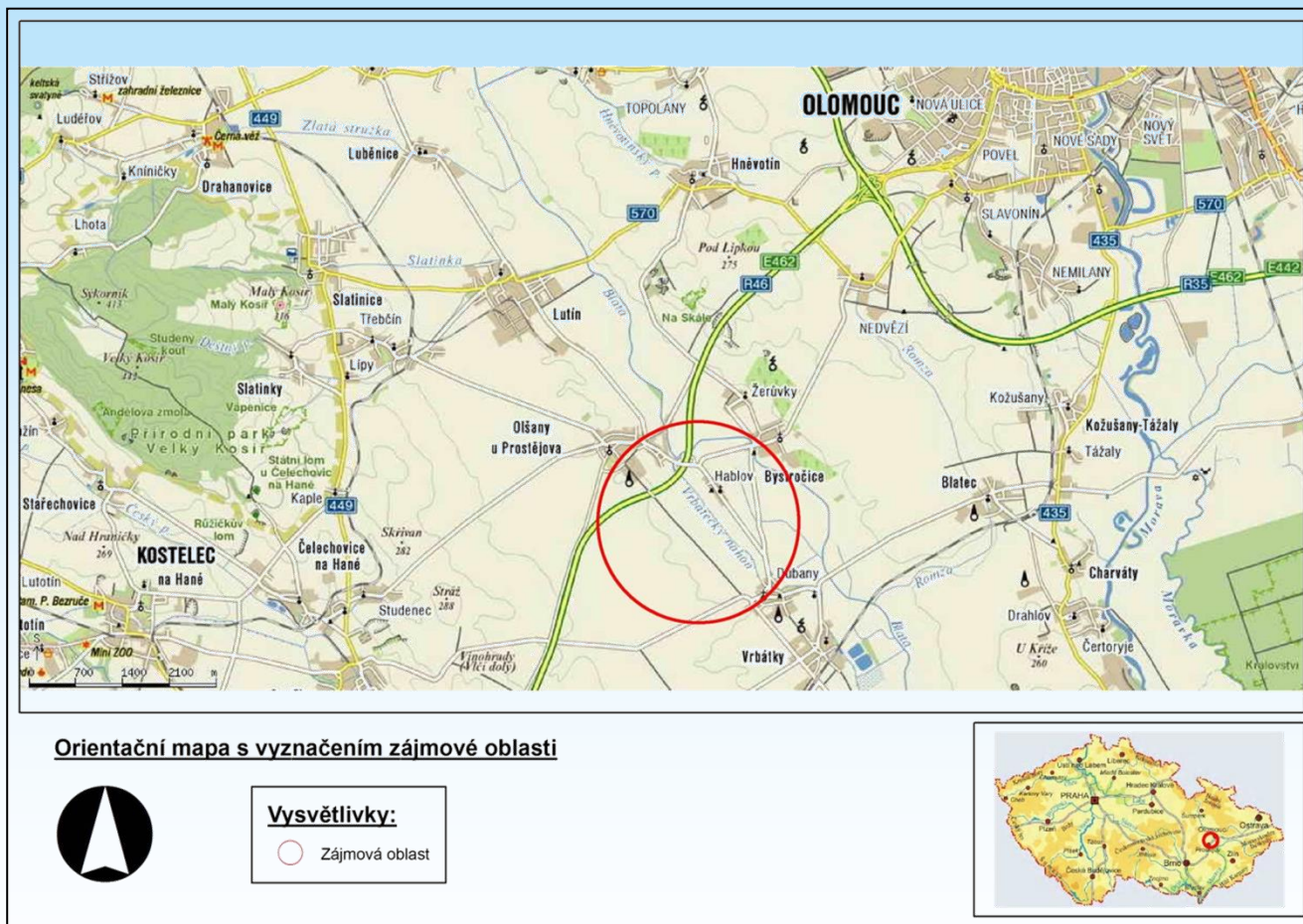


REMEDIACTION FEASIBILITY STUDY OF A FLOODPLAIN OF MORAVA RIVER IN CZECH REPUBLIC CONTAMINATED BY CHLORINATED ETHENES



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History of locality



Source:

activities in former company SIGMA Lutín a.s.
(their main products were water pumps)

Contamination:

