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TERRAENERGY
THE ALTERNATIVE SOLUTION

Combining ATES with groundwater remediation

Richard Lookman

CityChlor Final Conference – 16-17 May 2013 – Ghent, Belgium

CityChlor

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
nwe
INTERREG IVB

SAMEN MAKEN WE MORGEN MOOIER
VAM

The combination of aquifer thermal energy storage (ATES) and groundwater remediation

- **Research project commissioned by OVAM (2011)** fitting in trend for 'green/sustainable remediation': minimize or recycle energy consumption

- **Literature review and preliminary (theoretical) examination** of possibilities to combine groundwater energy systems (GWE) with groundwater remediation (chlorinated solvents)

- **Original situation in Flanders**:
  - Pumping groundwater (>30.000m^3/year) requires environmental permit
  - GWE not 'forbidden' but mostly not installed if groundwater is contaminated (risk of increasing contaminated volume)
  - Suitable framework needed defining allowed boundary conditions, based on field experience.

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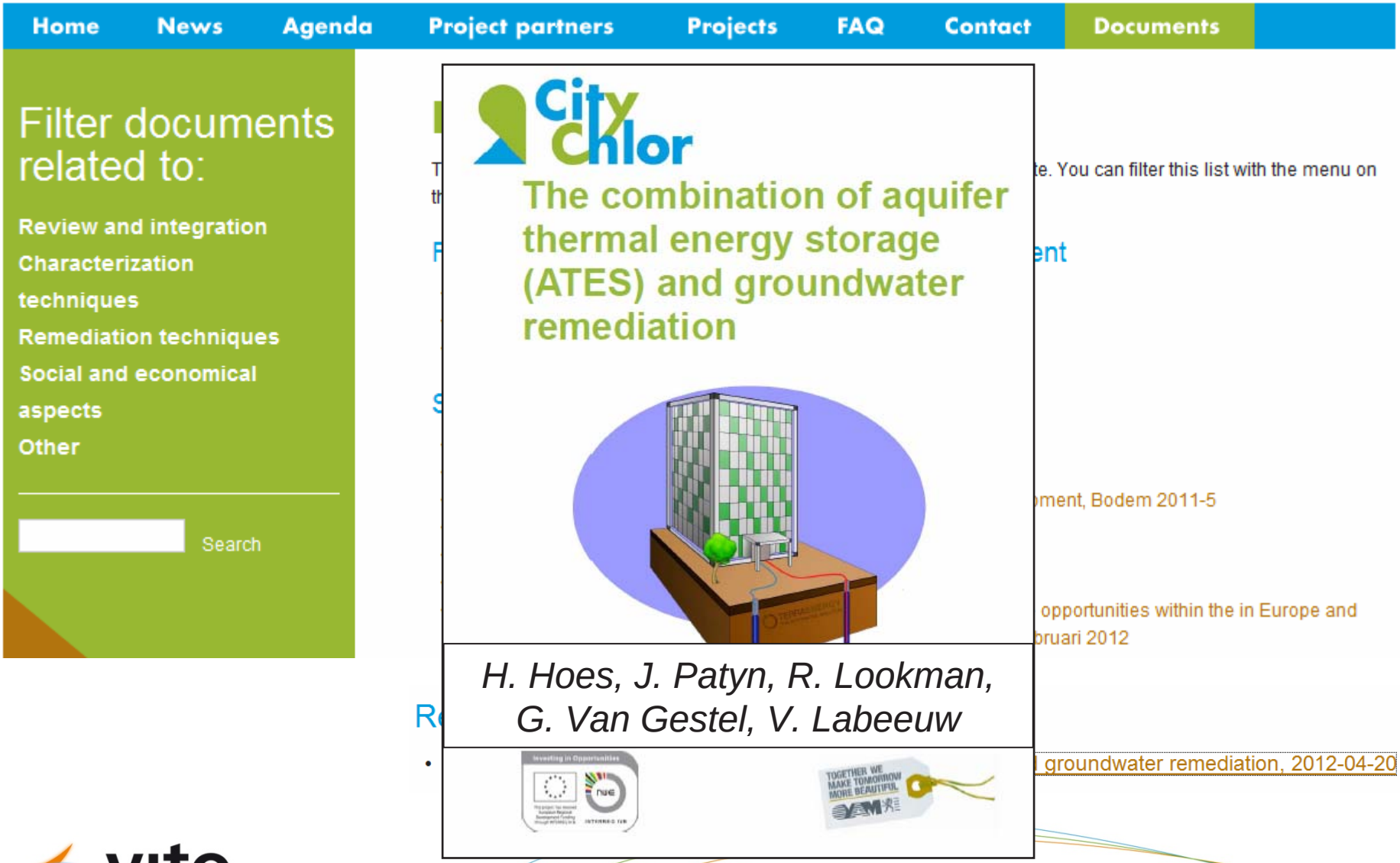
www.citychlor.eu



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Overview of aquifer thermal energy systems

