CityChlor

FINAL CONFERENCE,
May 16th 2013, Ghent, Belgium

PILOT PROJECT « ILE DE FRANCE »

- Direct Push Technologies (DPT)
- Passive Samplers for groundwater sampling
- Soil-gas well designs and soil-gas sampling techniques
- Natural Attenuation

This project has received European Regional Development Funding through INTERREG IV B.

nwe INTERREG IVB

INERIS controlling risks for sustainable development

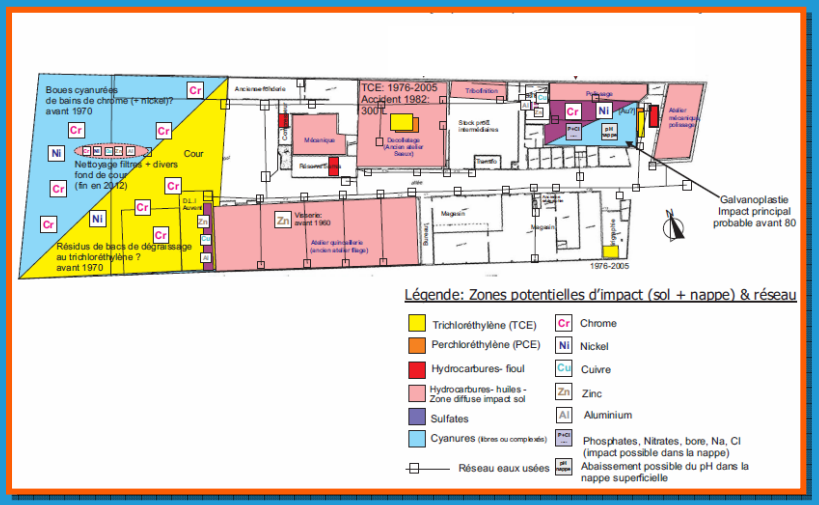
Marie Lemoine, Olivier Bour, Guillaume Gay, Francis Guillot, Corinne Hulot, Julien Michel, Pauline Molina, Fabrice Quiot, Frabrice Richez, Amadou Thiam

PILOT PROJECT « ILE DE FRANCE »

Pilot Project general presentation

- **hardware manufacturing**
  - in the earth of a city of **50.000 citizens,**
  - in operation **since 1930,**
  - in an area of **6700 m²**

- **activities development over time, at different scales**
  - electroplating *(from 1930 to 2006)***,**
  - foundry,
  - degreasing *(**chlorinated solvents**)*,
  - scouring *(sulfuric acid)*,
  - screwing,
  - silkscreen printing *(small scale)*,
  - storage area *(up to 1970)*,
  - …



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Pilot Project general presentation

- Impacts of degreasing activities
  - use of **chlorinated solvents**
    - **PCE** (1t/year from 1930 to 1980; 10t/year from 1980 to 2003)
    - **TCE**, (about 10t/year since 2003)

Historical Study

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soil and groundwater contamination on site

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Techniques selection

… tools for better site characterization

- **Direct Push Technologies** for screening
- **Passive Samplers** for groundwater quality measurement
- **Soil-gas sampling installations and soil-gas sampling techniques** for multi-depth sampling
- **Soil-gas and ambient air sampling for data acquisition** in the frame of transfer modeling

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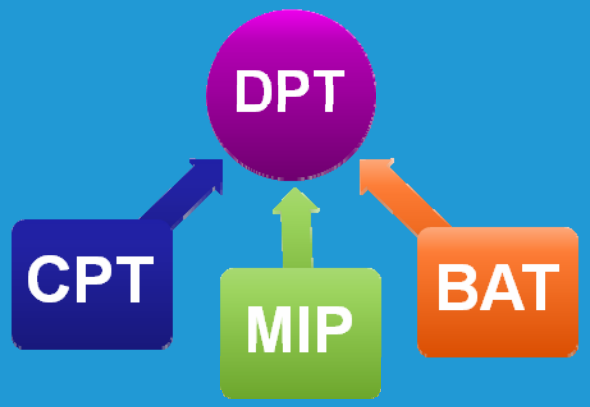
Direct Push Technology

- **measurement and sampling techniques of soil, soil gas and groundwater, pushing steel rods into the ground** (unconsolidated soils, sediments)
  - in-situ analysis of contaminants
  - geophysical data
  - continuous logging of subsurface conditions



cost effective techniques

3D conceptual model construction

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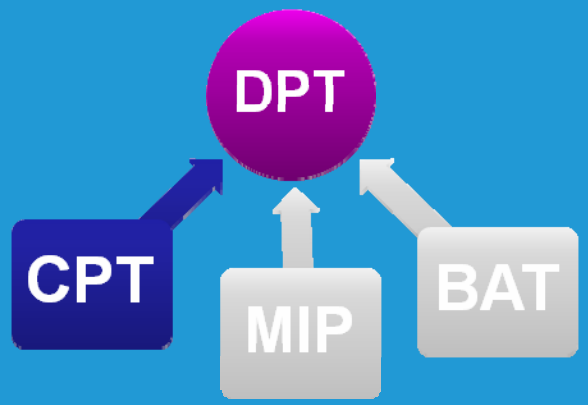

cost effective techniques

3D conceptual model construction

Cone Penetrometer Test (CPT)

determine soil geotechnical engineering properties and soil stratigraphy

- ✓ total penetration resistance
- ✓ friction generated by the rod string

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Direct Push Technology

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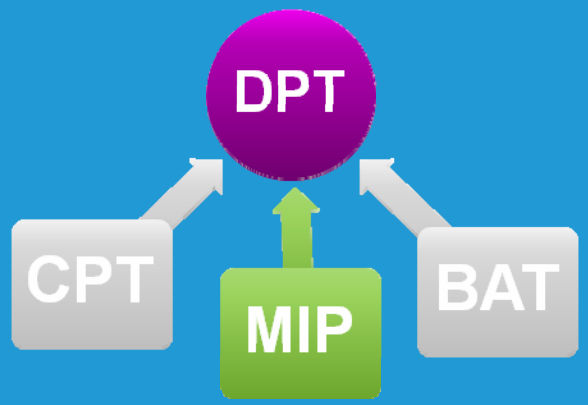


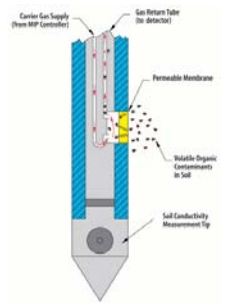
cost effective techniques

3D conceptual model construction

Membrane Interface Probe (MIP)

Logs VOC contaminants (chlorinated solvents, BTEX) with depth

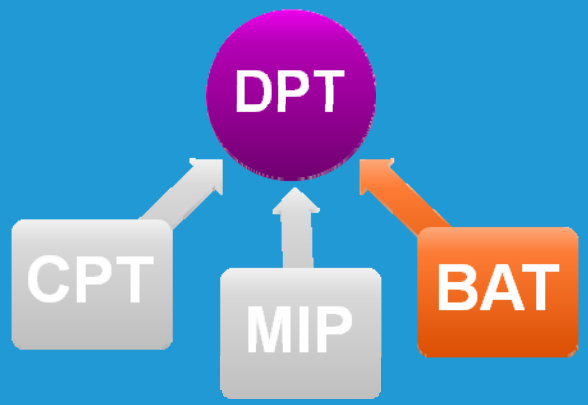
- ✓ heated semi-permeable membrane diffuses VOCs compounds
- ✓ several detectors used (FID, PID and DELCD)



