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Source Zone Remediation with innovative Technologies

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Geologist & Head of Department

950 employees
250 Environmental specialists

NIRÁS Source zone & plumes

- > 95 - 99 % of the total mass
- Relatively small volume
- High soil concentrations
- Mobile free phase and/or residual droplets
- Dissolved concentrations > 1 % of solubility
- Altered redox conditions

Source zone
Volatile/semi-volatile contaminants: Oil products, chlorinated solvents etc.

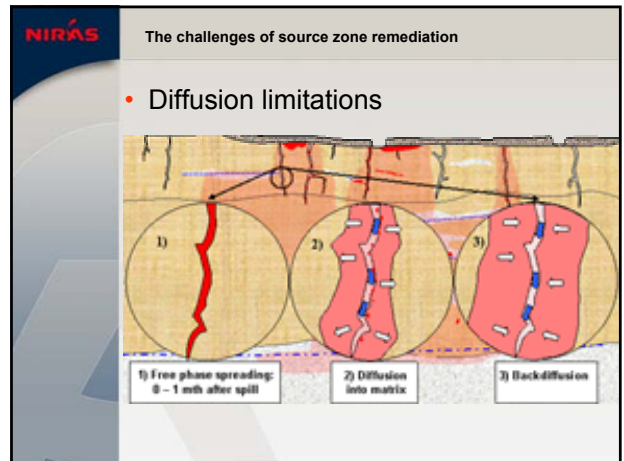
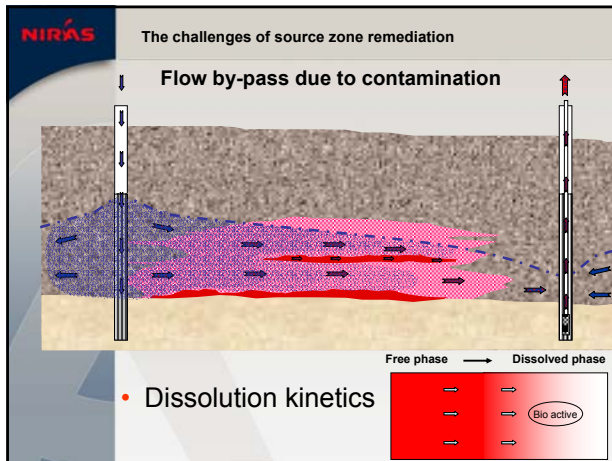
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4 major challenges in the source zone !!!

NIRÁS The challenges of source zone remediation

- Very large reductions wanted/needed

Typical dry cleaner with PCE	
Pre-remedy	Remedial goal (MCL)
10.000 µg/l	1 µg/l
- Variations in permeability/2-phase flow

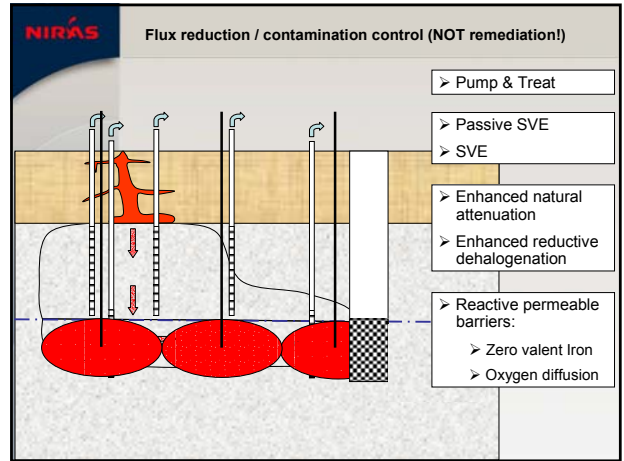
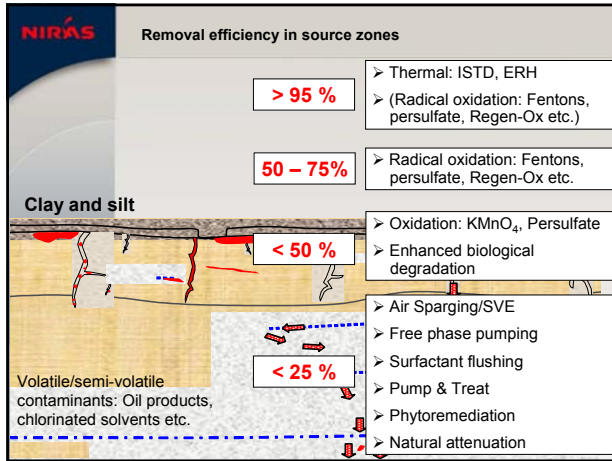