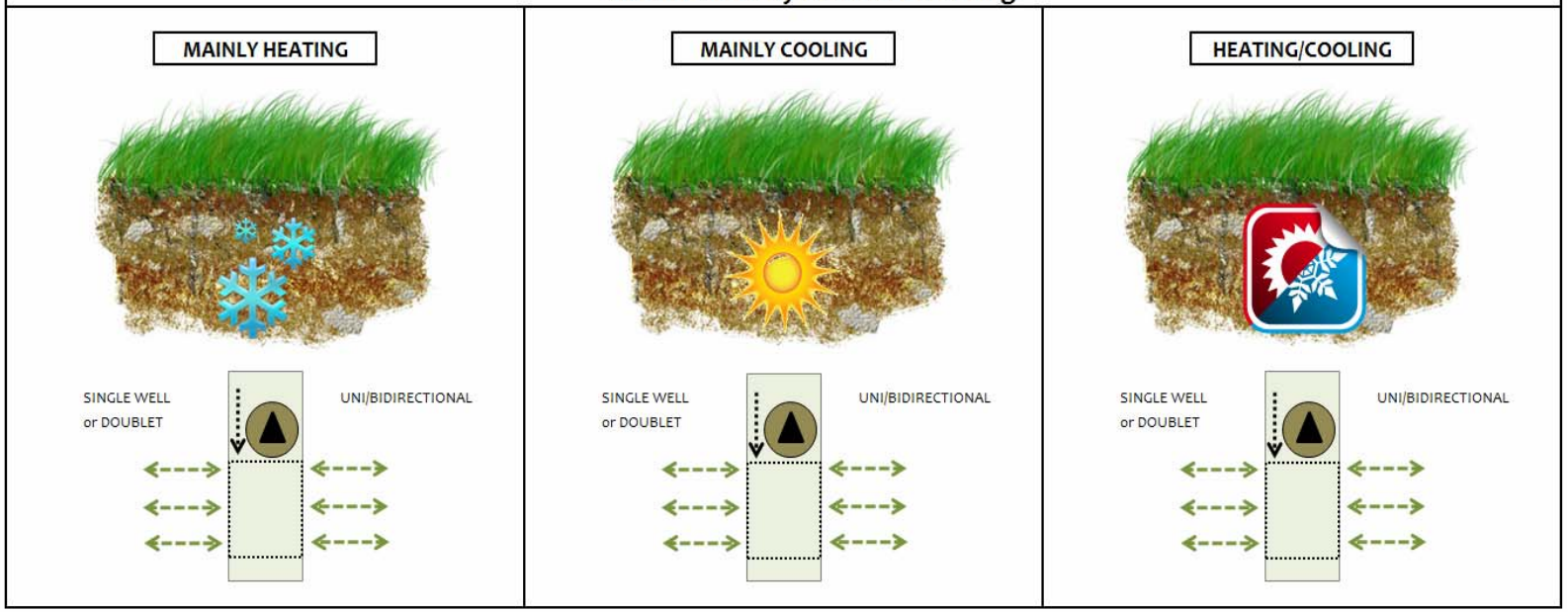
Classification by well operation

Classification by well configuration

Classification by flow rate / power

Classification by well temperature range

Classification by thermal balancing



ET CETERA, ET CETERA…

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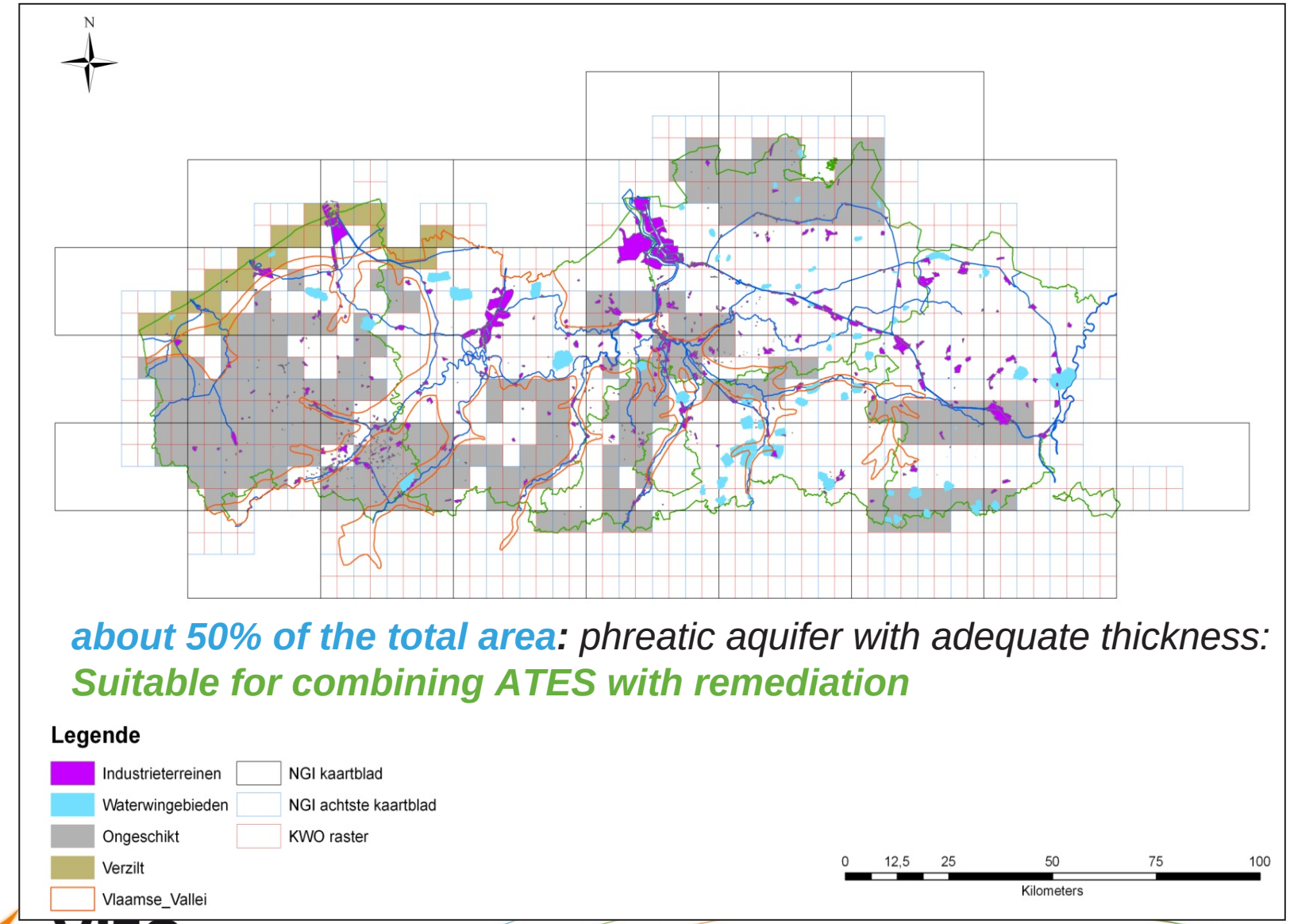
Geographical suitability analysis



about 50% of the total area*: *phreatic aquifer with adequate thickness:
Suitable for combining ATES with remediation

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Screening of relevant literature

- **Specific literature** on combining GWE and remediation is **scarce**
- **Many studies** on **effects of ↗ T°C** on physical, chemical and biological behaviour of pollutants in the subsurface
- Relevant T°C interval for 'normal' GWE systems limited; thus biological and geochemical reaction rates only slightly affected
- The **groundwater flushing and mixing effect caused is most relevant**
- Basic principles for GWE system design not different if combined with remediation but
  - **intensified monitoring needed** (groundwater and pollution transport)
  - extra attention to **avoid well clogging**

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Modeling of aquifer thermal energy storage (ATES) and groundwater remediation

- GWE-systems are active for decades: groundwater flow and reactive solute **modeling** essential
- We used FeFlow 6.0 modeling package (other modeling tools e.g. Modflow also applicable)
- Several **hypothetical scenarios** calculated
- Focus on shallow Open-Loop systems, limited to the flow and mass-transport component