PILOT PROJECT « ILE DE FRANCE »

Direct Push Technology

- **measurement and sampling techniques of soil, soil gas and groundwater, pushing steel rods into the ground** (unconsolidated soils, sediments)
  - in-situ analysis of contaminants
  - geophysical data
  - continuous logging of subsurface conditions



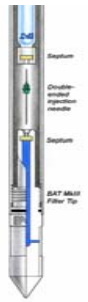
cost effective techniques

3D conceptual model construction

BAT Sampler

groundwater sampling at a specific depth

- ✓ screened interval opened at the measurement depth
- ✓ groundwater sampled in a sample tube supplied with a double ended injection needle



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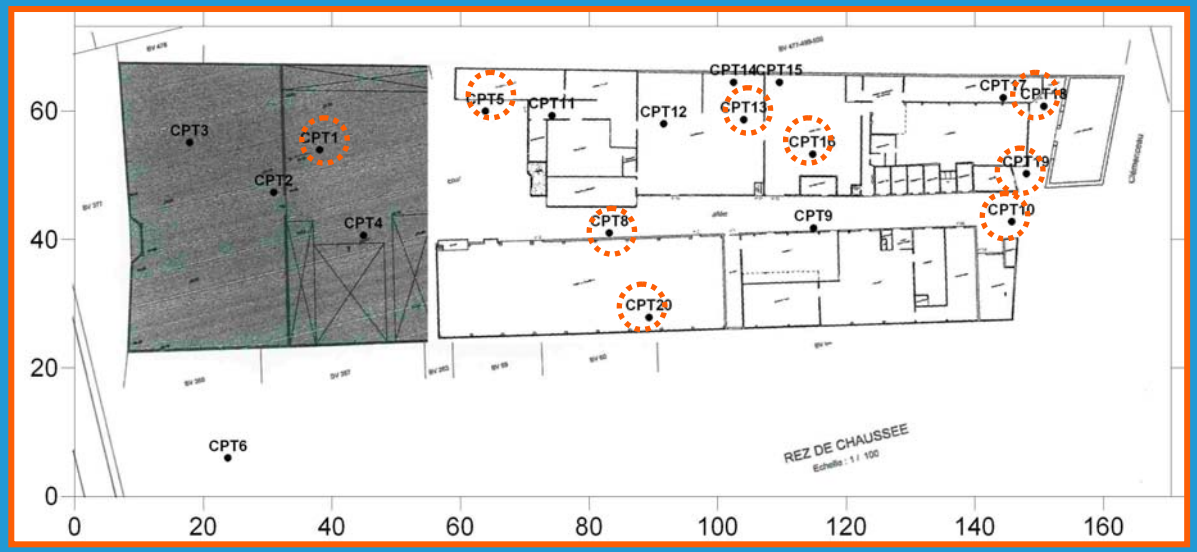
Direct Push Technology

- **Direct Push investigations carried out**
  - lithology with depth information
  - contamination information



Measurement:

Step1: **CPT/MIP measurements** at **19 locations**, close to the sources of pollution (indoor and outdoor), until 4.2 to 7.6 meters deep

Step2: **BAT Sampling** at different contaminated areas (2 or 3 different depths)

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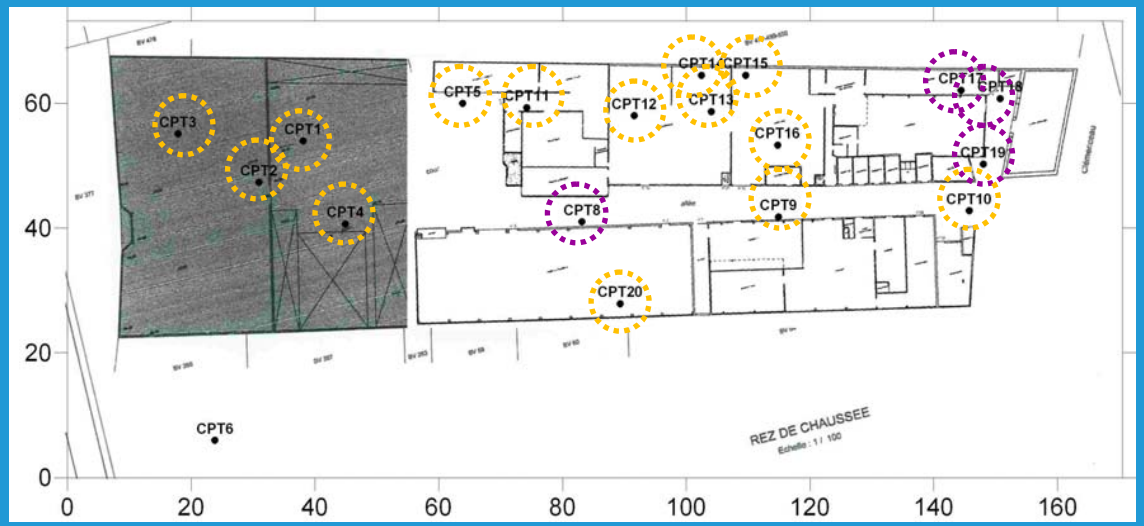
Direct Push Technology

- **Direct Push investigations: CPT/MIP results**

Two main lithologic profiles:

embankment not detected/identified



- from 1 to 4 meters deep: **peat/clay**
- from 4 to 6 meters deep: silty clay/sand/gravels

- from 1 to 5 meters deep: **peat/clay**
- from 5 to 6 meters deep: silty clay/sand/gravels

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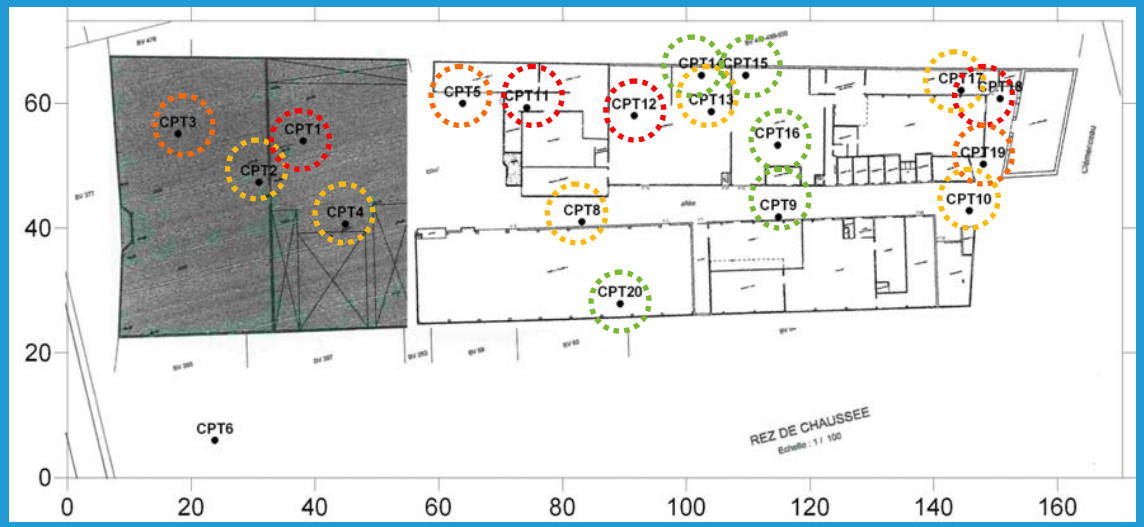
Direct Push Technology

