High Resolution Site Characterization of a PAH contamination in Gent, Belgium

By application of the Optical Image Profiler (OIP)

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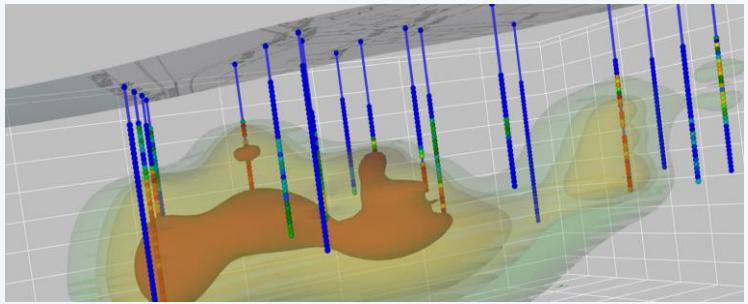
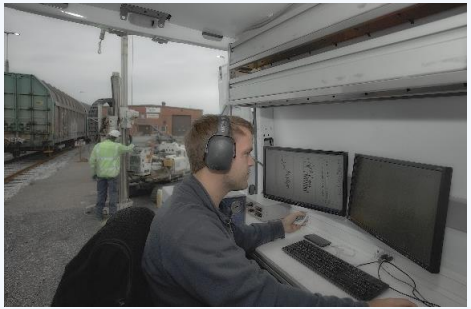
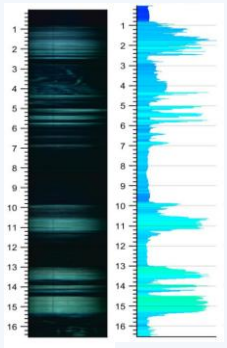
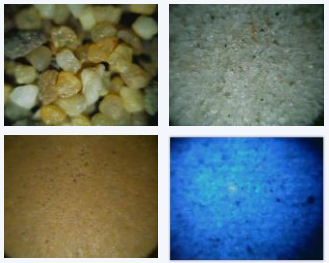
EnISSA
enhanced in-situ soil analysis

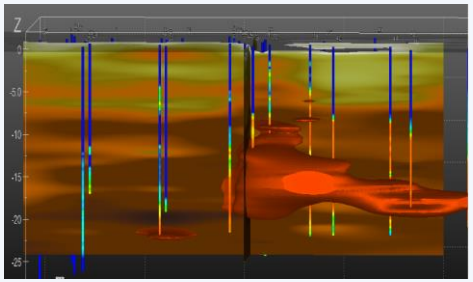
EnISSA – Enhanced In Situ Soil Analysis

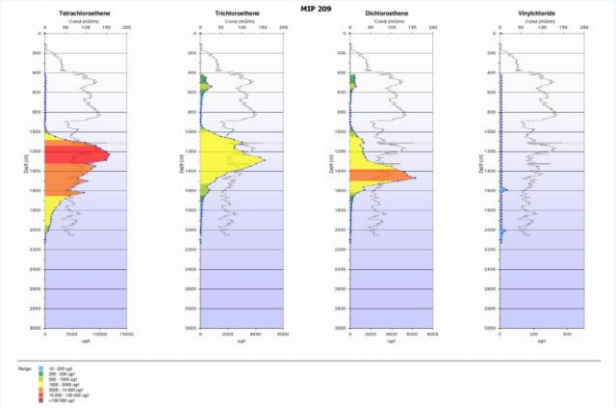












Introduction

- “Oude Dokken” project.
- urban renewal project where the city wants to redevelop old industrial sites into commercial and living spaces.
- On behalf of OVAM (Public Waste Agency of Flanders) Witteveen+Bos is conducting a detailed investigation to evaluate different remediation scenarios.

Financed and approved by OVAM

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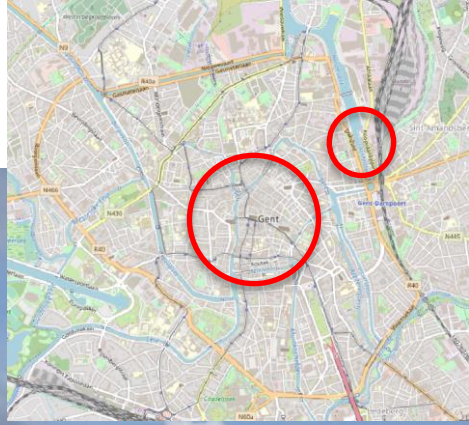
The site