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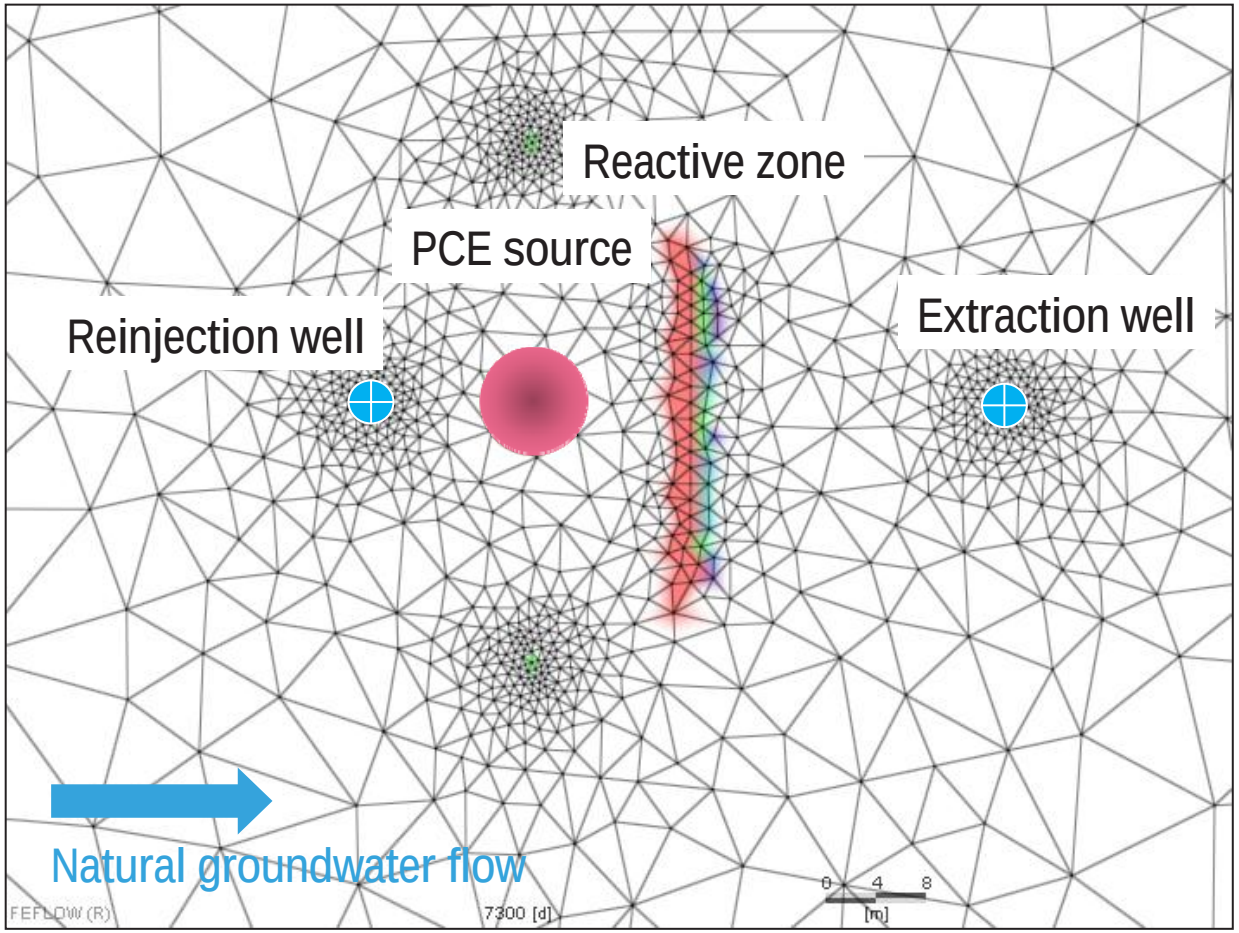
Example scenario – unidirectional GWE with reactive zone



- **2 wells** (20 - 30m bgl),
- **50 m** interdistance
- **15 m³/h** – 50/50% heating cooling mode (ΔT 5°C)
- **reactive zone** (ZVI or biological reduction of chlorinated ethenes)
- **model**: first 20y GWE inactive; after 20 years GWE 30y active.

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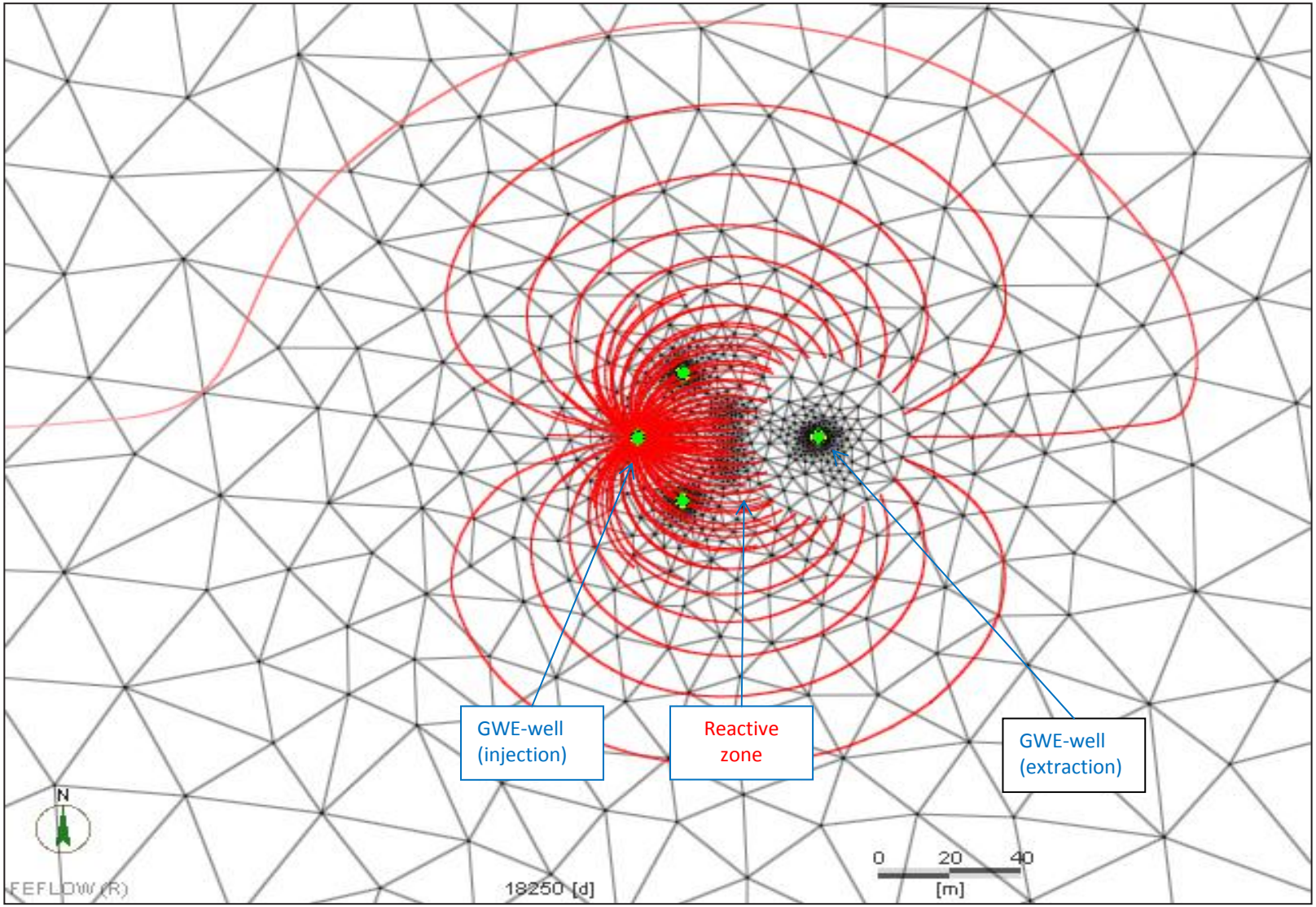
GWE-well
(injection)
Reactive
zone
GWE-well
(extraction)
N
FEFLOW (R)
18250 [d]
0
20
40
[m]

