Aerobic Biological In-situ Remediation

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16th of July 2013

Content

1. Contaminants
2. Biological Degradation (Aerobic)
3. In-situ Remediation
4. Case 1
5. Case 2
6. Case 3
7. Case 4
8. Case 5

Contaminants

Hydrocarbons such as Mineral oil, BTEX, PAH

- Free phase (mostly LNAPL (sometimes) DNAPL)
- Smearzone
- Hydrofobic
- Aerobic biodegradable

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In-situ Treatment

Biological Remediation :
Optimalisation of environment in the soil to stimulate natural biodegradation

Soil = bioreactor

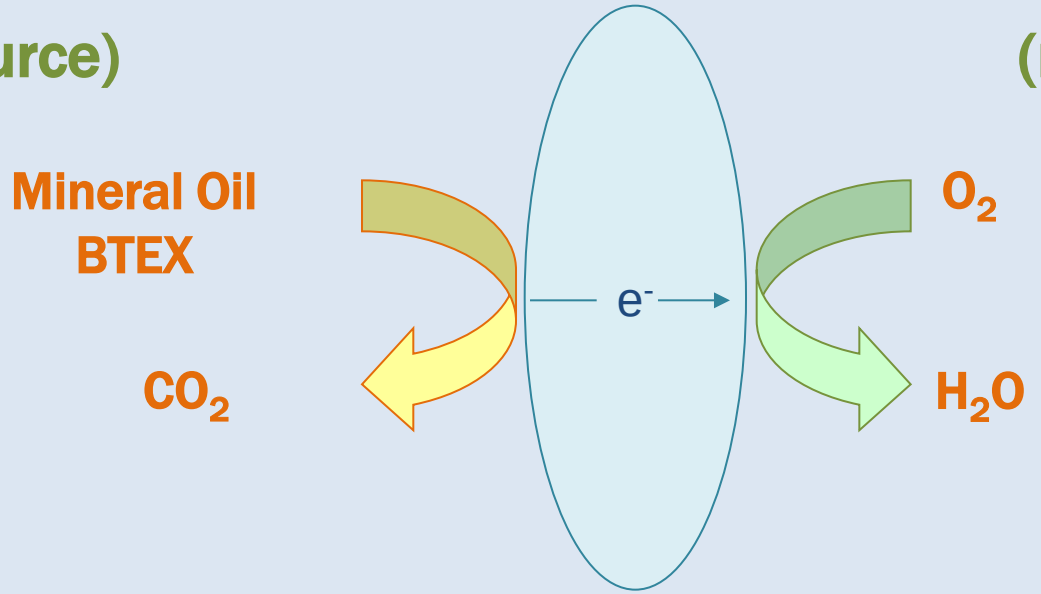
In-situ Treatment

Electrondonor

(C –source)

Electronacceptor

(respiration)



Nutrients (Nitrogen, phosphate)

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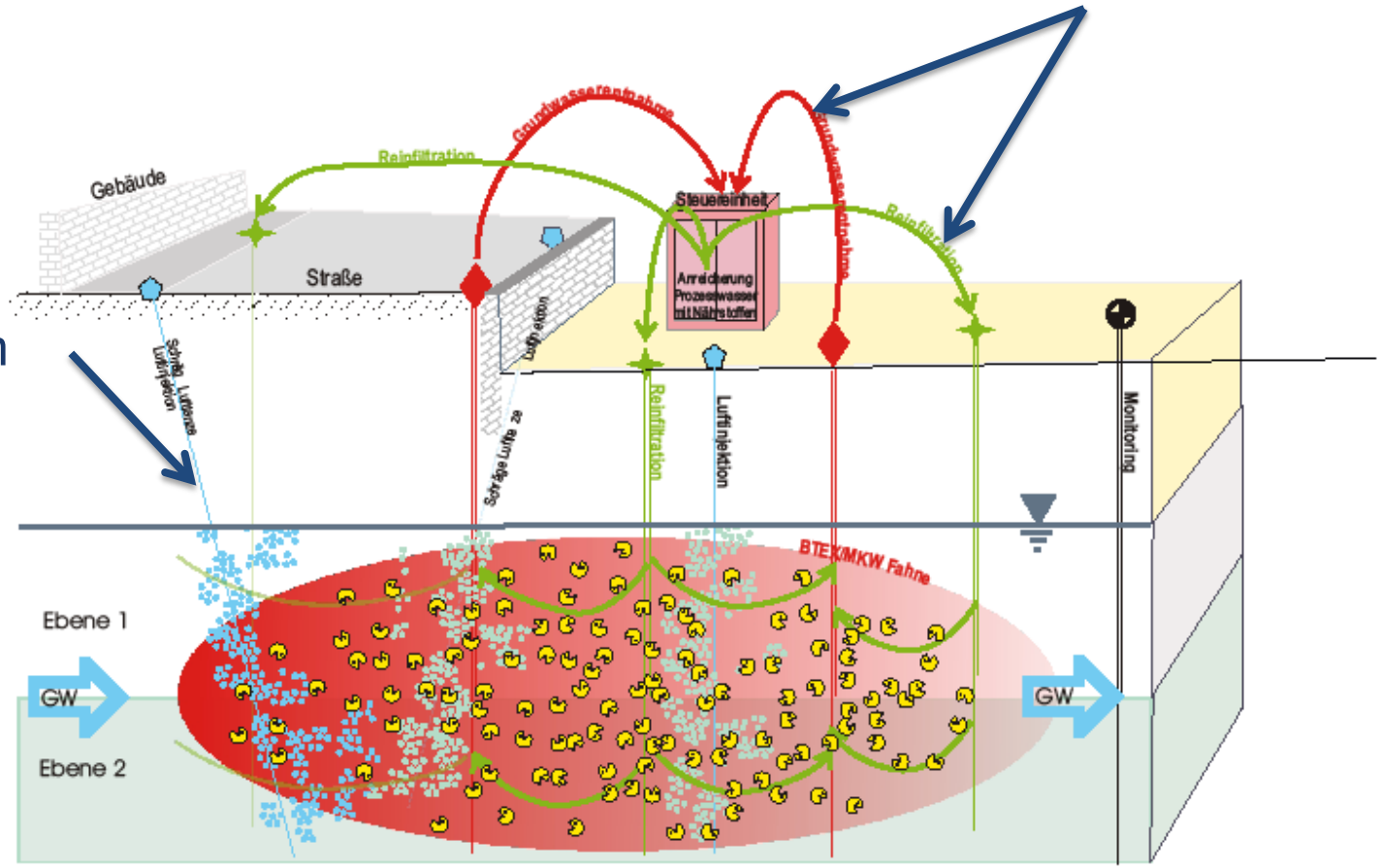
In-situ Treatment