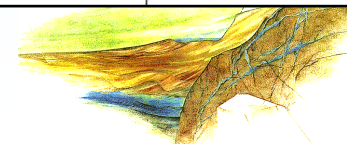
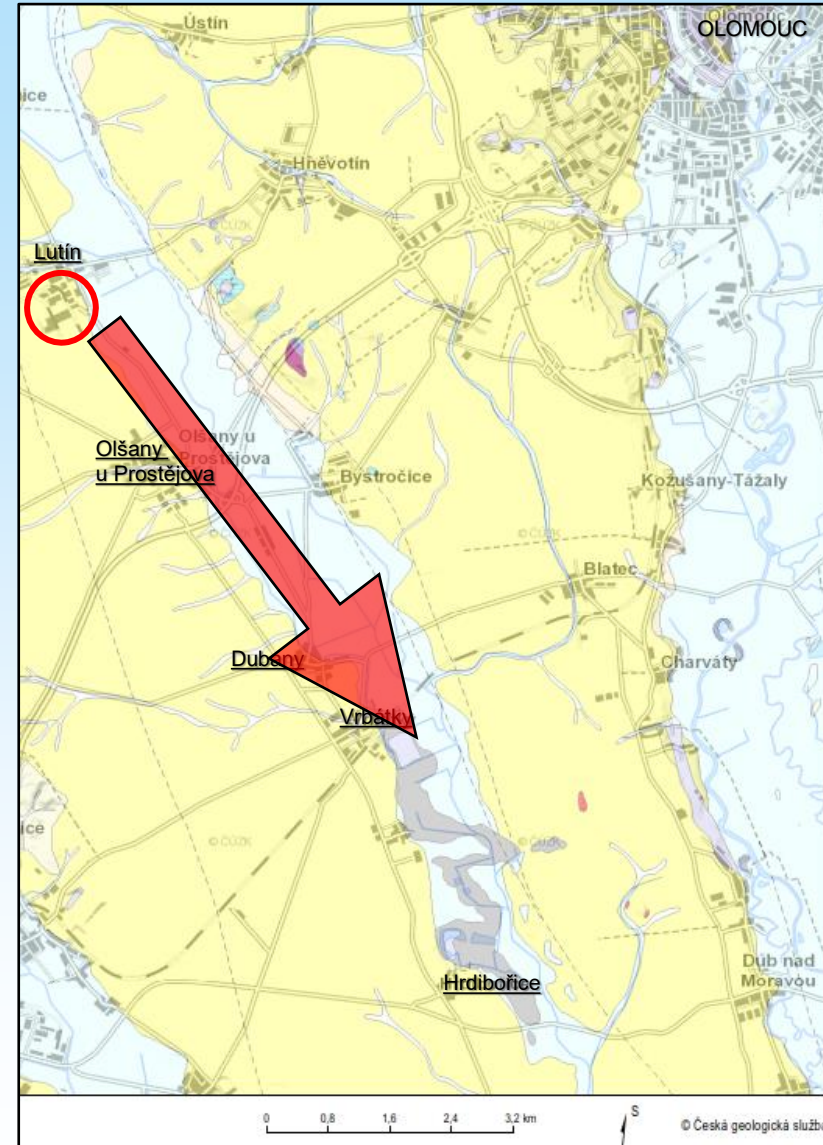
chlorinated aliphatic hydrocarbons
(they were used as degreasers)

Affected area:

unsaturated and saturated zone
(in the company premises and its immediate surroundings)

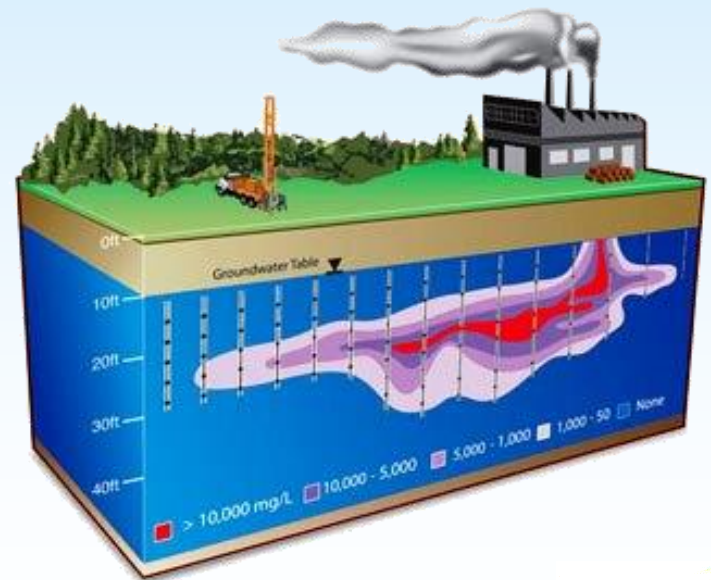
Solutions:

remediation actions only in ambient area of the source (1997 – 2006)

