



SERFIM ENVIRONNEMENT

Polymer gel injection:

A scalable solution for in situ degradation of lindane

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Company overview

SERFIM ENVIRONNEMENT

Locations and facilities

SERPOL
TERENVIE
ECOFHAIR
REVALGREEN

TERECOVAL
SAR ENVIRONNEMENT
SERFIM RECYCLAGE
NANTET

CARRIÈRES MBTP
ENÈREGY
GEOAMBIENT



600
Employees

11
Companies

510,000 t
Recycled in 2024

160 M€
Revenue

SERPOL 4 business lines

200
Employees

8
Locations

38 M€
Revenue

- Subsurface environmental remediation works and projects
- Wastewater treatment
- Asbestos decontamination and removal
- Integrated landfill management

Certifications: ISO 9001 | MASE | QUALIBAT | LNE B & LNE C | ECOVADIS (silver)



GEOAMBIENT

SERFIM ENVIRONNEMENT

25

Employees

Engineers
Geologists
Environmental scientists
Hydrogeologists
Installers

4

Locations

Barcelona
Madrid
Oviedo
Valencia

> 800

Projects

Soil
Water
Waste
R&D&I

Certifications



Entidad
colaboradora
de la
administración
hidráulica

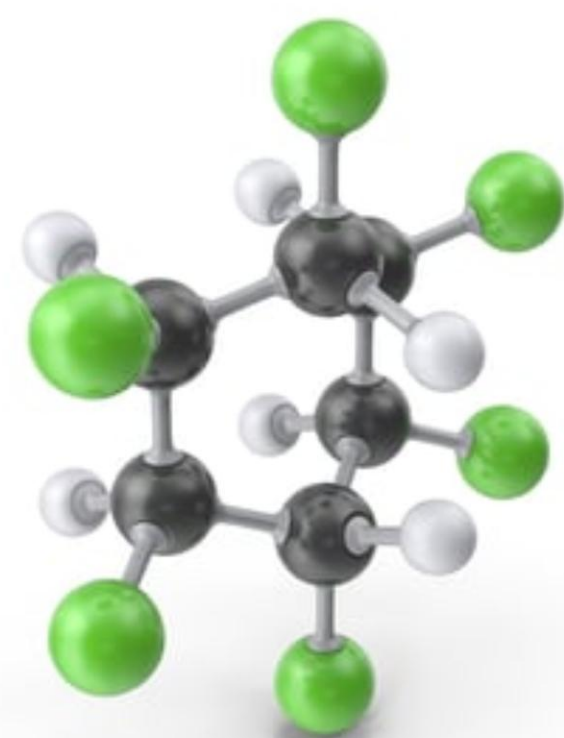
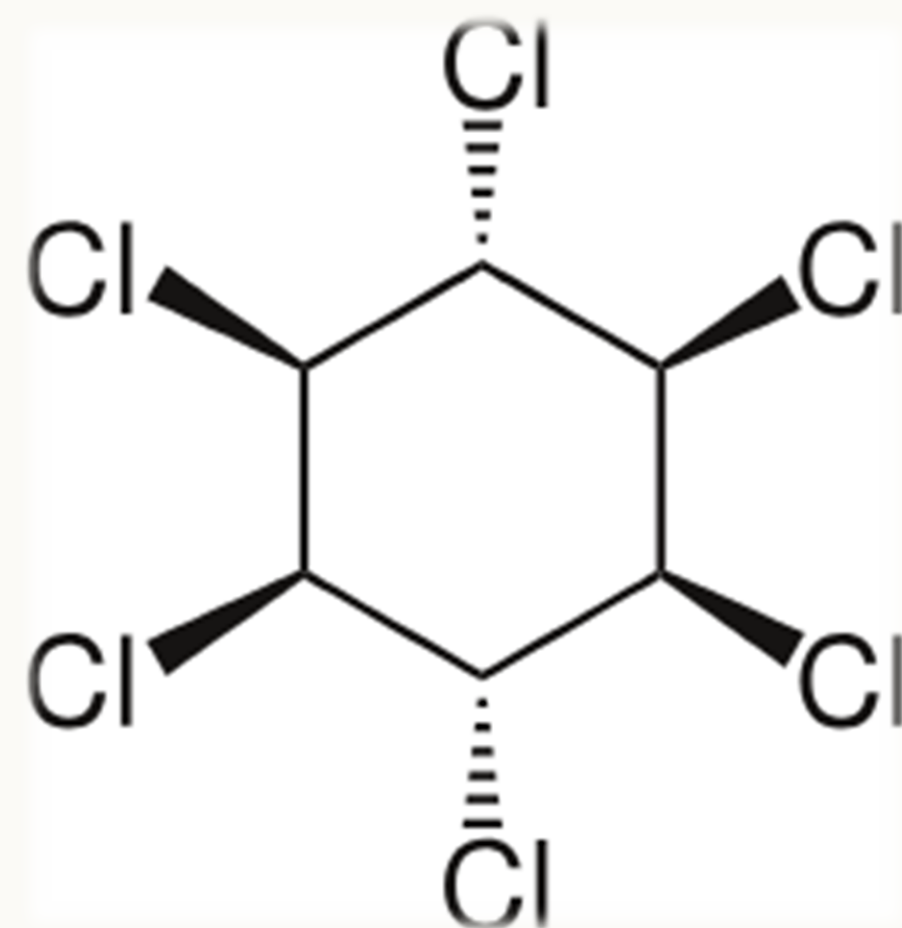




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Lindane (HCH)

Lindane (HCH)



A persistent legacy

ORIGIN AND PRODUCTION

- Organochlorine insecticide (γ -HCH) produced since the 1940s.
- 1 t product $\rightarrow$ 8–12 t of waste (α , β , δ -HCH)



PROHIBITION

- Persistent organic pollutant (POP)
- Banned in the EU in 2000
- Listed under the Stockholm Convention in 2009.
- Classified by IARC (2015) as carcinogenic to humans (Group 1).



Lindane (HCH)



A persistent legacy

ENVIRONMENTAL ISSUES

- Persistent
- Bioaccumulative
- Neurotoxic and carcinogenic (Group 1)
- Waste in uncontrolled landfills.
- DNAPL form with chlorobenzenes
- Generates aquifer plumes lasting decades.

