Enhanced Reductive Dechlorination With the TCE concept Site Sportlaan 32 Driebergen, the Netherlands

Study tour Soil Remediation "from legislation to innovative remediation"

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This site is being remediated by a consortium of Vink (contractor), Logisticon (TCE bioreactor system) and Bioclear (design, monitoring & control)

Site Sportlaan 32, Driebergen:

- 1927 – 1954 div. activities (laundry, garage)
- Rubber factory “Tirub” 1954 – 2002
- Hydraulic oils (two tanks of 3000 & 5000 L)
- Subsurface fuel oil tank (6000 L)
- Degreasing with Tetra, TRI and 1,1,1-TCA
- The factory site will be redeveloped (housing)

bioclear

Soil contamination:

- Metals (Zn, Cu) & PAH in shallow soil
- Fuel oils: 1.100 m^3 > S; 625 m^3 > I
- Hydraulic oils: 4.000 m^3 > S; 1.875 m^3 > I
- Tetra, Tri & Cis-DCE: 33.000 m^3 > S
- 1,1,1-TCA: 24.000 m^3 >S

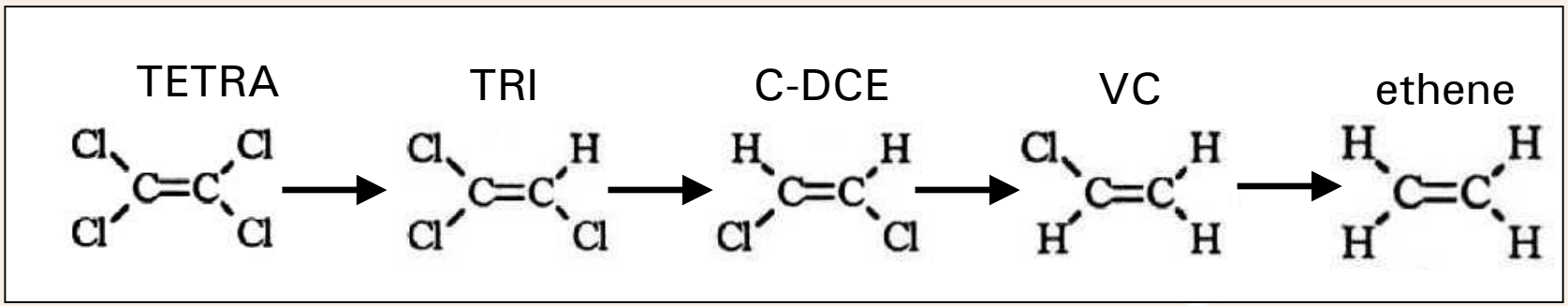
Remediation:

Excavation of oil contaminations
ERD of chlorinated ethenes & ethanes

Potential for Natural Reductive Dechlorination of chlorinated ethenes:

- organic carbon
- redox conditions
- presence of the right organisms
- pH

Reductive Dechlorination route:

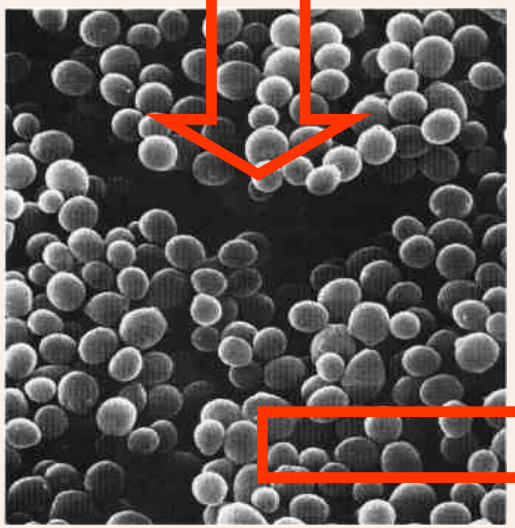


Influence of Redoxconditions on Reductive Dechlorination

Process	E-acceptor	Product	Potential for Reductive Dechlorination
Aërobic	O_2	H_2O	No red. dechlorination of Tetra
Denitrification	NO_3^-	N_2	No red. dechlorination of Tetra
Iron reduction	Fe(III)	Fe(II)	Partial red. dechlorination to DCE
Sulfate reduction	SO_4^{2-}	S^{2-}	Partial red. dechlorination to DCE
Methanogenesis	CO_2/CO_3^{2-}	CH_4	Complete red. dechlorination to ethene

Bacteria & Reductive Dechlorination

Bacterial strain	Degradation to
Dehalobacter restrictus	C-DCE
Dehalospirillum multivorans	C-DCE
Desulfuromonas chloroethenica	C-DCE
Desulfitobacterium sp	C-DCE
Dehalococcoides ethenogenes (D.E.)	**Ethene**



