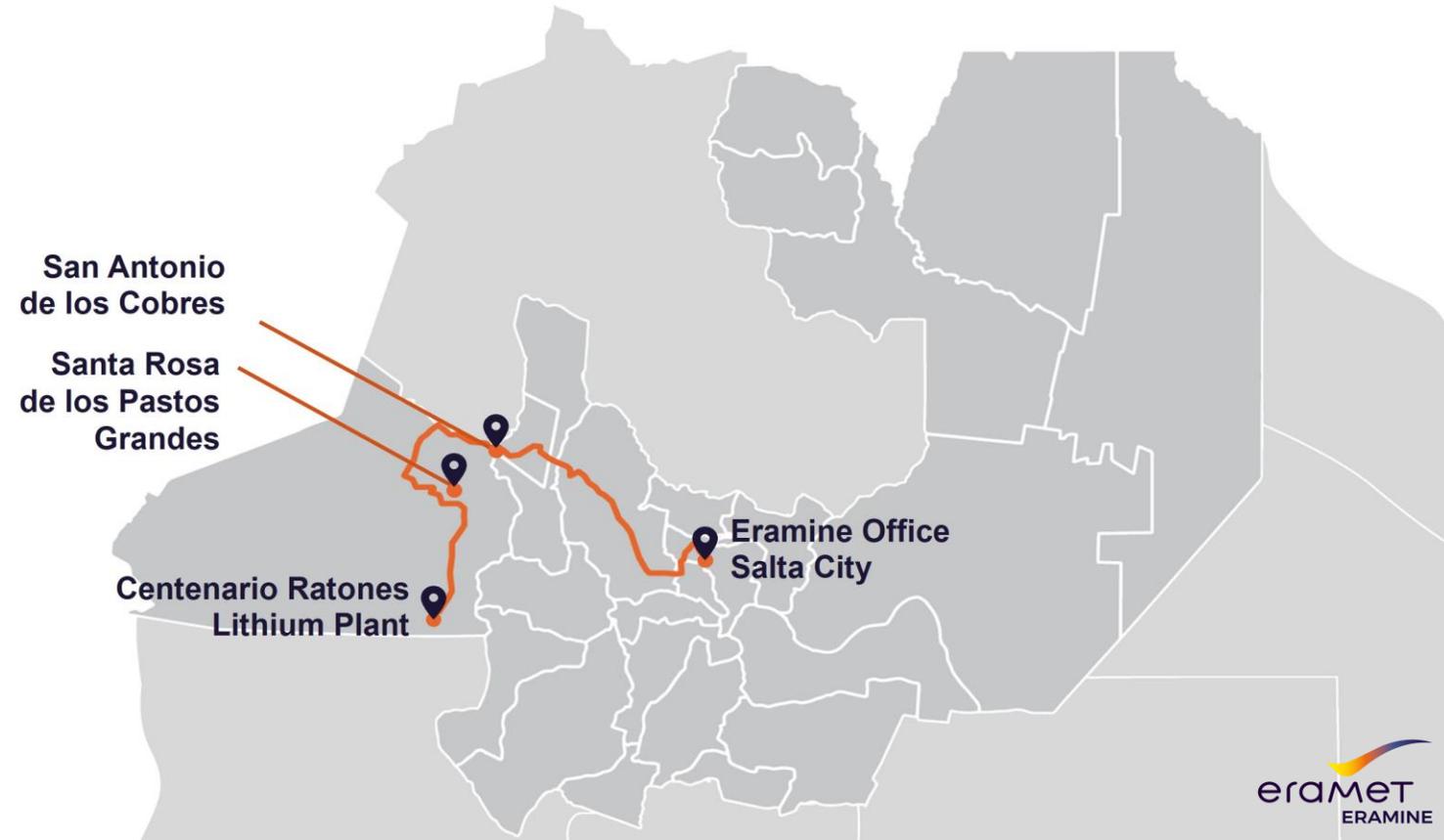
Distancias geográficas



Salta to SAC: **177 km**

Salta to SRPG: **244 km**

Lithium carbonate plant from Salta to Centenario Micones: **326 km**



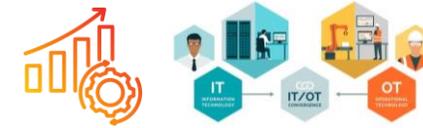
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“LIMITATIONS”

Ciclo de sesiones técnicas: tecnologías, conocimiento e innovación aplicada al litio

The "Limitations"



Limitation #1

- Hydric (or water) Balance
- Fresh/Brackish/Brine water distribution

Limitation #3

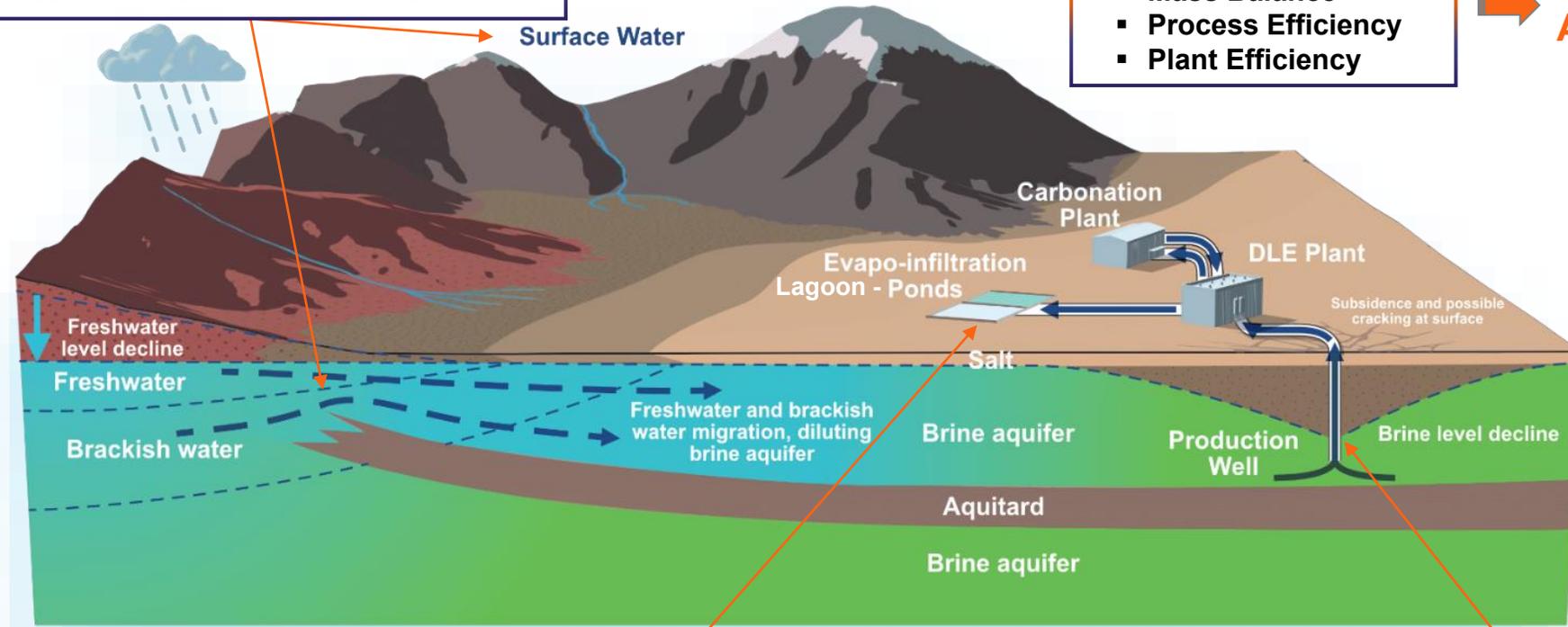
- Mass Balance
- Process Efficiency
- Plant Efficiency