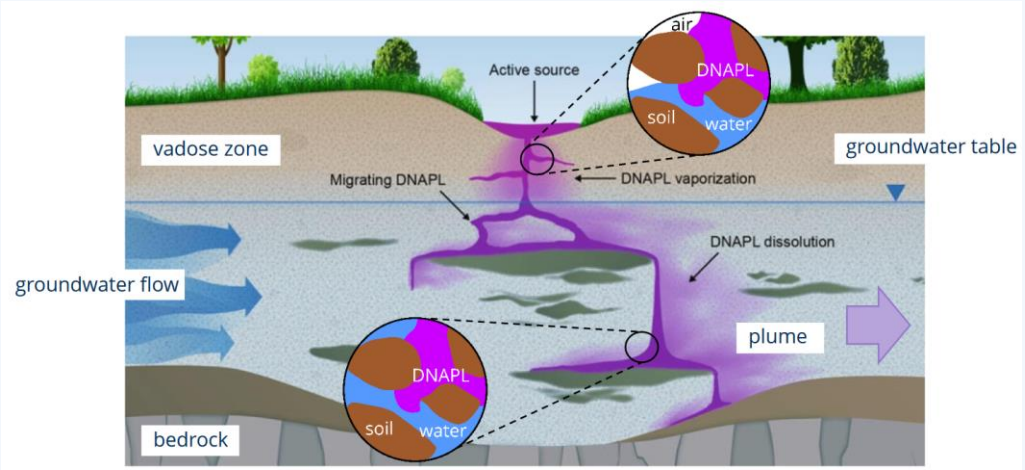


History

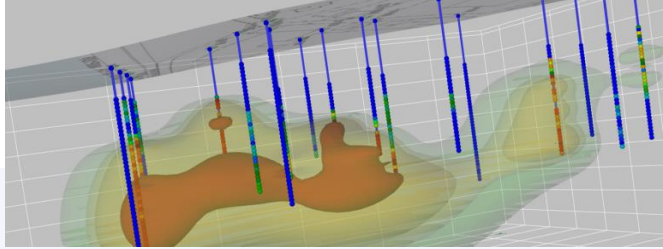
- Industrial activities starting from late 19 century
- Starting with a treatment facility for railway sleepers
- To a storage yard for fuels and coal with a repair shop, including a pit for oil changes
- And finally a metal scrapyard

Dense Non-Aqueous Phase Liquids - DNAPL

- $\rho_{DNAPL} > \rho_{Water}$
- DNAPL migration is strongly dependent on differences in soil characteristics
- Finer grained material (capillary resistance): acts as barrier ➔ DNAPL pooling & lateral spreading
- Matrix diffusion and advection: DNAPL is 'stored' in smaller pores.
- Slow dissolution and extended long term groundwater plumes

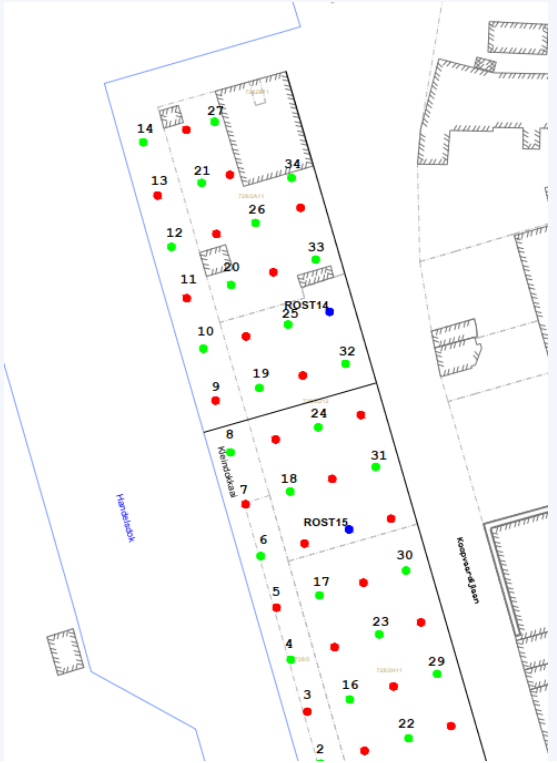


Source: Kueper et al., 2014



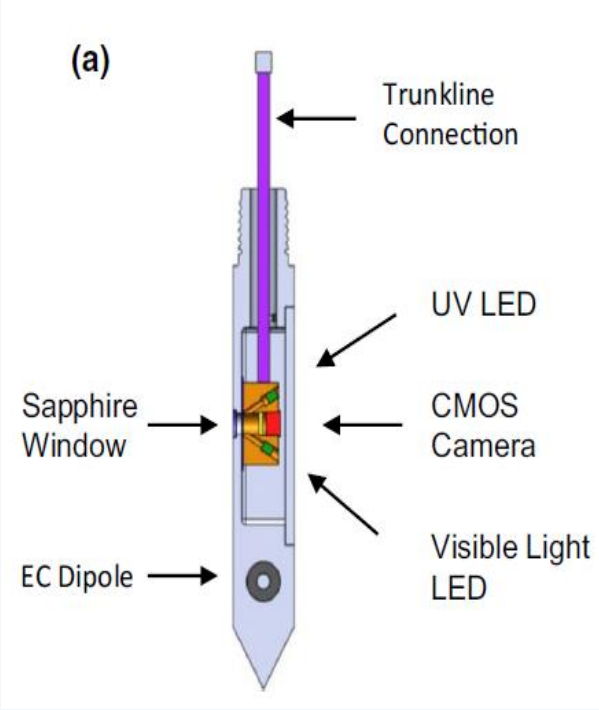
Hight resolution site characterization - HRSC

- Previous attempts at characterizing the contamination on site were unsuccessful.
- A HRSC approach was proposed with an initial grid layout using the Optical Image Profiler (OIP).
- The results from this initial screening, guided the subsequent soil and groundwater sampling campaign.