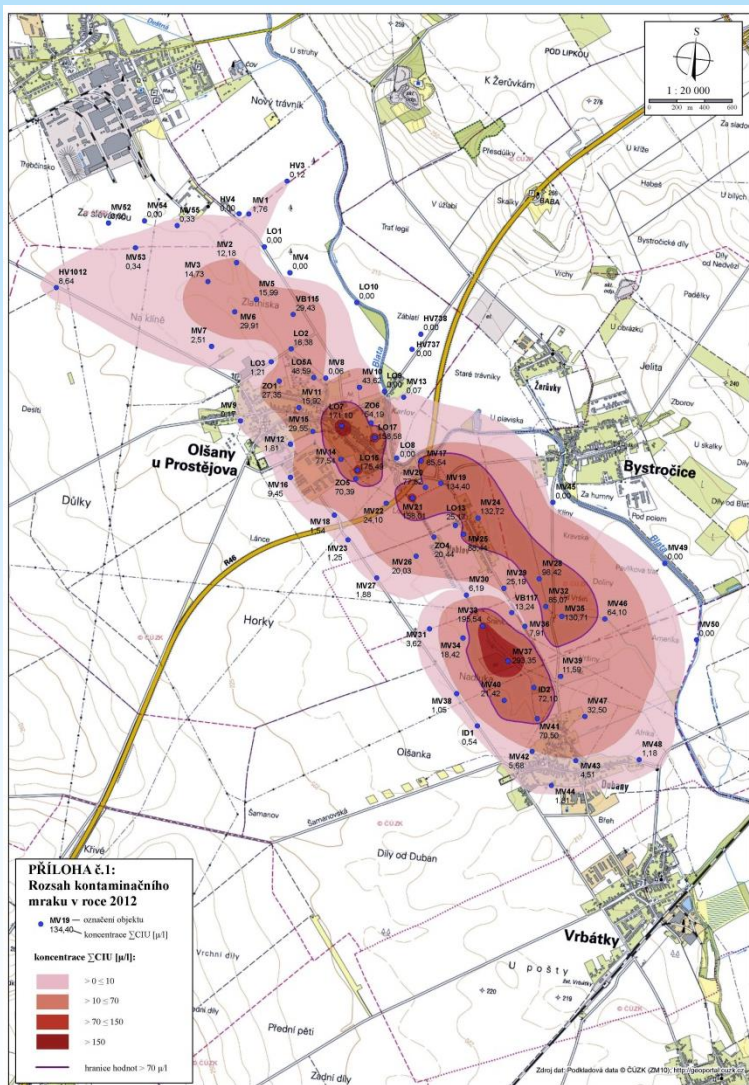


Additional geological investigation

- **2008** (ALTEC International s.r.o.): „AR update“
- **2010 – 2012** (DEKONTA, a.s.) : supplementary survey and verification of suitable remedial technologies



Situation in 2012



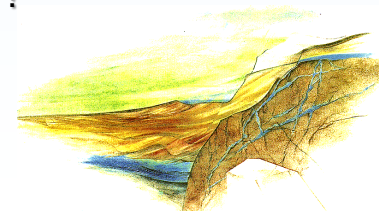
Spread of pollution (total CIU) - situation in 2012

PLUME OF CHLORINATED HYDROCARBONS (cutted off)

