Enhanced Reductive Dechlorination of PCE in a source zone via recirculation: pilot test and results

03/03/2020, Pieterjan Waeyaert




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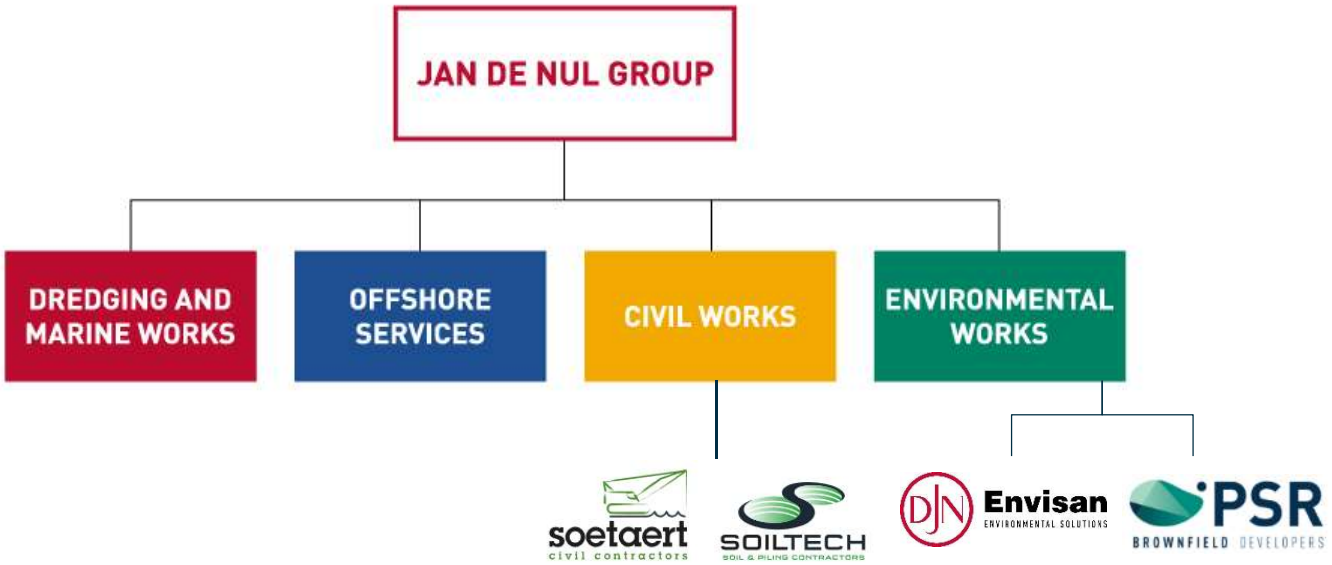
The Environmental Expert of JDN Group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CLEANING UP CONTAMINATED AREAS

- Environmental dredging:
  - Remediation of polluted harbours, sea- and riverbeds
  - On- and Off-site sediment treatment
- On- and Off-site soil remediation (wide range of techniques)
- Groundwater remediation (in-house D&B of installations)

VALORISATION, RE-USE & RENEWABLE ENERGY

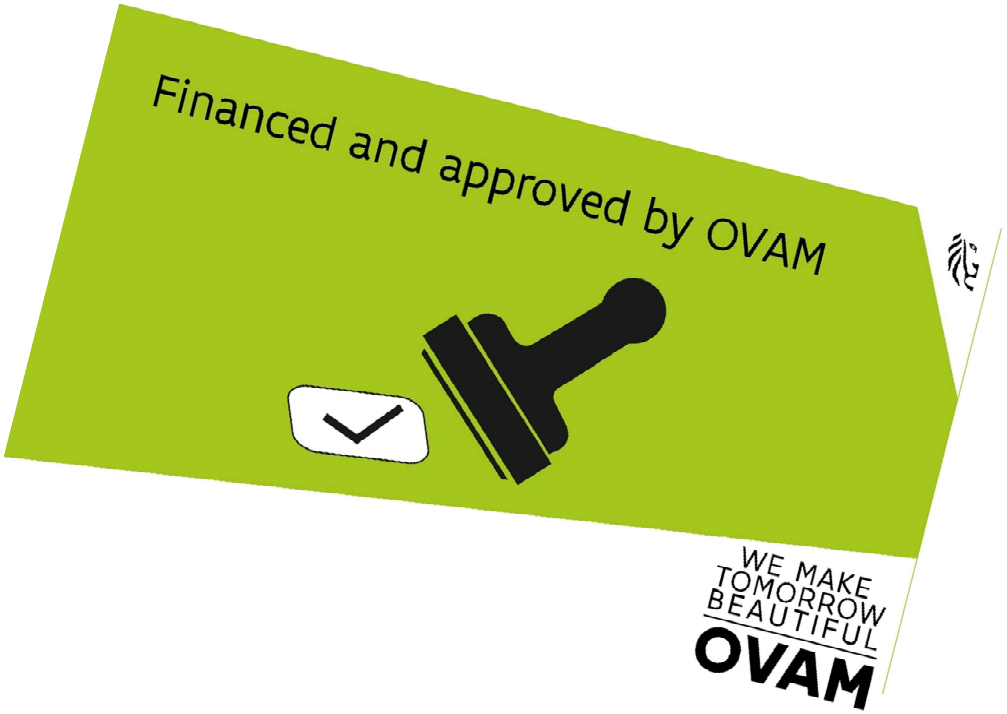
- Treatment of contaminated soil/sediments in one of our 7 treatment centres (BE-FR)
- Re-use of treated sediments/soil as secondary raw materials
- Infrastructure works with engineered sediments (e.g. dike construction)

SUSTAINABLE WASTE MANAGEMENT

- Treatment of specific wastes (oil sludge, gypsum,...)
- Rehabilitation of old and construction of new landfills
- Integration of renewable energy (solar/wind park, landfill gas)