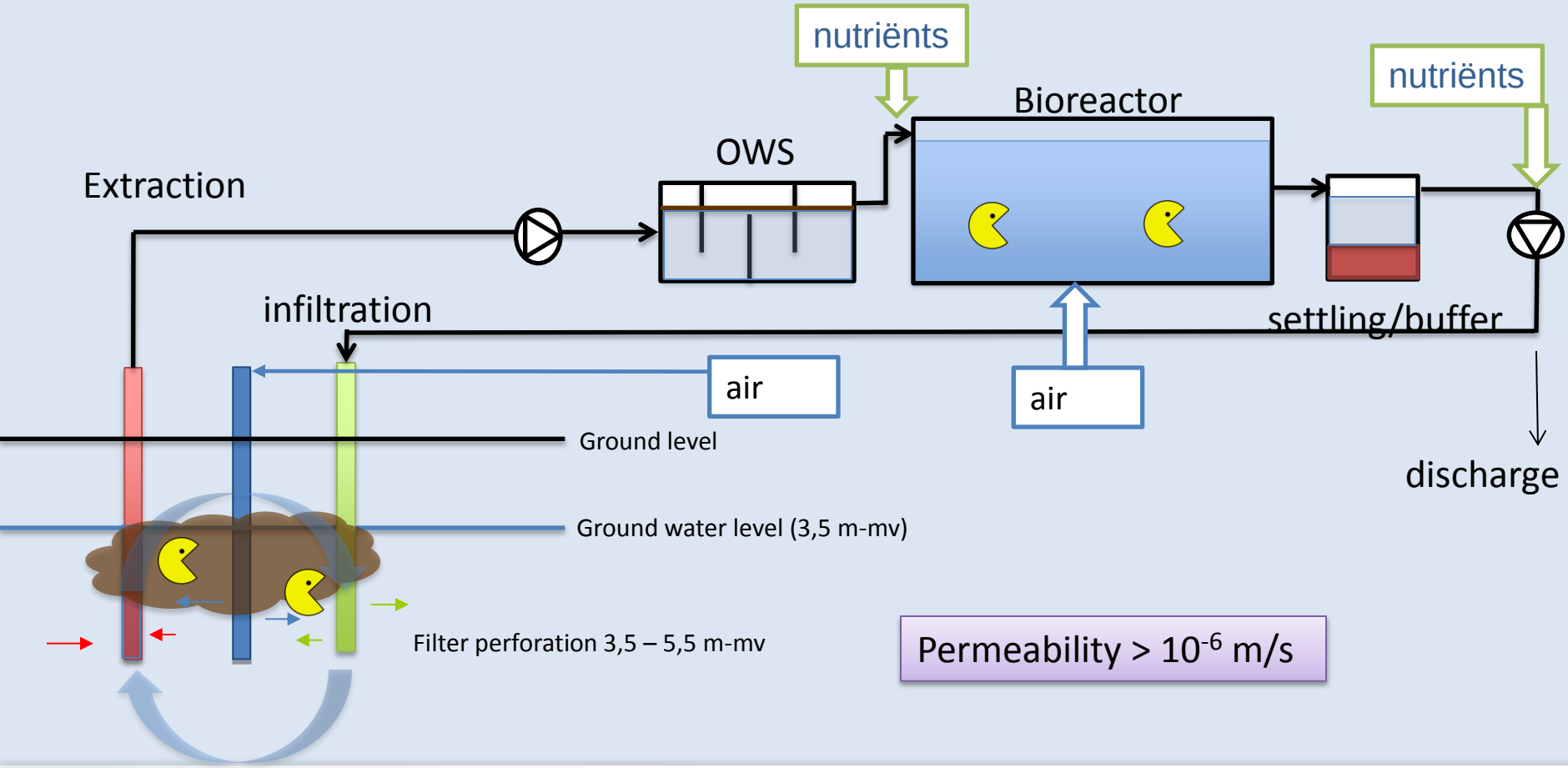
Aerobic Remediation

Groundwater circulation for distribution of nutriënts

Air injection for supply of oxygen



In-situ remediation

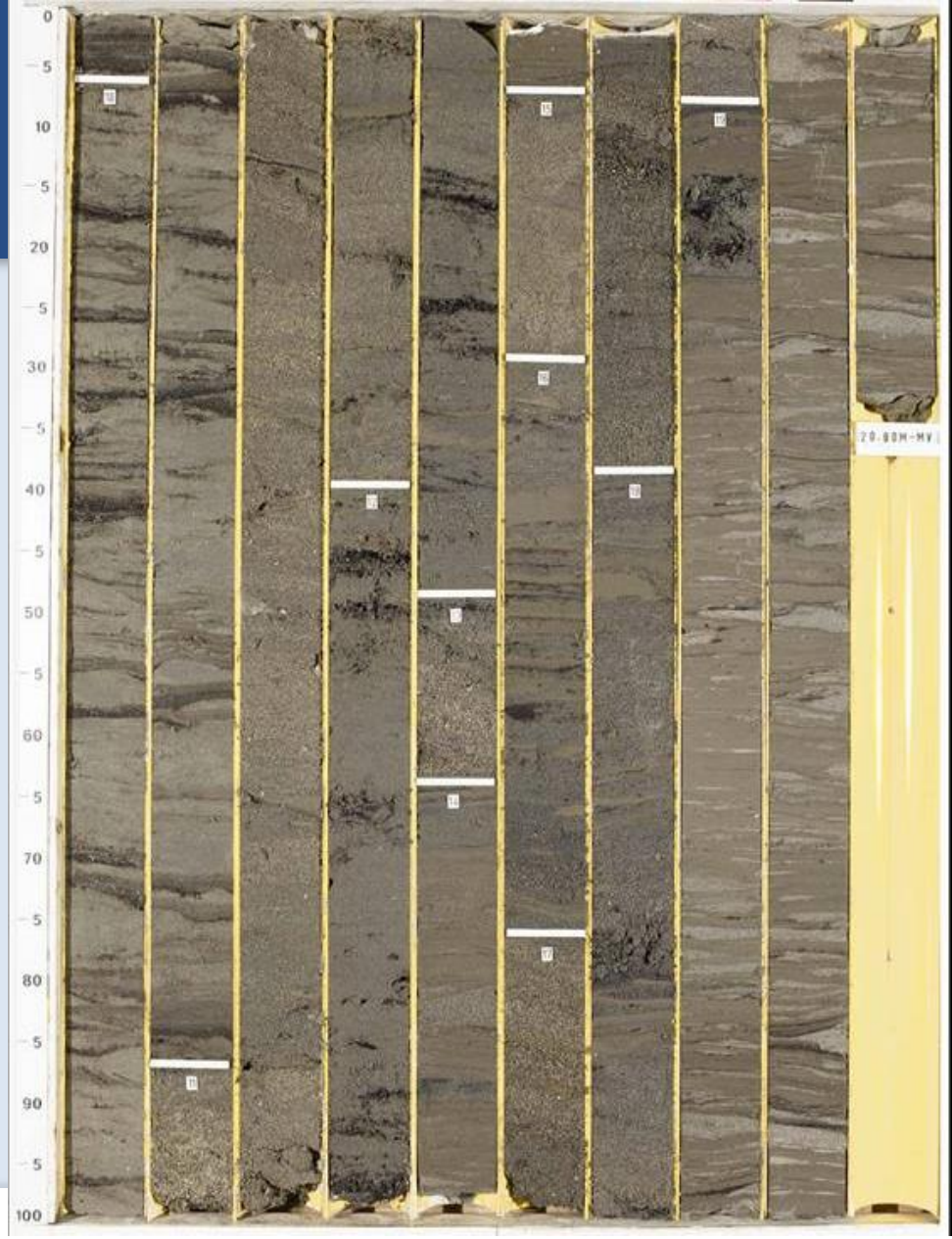


In-situ Bioreactor

In-situ Treatment

Important:

- Cyclic design
- Soil structure



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Case 1: Quilicura Chile

Project description

- Soil and groundwater contamination with BTEX and Styrene
- Contamination has spread up to 16 m-gl
- The contamination covers an area of 1.5 ha.
- Groundwater table is at 10,5 m-gl
- Soil structure is very complex
- Location is still operational

