



# TECHNOLOGY DEVELOPMENT PROJECT REMEDIATION OF GROUNDWATER PLUMES IN DENMARK

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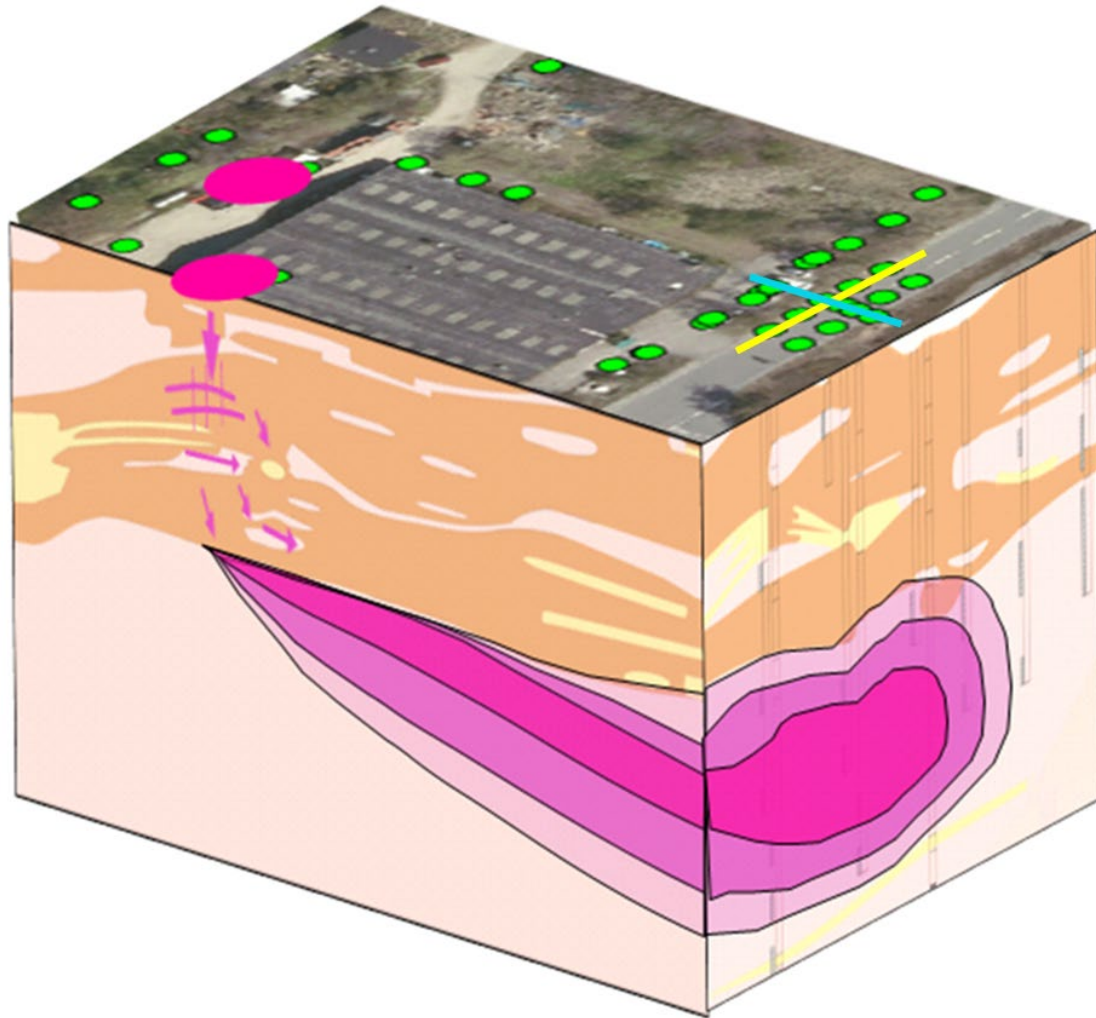
**REGENESIS**

# AGENDA

- Background DK
- Method
- Baseline investigation
- Injection design
- Monitoring – groundwater
- Challenges and lessons learnt



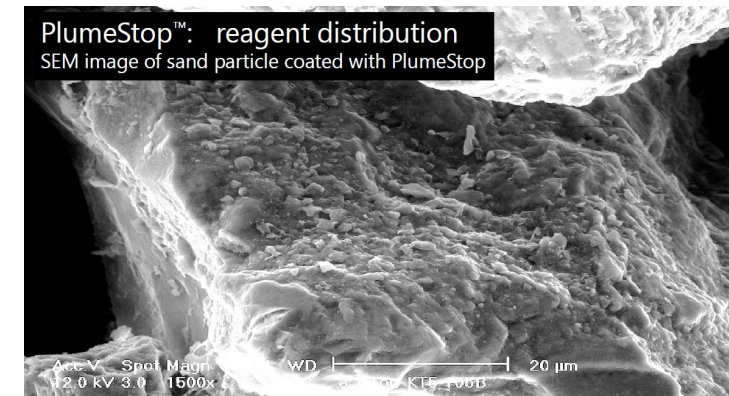
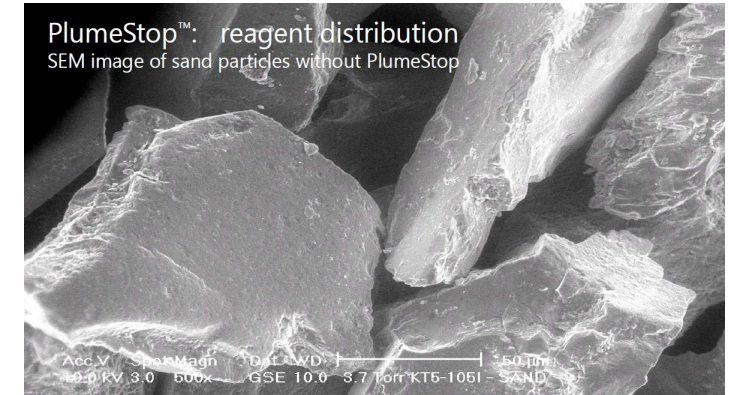
# BACKGROUND



- 100 % of drinking water originates from groundwater
- Sandy aquifers
- Chlorinated plumes
- Costly source remediation
- Lengthy P&T
- → Test of new methods – effectiveness, cost, sustainability