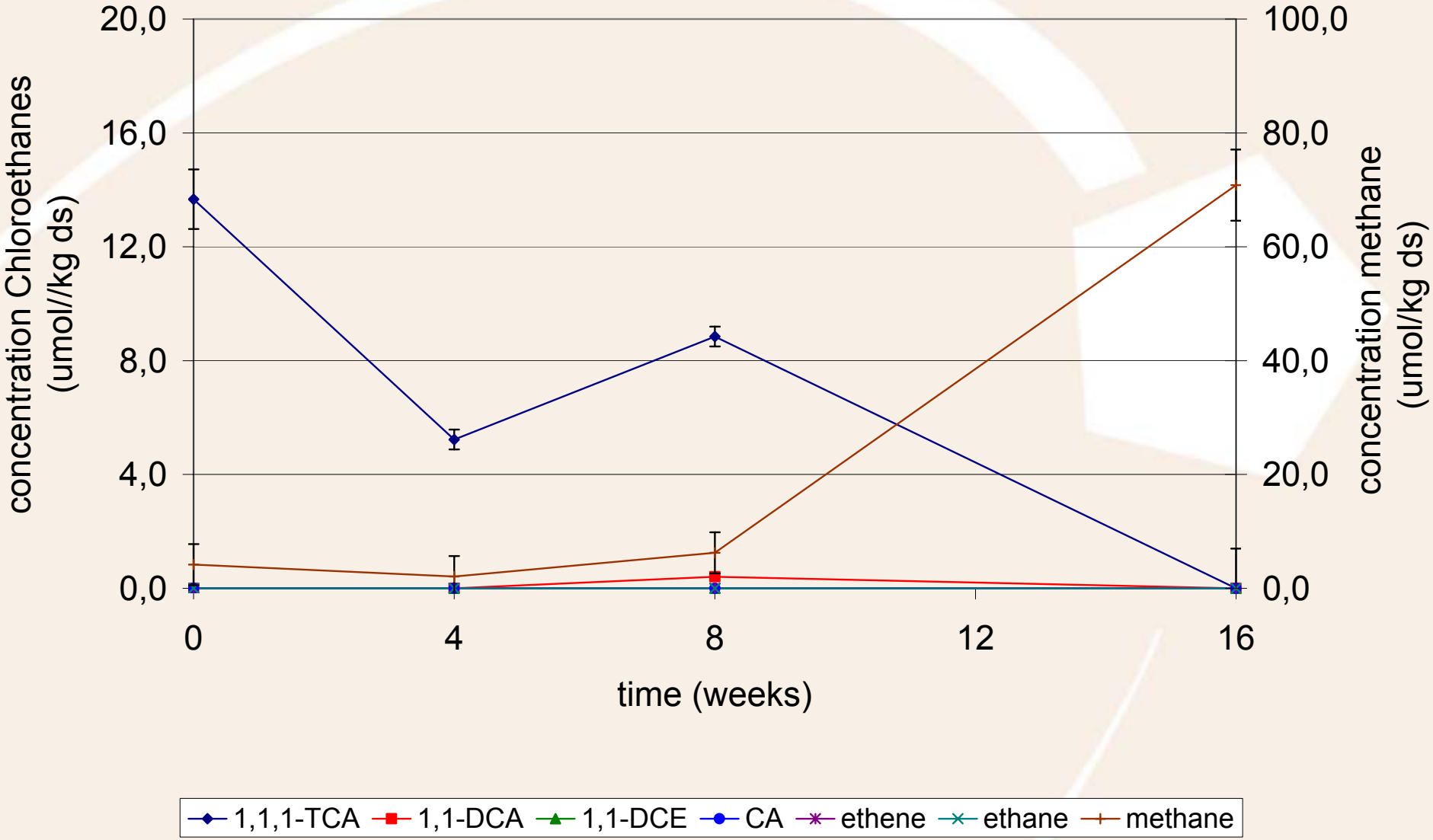
Specific DNA

Monitoring of processes in the soil and groundwater

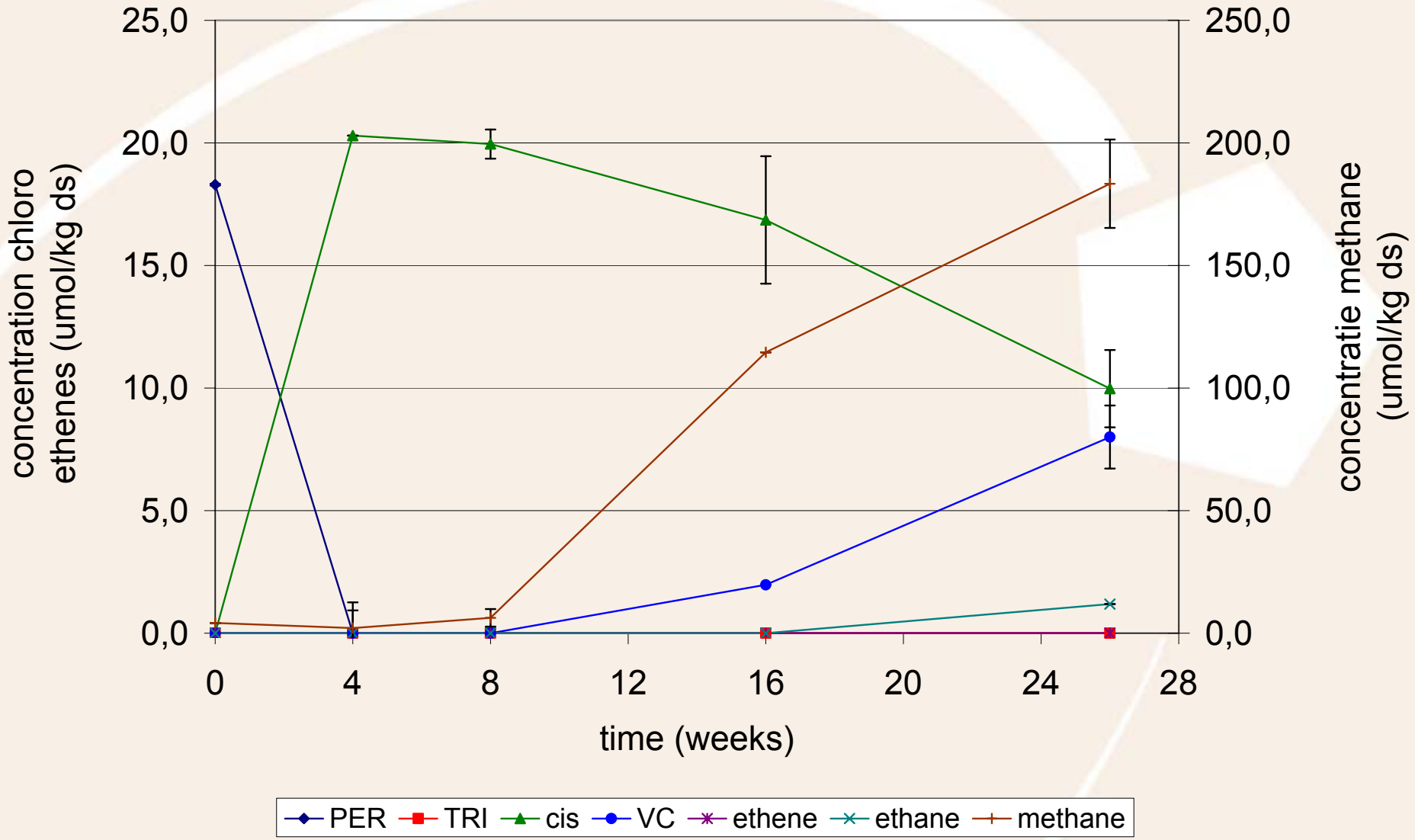
Labscale feasibility studies Driebergen (potential for ERD: addition of carbon source)

- anaerobic batch testing 1,1,1-TCA reduction
- anaerobic batch testing tetra- and tri reduction

Results 1,1,1-TCA degradation:



Results Tetra and Tri degradation:

