

intersoil'2026

International Conference on Soils, Sediments and Water

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International Conference
on Soil, Sediment and Water
Contamination

SCIENCE
SOLUTIONS
SUSTAINABLE LAND

CLEANER
GROUNDWATER
BRIGHTER
FUTURES

*In-situ reductive dechlorination by direct push injection
of groundwater contaminated with perchloroethylene*

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Contents

Site

Location, context and conceptual model

Treatment methodology applied

ISCR

Contaminant degradation pathway

PCE and degradation products $\text{TCE} \rightarrow \text{DCE} \rightarrow \text{VC} \rightarrow \text{ethene}$

Remediation progress

Progress and monitoring

Conclusions

Former facility



Textile production
for the automotive
industry



Activity ceased in 2009



Located a few meters from a
river



Groundwater impact from the
former activity

Currently

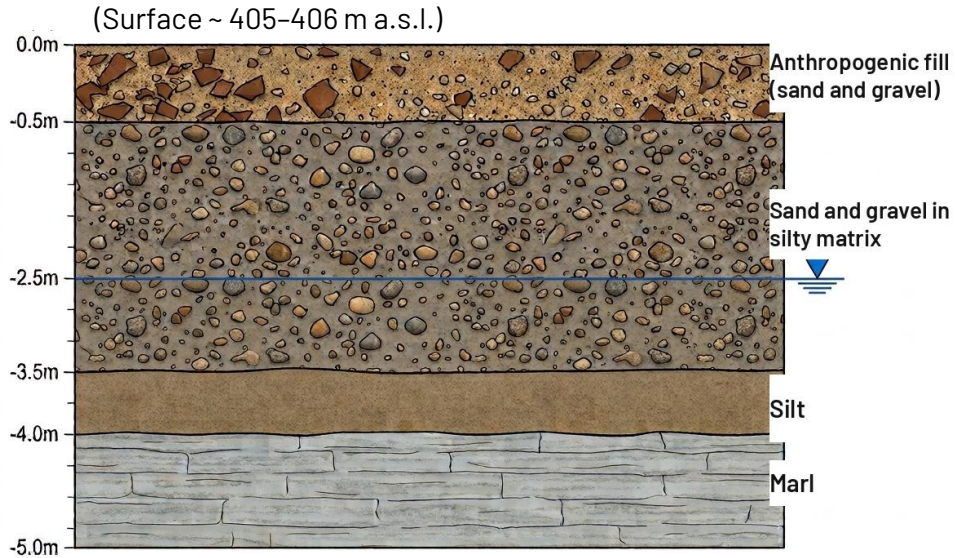


Wholesale supermarket

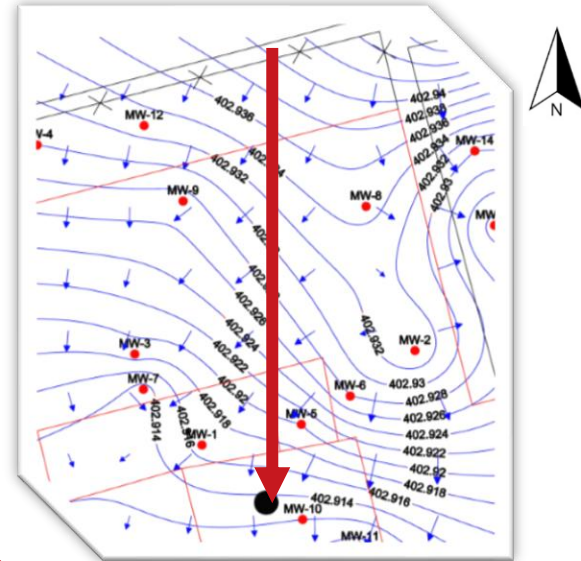


The site is located in a **well-established industrial area**, close to a **sensitive receptor** (a river) and **groundwater impact** associated with the former activity

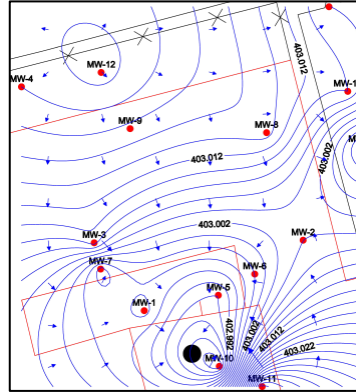
Geological profile



Main direction and orientation of groundwater flow



Shallow aquifer in alluvial materials, **with preferential groundwater flow toward the south**



Total:
23 PIEZOMETERS
28 VAPOR PINS

Over a decade of
investigation before the
intervention...

