EnISSA
enhanced in-situ soil analysis

Kijken in de ondergrond: Sondeertechnieken

9 – 2 - 2023 – Bodembreed

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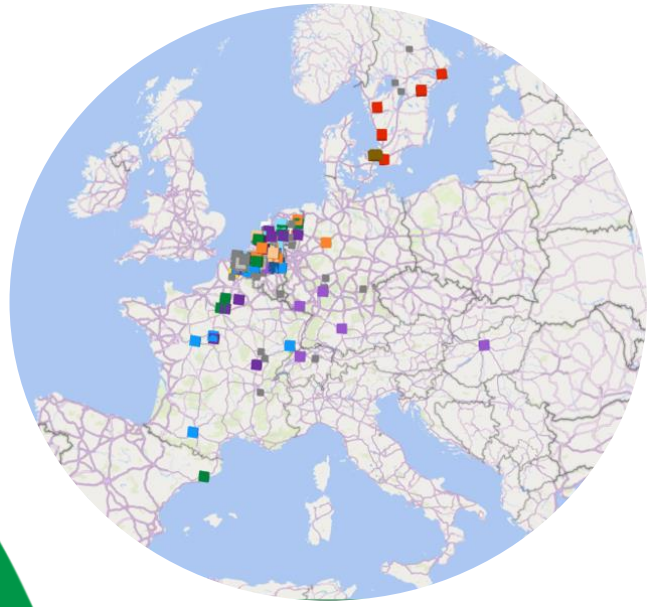

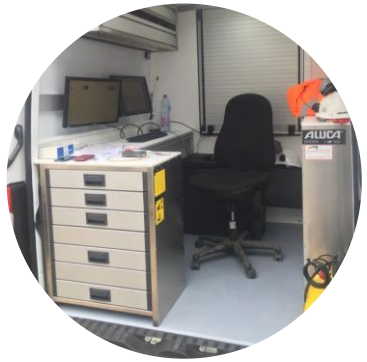

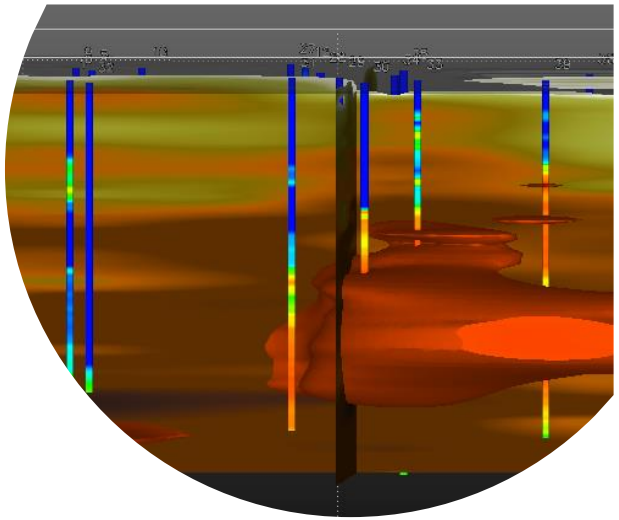

Vanuit Steenokkerzeel - Belgie

Team > 10

2 direct push rigs (Geoprobe) (standard en Low clearance <3m)

2 field labs :

3 MIP systems

HPT, CPT, OIP, GWP

Machinale boringen (BRL SIKB) en bemonsteringen van grondwater

Dataverwerking : dashboard, 3D visualisatie en modellen

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Voorspellingen over saneringstijd, -volume, -budget en effectiviteit blijken regelmatig erg moeilijk (=onbetrouwbaar en onnauwkeurig).

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Heterogeniteit van de ondergrond

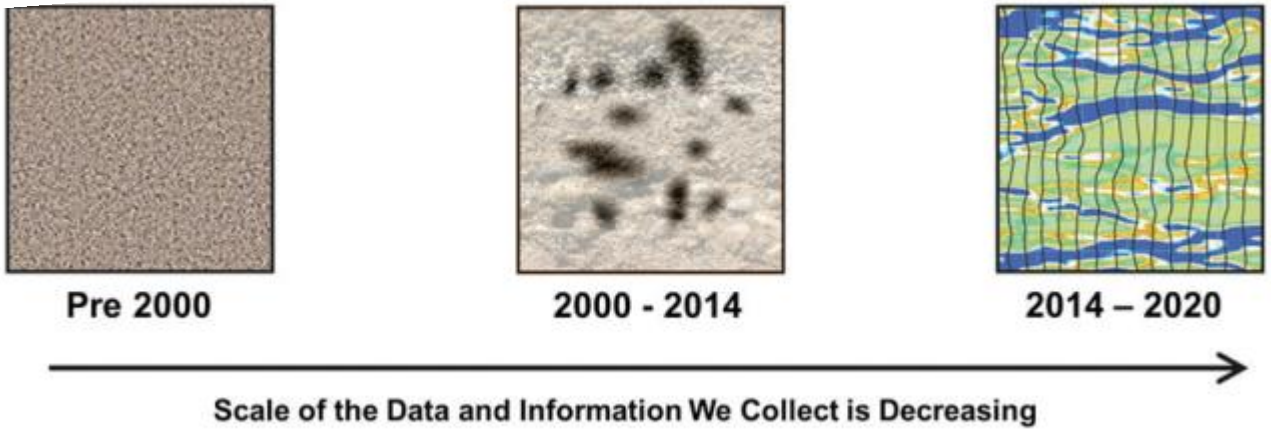
Groundwater Monitoring & Remediation
NGWA The Groundwater Association

Advances in Remediation Solutions

Rethinking Conceptual Site Models in Groundwater Remediation

by Suthan S. Suthersan, Scott T. Potter, Matthew Schnobrich, Jennifer Wahlberg, Joseph Quinnan, Nicklaus Welty, Tom Fewless

First published: 20 December 2016 | https://doi.org/10.1111/gwmr.12192 | Citations: 11



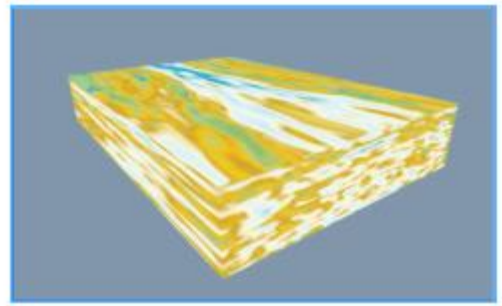


Figure 3. Three-dimensional depiction of variations in hydraulic conductivity and heterogeneous conditions within an alluvial aquifer.

Representatieve bemonstering: datadichtheid ?

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Bodem- en grondwaterbemonstering :

Kwantitatieve en kwalitatieve meting

Algemeen aanvaard door regelgevers

Basis voor wetgeving/normen

boor- en bemonsteringsmethoden zijn tijd- en kostenintensief

hoge kosten / datapunt

lage gegevensdichtheid

> lacunes in de gegevens en onzekerheid in het conceptuele locatiemodel

Representatieve bemonstering:
schaal ?

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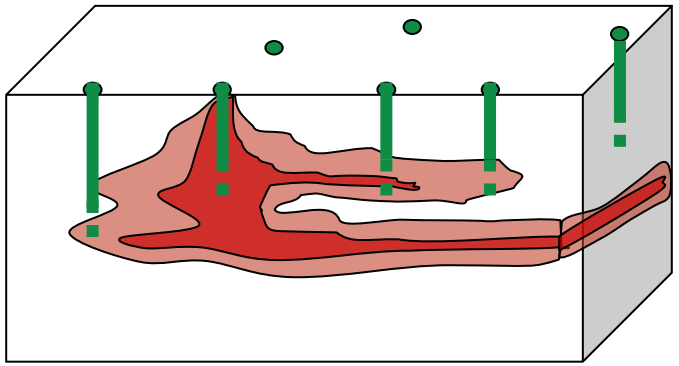

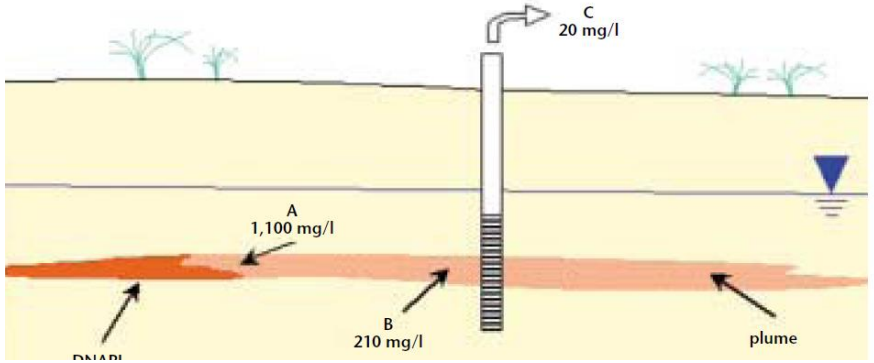

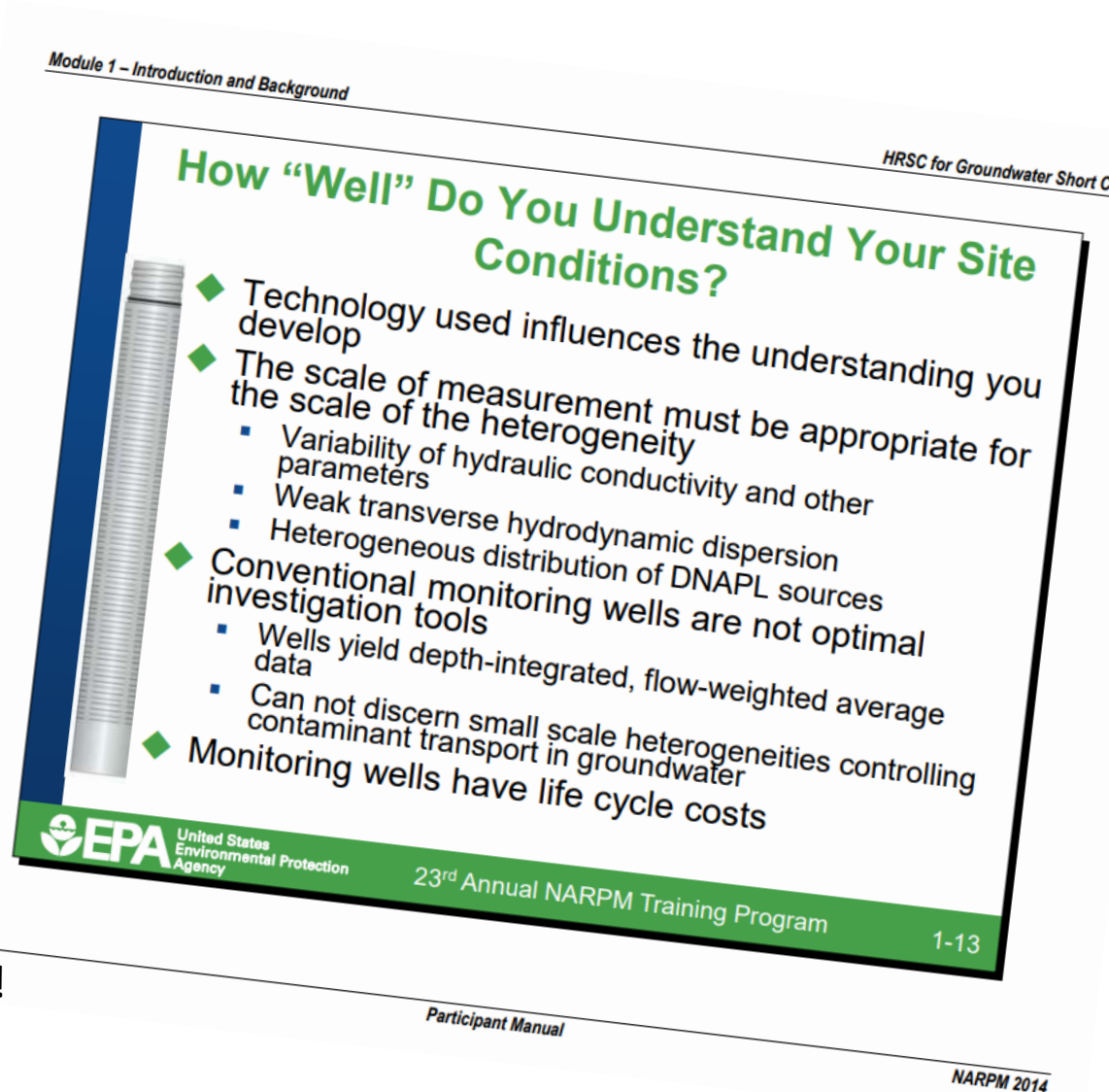

depth-integrated, flow-weighted average data !
Risc of missing the plume !

Onzekerheden in het conceptual site model

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DNAPL's….