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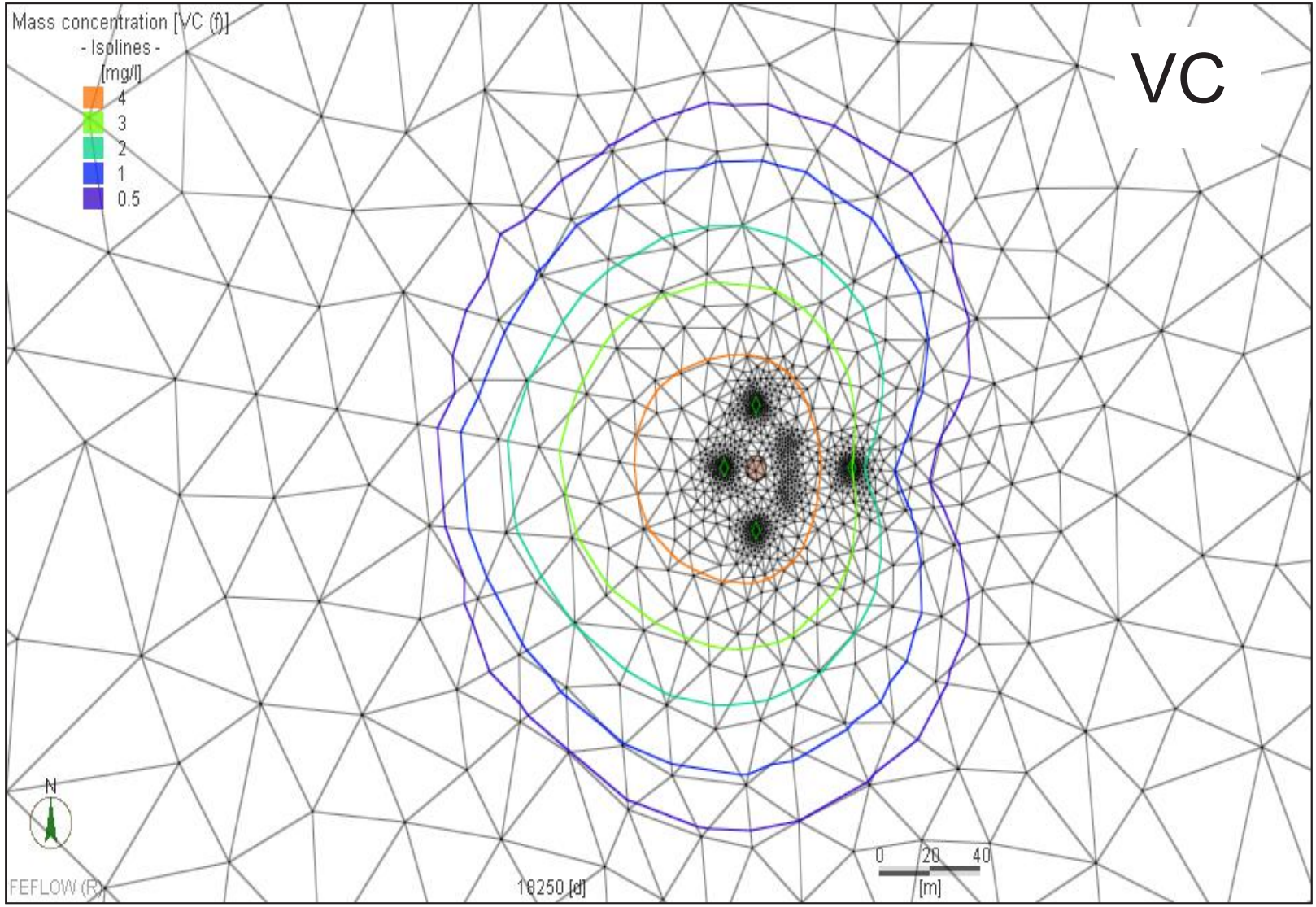
Mass concentration [VC (f)]
- Isolines -
[mg/l]
4
3
2
1
0.5
VC
N
FEFLOW (R)
18250 [d]
0
20
40
[m]

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Hydraulic head
Isolines
[m]
24
2
2
22
22
2
2
2
2
9
9
N
FEFLOW (R)
0 [d]
0
150
300
[m]

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Conclusions Preliminary Study

- **Not** GWE system temperature effects but **induced groundwater flow** significant for remediation
- Groundwater and reactive solute **modeling needed** to predict the behaviour of the groundwater pollution when GWE-systems are active
- Hypothetical scenarios demonstrated significant migration effects, **especially for mobile partial dechlorination products DCE and VC**
- **Field pilot** to examine practical applicability on a **real contaminated site in Turnhout** (ARCADIS Belgium, Mourik, Philips and OMC vzw)

→ **Karen Van Geert (Arcadis)**

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Demonstration project: combination of Ground water energy system and remediation

2012-2015

ARCADIS- Mourik - Philips –OVAM- OMC

Imagine the result

ARCADIS

Partners

SAMEN MAKEN WE MORGEN MOOIER

YAM

PHILIPS

sense and simplicity

MOURIK

OMC

OPEN MANUFACTURING CAMPUS

a Philips initiative

ARCADIS

Infrastructuur · Water · Milieu · Gebouwen

Outline

1. Framework of the project
   - Aim and challenges
2. Overview of project case
   - Conceptual site model
   - Task 1: Pilot test: remediation concept with recirculation and injection of C source (enhanced reductive dechlorination)
   - Overview future tasks (2013- 2015)