Economics:

- Reagent consumption
- Product quality

Act for + mining:

- Water consumption
- Energy Efficiency (CO²)



Limitation #4

- Depleted Brine Management
 - Depleted brine natural lagoon
 - Reinjection

Limitation #2

- Resource & Reserves
- Reservoir Hydraulic Performance
- Chemical Brine Composition

Mine Life Cycle

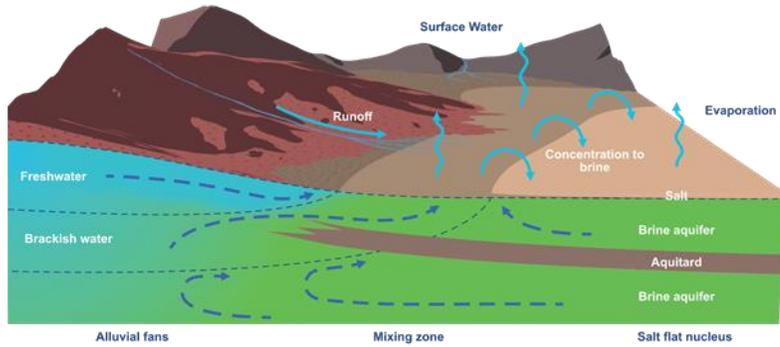
Block diagram taken from Reinjection White Paper, 2024.



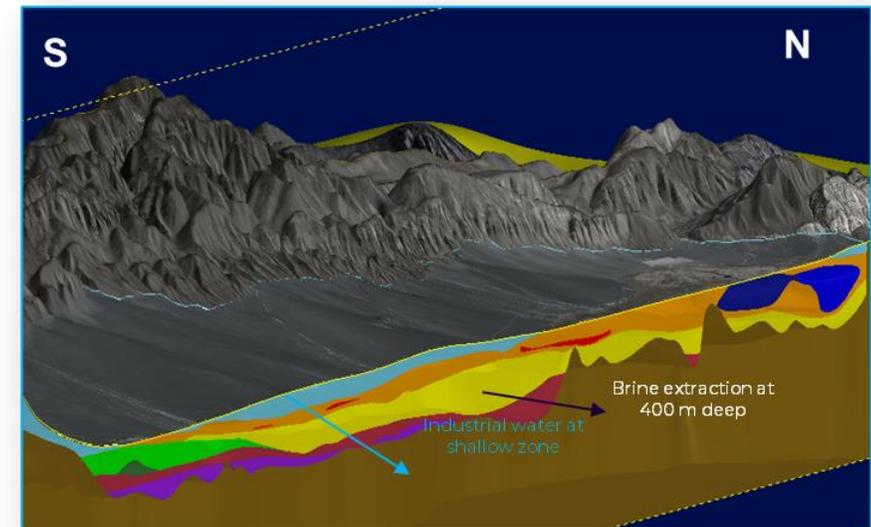
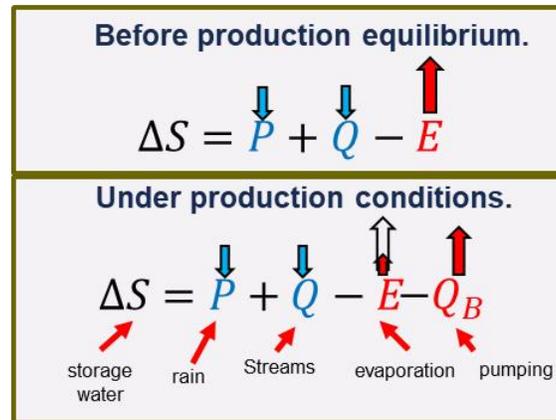
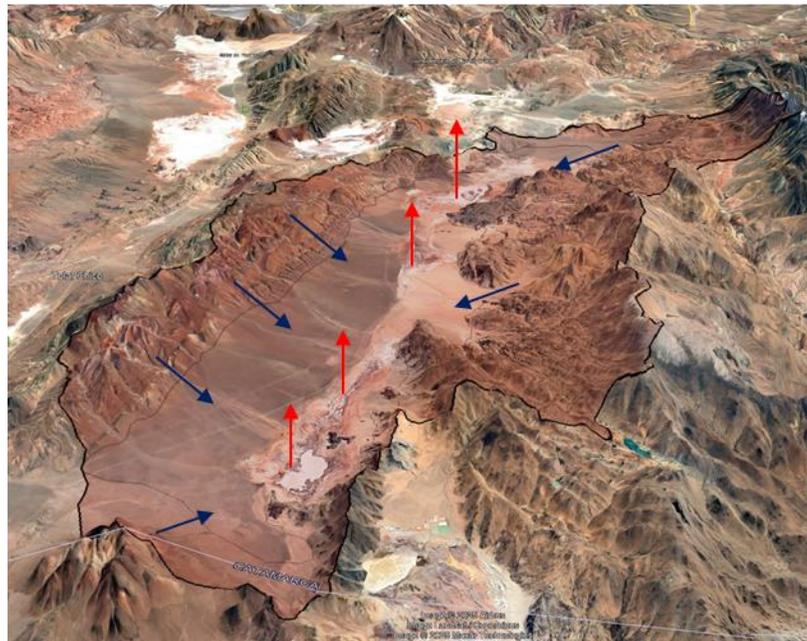