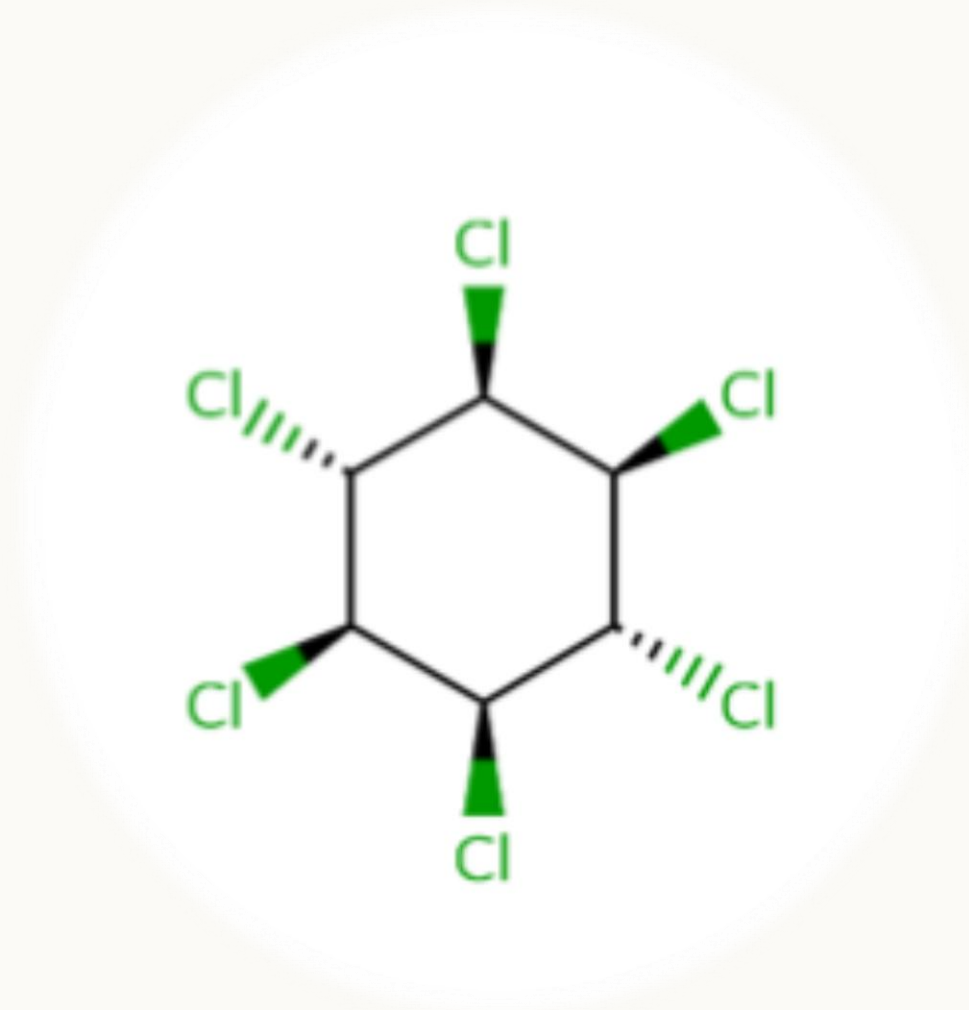
EUROPE-WIDE PROBLEM

- Areas heavily impacted by production waste
- Not treatable with conventional techniques



Reactive gel

Reactive gel: Properties



LINDANE

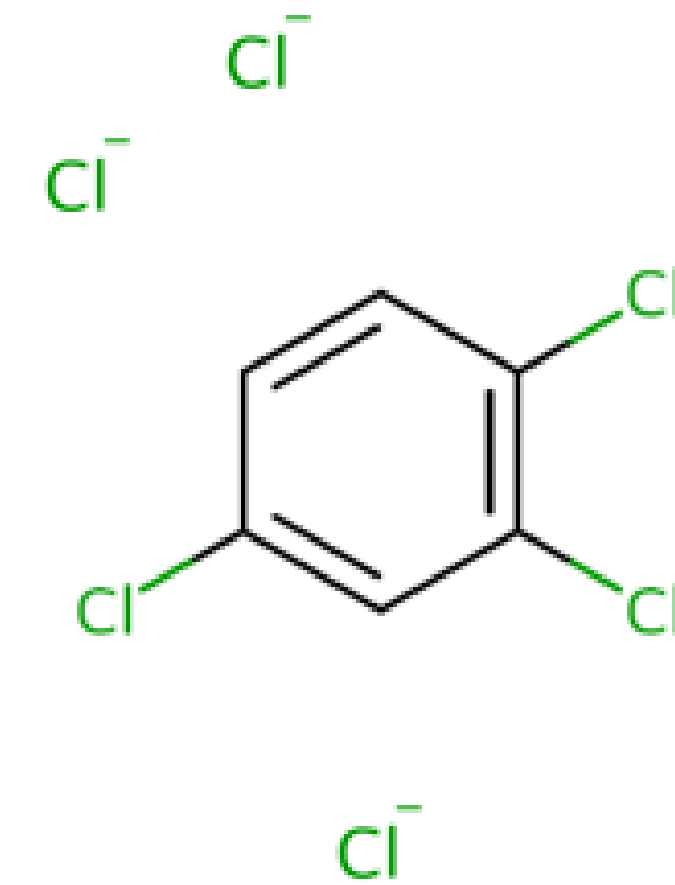
Persistent organic pollutant
(POP)

Low mobility
(low vapor pressure and solubility)

NOT TREATABLE

By conventional methods

+
ALKALINE
AGENT



1,2,4-Trichlorobenzene

Not classified as POP

Much higher mobility
(vapor pressure x400)

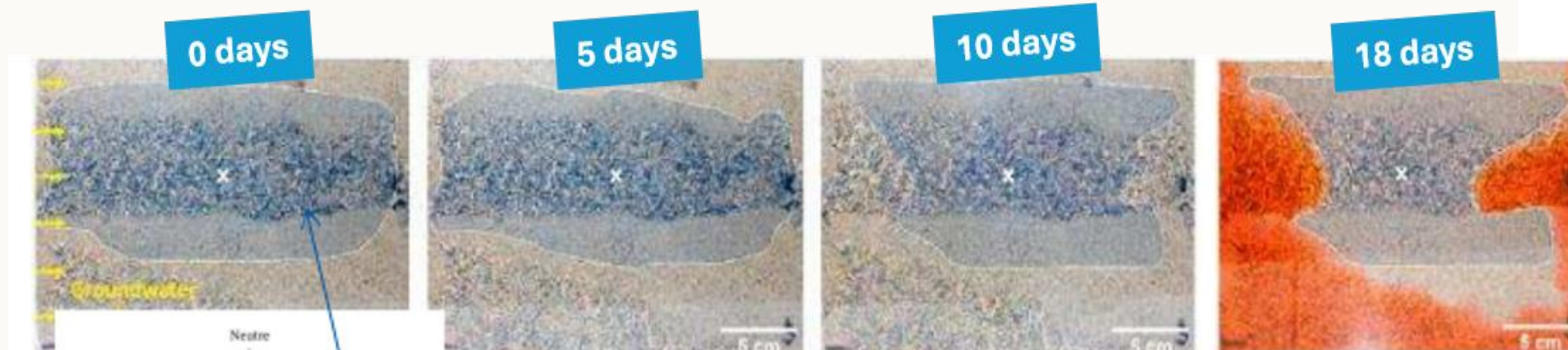
TREATABLE IN SITU

By conventional methods
(sparging/venting)