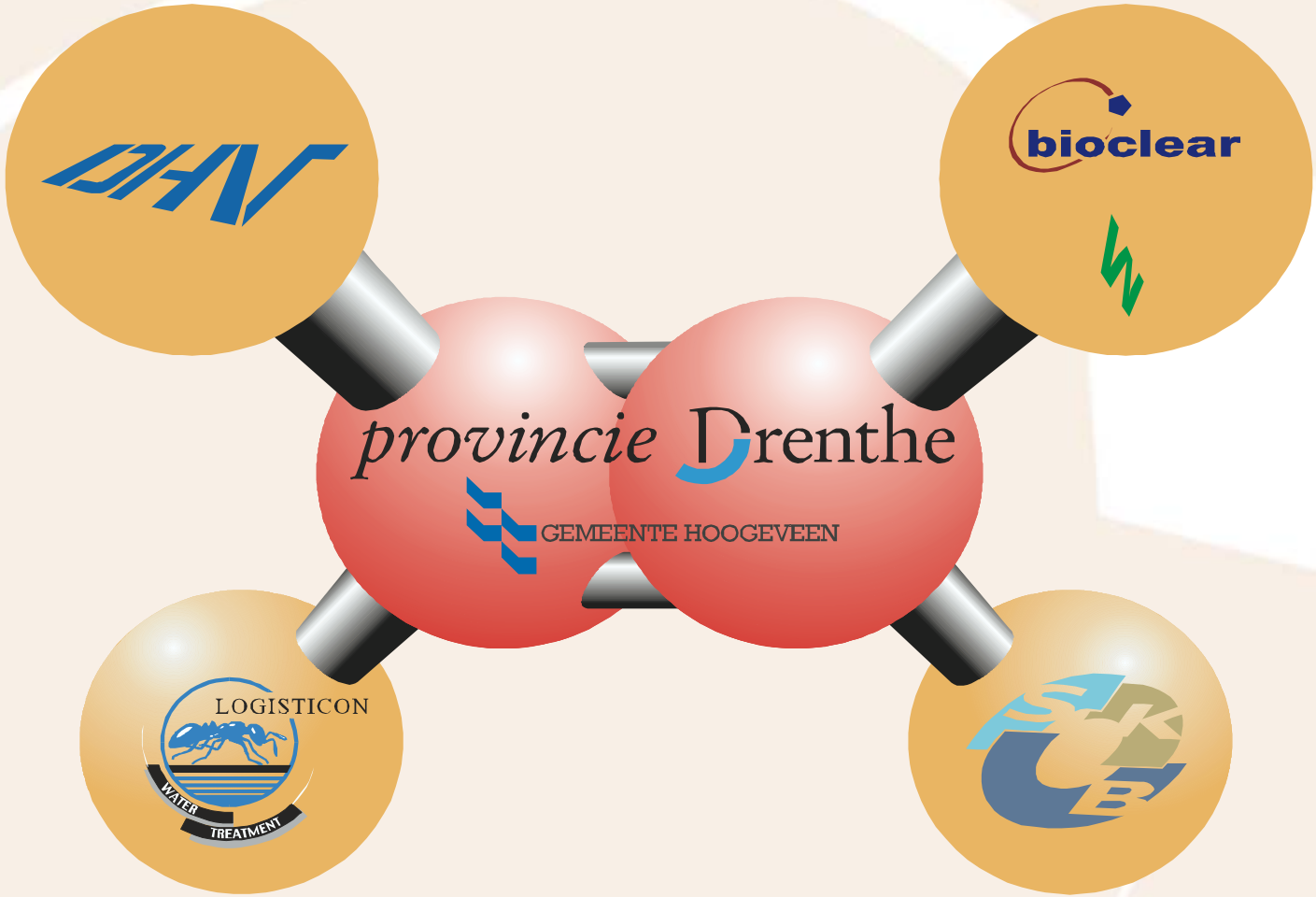


Conclusions Lab scale feasibility study:

1. A natural 1,1,1 TCA degrading population is present at the site and can be stimulated by addition of carbon source
2. A natural Tetra- and Trichloroethene degrading population is present at the site, but formation of Vinylchloride an ethene is very slow
3. The naturally occuring degradation processes can be greatly enhanced through addition of suitable carbon source. Addition of an active dechlorinating culture (including *Dehalococcoides* sp.) would probably lead to much faster reductive dechlorination

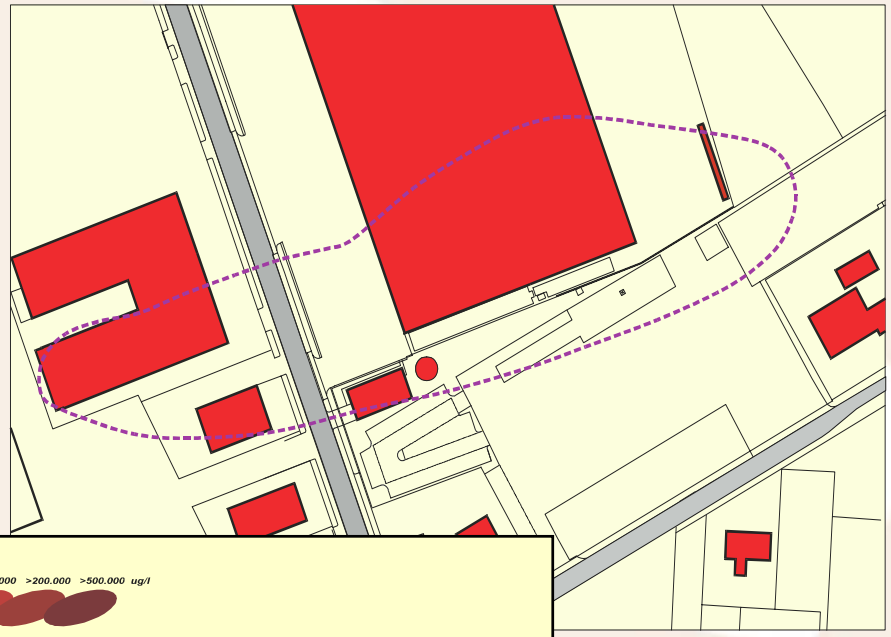
→ *The TCE concept was proposed as remediation technique*