Pilot test recirculation & ERD

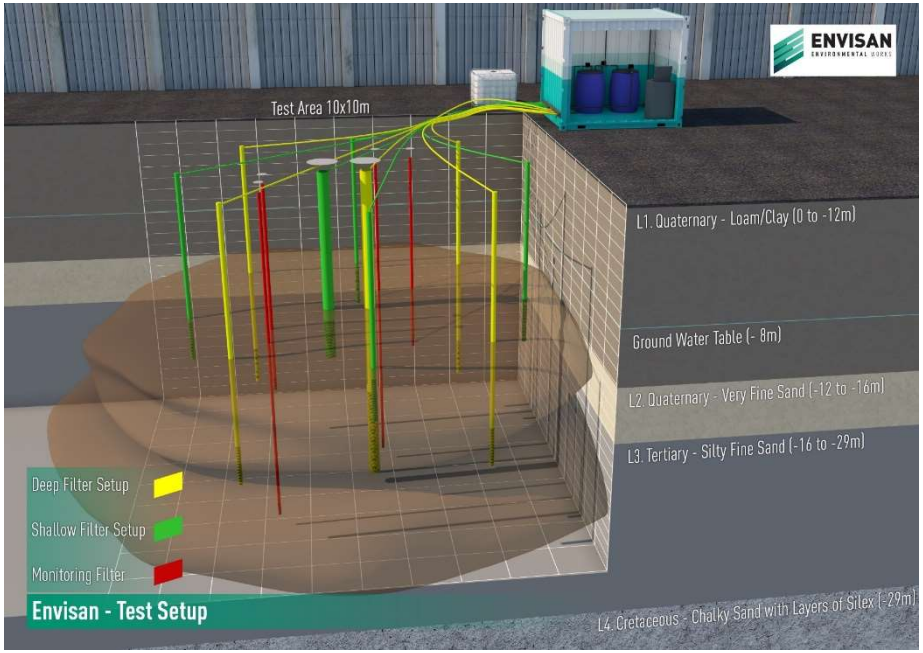
- Where
- Why
- How
- Results



SITE OVERVIEW

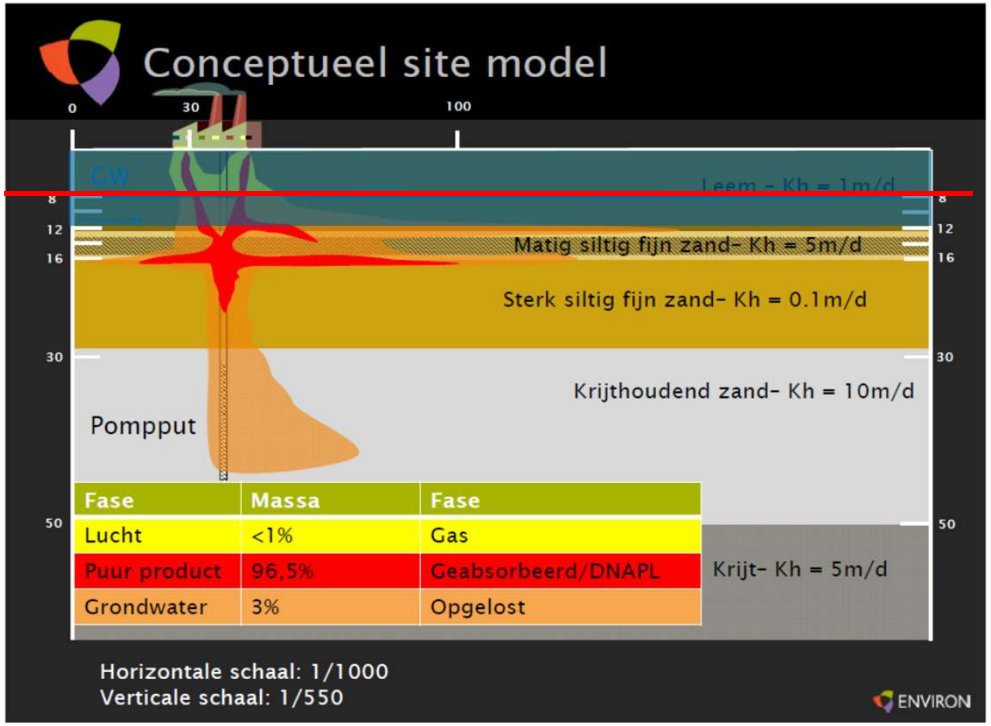
- Location: Tongeren, Belgium
- Client: OVAM
- User: manufacturing plant of electronic devices
- Pollution: chlorinated ethenes

WHY RECIRCULATION IN COMBINATION WITH ERD?



GEOLOGY

- L1: loam/clay (Q)
- L2: fine sand withcloam/clay & gravel intercallations (Q)
- L3: fine sand with silt and loam (T)
- L4: sand layer with chalk and silex layer (C)

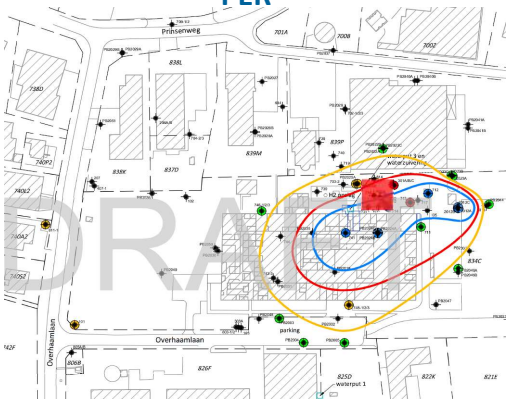


CONTAMINATION (GW)

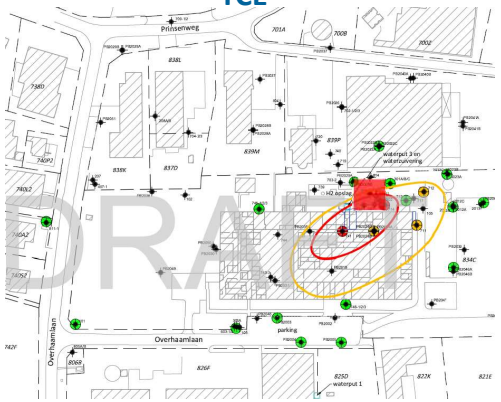
Layer L1 (8-12 m bgl)

- DNAPL
- Source zones
- Limited dispersion
- Limited natural degradation

PER



TCE



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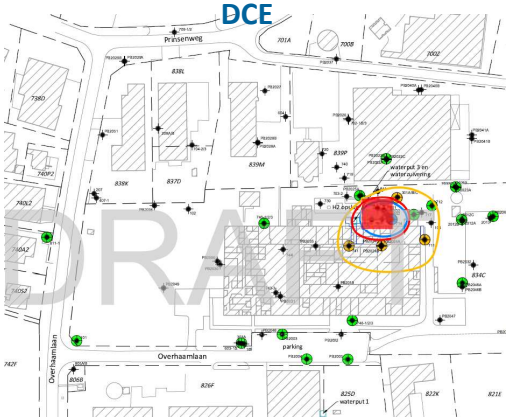
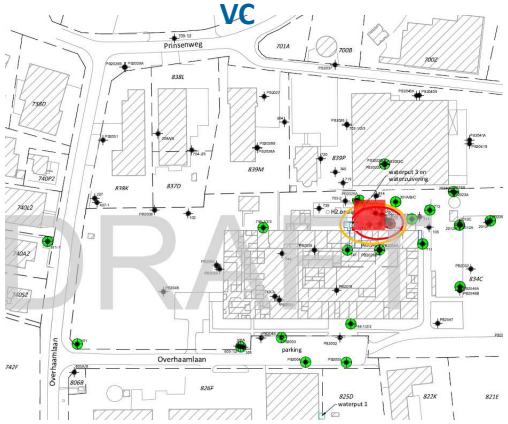


VC



Pilot test zone

> 10% solubility

> 1% solubility

> remediation target

GEOLOGY

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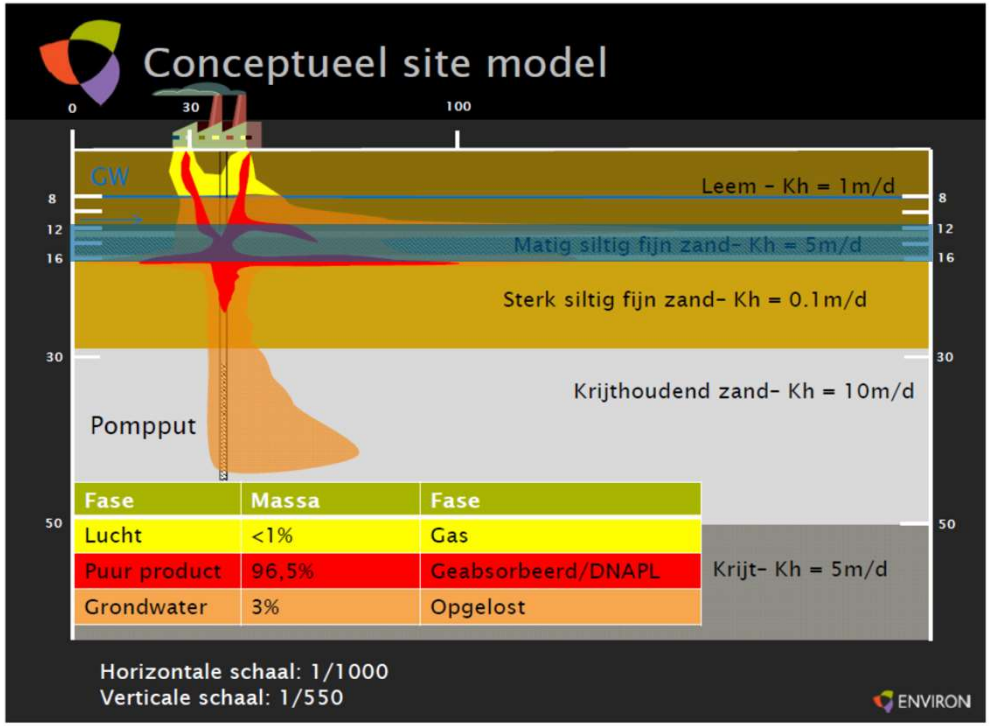
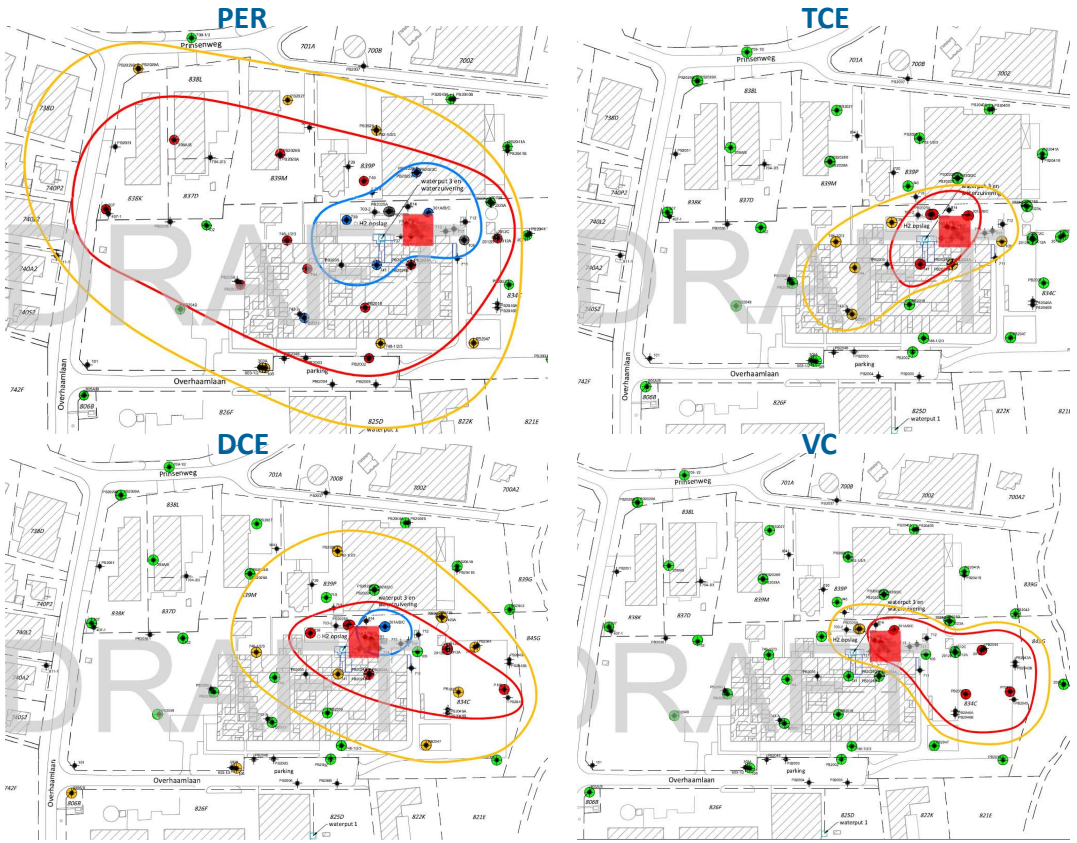