# THE METHOD

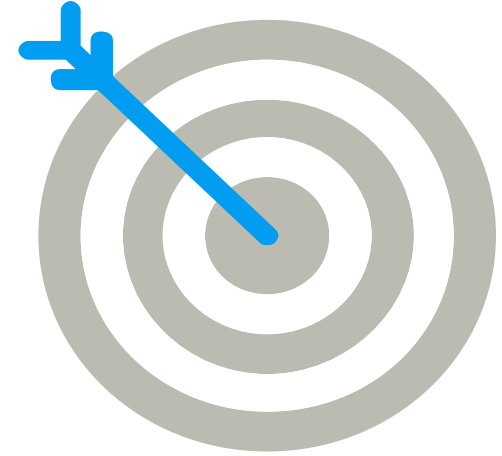
- PlumeStop
  - Activated carbon, 1-2  $\mu\text{m}$ , colloidal suspension  $\rightarrow$  sorption
- Electron donor
  - Slow release lactate; HRC primer, HRC, HRC-X
- Bacteria
  - BDI+, dehalococcoides  $\rightarrow$  ERD
  - Regeneration of sorption sites
- Products developed by Regenesis
- $\rightarrow$  Pilot test



# PILOT TEST - GOAL

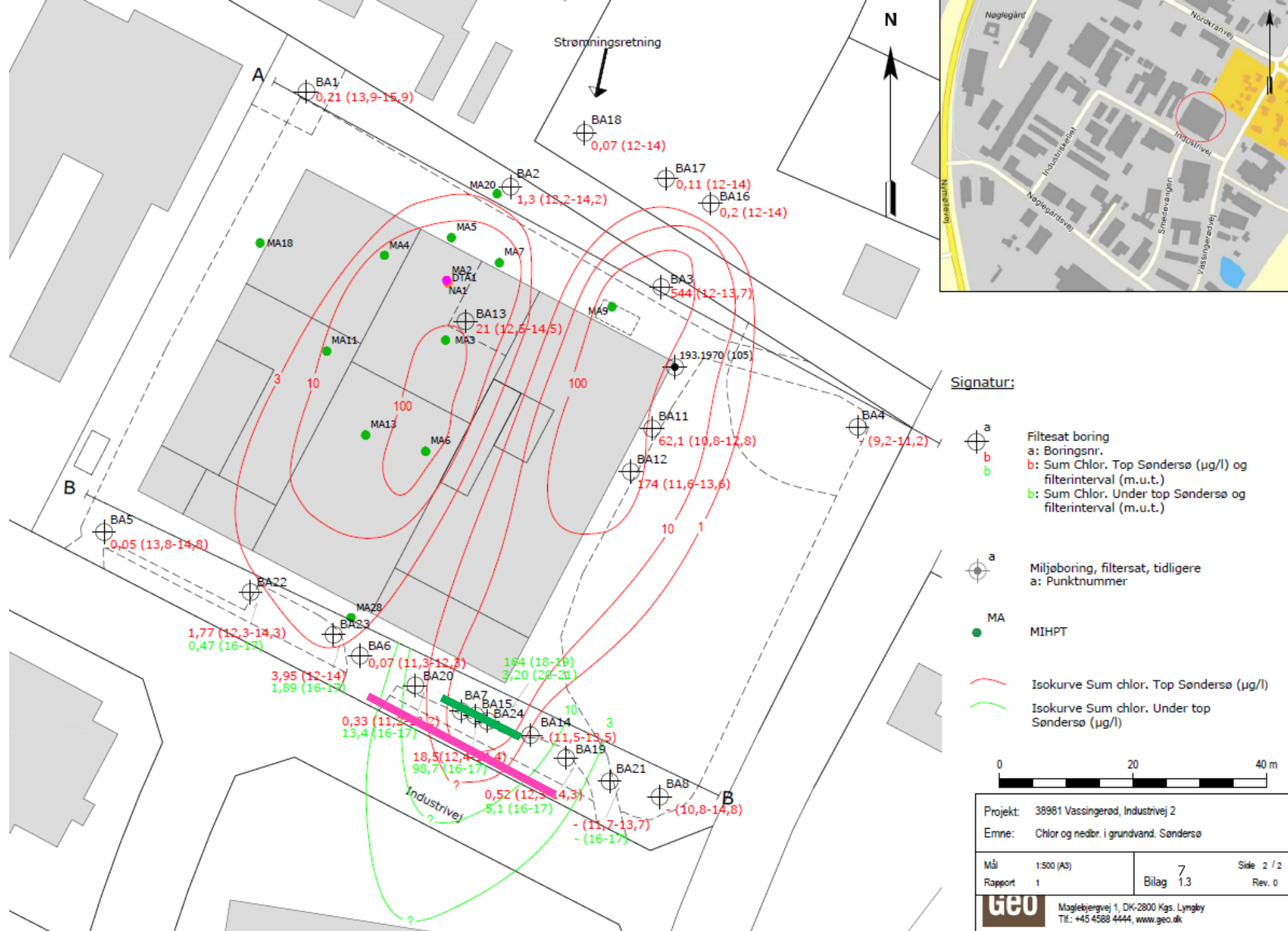
The following is studied:

- Distribution of PS (PlumeStop) in the soil (radius of influence)
- Sorption and possible release of degradation products
- Documentation of the degradation enhancement due to PS
- Documentation of remedial efficiency
- Quantification of sustainability