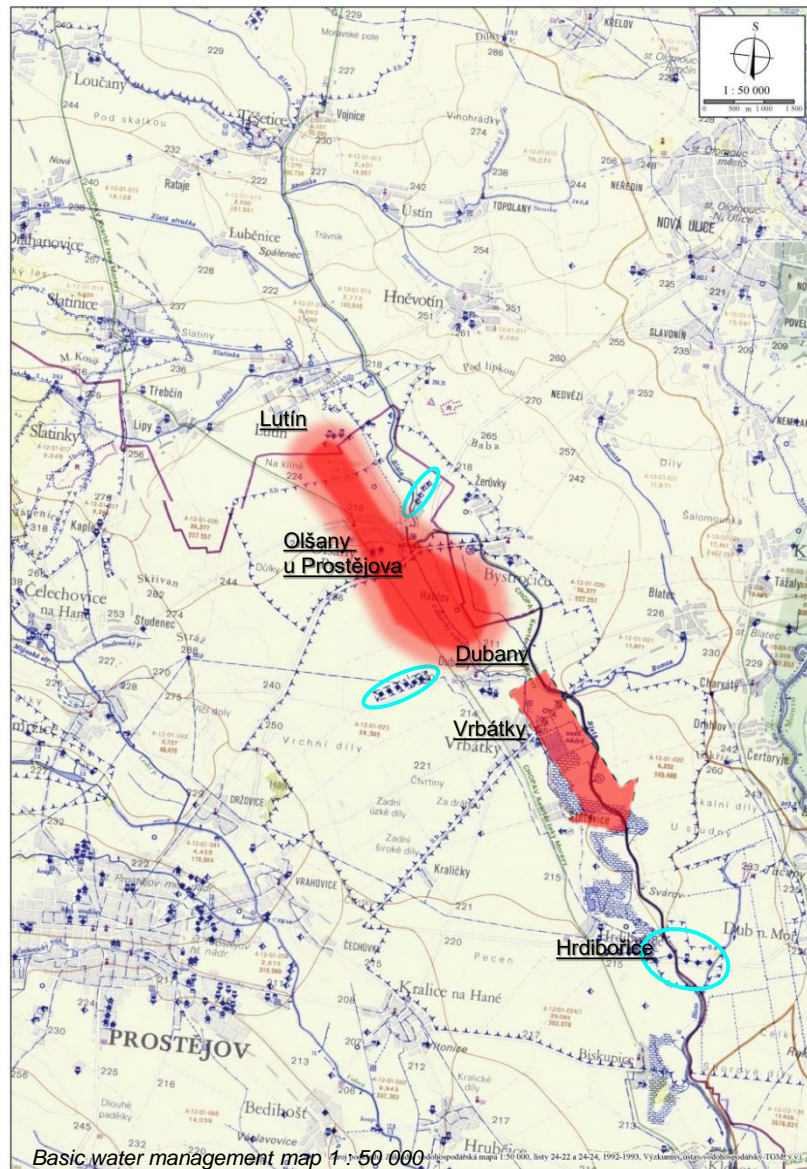
- Quaternary aquifer of the Morava River
- spreading in the SE direction approx. 50 m/year
- range: 5 km x 1 km, thickness ~25 m

KEY CONTAMINANTS

- PCE (tetrachlorethen)
 - toxic, potential human carcinogen
 - max 70 - 152 $\mu\text{g.l}^{-1}$ / 10 $\mu\text{g.l}^{-1}$
- TCE (trichlorethen)
 - toxic, potential human carcinogen
 - max 52,9 - 266 $\mu\text{g.l}^{-1}$ / 35 $\mu\text{g.l}^{-1}$
- 1,2-cis-DCE (dichlorethen)
 - the most extensive
 - toxic, potential human carcinogen
 - max 45,2 - 122 $\mu\text{g.l}^{-1}$ / 30 $\mu\text{g.l}^{-1}$
- VC (vinylchlorid)
 - high toxic human carcinogen !
 - max 61 - 150 $\mu\text{g.l}^{-1}$ / 10 $\mu\text{g.l}^{-1}$



Impact on receptors



Basic water management map 1:50 000

Affected areas

Olšany u Prostějova, Hablov, Dubany na Hané, Bystořice (4 000 residenst, 120 hectares)

Receptors

1. Residents of the affected municipalities
 - domestic wells - irrigation, washing, showering
2. Farming facilities: Olšany, Hablov, Vrbátky
 - large capacity wells: drinking water - livestock breeding, utility water - irrigation, washing, etc.

