



# Thermal **D**esorption: A Solution for Insoluble Case

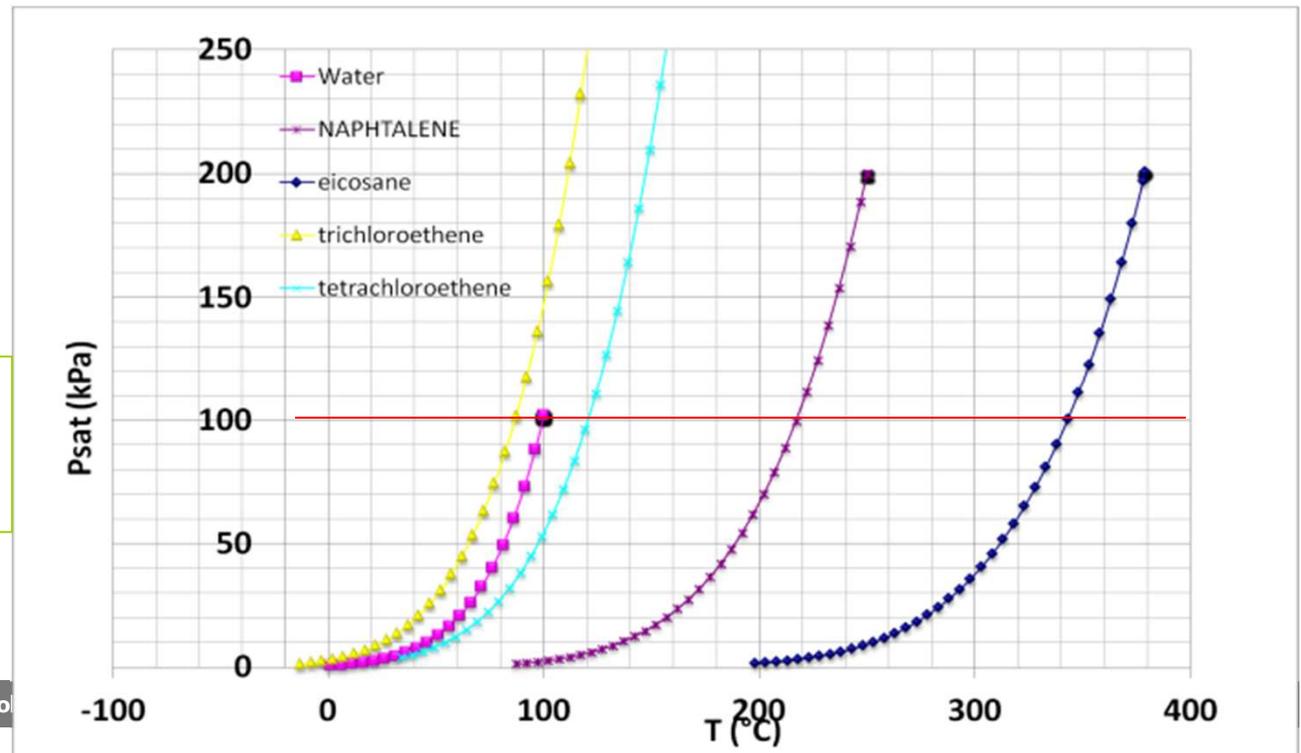
**Session C** : innovations techniques



## Technical Principle

- Based upon **venting** principles
  - Only available for pollutants with a high vapor saturation pressure:  $P_{\text{sat}} > 100\text{-}150 \text{ Pa}$  (1 mm Hg)
  - Now,  $P_{\text{sat}}$  is greatly influenced by temperature  $\rightarrow$  given by Antoine's Equation

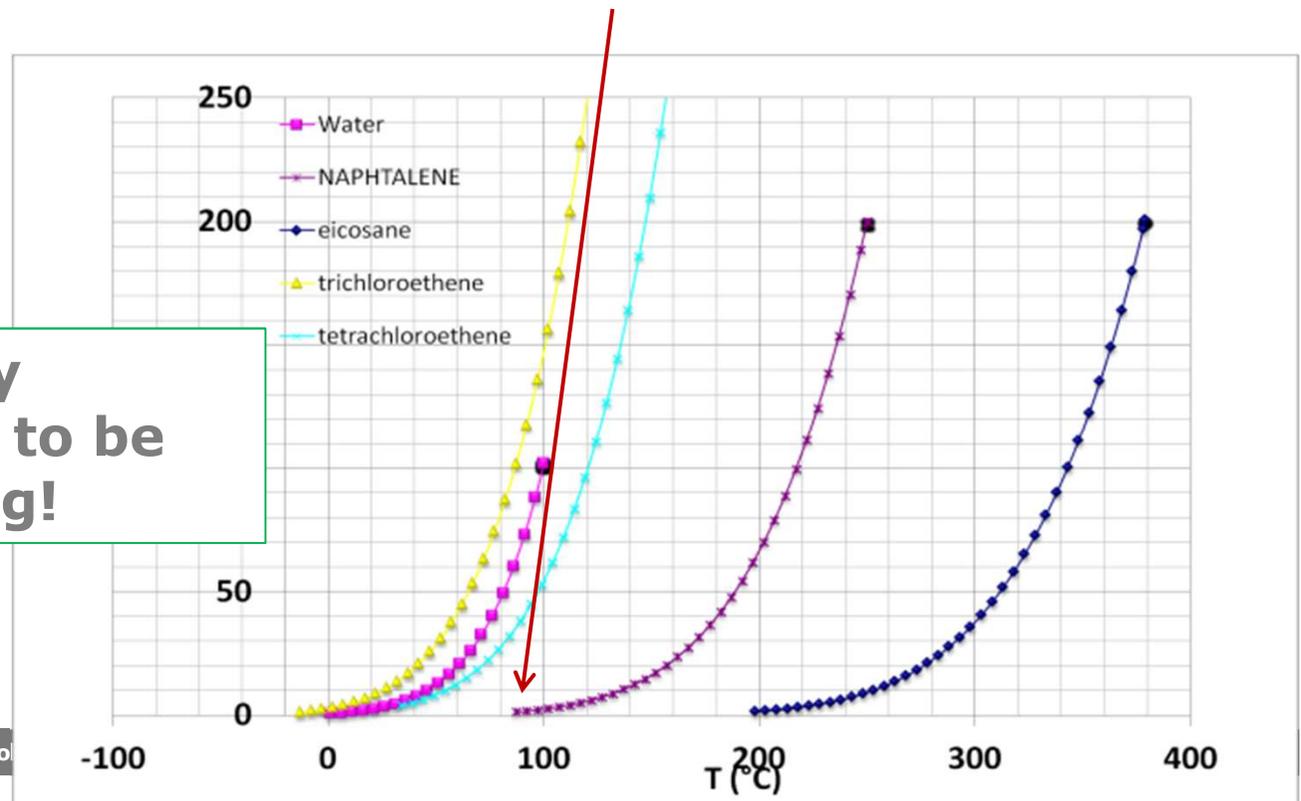
Curves of saturation pressure : for each compound, the vapor partial pressure grows with temperature  
100 kPa = BP under 1 atm pressure



## Technical Principle

- $P_{\text{sat}}$  for naphthalene at 20°C is about 7,2 Pa (too low to be drawn). We reached an average temperature of 87°C →  $P_{\text{sat}}$  raises to 1,37 kPa
- It is 190 times more; it means remediation should go 190 times faster