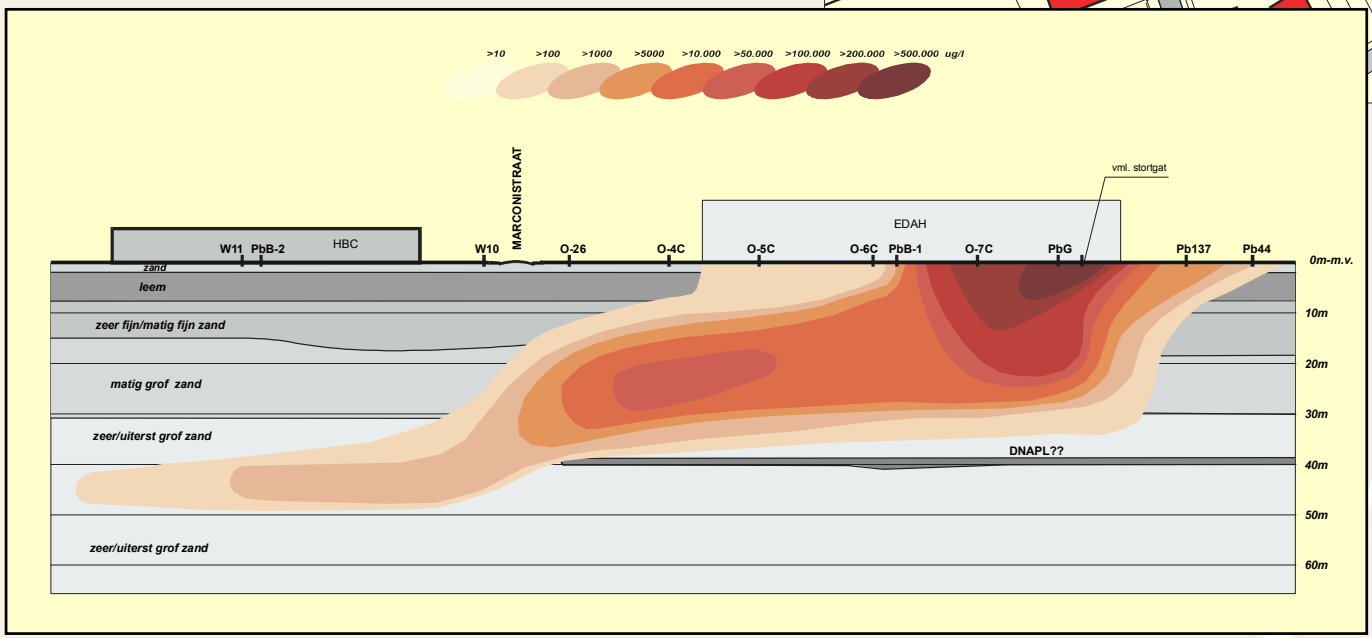
TCE concept: Total Concept Evenblij



Contaminated site Evenblij

- pure product in upper layer
- plume > 200.000 m^3
- no NA and no complete dechlorination after carbon source addition