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What can the technologies achieve in real life?

NIRÁS Removal efficiency in source zones

<p>Homogeneous sandy soil</p> <p>Sand</p> <p>Volatile/semi-volatile contaminants: Oil products, chlorinated solvents etc.</p>	> 95 %	<ul style="list-style-type: none"> ➢ Thermal: Steam, ISTD, ERH ➢ Radical oxidation: Fentons, persulfate, Regen-Ox ➢ (Oxidation: KMnO_4/Persulfate)
	50 - 75 %	<ul style="list-style-type: none"> ➢ Oxidation: KMnO_4, Persulfate, ozone, H_2O_2 ➢ (Enhanced biological degradation) ➢ (Air Sparging/SVE)
	< 50 %	<ul style="list-style-type: none"> ➢ (Enhanced biological degradation) ➢ Air Sparging/SVE ➢ Free phase pumping ➢ Surfactant flushing
	< 25 %	<ul style="list-style-type: none"> ➢ Pump & Treat



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Case:

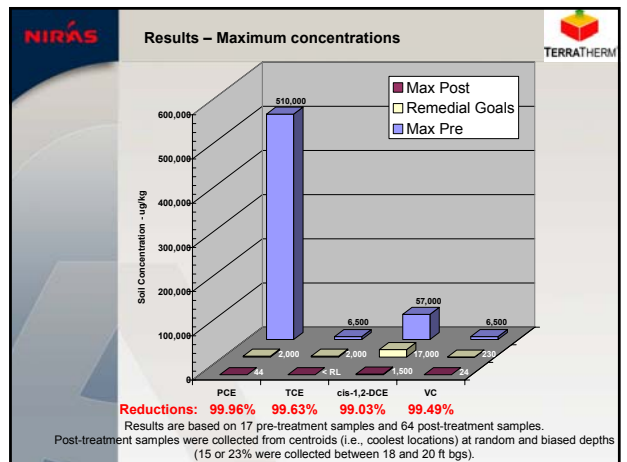
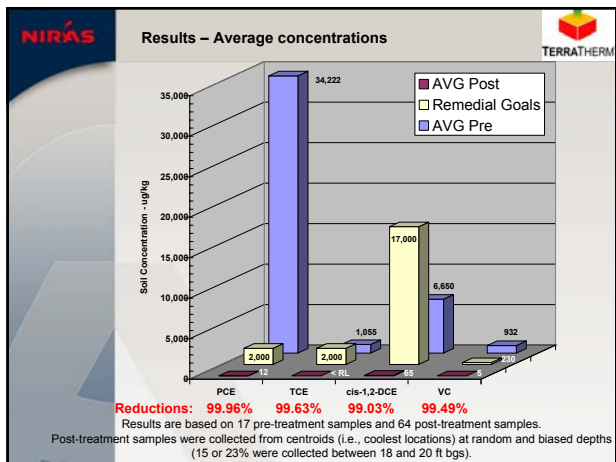
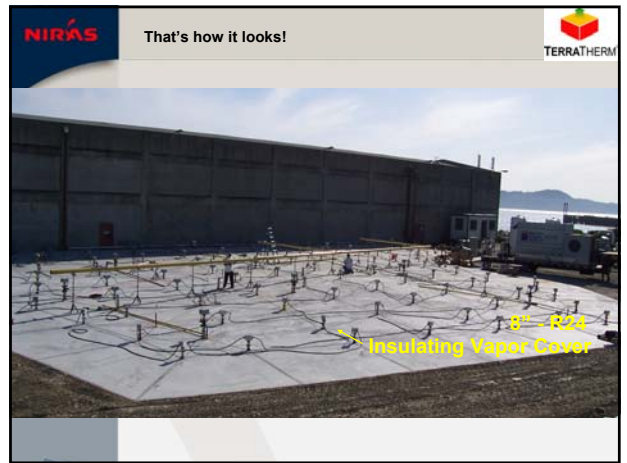
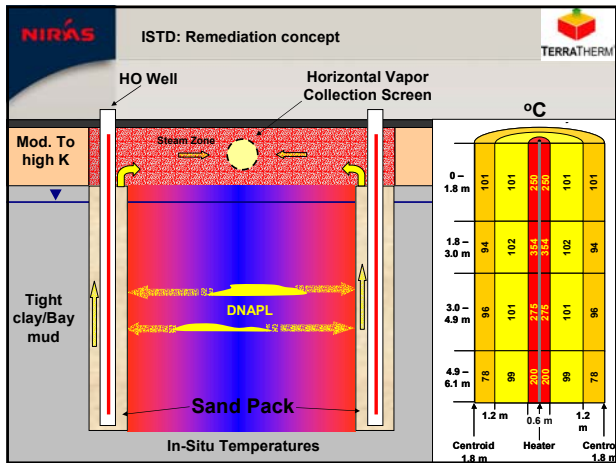
In Situ Thermal Desorption