CONTAMINATION (GW)

Layer L2 (12-16 m bgl)

- DNAPL
- Widespread
- Limited degradation
- Back-diffusion(!)



Pilot test zone
> 10% solubility
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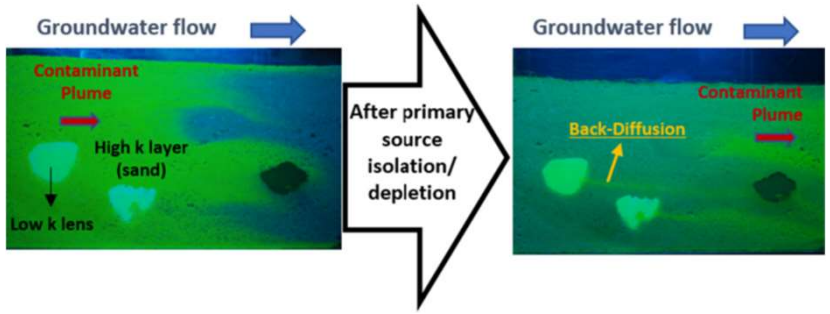

Ref. Tatti et al. 2017 Contaminant back-diffusion from low-permeability layers as affected by groundwater velocity: A laboratory investigation by box model and image analysis. Elsevier, Science of the total environment

BENEFITS ERD & RECIRCULATION

1. Vertical gradient in the low permeable lenses/layers
2. Keeping diffusive gradient high between low and high permeable lenses/layers
    - Immediate degradation when in solution
    - Constant removal of high concentrations by extraction
3. Introducing TOC in the low permeable lenses/layers

GEOLOGY

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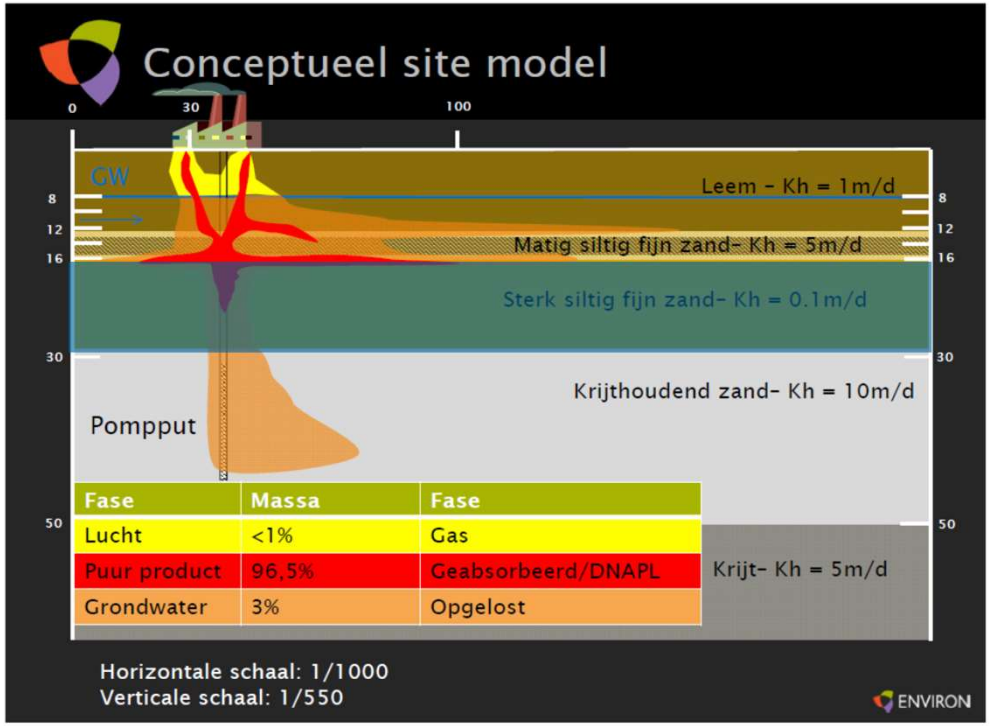
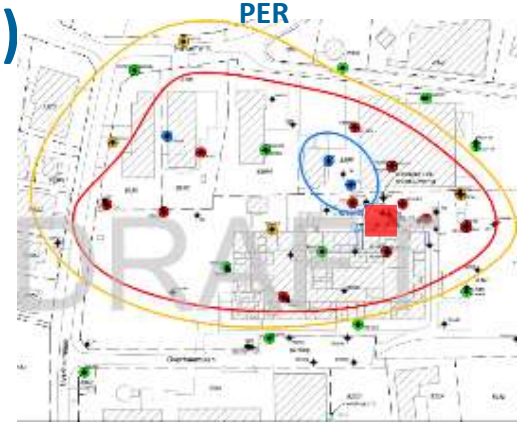


CONTAMINATION (GW)

Layer L3 (16-27 m bgl)

- Vertical migration due to deeper groundwater extraction
- No DNAPL

PER



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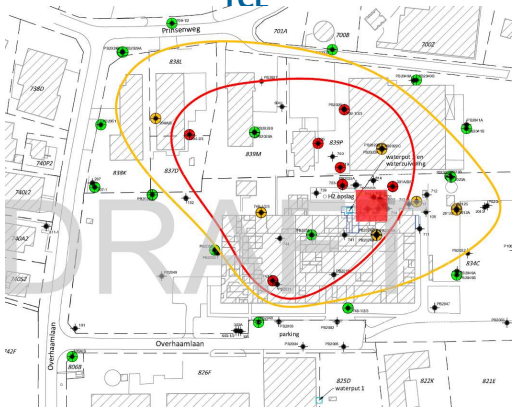

