Remediation Strategy
for Dover AFB SMU Area 2 And Area 9

South Management Area (Area 2 and Area 9) at Dover Air Force Base

Oak Ridge National Laboratory's (ORNL) Environmental Sciences Division (ESD) in conjunction with Dover Air Force Base and URS has successfully implemented in situ AAB to treat chlorinated solvents within the shallow water table near an old release site at DAFB. At SS07 the primary contaminants of concern are TCE and PCE (Table 1.)

The plumes (Area 2 and Area 9) are located in DAFB's South Management Area Unit (SMU). In the SMU contamination is greatest around the SS07 site with an area in yellow that has a chlorinated aliphatic hydrocarbon (CAH) contour of 500 ug/L volatile organic compounds (figure 1.) The rest of the plumes, highlighted in green have a CAH contour of 5 ug/L (Fig 1.). Natural Biodegradation is occurring in all the plumes but the rate of bio-degradation in SS07 appears to be insufficient to prevent migration beyond the Base boundary at levels exceeding EPA's Maximum Concentration Levels (MCL's).

Remediation Strategy

The strategy concept to remediate Area 2 and Area 9 is based on a two prong approach combining an aggressive and passive method.

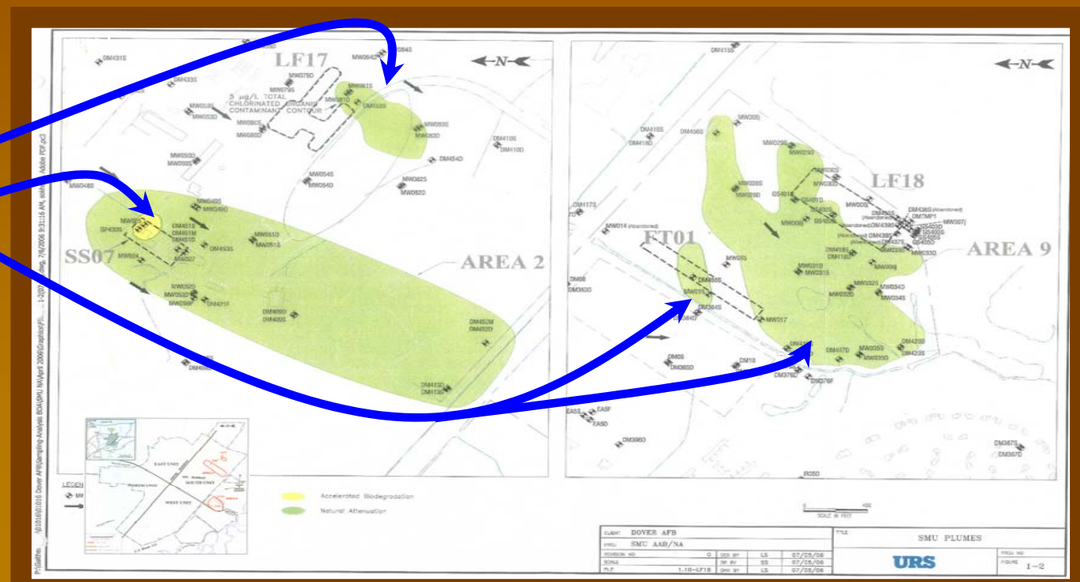
Accelerated Anaerobic Biodegradation (AAB) invokes an aggressive method and will be used to treat groundwater contaminants within the SS07 plume exceed 500 µg/L (Figure 1). The AAB treatment objective is to enhance the natural microbial activity that reductively dechlorinates chlorinated solvent contaminants, thus reducing the overall time required to reach MCLs within the Area 2 plume. To achieve this environment, a persistent carbon substrates (emulsified vegetable oil) , a readily available short lived carbon source (sodium lactate) and metabolic nutrients (dibasic ammonium phosphate, DAP) were added to potable water in sufficient quantities to provide 1750 mg/L of total organic carbon (TOC) for the source area.