Dichtheid > water

zinken tot grote diepte : DNAPL-pool

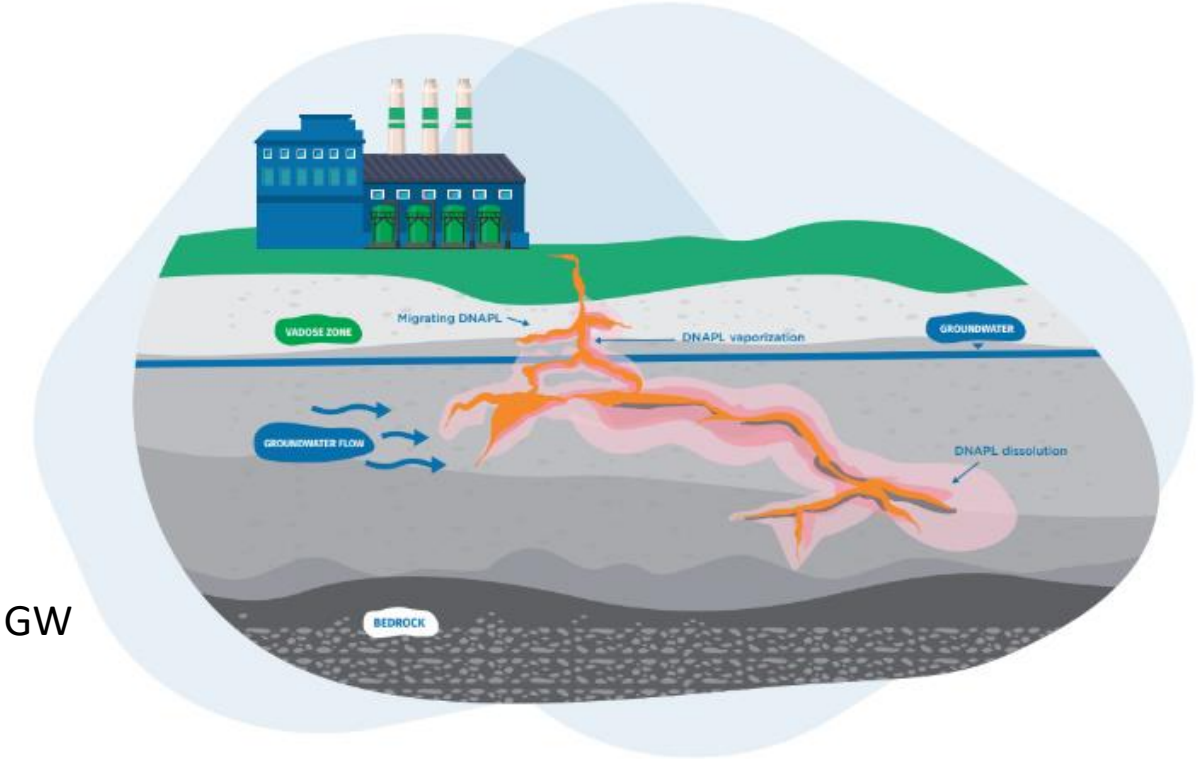
DNAPL-verdeling is sterk afhankelijk van verschillen in bodemkenmerken

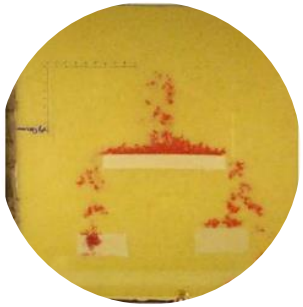
fijnere bodemstructuur werkt als capillaire barrière

DNAPL pooling & laterale distributie (kan tegengesteld zijn aan GW stroomrichting!)

Diffusie: Opslag van DNAPL in nauwe poriën.

Advectie: vorming van langdurige GW-pluimen





….grote uitdaging

De horizontale en verticale verspreiding wordt gestuurd door (subtiele) variaties in de bodem

onvoorspelbare architectuur van pluim en bron

Schaal van variabiliteit kleiner dan algemeen aangenomen

Van een 2D naar 3D benadering van de ondergrond

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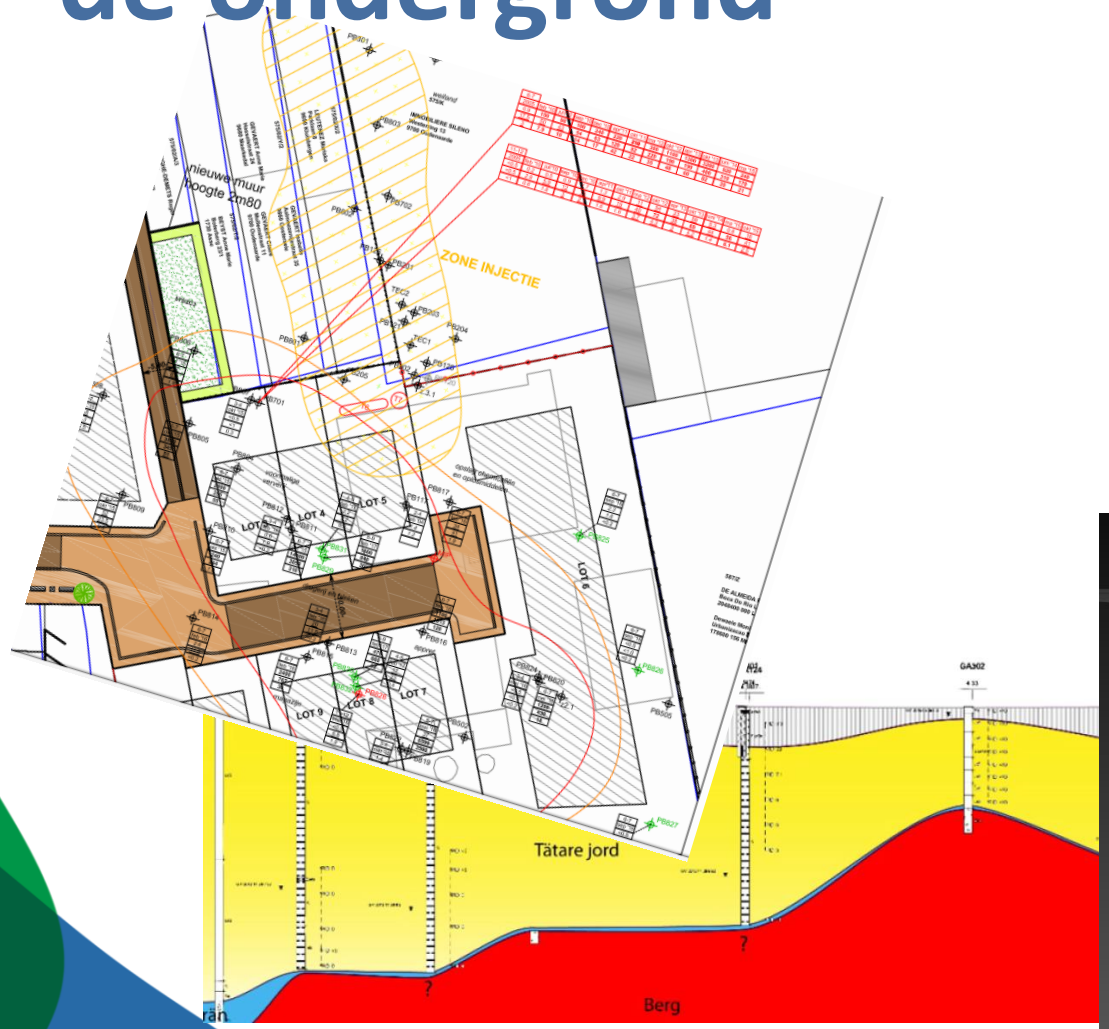

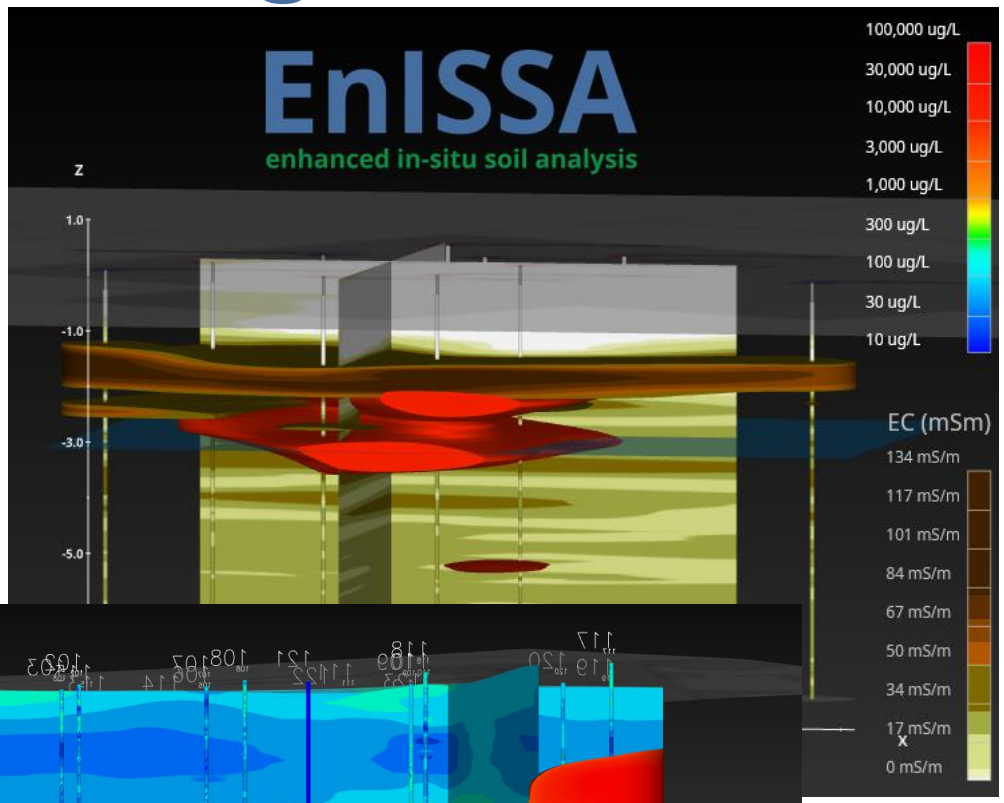

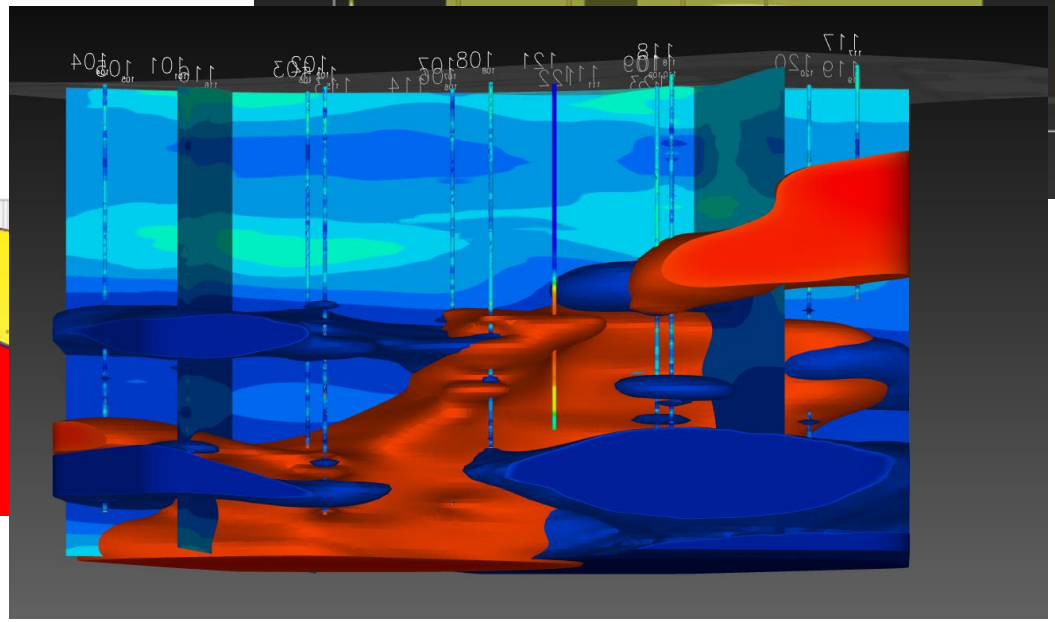

Reduceren van onzekerheid in het conceptual site model: HRSC

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High Resolution Site Characterization