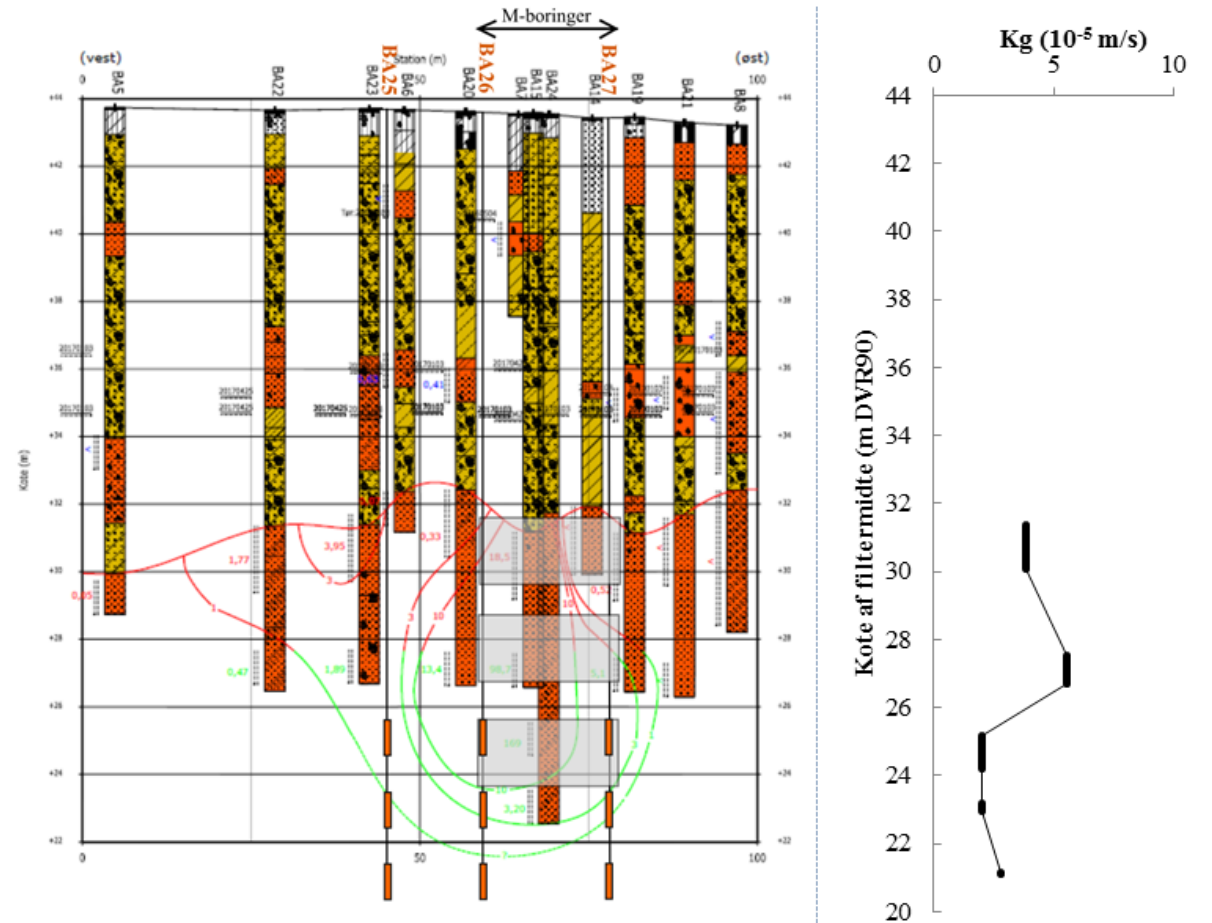
# SITE

Barrier



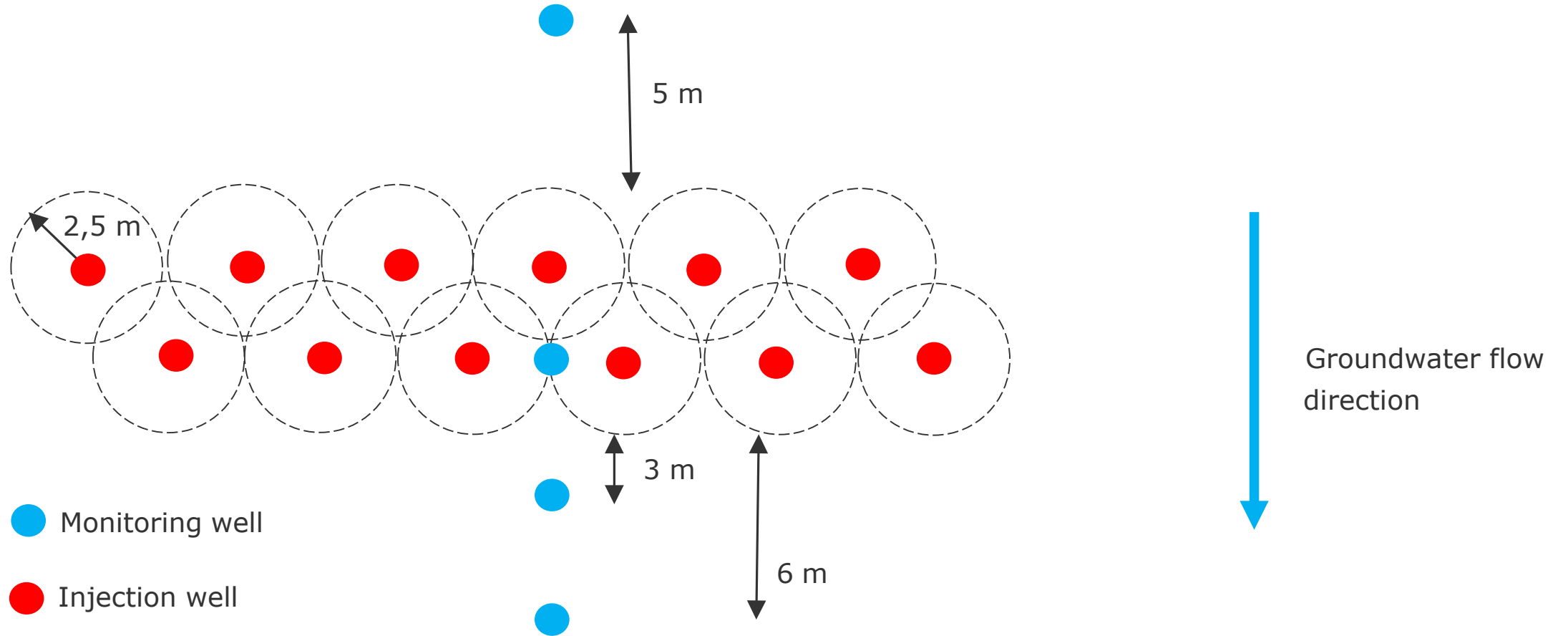
# MONITORING - BASELINE

- K (slugtest)
  - typical  $10^{-5}$ - $10^{-4}$  m/s
  - average  $2-6 \times 10^{-5}$  m/s
- V (flow velocity)
  - 14,8 m/y
  - 0,5 year transect 2 → 3
- Fine sand, silty with depth