2011

**Start of
exploratory and
detailed
investigations**
(former owner)

2019

**Detailed investigations
and risk assessment** for
the new activity (current
owner)

2021

**Detailed investigation
of soil and
groundwater**

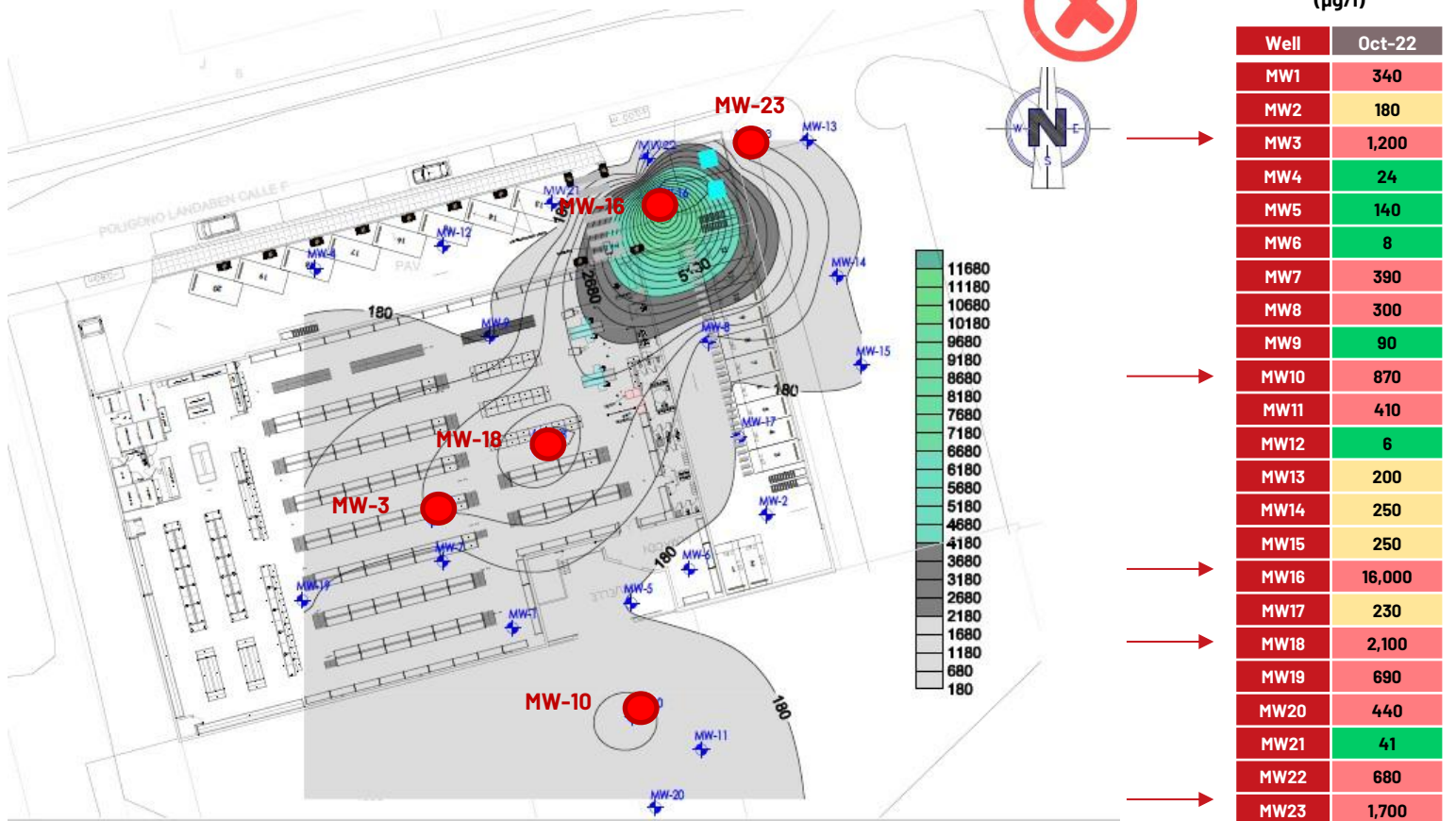
2022