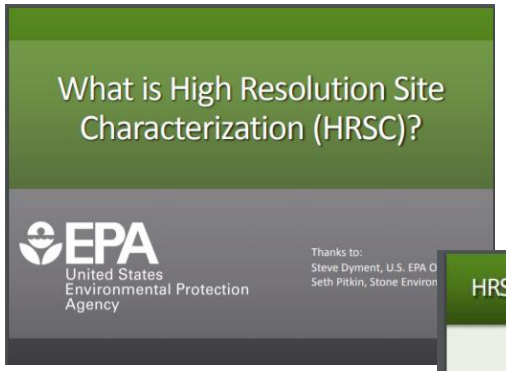
Geschikte meetmethoden op schaal

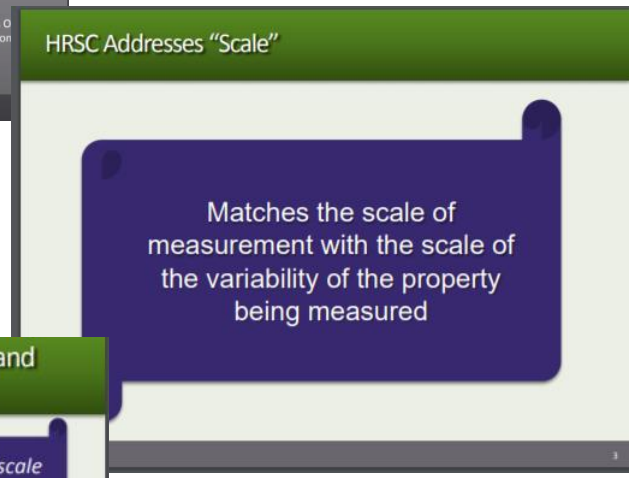
Kosteneffectieve gegevensverzameling

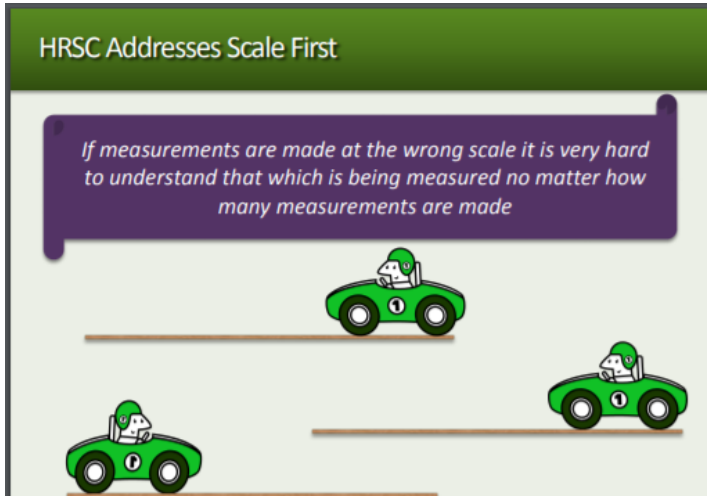
Dynamische bemonstering & kortere onderzoekscycli

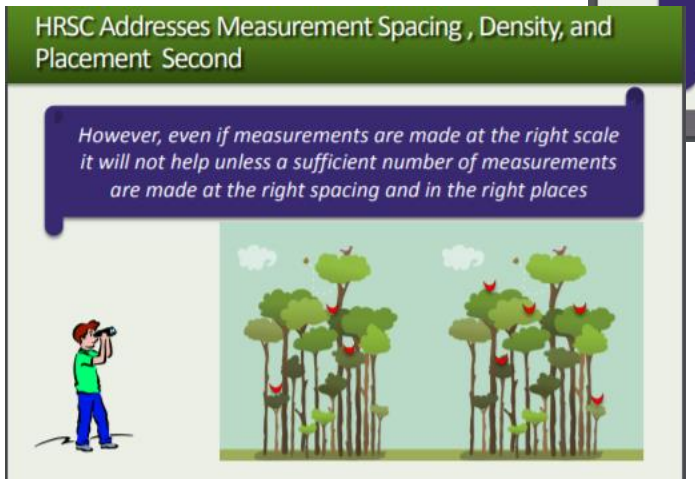
Minder onzekerheden & betere inzichten

➔ **snellere en effectievere sanering van locaties**









Value of investigation & Remedial Design Characterisation (RDC)

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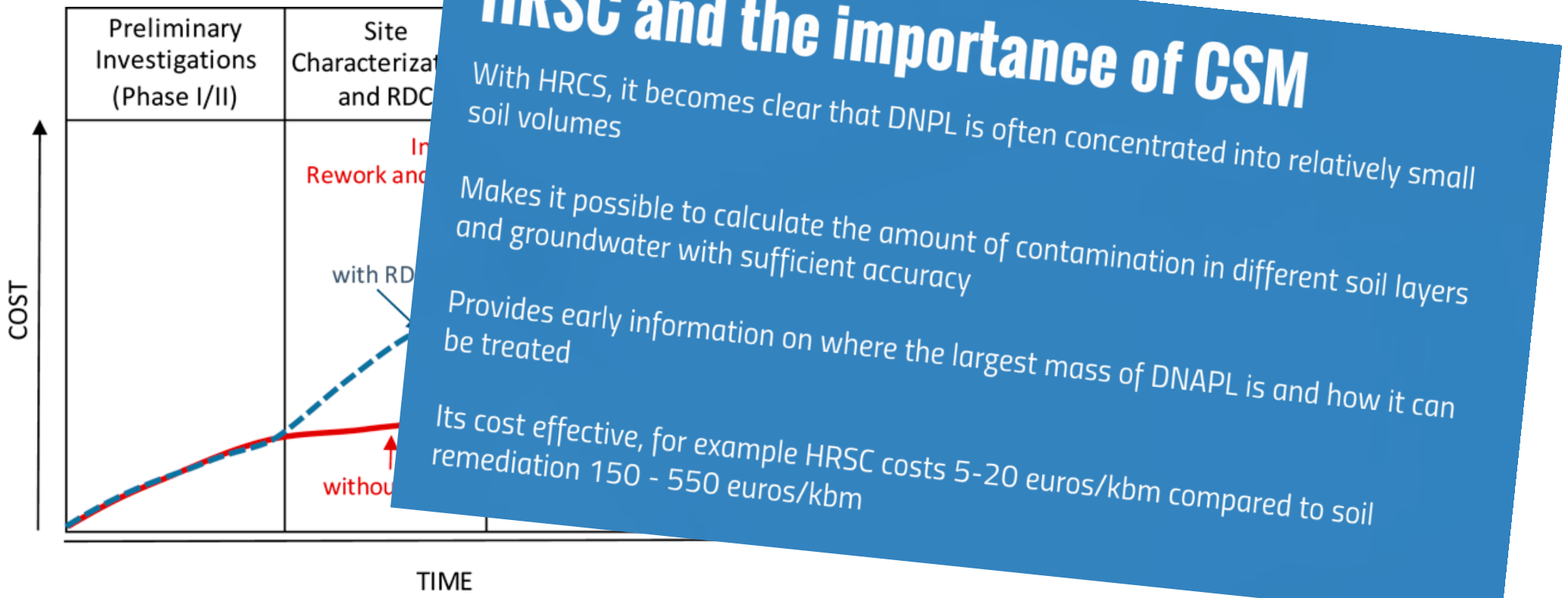

HRSC and the importance of CSM

With HRCS, it becomes clear that DNPL is often concentrated into relatively small soil volumes

Makes it possible to calculate the amount of contamination in different soil layers and groundwater with sufficient accuracy

Provides early information on where the largest mass of DNAPL is and how it can be treated

Its cost effective, for example HRSC costs 5-20 euros/kbm compared to soil remediation 150 - 550 euros/kbm

Conceptual project lifecycle costs with and without RDC.
Source: Modified from (ITRC 2015)

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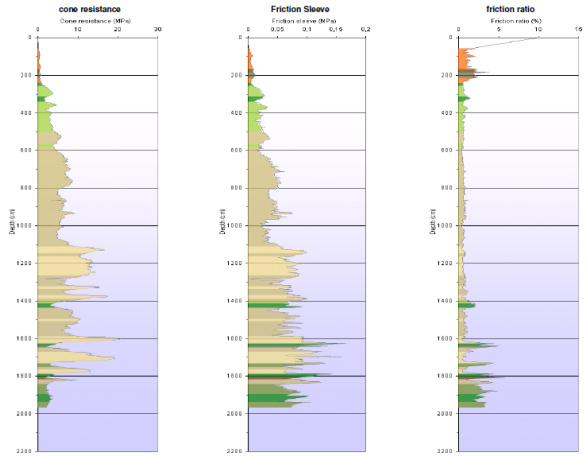
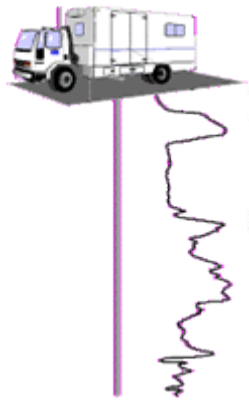
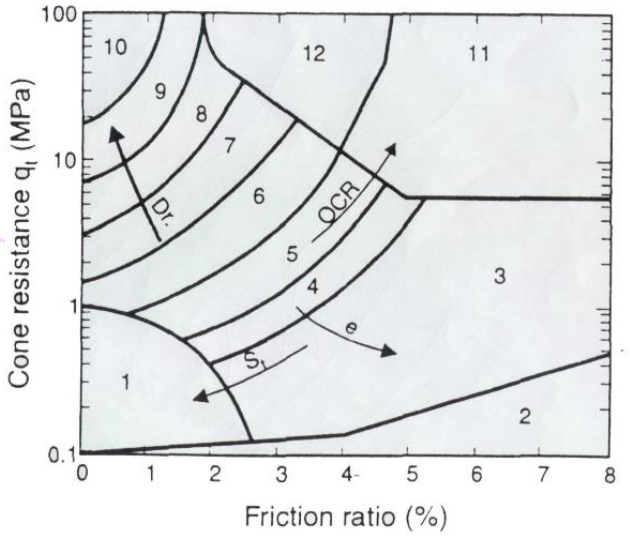
Sonderen - CPT







Cone Penetrometer Test

- Sondeerconus wordt in de ondergrond gedrukt
- Registratie van
  - Puntweerstand
  - Kleefweerstand
  - (poriewaterdruk)

    ….
- Classificatie in 12 bodemtypes


© Geomil

Magnetometer – UXO
Video
Seismische metingen

MIP Membrane Interface Probe

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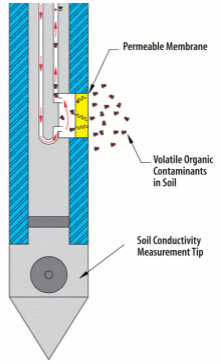

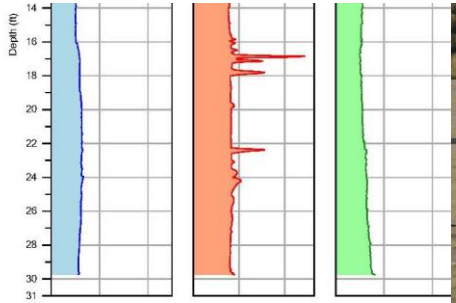

Interpretatie van MIP resultaten

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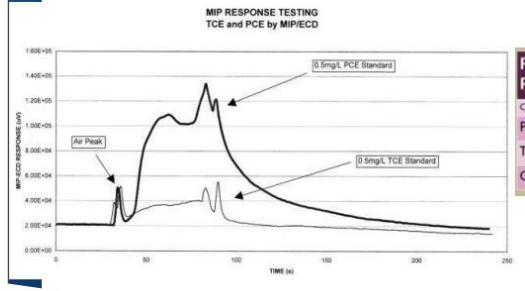
MIP Strengths and Limitations

- Strengths
  - Vertically continuous, real-time data on VOC distributions and soil electrical conductivity
  - Can typically complete 150 to 250 linear feet of exploration per day
  - Ideal for locating source areas and plume cores
- Limitations
  - "Delicate" instrumentation and limited depth penetration
  - Units (volts) not the same as with soil or water concentration
  - Correlations with soil and water concentrations problematic
  - Generally does not distinguish between analytes
  - Apparent "dragdown" of contamination

Variability in Detector Response

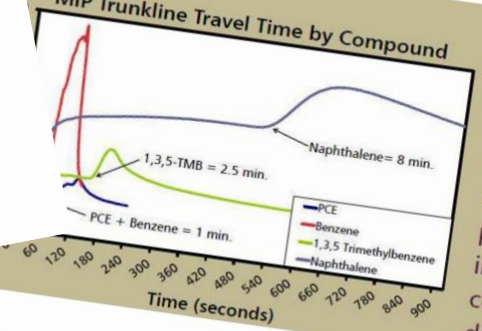


Response Test Results: ECD & PID with PCE, TCE and c-DCE

Compound	ECD Response, mV		PID Response, mV	
PCE	1800	Dramatic Decrease	16	No Significant Change
TCE	690		23	
C-DCE	22		19	

Factors Impacting MIP Performance

Time Disparity



- Different compounds travel at different rates, causing potential inaccuracies in contaminant distribution