Chlorinated Solvents from a former Tank farm

NIRÁS In Situ Thermal Desorption

The complex block features a map of the San Francisco Bay Area with a red circle highlighting the 'SITE' location. An aerial photograph shows the site's layout, including a 'Ferry Ramp', 'Harbor Club', 'Harbor Club Inn', 'Harbor Club', 'Harbor Club', 'Harbor Club', and 'Harbor Club'. A photograph of a sunset over the water is also included.

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Project completed on time and on budget

- Performance guaranteed
- Remedial goals achieved

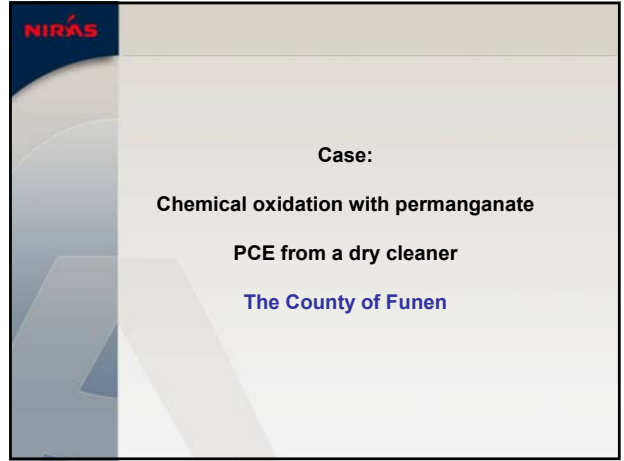
Improved approach verified

8 months for construction and treatment

Total TT project cost: ~\$1.7M, ~ 7.000 yd³

Cost of power: \$350K (\$0.16 per kW-hr!!)