Another threats

CHOPAV - Quarter of the Morava River

- **WS Olšany**: not yet in operation due to possible CIU contamination
- **WS Dubany**: 4,8 l.s⁻¹ / 30 l.s⁻¹ (Olšany, Prostějov)
- **WS Hrdibořice**: 32 l.s⁻¹ / 40 l.s⁻¹ (Hrdibořice, Prostějov)

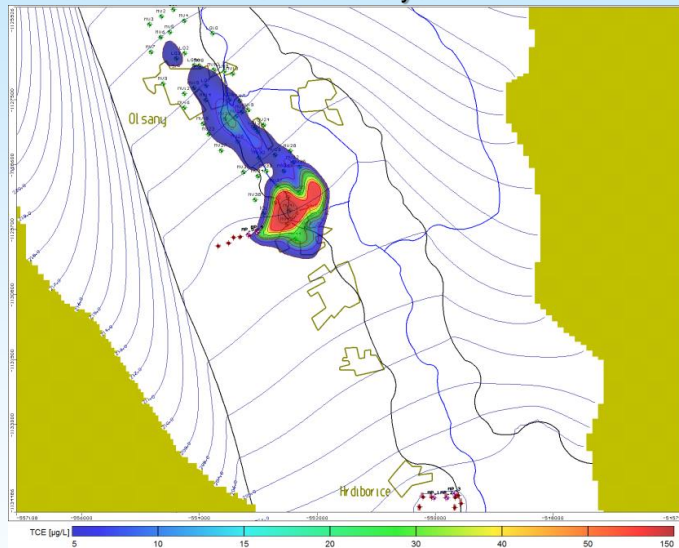


Potential impact without the remediation

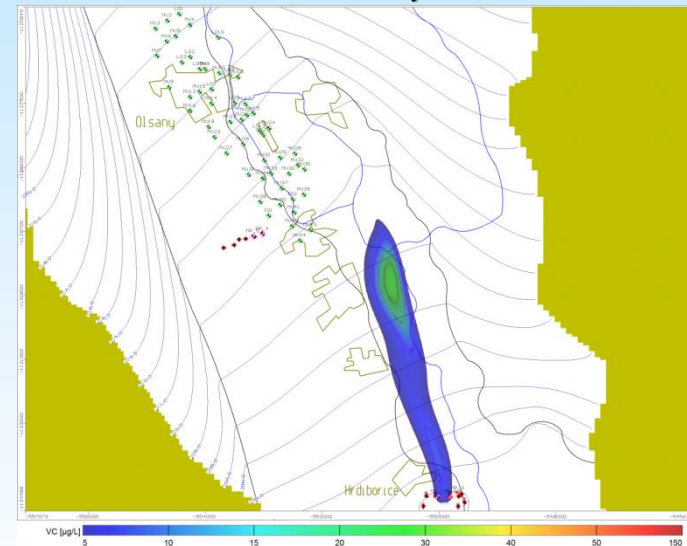
A hydraulic and transport model of contaminants spreading (DEKONTA, a.s. 2010) – 3 scenarios of water collection in the catchment area of Dubany na Hané :

- Variant A – amount of water 4,8 l.s⁻¹.
- Variant B – amount of water 9,6 l.s⁻¹,
- Variant C - amount of water 14,4 l.s⁻¹.

Contamination TCE – after 8 years – variant C

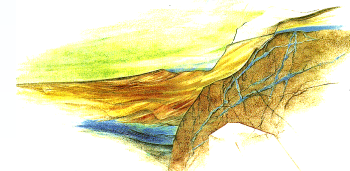


Contamination VC – after 75 years - variant A



- the influence of groundwater quality in the Dubany catchment area is strongly dependent on the amount of groundwater withdrawn

- the spreading speed of the contamination cloud is approx. 50 m/year
- contaminated groundwater with TCE, 1,2-cisDCE and VC will reach the catchment area in Hrdibořice in approx. 50-70 years



Goals and target parameters for remediation

Results from AAR (2012): to eliminate the health risk and the risk of deterioration of the groundwater quality, an active remedial intervention is necessary

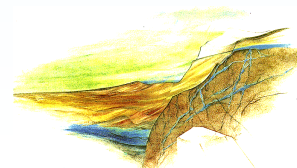
The main goals of the remedial actions are:

1. Minimize the exposure of identified risk beneficiaries by reducing CIE concentrations so that the level of acceptable risk is not exceeded.
2. Inform local residents about the risks associated with the use of groundwater.
3. To avoid contamination of catchment areas and supply wells

Target parameters for remediation of saturated zone:

(for the exposure scenario: use of groundwater for utility purposes - washing / showering by local residents)