Natural Attenuation (NA)
NA invokes a passive approach and relies on the naturally occurring biological and physical processes to reduce contaminant toxicity, mobility, or volume to levels that are protective of human health and the environment. NA will be used to reduce contaminant concentrations at all 4 sites except the small area near the source in SS07.

Assessing the Performance of the Remedial Strategy

Groundwater samples are collected from the monitoring well network consisting of 41 wells in Area 2 and Area 9 to assess the performance of the Carbon Substrate injections and to provide data on both AAB and NA effectiveness. Groundwater samples will be analyzed for AAB indicators (e.g., dissolved oxygen, oxidation-reduction potential, iron) and VOCs such as TCE, PCE, Cis-1,2-DCE and vinyl chloride.

SS07 Source Area and Plume in Area 2.



Contaminants In Area 2 and Area 9

Contaminant	LF17	SS07	FT01	LF18	RAO* (ug/L)
Benzene	X		X		5
Chlorobenzene			X		100
Cis-1,2-DCE	X	•		•	70
PCE	X	X		X	5
TCE	X	X		X	5
Vinyl Chloride	X	•		•	2

X - COC present at this site.
• - Potential COC due to the breakdown of other COCs.
*RAO is the federal MCL (EPA 816-F-03-016)

Table 1. Quantatative Groundwater RAOs in the South Management Area.

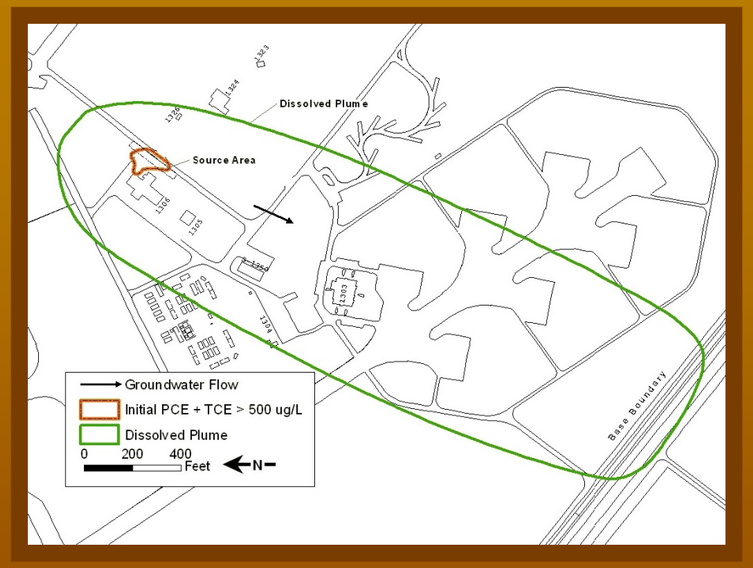


Figure 2.

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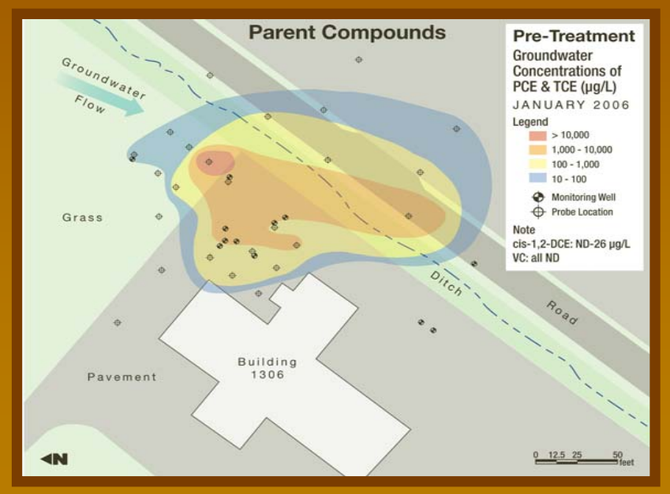
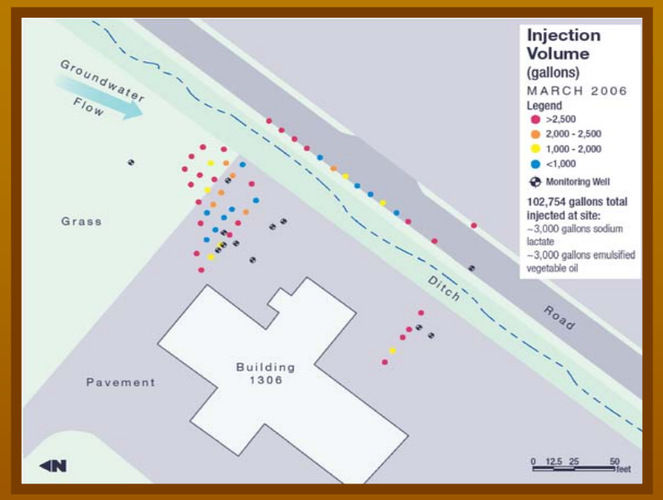
Assessment of AAB In the SS07 Plume
for Dover AFB SMU Area 2