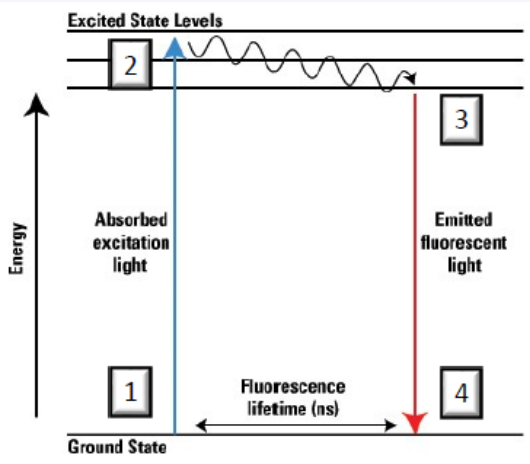
OIP probe (© Geoprobe)

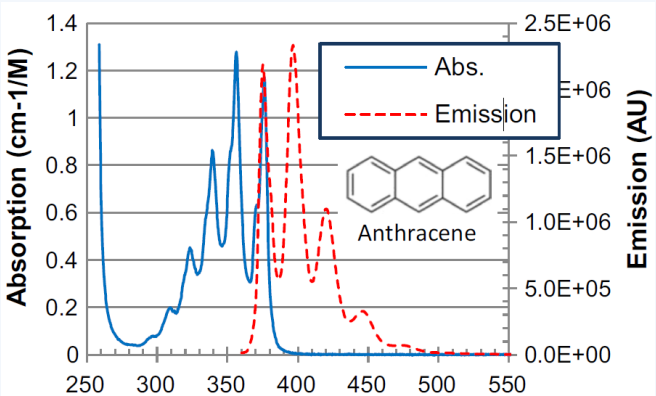
- The OIP probe uses a 275-nm UV LED light source and optimized CMOS camera to excite and capture in-situ contaminants at 30fps.
- Visible light LED is present to view and inspect subsurface lithology.
- Also included is an EC dipole to indicate what type of lithology is present.



UV fluorescence, how does it work?

- Fluorescence works on the principle that photons of a certain wavelength are absorbed by a molecule, thereby exciting an electron. When this electron changes back to its ground state another photon is released.

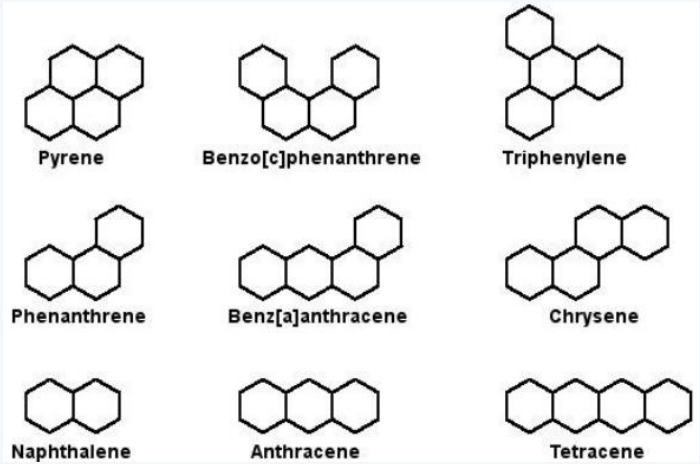




- The absorption and emission patterns are different for each molecule.

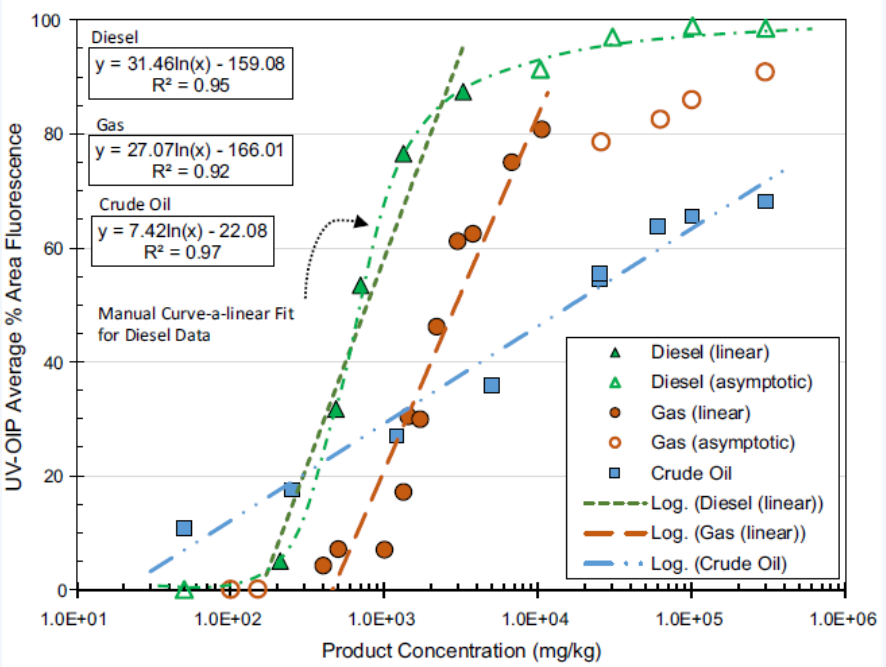
Polycyclic Aromatic Hydrocarbons (PAH)