Key contaminants with target parameters	Contaminated area (m ²)	Thicknes of aquifer (m)	Volume of contaminated aquifer (m ³)	Volume of contaminated water (m ³)	Weight of contaminants (kg)
TCE - nad 35 µg.l⁻¹	40 0000	30	12 000 000	1 800 000	63
1,2-cis-DCE - nad 30 µg.l⁻¹	40 0000	30	12 000 000	1 800 000	54
VC - nad 10 µg.l⁻¹	60 0000	30	18 000 000	2 700 000	27
suma CIU - nad 70 µg.l⁻¹	1 193 287	30	35 798 610	5 369 792	376



Strategies for remediation

5 variants of remedial proposals

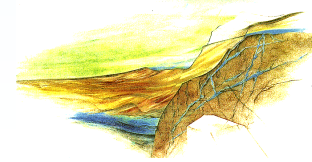
- Variant No. 1 – No action
- Variant No. 2 – Institutional measures
- Variant No. 3 – Active in-situ remediation
- Variant No. 4 – Intensification of an active in-situ remediation
- Variant No. 5 – Full-scale remediation

Pilot tests

- Contaminant reduction using nanoparticle suspension Fe (NZVI) / + BRD,
- Biological reductive dehalogenation (BRD),
- Airsparging combined with ventingem.

Variant No. 4: BRD + ISCR – the most suitable variant

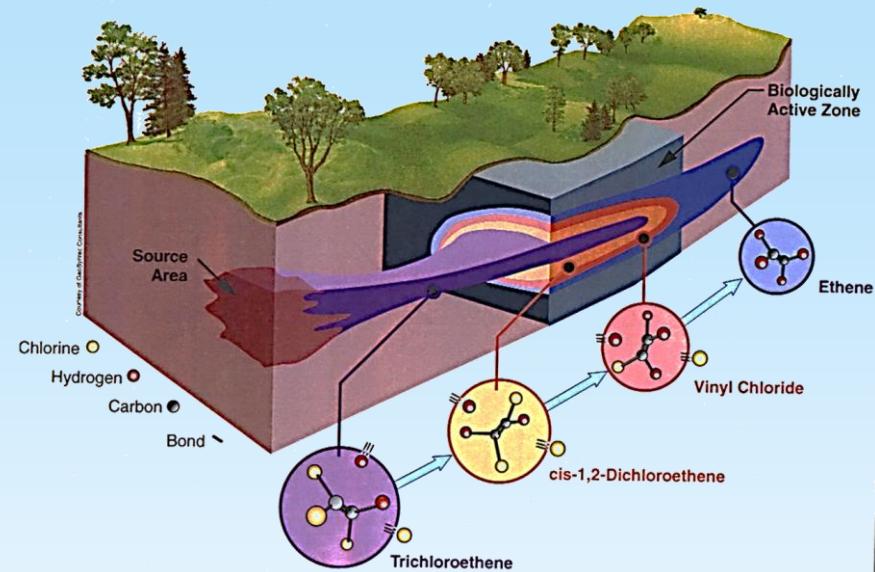
- shorter duration of remediation;
- creation of faster and more significant redox conditions in aquifer and set up of optimal conditions for BRD;
- sustainable and final effect of the remediation solution;
- less negative impact on the surrounding community and environment.



ISCR + BRD - principles

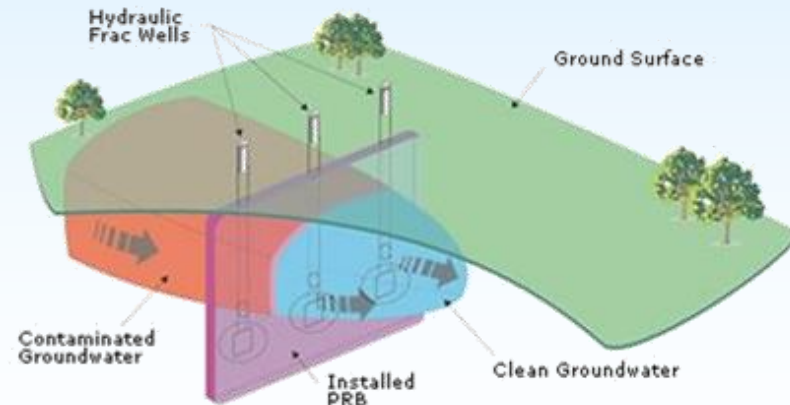
Principles of the remediation method:

- support of natural biodegradation by autochthonous organisms in the environment.
- by regular application of a suitable substrate into the saturated zone a reducing conditions will be created what enhance degradation of chlorinated hydrocarbons: $\text{PCE} \rightarrow \text{TCE} \rightarrow \text{DCE} \rightarrow \text{VC} \rightarrow \text{ethen} \rightarrow \text{ethan} + \text{CO}_2$.