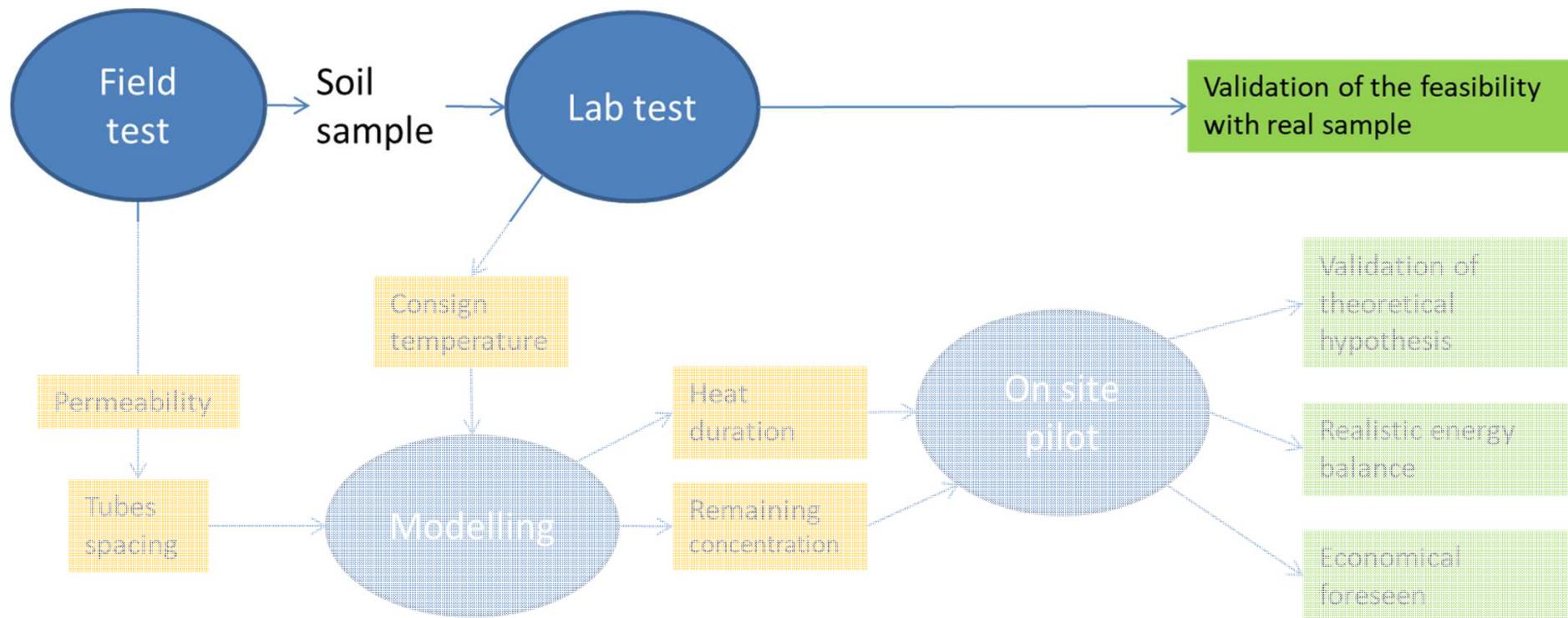
➤ To allow a weakly volatile pollutant to be treated by venting!





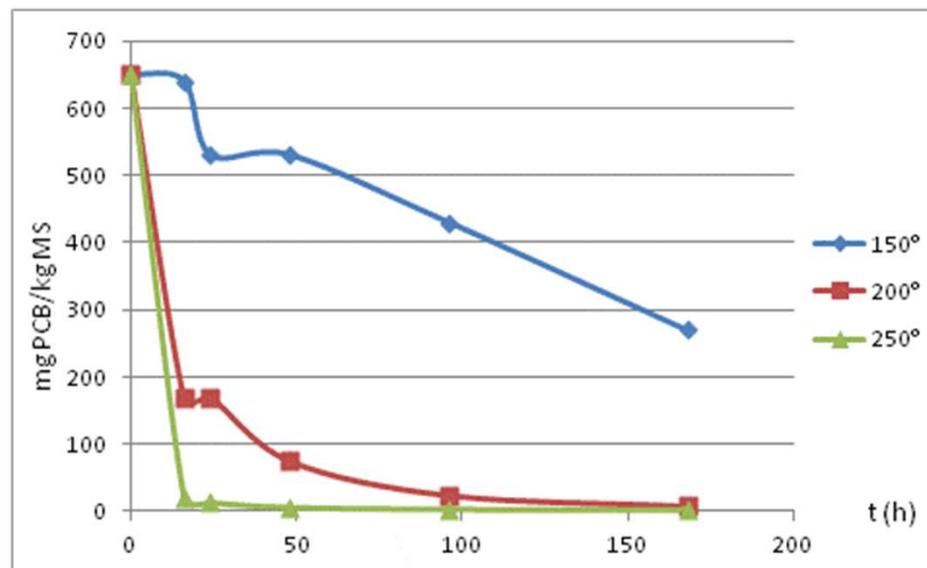
# VALGO's Approach

- A Strategy based upon modelling and pilots:



- Preliminary assays In VALGO's lab:

Contaminated soils are held in a desorption unit (oven), with a ventilation, at several temperatures. Heated soils are periodically sampled during desorption and remaining amount of pollutants is measured, to draw kinetics.

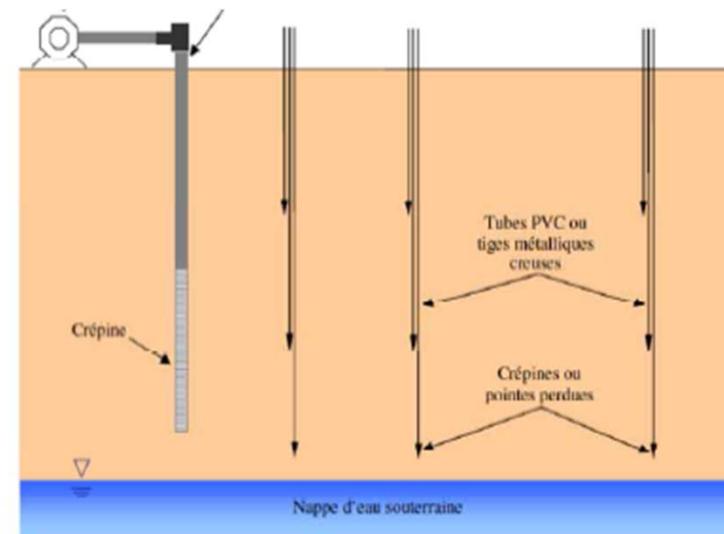


## Validation of chemical interactions

- Air permeability assay



- Plot depression data in soil and all other parameters used to adjust MFRKINV model:

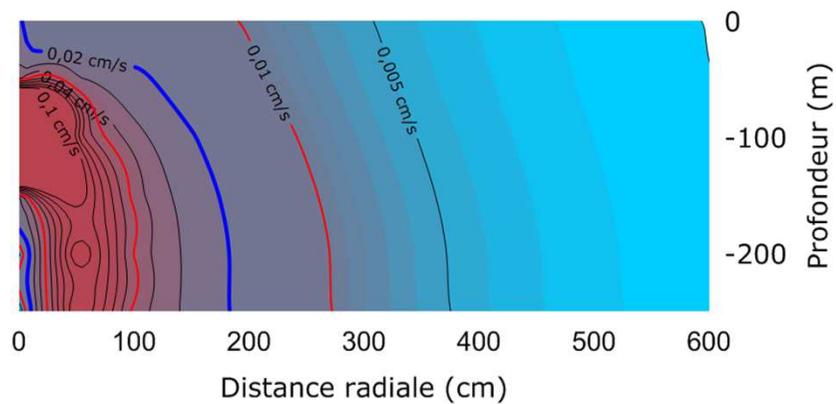


**Determine radial and vertical parameters of soil's permeability to air**



## ON SITE TESTS

- Air permeability test



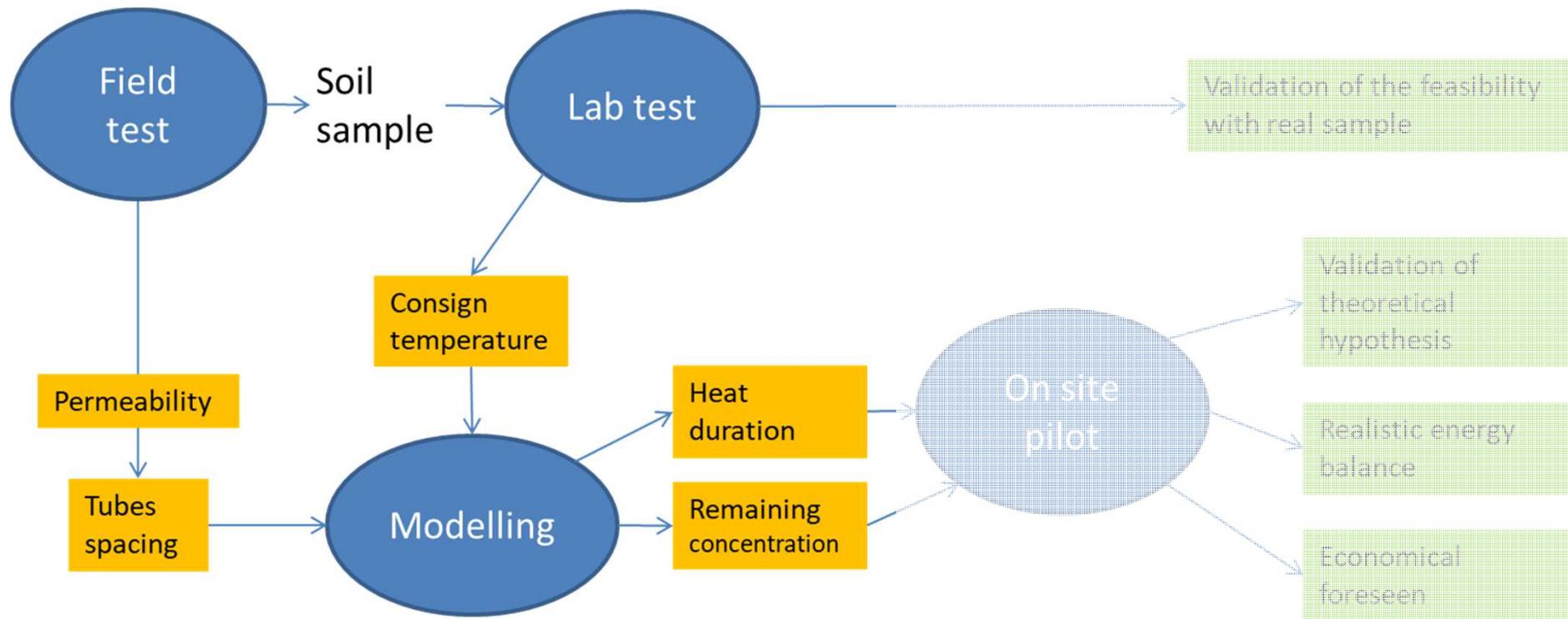
choose a pore flow speed over 0,01 cm/s



**Determine the ROI (radius of influence) of the extraction needles**



# MODELLING





# MODELLING PHASE

- Partnership with IMFT
- The multi-physical model (OpenFoam) for the flow in porous medium is taking account of air gases, water and a pollutant.
- Soil's matrix is defined by several dimensions, including permissivity
- Calculation starts when applying a temperature and a pressure differences between 2 points
- The program calculates flow and pressure vectors and their place-to-place evolution during time

The image shows a code editor window displaying the `transportProperties` dictionary for an OpenFOAM simulation. The code defines various physical properties for a multi-phase flow model, including permeability, dynamic viscosity, phase ratios, densities, thermal conductivity, diffusion coefficients, and specific heats for different species (water, nitrogen, CO2, oxygen, and a pollutant). It also sets the gas constant and initial pressure.

```
format      asCll;
class       dictionary;
location    "constant";
object      transportProperties;
}
// ***** //

transportModel Newtonian; // necessaire pour la boucle pimple
nu           [ 0 2 -1 0 0 0 0 ] 1e-05; // necessaire pour la boucle pimple(modele de turbulence en realite desactive dans le
createFields.H)

// [kg m s K kgMol A cd ]
k            k [ 0 2 0 0 0 0 0 ] 1e-10; //perméabilité en m/s
mu          mu [ 1 -1 -1 0 0 0 0 ] 1.8e-05; //viscosité dynamique de la phase gazeuse - ici air sec
eps_l       eps_l [ 0 0 0 0 0 0 0 ] 0.1; //ratio de phase liquide dans le sol
eps_g       eps_g [ 0 0 0 0 0 0 0 ] 0.3; //ratio de phase gazeuse dans le sol

rho_l       rho_l [ 1 -3 0 0 0 0 0 ] 1000; //masse volumique de la phase liquide
rho_P       rho_P [ 1 -3 0 0 0 0 0 ] 1162; //masse volumique de la phase polluante - ici naphtalène
rho_s       rho_s [ 1 -3 0 0 0 0 0 ] 1800; //masse volumique de la phase sol

lambda      lambda [ 1 1 -3 -1 0 0 0 ] 0.8;
D           D [ 0 2 -1 0 0 0 0 ] 1e-6;
Cpg         Cpg [ 0 2 -2 -1 0 0 0 ] 1000;
Cps         Cps [ 0 2 -2 -1 0 0 0 ] 2000;
Cpl         Cpl [ 0 2 -2 -1 0 0 0 ] 2000;

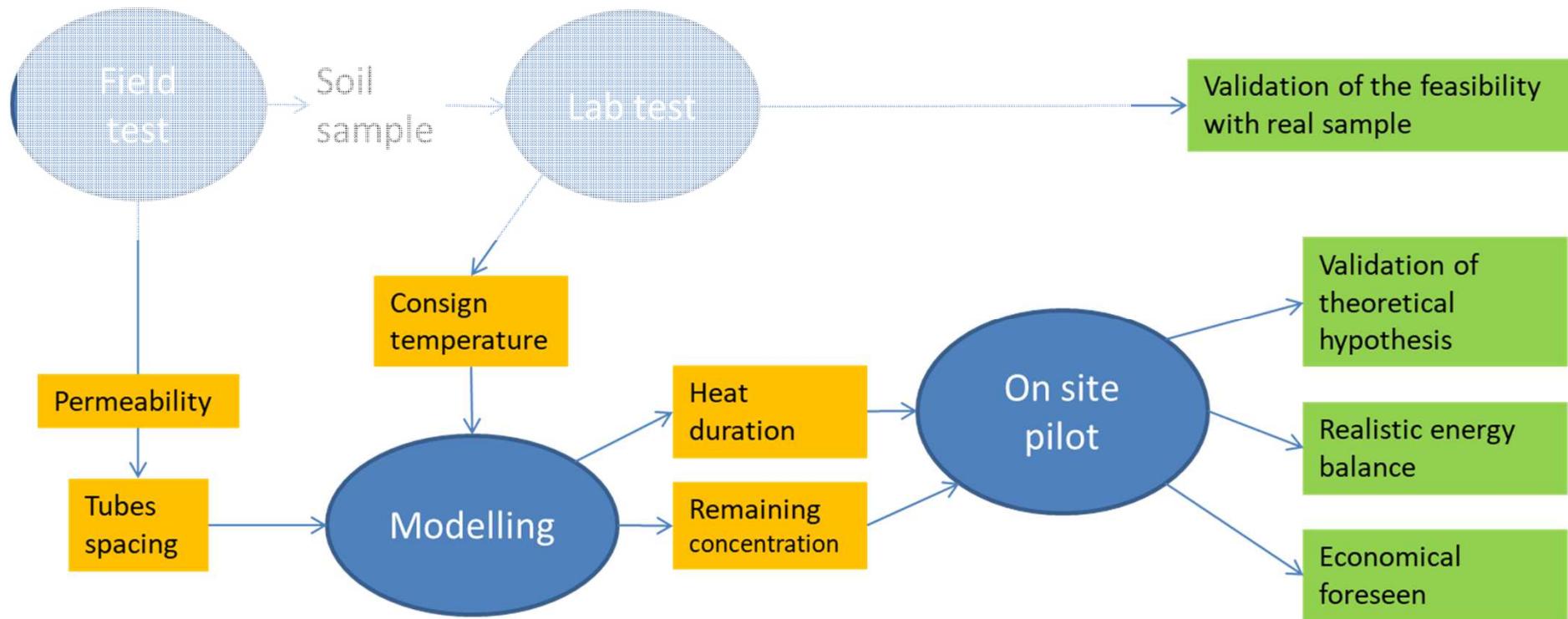
M_h2o       M_h2o [ 1 0 0 0 -1 0 0 ] 18; //masse molaire de l'eau
M_N2        M_N2 [ 1 0 0 0 -1 0 0 ] 28; //masse molaire de l'azote
M_CO2       M_CO2 [ 1 0 0 0 -1 0 0 ] 44; //masse molaire du CO2
M_O2        M_O2 [ 1 0 0 0 -1 0 0 ] 32; //masse molaire de l'oxygène
M_P         M_P [ 1 0 0 0 -1 0 0 ] 128; //masse molaire du polluant - ici naphtalène

R           R [ 1 2 -2 -1 -1 0 0 ] 8314.4621; //Constante gaz parfait
p0          p0 [ 1 -1 -2 0 0 0 0 ] 101325; //pression à l'état 0 en Pa
```

The bottom part of the image shows the ParaView 3.12.0 GUI. The Pipeline Browser on the left shows the simulation setup. The main window displays a 3D visualization of the flow field with a color scale for temperature (T) ranging from 292.8411 to 393. The Object Inspector at the bottom shows the selected variable `arc_length` and its visualization settings. A 2D plot in the bottom right corner shows the evolution of temperature (T), velocity (U), and pressure (p) over time, with the x-axis representing time from 0 to 2 and the y-axis representing the variable values from -1000 to 1000.