PCE and TCE concentrations before Accelerated Anaerobic Biodegradation in Source area of SS07.

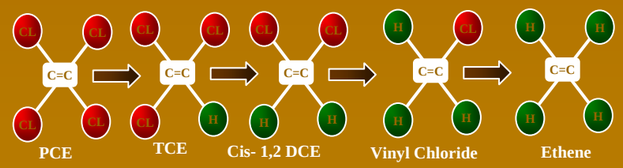


Distribution of injectate was not uniform due to aquifer heterogeneity.

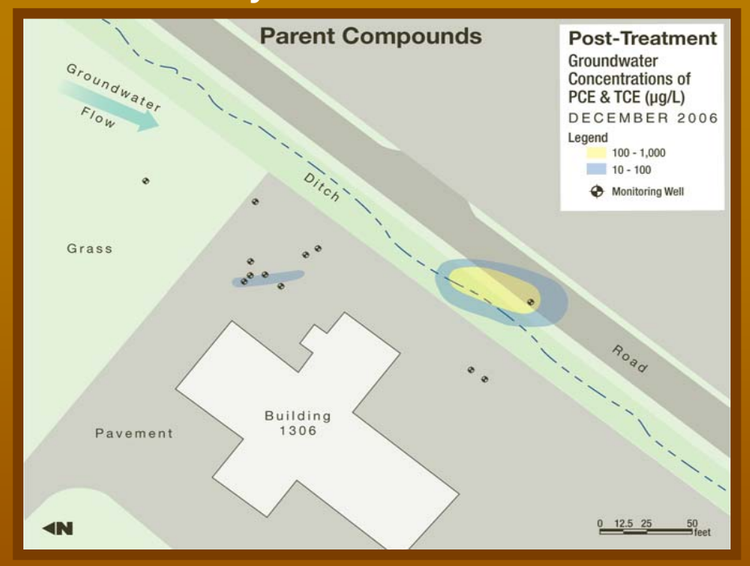


The Accelerated Anaerobic Biodegradation (AAB) treatment objective is deemed effective when geochemical conditions are conducive to reductive dechlorination of Chlorinated Aliphatic Hydrocarbons (CAH). Ultimately decreasing CAH concentrations over time will indicate effective AAB treatment.

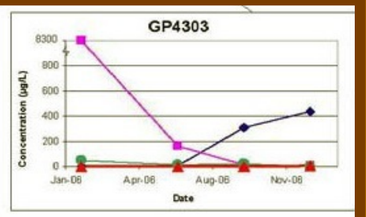
Reductive Dechlorination of Contaminants is a stepwise process of chlorine atom replacement with Hydrogen via oxidation-reduction (redox) reactions. PCE degrades to TCE, which degrades to DCE, which degrades to VC which degrades to ethene.



PCE and TCE Concentrations after a year of AAB treatment.