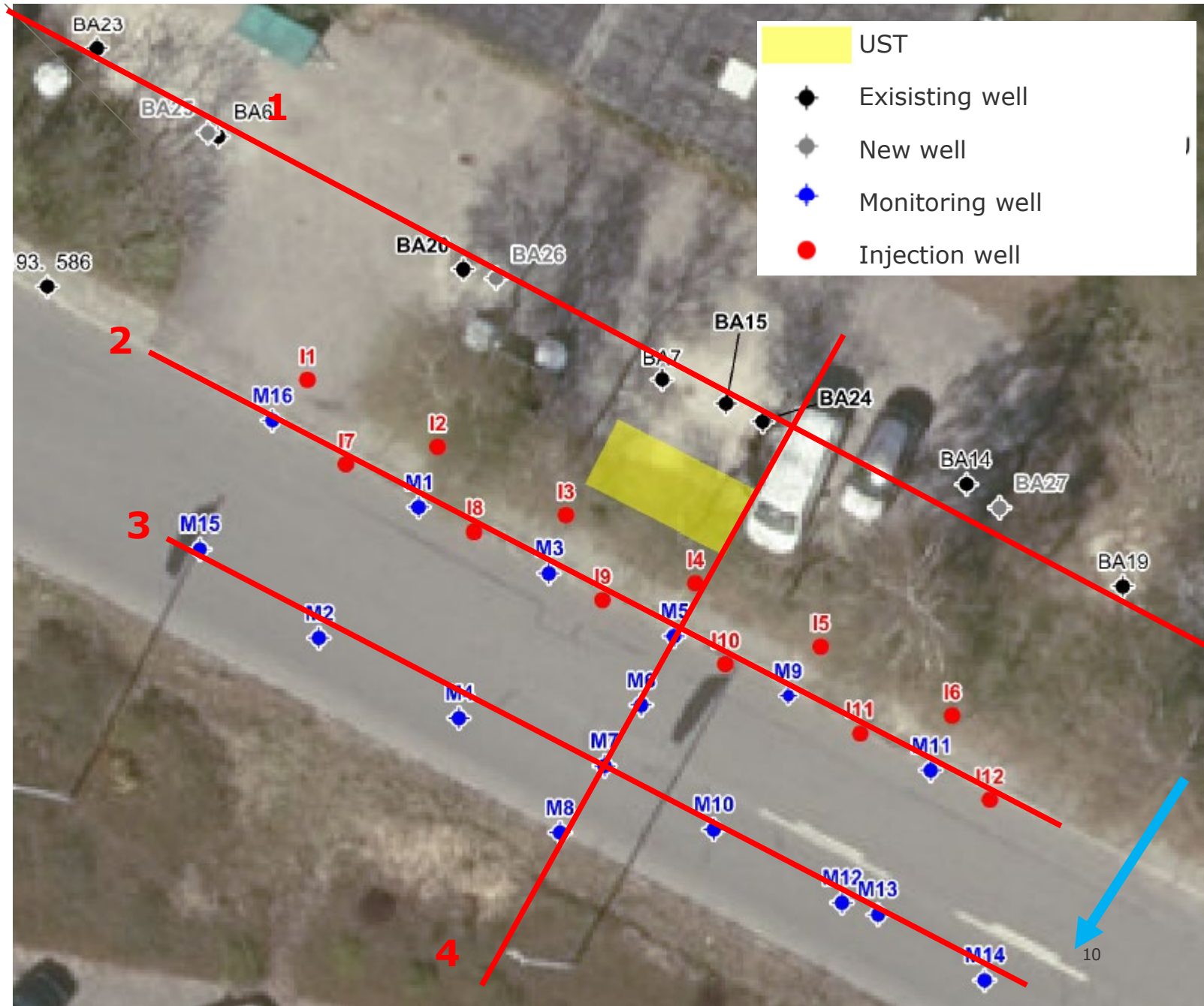


# DESIGN



# DESIGN

- 12 injection points I1-I12 (12-21 m bgl)
- 16 monitoring wells (M1-M16) each with 3 screens
- 4 transects