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Water balance (L#1)



- Geological layers, pressures, and mineral precipitation are important. Brine fluids mix completely, unlike hydro- carbon projects where they remain separate.
- Basin Recharge¹ : 750 l/s, Evaporation av. rate: 5 mm/d.**
- Average precipitation: 159.3 million m³ per year (90 mm/y vs Atacama 30 mm/y)

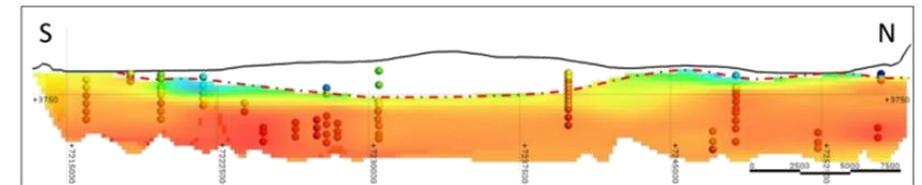
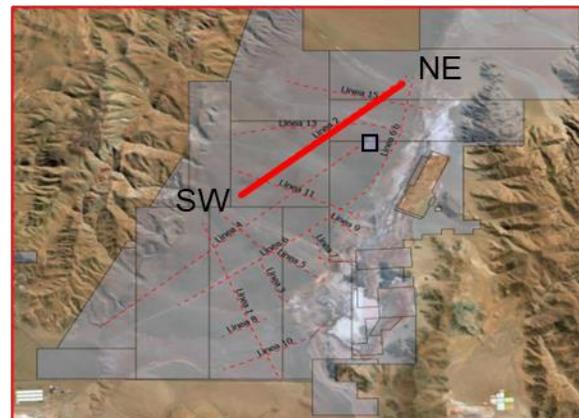
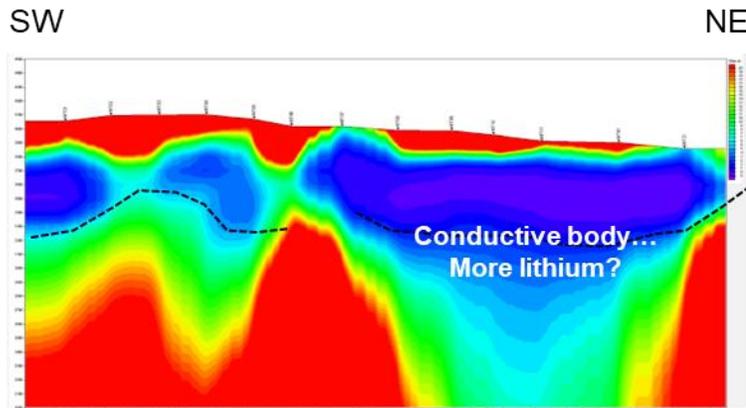
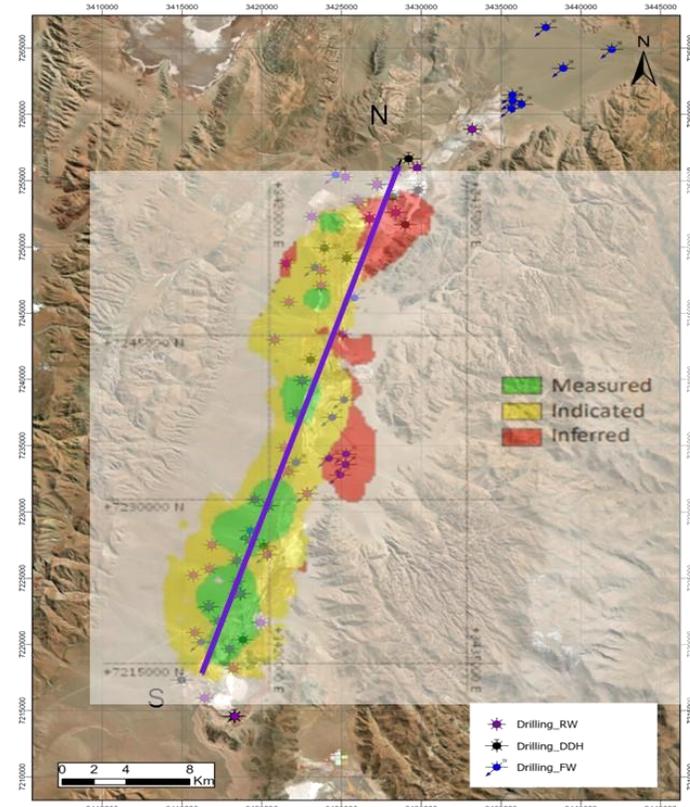


1. Water Balance validate by Montgomery.

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Resource & Reserve Progression (L#2)

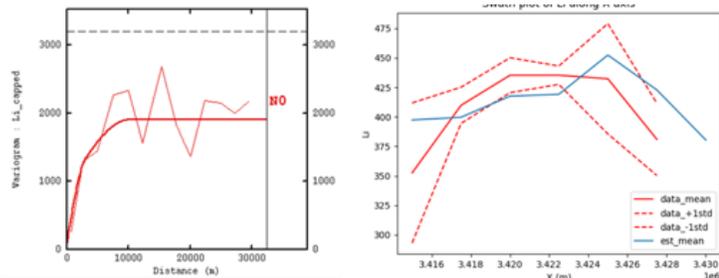
- Volumetric estimation:
 - How to define lateral limits?
 - How to link aquifer lithology with brine types? (Lithology \equiv % Li,)
 - Effective porosity (Φ_{ef}), k , $S_y \Rightarrow$ H.C.
- Dynamic resource (it flows very slow naturally or pumping) need hydraulic characterization of reservoir.
- Weather: precipitation can affect grade distribution and water balance.
- Dilution: fresh water lateral inflow (recharge) – reinjection.