**Supplementary
characterization**

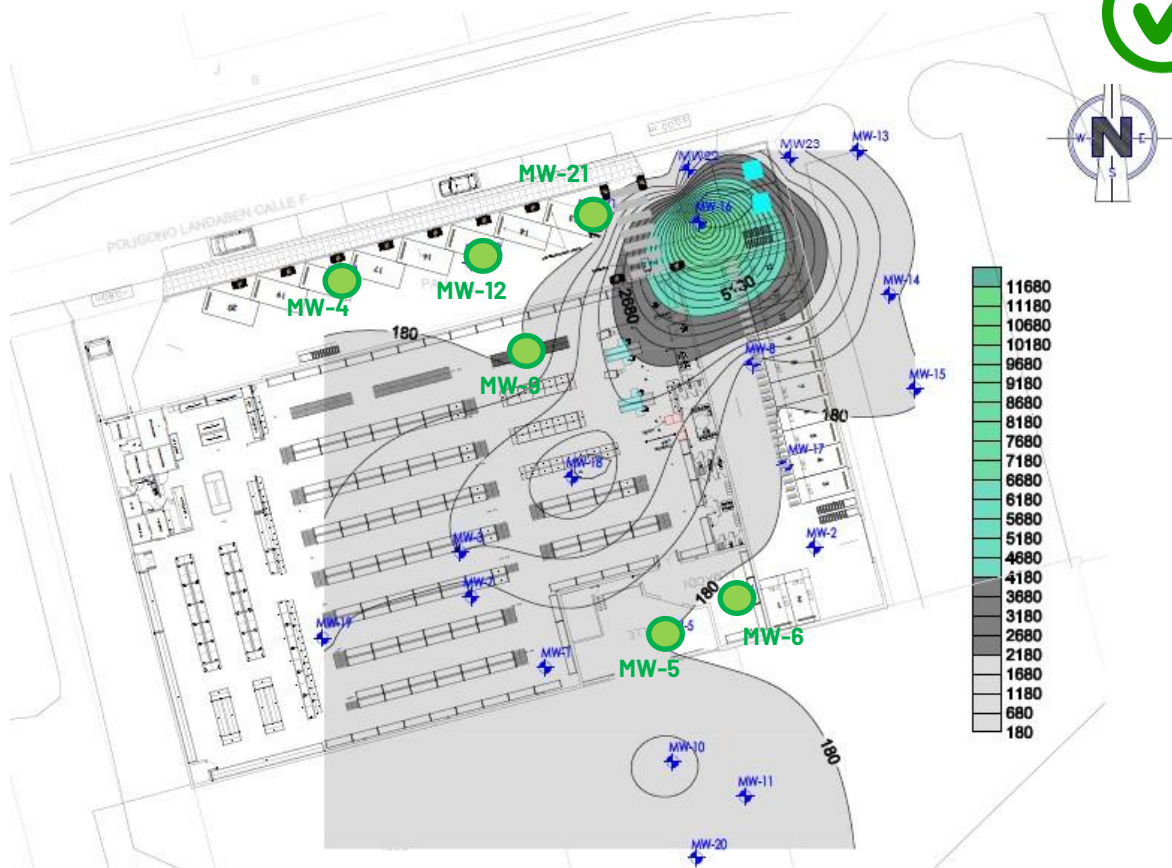
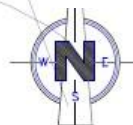
2023

Approval by the River
Basin Authority (CH)
and start of **treatment**

SITE: Initial conditions



SITE: Initial conditions



Initial PCE concentrations
(µg/l)