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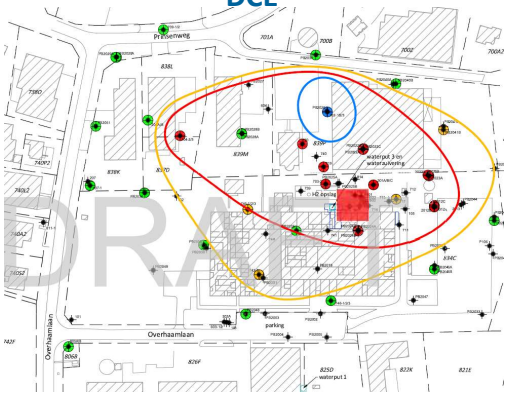
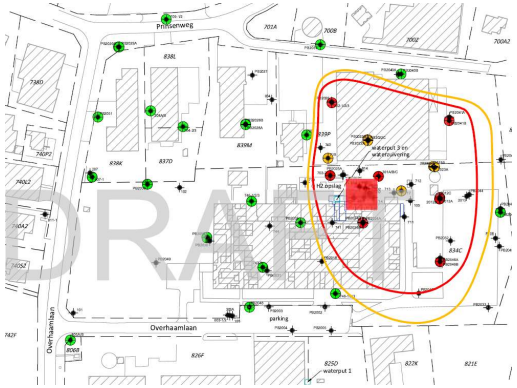


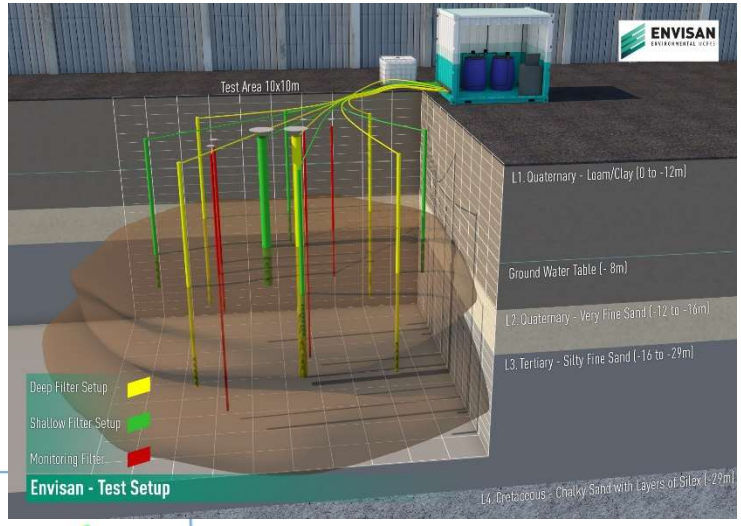
VC

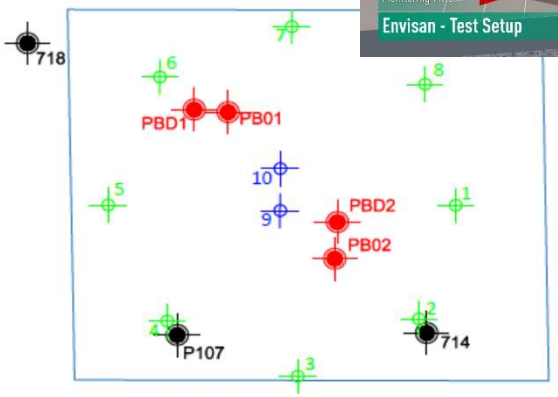


Pilot test zone
> 10% solubility
> 1% solubility
> remediation target

PILOT TEST SET-UP

- Two-layer system (L2 and L3)
- 10 m x 10 m
- Per layer:
  - 1 central extraction well
  - 4 injection wells
  - Monitoring wells
- Underground piping

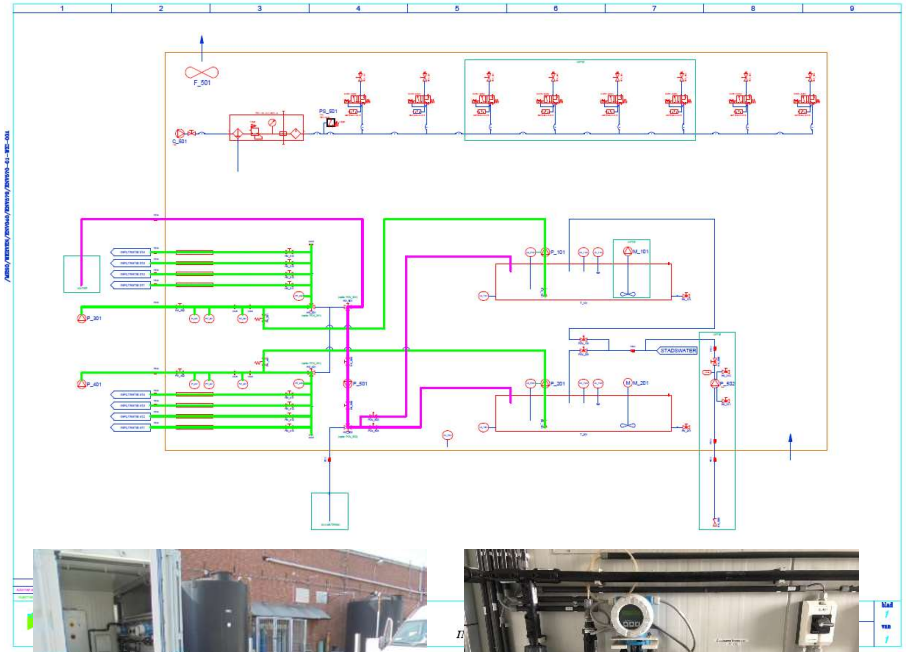




PILOT TEST SET-UP

In house built recirculation unit

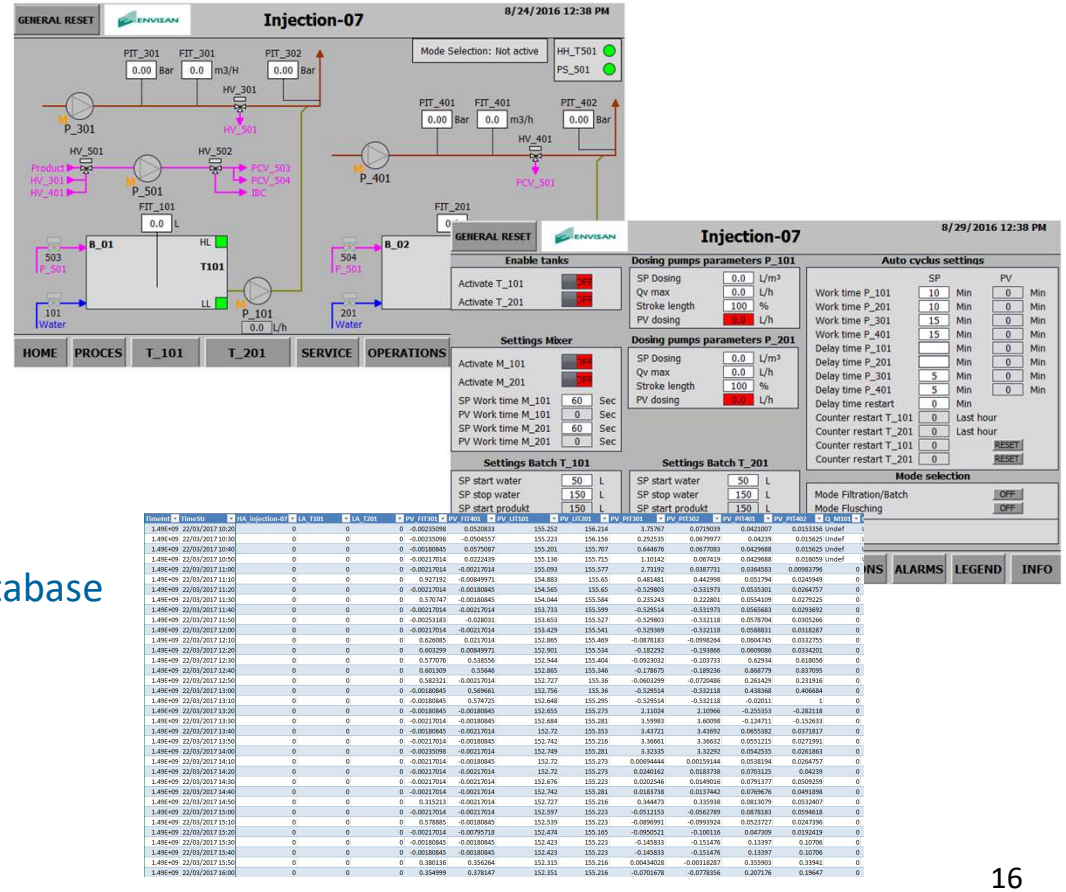
- Two manifolds
- Instruments: digital pressure gauge, flow meter, level sensors
- Dilution and dosing system
- PLC with HMI screen