- **Direct Push investigations: CPT/MIP results**

Different levels of contaminations identified with DELCD:



- no contaminant detected (TCE equivalent)

- from 1 to 10 mg/L (TCE equivalent)
- located in the saturated zone (> 3 m)

- from 0.3 to 1 mg/L (TCE equivalent)
- located in the saturated zone (> 3 m)

- from 1 to 100 mg/L (TCE equivalent)
- located in the vadose and saturated zones

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Direct Push Technology

- **Direct Push investigations: BAT Sampling**
  - Different levels of contaminations identified :

Two sampling depths:
- 3.6-3.7 meters deep
- 4.6-4.7 meters deep

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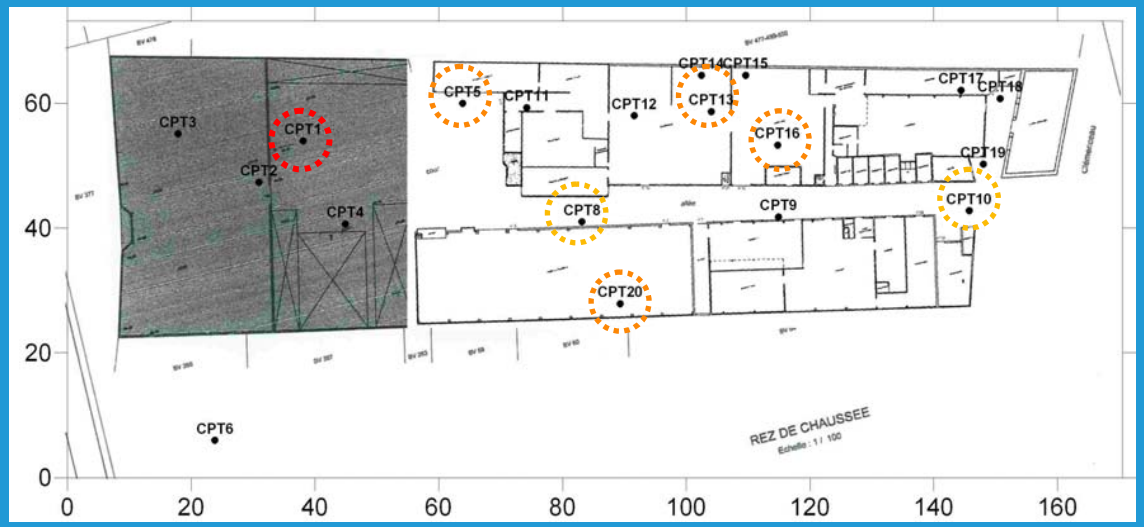
Direct Push Technology

- **Direct Push investigations: BAT Sampling**

Different levels of contaminations identified :

Two sampling depths:
- 3.6-3.7 meters deep
- 4.6-4.7 meters deep



- from 0.4 to 0.9 mg/L
- from 2 to 4 mg/L
- from 20 to 40 mg/L

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Direct Push Technology

- **Direct Push investigations:**

Main conclusions:

- confirm historical study conclusions **but also identify other contaminated zones**
- some specific zones cannot be investigated
- **BAT Sampler results confirmed MIP results concerning VOCs detection**

VERY HELPFUL FOR SITE SCREENING

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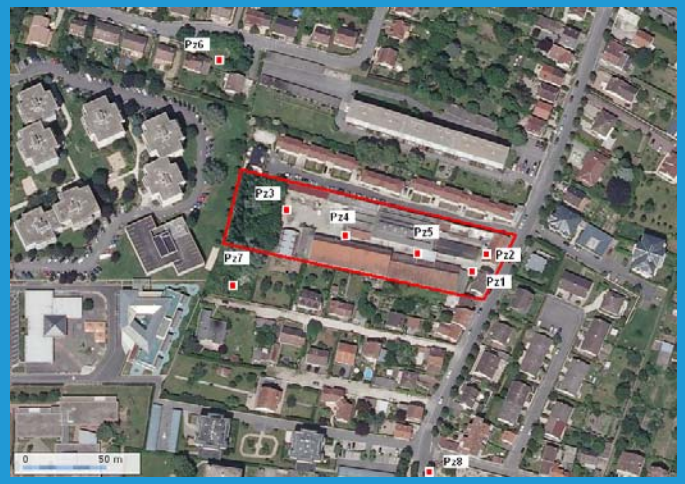
Groundwater investigations

- **Groundwater monitoring**
  - using **on site groundwater wells**
  - conventional sampling (pumping method)



Precautions

- ✓ **for each sampling event,** various parameters measured:
  - water level
  - pH, conductivity, temperature, redox potential (with depth)
  - weather conditions

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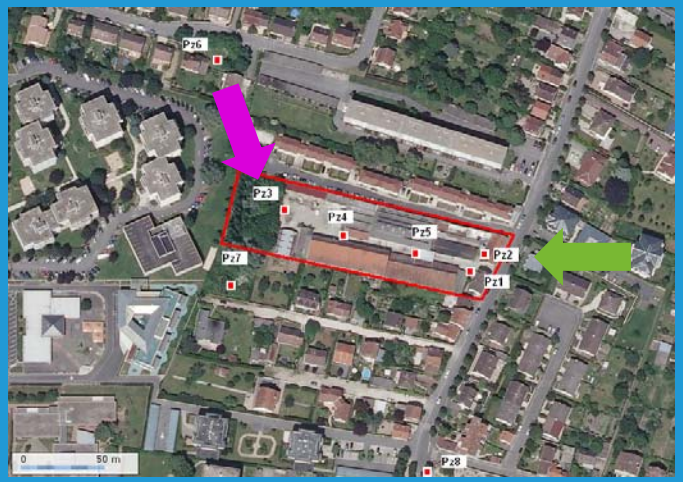
Groundwater investigations

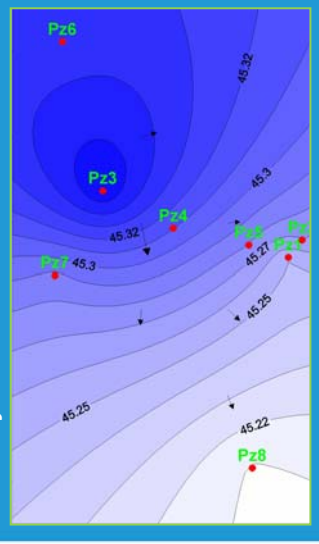
- **Groundwater flow direction**
  - using **on site groundwater wells**
  - conventional sampling (pumping method) on site