EnISSA: MIP met GC-MS detectie

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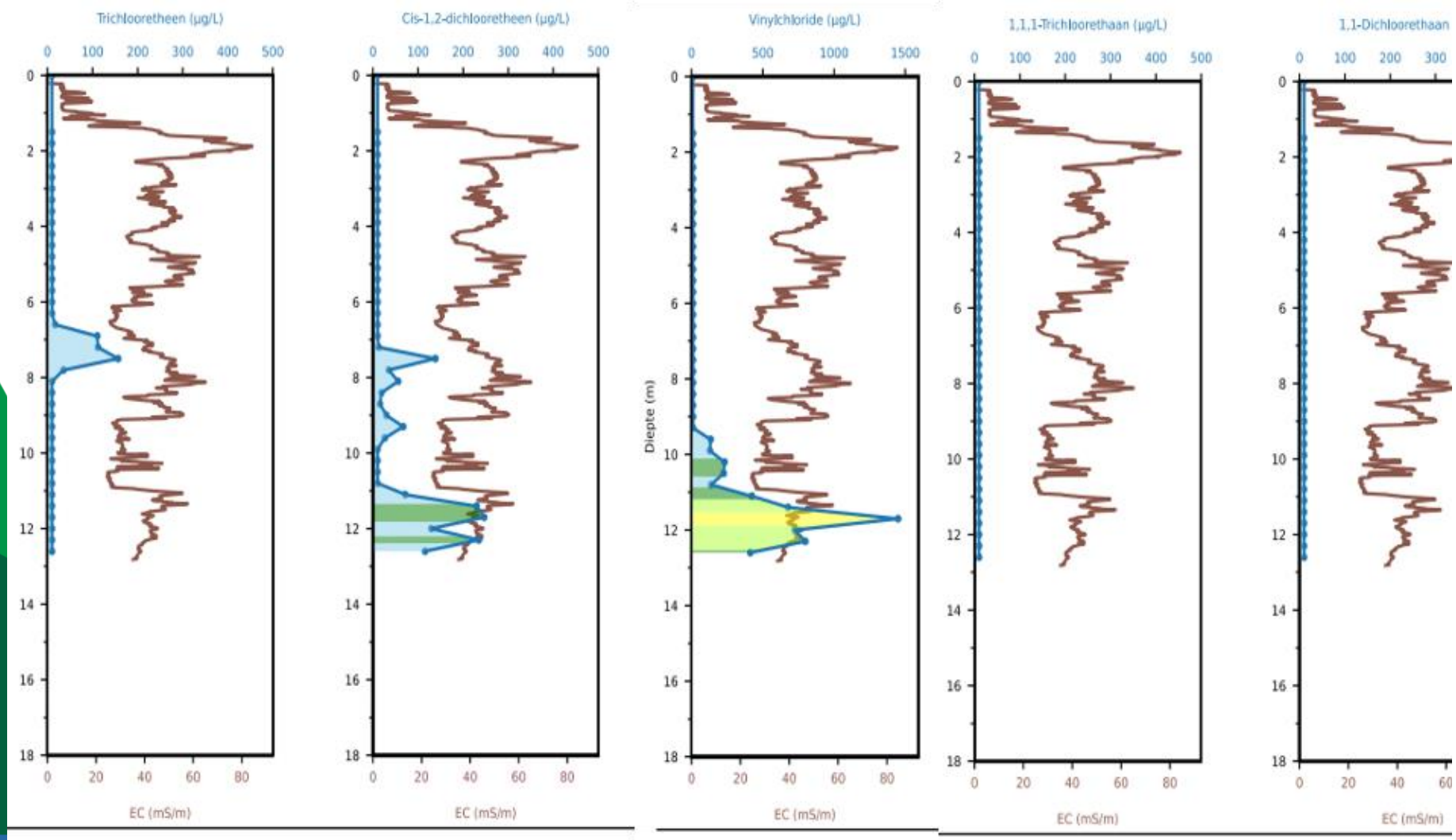
EnISSA MIP : gevoelige en gedetetailleerde detectie



EnISSA –MIP compounds

Chlorinated Solvents:

- PCE; TCE; cis-1,2-DCE; 1,1-DCE, trans-1,2-DCE, VC
- 1,1,1-TCA; 1,1,2-TCA; 1,1-DCA; 1,2-DCA, chloorethaan
- Tetrachloormethaan, Trichloormethaan, dichloormethaan, chloormethaan
- Freons
- Monochlorobenzene,
- ….

BTEX, Naphthalene

MTBE, TBA

trimethylbenzene

tetrahydrofuran, aceton, Isopropyl Alcohol, hexaan, methyl-hexaan, cyclohexane, Diethyl ether, MEK, n-butylacetate

Indane, indene,

2,2,5,5-Tetramethyltetrahydrofuran , 2-methyl-2-propanol

tetrahydrothiophene

EC – electrical conductivity - Geleidsbaarheidsondering

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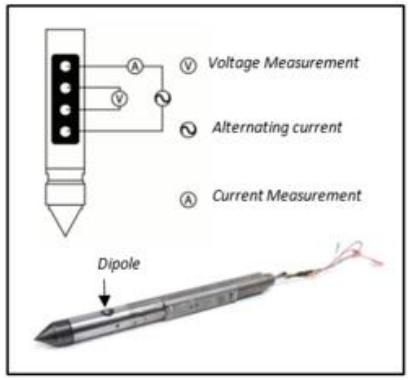
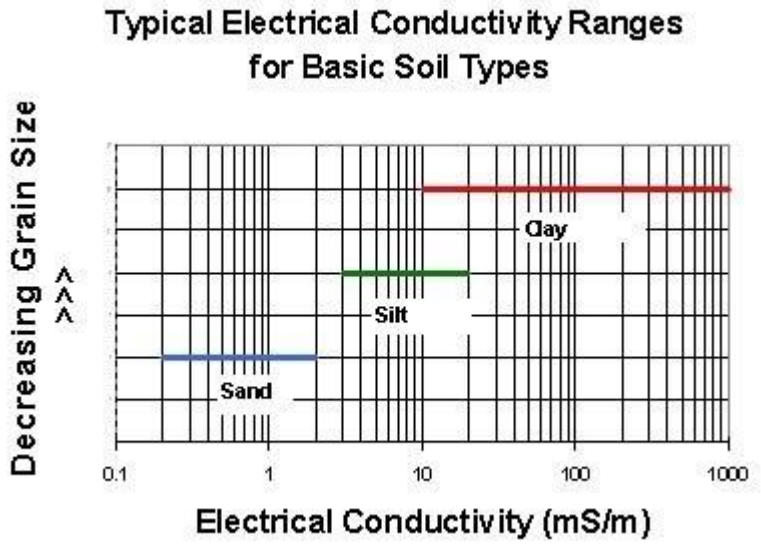
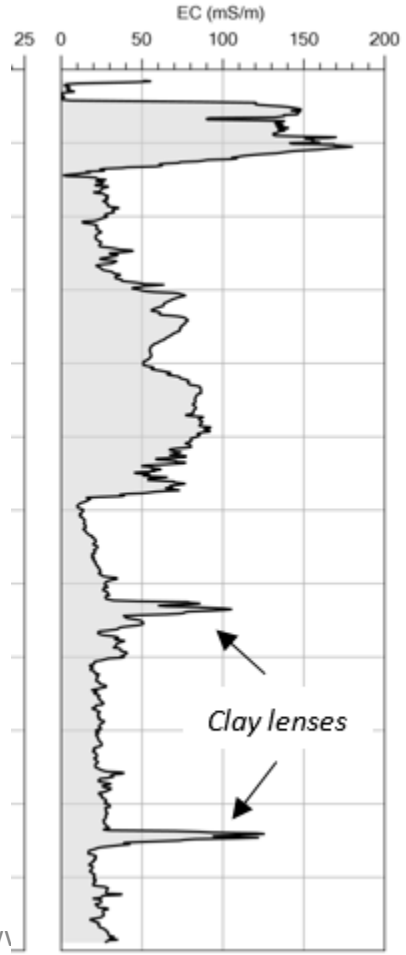
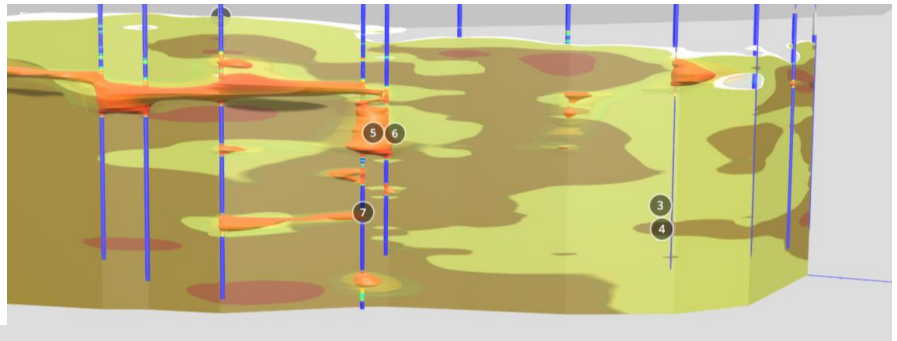


- Wenner array op EC probe of Dipole sensor op MIP sode
  - Electrical Conductivity (EC) ~ korrel grootte
    - Klei hoge EC, Zand lage EC





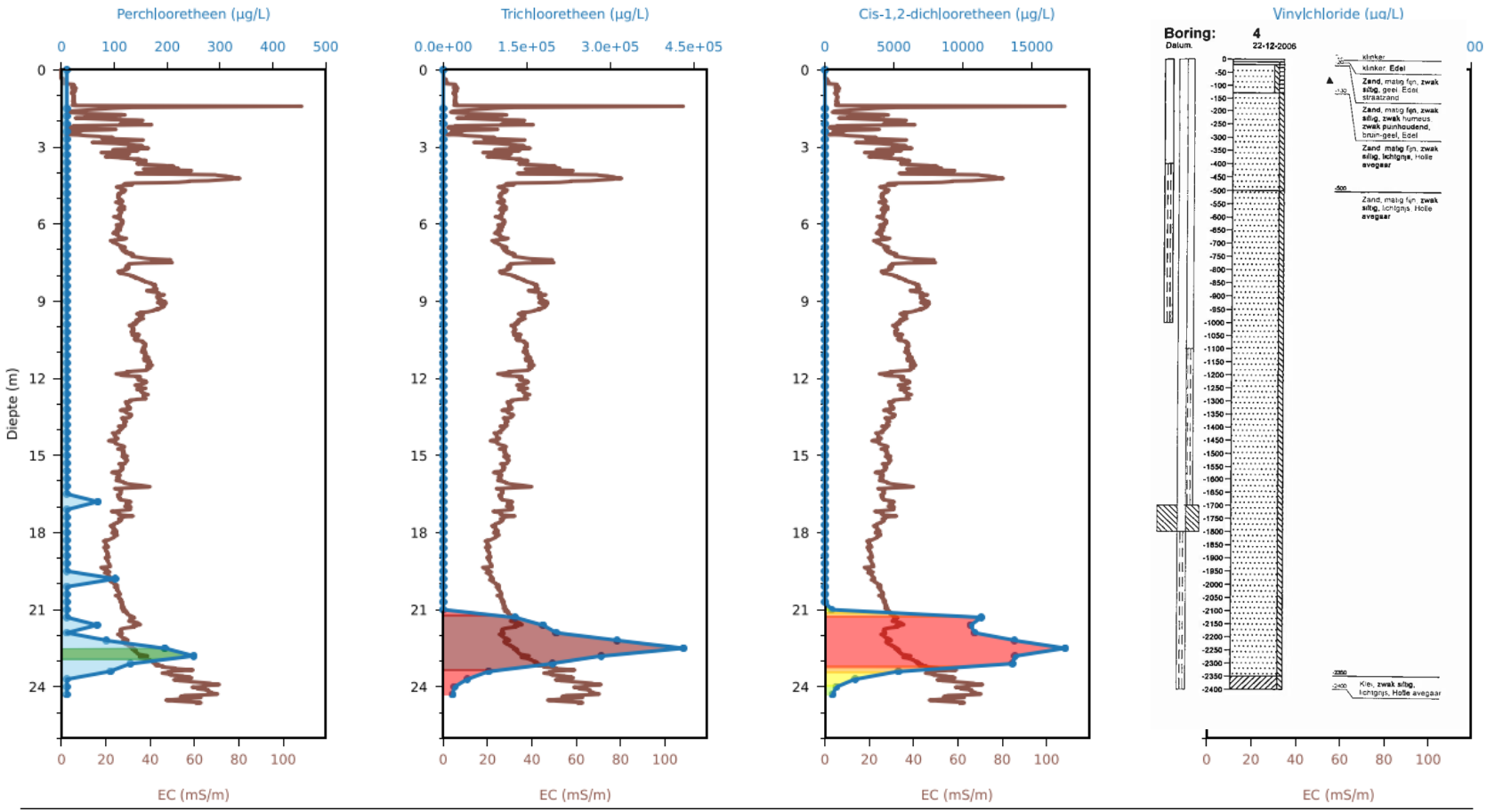
  - Ook beinvloed door porievloeistof!
    - Zout/brak water
    - Remediation products/tracer
  - Identificatie van (subtiele) verschillen
    - Vaak niet eenvoudig zintuiglijk vast te stellen



MIP en EC metingen regio ‘s-Hortogenbosch

TRI zaklaag op klei (verhoging EC vanaf 23 m-mv

Relatief lage EC op het einde toenemend (klei)