Remediation approach

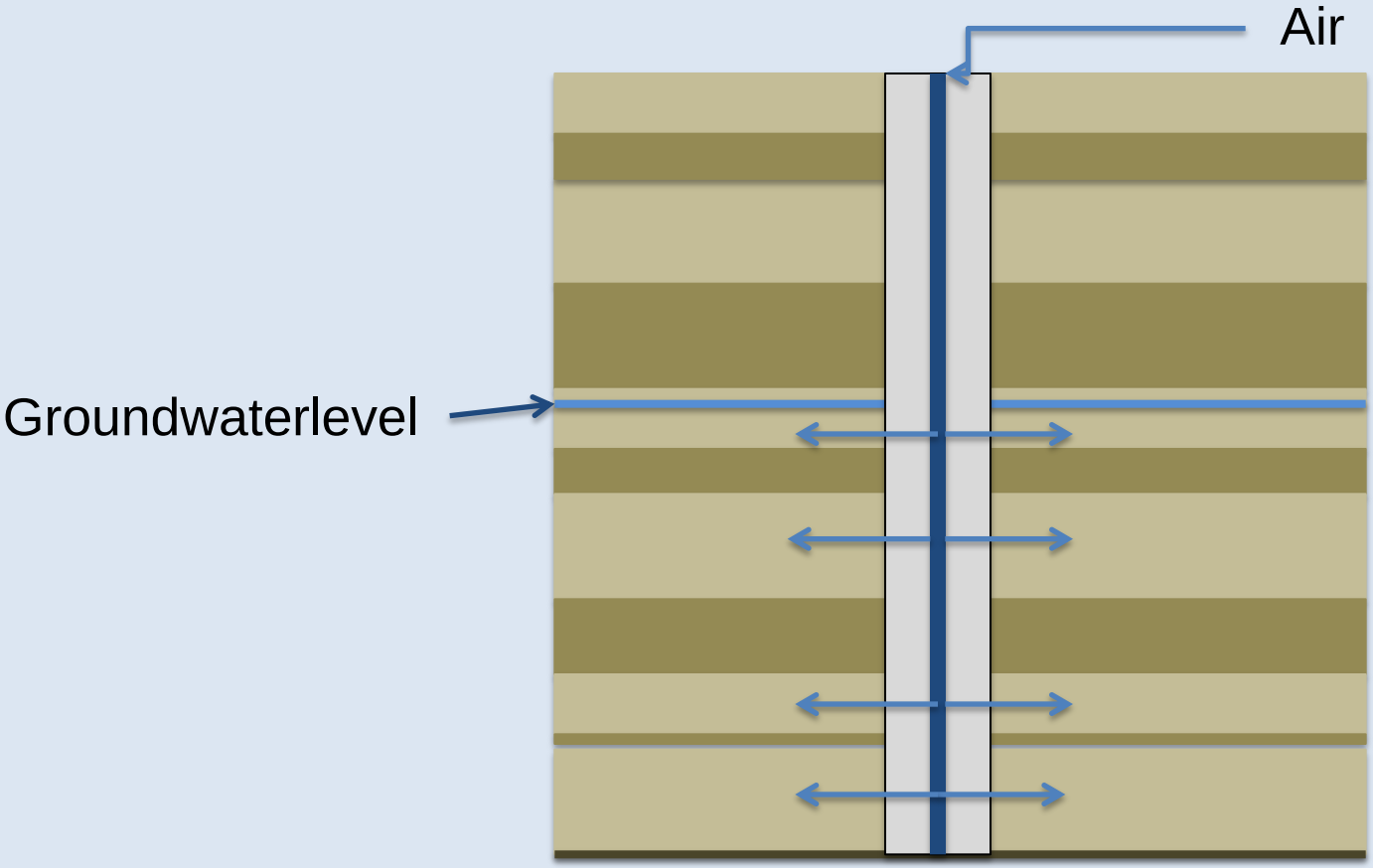
The unsaturated zone: ***Soil Vapour Extraction***:

- SVE filters 3-9,5 m-gl
- Biofilters for cleaning of Vapour

The saturated zone: ***Enhanced Biological Degradation***

- Extraction wells 16 m-gl
- Water treatment : bioreactors
- Infiltration wells 16 m-gl
- Airsparging lances 16 m-gl

Remediation approach



bioSoil

Project Results

Final verification, about 40 soil samples only two exceeding detection limit of the lab:

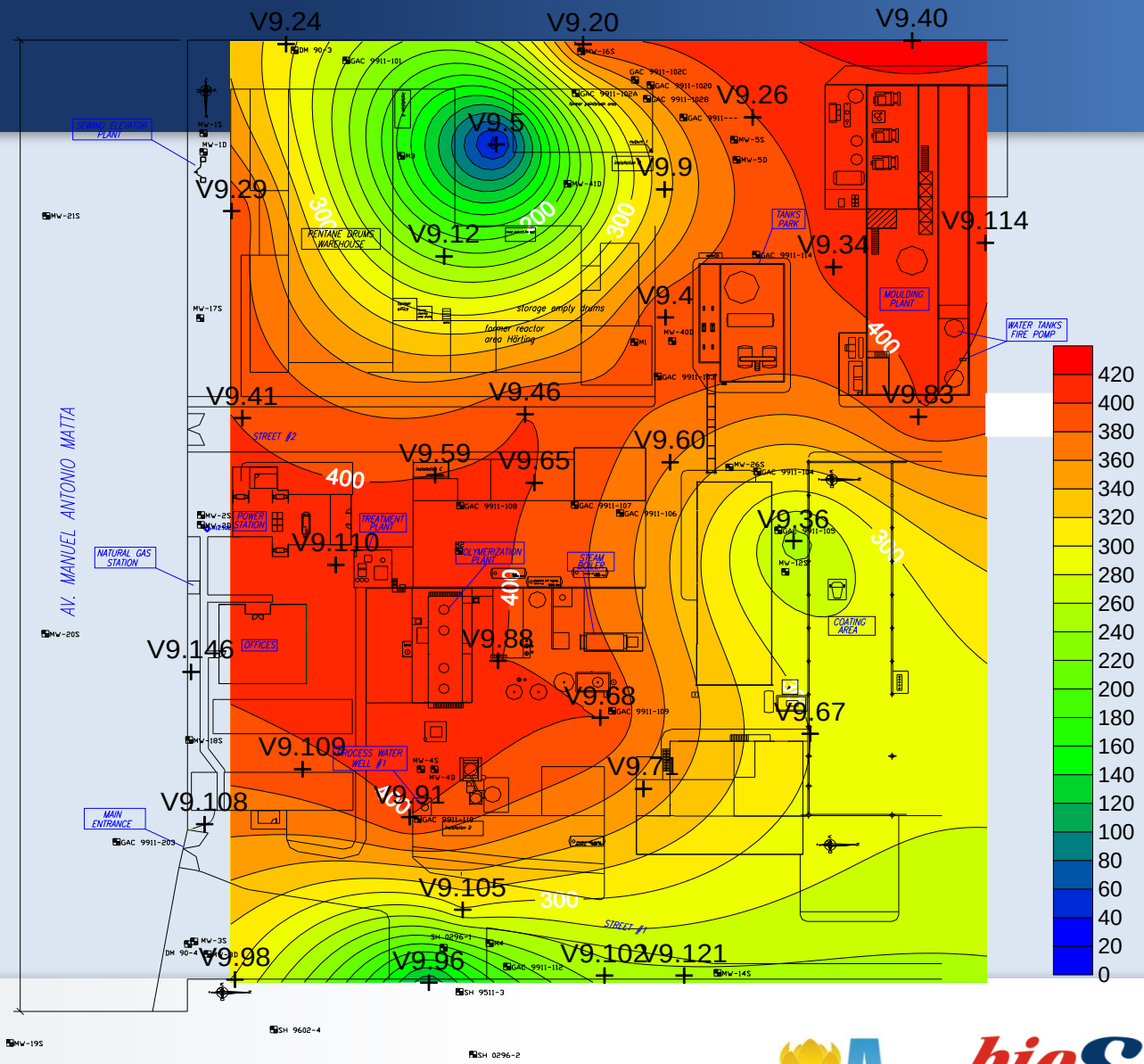
Parameter	Start	Objective Soil (mg/kg)	B26 (7,5-8,0 m-mv)	D16-15 (8,0-8,5 m-mv)
Benzene	22,0	0,3	<	<
Toluene	27,3	7	<	<
Ethylbenzene	341,3	5	<	0,06
Xylene	2.616,6	25	<	0,43
Styrene	20.000,0	25	0,38	5,3