- Smaller PAH compounds (Naphthalene,…)
  - Gas, Diesel and Motor oil
  - UV detectable
- Larger PAH compounds
  - Tar/Creosoot
  - UV detectable but possible quenching
  - Different source necessary with shorter wavelengths (OIP green)
- BTEX (and CVOC's)
  - Not OIP detectable
  - Can be detected with MIP



Bench study by Geoprobe

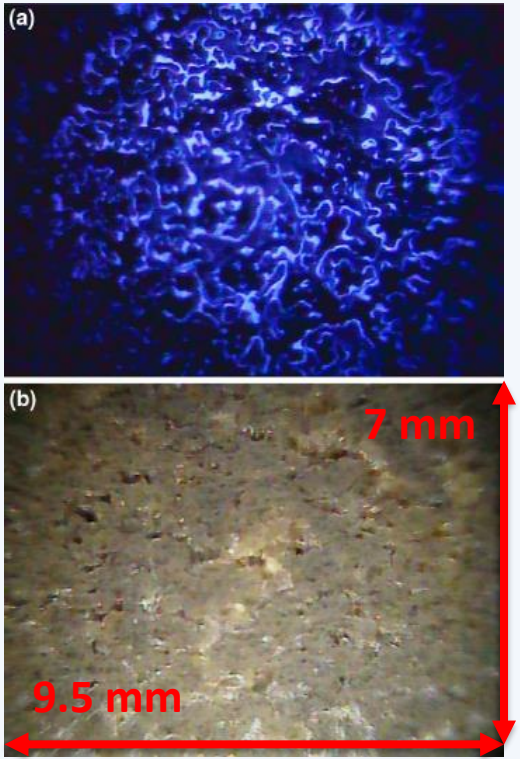
- Laboratory experiments have been conducted with OIP. Spiking sand samples with varying concentrations of diesel, gas and crude oil.
- It shows the useful ranges of concentration in which OIP can be used.



OIP field operation

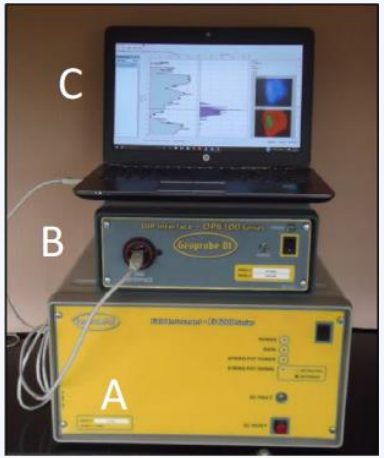
- The OIP probe is advanced into the subsurface and takes every 15 mm a UV image
- The images are 9.5 mm x 7.0 mm at 640 x 480 pixels.

- When rods are changed a still image is automatically taken using UV and visible light.



OIP field operation

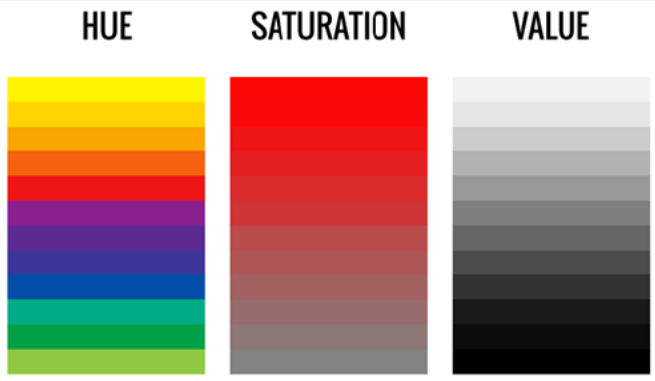
Under good conditions a production rate of 100m/day should be no exception.



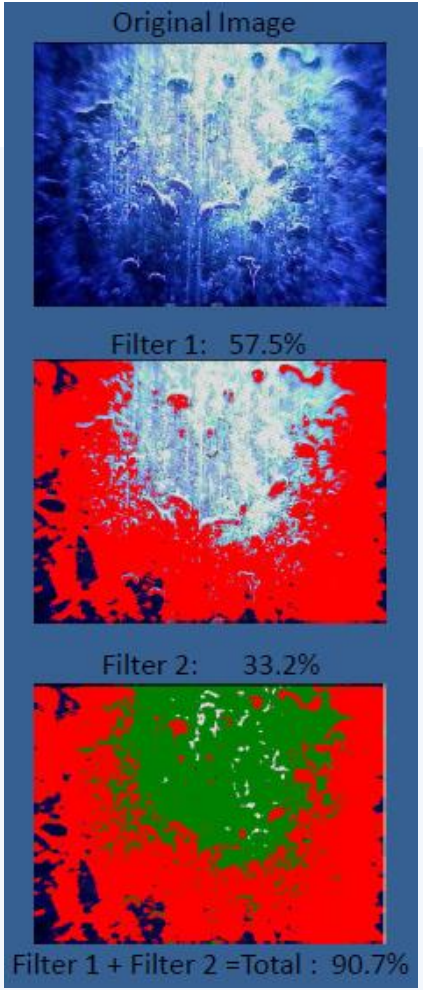
A: FI6000 Field Instrument
B: OIP6000 Optical Interface
C: Lap top computer with software

OIP image analysis

- The images this produces are analyzed using a 2 stage digital filter based on HSV criteria. That determines if a pixel is showing fluorescence.