Well	Oct-22
MW1	340
MW2	180
MW3	1,200
MW4	24
MW5	140
MW6	8
MW7	390
MW8	300
MW9	90
MW10	870
MW11	410
MW12	6
MW13	200
MW14	250
MW15	250
MW16	16,000
MW17	230
MW18	2,100
MW19	690
MW20	440
MW21	41
MW22	680
MW23	1,700

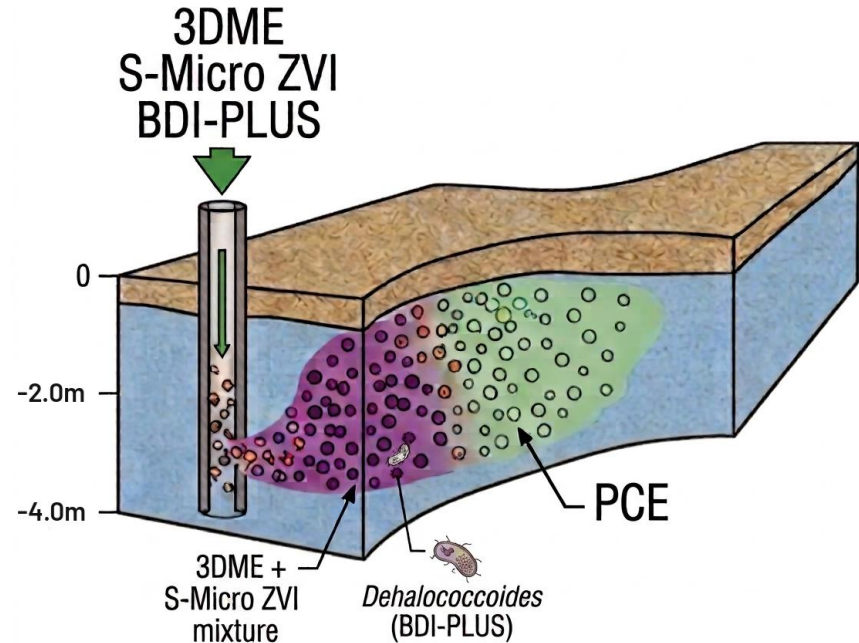
Long-lasting hydrogen release
3-D Microemulsion (3DME)

+

Reagent made of zero-valent iron microparticles
(S-MicroZVI)

+

Additionally, at the most contaminated points
Bio-Dechlor INOCULUM Plus (BDI-PLUS)



CHEMICAL and BIOLOGICAL treatment

3-D Microemulsion (3DME)

3DME is made up of three electron-donating sources:



Free lactate

Readily available electron source



Lactic acid tetramers (polylactate)

Controlled, medium-term electron release



Fatty acids

Mainly unsaturated C-18 fatty acids (such as oleic acid).
Controlled release of electrons (hydrogen) into groundwater for more than 5 years