Project Results Groundwater

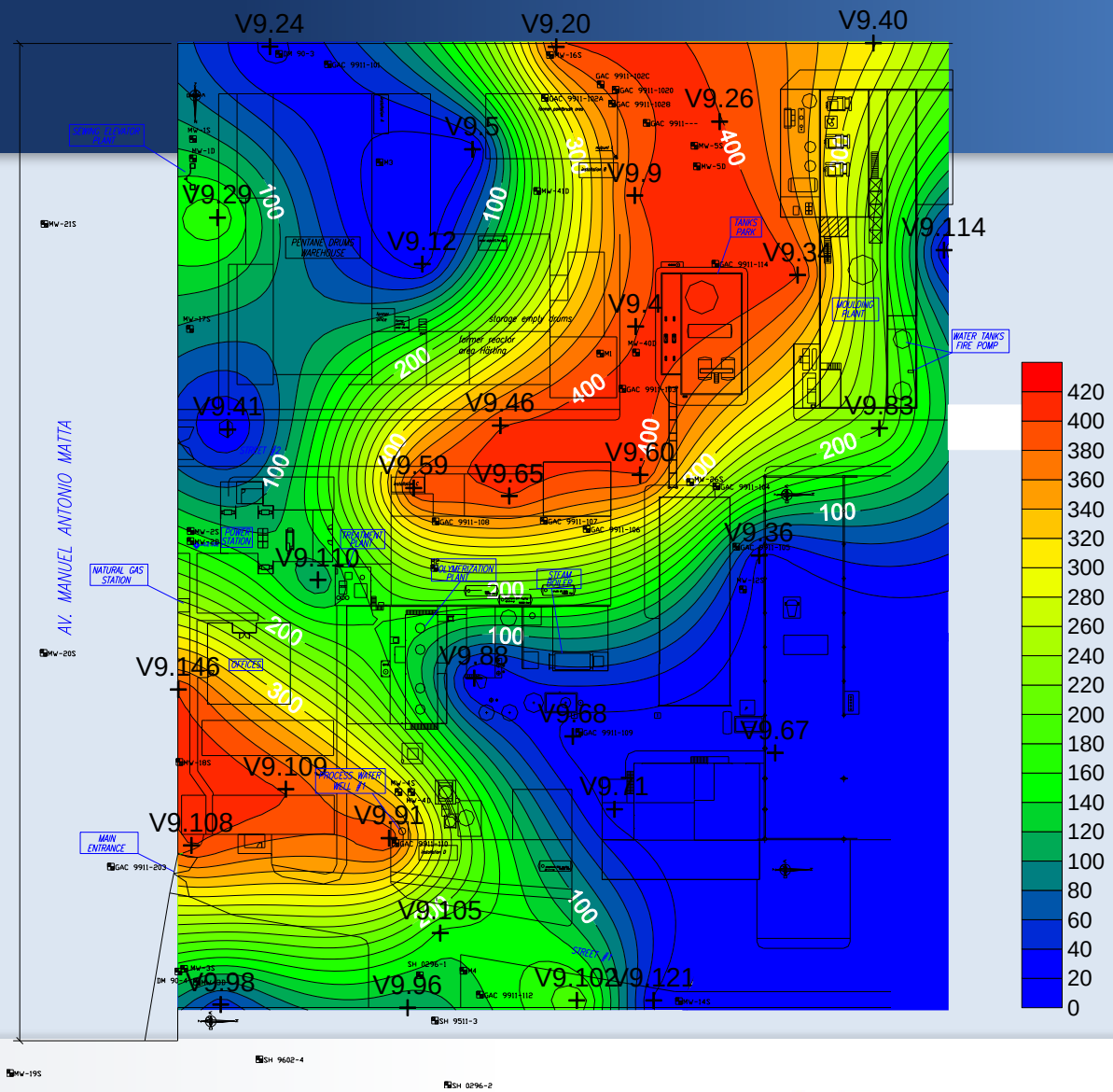
Final verification in 2 events about 40 watersamples, only few samples exceeding the detection limit of the lab:

Parameter	Start	Objective Groundwater (µg/l)	Event I (Juli 2009)	Event II (November 2009)
Benzene	840	700	<	GAC911-112 (1,0 µg/l)
Toluene	51.100	10.000	<	<
Ethylbenzene	46.800	10.000	<	GAC911-112 (0,39 µg/l)
Xylene	1.146.000	5,000	<	GAC911-112 (0,44 µg/l)
Styrene	32.100	5,000	<	<

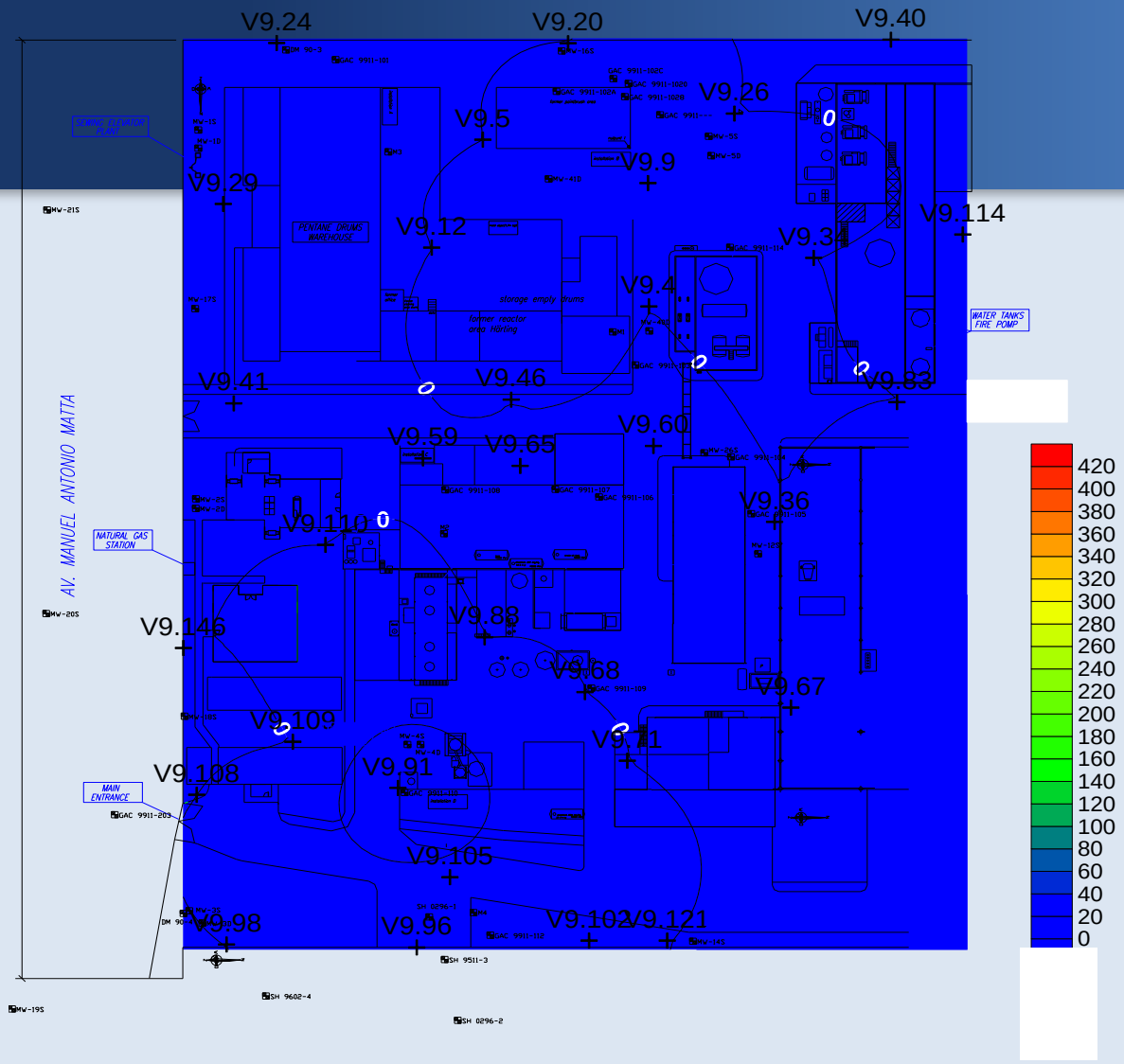
Vapor extraction - Xylene - (ppm) (August 2004)



Vapor extraction - Xylene - (ppm) (March 2005)



Vapor extraction - Xylene - (ppm) (March 2006)