MIP en EC metingen Noord Frankrijk

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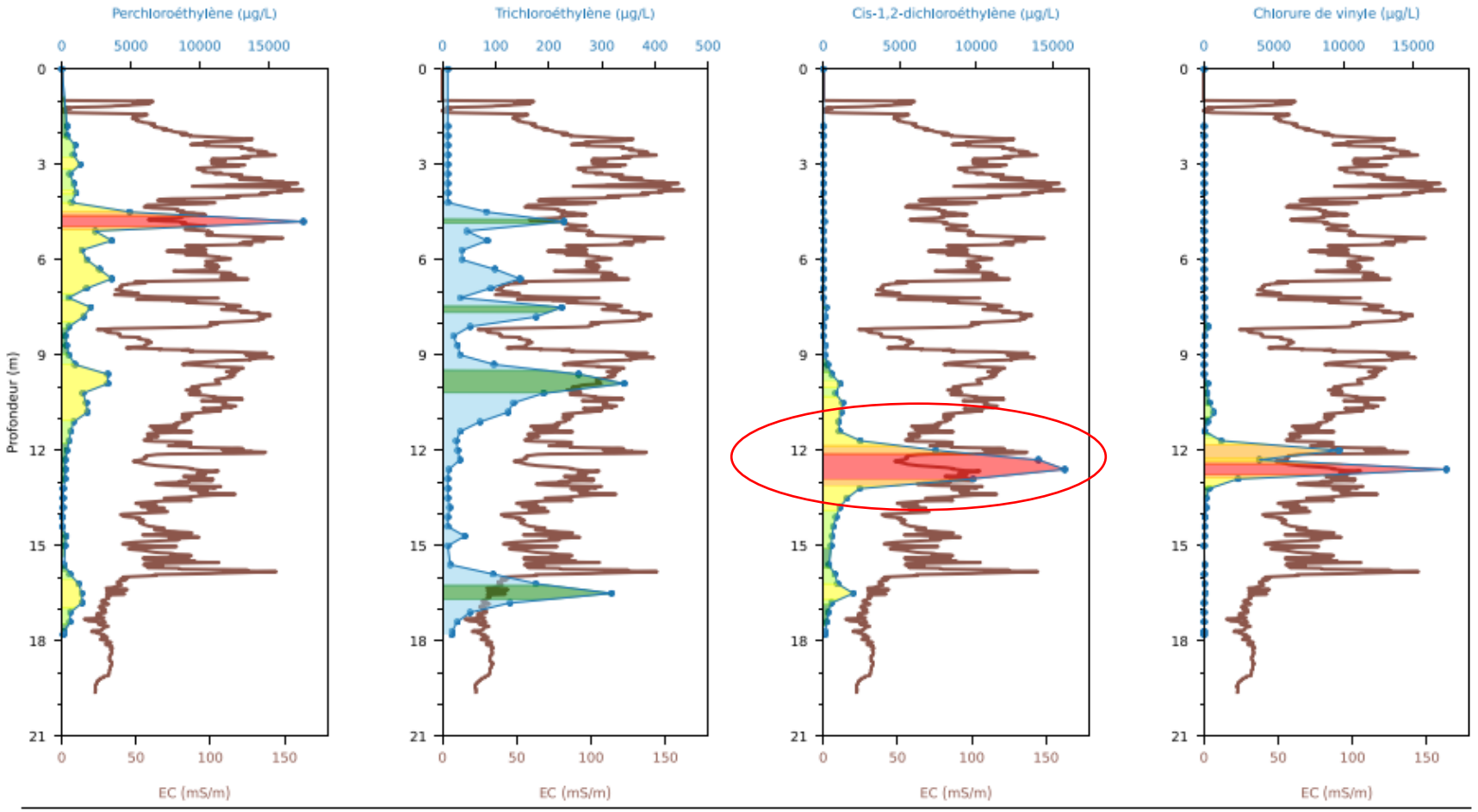
Grondwater op 8 m-mv