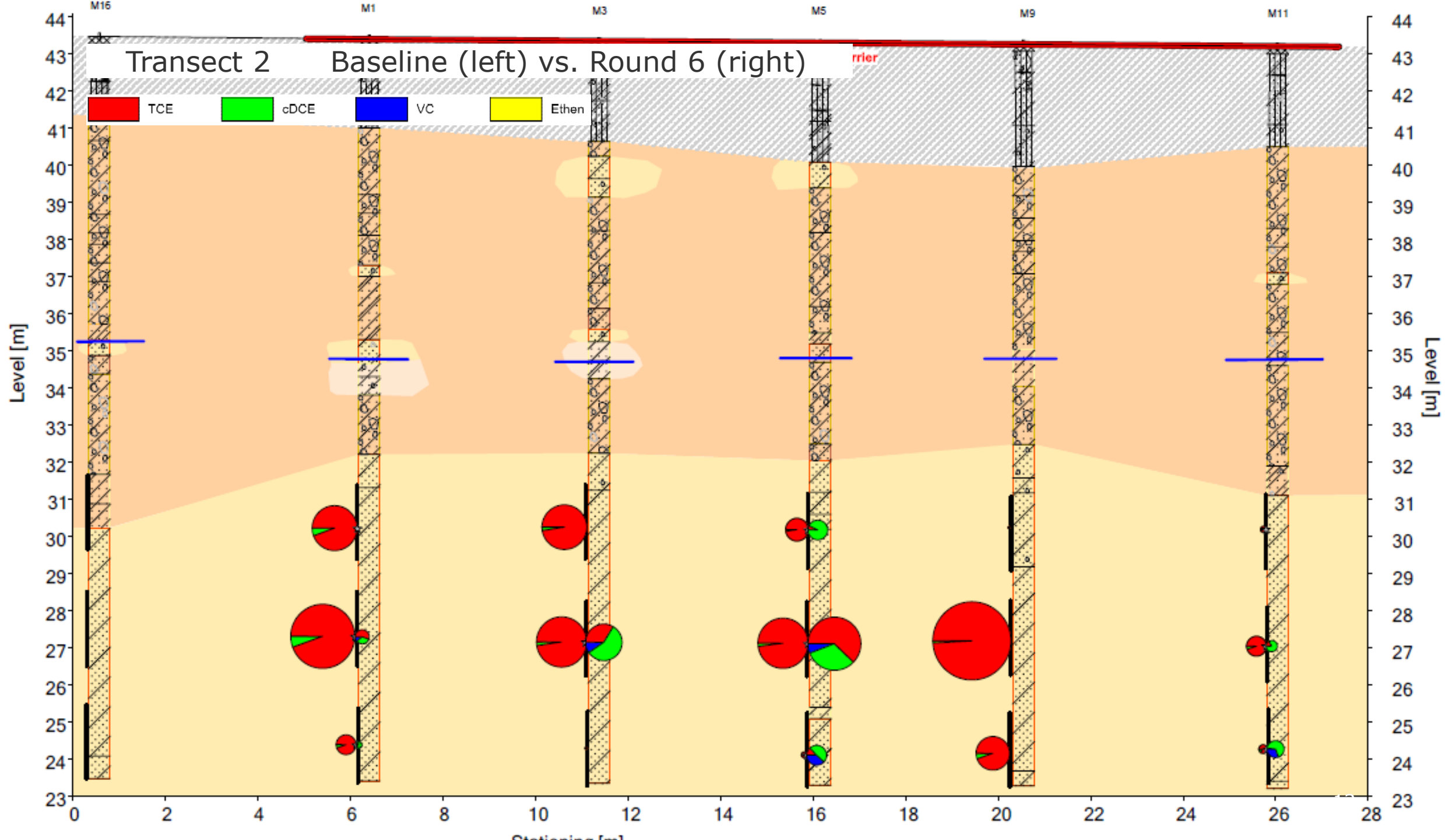


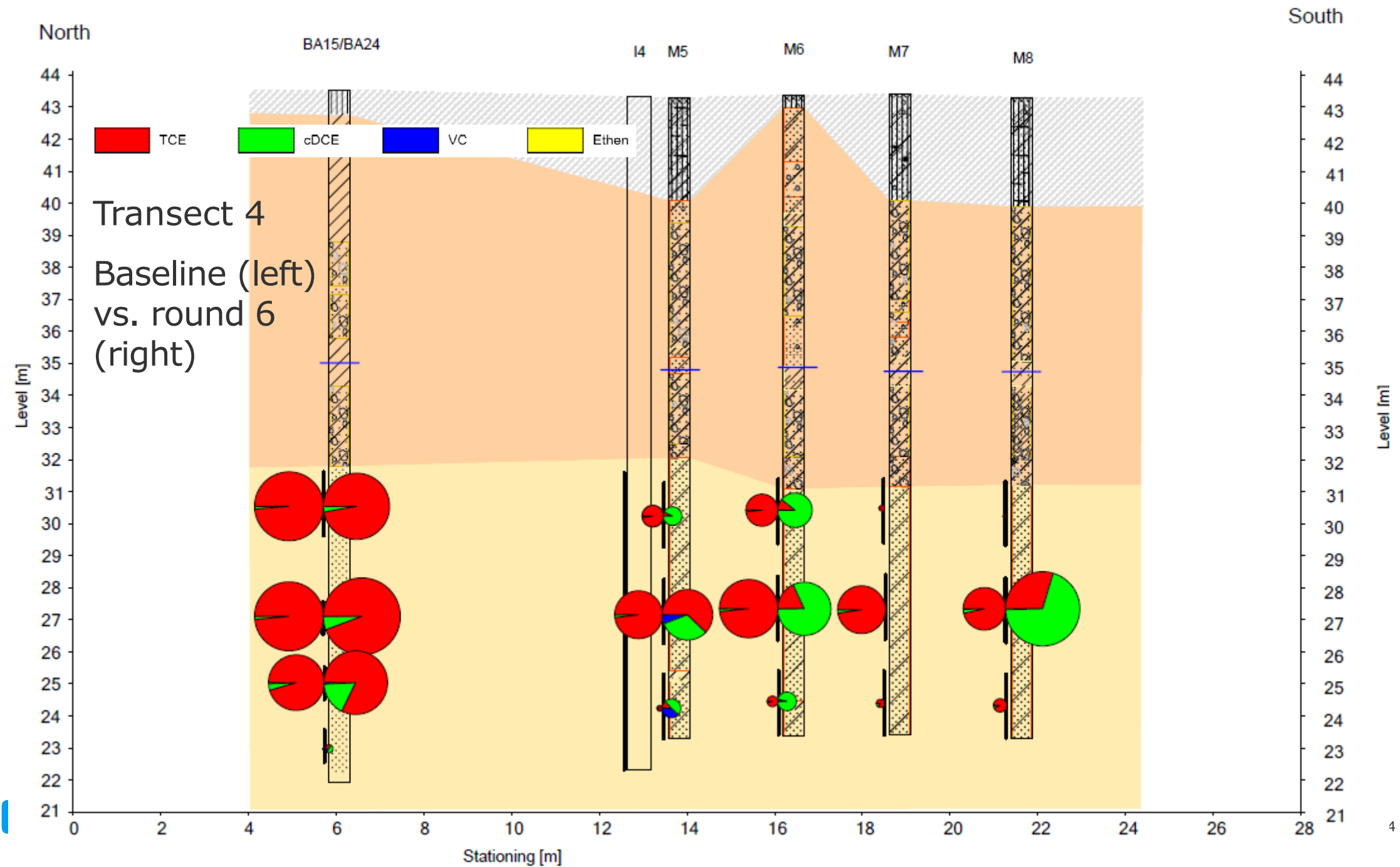
Injection of PlumeStop in fixed wells

# MONITORING - GROUNDWATER

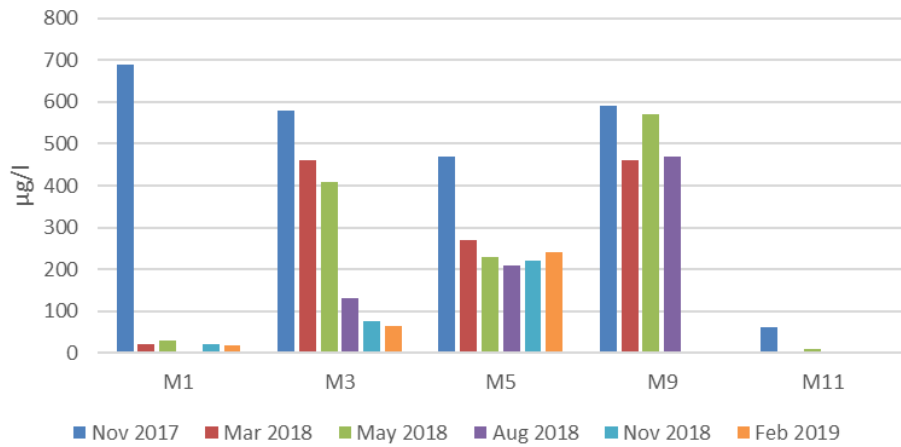
- Chlorinated ethenes and degradation products
- Redox parameters and ions
- Ethene and ethane
- VFA
- Quant array / gentests incl. cerA
- Stable isotopes (CSIA)
- EC-log
- Slugtests
- Flux