PILOT TEST SET-UP

PLC system

- Fully automated system
- Adjustable parameters
  - Recirculation and dosing time
  - Max. overpressure
  - Dosing levels
  - Dilution level of carbon source
- Continuous data collection in central database



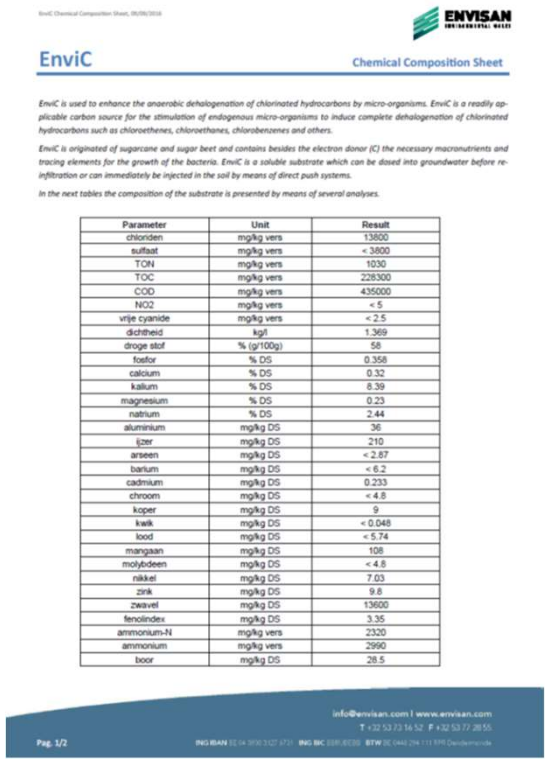
PILOT TEST SET-UP

PILOT TEST SET-UP

Carbon Source = EnviC

- In house developed
- Natural product
- Water soluble
- Short and long C-chains
- Necessary macro- and micronutrients

Start 22/03/2017 - end 24/04/2018



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EnviC — Chemical Composition Sheet

EnviC is used to enhance the anaerobic dehalogenation of chlorinated hydrocarbons by micro-organisms. EnviC is a readily applicable carbon source for the stimulation of endogenous micro-organisms to induce complete dehalogenation of chlorinated hydrocarbons such as chloroethenes, chloroethanes, chlorobenzenes and others.

EnviC is originated of sugarcane and sugar beet and contains besides the electron donor (C) the necessary macronutrients and tracing elements for the growth of the bacteria. EnviC is a soluble substrate which can be dosed into groundwater before re-infiltration or can immediately be injected in the soil by means of direct push systems.

In the next tables the composition of the substrate is presented by means of several analyses.

Parameter	Unit	Result
chloriden	mg/kg vers	13800
sulfaat	mg/kg vers	< 3800
TON	mg/kg vers	1030
TOC	mg/kg vers	228300
COD	mg/kg vers	435000
NO2	mg/kg vers	< 5
vrije cyanide	mg/kg vers	< 2.5
dichtheid	kg/l	1.369
droge stof	% (g/100g)	58
fosfor	% DS	0.358
calcium	% DS	0.32
kalium	% DS	8.39
magnesium	% DS	0.23
natrium	% DS	2.44
aluminium	mg/kg DS	36
ijzer	mg/kg DS	210
arseen	mg/kg DS	< 2.87
barium	mg/kg DS	< 6.2
cadmium	mg/kg DS	0.233
chroom	mg/kg DS	< 4.8
koper	mg/kg DS	9
kwik	mg/kg DS	< 0.048
lood	mg/kg DS	< 5.74
mangaan	mg/kg DS	108
molybdeen	mg/kg DS	< 4.8
nikkel	mg/kg DS	7.03
zink	mg/kg DS	9.8
zwavel	mg/kg DS	13600
fenolindex	mg/kg DS	3.35
ammonium-N	mg/kg vers	2320
ammonium	mg/kg vers	2990
boor	mg/kg DS	28.5

info@envisan.com I www.envisan.com

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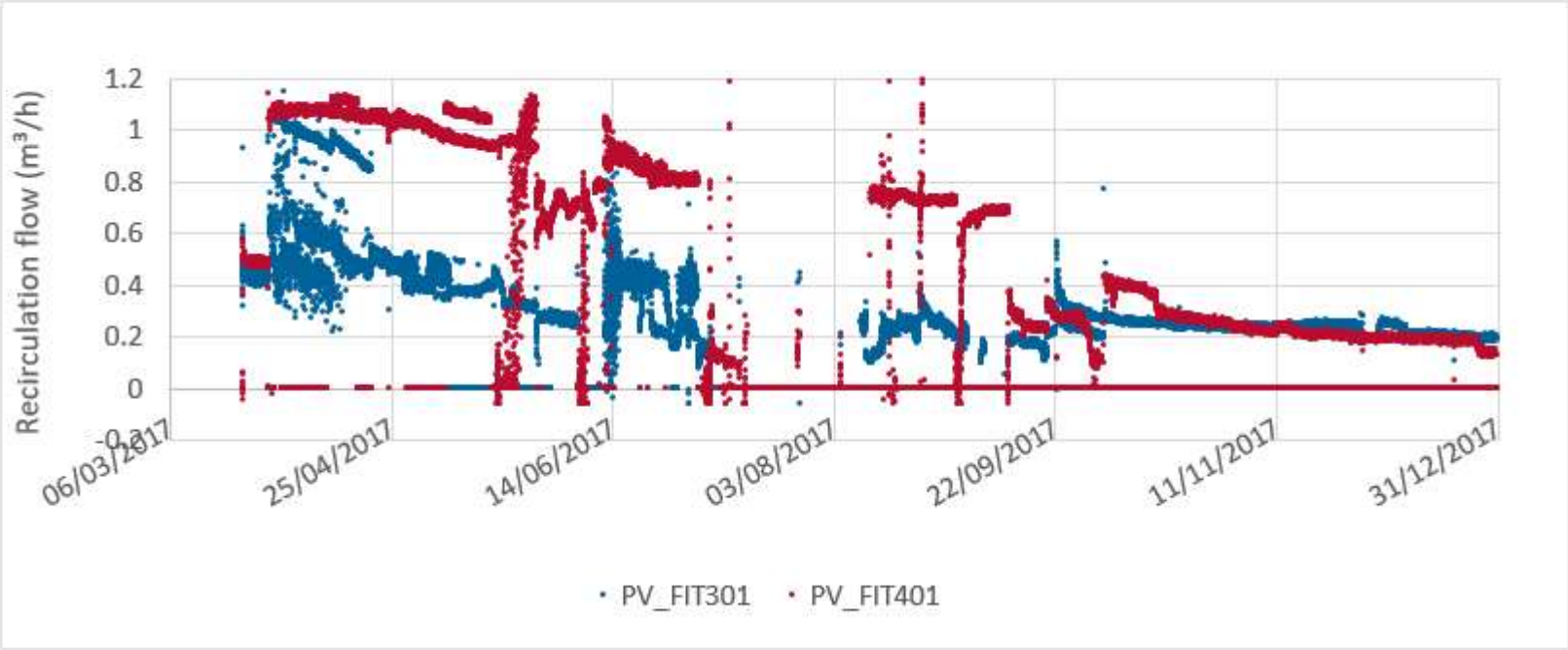
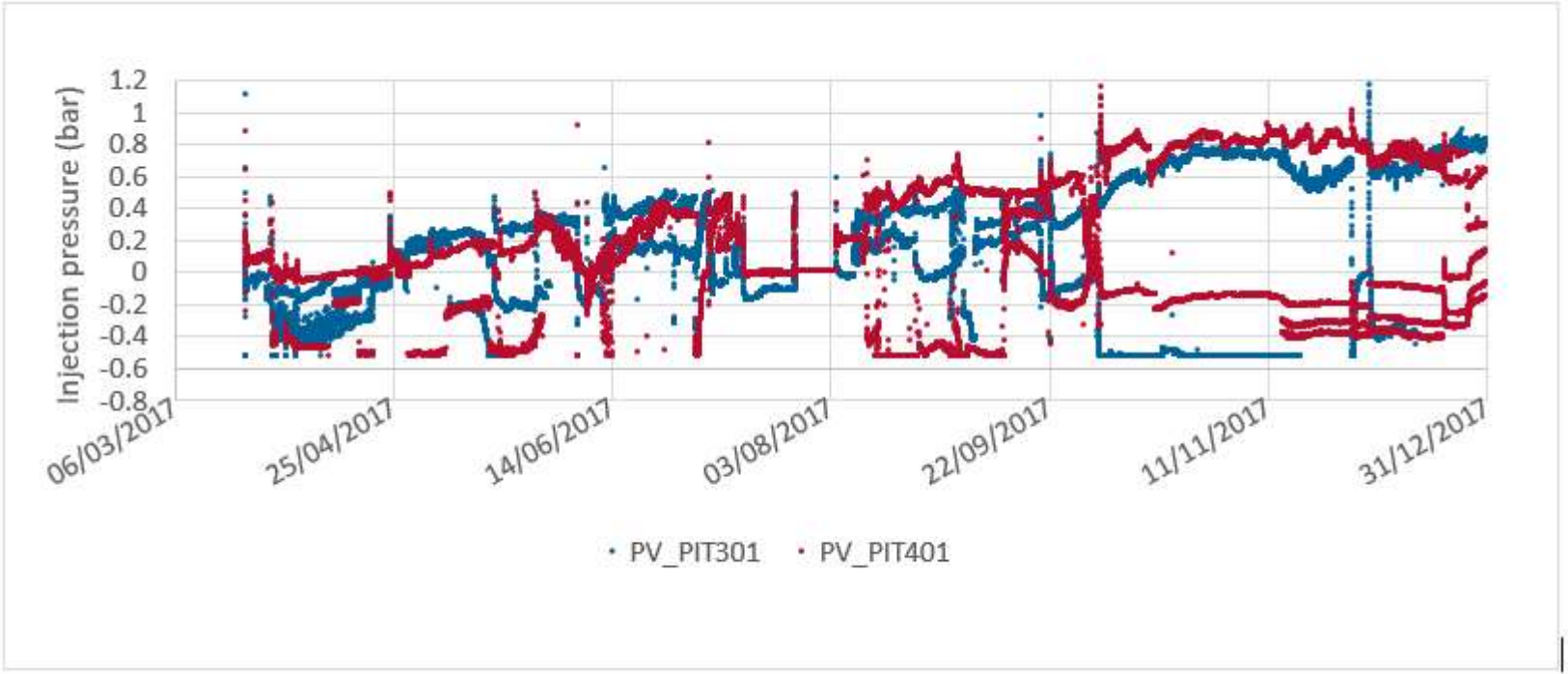
RESULTS