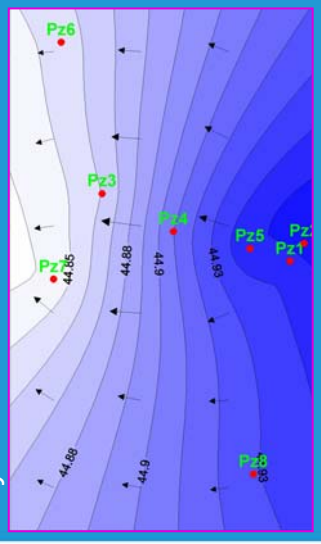
Information provided

- ✓ groundwater flow direction
- ✓ contaminants concentration ranges on site

Three more groundwater wells implemented in the frame of CityChlor



Groundwater flow direction, January 2011



Groundwater flow direction, July 2011

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Groundwater investigations

- **Comparison of passive samplers and conventional sampling method**

- comparison based on **chlorinated solvents concentrations** (PCE, TCE, DCE, VC)
- exposure duration according to the passive sampler
- **21 sampling campaigns** carried out, between **September 2011 and January 2013**

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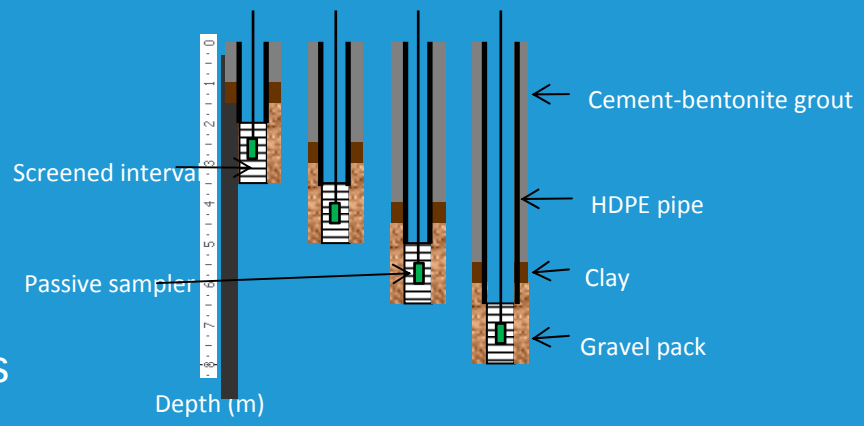
Groundwater investigations

- **Comparison of passive samplers and conventional sampling method**
  - using **four wells** (short screened interval: 1.5 m)
  - passive samplers set up **in the middle of each screened interval**



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Precautions

✓ **For each sampling event,** various parameters measured:

- water level
- pH, conductivity, temperature, redox potential (with depth)
- weather conditions (few days before and few days after the sampling event)

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Groundwater investigations

- **Comparison of passive samplers and conventional sampling method**

  - using **four wells** (short screened interval: 1.5 m)
  - passive samplers set up **in the middle of each screened interval**

Main conclusions:

- **concentrations** measured with passive samplers and conventional sampling are of the **same order of magnitude and comparable** (PDB, Dialysis Membrane, Gore® Sorber Module)
- **concentrations measured with ceramic dosimeters not always comparable**
- **good reproducibility on the result**s (PDB, Dialysis Membrane, Gore® Sorber Module)

➡ EFFICIENT FOR GROUNDWATER QUALITY MEASUREMENT

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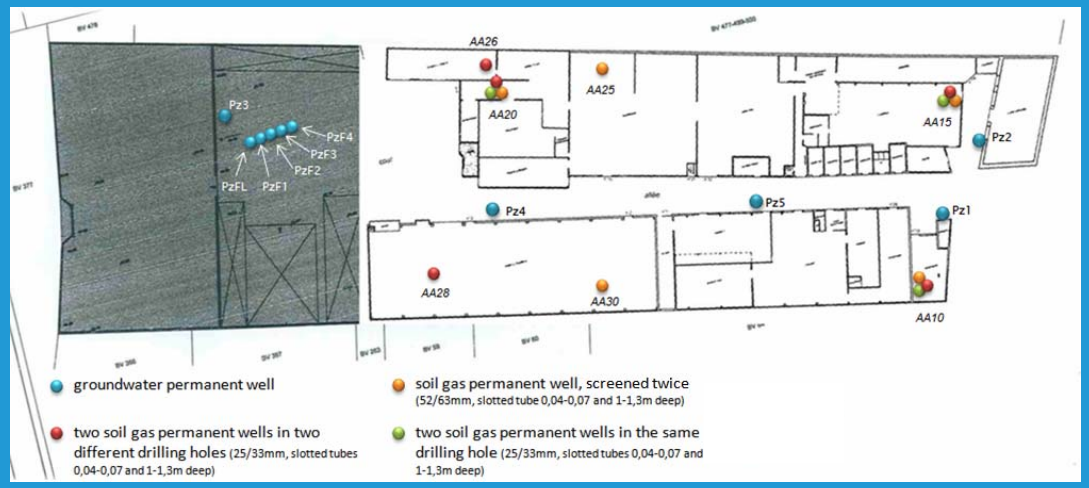
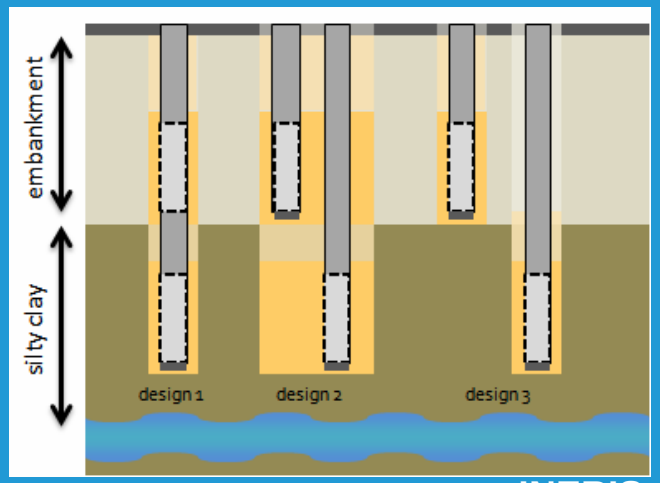
Soil-Gas investigations

- **Soil-gas installations and soil-gas sampling**

  using **thirteen wells** (**three different designs**, screened interval located in embankment (0.3-0.7 meters deep) and silty clay (1.0-1.3 meters deep)





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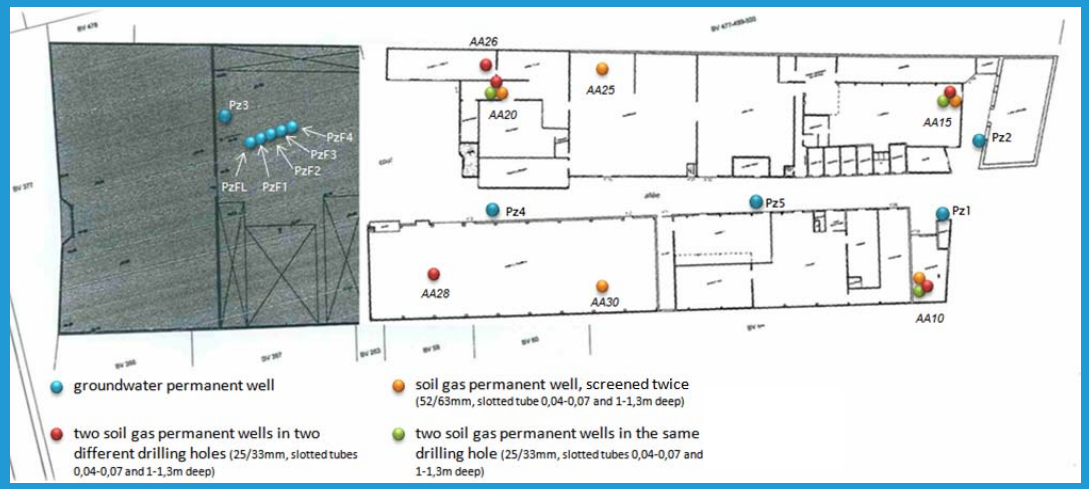
Soil-Gas investigations