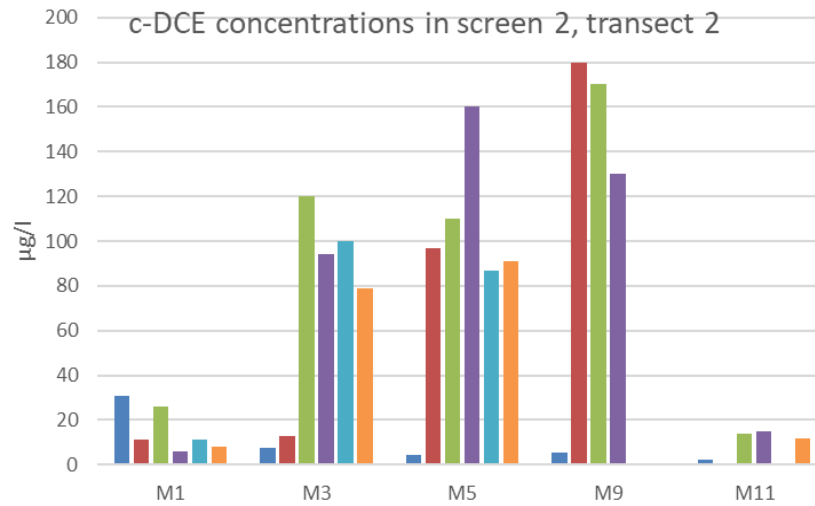




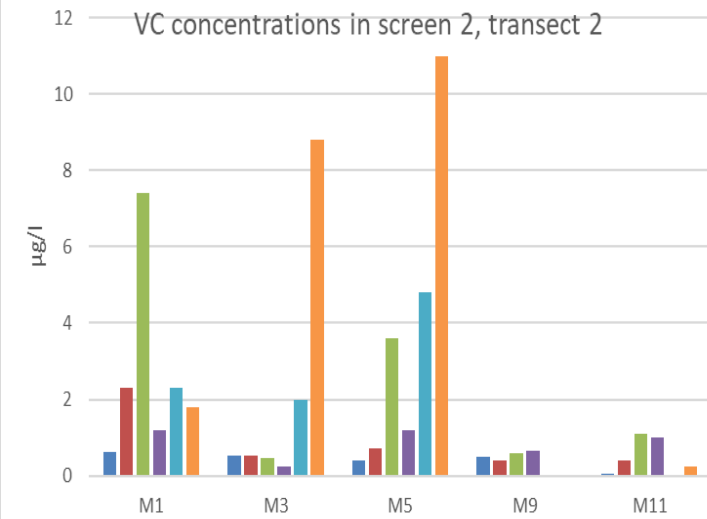
TCE concentrations in screen 2, transect 2



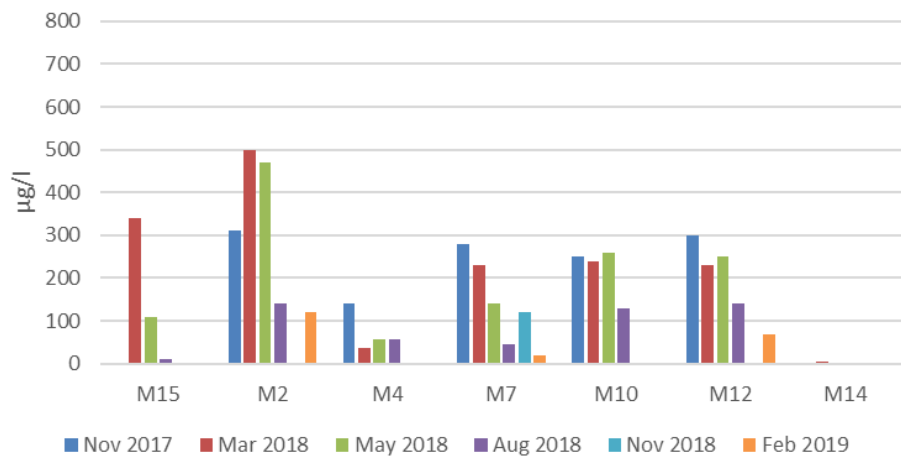
c-DCE concentrations in screen 2, transect 2



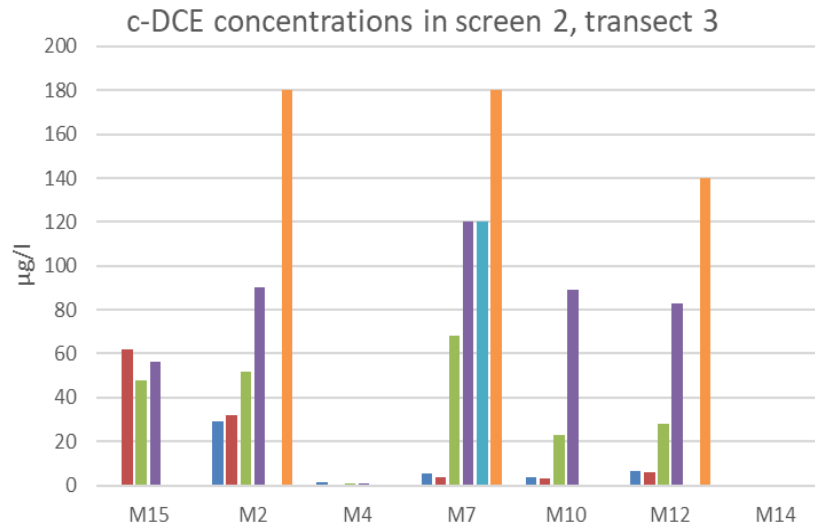
VC concentrations in screen 2, transect 2



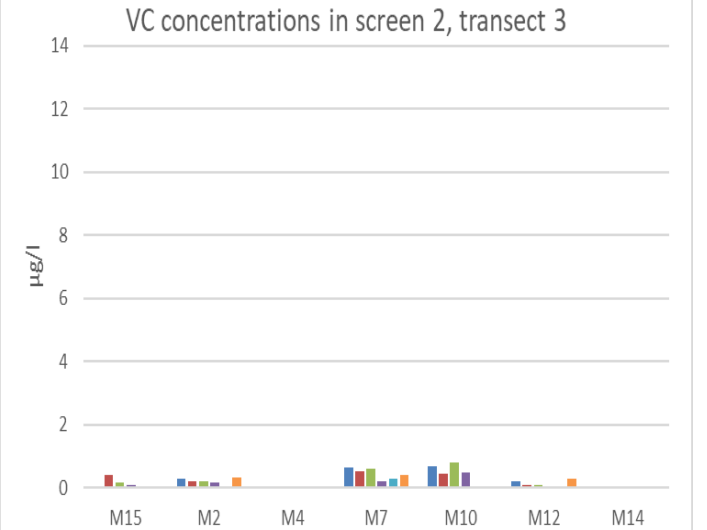
TCE concentrations in screen 2, transect 3