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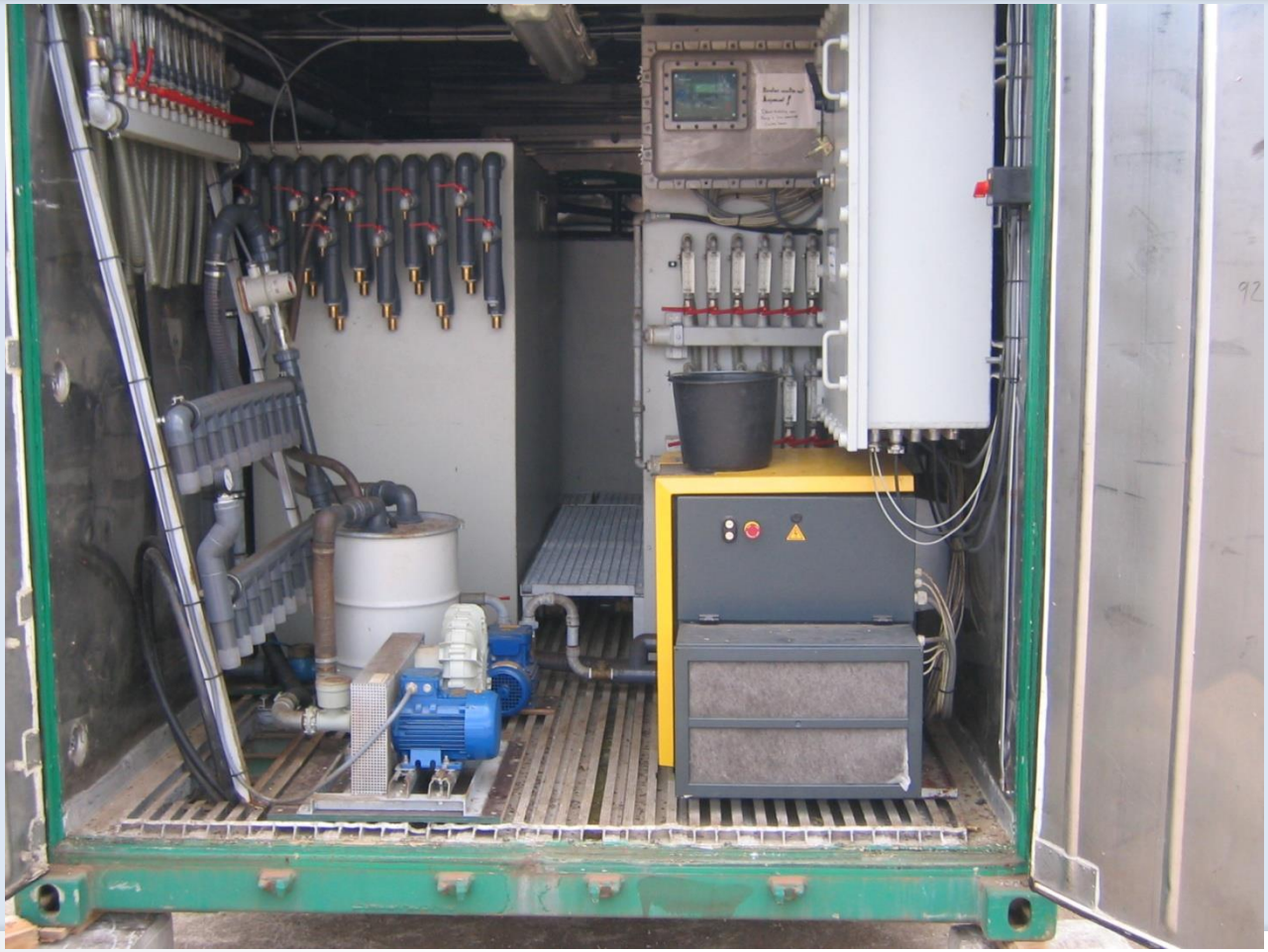
Case 2: Sao Paulo State, Brazil



Project description

- Historical contamination of soil and groundwater with various contaminants:
- Soil structure clay / silt / sand

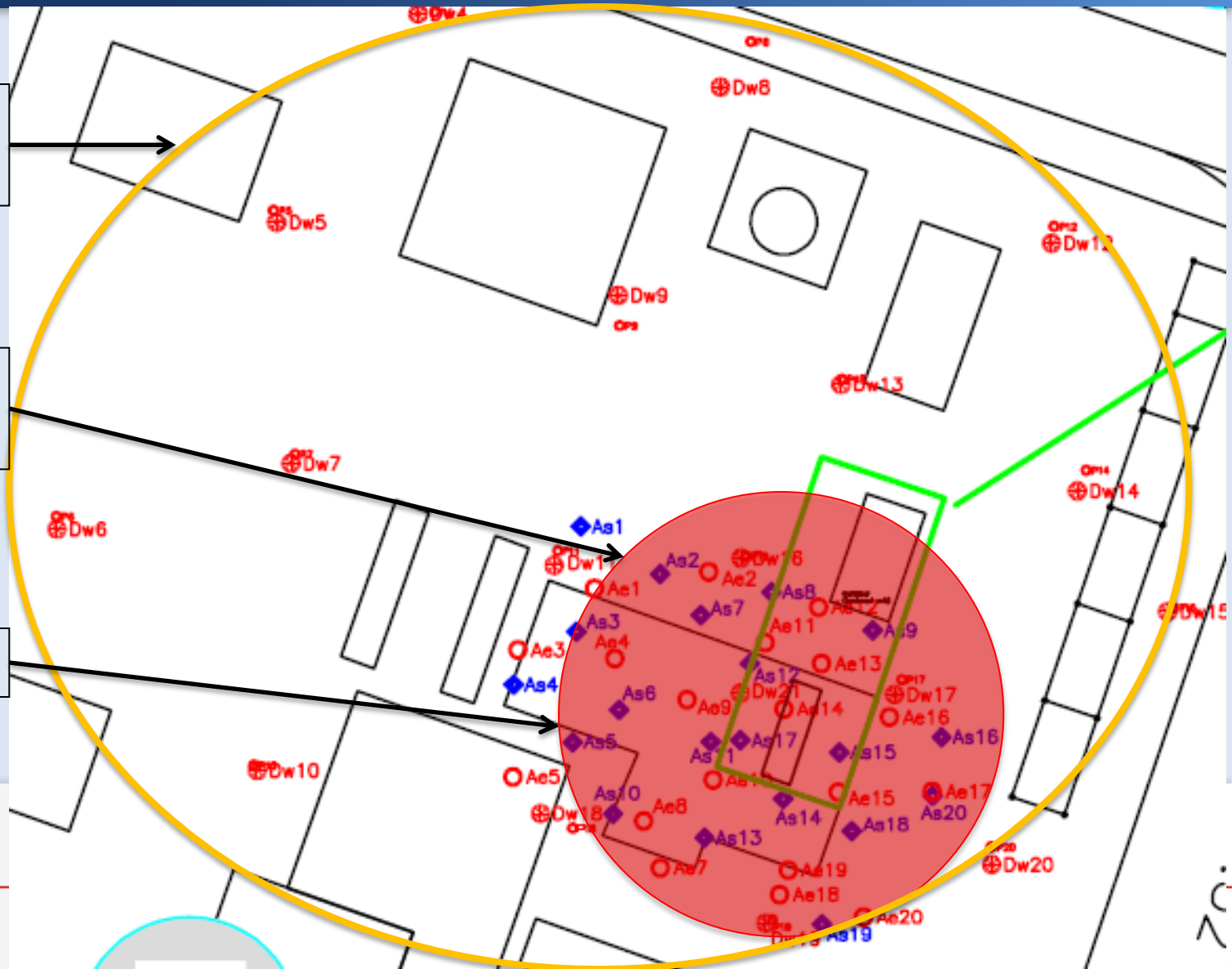
Contaminant	max level (µg/l)	Objective
Benzene	5,100,000	5
Toluene	2,900	170
ethylbenzene	8,300	200
o-xylene	15,000	300
m- and p-xylene	25,000	300
1,3,5-trimethylbenzene	160	1,900
1,2-dichloroethane	34,000,000	10
dichloromethane	42,000	20

Remediation Design

GW extraction in plume

Biostimulation in source

SVE in source



Project Result

Well	Date	DCM	Benzene	1,2 DCA	Toluene
P21	Aug 09	20,320	7,143	159,910	4,593
	Dec 09	49	20	271	10
	March 10	223	72	1028	35
	July 10	<d	18	70	<d
	nov-10	NA	96	NA	44
	March 11	706	190	2,545	140
	oct-11	149	26	1,525	11
	sep-11	63	95	1,500	69
	Dec 11	108	272	376	250
	jun-12	19	11	500	6
	aug 12	<d		35	
	sep-12	<d	<d	19	<d
	Dec-12	<d	<d	<d	<d

Project Result

- After 2,5 years active remediation ended
- Currently monitoring of the result 1 year, still all results are good.