Post-development value: ~\$300M



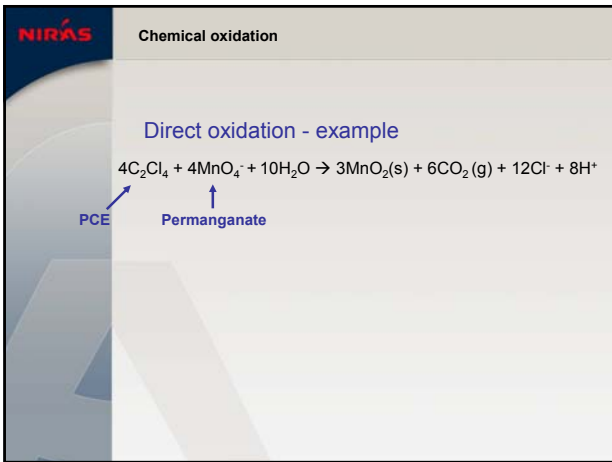
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Case:

Chemical oxidation with permanganate

PCE from a dry cleaner

The County of Funen



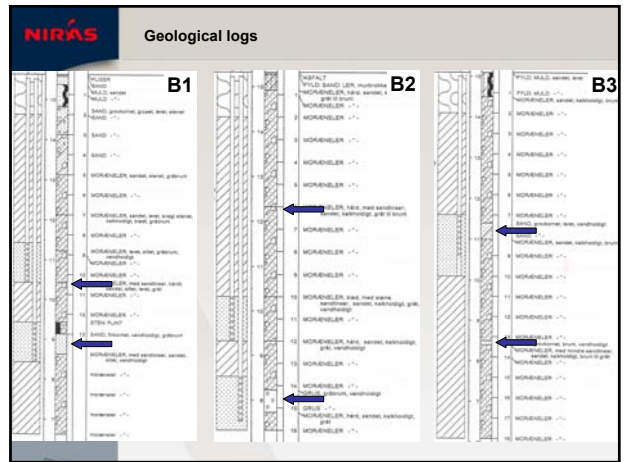
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Chemical oxidation

Direct oxidation - example

$$4\text{C}_2\text{Cl}_4 + 4\text{MnO}_4^- + 10\text{H}_2\text{O} \rightarrow 3\text{MnO}_2(\text{s}) + 6\text{CO}_2(\text{g}) + 12\text{Cl}^- + 8\text{H}^+$$