Reactive gel: Advantages

The gel spreads predictably in both high- and low-permeability zones

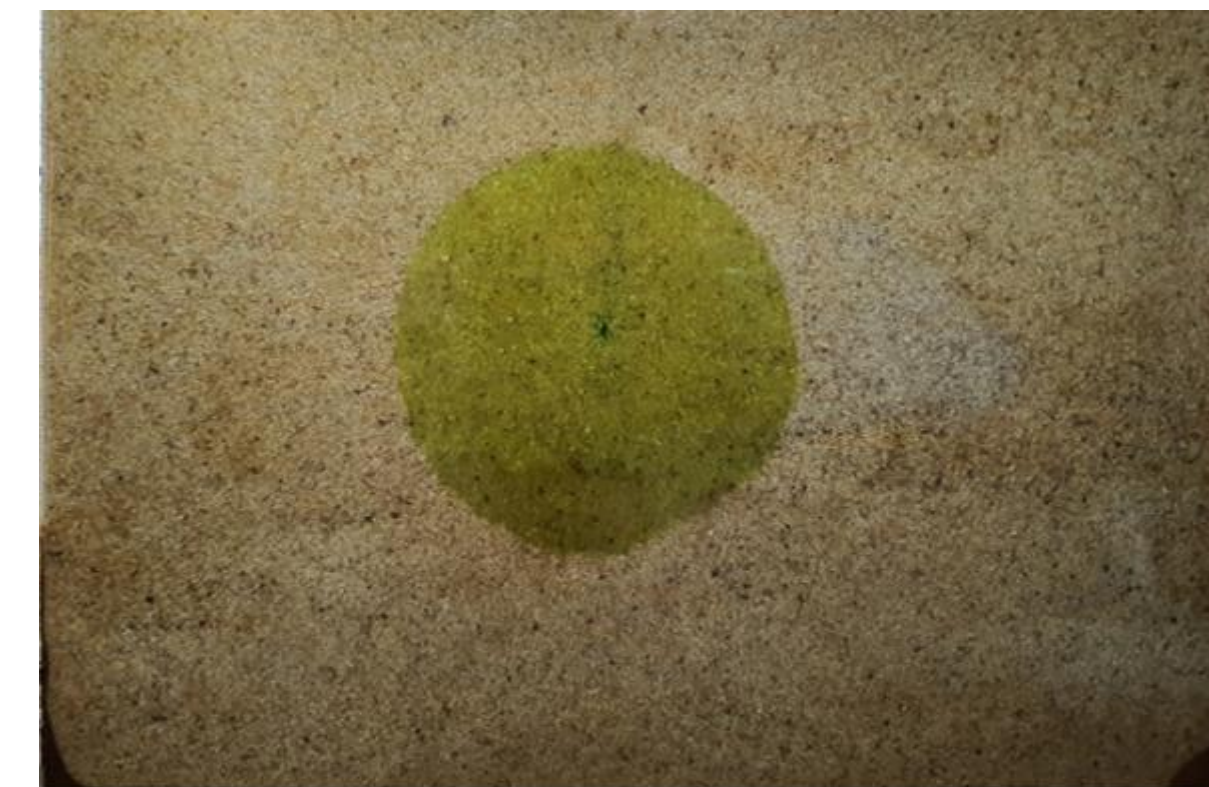
The gel remains in place for long periods despite washout by groundwater (saturated zone) or gravity drainage (unsaturated zone)



Bouزيد et al.



Aqueous reagent
Sensitive to gravity
Poor ROI



Gelled reagent
Insensitive to gravity
Good ROI, predictable



Pilot test in the unsaturated zone

Pilot test

Unsaturated zone

Particular case

Mono-waste landfill of lindane production waste

- Location within an active industrial plant
- Heterogeneous lithology: clayey silts, sands and gravels
- Presence of pure lindane waste
- Elevated deposit bounded by rockfill walls
- Irregular topography with steep slopes
- Waterproofed with surface capping
- No base/sidewall lining of the landfill
- Water level with high seasonal fluctuation
- Very high α - and β -HCH concentrations (up to 65 g/kg and 2 g/kg)



Pilot test

Unsaturated zone

Initial approach

Phase 0. Characterization and preliminary tests.

Phase 1. Initial setup.

Phase 2. Reactive gel injection.

Phase 3. Post-injection monitoring, venting and pumping.

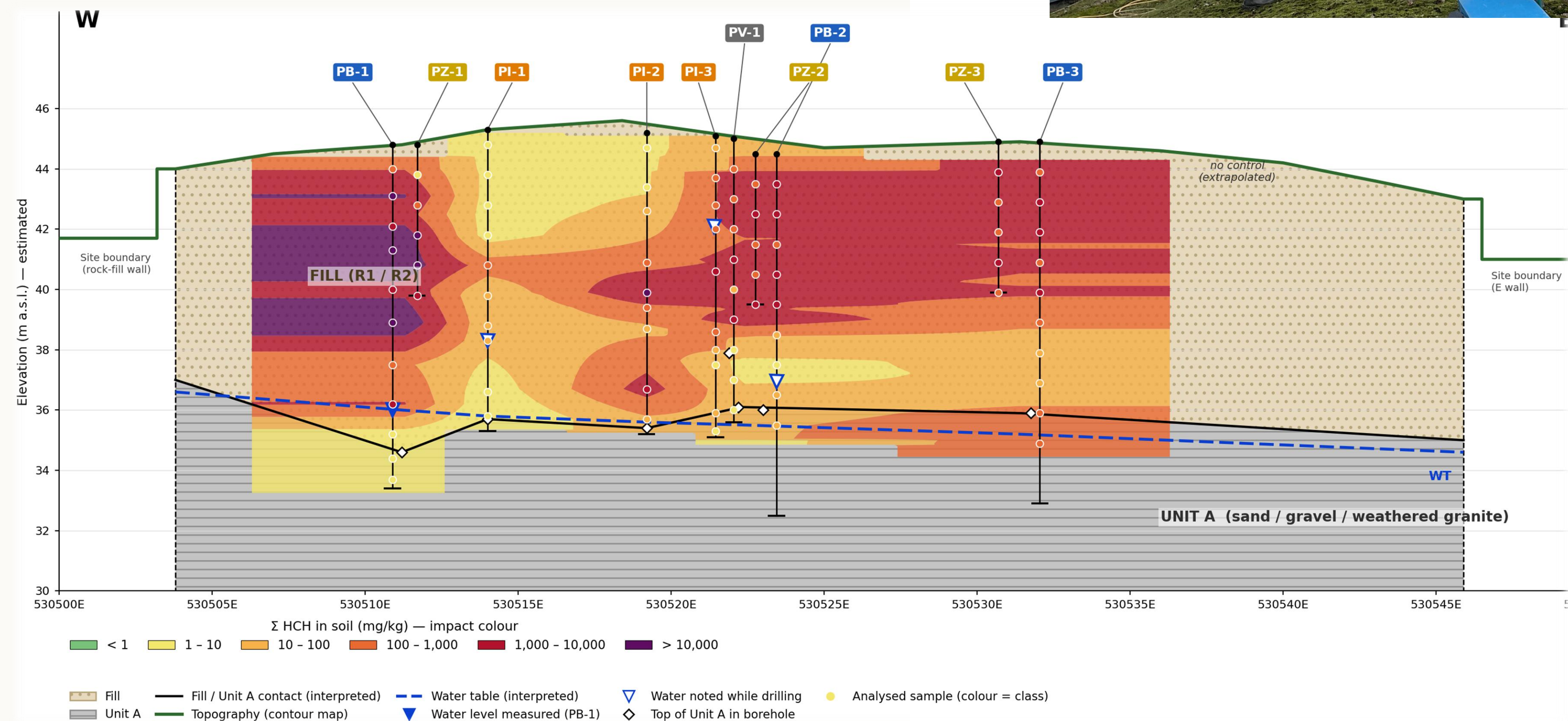
Phase 4. Final monitoring.