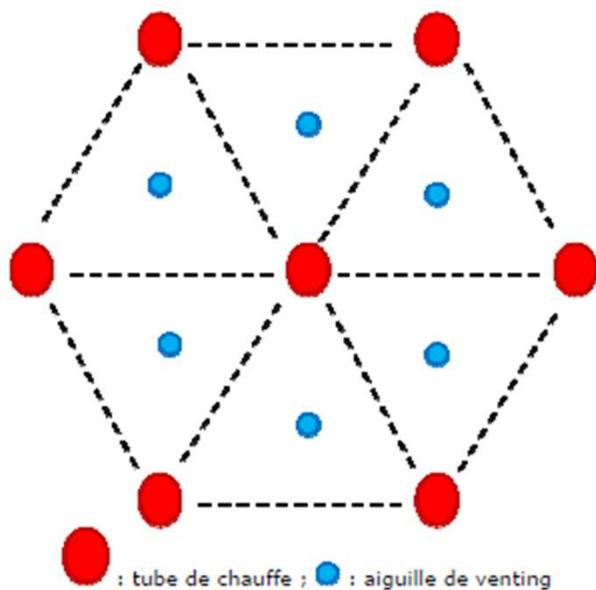


# PILOT PHASE





## PILOT PHASE





## PILOT PHASE



→ validation of choice



## FULL SCALE – VALGO'S OFFER

- Optimize each step of the process
  - **Heating**
  - **Gases collection**
  - **Cooling**
  - **Implementation & treatment**



# HEATING

- Calculate the total amount of energy to provide

## PRE DIMENSIONNEMENT TRAITEMENT EN PILE RECHAUFFEURS ELECTRIQUES

Renseigner les cellules en jaune  
Résultats dans les cellules en vert

Données d'entrée	
Pression de humidité	21 °C
T° ambiante	28 °C
Poids spécifique l'eau	1000 kg/m³
Valeur de l'eau	1000 m³
della T° l'eau entre T° ambiante et objectif (°C)	38 °C
Travaux de poids total (JH)	2200 JH
Palier 3 la longueur de la pile	70 s
Palier de la pile des l'eau	407 m³

Résultats de dimensionnement	
nombre de chauffeuses nécessaires	990 n
Palier de la pile des l'eau	407 m³

PRESENTATION RESULTATS POUR MEMOIRE TECHNIQUE		
Paramètre	Valeur	Unité
Chaleur spécifique de l'eau	4	KJ/Kg°C
Pression de humidité	21	°C
T° ambiante	28	°C
Valeur de l'eau	1000	m³
Poids spécifique l'eau	1000	kg/m³
Poids de l'eau	2200000	kg
Poids de l'eau	2200000	kg
Chaleur spécifique de l'eau	4	KJ/Kg
Rendement de la chauffe	95	%
Différence	38	°C
Perte d'air chaud	1	°C
Travaux de poids total	2200	JH
Chaleur nécessaire à la chauffe à T°	110000000	kJ
Chaleur nécessaire à la superchauffe de l'eau	182000000	kJ
Chaleur totale	745875	kJ/h
Travaux de chauffe	2200	s
Palier de l'eau	407	m³
Palier de la pile	407	m³

Géométrie pile	
Longueur l	24,00 m
Longueur de la face des chauffeuses	37,00 m
Perte des l'eau de la pile (JH/°C par m²)	
W	1,0
V	1,0
Métrage pile	
Nombre pile	1,00
Epaisseur de l'eau de chauffeuses	8,00
Epaisseur des l'eau	1,00

**Zone de calcul**

Données rendement et efficacité	
Chaleur spécifique de l'eau	2257 KJ/Kg
Chaleur spécifique de l'eau	4 KJ/Kg°C
Chaleur spécifique de l'eau	4,18 KJ/Kg°C
Rendement de la chauffe	95%
Perte d'air chaud	1%
Différence	38°C

Calcul énergétique	
poids total	2200000 kg
poids l'eau	2200000 kg
Chaleur nécessaire à la chauffe l'eau	110000000 kJ
poids de l'eau	2200000 kg
Chaleur nécessaire à la chauffe de l'eau	182000000 kJ
Chaleur nécessaire à la superchauffe	182000000 kJ
Chaleur totale	745875 kJ/h
Palier de l'eau	407 m³
Palier de la pile	407 m³