PCE \uparrow Permanganate



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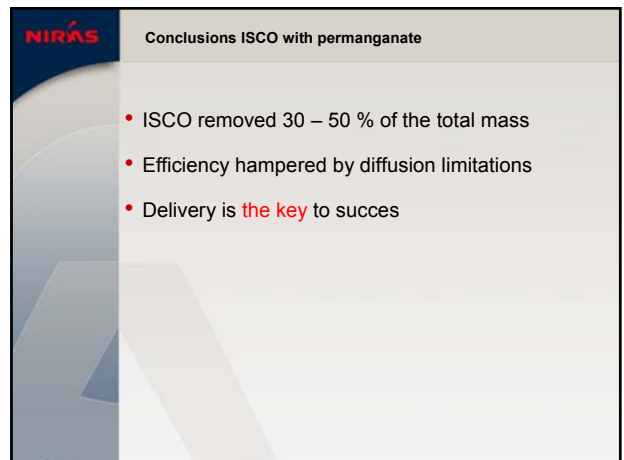
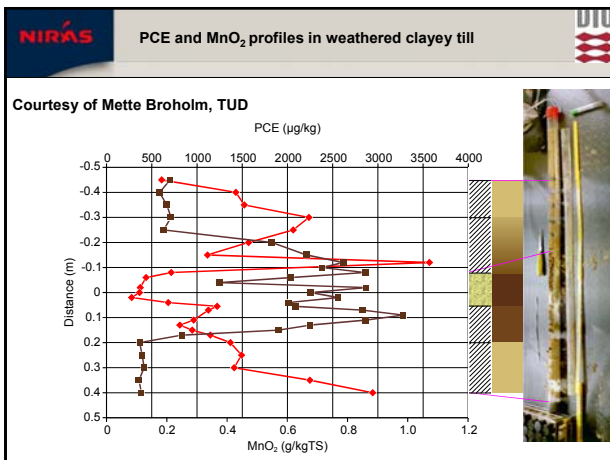
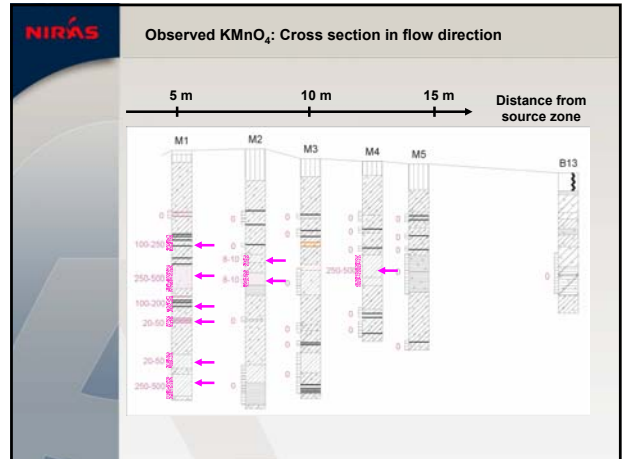
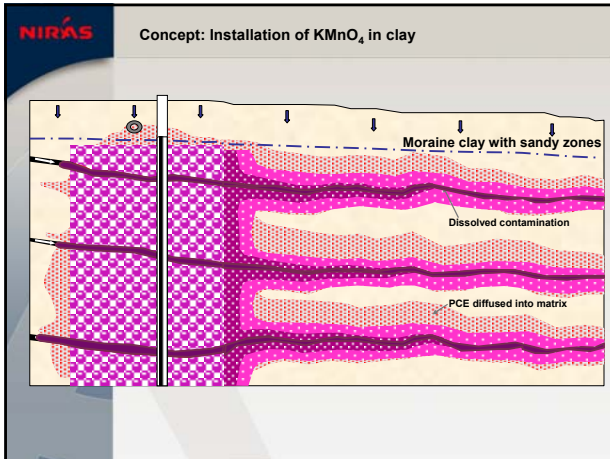
Geological logs

B1

B2

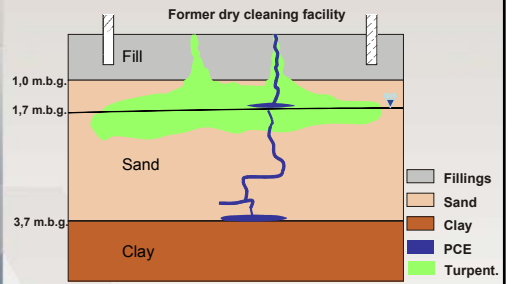
B3

Geological logs showing stratigraphic columns B1, B2, and B3 with various soil and rock layers and depth markers.



Case:
Steam Enhanced Extraction
PCE and Stoddard Solvent from a former dry cleaner
The County of Northern Jutland