ARCADIS

AIM OF THE DEMONSTRATION PROJECT

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Aim

-**Demonstration project** of the combination of remediation and GWE ➔ first project in Flanders

-**Feasibility study of a project case in Flanders:**

Is win-win possible for combination of remediation and GWE? what are the potential bottlenecks *"in the field"?*

- *stakeholders participation?*
- *Cost reduction?*
- *Migration of contamination?*
- *Flow rate (remediation vs energy)*
- *Continuous system vs seasonal driven system*
- *…..*

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OVERVIEW PROJECT CASE

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Conceptual site model of case study

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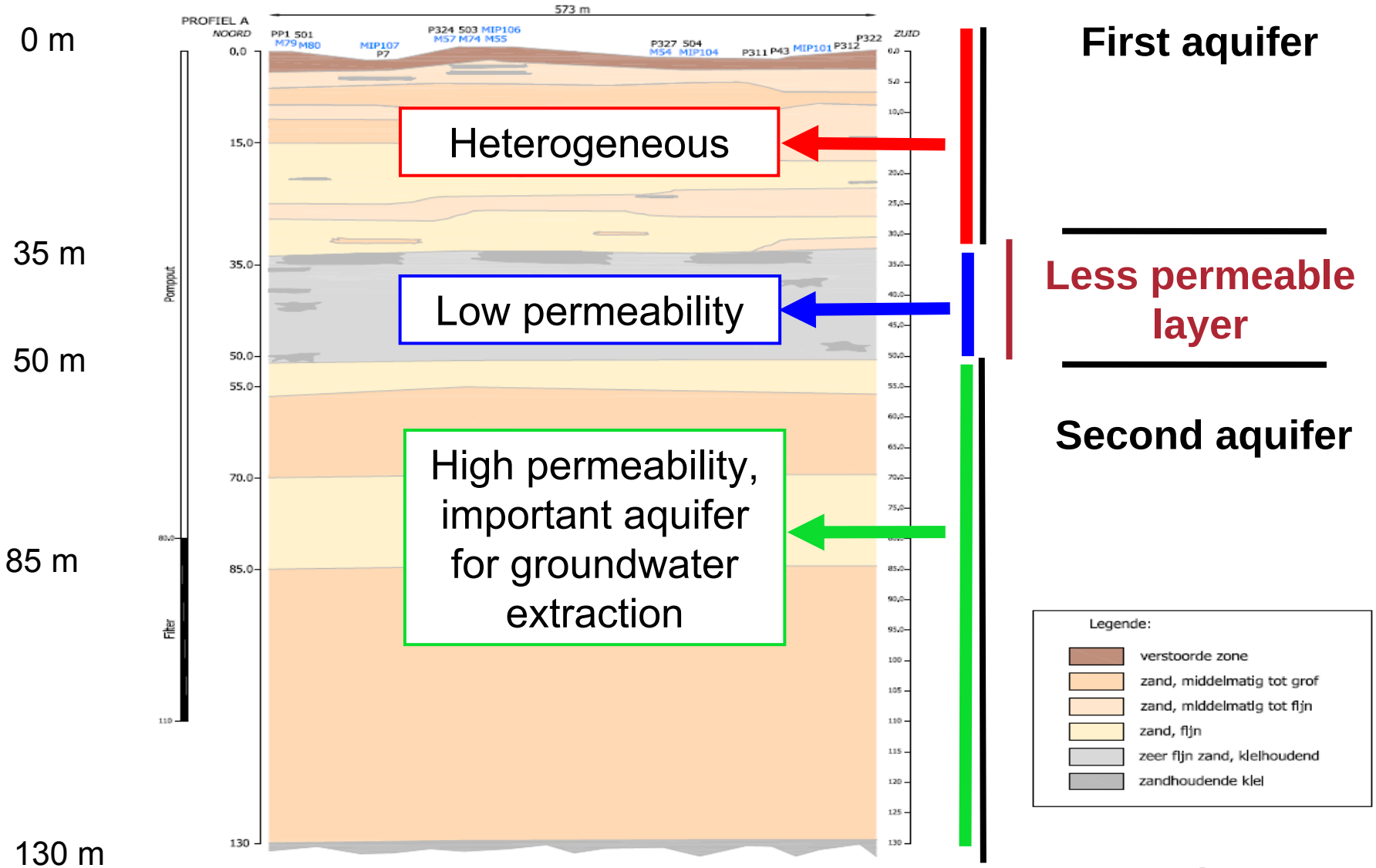
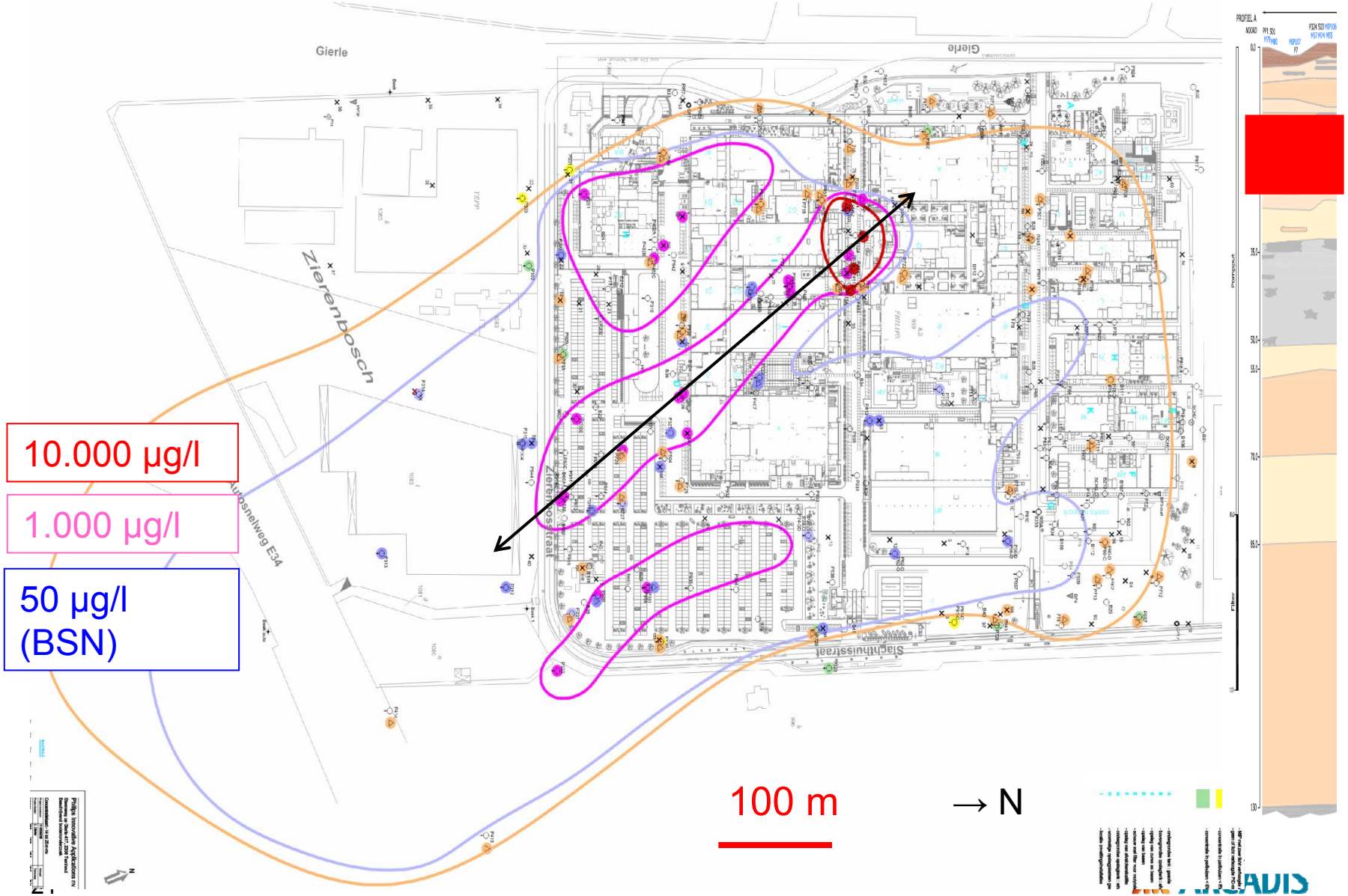
Geology