Erg heterogene alluviale afzetting

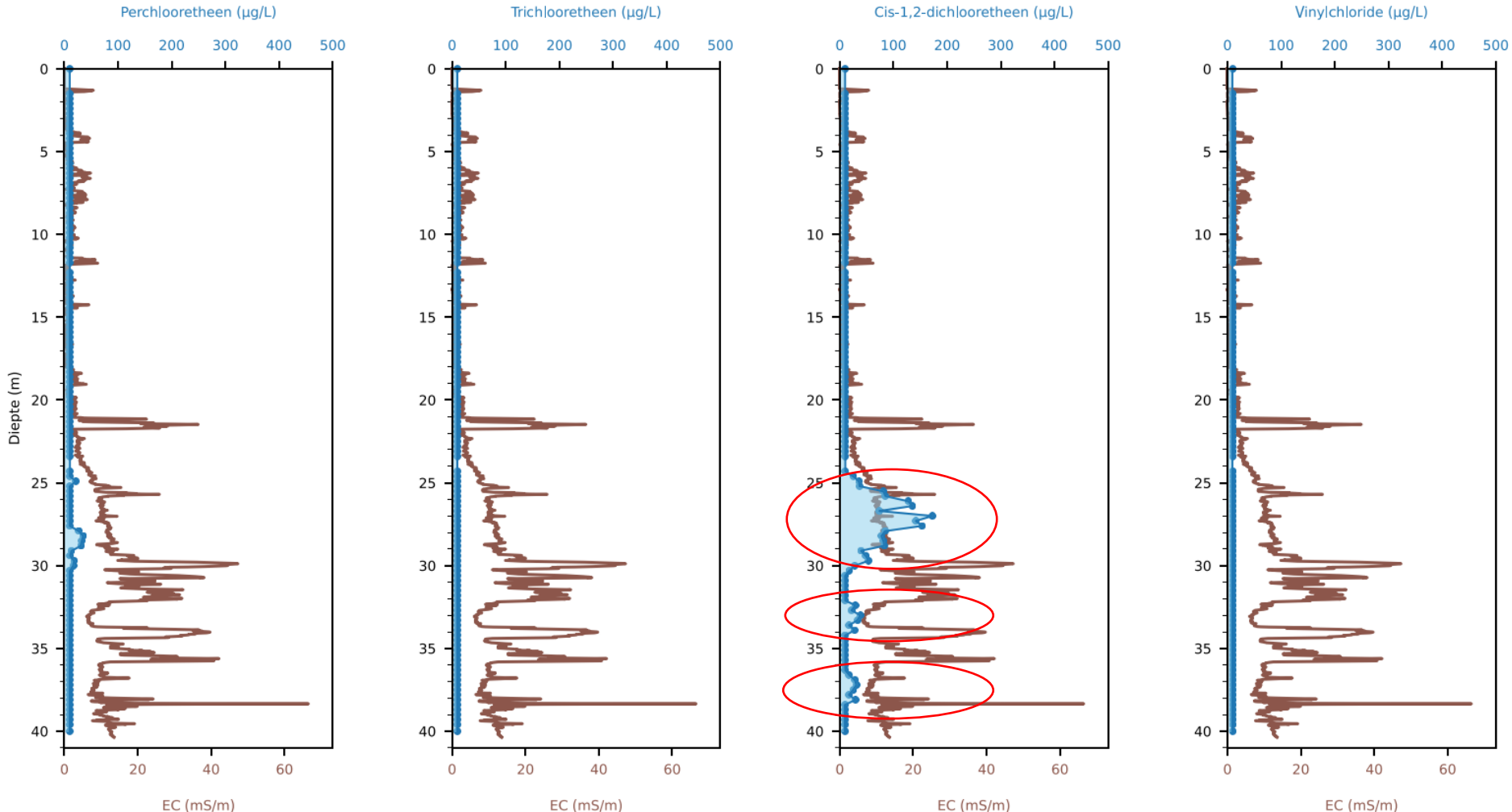
Dunne kleilaag net boven kalk 16 m-mv

Specifieke afbraak condities tss 12-13 m-mv



MIP en EC metingen regio Tilburg

- Afperking VOCL pluim
- Verspreiding verontreiniging in lage EC lagen



MIP en EC metingen Stuttgard regio

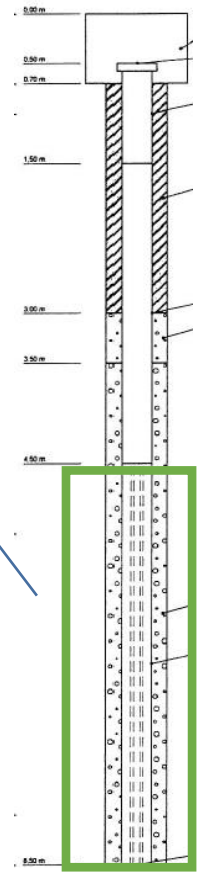
Pump and treat Sanering

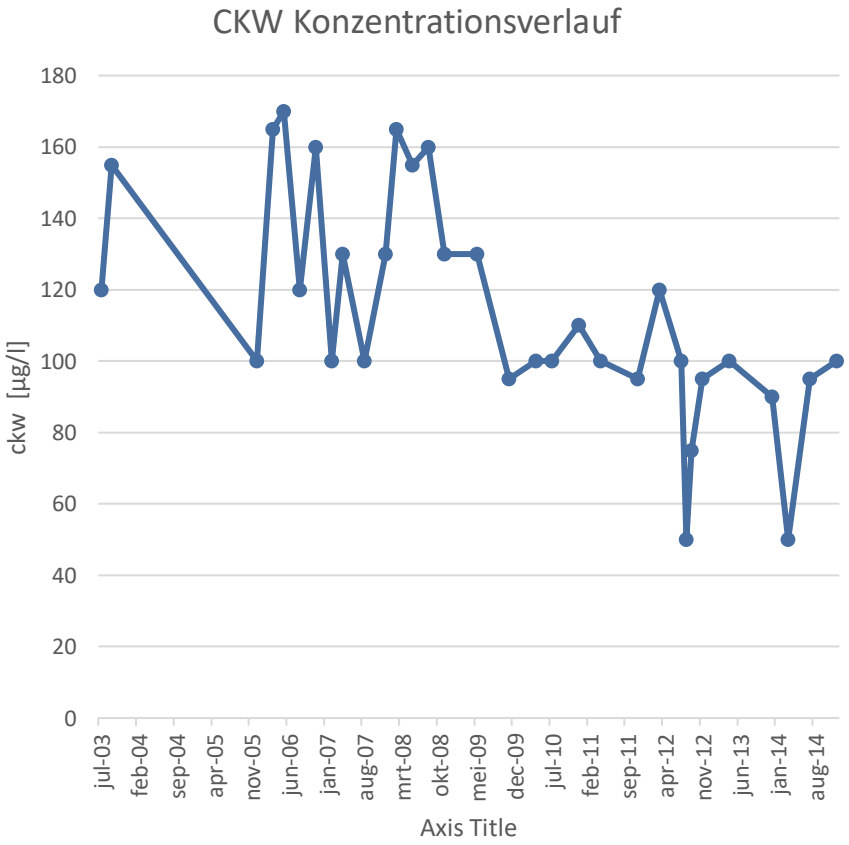
Extraction Wells 4.5-8.5 m-mv

10 jaar actief zonder gewenste resultaat

VOCL blijft stabiel op ca 100 µg/L

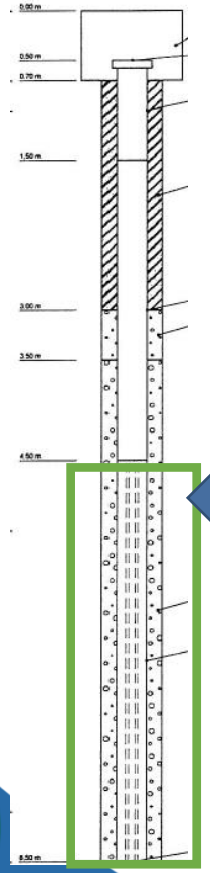
Extraction Well

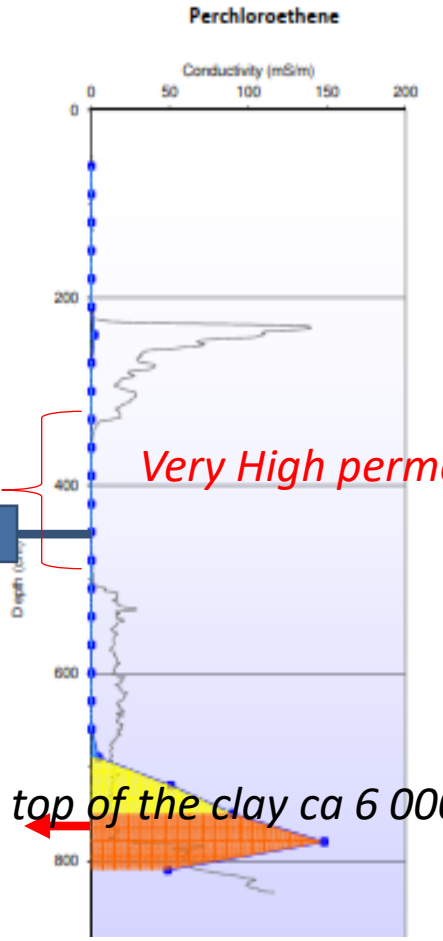


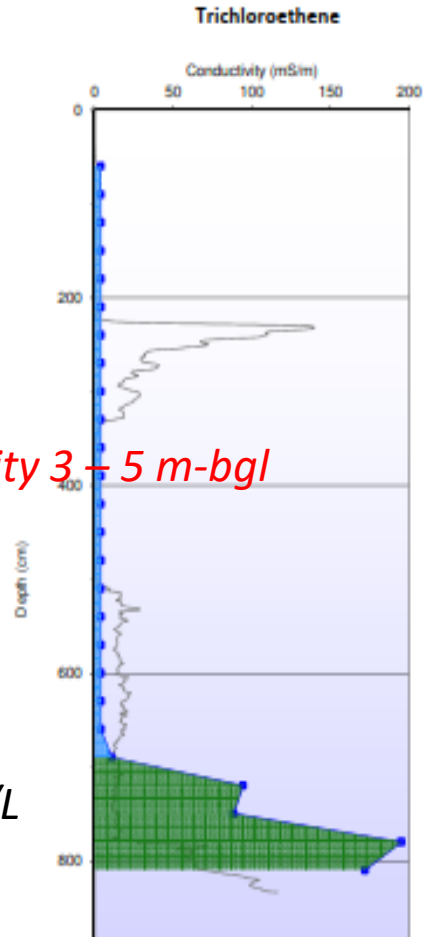


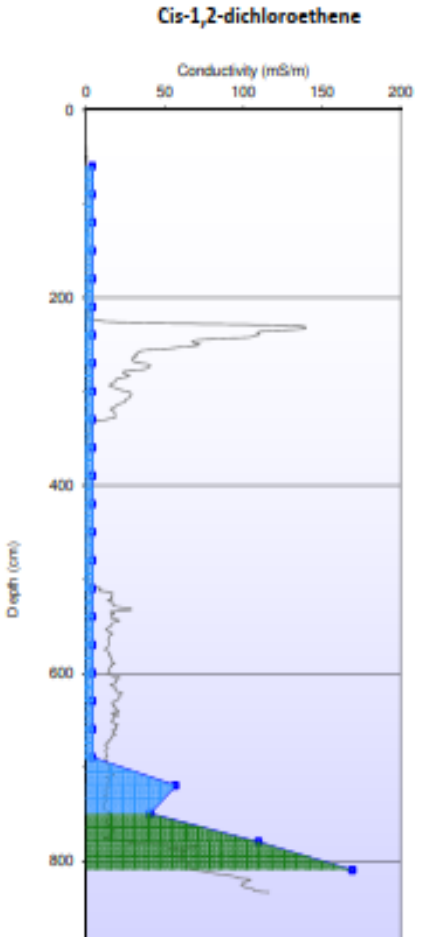
MIP en EC metingen Stuttgard regio

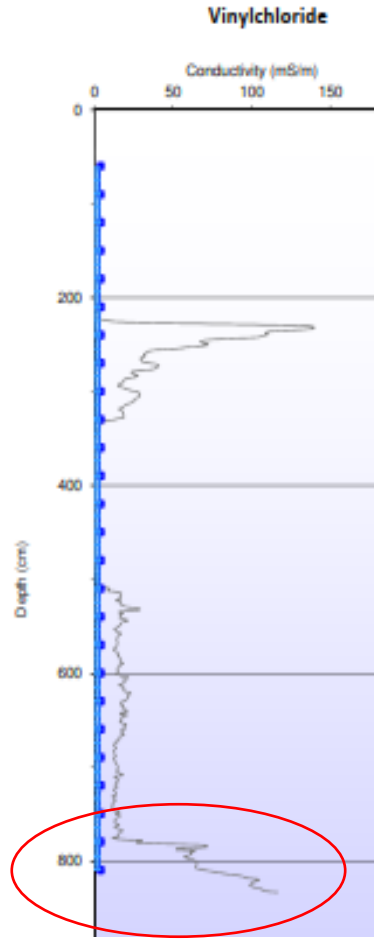
Extraction Well











Very High permeability 3 – 5 m-bgl

PCE on top of the clay ca 6 000 µg/L

HPT – Hydraulic Profiling Tool

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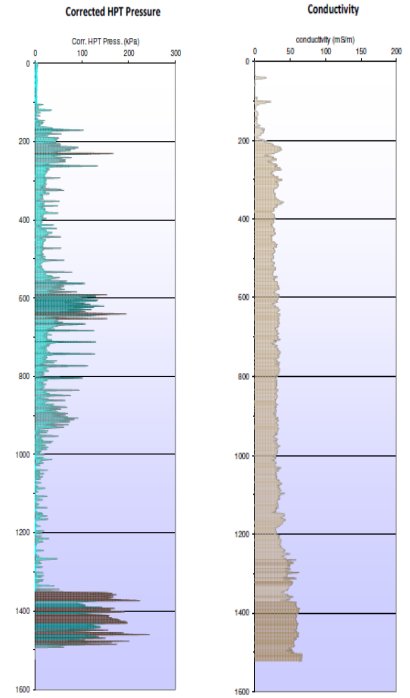
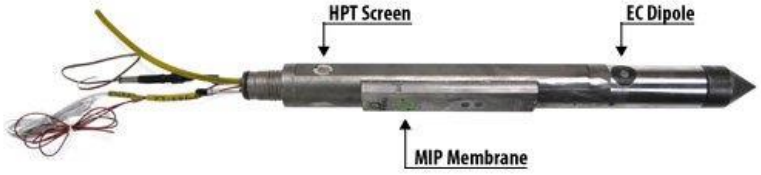
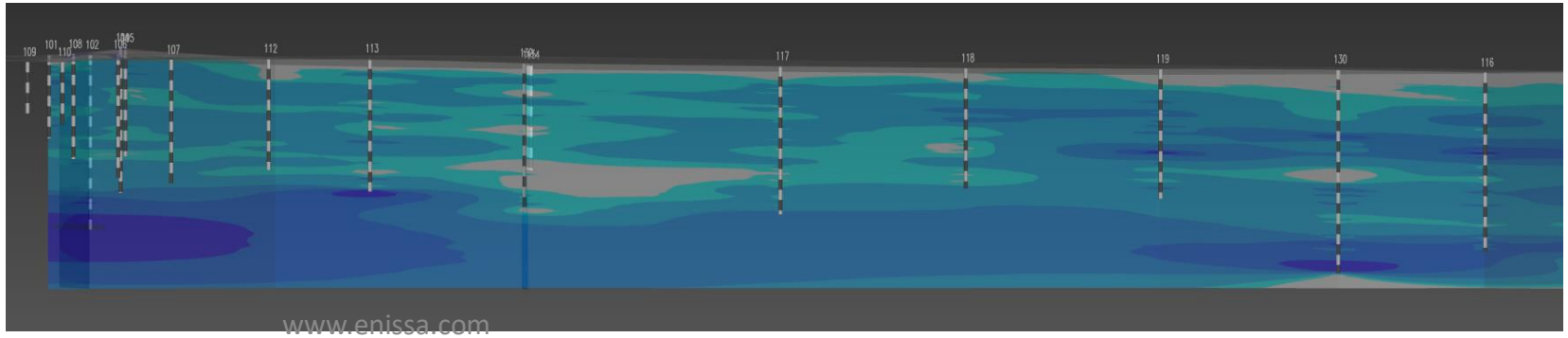
- Hydraulic Profiling Tool (HPT)
  - continue injectie van water door een debietgeregelde pomp
  - De injectiedruk is een maat voor de lokale permeabiliteit.
  - Een real-time gedetailleerd druk- en sflow log wordt gegenereerd voor elke sondeerlocatie, wat meer inzicht geeft in de hydrogeologie.

- Soil stratification
- Understand contaminant pathways
- Storage and transport zones

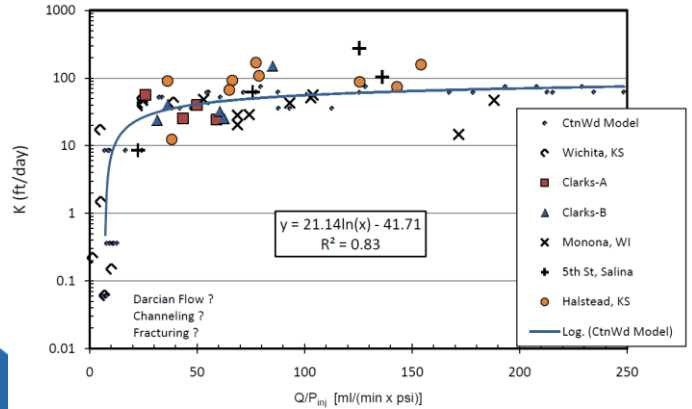


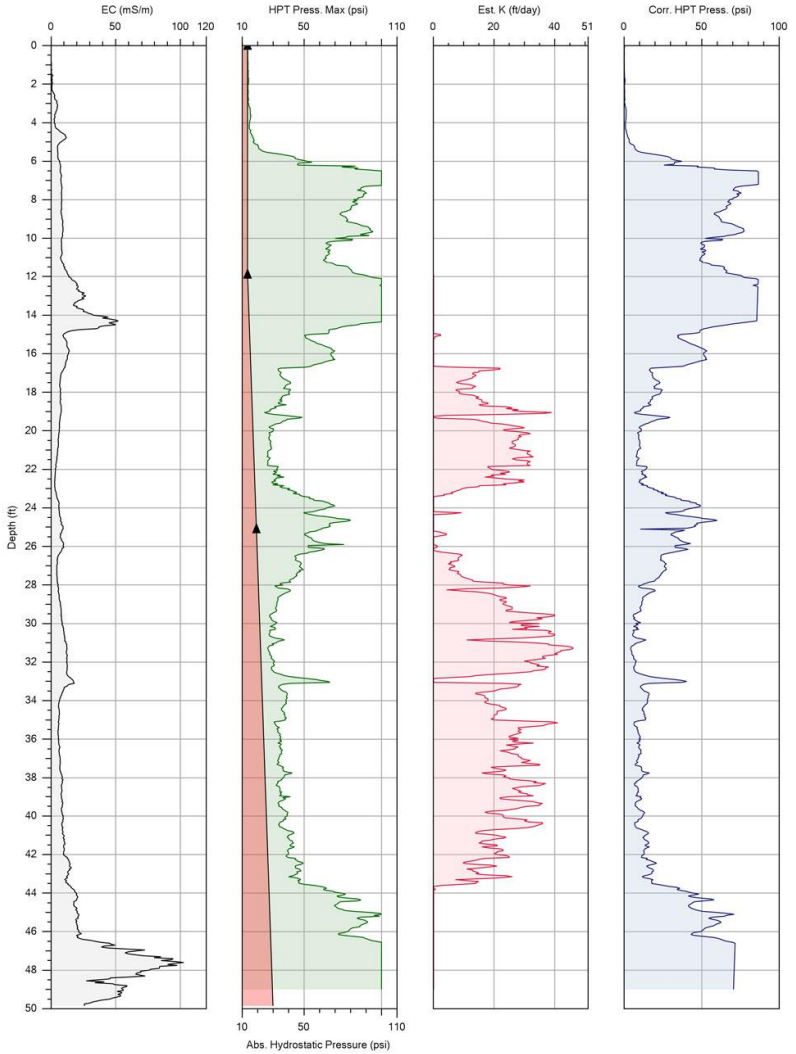


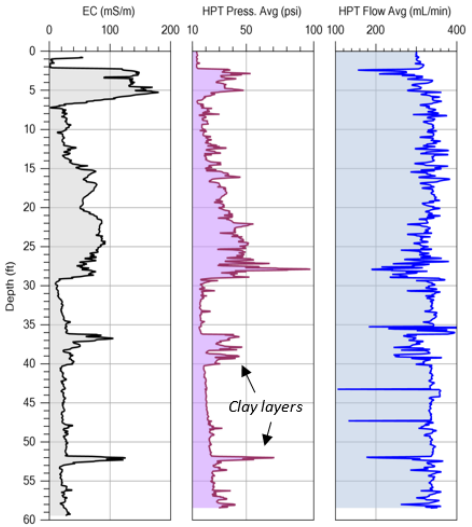


HPT – Hydraulic Profiling Tool

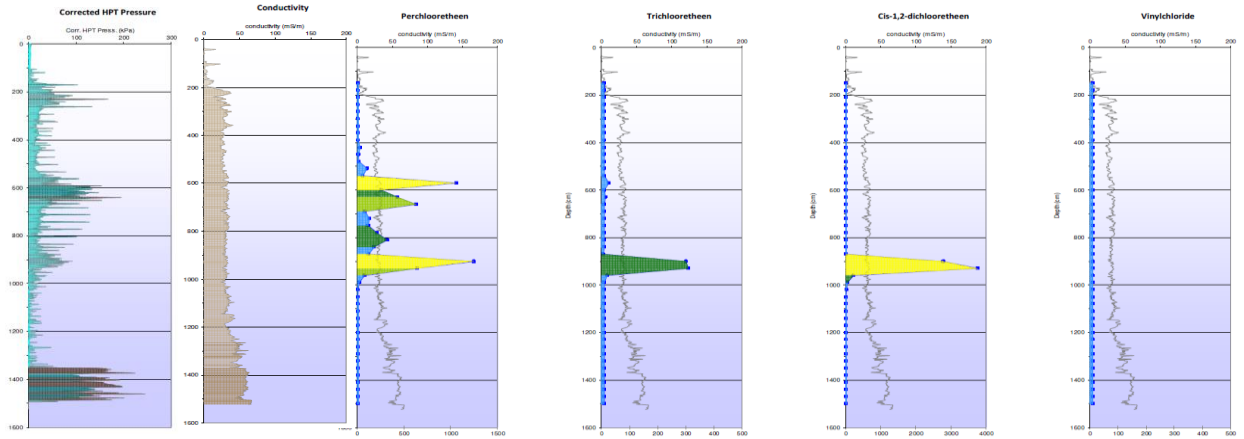
- Dissipatietest
  - No flow drukmeting
    - Hydrostatische druk
      - Grondwaterniveau
      - Gecorrigeerde druk
- hydraulische geleidbaarheid
  - Empirische inschatting van doorlaatbaarheid