c-DCE concentrations in screen 2, transect 3

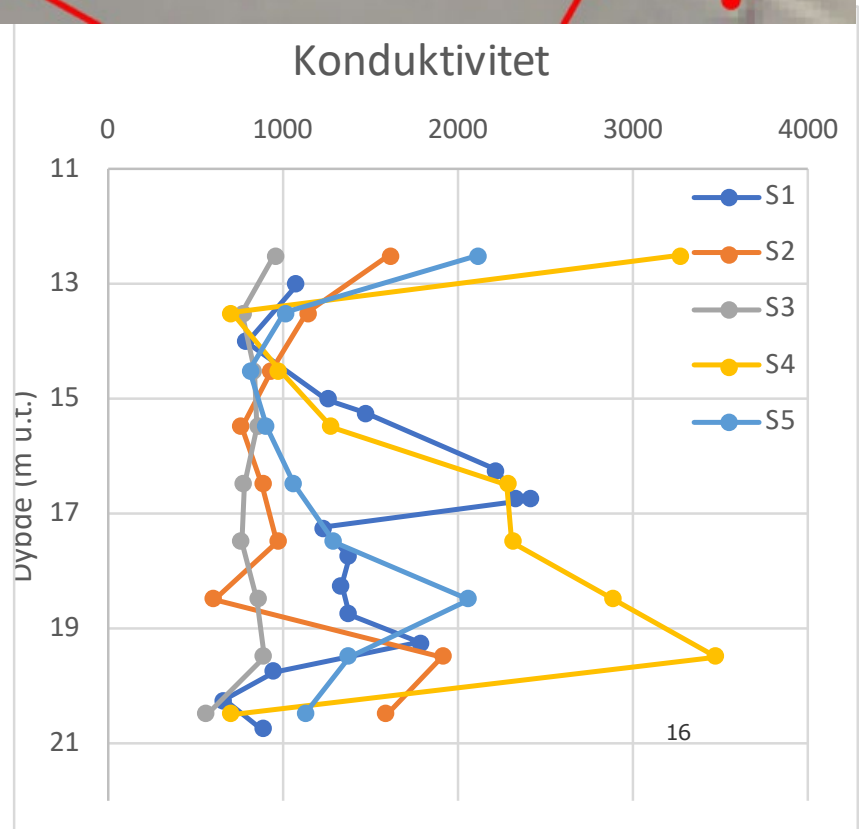
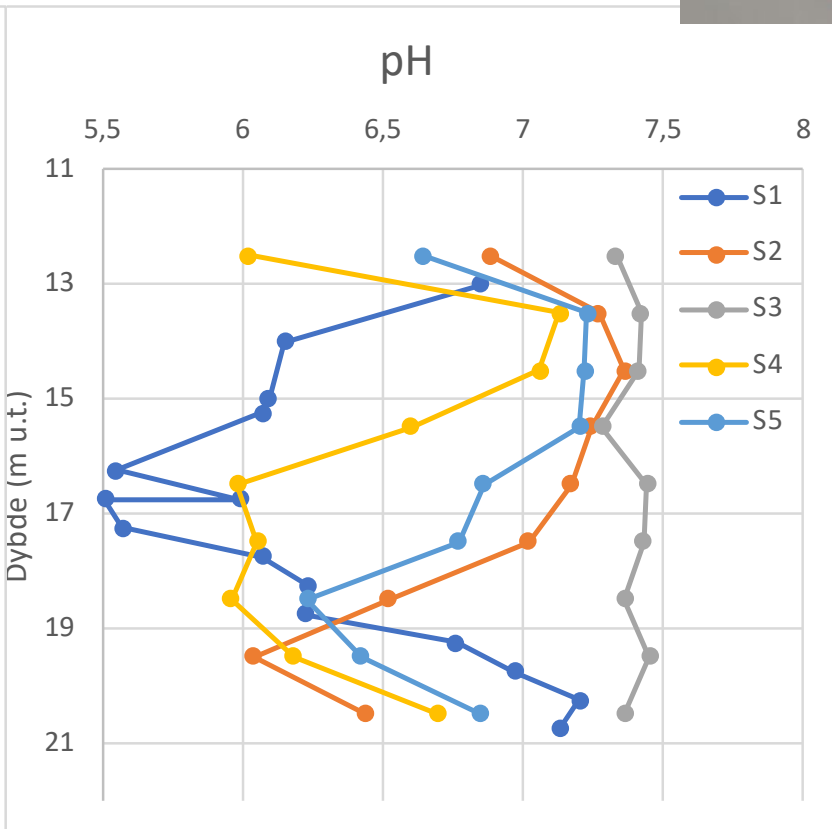
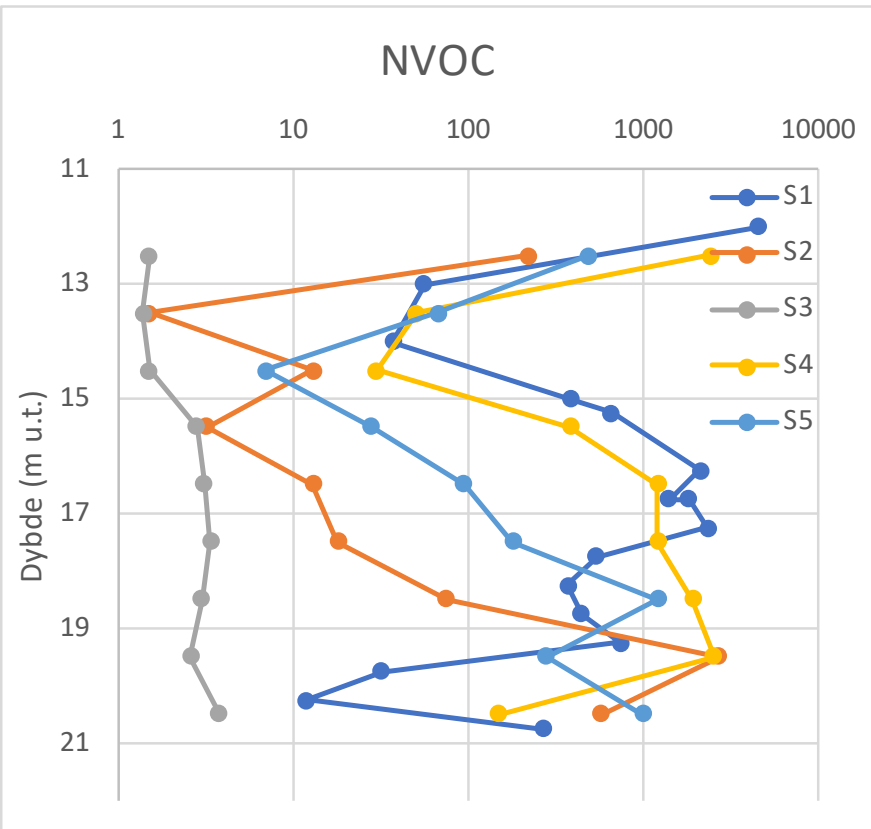