Pilot test

Unsaturated zone

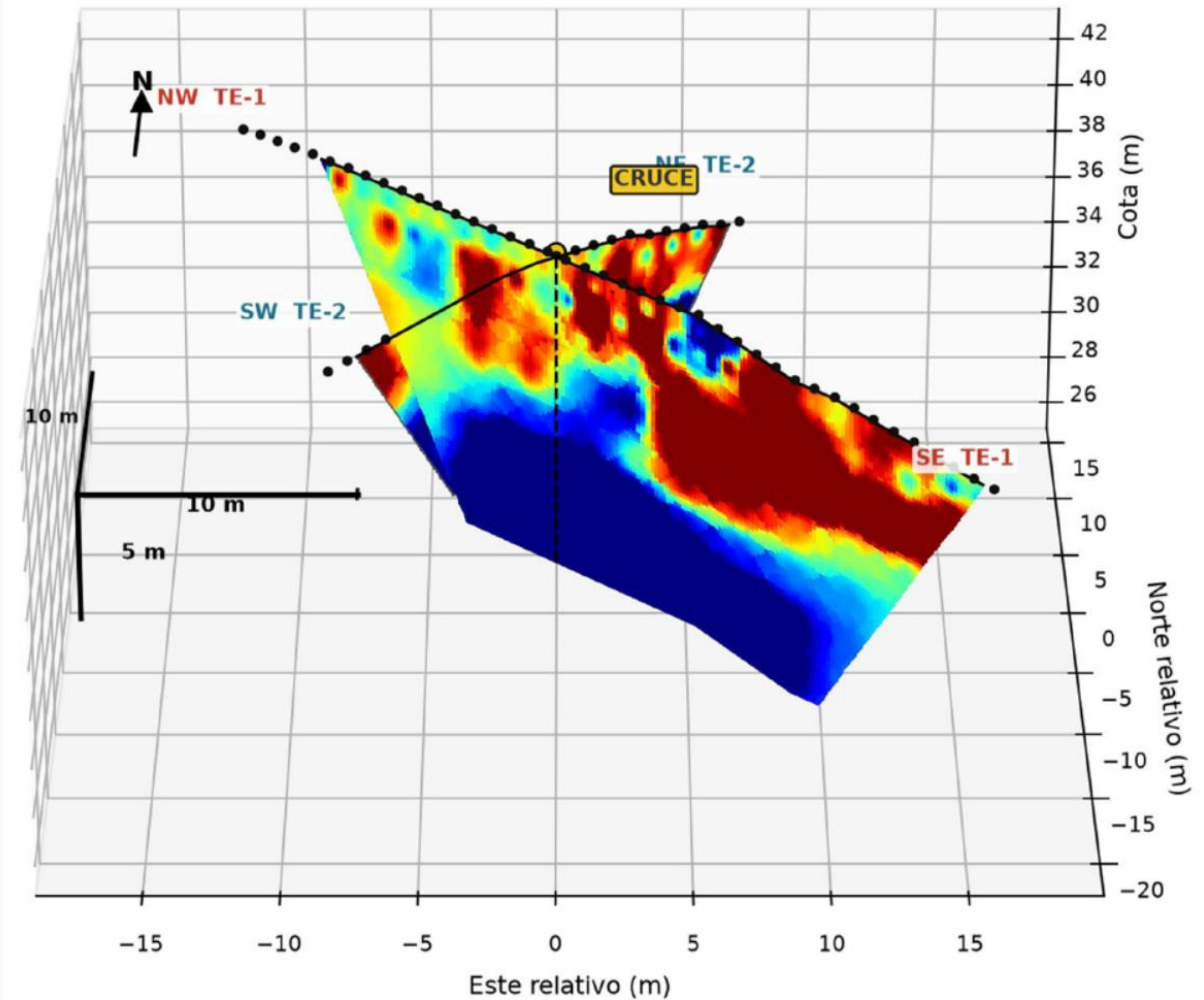
Phase 0. Characterization and pre-tests.