Recirculation flow



RESULTS

Injection pressure

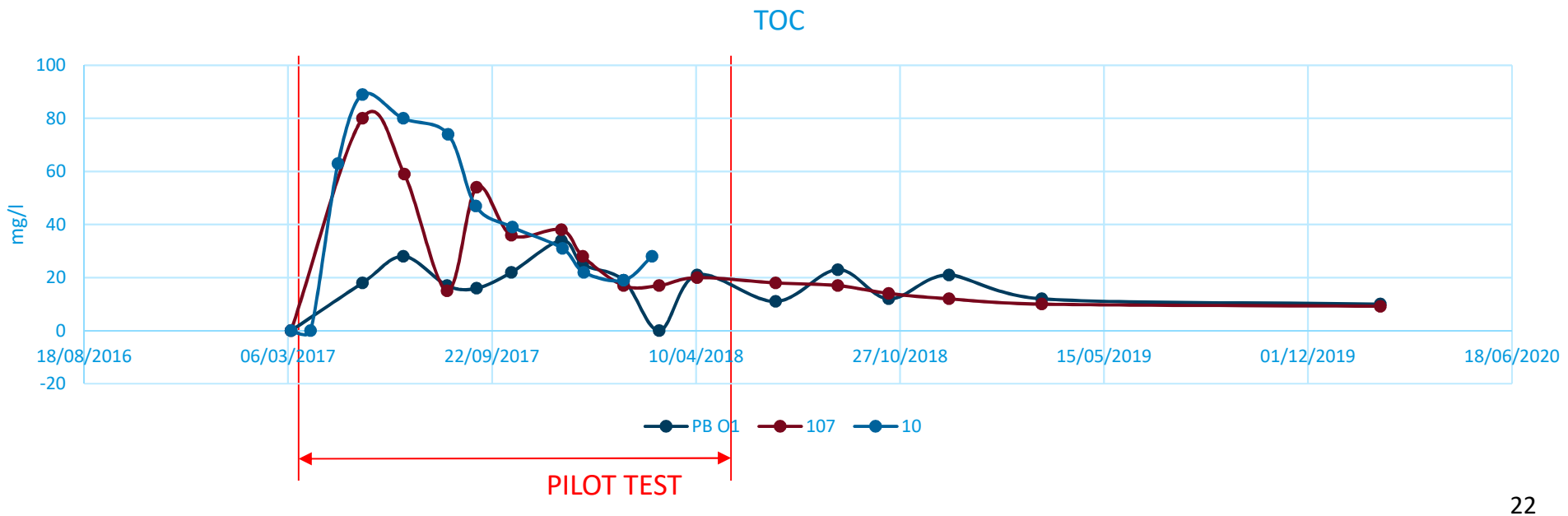


RESULTS

- Total flow:
  - 2853 m³ for shallow layer L2
  - 1587 m³ for deeper layer L3
- Total dosage of EnviC:
  - 540 litres for L2 (= 63 mg TOC/l)
  - 520 litres for L3 (= 98 mg TOC/l)

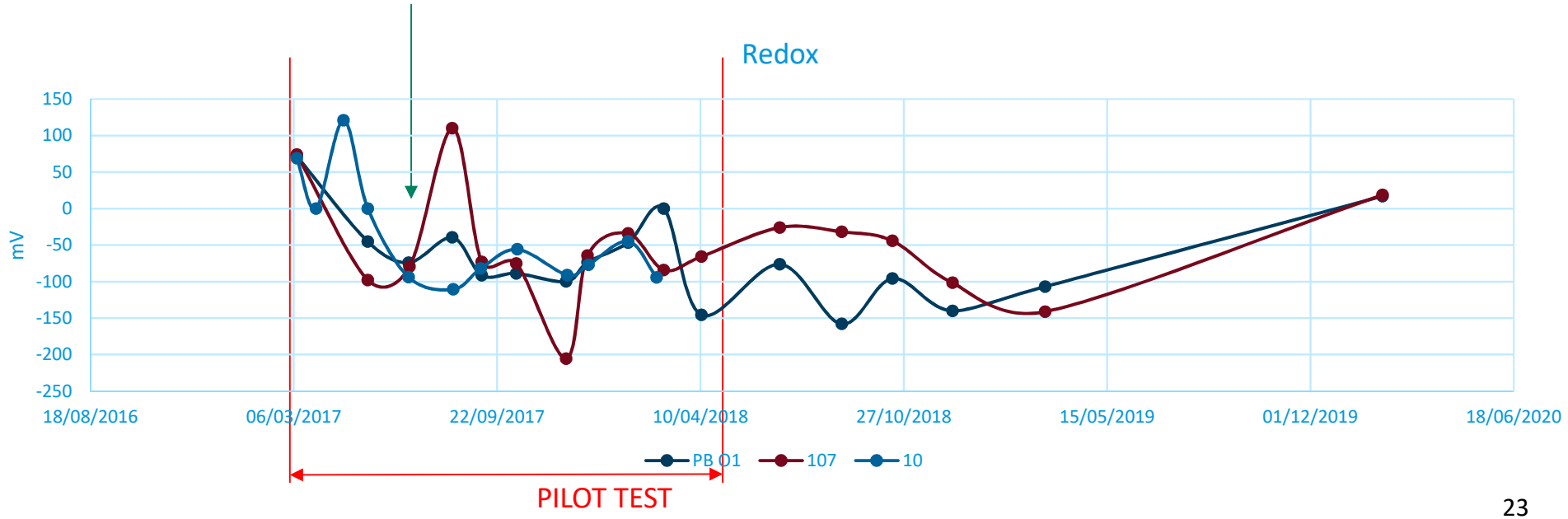
RESULTS LAYER L2

- TOC: very fast distribution within the test zone → slow decrease



RESULTS LAYER L2

- TOC: very fast distribution within the test zone → slow decrease
- Redox & sulphate: optimal environment after app. 3 months