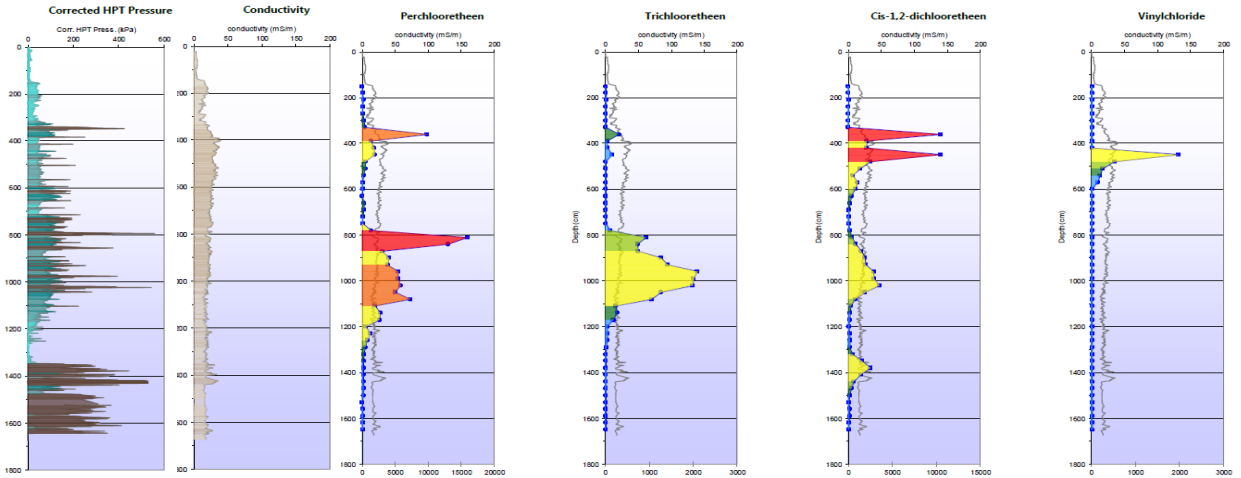






MIP en HPT metingen central Duitsland





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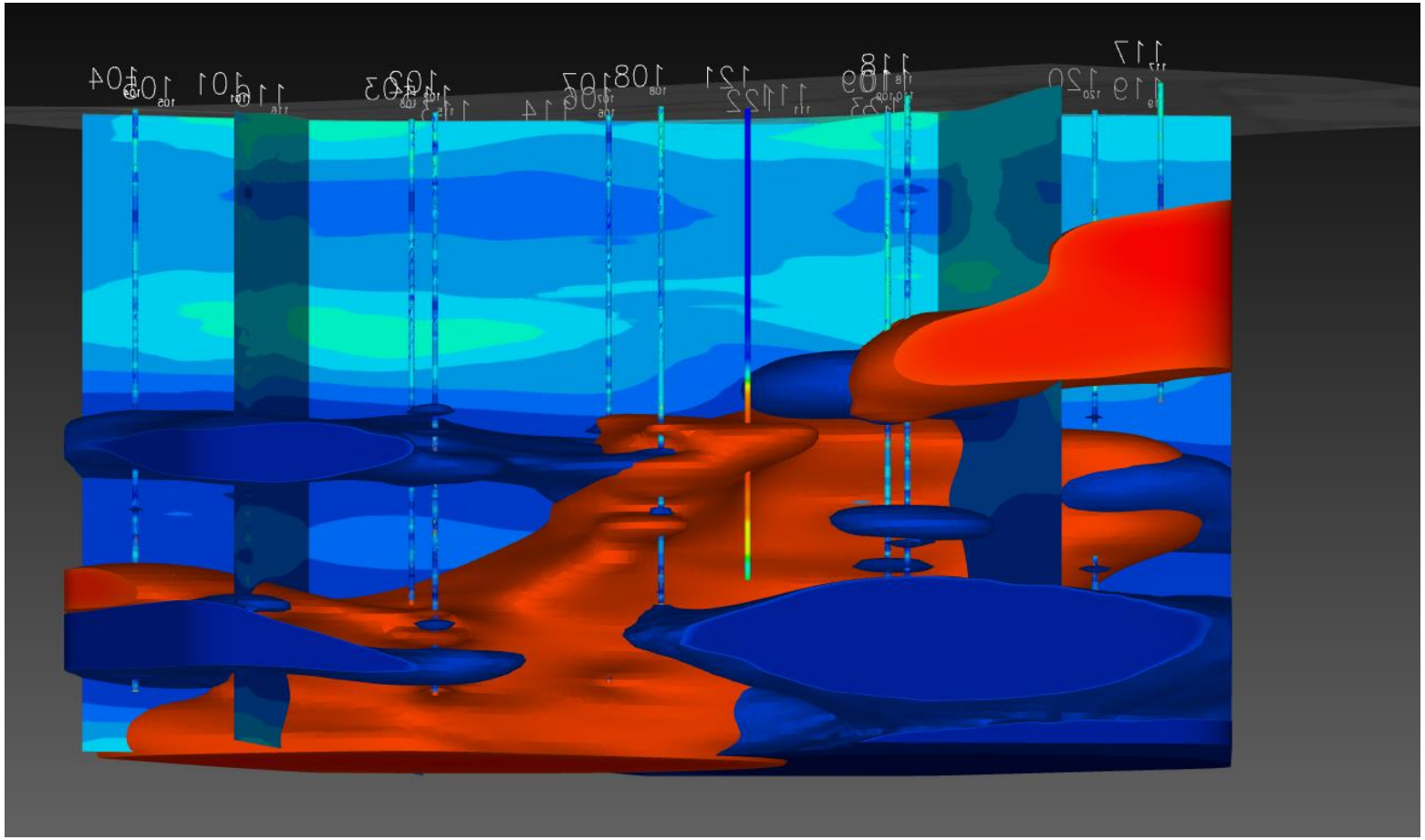
MIP en HPT metingen Oost-Vlaanderen



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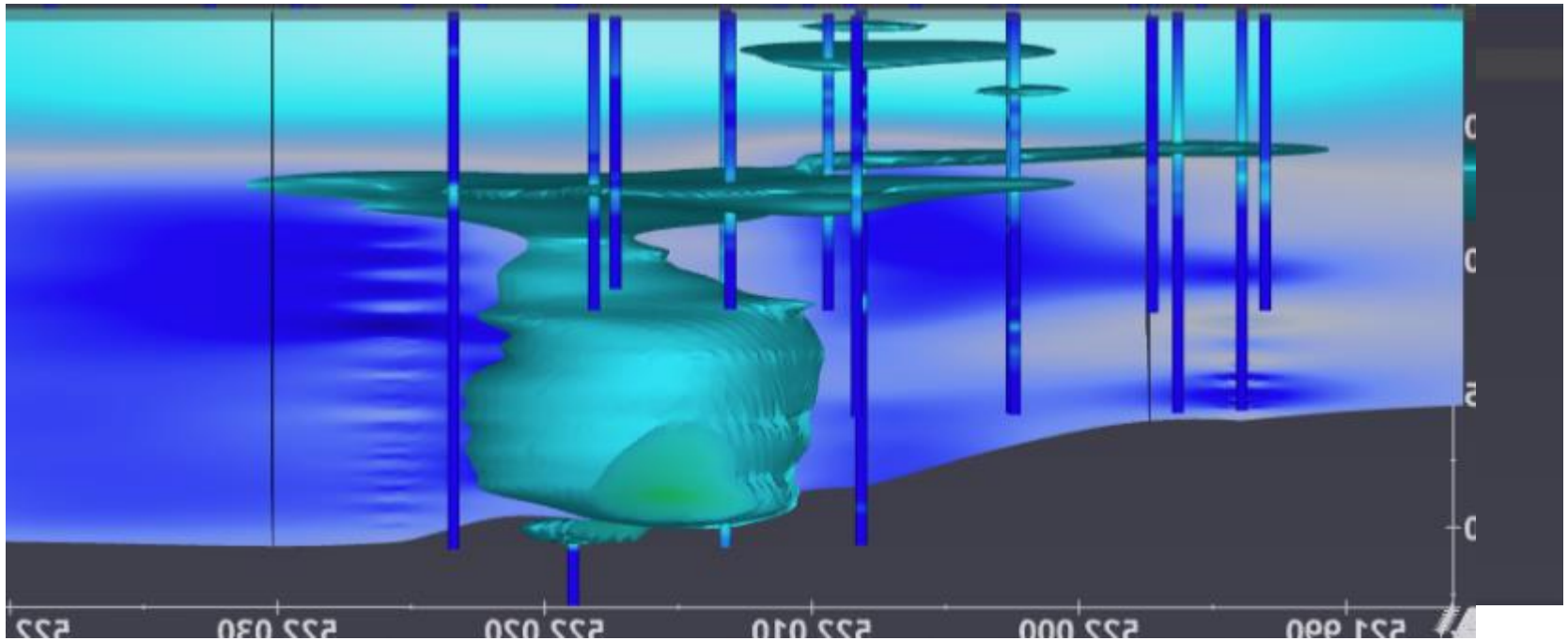
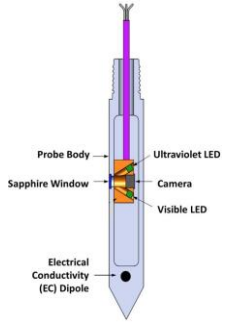
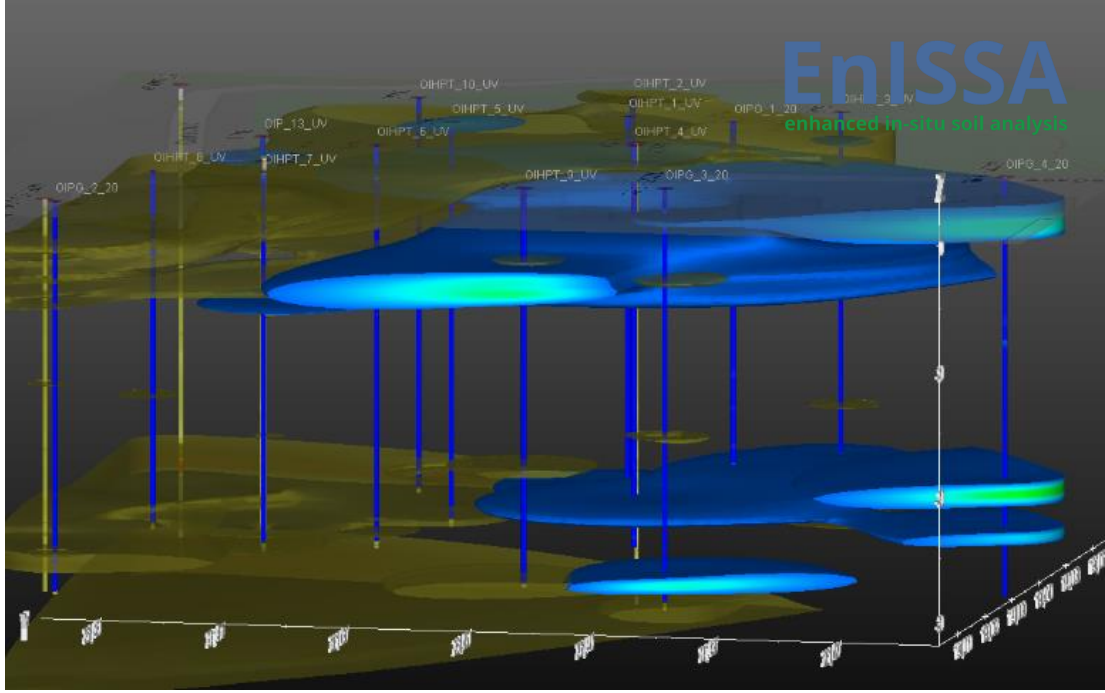
MIP en HPT metingen Zuid Zweden

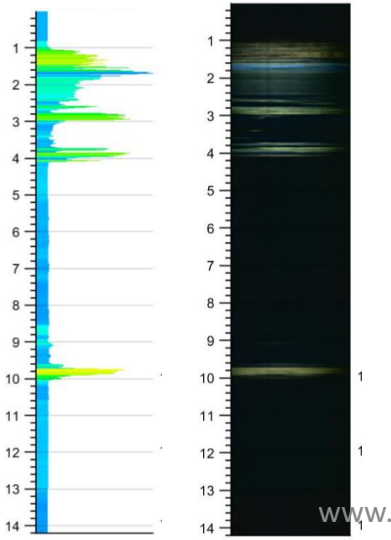


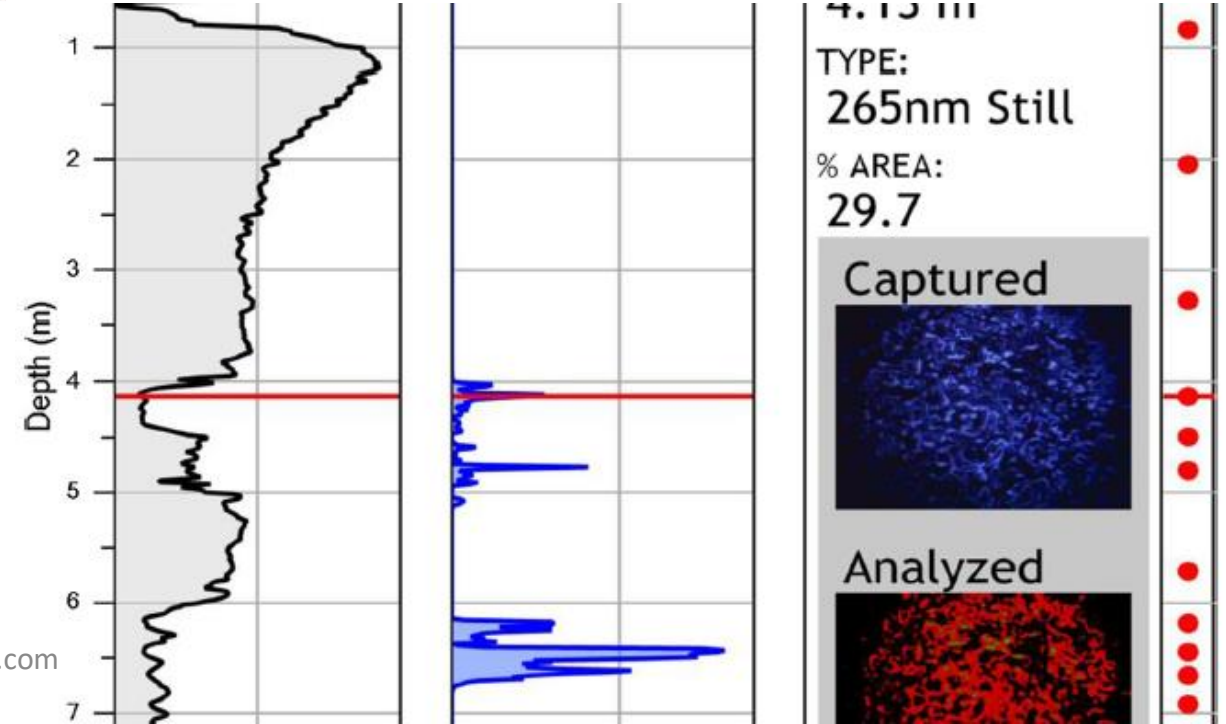
Optical Image Profiler

- New Geoprobe ™ direct push voor de bepaling van de aanwezigheid en de verdeling van NAPL's van brandstoffen en olie in de ondergrond
- Fluorescentie van PAK's wordt geïnduceerd door UV of groene LED's en vastgelegd door de in-probe camera.