Pilot test

Unsaturated zone

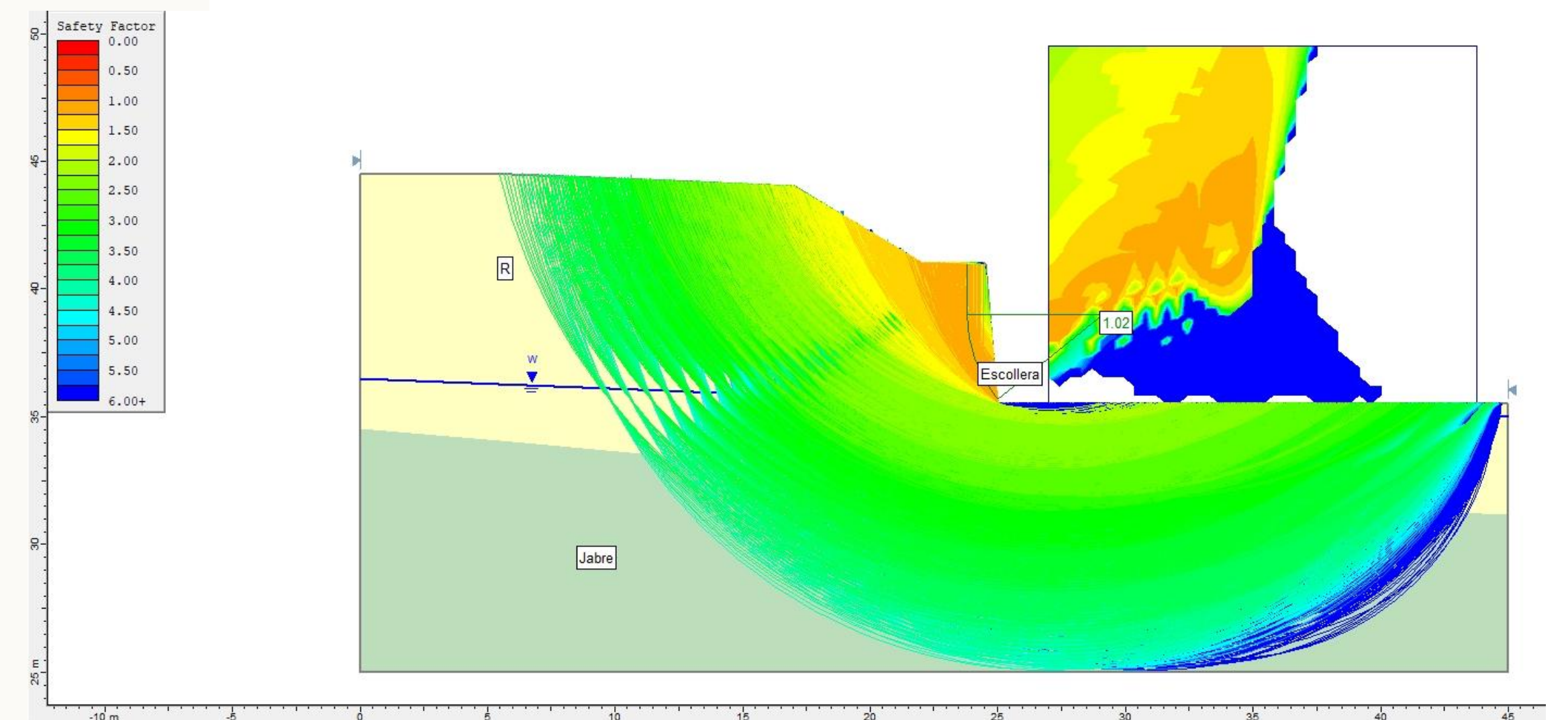
Phase 0. Characterization and pre-tests.



Pilot test

Unsaturated zone

Phase 0. Characterization and pre-tests.