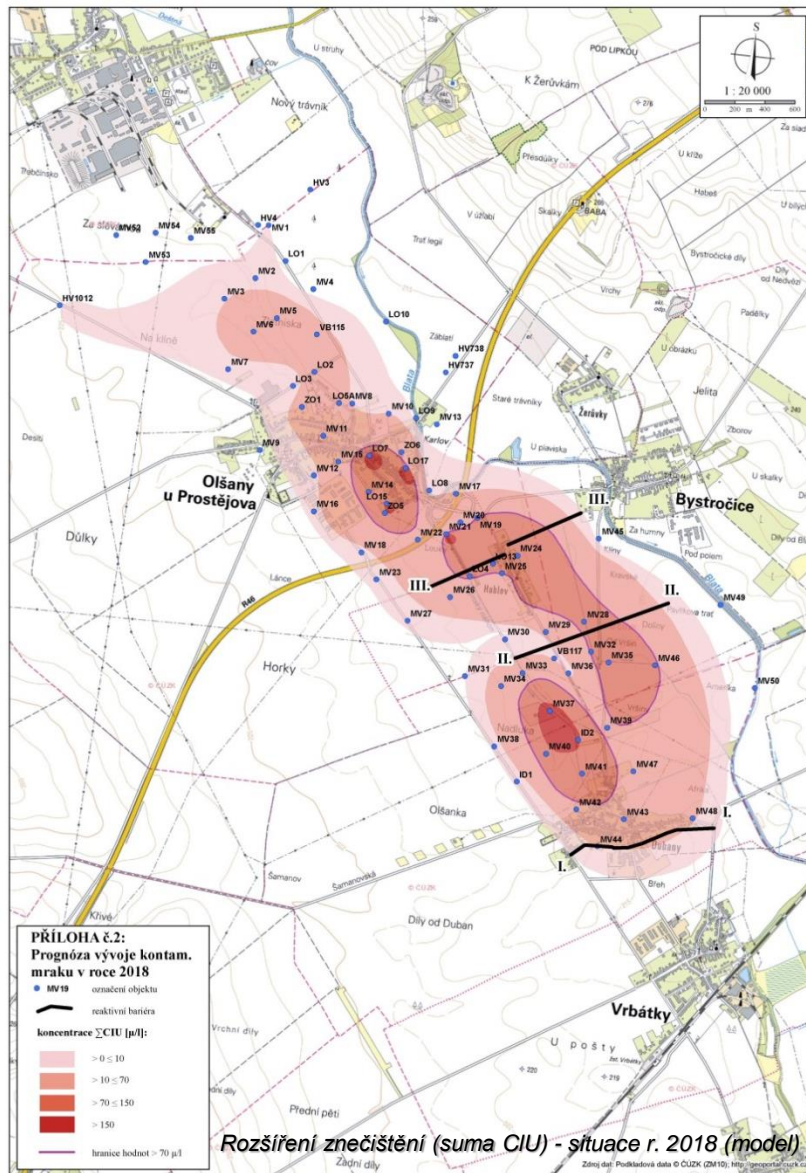


Remediation intervention procedure:

- systematic application of organic substrate and nutrients to injection wells installed in lines in a direction perpendicular to the contamination spreading
- initial support of the ISCR method by targeted application of NZVI



ISCR + BRD - setup



3 lines of injection wells for BRD

- line length approx. 1 km
- the distance of the wells from each other is about 10 m
- a total of 300 wells (100 pcs in each line)
- depth of wells approx. 30 m

Why application

- in the form of an aqueous solution
- delivery by tanker
- 150 l/well/application
- frequency 1 x 3 months
- nutrients 1 x 8 months

Intensification: targeted application of NZVI suspension by the direct-push method into the inflow part of the remediation line

Other works: build a road, remediation and post-remediation monitoring, well renovation,...

Estimated duration: totally 20 years in 2 stages:
I. stage: 6 years (financing from the EU), approx. 5,4 million EUR

II. stage: 14 years (financing from the national program of the CR), approx. 4 million EUR