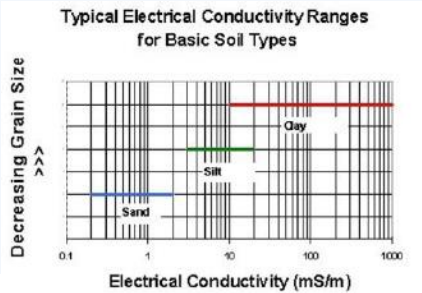


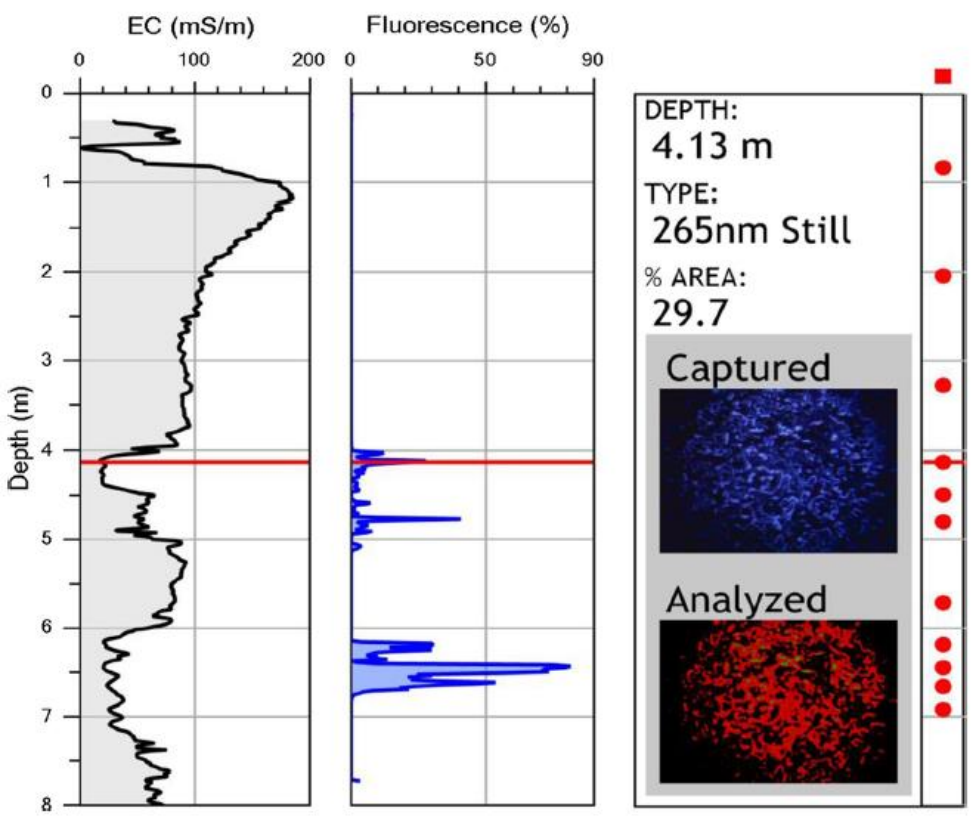
- This in turn gets expressed as a % of fluorescent pixels per image and plotted along a log graph that keeps track of the depth and EC measurements
- If no NAPL's are present only a dark image will be captured.