- **Soil-gas installations and soil-gas sampling**

  - using **thirteen wells** (**three different designs**, screened interval located in embankment (0.3-0.7 meters deep) and silty clay (1.0-1.3 meters deep)
  - 5 active sampling campaigns using **sorbent tubes** (activated charcoal)



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Soil-Gas Investigations

- **Soil-gas installations and soil-gas sampling**

  ➥ using **thirteen wells** (**three different designs**, screened interval located in embankment (0.3-0.7 meters deep) and silty clay (1.0-1.3 meters deep)

  ➥ 5 active sampling campaigns using **sorbent tubes** (activated charcoal)

Precautions

✓ **for each sampling event,** various parameters measured:
- soil-gas well purge
- PID measurements before and after sampling
- temperature and humidity
- weather conditions (pressure, temperature, raining events…)

Tests carried out

✓ purge monitoring with PID
✓ active soil-gas sampling in the three different soil-gas well designs
✓ recirculation tests

detailed in « soil-gas characterization » presentation

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Soil-Gas investigations

- **Soil-gas installations and soil-gas sampling**

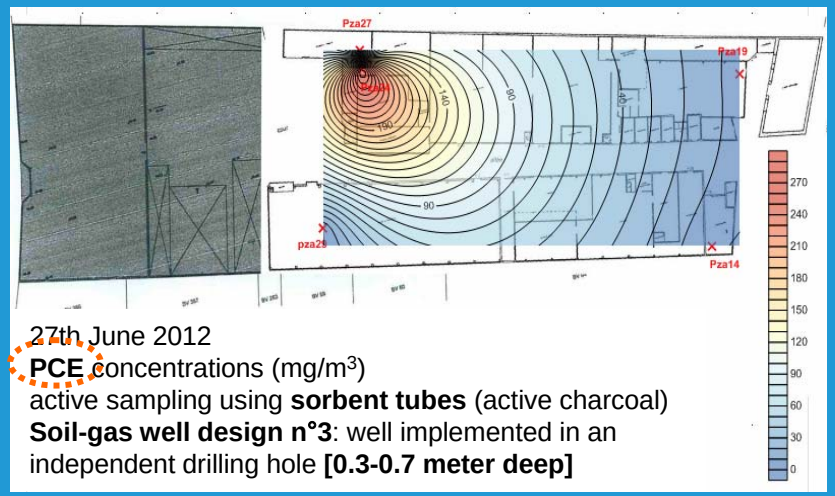
  ➥ using **thirteen wells** (**three different designs**, screened interval located in embankment (0.3-0.7 meters deep) and silty clay (1.0-1.3 meters deep)

  ➥ 5 active sampling campaigns using **sorbent tubes** (activated charcoal)

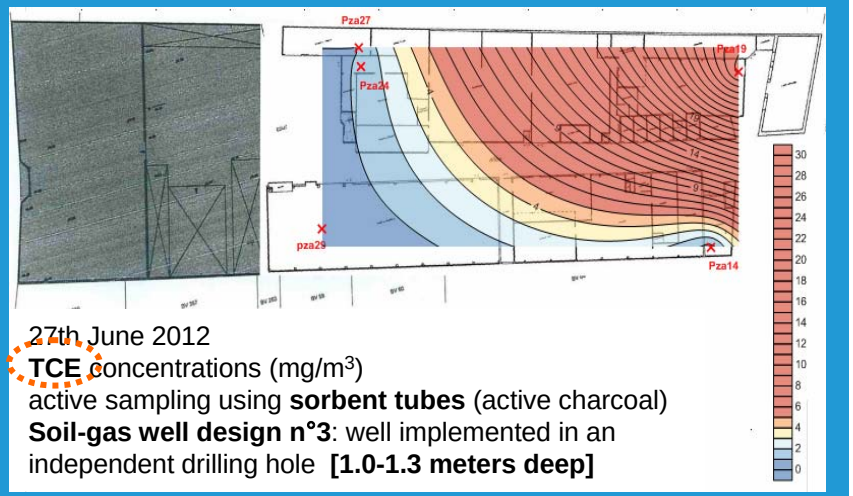
Information provided

✓ **soil-gas concentrations** (PCE, TCE, cis-DCE, trans-DCE, Vinyl Chloride, BTEX) at two different depths (0.3-0.7 meters deep and 1.0-1.3 meters deep)

Comparison of soil-gas concentrations depending ofthe targeted compound



27th June 2012
PCE concentrations (mg/m^3)
active sampling using **sorbent tubes** (active charcoal)
Soil-gas well design n°3: well implemented in an independent drilling hole **[0.3-0.7 meter deep]**



27th June 2012
TCE concentrations (mg/m^3)
active sampling using **sorbent tubes** (active charcoal)
Soil-gas well design n°3: well implemented in an independent drilling hole **[1.0-1.3 meters deep]**

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Soil-Gas Investigations

- **Soil-gas installations and soil-gas sampling**

  - using **thirteen wells** (**three different designs**, screened interval located in embankment (0.3-0.7 meters deep) and silty clay (1.0-1.3 meters deep)
  - 5 active sampling campaigns using **sorbent tubes** (active charcoal)

Information provided

- ✓ **soil-gas concentrations** (PCE, TCE, cis-DCE, trans-DCE, Vinyl Chloride, BTEX) at two different depths (0.3-0.7 meters deep and 1.0-1.3 meters deep)
- ✓ get **feedback** on the **soil gas well design** implemented
  - by comparing the concentrations measured
  - carring out other tests (purge monitoring, recirculation test…)

  detailed in « soil-gas characterization » presentation

- ✓ providing data for modeling gas transfer from soil to indoor air

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Soil-Gas investigations

- **Soil-gas installations and soil-gas sampling**

  ➥ using **thirteen wells** (**three different designs**, screened interval located in embankment (0.3-0.7 meters deep) and silty clay (1.0-1.3 meters deep)

