



In-Situ Remediation of DNAPL Source and Plume at an Active Industrial Facility with Innovative Enhanced

Reductive Dichlorination Technology



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- Dry Cleaning / Repair Shop site active since the 1960s
- Excavation remediation in 2003 / 2004
- Pump & Treat active for 5 years
- Air/Bio Sparging active for few years post excavation works, then discontinued
- PCE plume forcing private house holders 2 km downgradient to discontinue pumping wells in their gardens



Ejlskov End to End Plan





3. Active Remediation

- Conduct remediation / injection works
- Use of RDC data allows for efficient use of remediation budget

4. Performance Monitoring

• Soil and groundwater data to be compared against baseline values based on agreed monitoring programme







MIP Investigation

- Regular and Low Level MIP used to assess lateral and vertical extent of contamination
- MIP screening allowed to identify source zone located in area totally unknown to client and secondary off-site minor source zone
- Follow up soil sampling and GW wells installation based on MIP profile – TARGETED EFFORT









PCE Soil and MIP Data Interpolation









Injection works completed between April and August 2017. A total of 702 injection points were completed across subareas A through E.

Approx. 52,000 Kg of CAT100 (incl. 1,600 kg of BOS100[®]) were installed

SOIL	SUBAREA ID	AREAL EXTENT	PCEMA
	JUDARLAID	(m2)	FCL MA
TTE	AREA A	350	16,0
	AREA B	500	25
	AREA C	250	15
No to	AREA D	800	1,0
	AREA E	250	50
ı/I ∞			
,000	R C	MW-61	
,000	E MW-60	X002 H2T MW-62	C.F.T
,000		MW-25	
100	MIV/465	W64 MVV-63	
10		MW-23	
	HP109B	NV-66	
MW41			
	MW-33B		Constant of
MVV40	MW-9B		-
	HP110C		2-3
MW18	MW15 HP128		
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BOS 100[®] - Degradation of Chlorinated Solvents

- Contaminants dissolved in groundwater are absorbed to the carbon based on carbon maximum absorption capacity
- PCE and TCE have higher absorption affinity then DCE and VC
- As mother products are degraded \bullet to daughter products, absorption availability is generated for more dissolved phase contamination to be absorbed





- Complete degradation to non-toxic ulletend products is achieved
- Dissolved gases typically observed in ulletgroundwater samples are Ethylene, Acetylene and Chloride
- Trap and Treat[®] effect will last until • ZVI is available (IMPORTANCE OF REMEDIAL DESIGN)





CAT100 - Biodegradation of Chlorinated Solvents

- Contaminants dissolved in groundwater are absorbed to the carbon based on carbon maximum absorption capacity
- Within initial months after installation abiotic conditions will be predominant
- As starch is degraded to simpler • carbohydrates, CVOCs reductive bacteria start ERD processes increasing the generation of daughter products





- High concentrations of mother \bullet products (PCE/TCE) generally fall drastically after ERD conditions start prevailing (except DNAPL)
- Monitoring of DCE and VC in groundwater is a balance of residual mass of mother products available and carbon absorption
- As mother products will be fully \bullet treated, DCE and VC concentrations will decrease to non-detect



Installation / Injection Features – Key to success



- Mixing of slurry on site
- Top down injections one for every 0,5-0,6 meter
- Injections pressure up to 90 bar and flow up to 260 lpm
- High pressure allows for soil separation (clayey soils)
- High flow leads to turbulent mixing (sandy soils)
- Injection Hoses no loss of product in rod joints





WHY NOT LOW FLOW

- Pressure, Flow, Exit Velocity
- Injection Volumes
- Distribution
- Sand vs. Clay Formations



y 0,5-0,6 meter nd flow up to 260 lpm ation (clayey soils) g (sandy soils) ct in rod joints

	INJECTION	
	PRESSURE RESPONSE: <> RAPID SPIKE	
	< B> SLOW TO MOD DECLINE	ERATE
	< STABILIZATION	N
C	>	
IME (MINS)	>	
VELOPED WELLS		
P	PRESSURE: RAPID SPIKE →SLOW TO MODERATE DECLINE → STABILIZATION	
	FIGURE 7A	SCALE: N.T.S

Flow follows path of least resistance

No control over injectate location

Very poor distribution likely

ROI Unknown









Injection evidence















GW control program planned until end of 2022. Interim target is to bring PCE values at site boundary around 20-50

100

10,000

1,000



PCE Plume (Pre- and Post Injection)

December 2020







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Ethylene Plume Development (Pre-and Post Injection)



Mass Removal vs. Biological Evidence

DNAPL Trends - MW27



PCE Concentrations found in Soil at 50-60,000 mg/kg

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DNAPL evidence MW27 soil core

MW27 (Biological Activity) 2000 200 **INJECTION** PERIOD 1800 180 1600 160 (Ethylene) 1400 mg/l (Acetate) 1200 120 1000 100 (Chloride) 800 mg/| 600 60 400 200 20 0910612020 12020 12020 12020 12020 1610912019 02122019 020 0 0 1210912018 1212018 2710312019 1210612019 2210712027 03/04/2017 0710512017 04/06/2017 13/11/2017 30101/2018 21/03/2018 0510612018 0910812017 1910912017







Groundwater Trends CVOCs, fatty acids, dissolved gases





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Source Zone



Groundwater Trends CVOCs, fatty acids, dissolved gases

MW-65



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Plume downstream of source zone





Molar Mass Evaluation

















THANK YOU FOR YOUR TIME

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