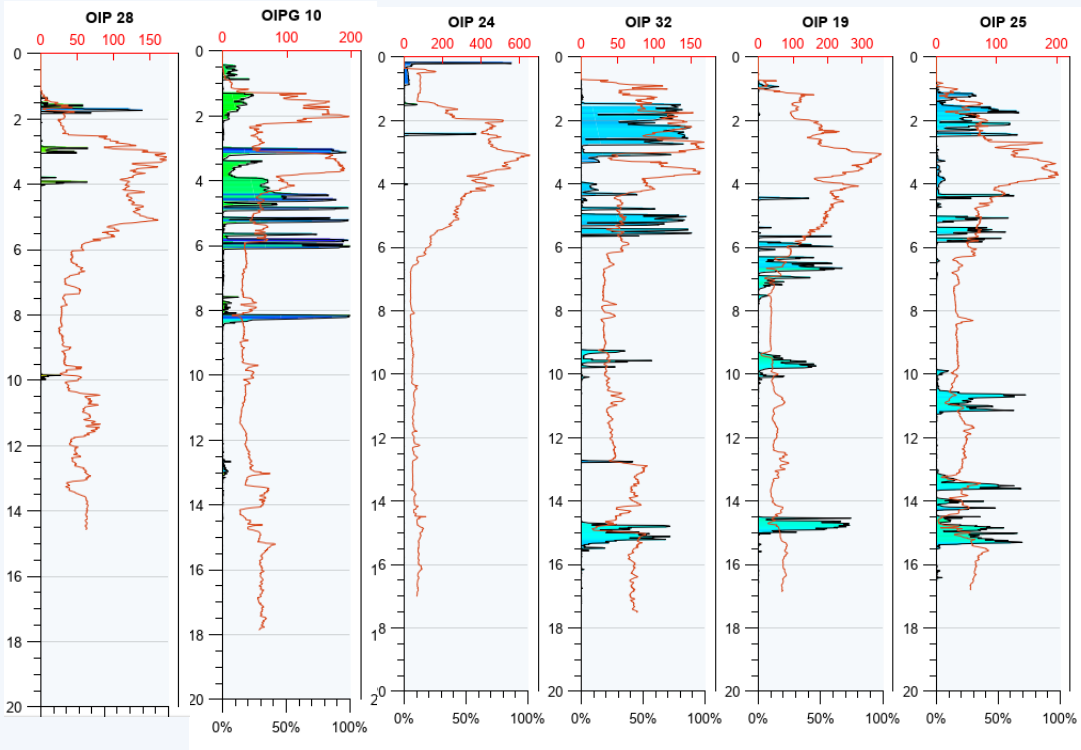
OIP profile

- On de right is an example profile with EC (Electrical Conductivity) and UV fluorescence %.
- The red dots on the right indicate locations that have still images using alternating UV and visible light.
- EC generally is an indicator for grain size.



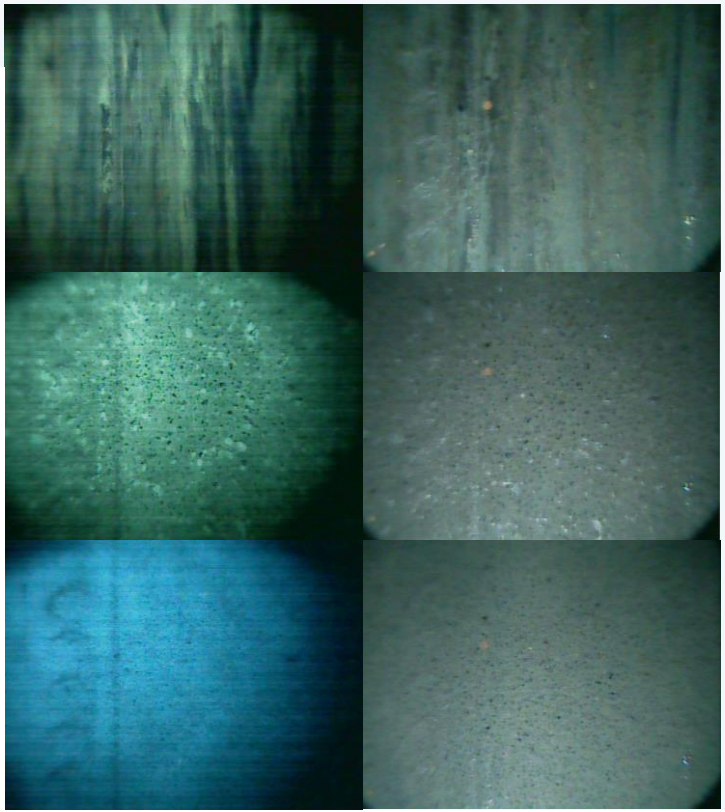


OIP data, Gent site



UV LED

Visible light



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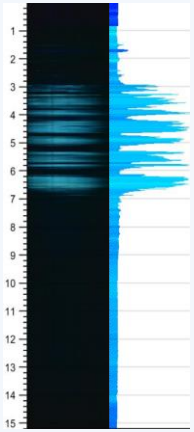