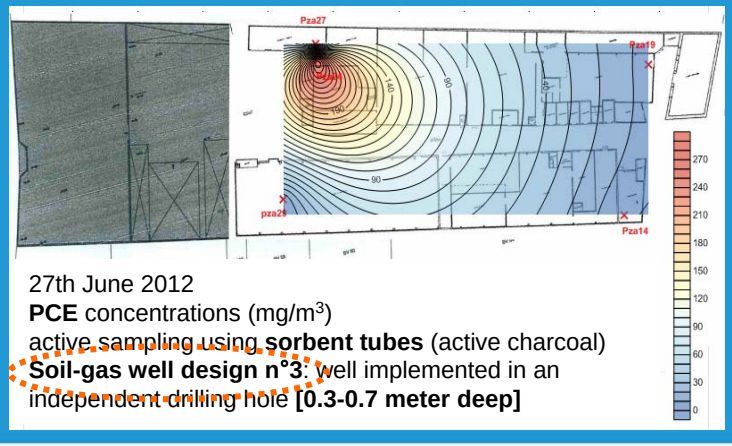
  ➥ 5 active sampling campaigns using **sorbent tubes** (activated charcoal)

Information provided

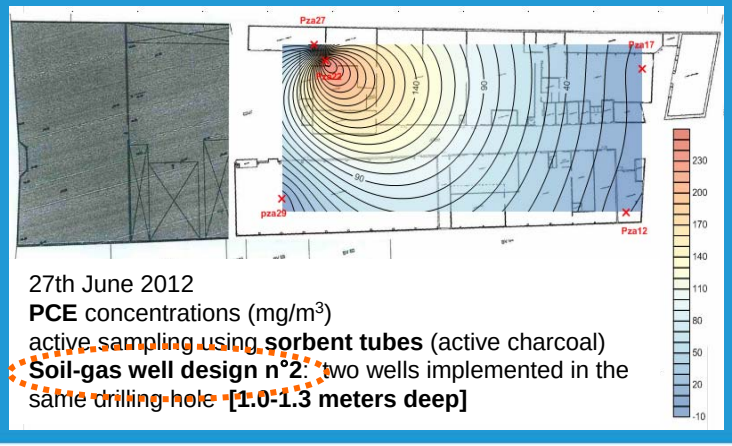
✓ **soil-gas concentrations** (PCE, TCE, cis-DCE, trans-DCE, Vinyl Chloride, BTEX) at two different depths (0.3-0.7 meters deep and 1.0-1.3 meters deep)

✓ get **feeback** on the influence of **soil gas well design**

Comparison of soil-gas concentrations depending of the soil-gas well design



27th June 2012
PCE concentrations (mg/m^3)
active sampling using **sorbent tubes** (active charcoal)
Soil-gas well design n°3: well implemented in an independent drilling hole **[0.3-0.7 meter deep]**



27th June 2012
PCE concentrations (mg/m^3)
active sampling using **sorbent tubes** (active charcoal)
Soil-gas well design n°2: two wells implemented in the same drilling hole **[1.0-1.3 meters deep]**

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Soil-Gas investigations

- **Soil-gas installations and soil-gas sampling**

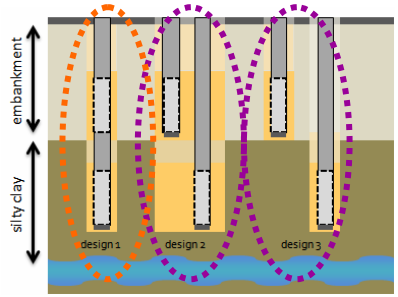
  ➥ using **thirteen wells** (**three different designs**, screened interval located in embankment (0.3-0.7 meters deep) and silty clay (1.0-1.3 meters deep)

  ➥ 5 active sampling campaigns using **sorbent tubes** (active charcoal)

Main conclusions:

➥ soil-gas well designs **n°2** and **n°3** provide similar results

➥ twice screened interval (design **n°1**) provides higher concentrations in embankment



DESIGNS N°2 AND 3 SEEM TO BE MORE ACCURATE FOR MULTI-LEVEL SOIL-GAS SAMPLING

DESIGN N°1 COULD BE USED ONLY IF IMPERMEABILITY TESTS ARE WELL- CARRIED OUT (PACKER PERFORMANCES)

➥ soil-gas sampling technique should be adapted depending on site specificities and contaminants

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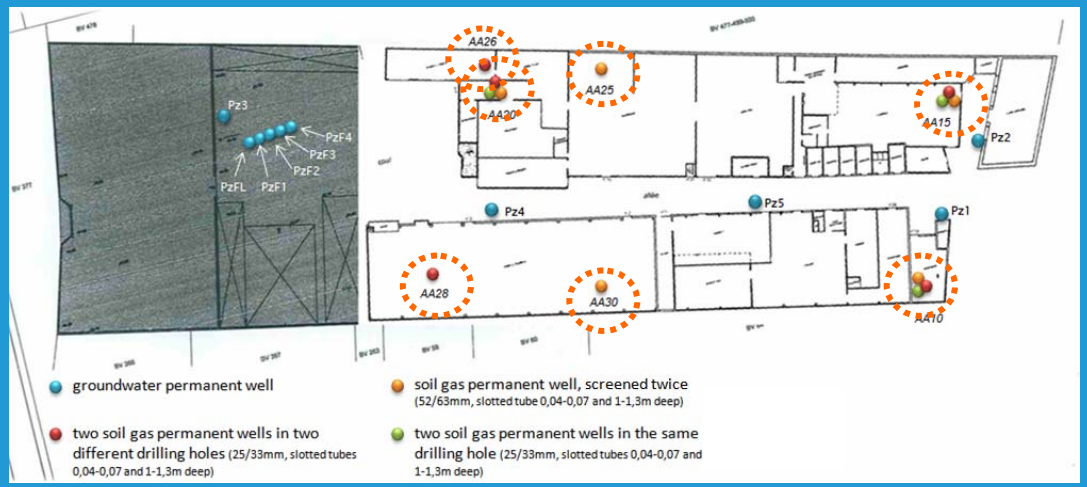
Ambient Air Investigations

- **Soil-gas installations and soil-gas sampling**
  - using 7 sampling locations (measurements at 0.1 and 0.5 meter high)
  - 5 active sampling campaigns using **sorbent tubes** (active charcoal)

Information provided

- ✓ providing data for modeling gas transfer from soil to indoor air



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Conclusion of the main investigations

- **Direct Push Technologies: CPT/MIP and BATSampler**
  - DPT investigations very helpful to get information on lithology as well as to identify high-contaminated zones (soil, soil-gas and groundwater) in the frame of site screening
  - good correlation observed between CPT/MIP and BATSampler results
  - investigations confirm the
- **Groundwater investigations**
  - passive samplers are relevant for groundwater monitoring
  - recommendations have been emitted concerning their use
  - investigations help to increase passive samplers market acceptance
- **Soil-gas investigations**
  - soil-gas multi-depth could be carried out using different soil-gas well designs (in two nested wells or in two soil-gas wells installed in two different but similar boreholes)
  - further investigations and tests should be carried out to provide complementary data (for recommendations)

PILOT PROJECT « ILE DE FRANCE »