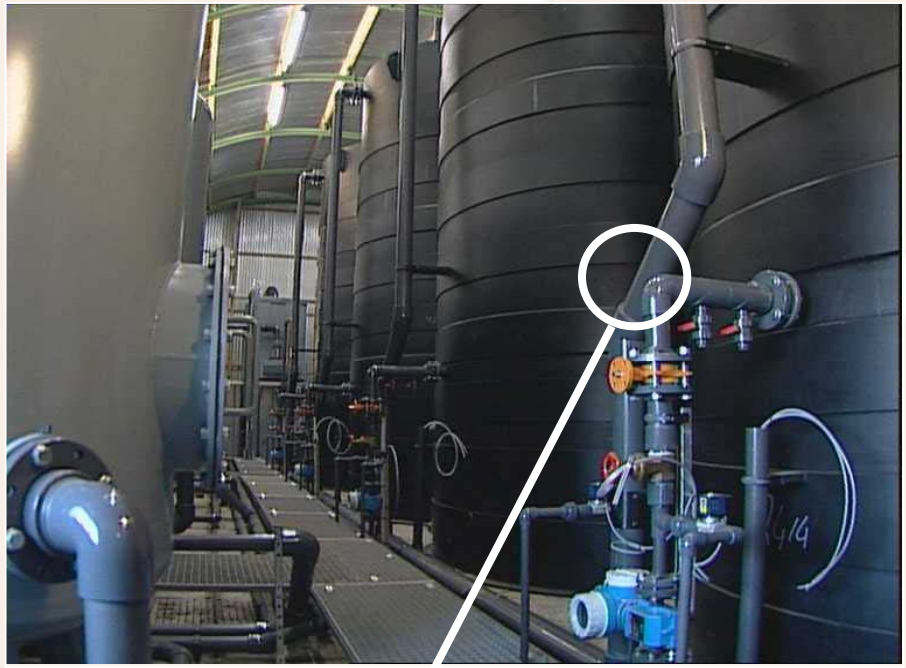




Contaminated site Evenblij

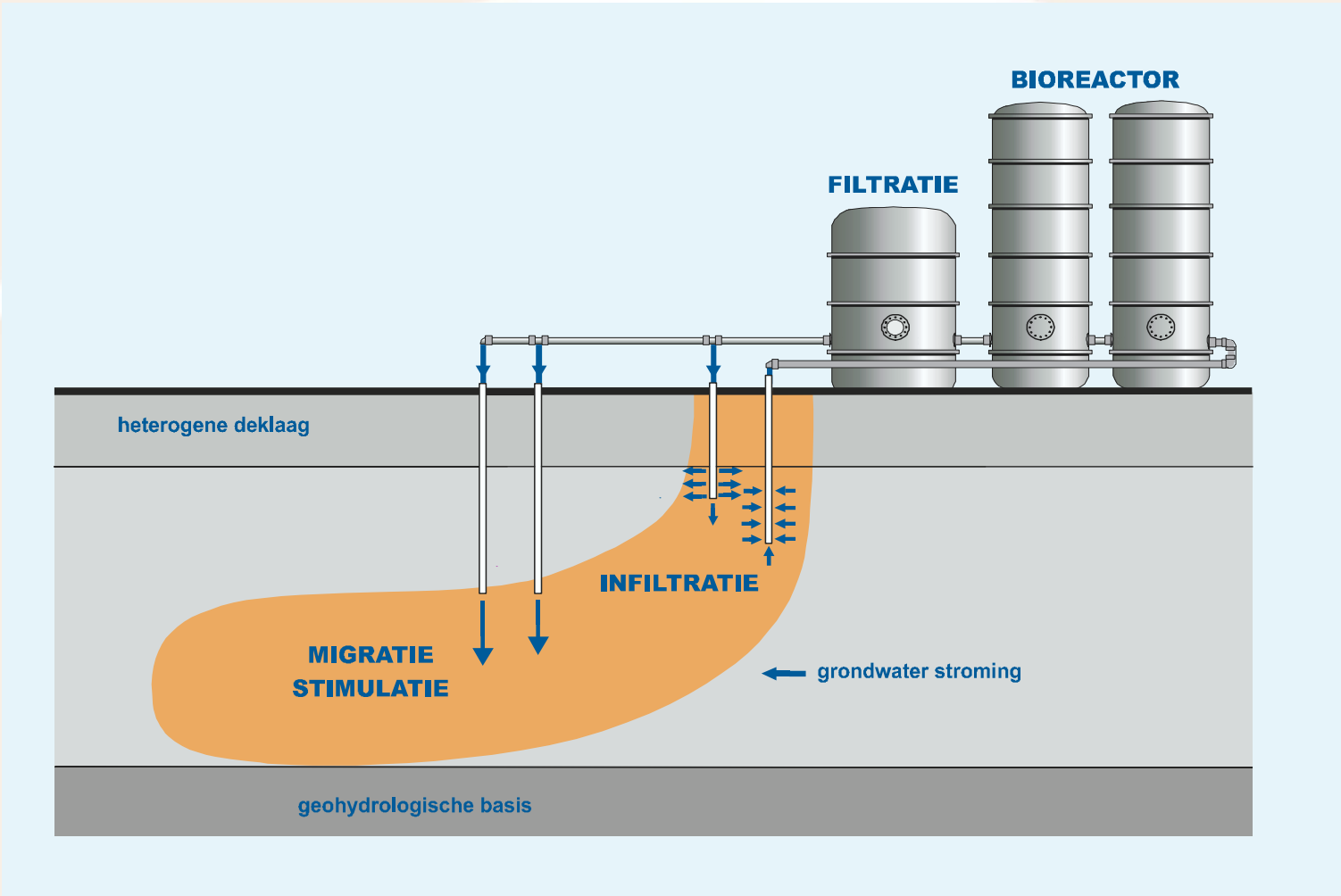
Column experiments 1995

Tetra -> ethene (99%)



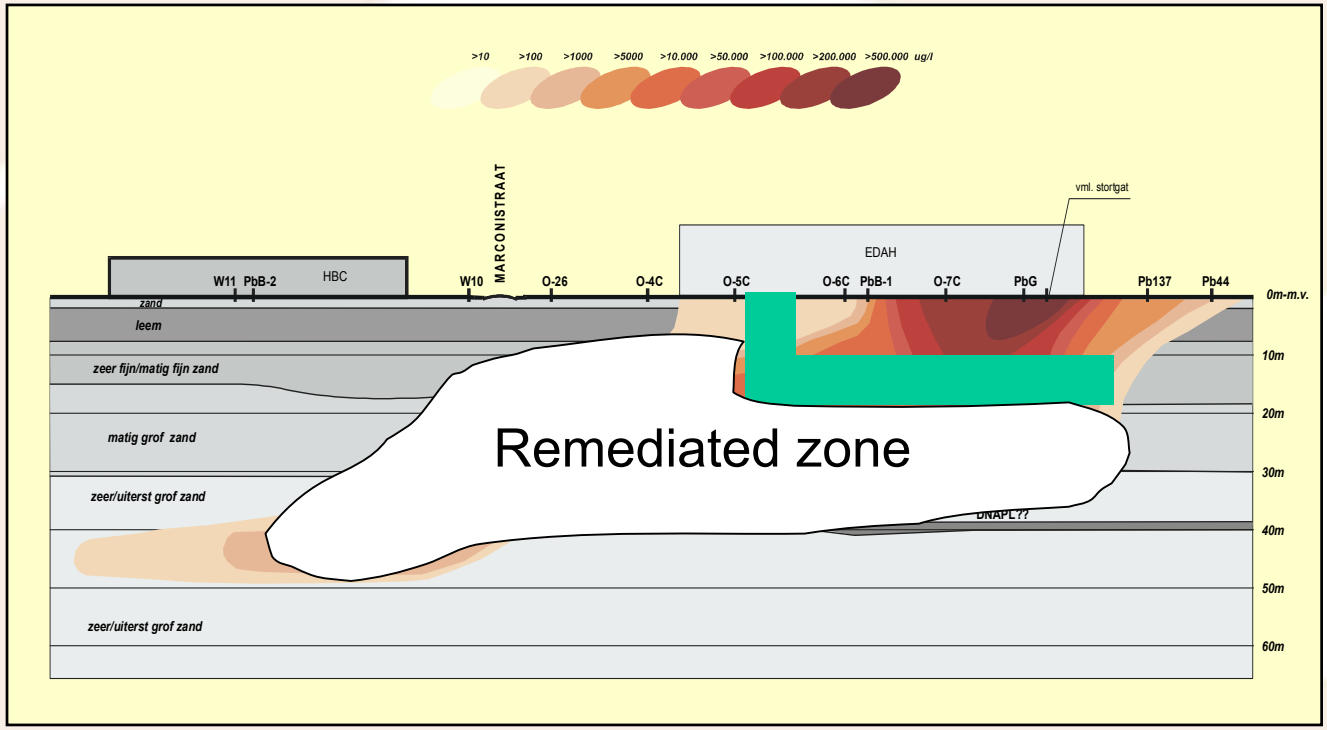
Effluent of bioreactor

- Tetra to ethene in 28 days
- Effluent: ≈10^5 cells/ml



Transfer of degradation capacity from bioreactor to the soil: infiltration of organisms