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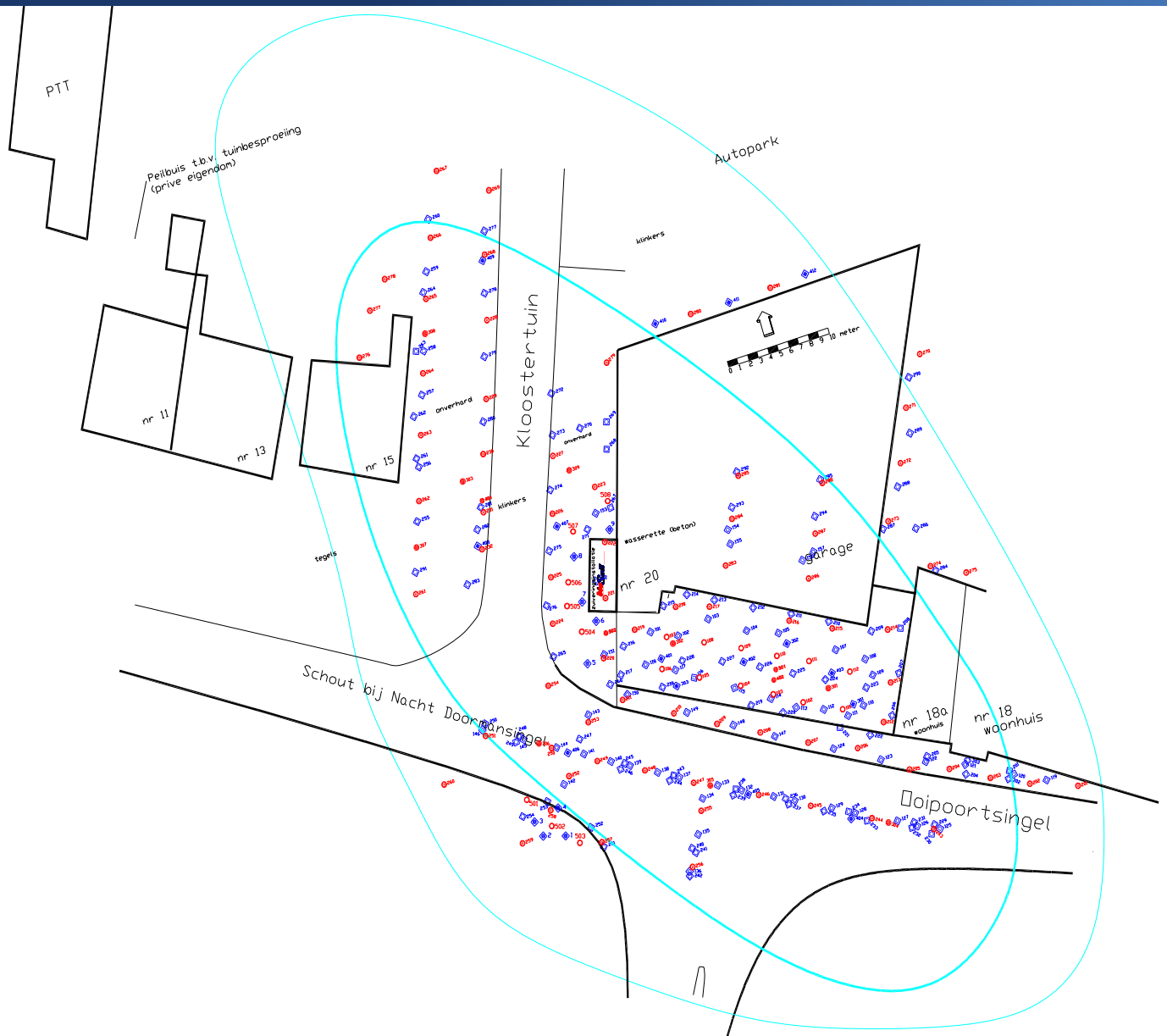
Case 3: Doesburg, the Netherlands

Project description

- Historical contamination of soil and groundwater with mineral oil and volatile organic carbons VOC
- Mainly Petrol and Diesel
- Free Phase LNAPL
- Soil structure sand and clay layer

T-Value	Soil (mg/kg)	Groundwater (µg/l)
TPH	500	325
Benzene	0.1	15
Toluene	13	500
Ethylbenzene	5	75
Xylene	2.5	35

Remediation design



Project Result

- After 3 years Groundwater < d
- Soil : 1.400 mg/kg Diesel.
- Remediation formally ended since no risk for spreading.

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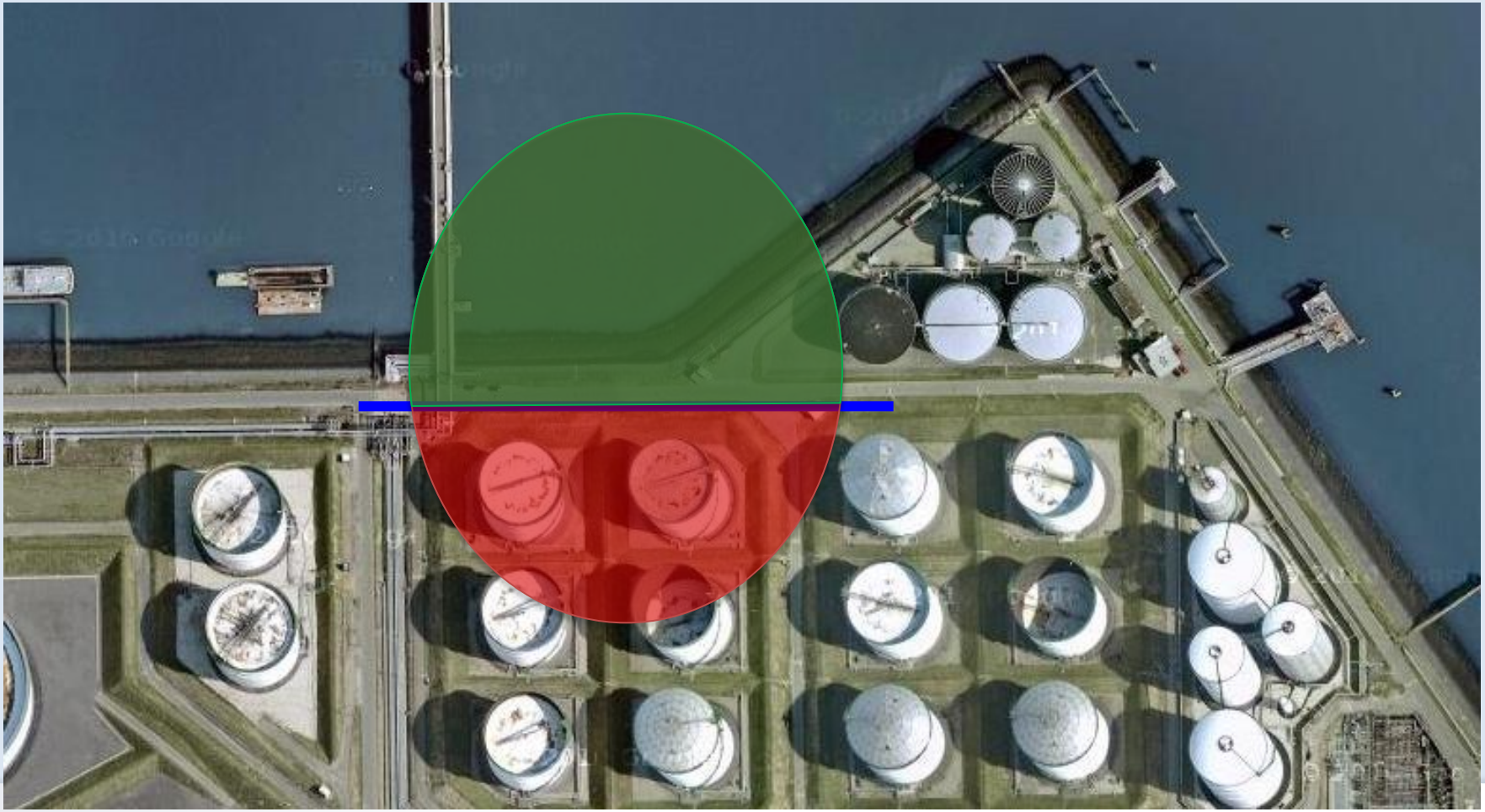
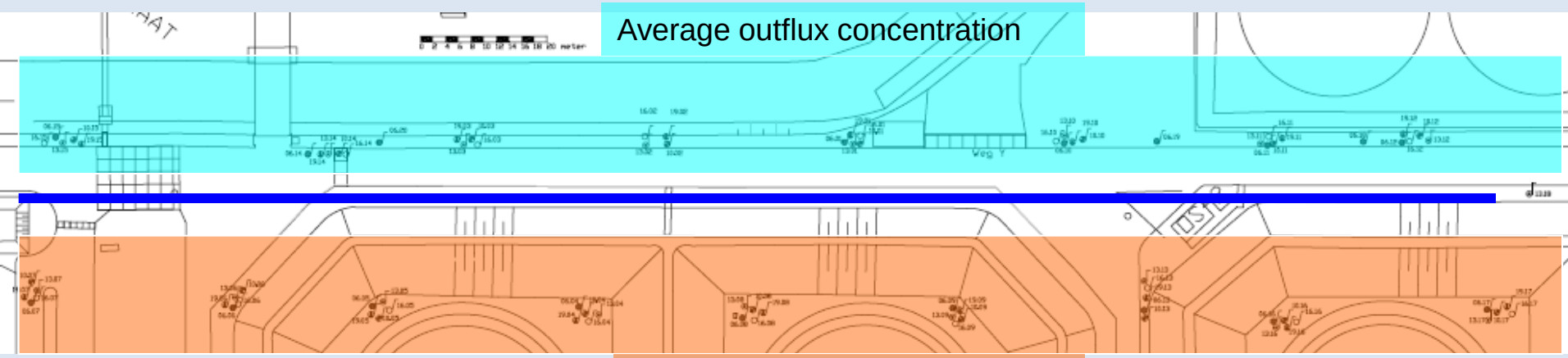
Aerobic Bioscreen