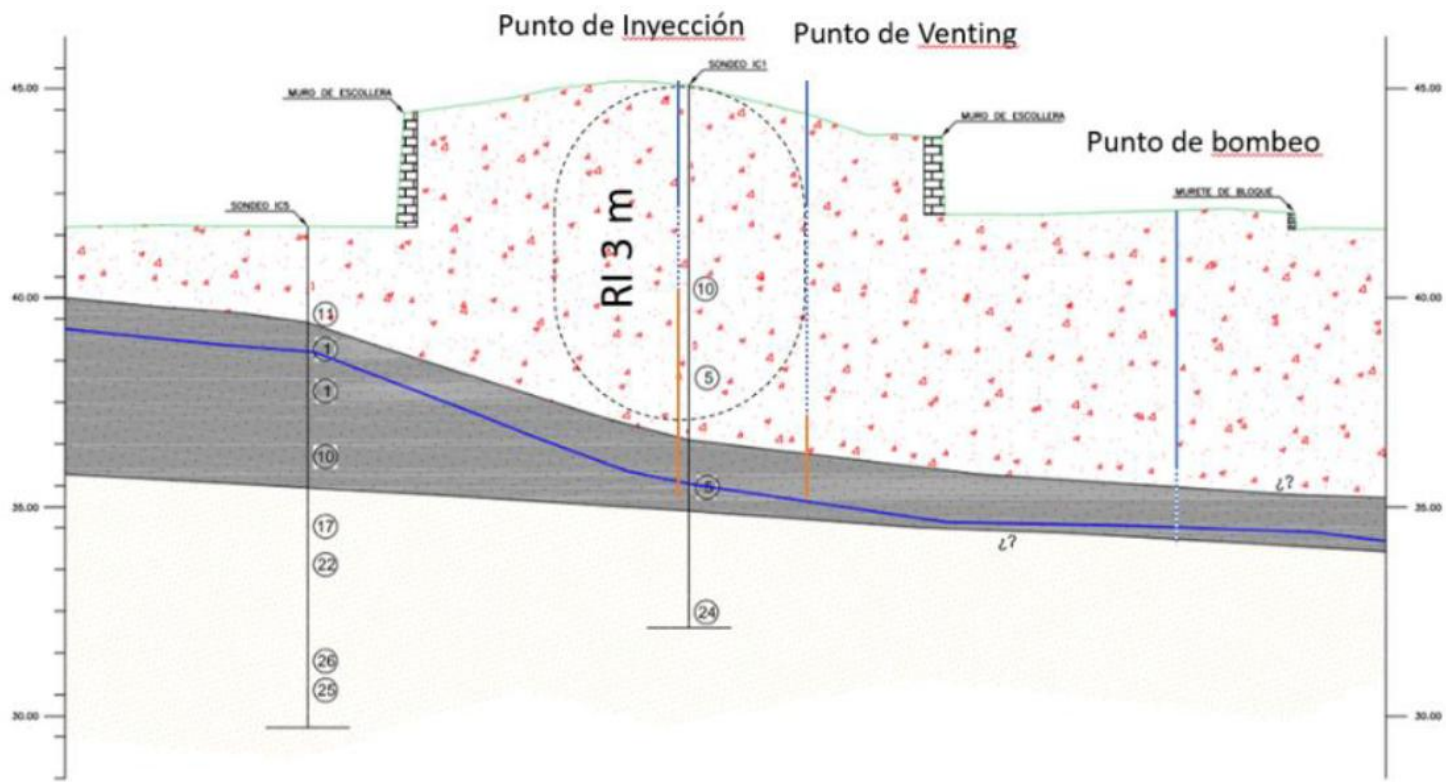


Pilot test

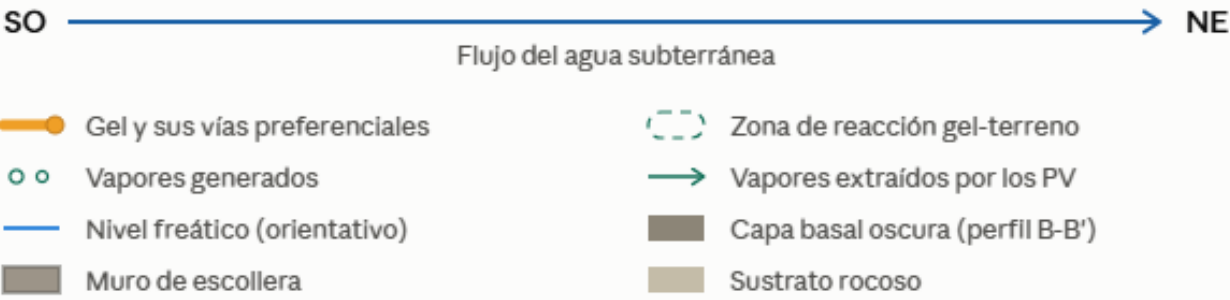
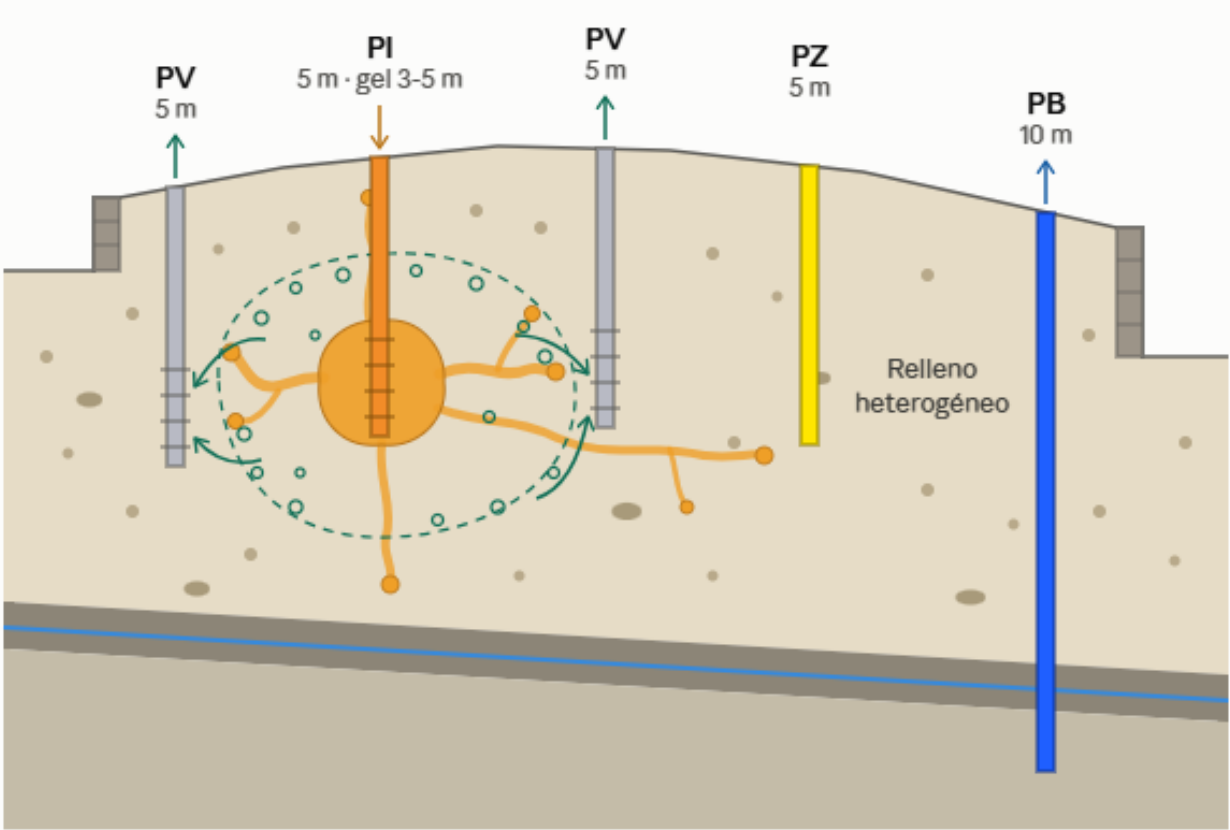
Unsaturated zone

Initial approach

Phase 1. Initial setup.



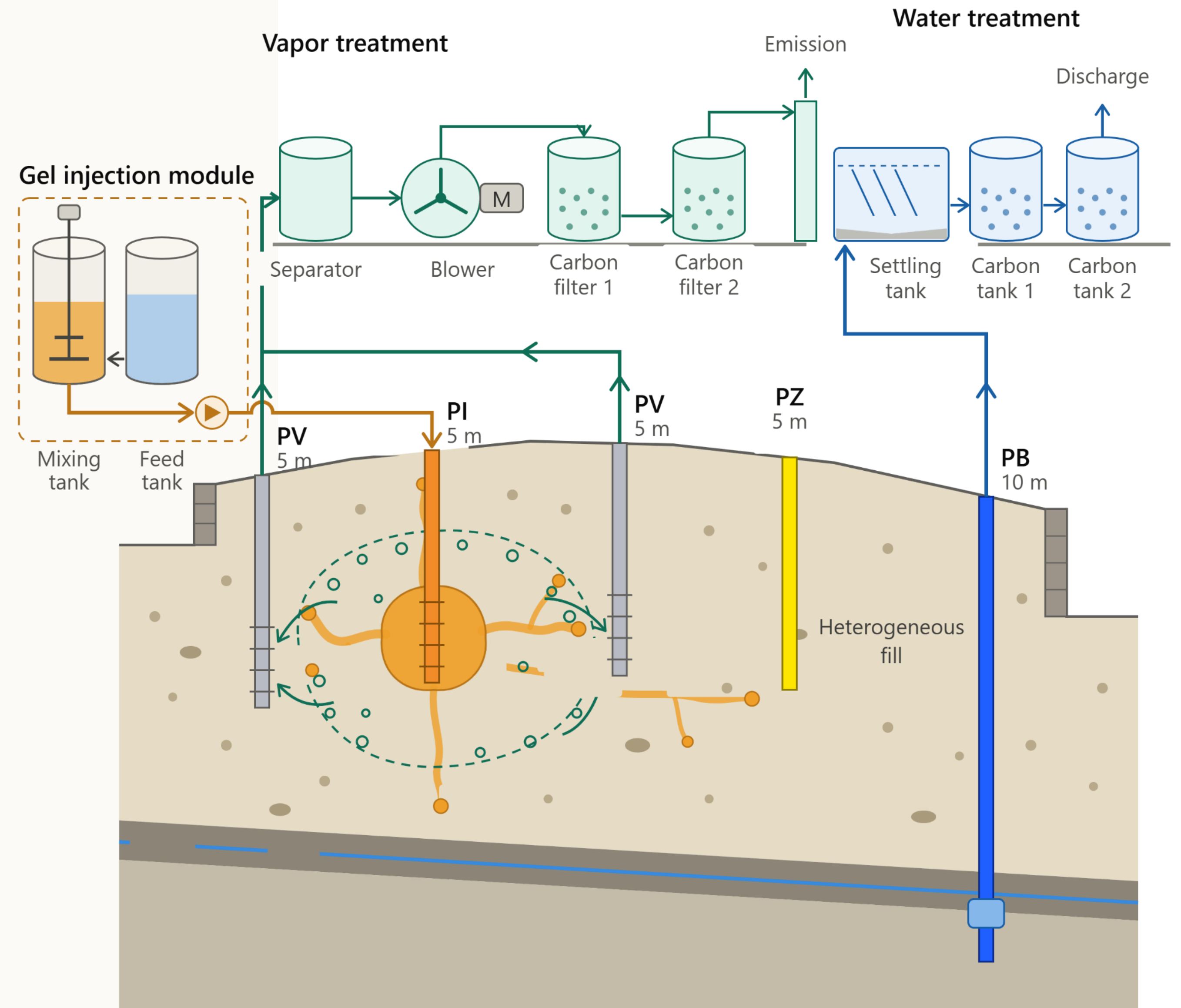
Layout staking



Pilot test

Unsaturated zone

Phase 1. Initial setup.