Cross-Section of Aquifer Showing the Lithium Concentration and Top Boundary Interface

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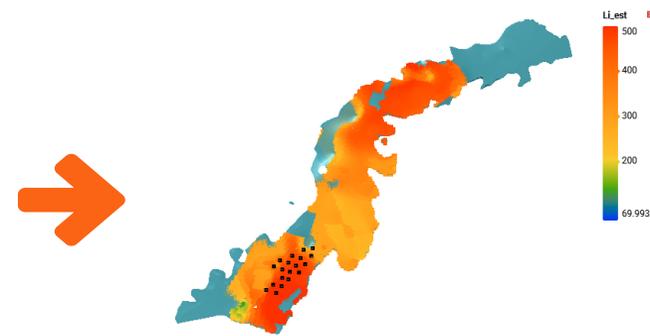
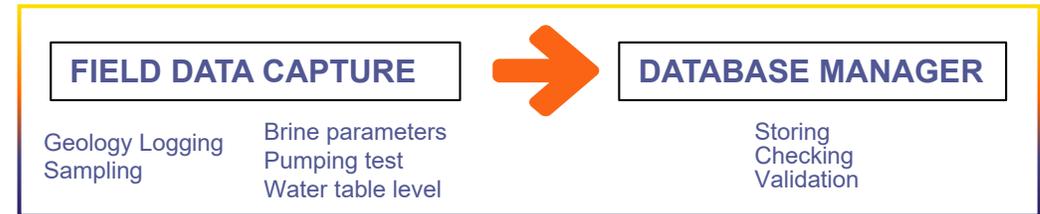
Workflow (Data Base + Leapfrog + Isatis-Feflow Software)



✓ Geostatistical evaluation of the geochemical dataset combined with porosity analysis



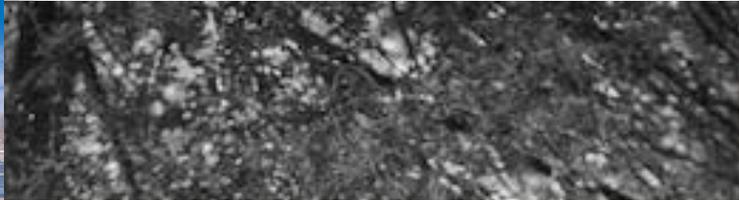
✓ Stratigraphic evaluation of the principal aquifer units in the salt flat



✓ Geochemical spatial distribution (brines and porosity) across the model units



✓ Based on the block model (containing information in each of its cells) the resource estimation calculations are performed and integrated with the hydrostratigraphic units in the FEFLOW model.

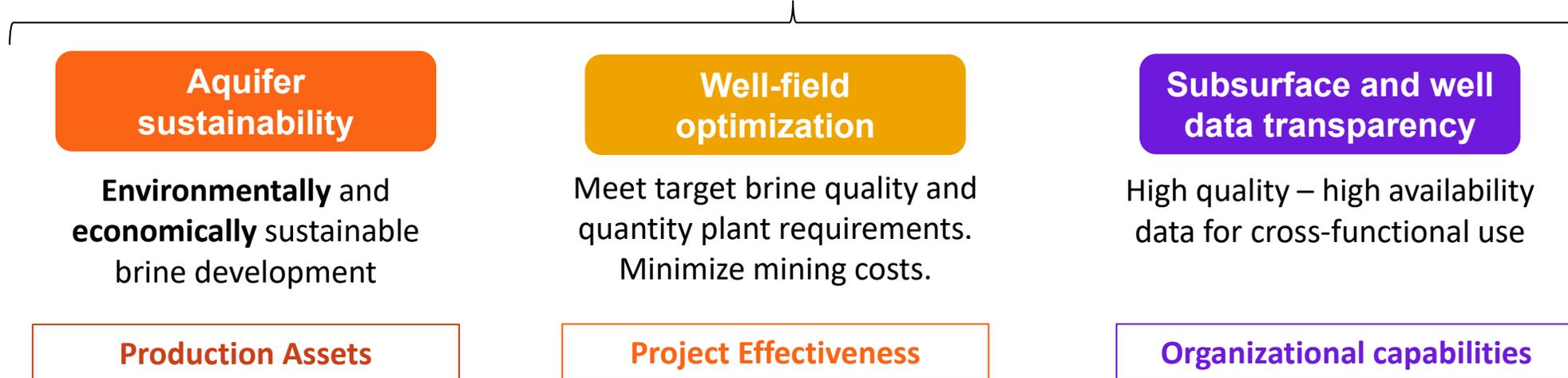




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MINE PLANNING (L#2 + #3 + #4)

Purpose: Monitor and develop groundwater resources to achieve a **sustainable** and **efficient** asset development.





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Lagoon storage, the current option, may be replaced by reinjection (L#4)

Pros

- ✓ Easy & low CAPEX.
- ✓ Already done and approved.
- ✓ High Evaporation rate.

Pros

- ✓ Potential water stress control.
- ✓ Lower environmental impact.
- ✓ Potential production enhancement.

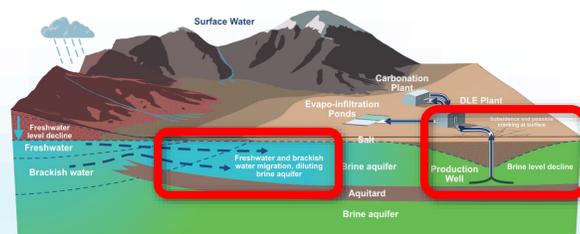
Cons

- ✗ Surface crust, change in drainage system.
- ✗ Higher surface & subsurface environmental impact.

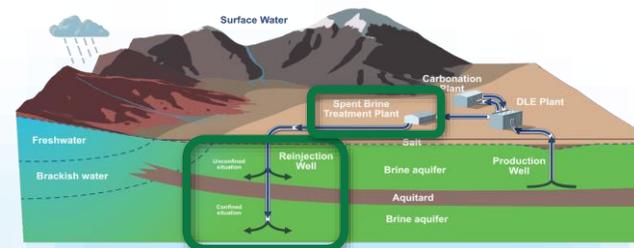
Cons

- ✗ **Industrial risk:** Risk of raw brine dilution.
- ✗ Aquifer equilibrium changes. requires detailed monitoring.
- ✗ Geotechnical hazards.