Pilot Site Outputs

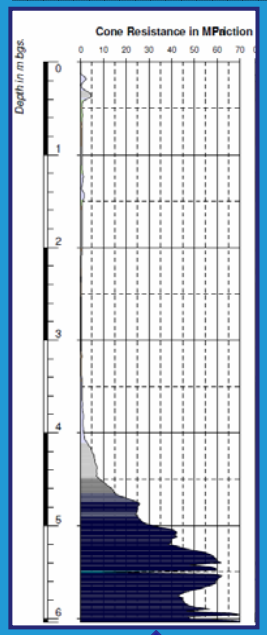
- **Pilot site investigations**
  - *Pilot Project "Ile de France", use of tools for groundwater, soil, soil-gas and indoor air characterization, in the frame of chlorinated solvent pollution in urban areas,* Julien Michel, Marie Lemoine
- **Soil-gas investigations**
  - *Soil-gas monitoring: soil-gas sampling installations and soil-gas sampling techniques,* Marie Lemoine, Olivier Bour, Corinne Hulot
  - *Attenuation of Vinyl Chloride in the vadose zone*, Olivier Bour
- **Groundwater investigations**
  - *Passive samplers as an innovative way for groundwater quality monitoring,* Julien Michel
- **Gas Transfer from soil to indoor air**
  - **Models for predicting transfers to indoor air,** Guillaume Gay, Amadou Thiam

PILOT PROJECT « ILE DE FRANCE »

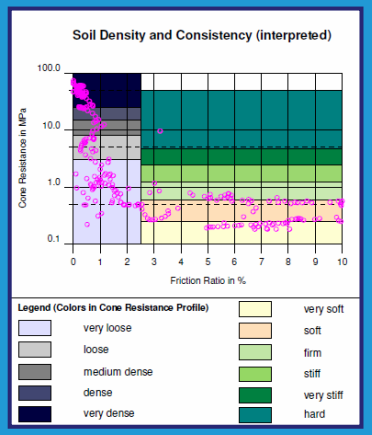
Direct Push Technology

- **Direct Push investigations: CPT/MIP results**

CPT results



cone penetration resistance with depth



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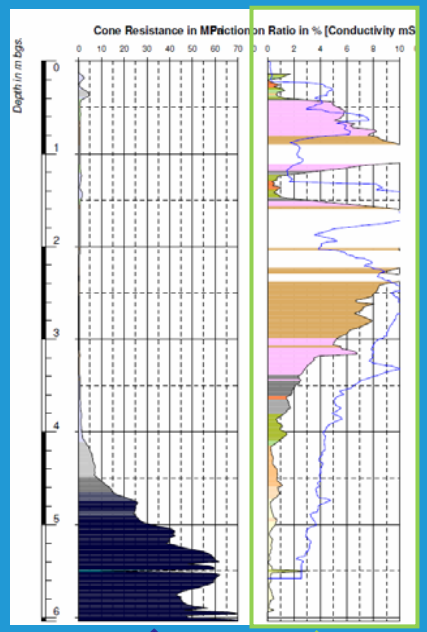
Direct Push Technology

- **Direct Push investigations: CPT/MIP results**

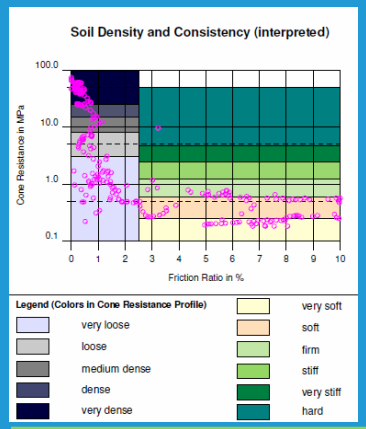
CPT results

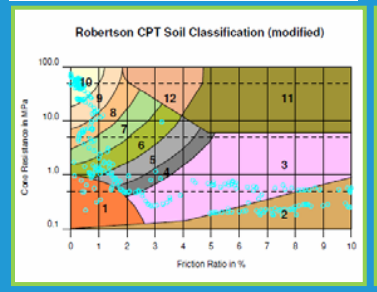


cone penetration resistance with depth

DELCD

conductivity ratio (%)





Legend (Colors in Friction Ratio Profile)

1 Sensitive, fine grained
2 Organic soils, peat
3 Clay
4 Clay to silty clay
5 Clayey silt to silty clay
6 Sandy silt to clayey silt
7 Silty sand to sandy silt
8 Sand to silty sand
9 Coarse to medium sand
10 Gravel to gravelly sand
11 Very stiff, fine grained
12 Very stiff sand to clayey sand

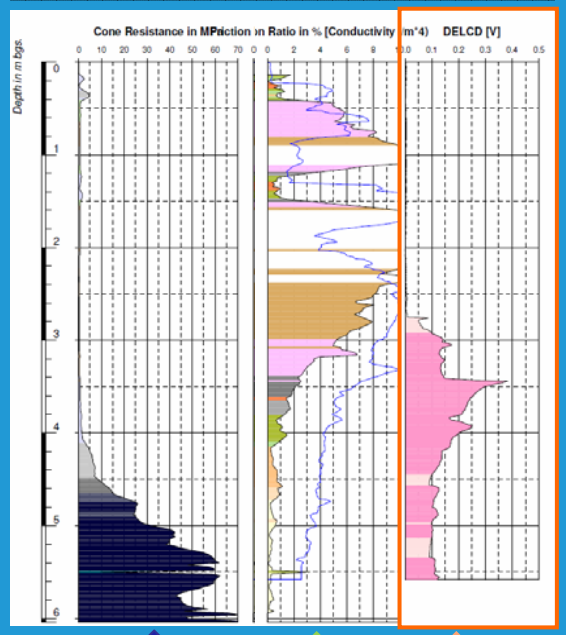
Soil types 11 und 12 are heavily overconsolidated or cemented

PILOT PROJECT « ILE DE FRANCE »

Direct Push Technology

- **Direct Push investigations: CPT/MIP results**

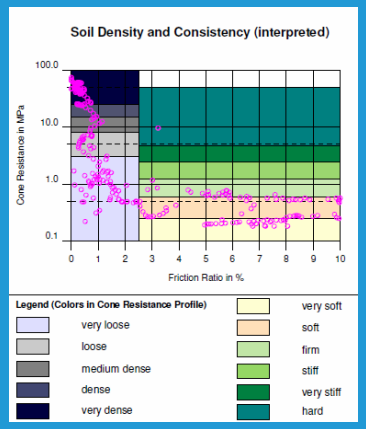
CPT results

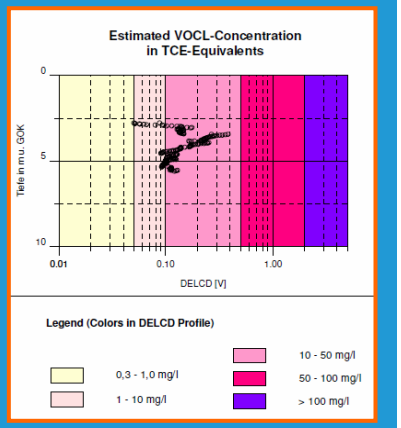


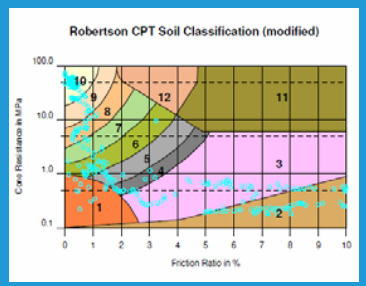
cone penetration resistance with depth

DELCD

conductivity ratio (%)