Present situation



- Plume (up to 50,000 µg/l PCE) clean (levels < 10 µg/l); (length 200 m; depth 50 m)
- Soil volume 300,000 m^3
- More than 98% degradation in 9 months
- Core zone stimulation by carbon source injection

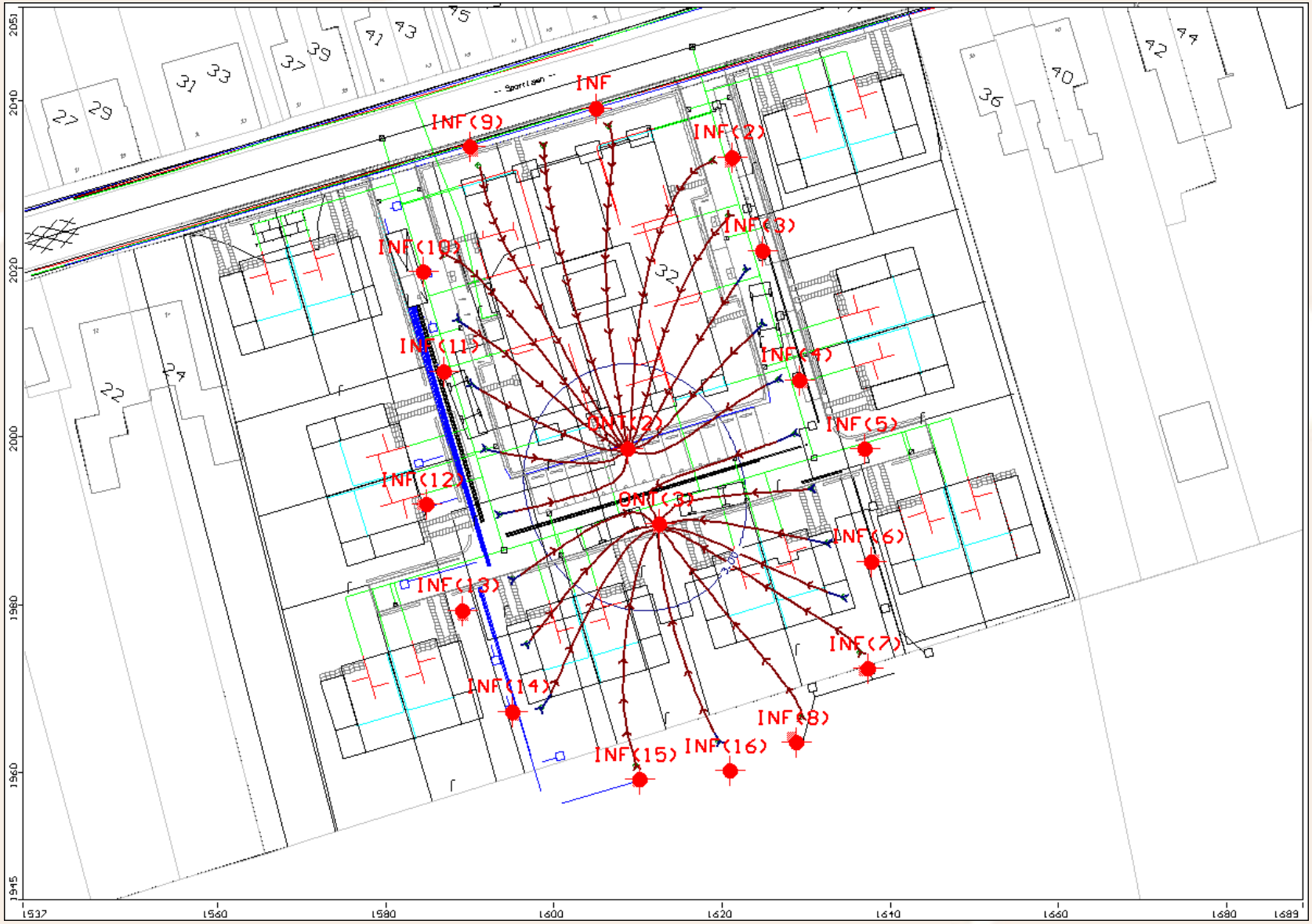
Development of technique (2-3 years):