Pilot test Unsaturated zone

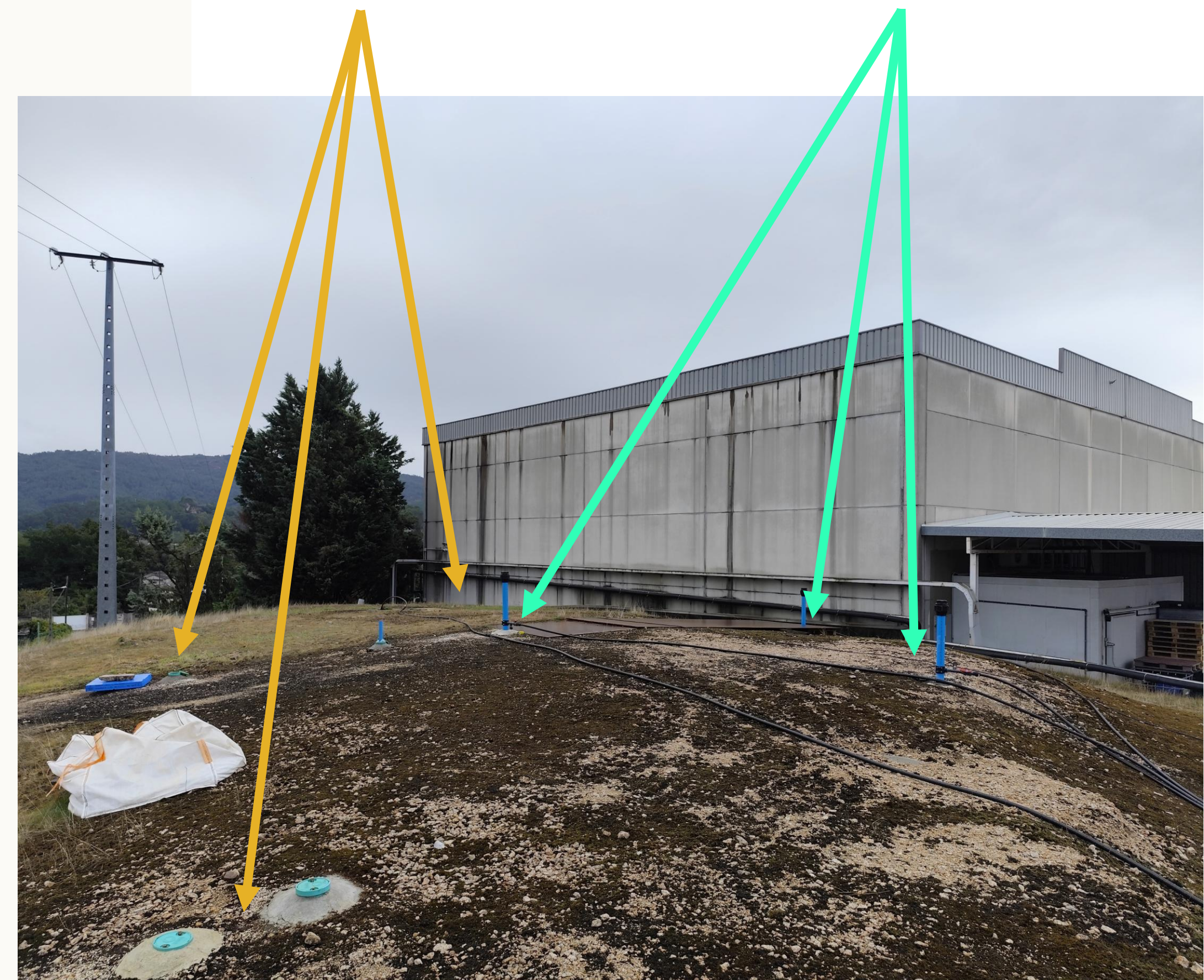
Phase 2. Reactive gel injection.