VC concentrations in screen 2, transect 3



# DISCRETE WATER SAMPLING

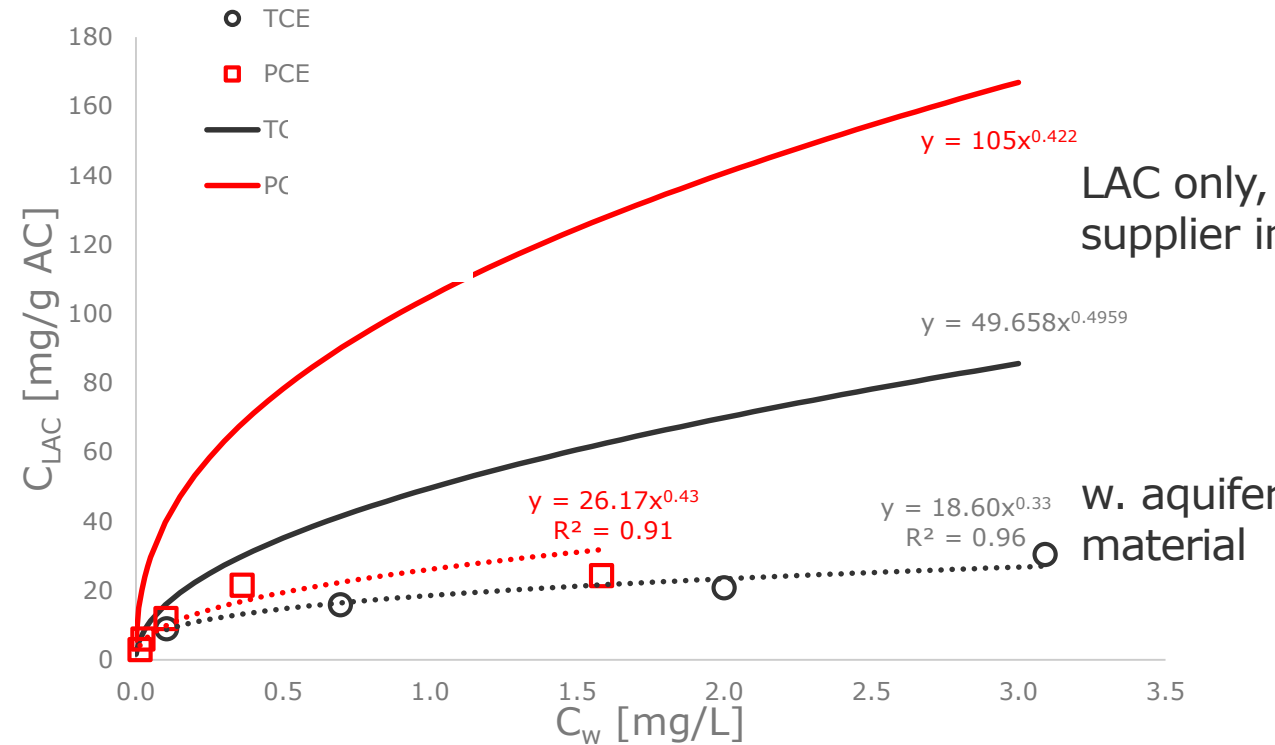
## S1-S5 – TOC, PH, CONDUCTIVITY





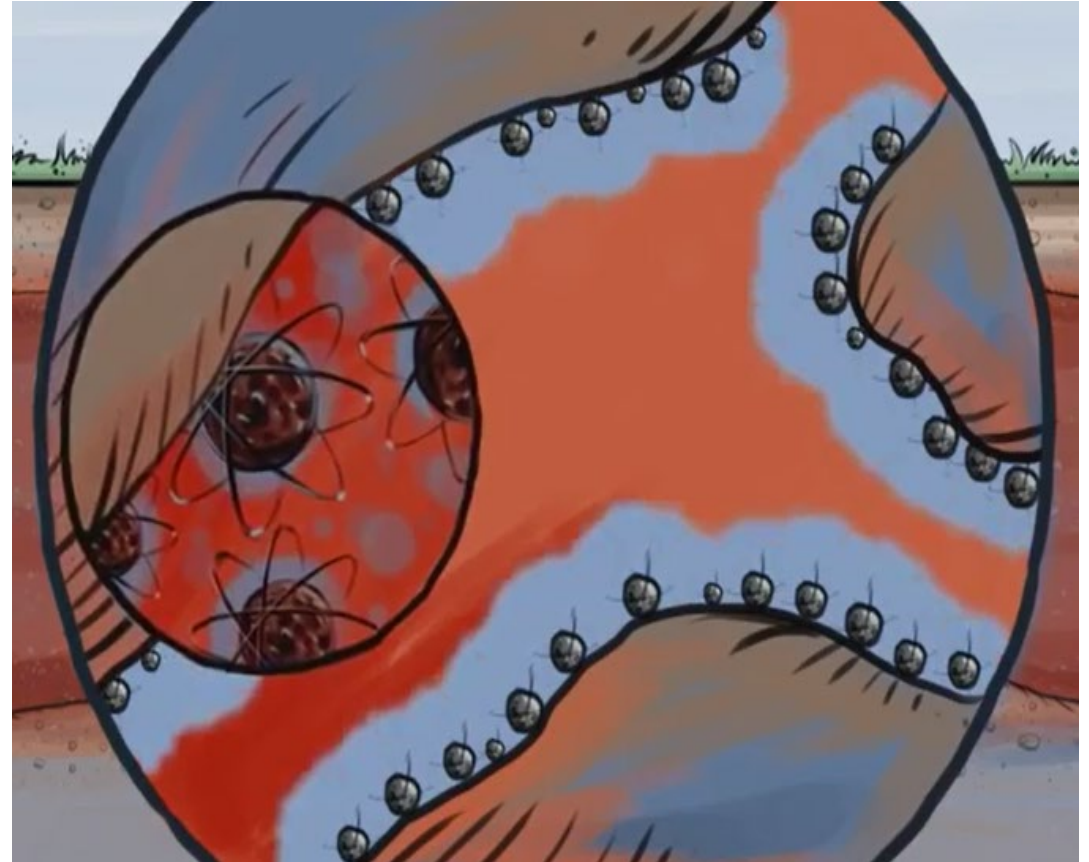
# CHALLENGES / LESSONS LEARNT

- Distribution of PlumeStop®
  - varying sorption observed
  - difficult to document
  - Injection critical for a good distribution and effective plume cut-off
- Sorption capacity of PlumeStop®
  - lab tests show sorption comparable to design criteria
  - => future monitoring tool



# CHALLENGES / LESSONS LEARNT

- Donor distribution – generally fine, however low pH in treated aquifer might be a problem
- Composition and quantity of bacteria
  - Ethene/ethane did not confirm complete RD
  - Activity, robustness and distribution – documentation early on
  - CSIA and gene tests
- => future reinjection planned



**THANK YOU**

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