Fixed system, 100 m^3 volume

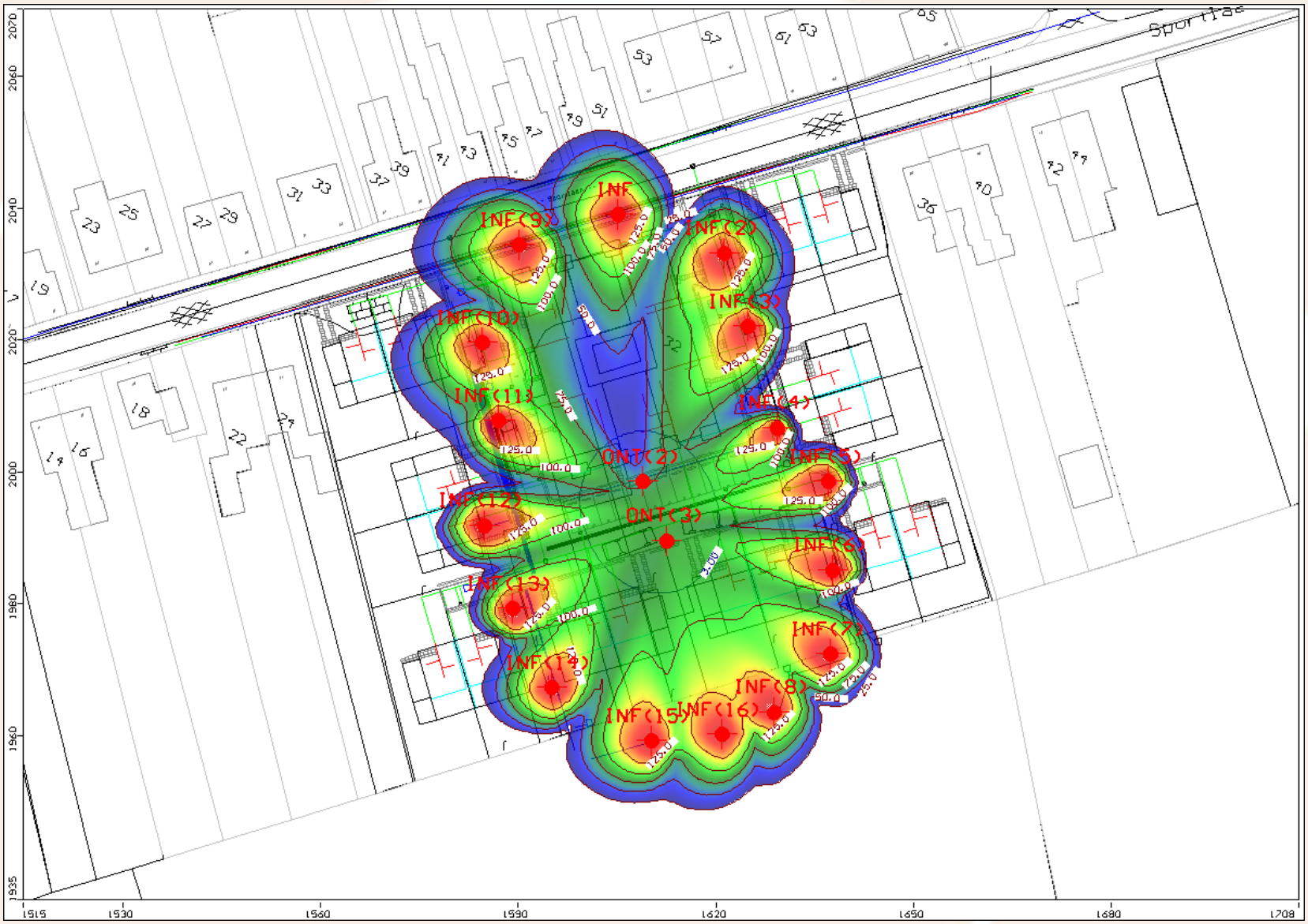
Mobile system, 30 ft container

System Logisticon Watertreatment

Design Driebergen : flush through time



Design : Carbon source distribution 90 days



Some monitoring results after 1,5 months

Well	300		301		302	
Depth of screen (m-sl)	3,0-5,0		3,0-5,0		2,5-4,5	
Date	18-7-2006	2-10-2006	18-7-2006	2-10-2006	18-7-2006	2-10-2006
pH (-)	7,85	5,82	5,61	4,8	5,94	6,17
Temperature (°C)	15,1	14,8	13,5	14,8	14,9	15,1
Conductivity (µS/cm)	458	469	417	318	318	451
Redox (mV)	140	-193	293	180	168	-180
Oxygen (mg/l)	0,1	0,2	0,1	0,7	0,55	0,2
Nitrate (mg/l)	130	3,2	170	84	97	<0,2
Sulphate (mg/l)	180	52	95	65	83	15
Methane (µg/l)	<25	1800	<25	<25	<25	1800
TOC (mg/l)	16	110	25	22	22	91
PER (µg/l)	1,1	20	<0,1	0,29	7,8	5,4
TRI (µg/l)	9,5	25	0,98	7,6	240	9,8
cis-DCE (µg/l)	0,16	39	<0,1	<0,1	15	69
VC (µg/l)	<0,1	2,4	<0,1	<0,1	<1	1,6
Etheen (µg/l)	<0,25	<0,25	<0,25	<0,25	<0,25	<0,25
Ethaan (µg/l)	<0,25	<0,25	<0,25	<0,25	<0,25	<0,25
1,1,1-trichloorethaan (µg/l	<0,1	7,1	<0,1	<0,1	<1	3,5