Control/pumping



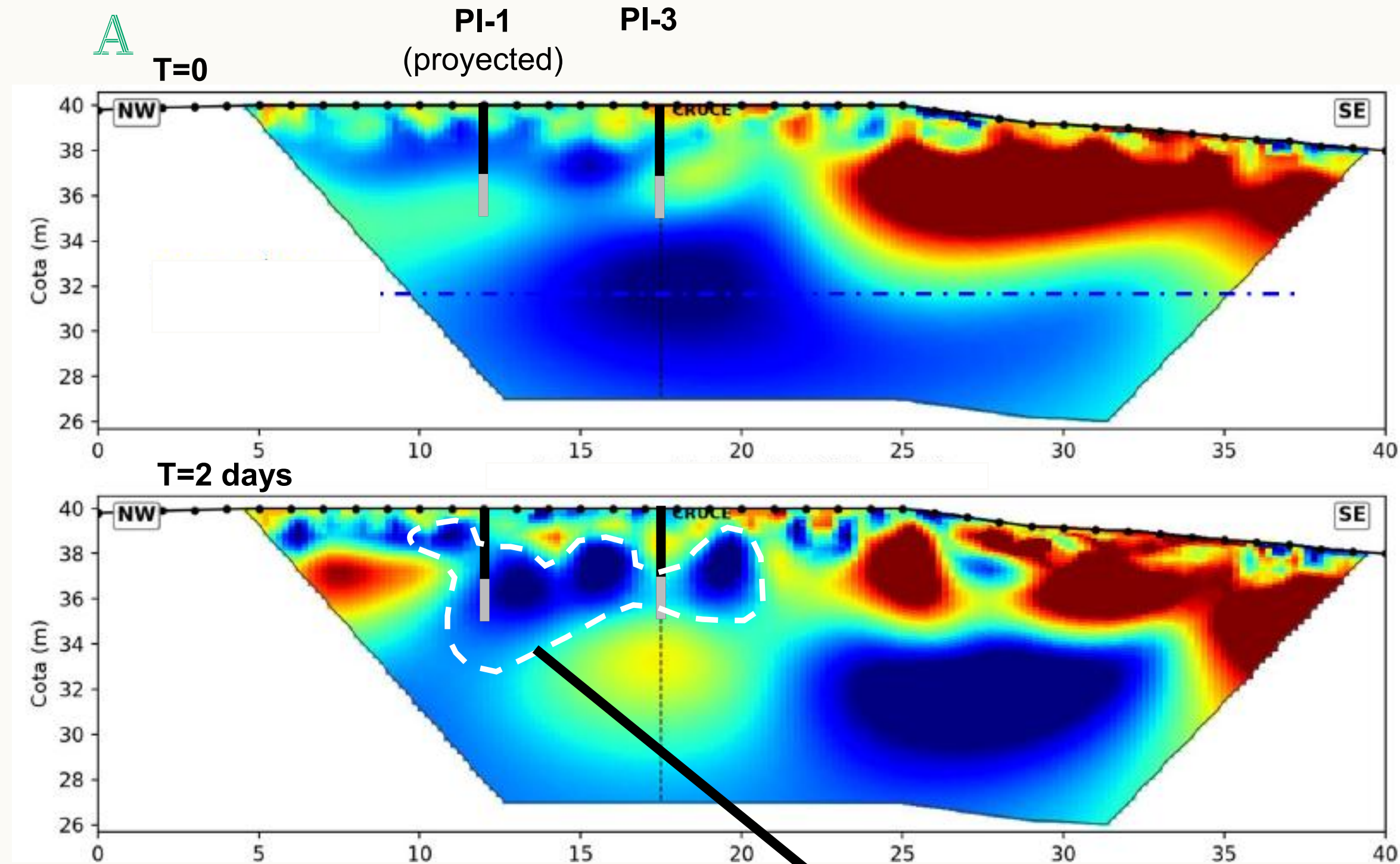
Injection



Pilot test

Unsaturated zone

Phase 2. Reactive gel injection.



Reactive gel



Pilot test

Unsaturated zone

Next phases

Phase 0. Characterization and pre-tests.

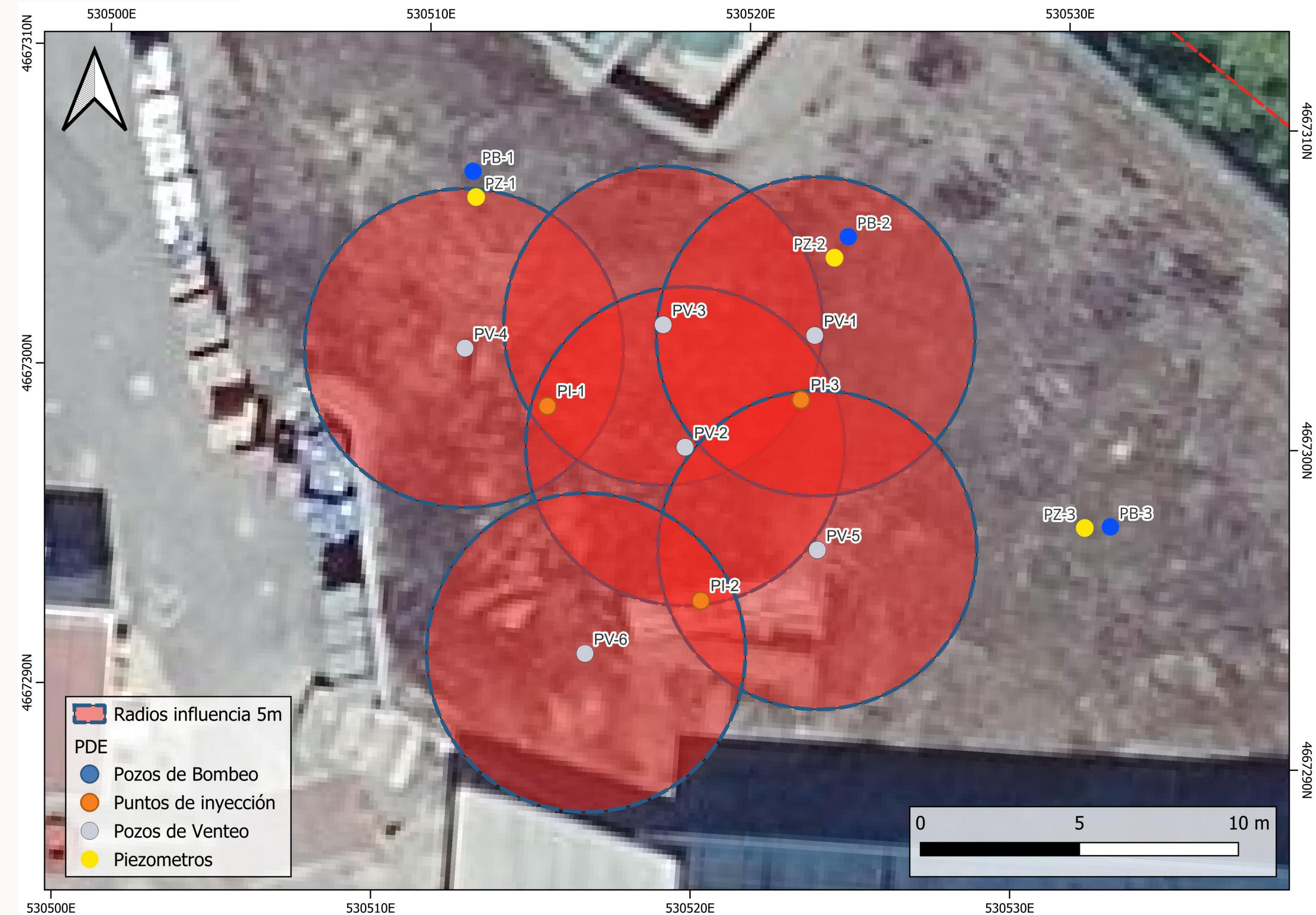
Phase 1. Initial setup.

Phase 2. Reactive gel injection.

Phase 3. Post-injection monitoring, venting and pumping.

Phase 4. Final monitoring.

Final evaluation of the new methodology.



To be continued...



Conclusions

Conclusions

- 1** Pseudoplastic gels combine **high viscosity** with **low injection pressure**.
- 2** The radius of influence exceeds several meters.
- 3** The gel **spreads homogeneously** in all directions, including upward and upgradient, even when injected into high-permeability unsaturated zones or high-velocity aquifers. **Spreading is predictable**.
- 4** Gel propagation can be **readily monitored by real-time electrical resistivity tomography**, which allows the treatment to be guided.
- 5** As a **reagent carrier**, the gel remains in place for months after injection, **increasing the contact time between the reagent and the adsorbed contaminant**.
- 6** In the soil it occupies, the gel blocks water flow, making it a viable option for temporary containment.



Thank you

for your time

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