Without brine recycling



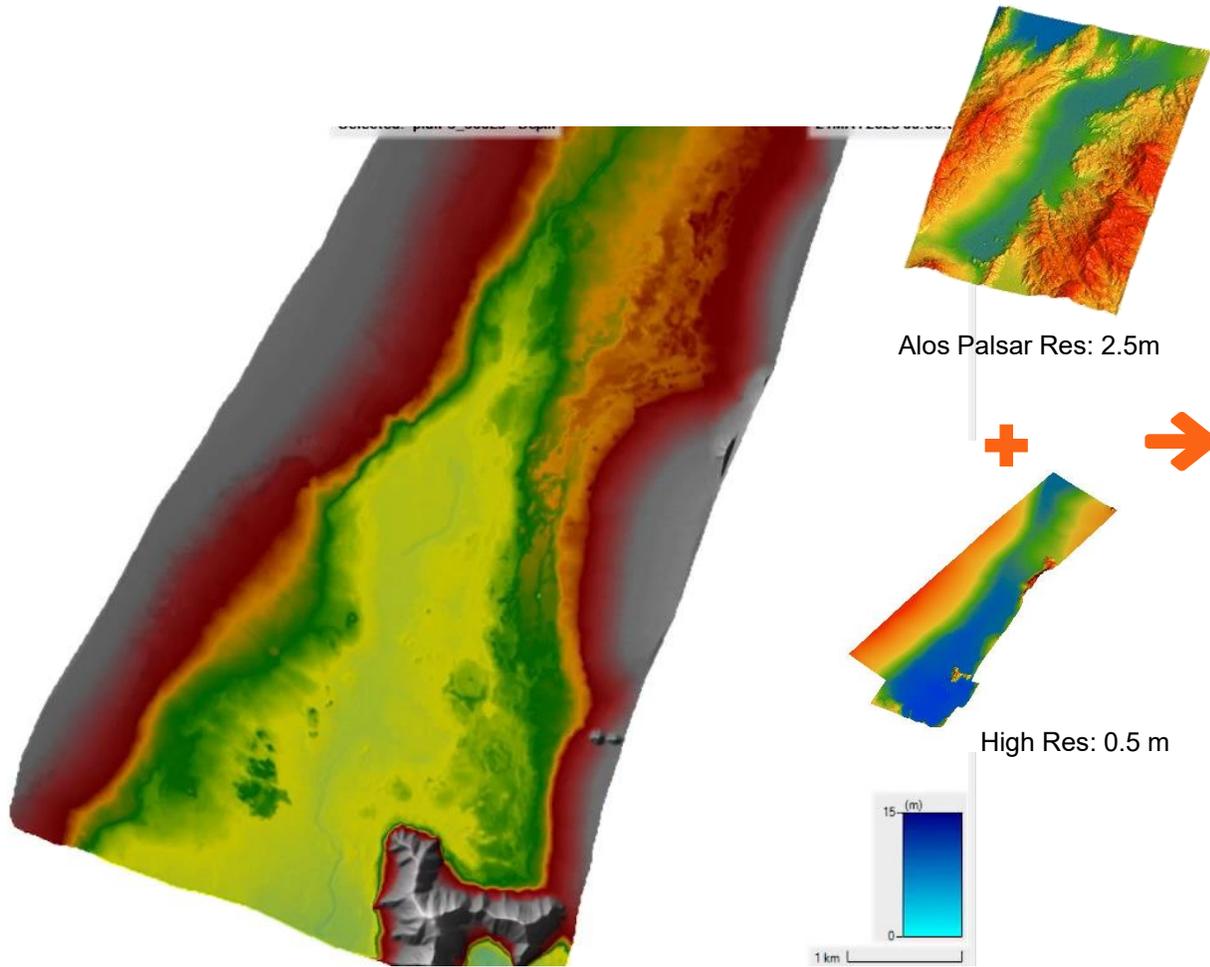
With brine recycling



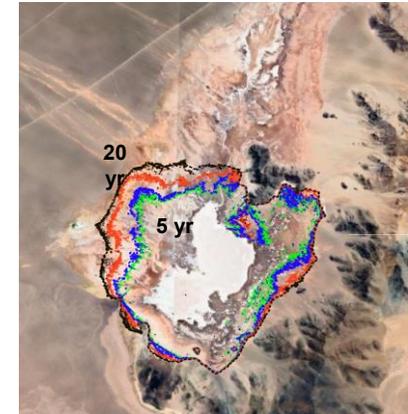
1. Block diagram taken from Reinjection White Paper, 2024.

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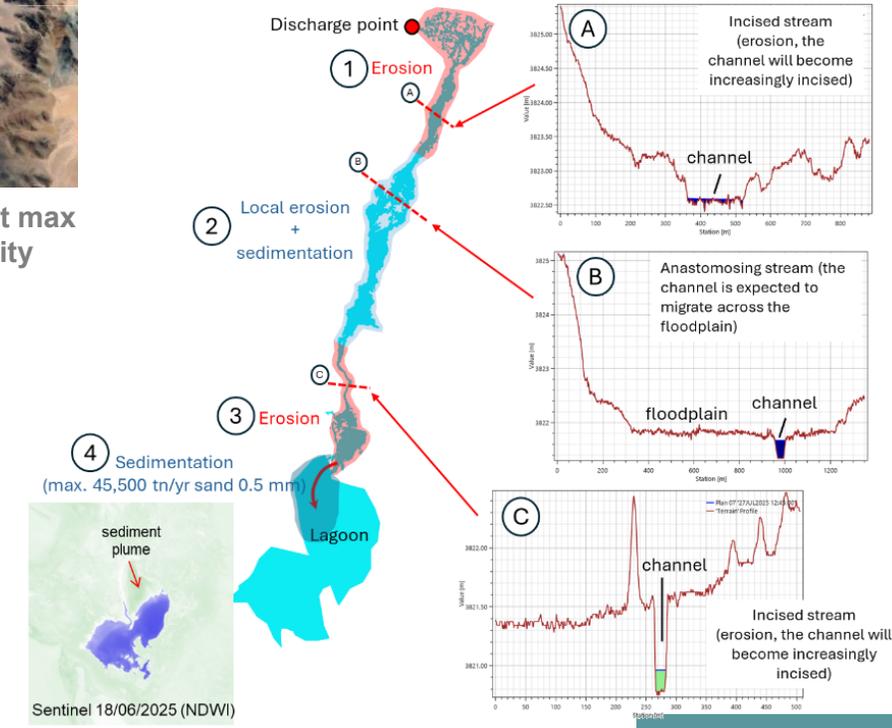
Depleted Brine Management (L#4)