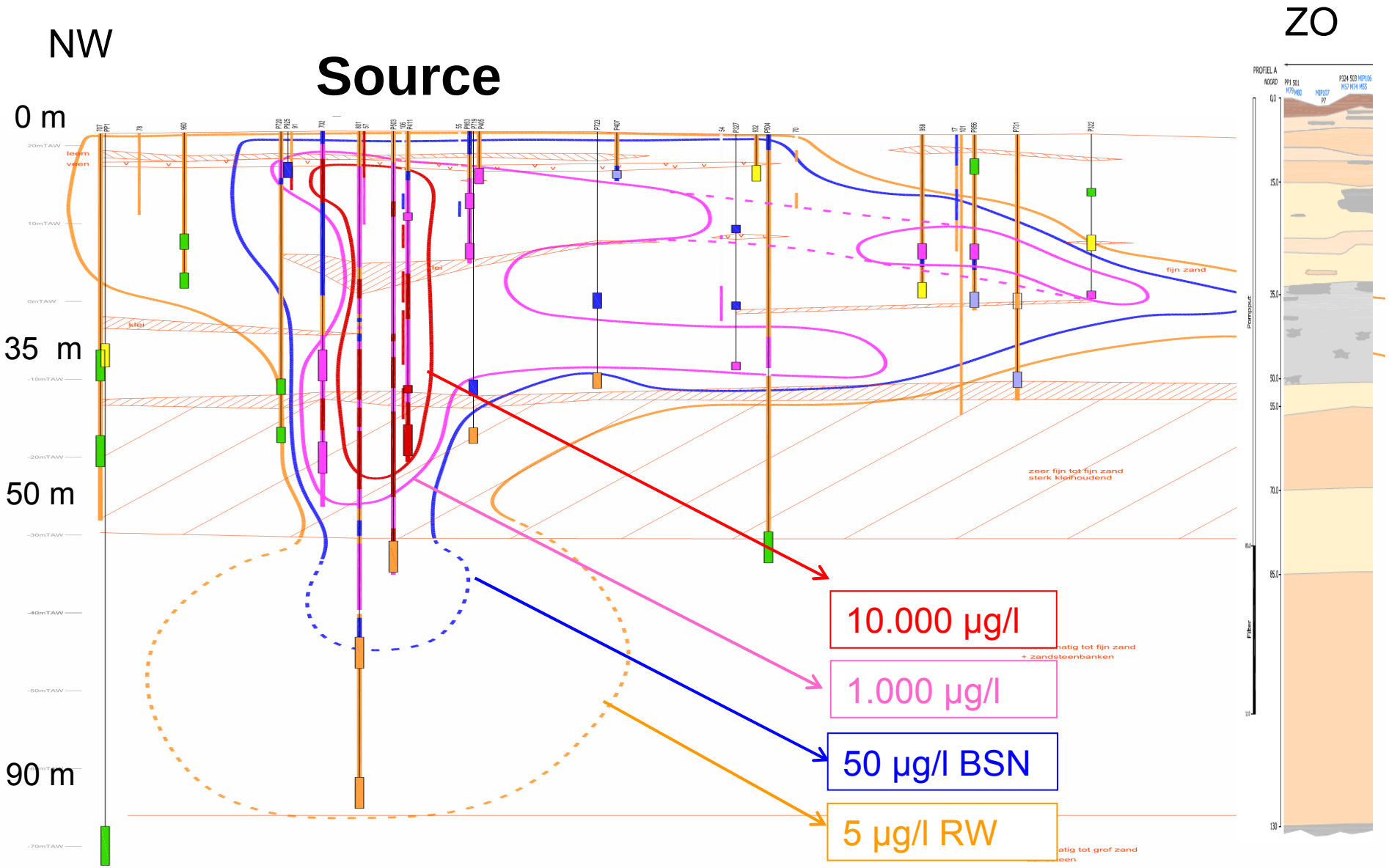

0 m
35 m
50 m
85 m
130 m
PROFIEL A
NOORD
ZUID
573 m
Pompput
Filter
Heterogeneous
Low permeability
High permeability, important aquifer for groundwater extraction
First aquifer
Less permeable layer
Second aquifer
Legende:
verstoorde zone
zand, middelmatig tot grof
zand, middelmatig tot fijn
zand, fijn
zeer fijn zand, kleihoudend
zandhoudende klei

Chlorinated solvents : 14 – 25 m-bgl



VOCl contamination: cross-section

CSM



Pilot test: remediation concept with recirculation and injection of carbon source

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Task 1: pilot testing recirculation

1. Evaluation of effects of recirculation combined with ERD (Enhanced Reductive Dechlorination) on spreading of contamination
2. Evaluation on effects of C source on degradation of contamination
3. Determination of infiltration and extraction flows.
4. Evaluation of effects on area around recirculation zone
5. Effects of fouling