3-D Microemulsion Release Profile

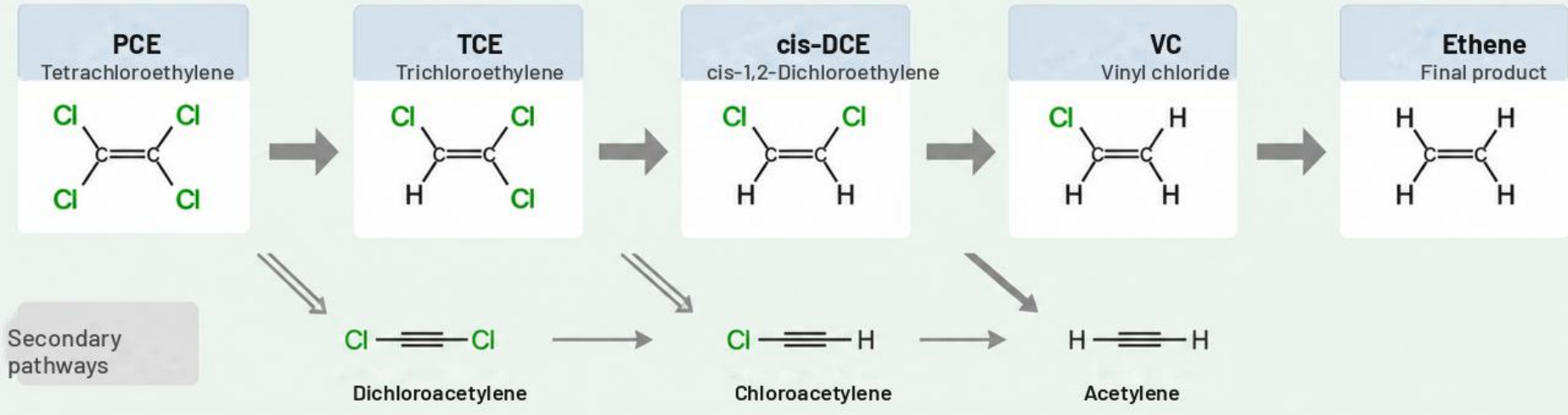


A **synergistic combination** of carbon sources that provide a **sustained release of electrons** to promote the reductive degradation of chlorinated compounds in the aquifer

S-MicroZVI (or S-mZVI)

S-MicroZVI **destroys contaminants abiotically and is applied to stimulate enhanced bioremediation**

Reductive degradation of chlorinated compounds



S-MicroZVI boosts chlorinated compounds removal through **abiotic reductive degradation**, complementing **natural bioremediation**

Bio-Dechlor INOCULUM Plus (BDI PLUS®)



Natural bacterial consortium containing
Dehalococcoides sp. (Dhc)



Stimulates rapid dechlorination

Accelerates the degradation of chlorinated compounds under reducing conditions



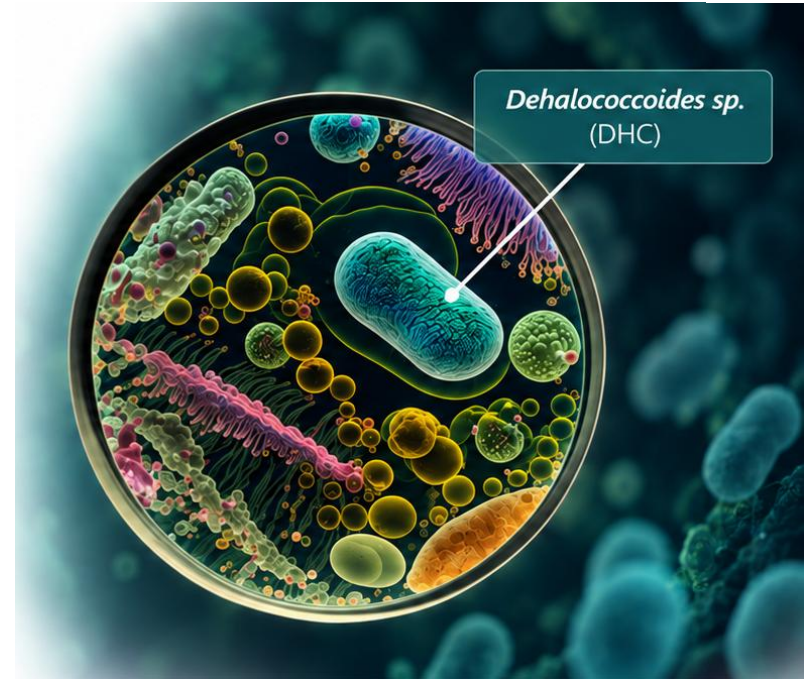
Complements the degradation of chlorinated solvents