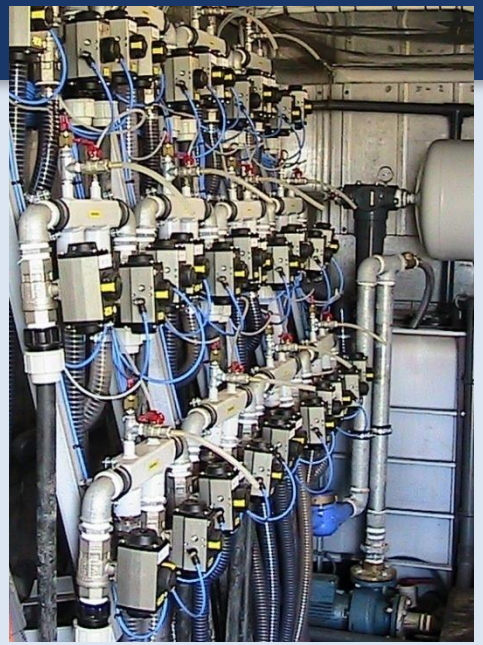
Location bioscreen and contamination

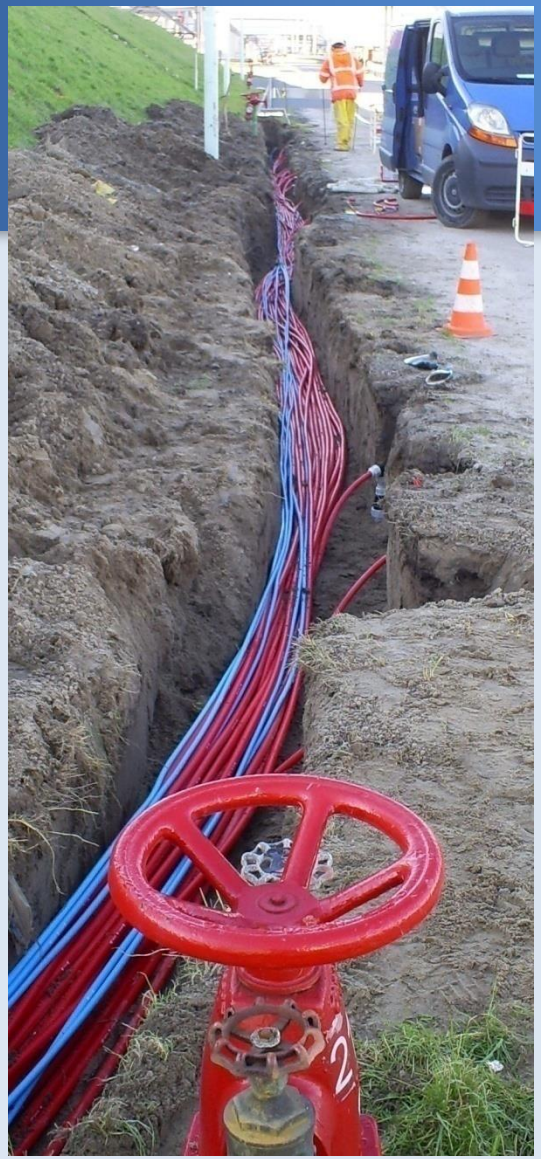


Monitoring effectiveness of the screen



Pictures

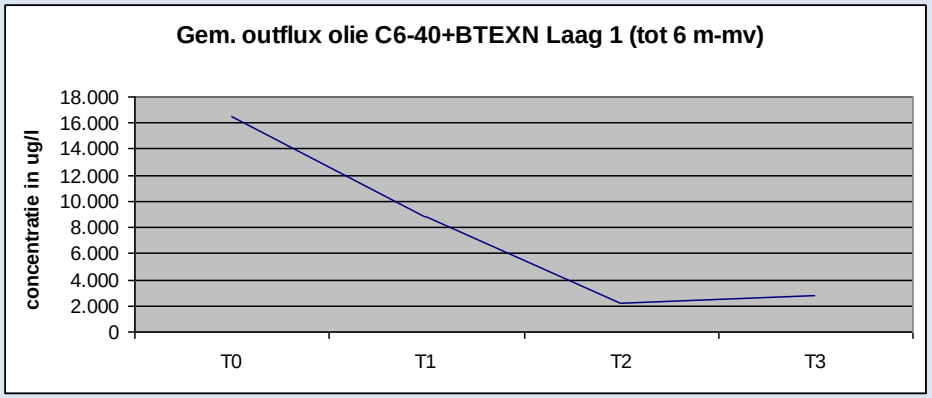


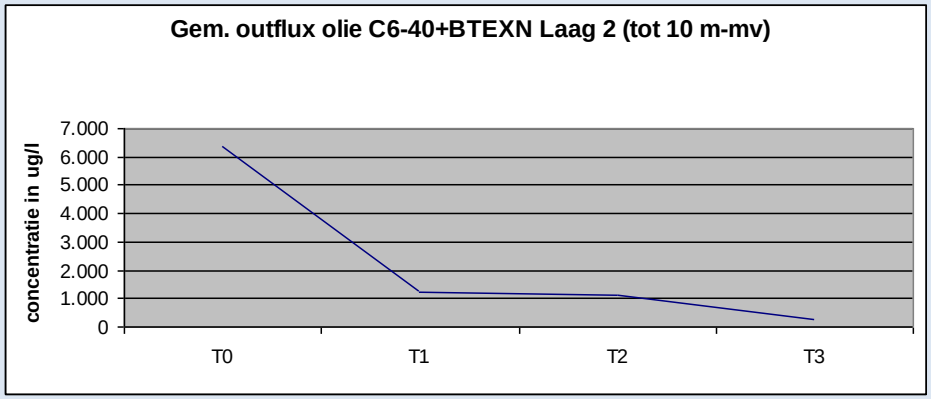


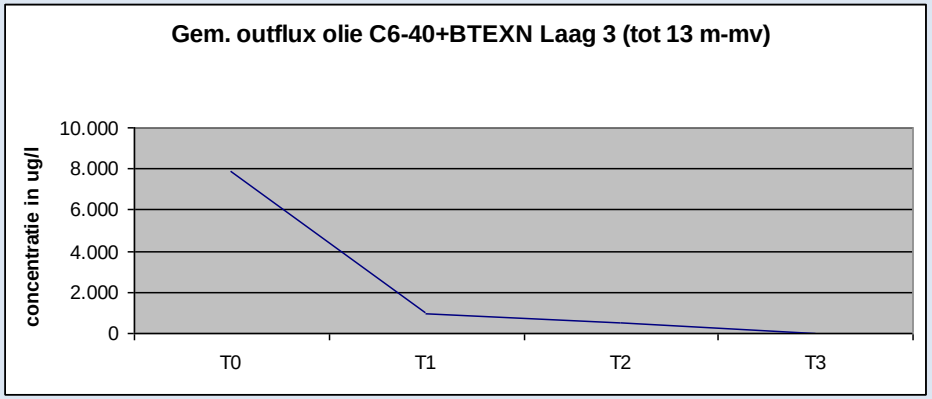
Result influx versus outflux

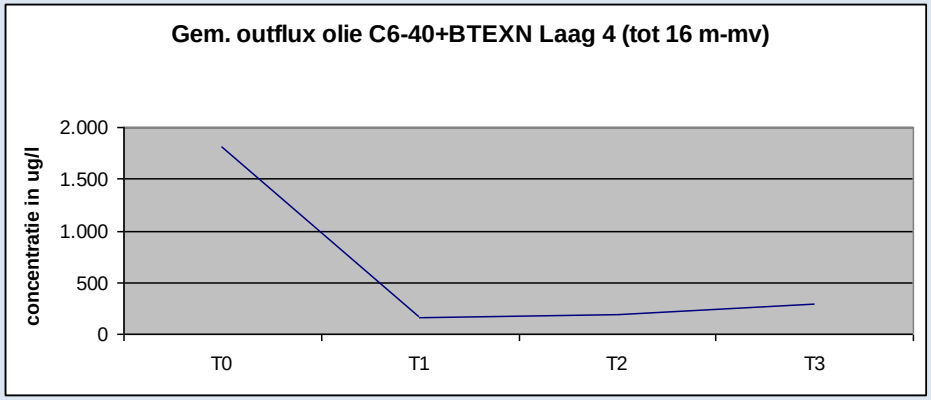
		bemonst. tijdstip	gem. influx olie+BTEXN µg/l	gem. influx af-/toename	gem. outflux olie+BTEXN µg/l	gem. outflux af-/toename	Saneringsrendement op olie C6-40 + BTEXN influx versus outflux
Laag 1	06. - filters	T0	30.300		16.536		45%
		T1	32.187	+6,2%	8.815	-46,7%	73%
		T2	30.096	-6,5%	2.225	-74,8%	93%
		T3	38.773	+28,8%	2.814	+26,5%	93% ←
Laag 2	10. - filters	T0	1.168		6.384		-447%
		T1	2.327	+99,3%	1.251	-80,4%	46%
		T2	2.421	+4,0%	1.136	-9,2%	53%
		T3	4.769	+97,0%	293	-74,2%	94% ←
Laag 3	13. - filters	T0	2.759		7.876		-185%
		T1	2.648	-4,0%	953	-87,9%	64%
		T2	3.143	+18,7%	520	-45,4%	83%
		T3	3.867	+23,0%	35	-93,3%	99% ←
Laag 4	16. - filters	T0	2.949		1.812		39%