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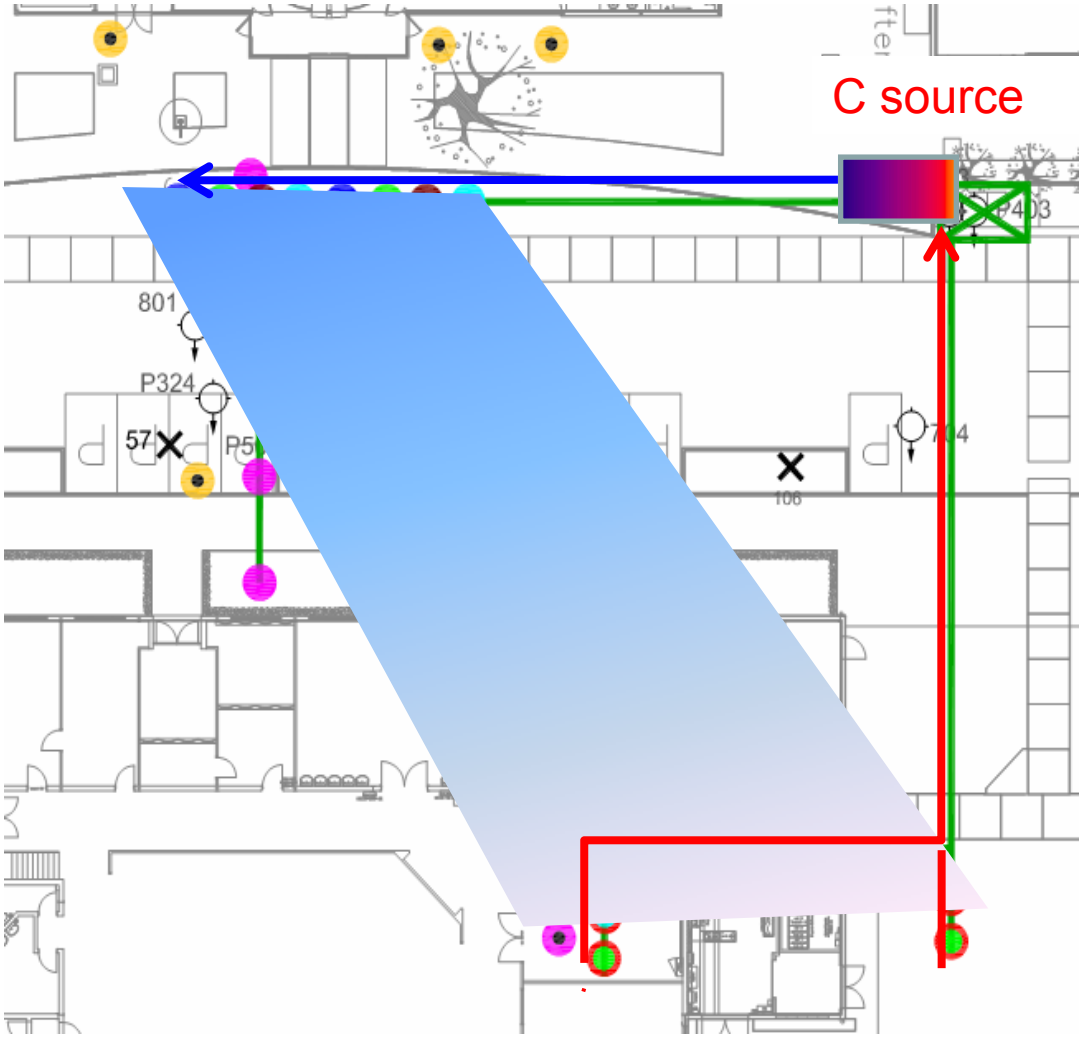
Enhanced Reductive Dechlorination 1st aquifer Concept Source



- Mean recirculation flow of 8 m³/h
  - 2x 2 extraction wells;
  - 2x 4 injection wells)
- circa 30.000 m³ groundwater recirculated
- 4 m³ C-carbon source injected
- Monitoring: 8 wells

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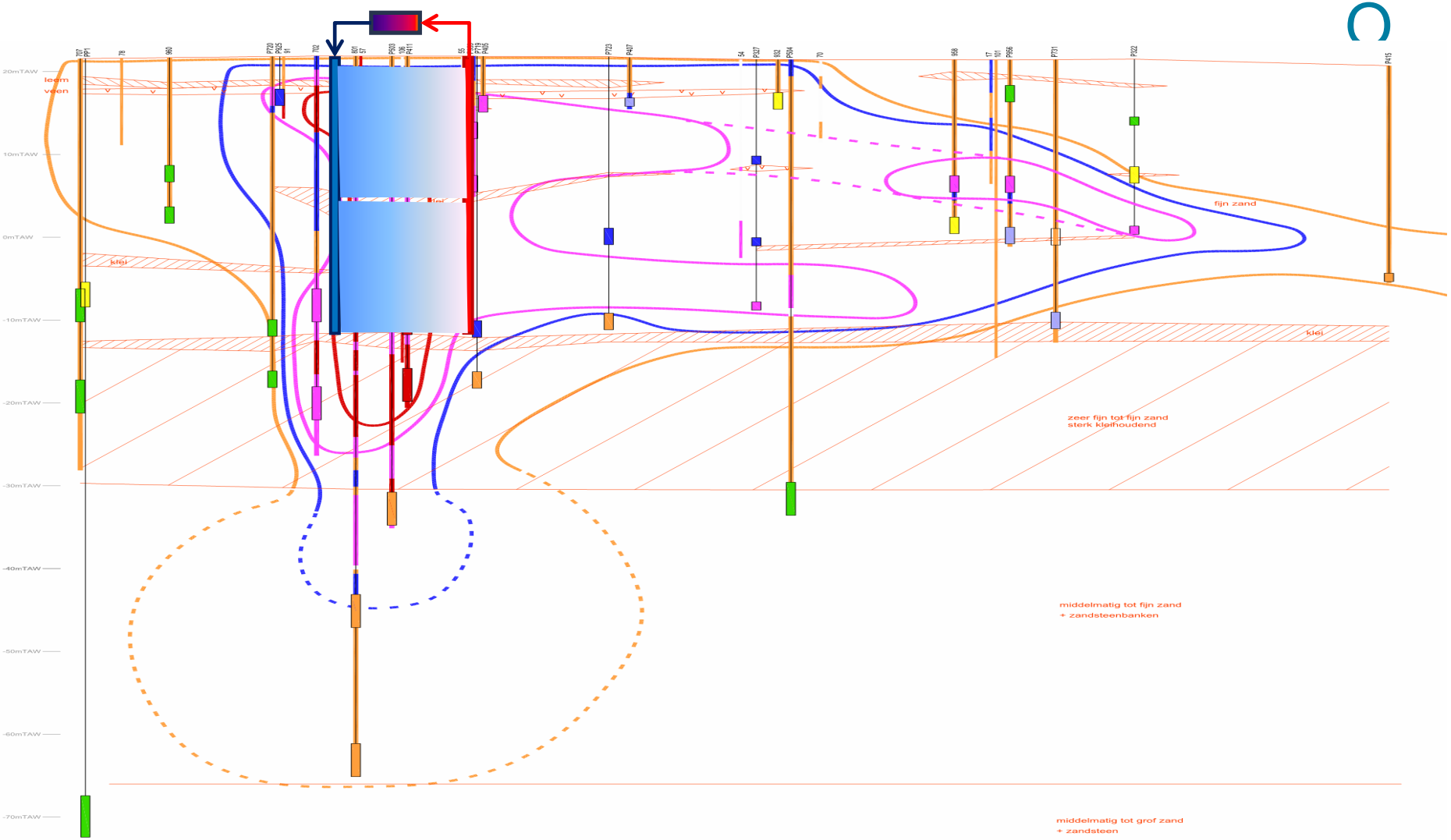
Vertical cross section