Acts on PCE, TCE, DCE, VC

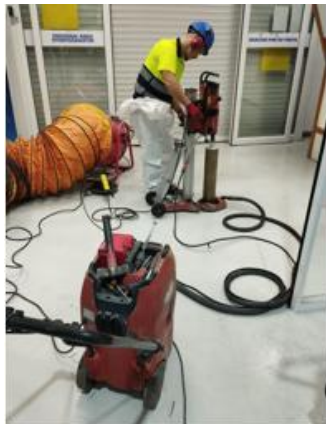


Non-toxic end products

Complete conversion to ethene, carbon dioxide and water



TREATMENT METHODOLOGY APPLIED: *The intervention – a single injection*



a



b



c



d



e



f



g

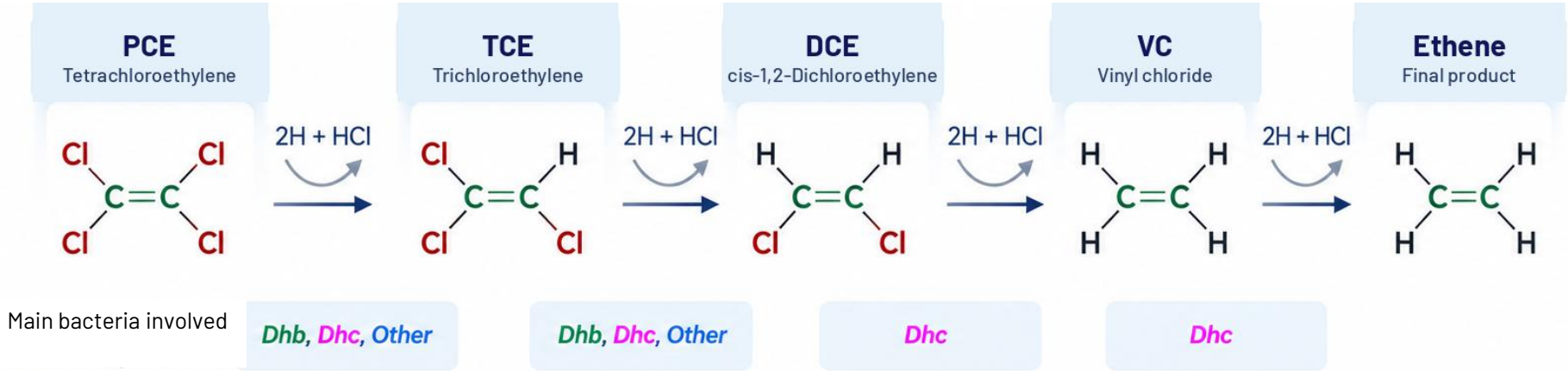


h



i

CONTAMINANT DEGRADATION PATHWAY: *Biochemical reduction*



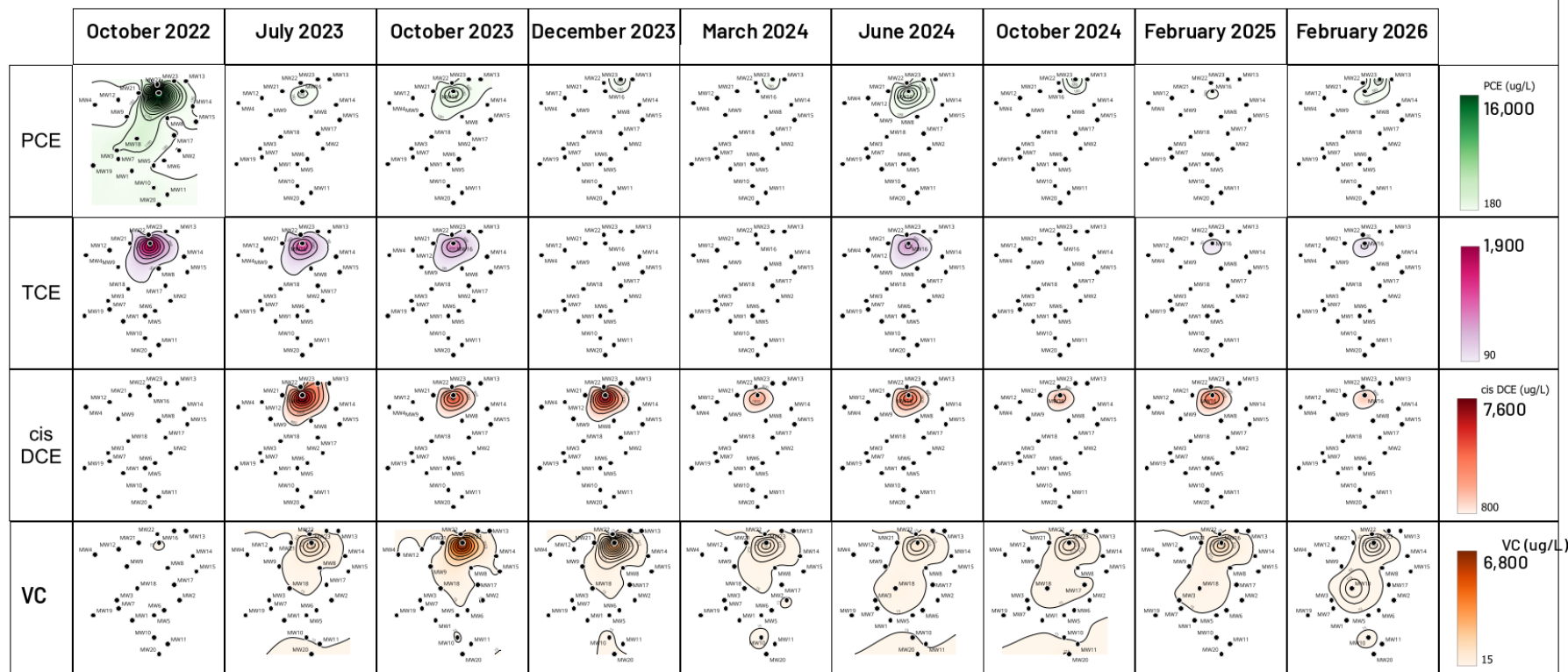
Decrease in bacterial population during degradation