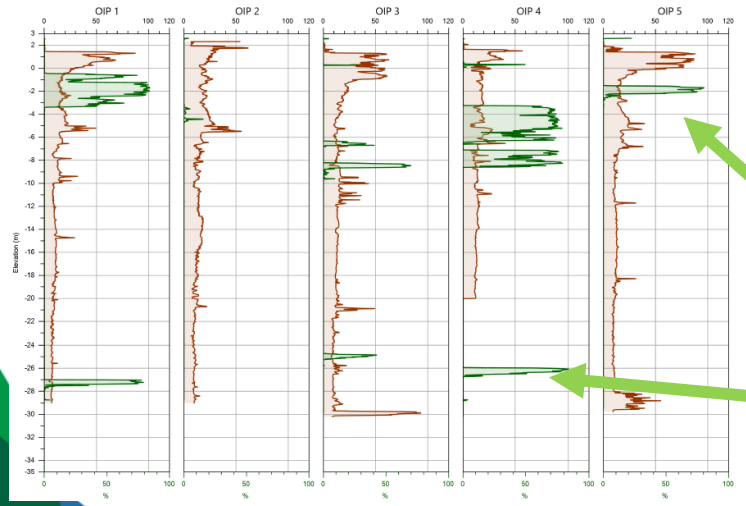


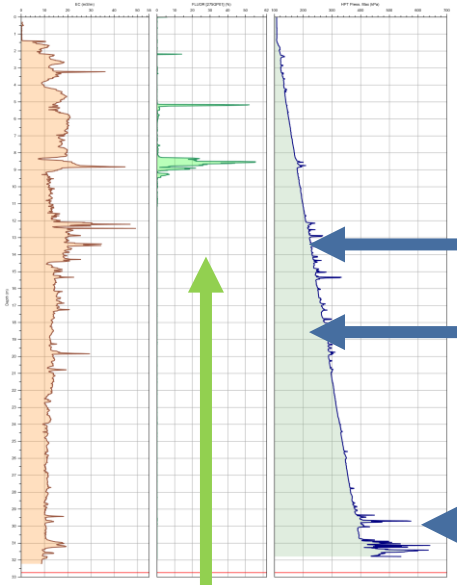






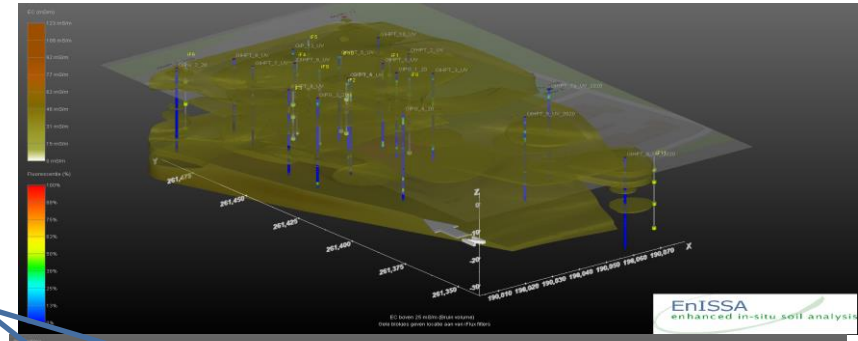
OIP en EC en HPT ‘s Gravenmoer

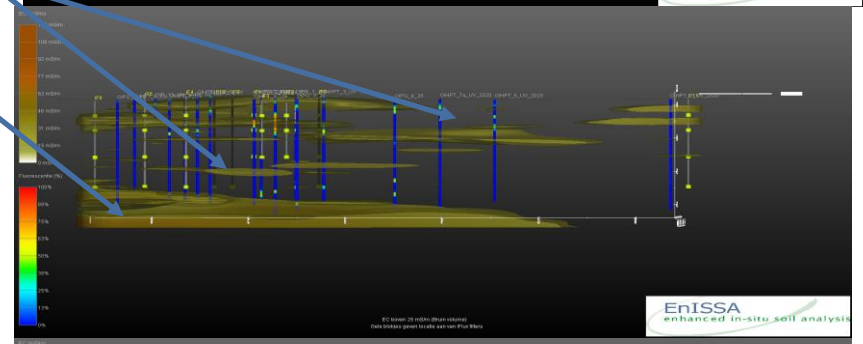


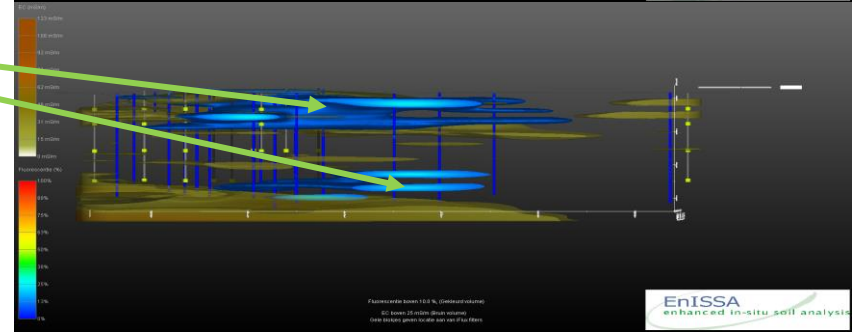


Minder doorlatende lagen

verontreiniging







OIP en EC en HPT ‘s Gent

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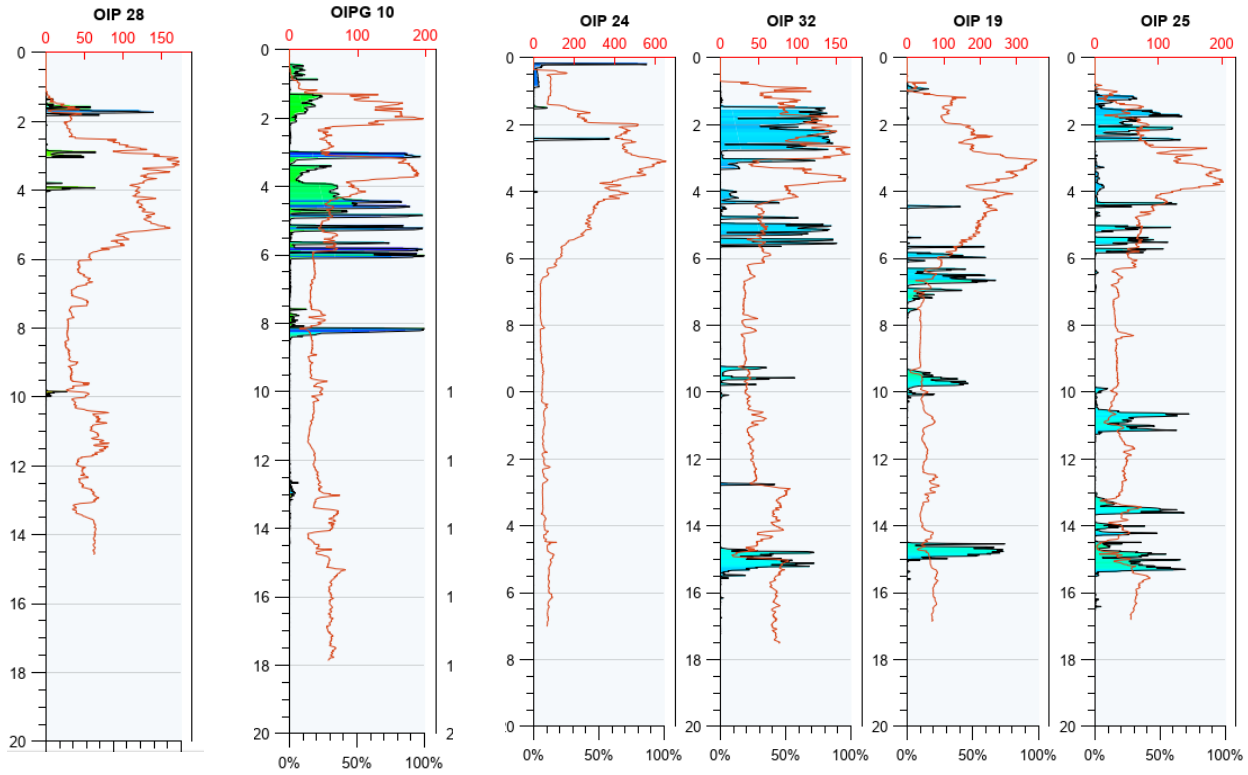
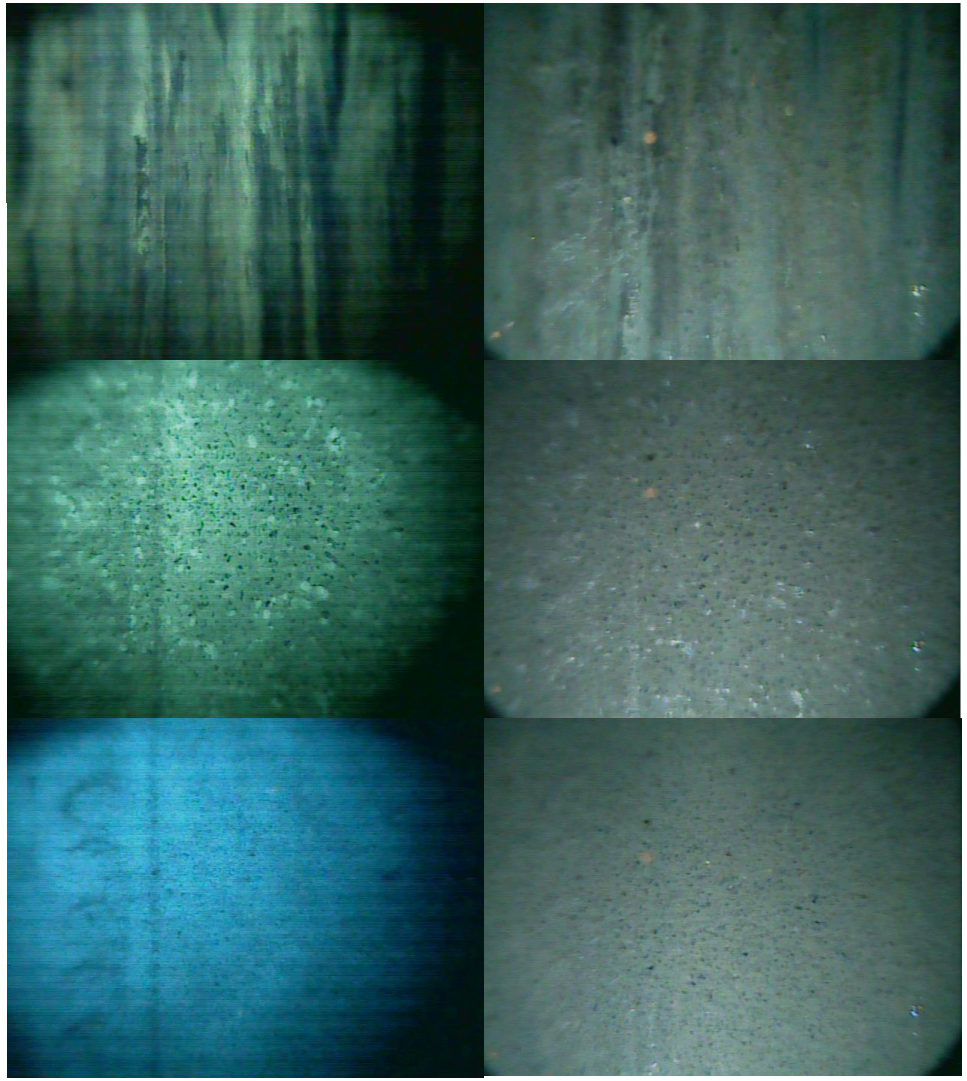
OIP data, Gent site



UV LED

Visible light



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