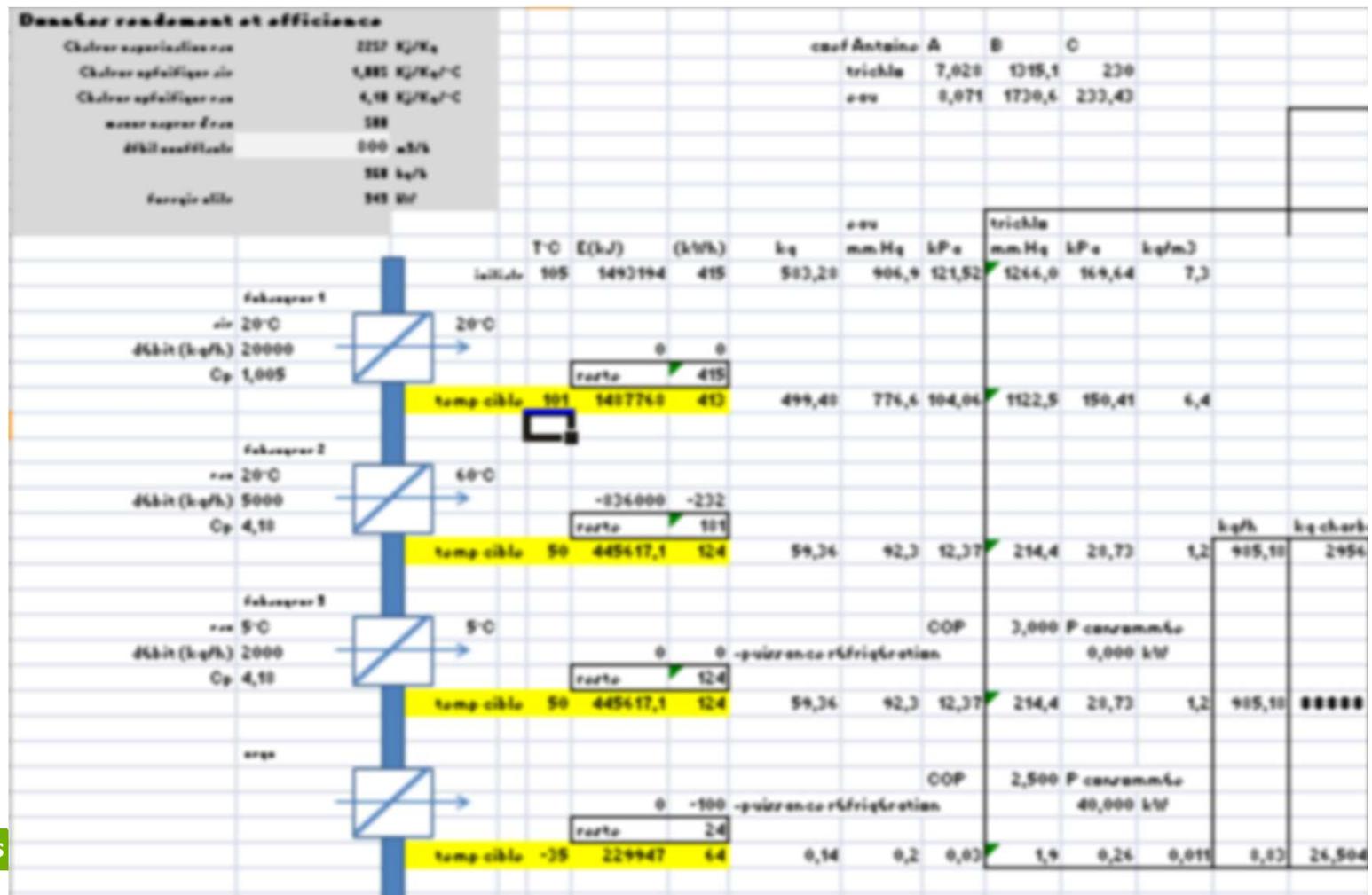
  

Section type d'une pile



# COLLECTING GASES

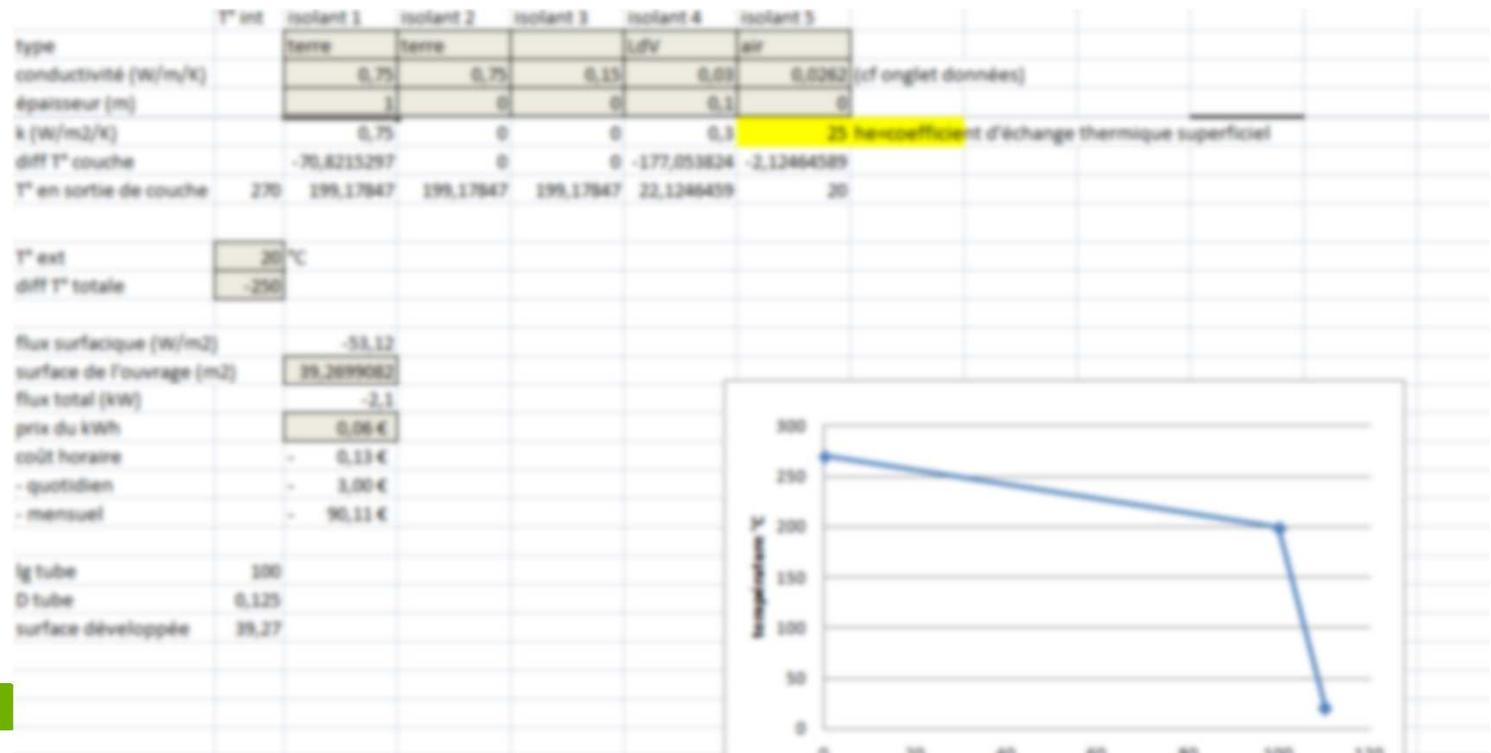
- Similar to "classical" venting but with heat resistant materials (steel, stainless steel, suited piping...)
- + cooling exchangers





# IMPLEMENTATION

- Building pile or in-situ?
  - pile: classical leveling engines
  - in-situ → needs drilling works
- Insulating → hunting losses, spare money
  - Depending of implementation, several solutions are available: rockwool panels, cellular concrete, clean earth





## CASE STUDY

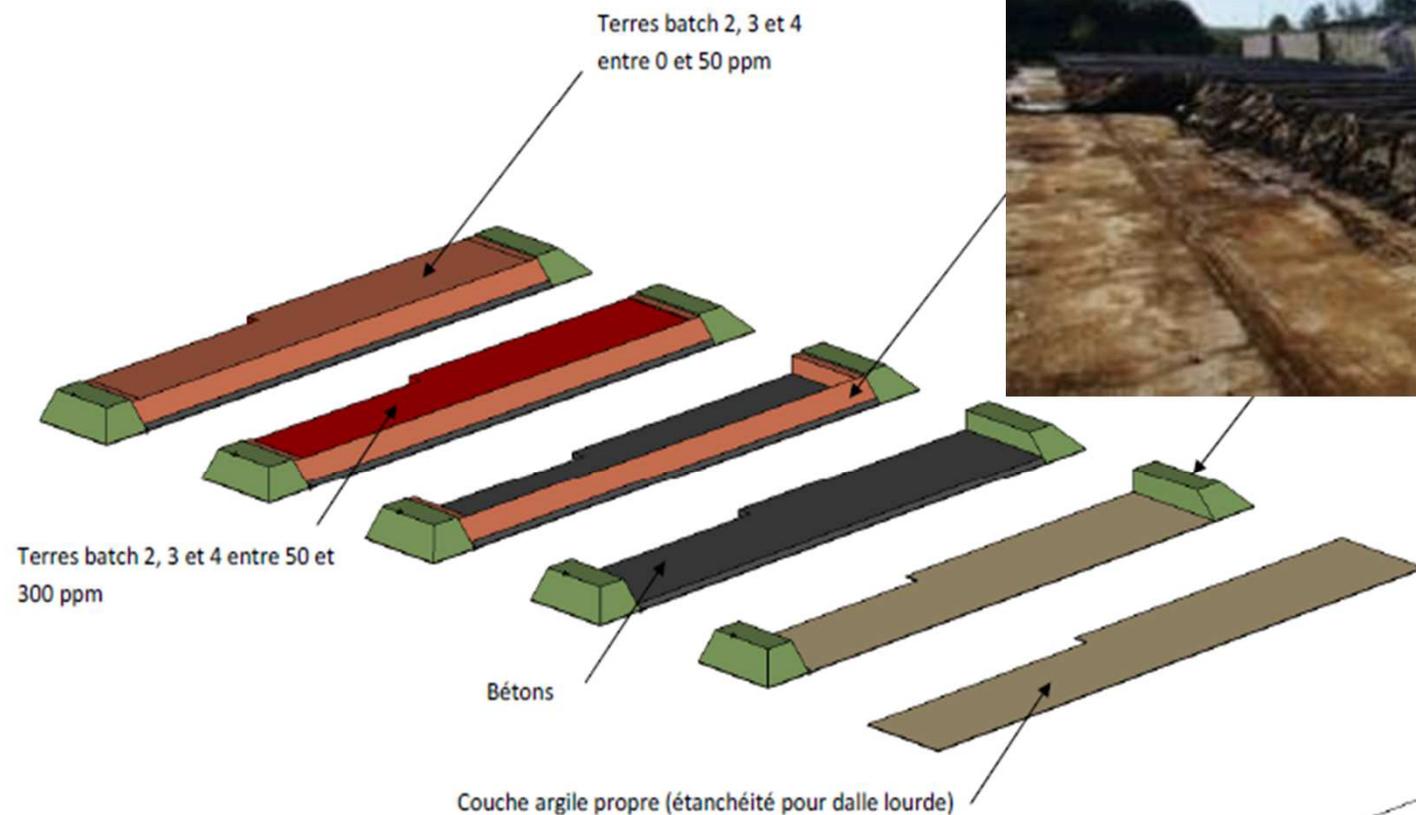
- Aluminium industry – Southwestern France
  - Electrical station → PCB spillage on the floor
  - Reported amounts between 20 and 200ppm.
  - About 3000m<sup>3</sup> of polluted soils to be treated