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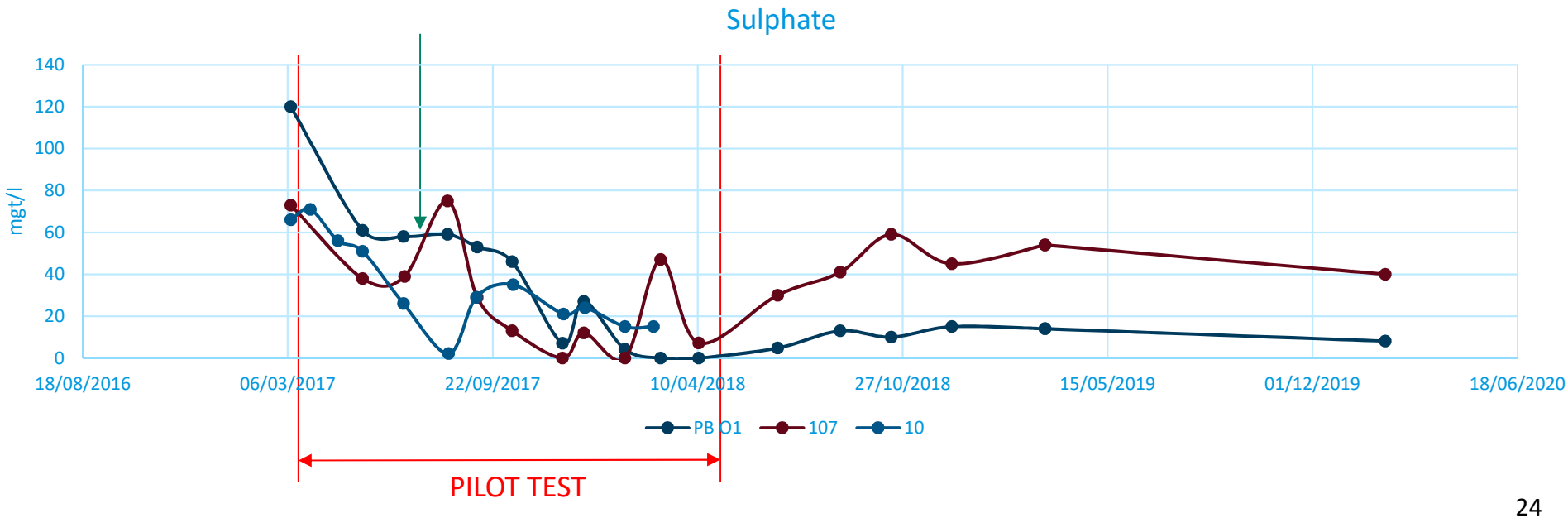
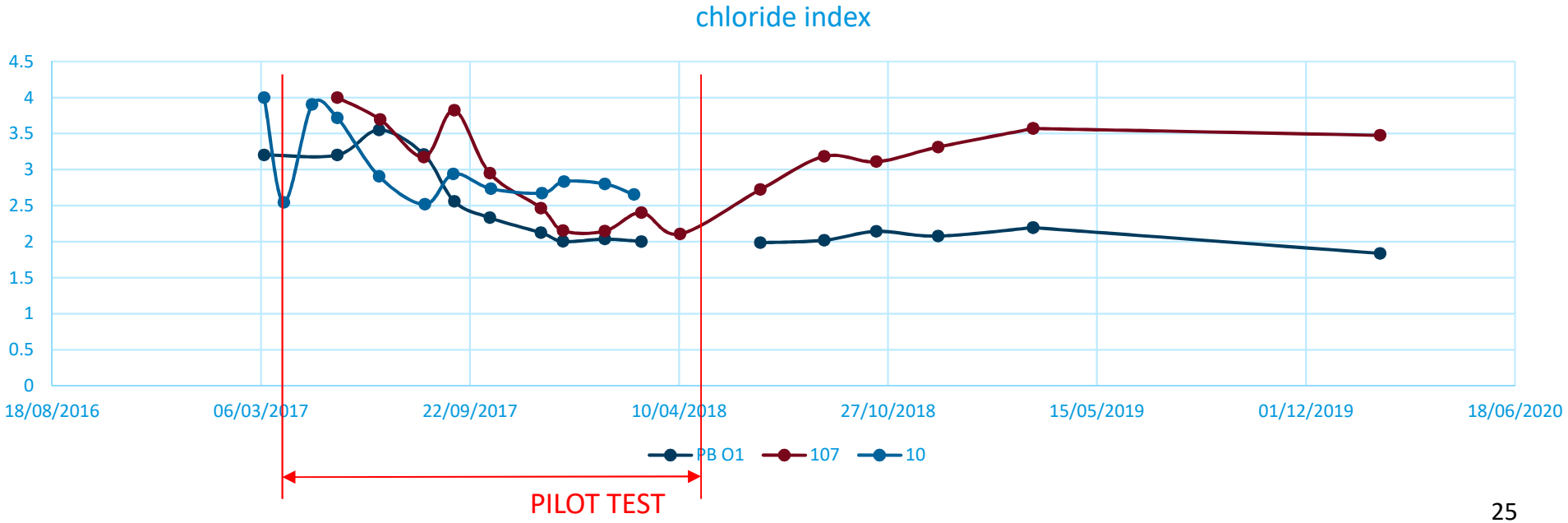


RESULTS LAYER L2

Chloride index

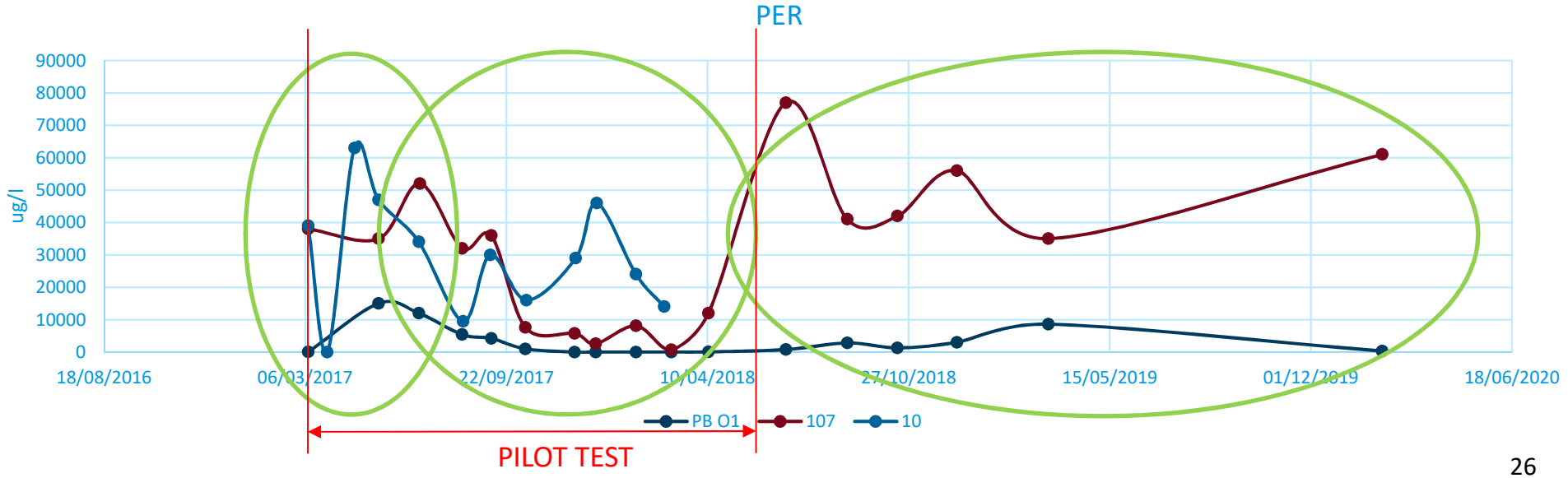
= ∑ (ni Cl x conc.VOCli)/ ∑ (totale VOCl conc.)