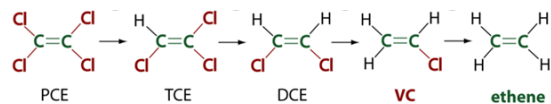
Dhb - *Dehalobacter* spp.
Dhc - *Dehalococcoides* sp.

The **reductive degradation of PCE** occurs **sequentially**, removing one chlorine atom at each step, until forming **ethene**, a final product that is **non-toxic**

REMEDIATION PROGRESS

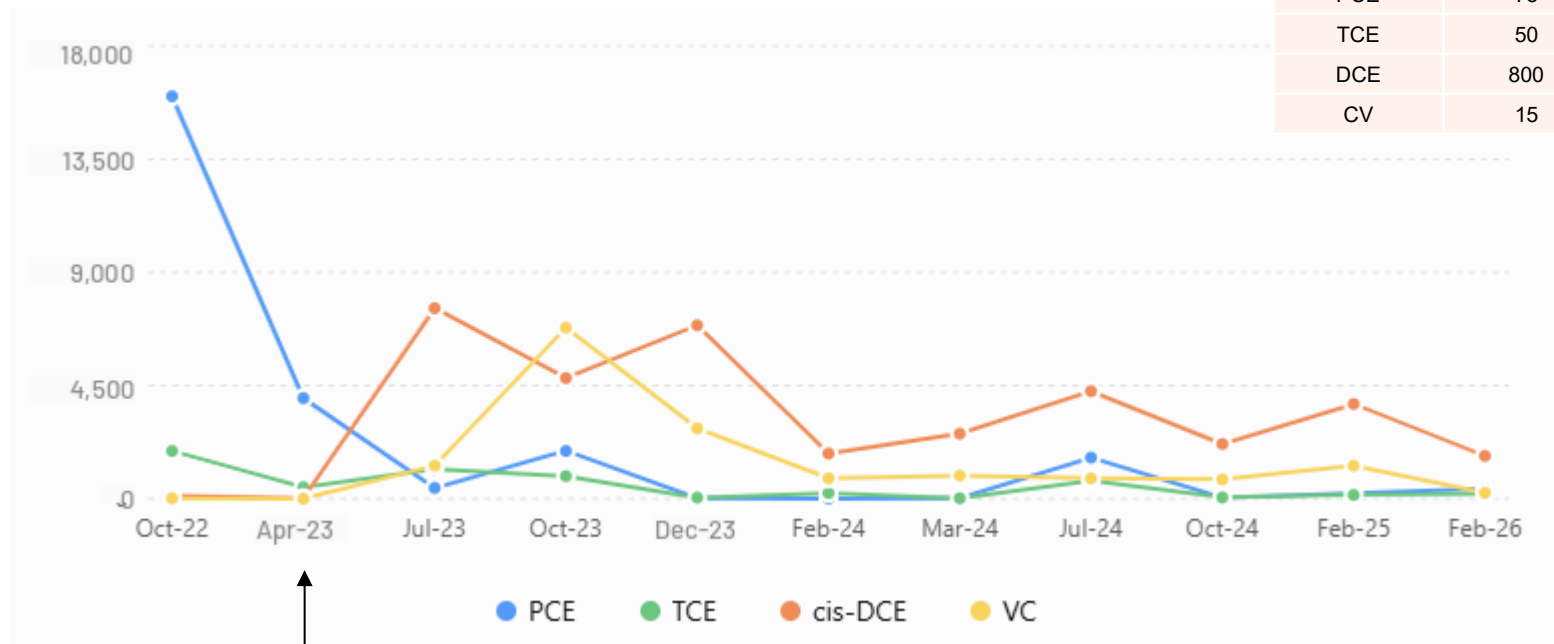


ETHENE



MW16 – Trend of PCE and degradation products

Compound	VGI (µg/l)
PCE	75
TCE	50
DCE	800
CV	15

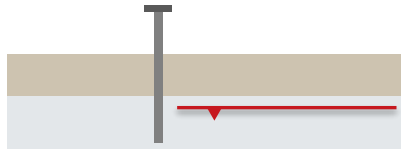


Injection



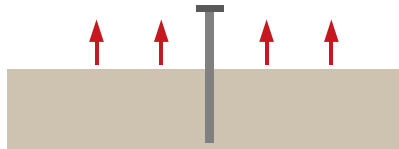
GROUNDWATER

- Periodic monitoring of groundwater quality during remediation.
- Tracking of degradation by-products.



SOIL GAS

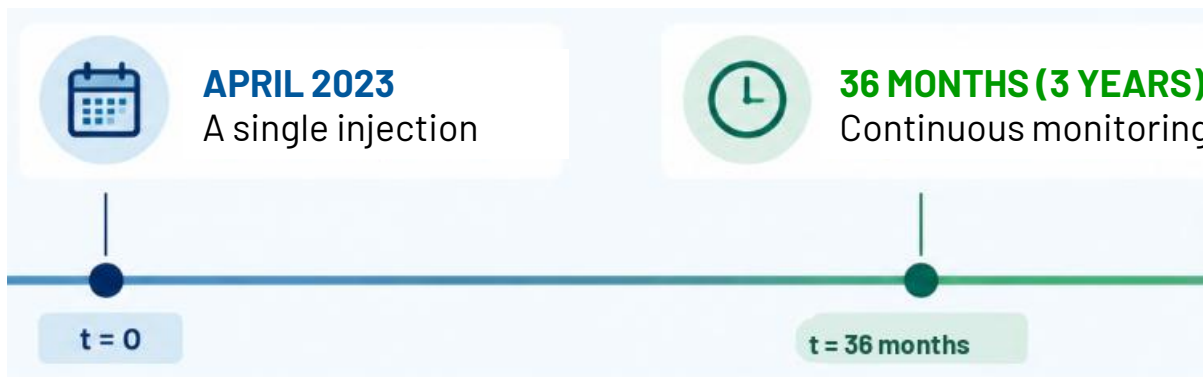
- Continuous monitoring of soil gas during remediation.
- Control of volatile organic compounds (VOCs) and degradation by-products.



RISK ANALYSIS

- Quantitative risk assessment updated to account for degradation by-products.
- Risk continues to be considered acceptable.





PCE

Significant decrease
in concentrations

Continued dechlorination

The reductive degradation
process continues

Intermediate products evolve

Formation followed by reduction
of intermediate compounds is
observed

Treatment is still active

Concentrations above
generic reference values (VGI)
still remain

1. A single injection produced a prolonged system response
2. The evolution of PCE, TCE, DCE and VC is consistent with sequential reductive dechlorination
3. Groundwater and soil gas monitoring make it possible to maintain control over the associated health risk of contaminants and their degradation products
4. After 36 months, the process continues, although not all remediation objectives have been fully achieved to date.

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