- ✓ Salt precipitation was included
- ✓ Elevation vs. Filled volume based on detailed DEM

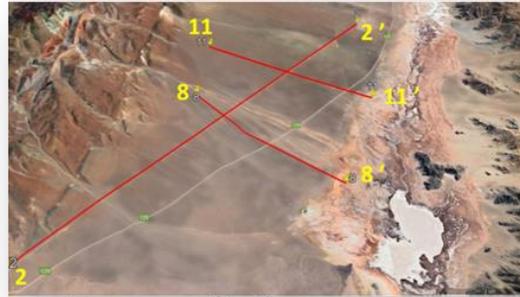


Lagoon Simulation at max production capacity

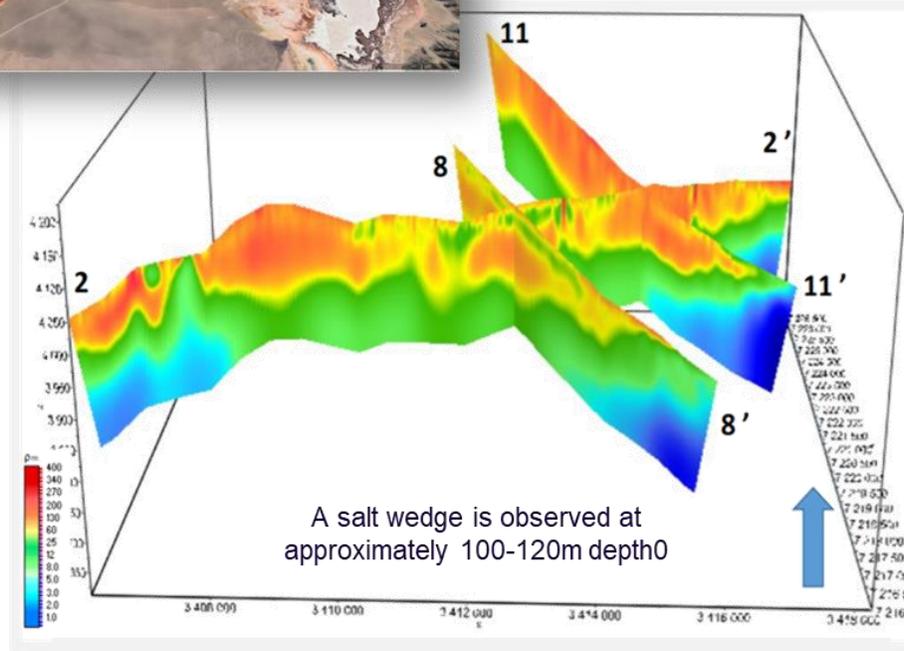


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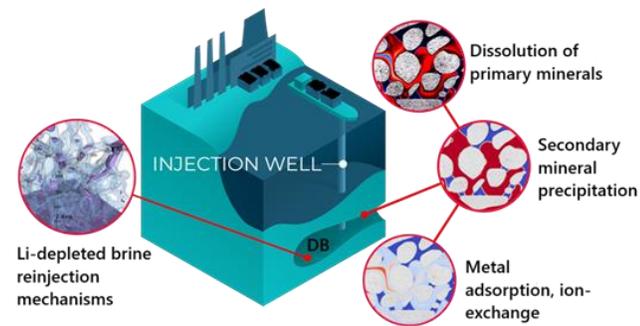
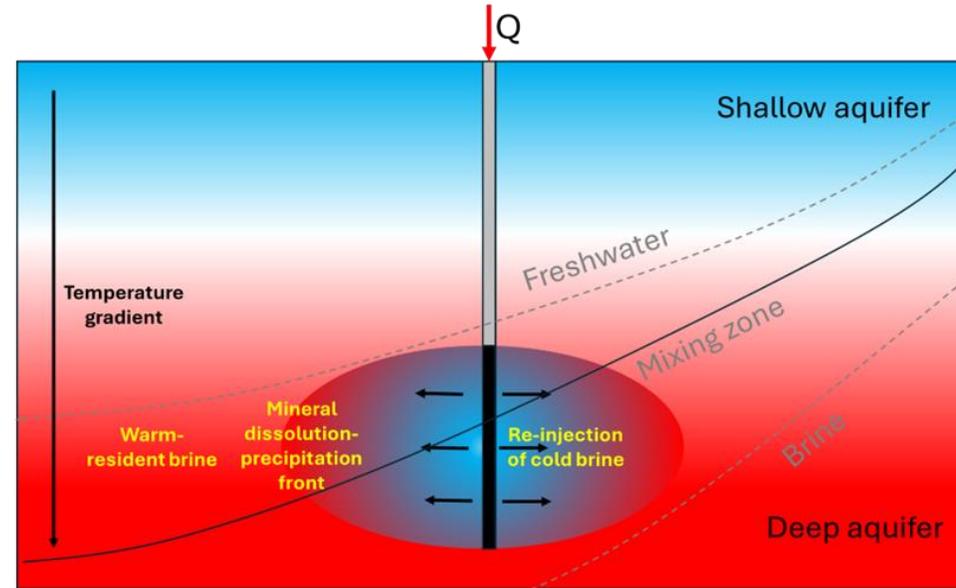
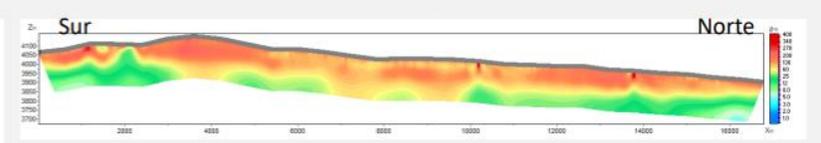
Geophysics - Saline wedge model



Observed 3 brine phases. Up to 50+ m free poral space (higher in margins) → good sign for reinjection