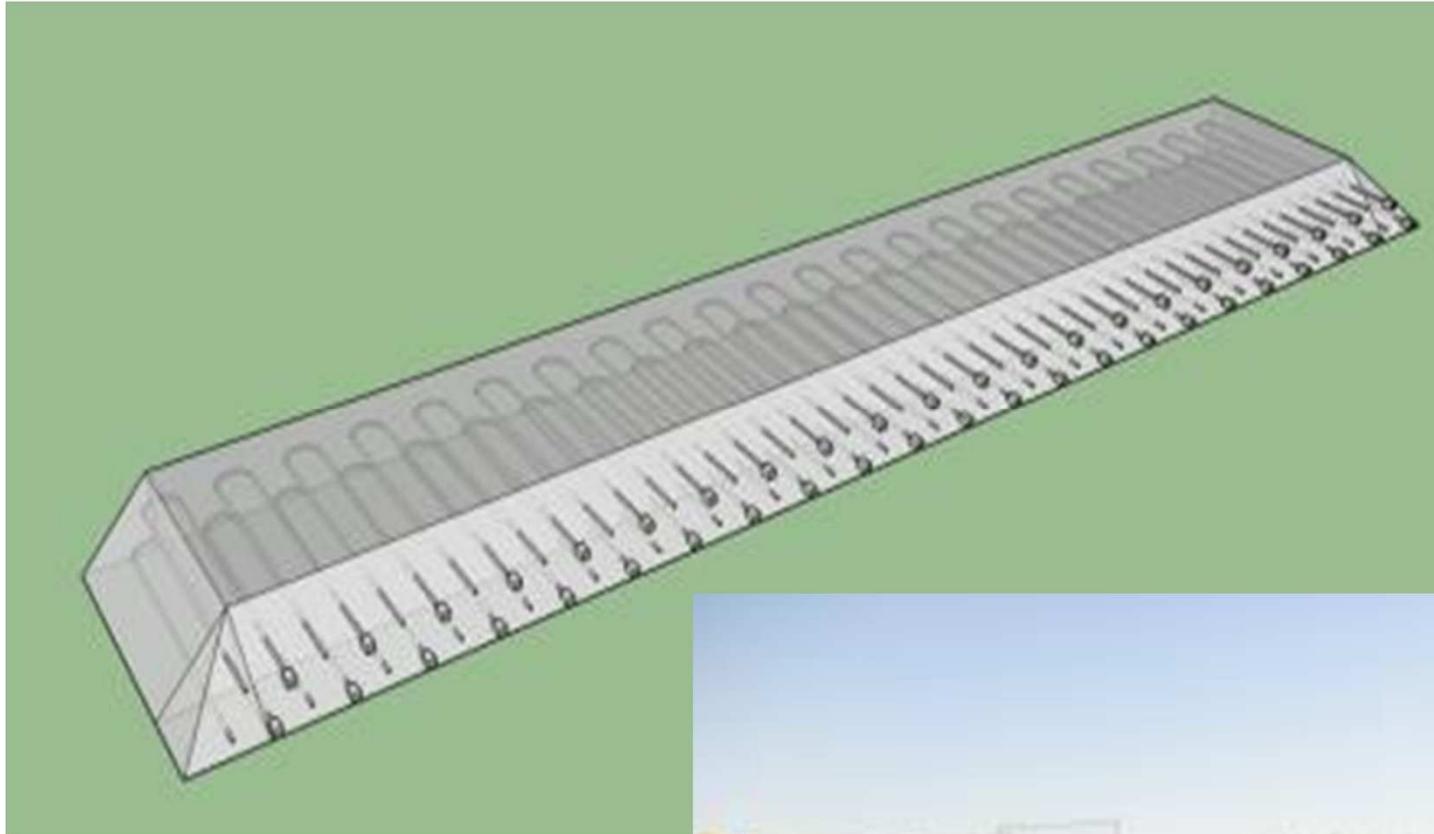
## CASE STUDY: implementation

Optimizing parameters  
→ Led to pile building



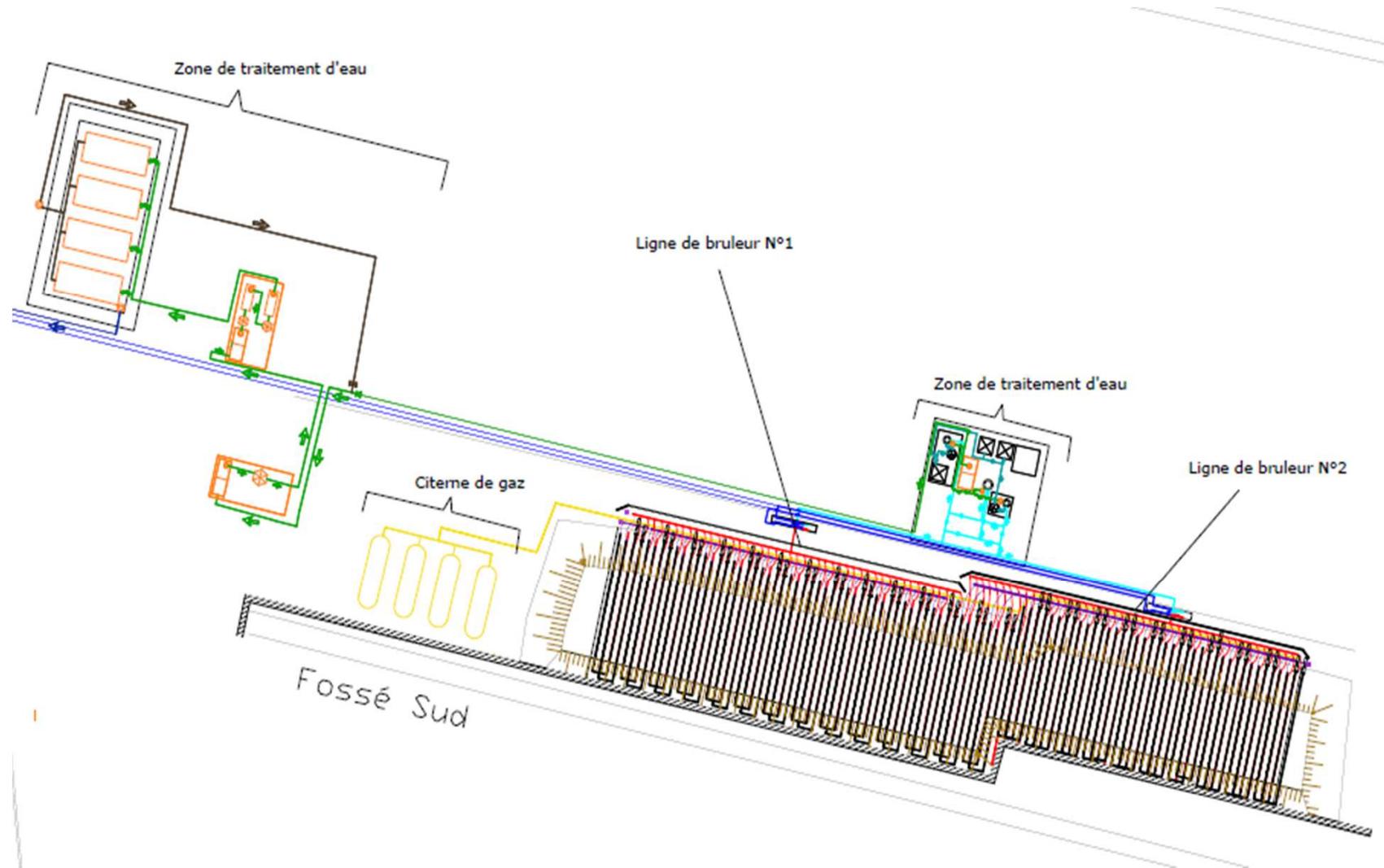


## CASE STUDY: heating



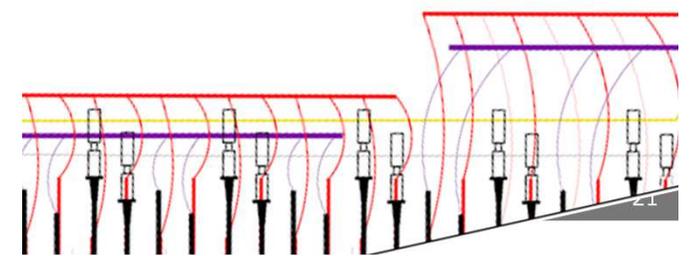
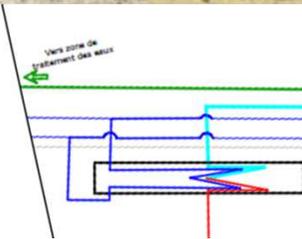
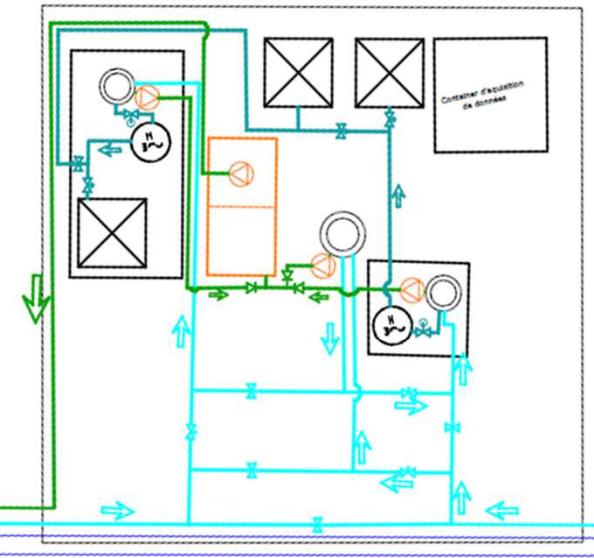


# CASE STUDY: whole plant



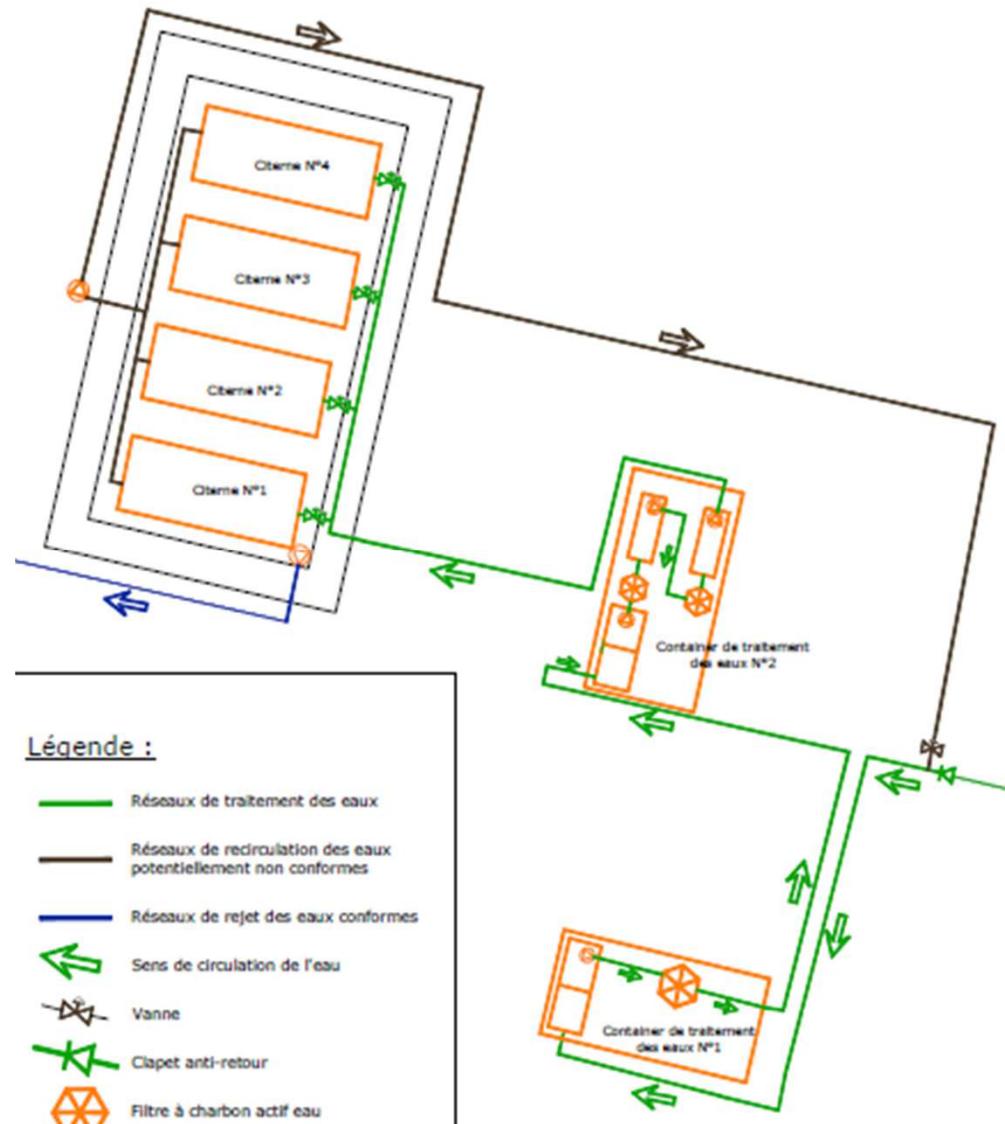


# EXTRACTION & TREATMENT OF VAPORS





# TREATING CONDENSATES





## STORAGE FOR CONDENSATES





## VERY INDUSTRIAL IMPLEMENTATION

- 47 heating tubes and burners.
- 94 Venting tubes
- 4 electrical panels
- 4 propane tanks
- 2 condensation skids
- 2 water and air treatment units
- monitoring unit + data acquirement