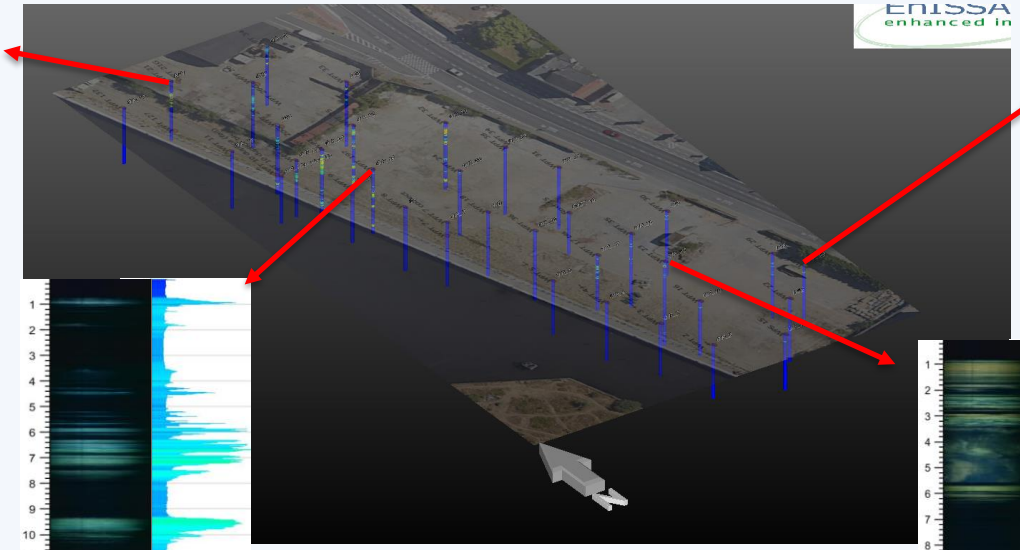

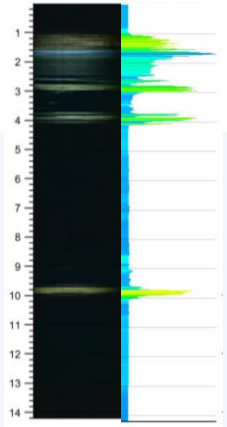

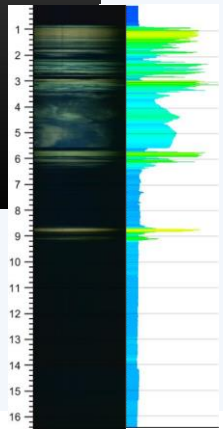

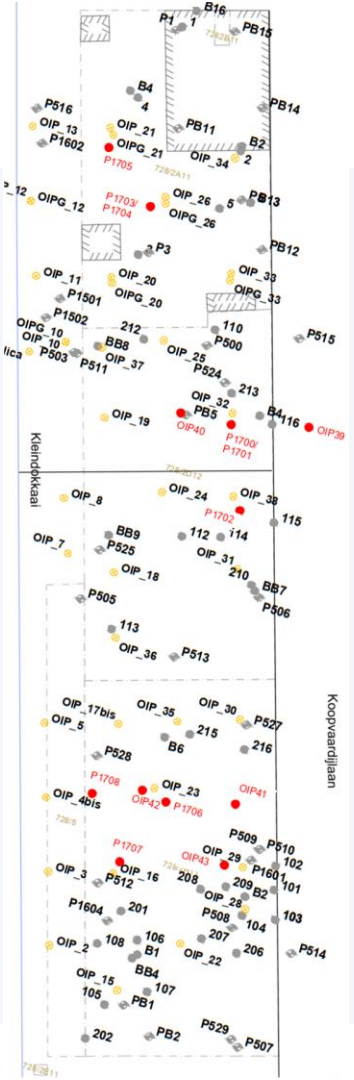

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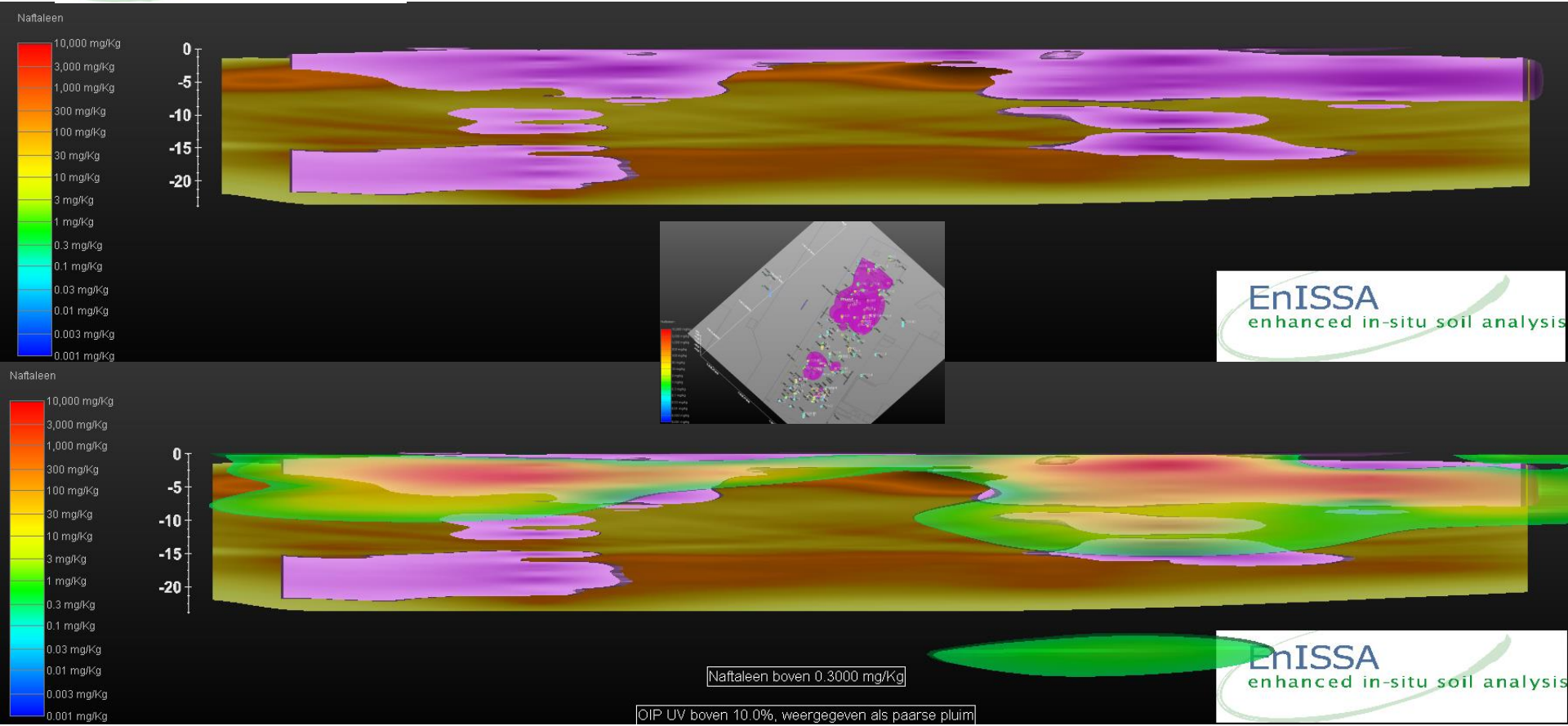
3D model