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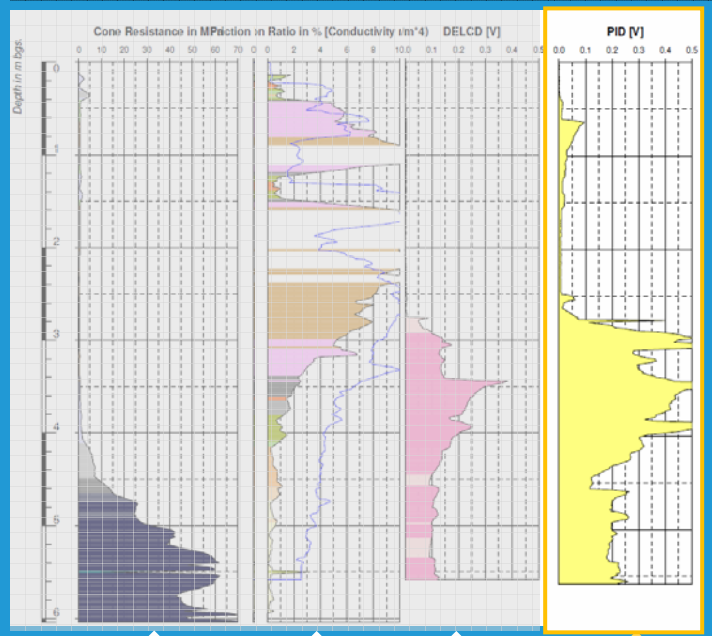
PILOT PROJECT « ILE DE FRANCE »

Direct Push Technology

Direct Push investigations: CPT/MIP results

CPT results | MIP results

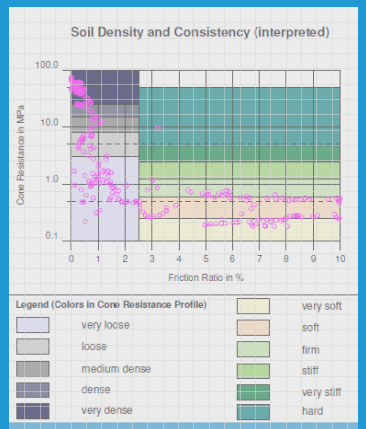


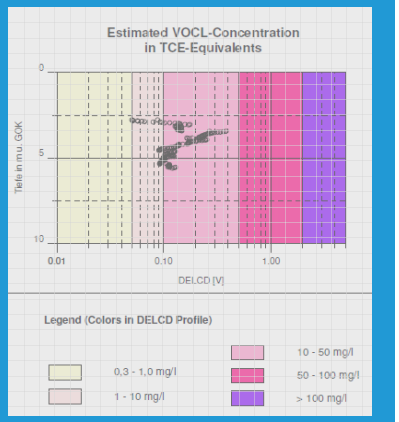
cone penetration resistance with depth

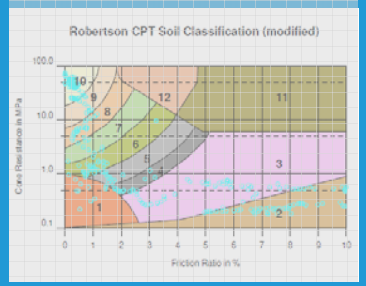
DELCD

conductivity ratio (%)

PID



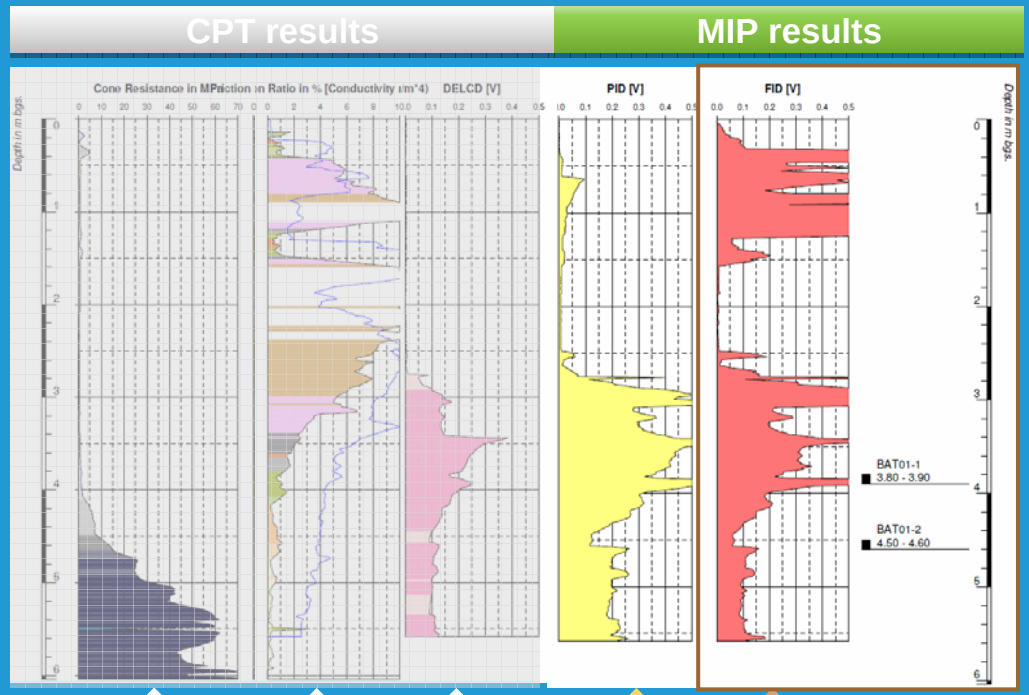


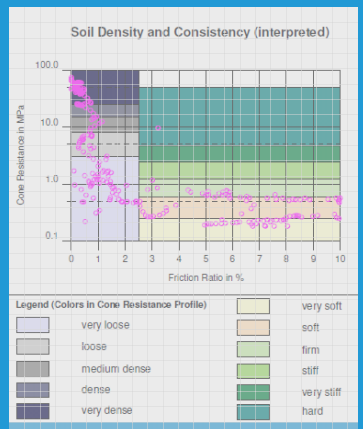


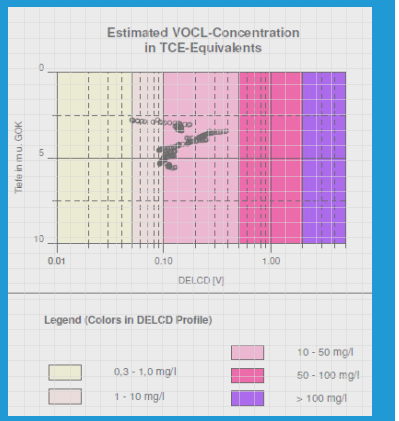
PILOT PROJECT « ILE DE FRANCE »

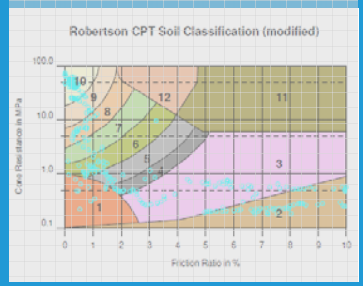
Direct Push Technology

Direct Push investigations: CPT/MIP results









cone penetration resistance with depth

DELCD

FID

conductivity ratio (%)

PID