NW

Z
O



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Some promissing results….

Injection Process

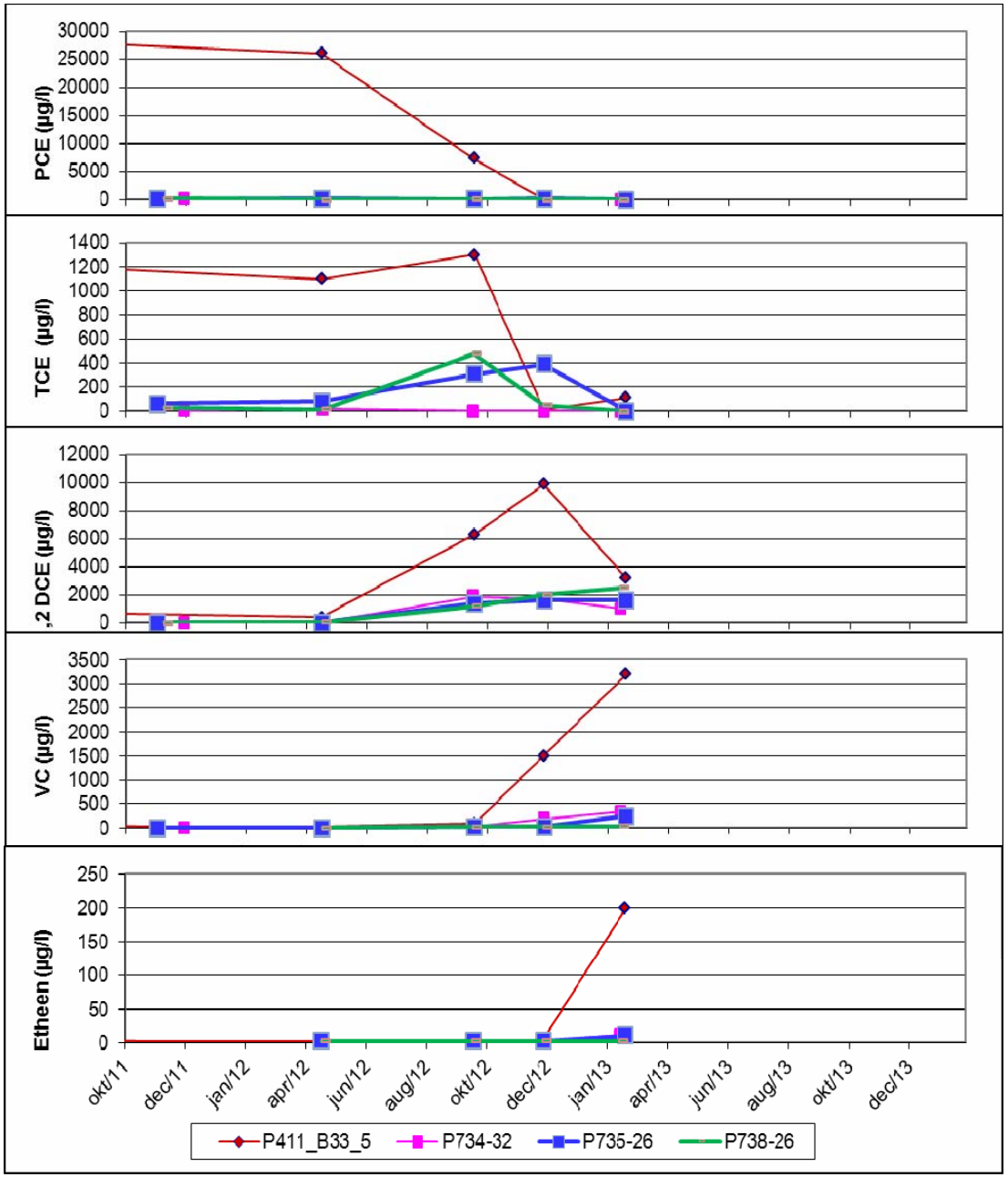
-No increase in pressure during whole injection period (5 months), no rinsing or redevelopment needed

- **Degradation**

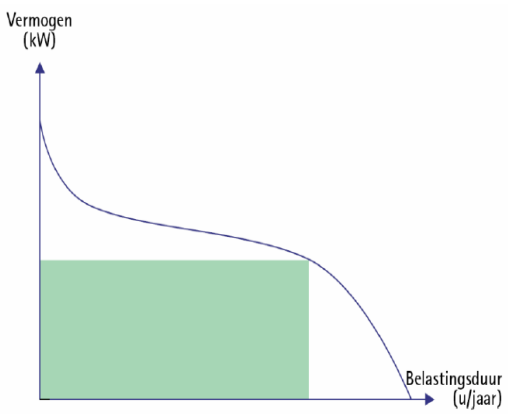
-PCE en TCE : deccrease
-DCE increase (ca 2000 µg/l)
-VC increase
-In P411B (30-32 m) ethene

Effects outside recirculation zone

- No major influence
- Evaluation ongoing (monitoring)



Ongoing and future tasks:



1.Estimation of energy needs (heat and cold) within the buildings that will be renovated➔ definition of optimal energy power

2.Calculation of different combined scenarios:

- Optimal remediation flow combined with energy
- Optimal energy flow combined with remediation
- ….

3.Modelling groundwater flow and heat, energy and cost calculation of different selected scenarios

4.Decision on installation GWE system

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THE FUTURE…

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Final outcome: workshop

- Results will be presented on future conferences
- Workshop on combination of remediation and GWE (by the end of the project)
- Information brochure: results, bottlenecks, ….

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Imagine the result

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