

## CASE STUDY

# ISTD remediation in clay till

Odense, Denmark

# KRÜGER



### Key facts

Contaminant:	PCE
Recovered mass of PCE:	3,500 kg
Treatment area:	222 m <sup>2</sup>
Treatment volume:	1330 m <sup>3</sup>
Depth of treatment zone:	10 m
Geology:	Glacial till
Location:	Dry cleaning facility in operation



### ISTD remediation Odense

## Challenge

Dense non-aqueous phase liquids (DNAPL) of Tetrachloroethylene (PCE) had migrated through 11 m of clay till into a sandy groundwater aquifer. The aquifer is confined by the low-permeable clay till layer and is remarkably high-yielding.

The contamination was situated beneath a dry cleaning facility in which activities had to remain in operation throughout the whole remediation period. The project addressed numerous complexities, including execution in very tight spaces as well as close proximity to urban infrastructure such as gas, sewer and electrical lines.

Calculations had shown that end concentrations of maximum 5 mg PCE/kg were required in order to eliminate the risk for the well field of local municipal water supply.

Since the dry-cleaner building was covering the whole treatment area a large number of level measurements were made in order to document subsidence if any.

## Solution

Besides excavation, heating was considered the only realistic process to effectively reduce the contamination in the tight clay. Moreover a thermal solution was favored in the saturated zone.

Combining two thermal remediation technologies in this project was the optimal way to achieve complete source-zone cleanup of both the clay, using ISTD, and the sandy aquifer, using steam-enhanced extraction (SEE). The groundwater flow in the aquifer was controlled by pumping throughout the project.



45 heater wells were installed in the clay to 10 meters depth. At each heater well an extraction screen was installed to 5 m depth in order to capture the high concentration vapors immediately.

The power was turned on in June 2008 with an estimated treatment period of 175 days and a target temperature of 100 °C.

### For further information:

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CASE STUDY

**ISTD remediation  
in clay till**  
Odense, Denmark

**KRÜGER**



**Key facts**

Number of heater wells: 45

Target temperature: 100 °C

Remediation target: 5 mg/kg TS

Heating period: 105 days

Process: ISTD combined with steam injection

Avg. end concentration: 0.51 mg/kg PCE

Client: Region Denmark South

Consultant: NIRAS

Contractor: Arkil Miljø

Subcontractor: Krüger A/S (ISTD)

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**Results**

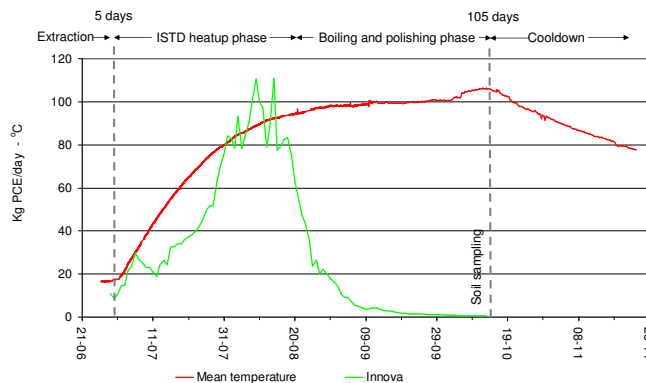
After a treatment period of 105 days 14 soil samples were taken in different depths from 5 borings within the treatment area.

All the soil samples showed concentrations below the remediation target of 5 mg/kg.

- 5 samples were below detection limit
- Average concentration: 0.51 mg/kg PCE
- Maximum concentration: 4.4 mg/kg PCE

3,500 kg of chlorinated solvents were recovered from the clay till layer while 500 kg were removed from the sandy aquifer. Recovery rate then exceeds 99% in both sand and clay layer.

No soil subsidence occurred as a consequence of the heating.



**Energy balance**

Volume, total	1.330 m <sup>3</sup>
Power Input	450 kW
Total Energy *	637.610 kWh
Total Energy/m <sup>3</sup>	479 kWh/m <sup>3</sup>
Energy Extracted	475.589 kWh
Average Temperature within TTZ	102 °C

\*ISTD input only

**PCE in soil samples (mg/kg)**

Boring	Before	After
GJ1	2000	1,1
	DNAPL	0,014
	13000	-
	2200	0,34
	1100	-
	DNAPL	4,4
GJ2	-	<0,005
	-	<0,005
	-	<0,033
	-	<0,005
GJ3	100	0,44
GJ4	160	0,055
GJ5	-	<0,005
	-	<0,005
	450	<0,005
	-	<0,005

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