## VERY INDUSTRIAL IMPLEMENTATION





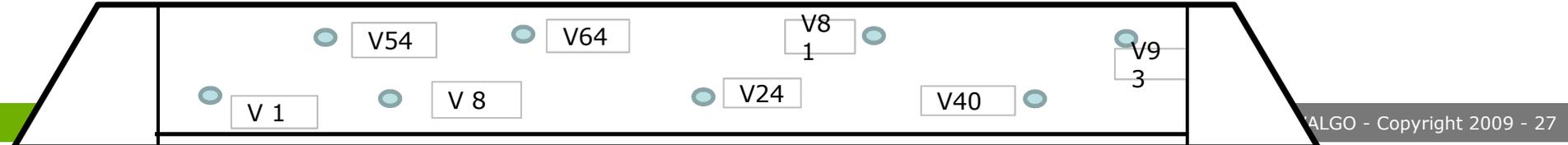
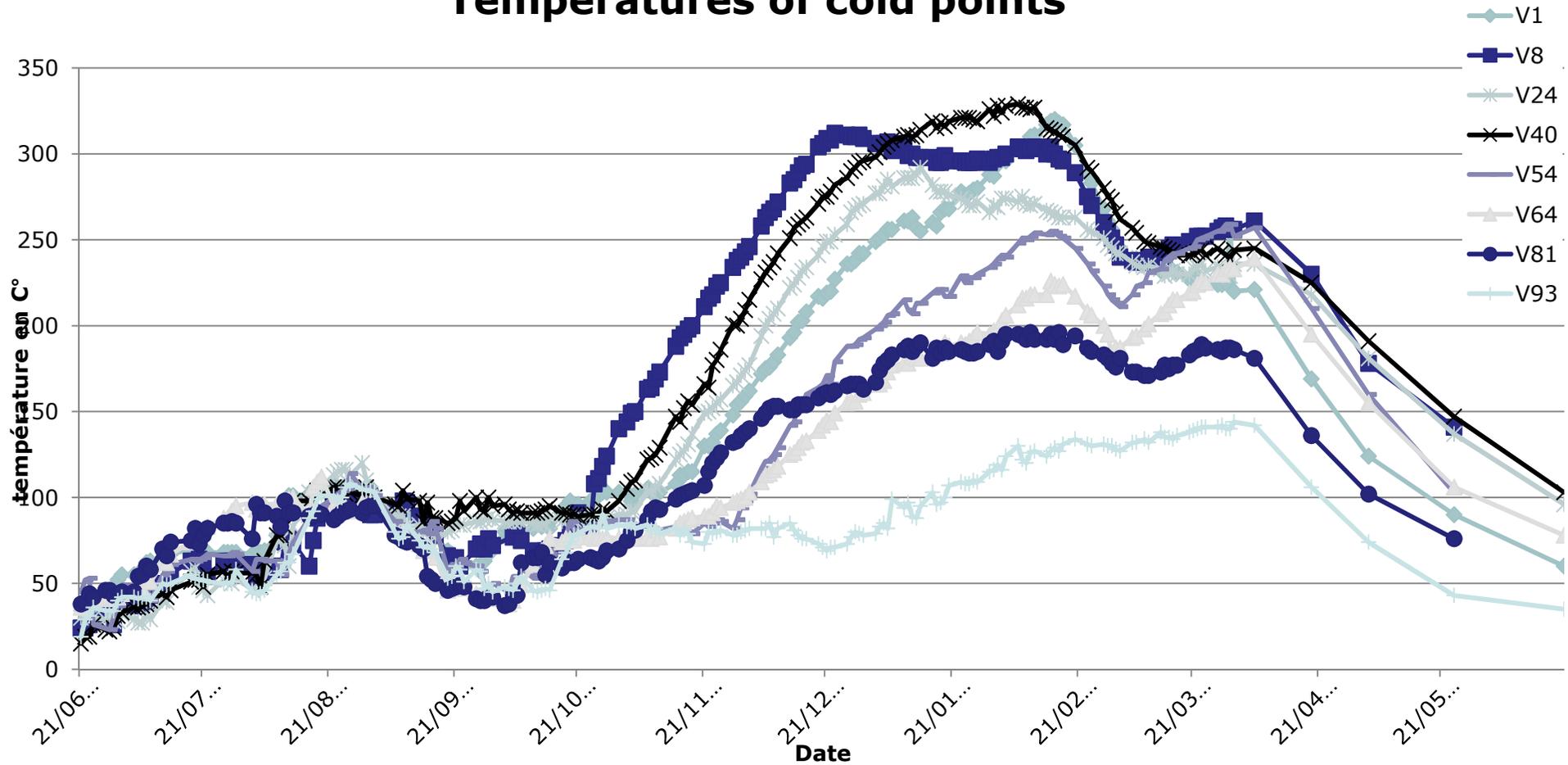
## SURVEY PROTOCOL

- Temperature
  - T° <200°C : light survey
  - T° >200°C : heavy survey
- Full survey of emissions: PCBs, HCl, (H)VOCs, Dioxins & Furanes
- combustion Exhausts : unburned compounds, CO, SO<sub>2</sub>, Nox
- Automated security management with GSM reports



# TEMPERATURE SURVEY

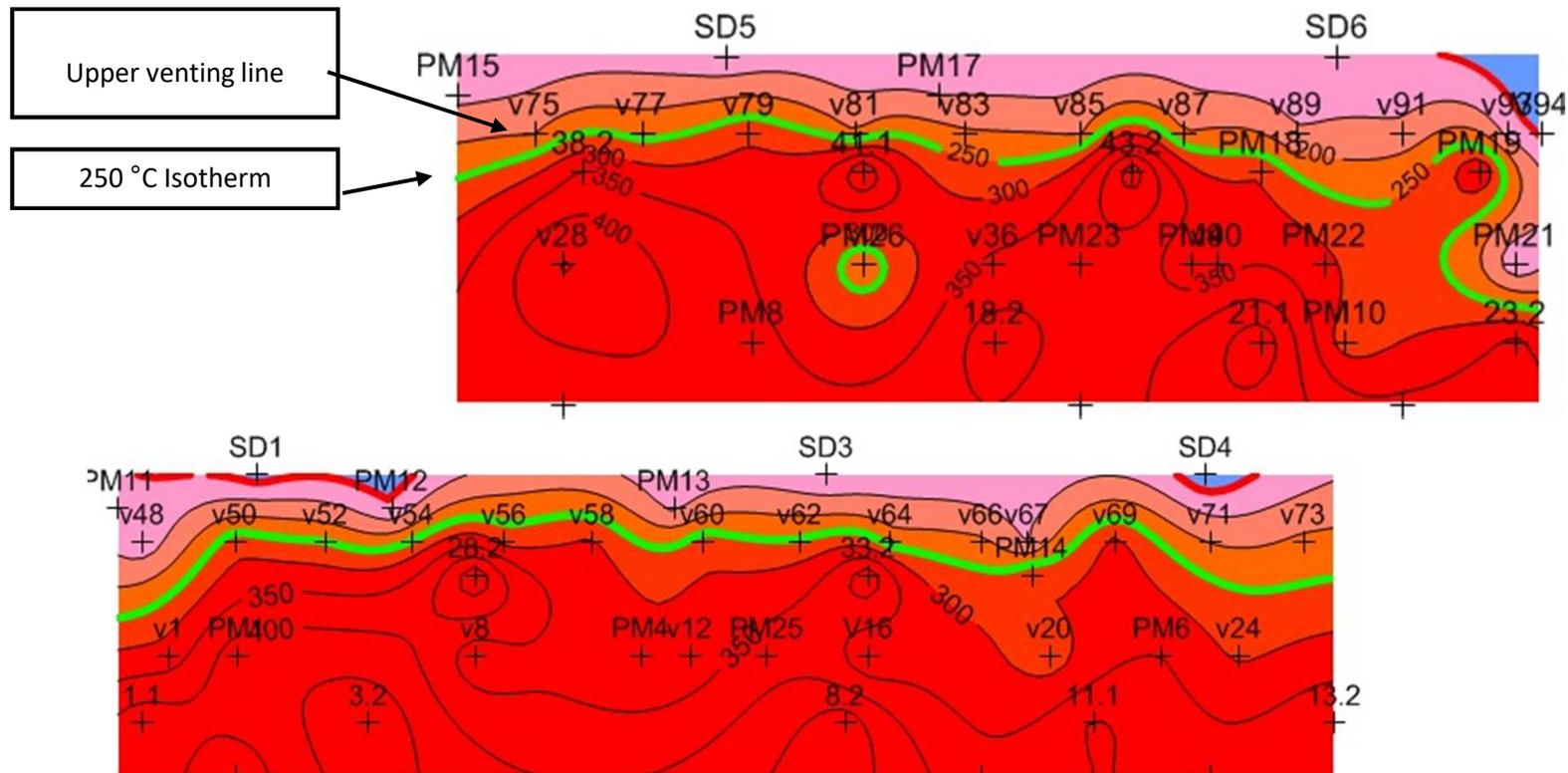
## Temperatures of cold points





# TEMPERATURE MAPPING

- Results





## ANALYTICAL RESULTS

### Final analysis

Maille	L2-1	L2-2	L2-3	L2-4	L1-1	L1-2	L1-3	L1-4
[PCB] mg/Kg	3,10	8,78	2,31	2,76	1,79	0,84	2,25	5,10

For a 10 mg/kg threshold

+ no impact in environment



## MERCI DE VOTRE ATTENTION



VALGO – Laboratoire  
72, bd A. Briand  
76650 PETIT COURONNE

Contact :

[laurent.thannberger@valgo.com](mailto:laurent.thannberger@valgo.com)

VALGO – Sud-Ouest  
2, av Gutenberg  
31120 PORTET sur Garonne

Contact :

[amine.haouara@valgo.com](mailto:amine.haouara@valgo.com)