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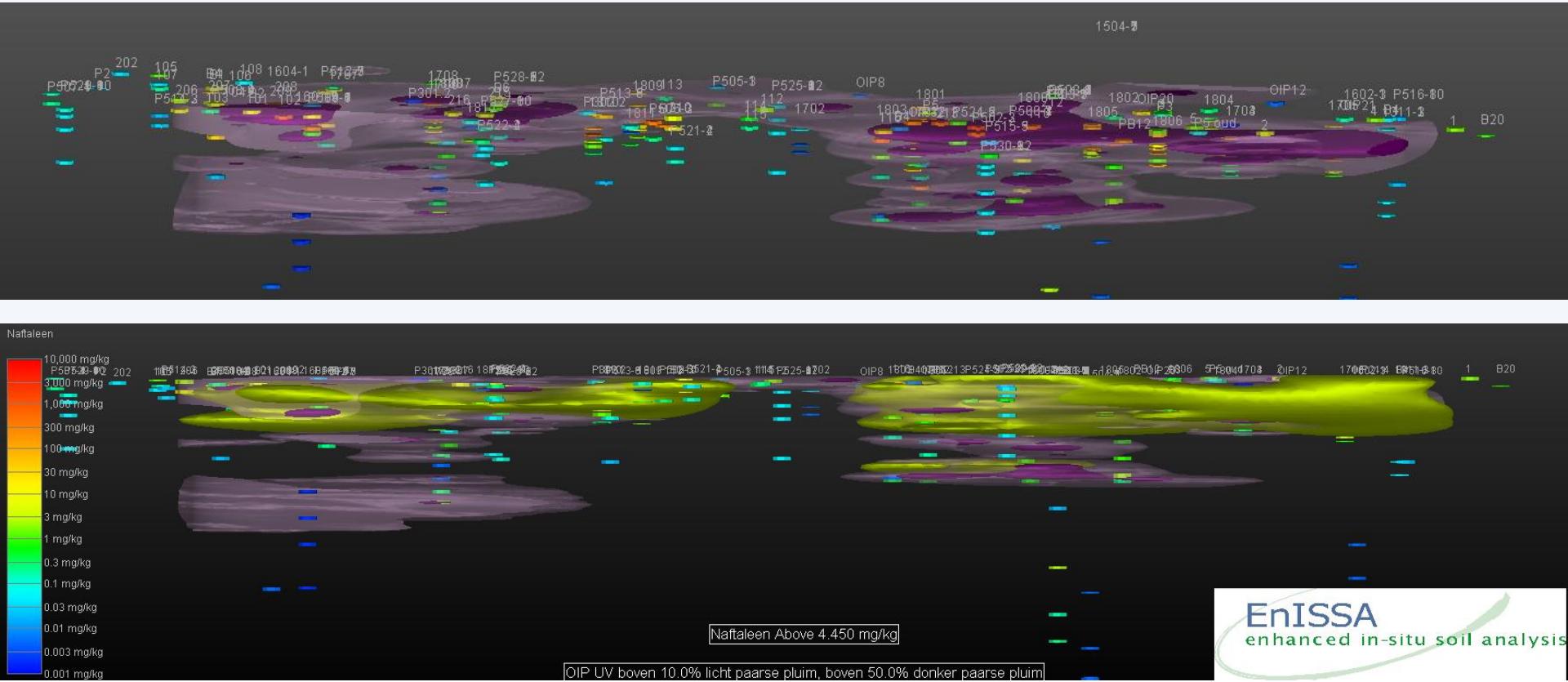
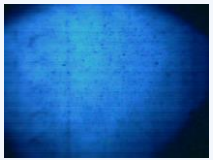
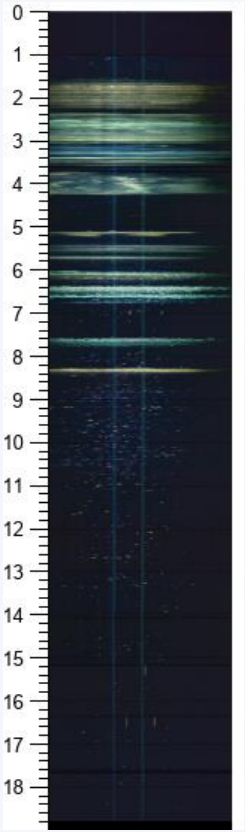

Naftaleen
10,000 mg/kg
3,000 mg/kg
1,000 mg/kg
300 mg/kg
100 mg/kg
30 mg/kg
10 mg/kg
3 mg/kg
1 mg/kg
0.3 mg/kg
0.1 mg/kg
0.03 mg/kg
0.01 mg/kg
0.003 mg/kg
0.001 mg/kg
Naftaleen Above 4.450 mg/kg
OIP UV boven 10.0% licht paarse pluim, boven 50.0% donker paarse pluim

Time and cost efficient collection of horizontal and vertical qualitative information on the contaminant distribution.

OIP profiles help to understand and explain the very heterogeneous dispersion of this type of contaminants

Approaching a contaminated site from different technological angles helps to cover the weaknesses inherent to each data type. Multiple lines of evidence will get us closer to the ground truth





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