Linea 2



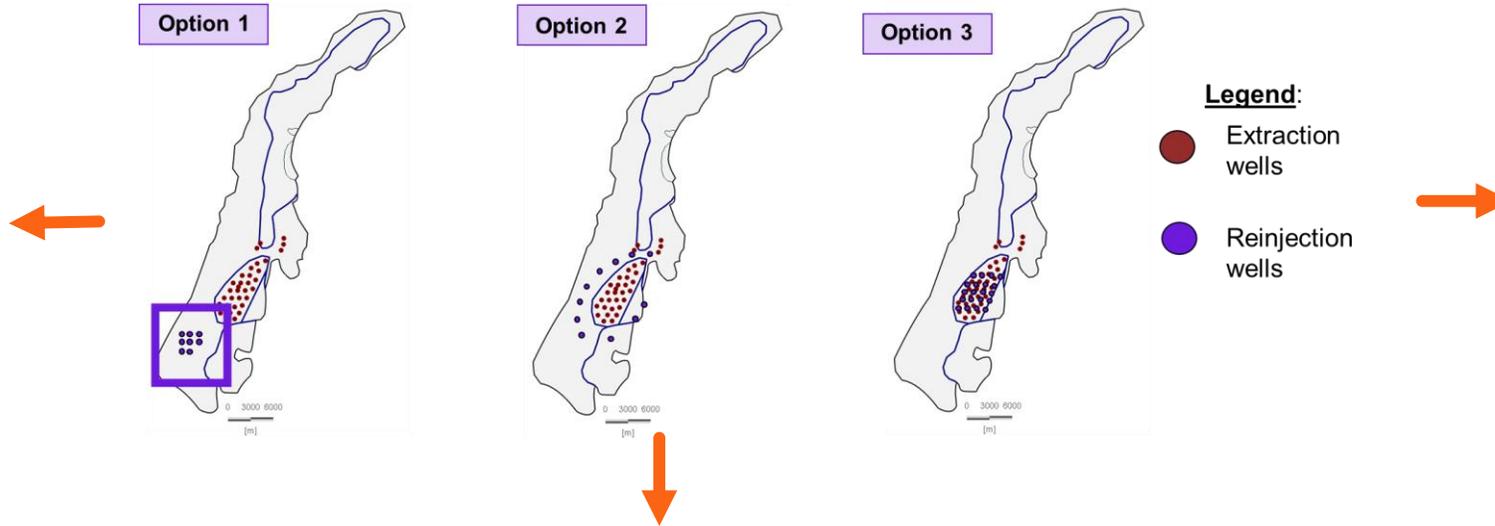


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Reinjection well field choosing the best options

1. Hydrogeological analysis

- Brine aquifer water level
- Reinjected brine plume's behaviours
- Freshwater resources impact



2. Hydrochemical analysis

- Raw & depleted brine mixing (depending on depleted brine properties)
- Depleted brine's reaction with subsurface water and rocks

3. CAPEX estimation

+ CO₂ footprint estimation



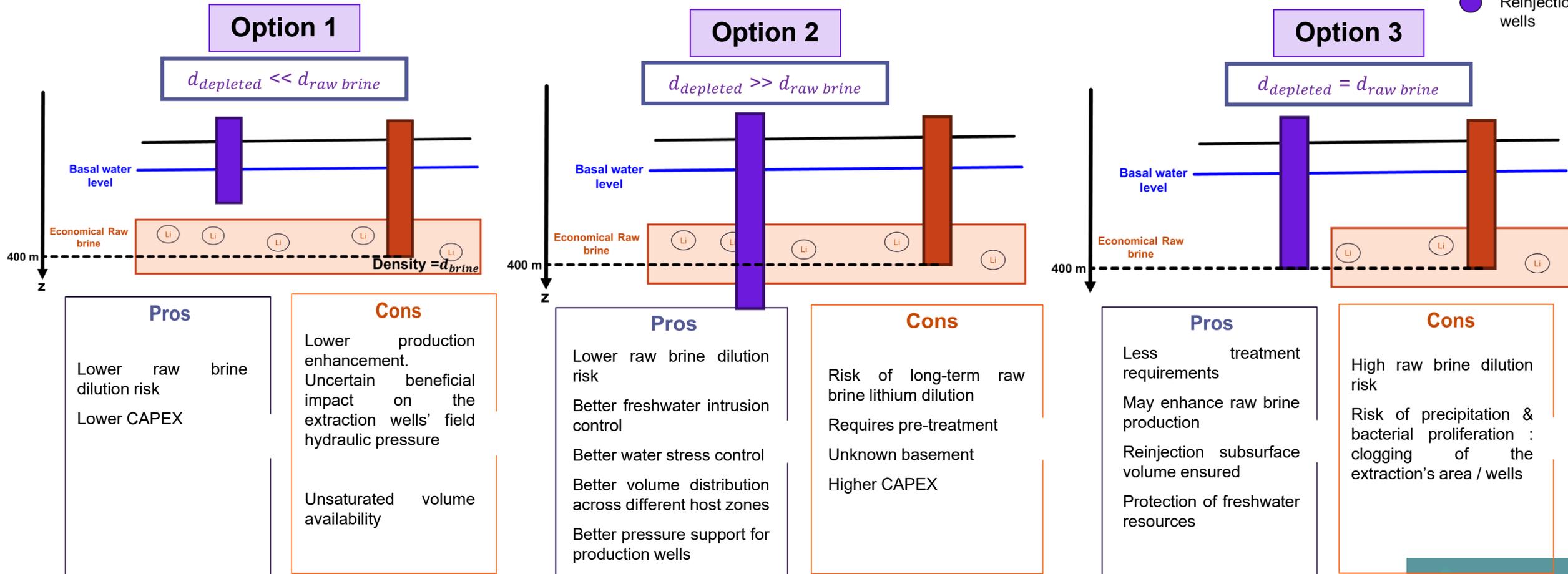
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Reinjection well field options

Three depths options are available, and may be linked to the injected **depleted brine's density**

Legend:

- Extraction wells
- Reinjection wells

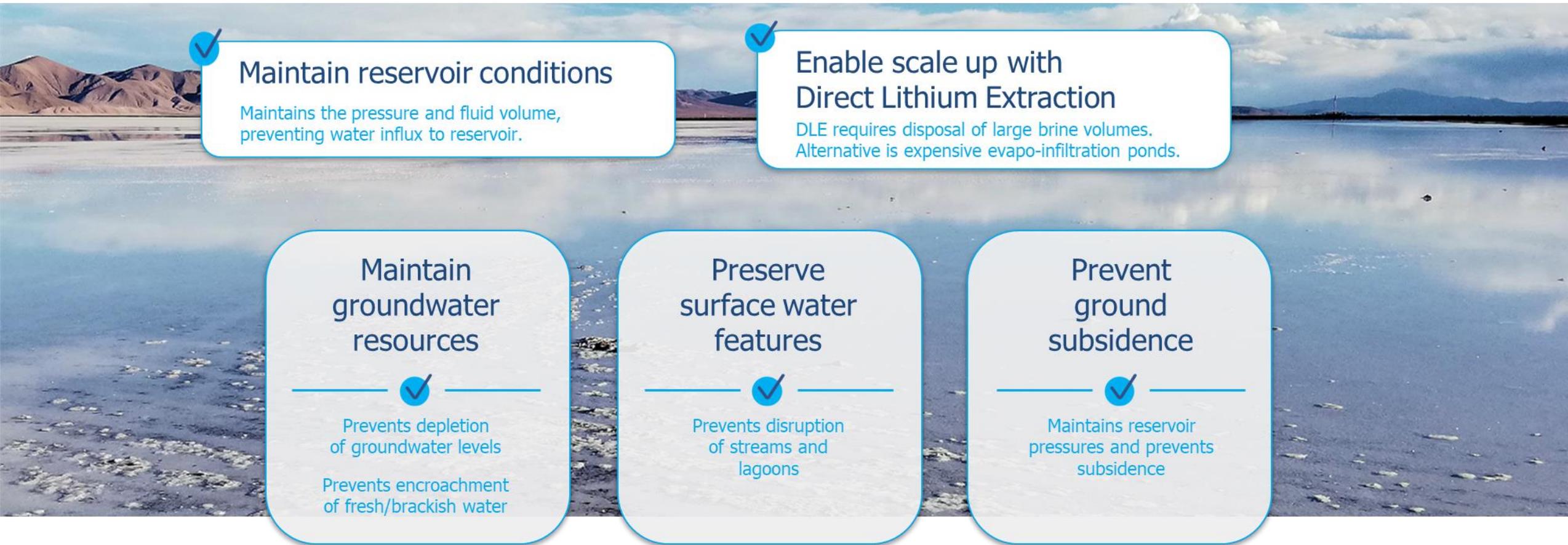




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Depleted Brine Management

- By recycling brine, the lithium industry can significantly reduce its environmental and social footprint.
- Recycling brine improves the overall efficiency of lithium extraction operations



✓ **Maintain reservoir conditions**
 Maintains the pressure and fluid volume, preventing water influx to reservoir.

✓ **Enable scale up with Direct Lithium Extraction**
 DLE requires disposal of large brine volumes. Alternative is expensive evapo-infiltration ponds.

Maintain groundwater resources

✓

Prevents depletion of groundwater levels
 Prevents encroachment of fresh/brackish water

Preserve surface water features

✓

Prevents disruption of streams and lagoons

Prevent ground subsidence

✓

Maintains reservoir pressures and prevents subsidence

1. Re-injection Project

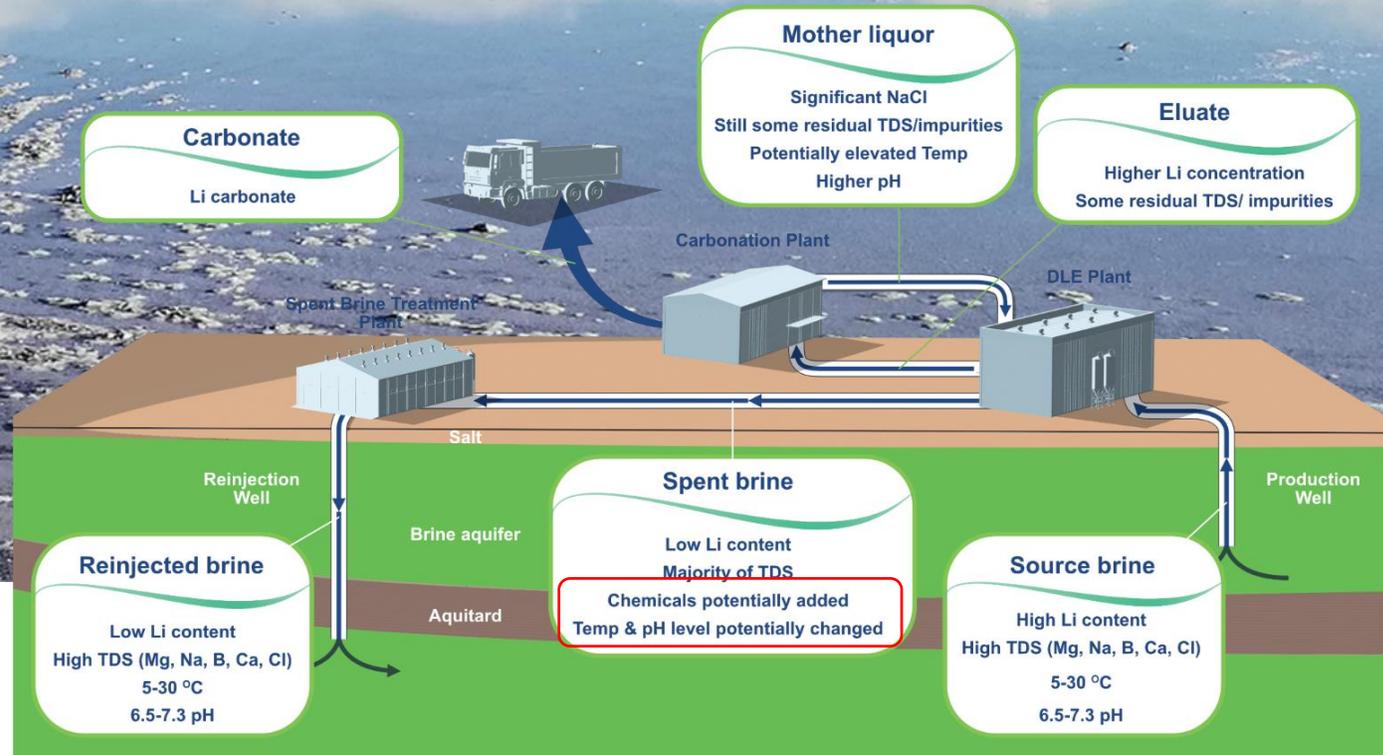


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Depleted Brine Management

! Brine chemistry changes on extraction
Care especially required where there is overlying brackish to freshwater

! DLE reagents change brine chemistry
Varies by technology
Can clog reinjection wells
Can create reservoir precipitates



Block diagram taken from Reinjection White Paper, 2024.