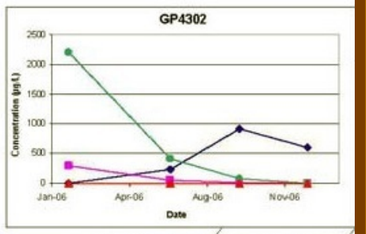


Indicators of an favorable environment for Reductive Dechlorination



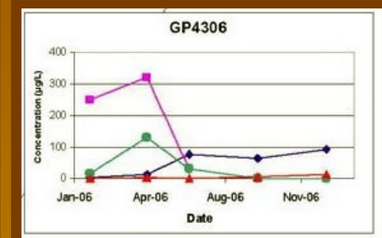
INDICATORS	DO mg/L	Iron mg/L	ORP mV	Sulfate mg/L
Feb-06	7.23		276	14.6
Apr-06	0.57	4	150	51.4
Apr-06	3.4	6	68.8	35.3
May-06	1.03	5	-47.3	20
Jun-06	1.53		40.9	10.6
Jul-06	2.11	30	26.7	5.03
Aug-06	0.5	80	-0.8	ND
Sep-06	1.8	60	268	ND
Dec-06	0.62	90	-42	ND

Dissolved Gases	Ethane µg/L	Ethene µg/L	Methane µg/L
Feb-06	ND	ND	0.8
Jun-06	0.77	2	4.7
Sep-06	0.76	1.2	240
Dec-06	ND	0.93	3700



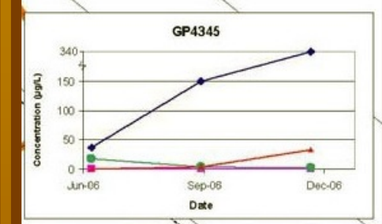
INDICATORS	DO mg/L	Iron mg/L	ORP mV	Sulfate mg/L
Feb-06	7.77	0.1	192.2	13.7
Apr-06	0.35	1.5	52.6	15.2
Apr-06	0.45	5	3.7	14.2
May-06	0.49	25	-115.7	5.59
Jun-06	0.46		-65	2.49
Jul-06	1.63	20	7	1.67
Aug-06	1	36	-58.7	ND
Sep-06	2	50	-39.1	1
Dec-06	0.28	112	-54.5	ND

Dissolved Gases	Ethane µg/L	Ethene µg/L	Methane µg/L
Feb-06	ND	0.61	1.5
Jun-06	ND	ND	2.2
Sep-06	ND	ND	270
Dec-06	ND	0.82	9900



INDICATORS	DO mg/L	Iron mg/L	ORP mV	Sulfate mg/L
Feb-06	2.21	0.6	72.9	13.7
Apr-06	0.31	10	16.1	47.2
Apr-06	0.78	21	-13.7	33.9
Jun-06	1.04	20	-57.7	1.23
Jul-06	1.49	50	-19.9	2.37
Aug-06	1.73	90	-15.9	ND
Sep-06	0.96	60	204.5	ND
Dec-06	0.4	45	-76.7	1.4

Dissolved Gases	Ethane µg/L	Ethene µg/L	Methane µg/L
Feb-06	ND	ND	1300
Apr-06	ND	0.72	2300
Jun-06	ND	0.99	3100
Sep-06	ND	0.73	5000
Dec-06	4.9	26	6000



INDICATORS	DO mg/L	Iron mg/L	ORP mV	Sulfate mg/L
Feb-06	2.21	0.6	72.9	
Apr-06	0.31	10	16.1	9.15
Apr-06	0.78	21	-13.7	1.07
Jun-06	1.04	20	-57.7	1.3
Jul-06	1.49	50	-19.9	0.547
Aug-06	1.73	90	-15.9	ND
Sep-06	0.96	60	204.5	ND
Dec-06	0.4	45	-76.7	ND

Dissolved Gases	Ethane µg/L	Ethene µg/L	Methane µg/L
Jun-06	ND	ND	59
Sep-06	ND	0.82	5700
Dec-06	ND	38	8200

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