		T1	1.698	-42,4%	157	-91,3%	91%
		T2	1.498	-11,8%	195	+24,3%	87%
		T3	2.731	+82,3%	289	+47,8%	89% ←
Laag 5	19. - filters	T0	1.878		12		99%
		T1	308	-83,6%	3	-77,9%	99%
		T2	100	-67,5%	142	+5438,1%	-42%
		T3	1.580	+1474,7%	76	-46,5%	95% ←

Concentration decrease behind the bioscreen









T0 =	januari	2009
T1 =	augustus	2009
T2 =	december	2009
T3 =	april	2010

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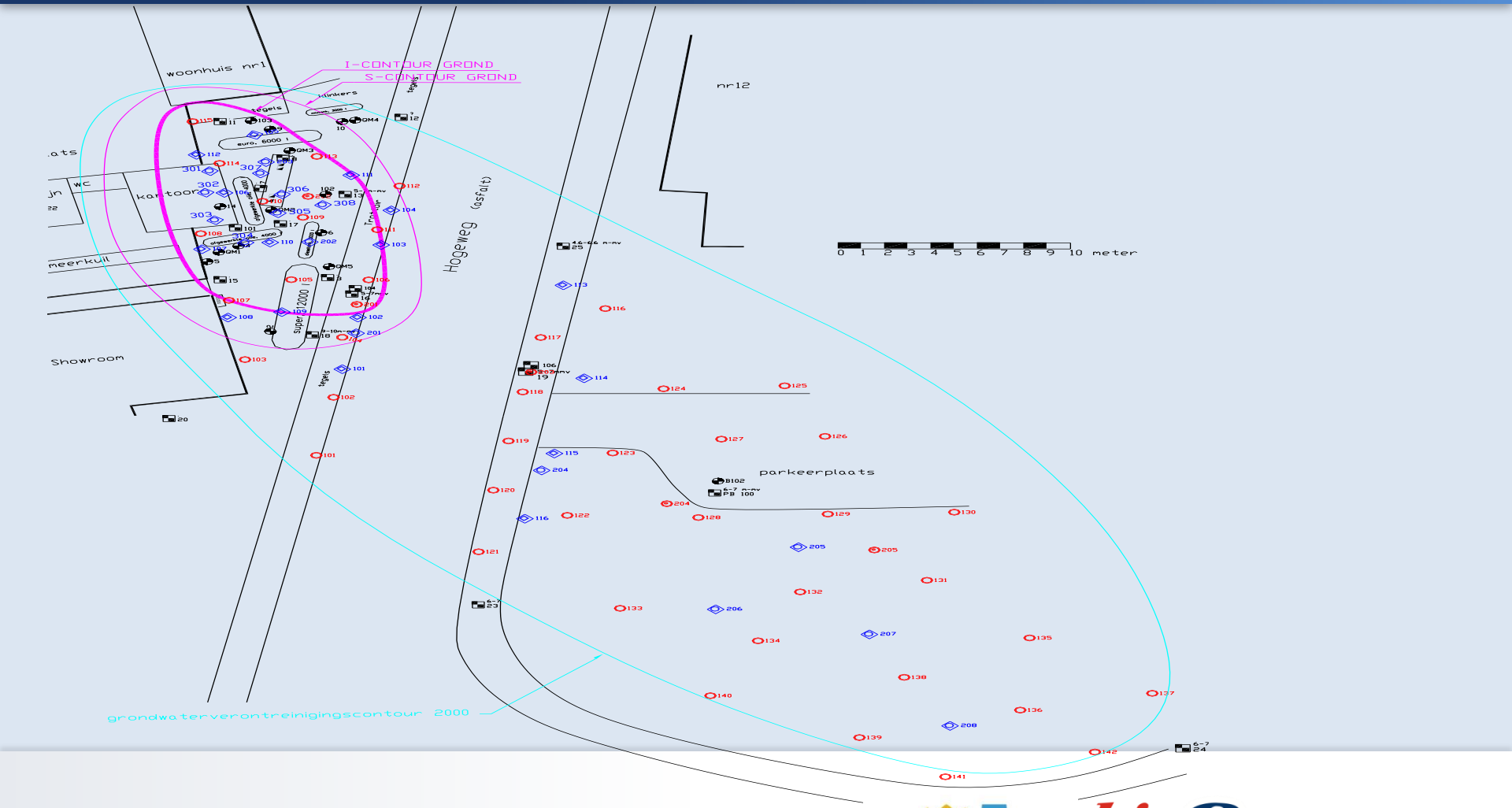
Case 5: Velp Hogeweg, the Netherlands

Project description

- Historical contamination of soil and groundwater with mineral oil and volatile organic carbons VOC
- Soil: 2,300 mg/kg TPH ; 710 mg/kg BTEX
- GW: 5,100 µg/l TPH ; 21,500 µg/l BTEX
- Soil structure sand
- Large groundwater plume

T-Value	Soil (mg/kg)	Groundwater (µg/l)
TPH	500	325
Benzene	0.1	15
Toluene	13	500
Ethylbenzene	5	75
Xylene	2.5	35

Remediation Design



Project Result

- After 2 years Groundwater << T- value just above detection limit.
- After 2.5 years Soil << T-value just above detection limit