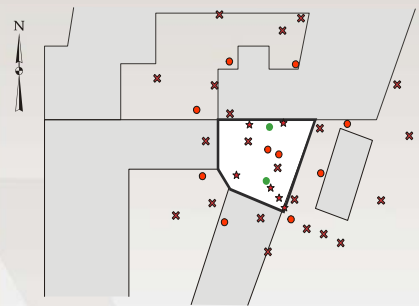
Contaminant distribution

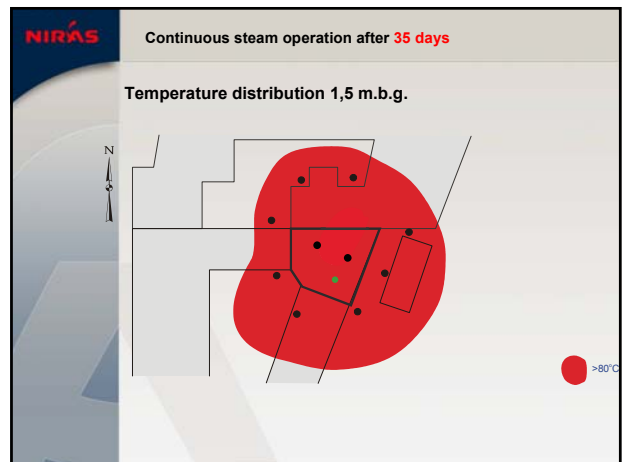
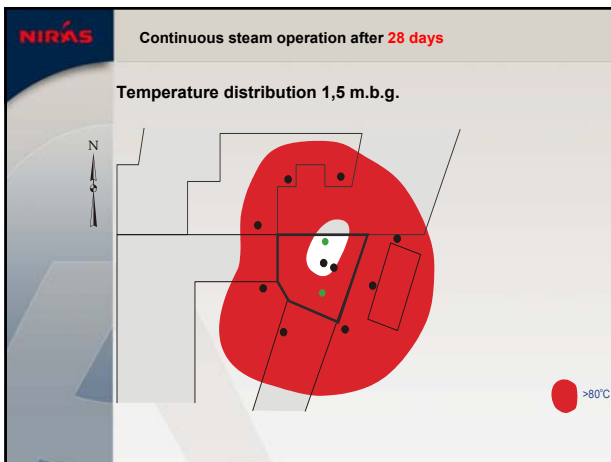
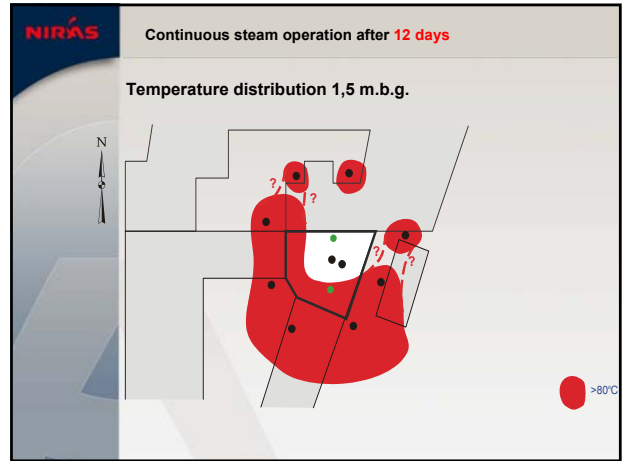
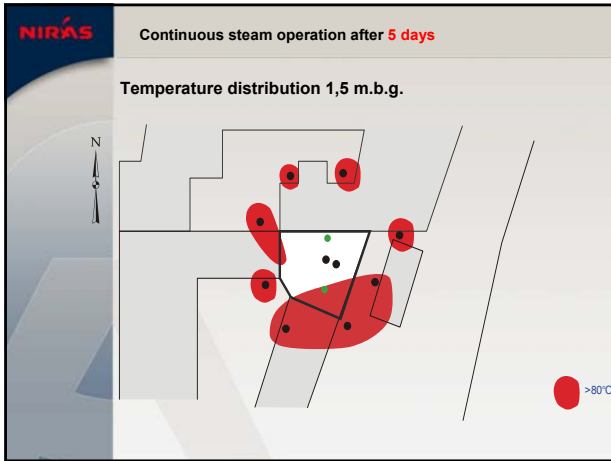


Site and treatment wells



Temperature monitoring points





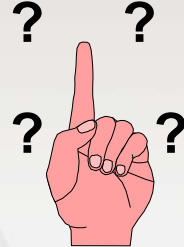
Results

- Extracted 900 - 1.000 kg PCE og turpentine
- Remaining contamination: Less than 5 - 8 kg

When ?		Groundwater µ g/l	Soil Vapor mg/m ³	Soil mg/kg
Before remediation	Max	Free phase	~2.500	Free phase
After remediation		0 - 62	0 - 600	0,04 - 37
Clean-up Efficiency		98 - 99		98 - 99

- Remediation goal satisfied
- Total costs ~ appr. dkr. 2,7 mill.

Thank you and:



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