RESULTS LAYER L2

Perchlorethylene

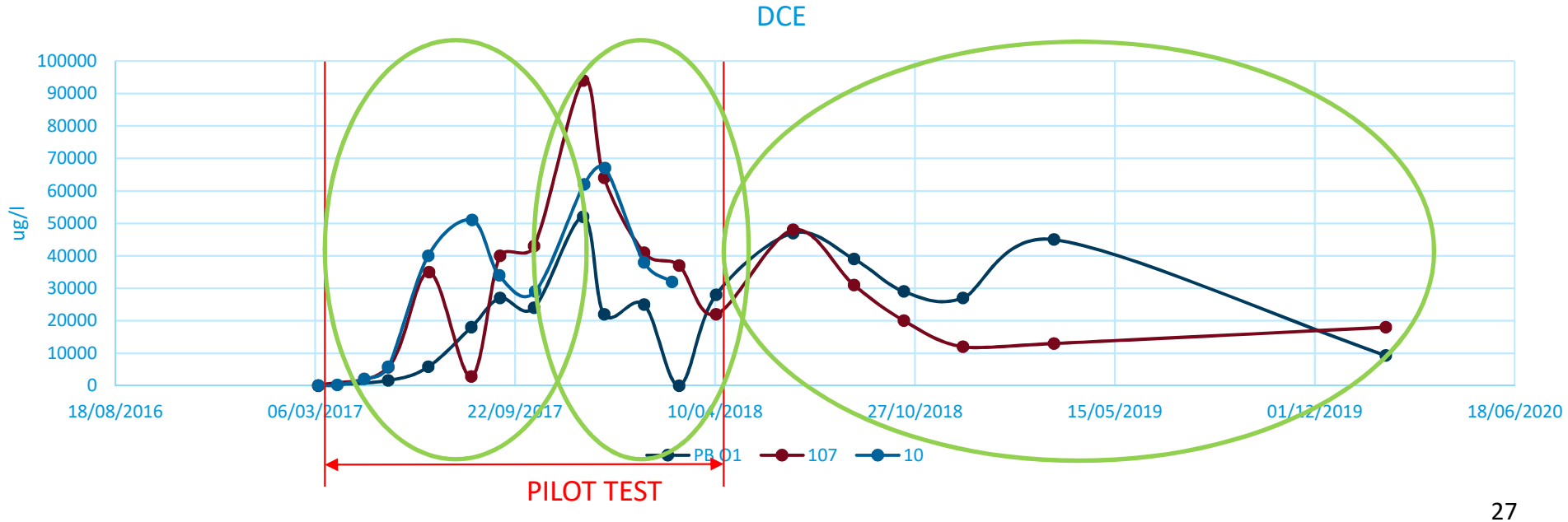
- DNAPL concentrations
- Mobilization → degradation → rebound & inflow



RESULTS LAYER L2

Dichlorethene

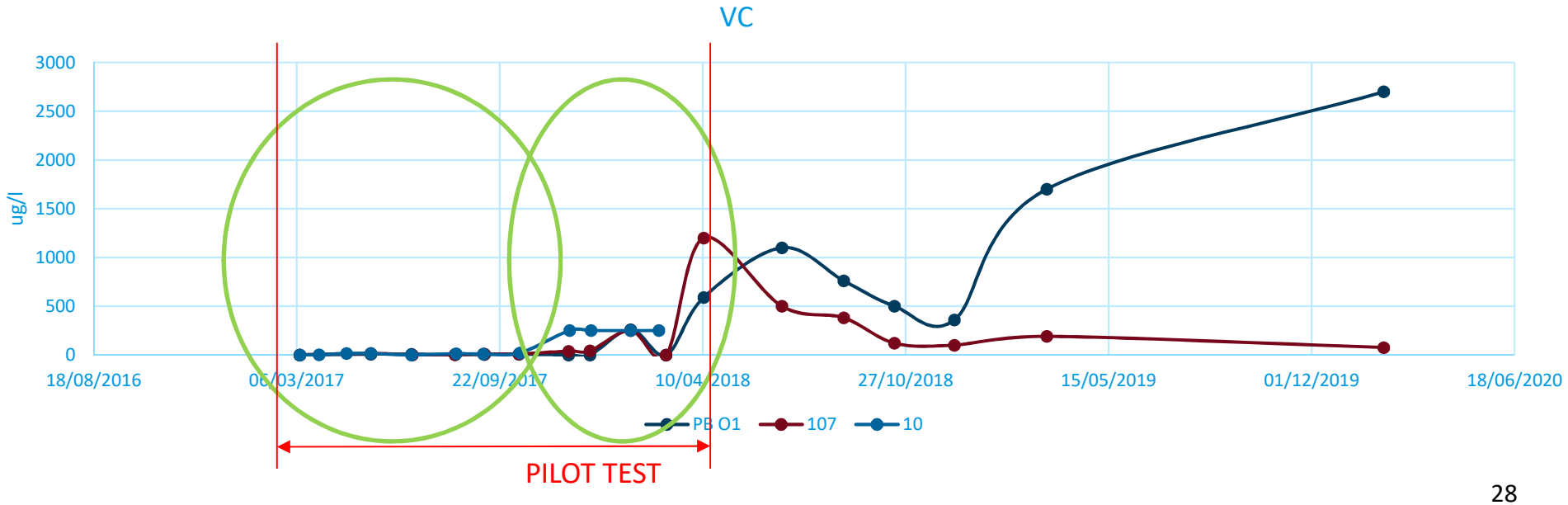
- accumulation → degradation → fluctuating concentrations



RESULTS LAYER L2

VC and ethene

- Lag time of 6-7 months → full dechlorination



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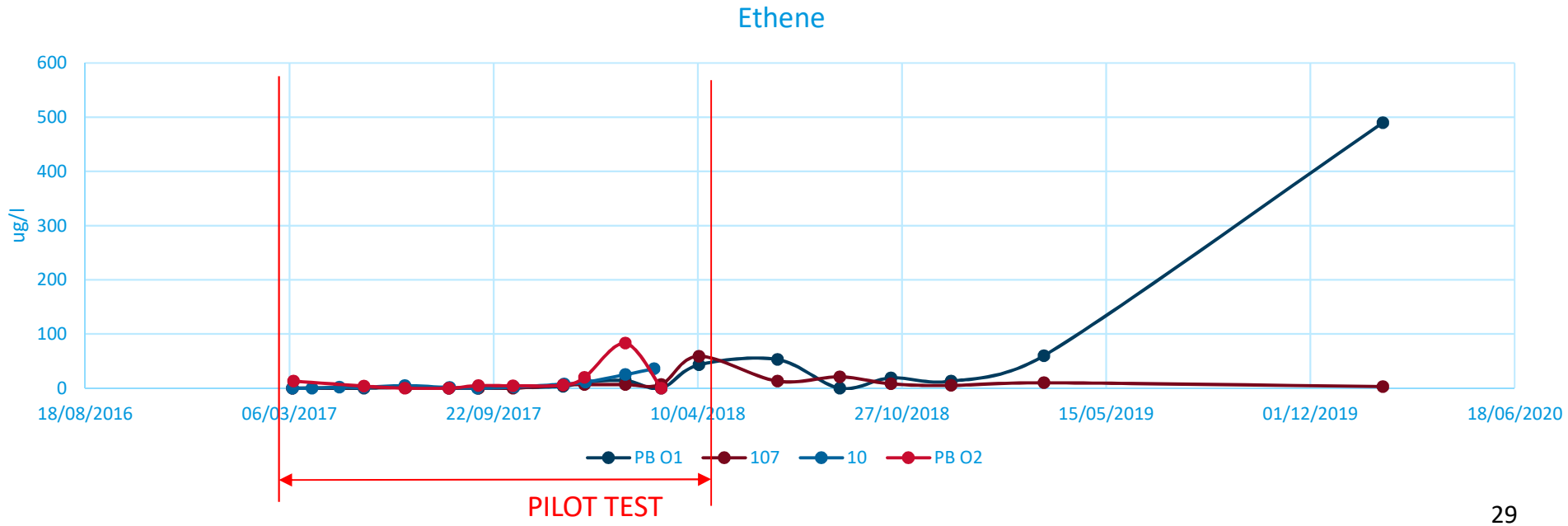
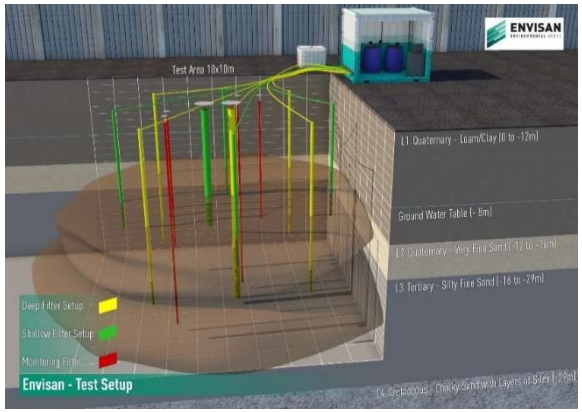


CONCLUSIONS

1. ERD is feasable without need of bioaugmentation
2. Recirculation is a response to the back-diffusion/rebound
3. EnviC is a successful carbon source



THANK YOU

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