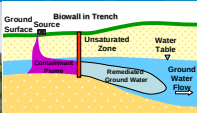




Sustainability of TCE Removal in the Mulch Biowalls at Altus AFB

John T. Wilson, U.S. Environmental Protection Agency
Hai Shen, U.S. Department of Energy
Cherri Adair, U.S. Environmental Protection Agency
John Skender, Independent Contractor



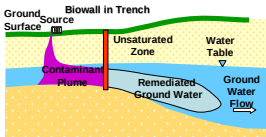
April 9, 2010/ 13:55-14:35

Office of Research and Development
National Risk Management Research Laboratory, Ground Water and Ecosystems Restoration Division



Special Thanks to Bruce Henry and staff of Parsons, Denver CO, who designed and built the Mulch Biowall.

1



U.S. EPA GWERD at Kerr Center in Ada, OK is contributing to a performance evaluation of mulch based biowalls to treat TCE contamination in ground water at Altus AFB, OK.

	Old Technology <i>Pump and Treat</i>	New Technology <i>Passive Reactive Barrier (Biowall)</i>
Approach	Pump out contaminated water and treat with activated carbon	Let the plume flow naturally through a trench filled with sand and shredded tree mulch
Anticipated Time Required	43 years	15 years
Estimated Cost	\$39.4 million	\$6.7 million

2

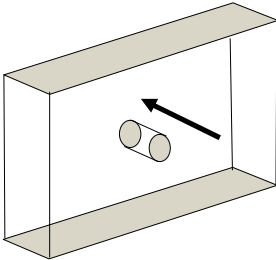


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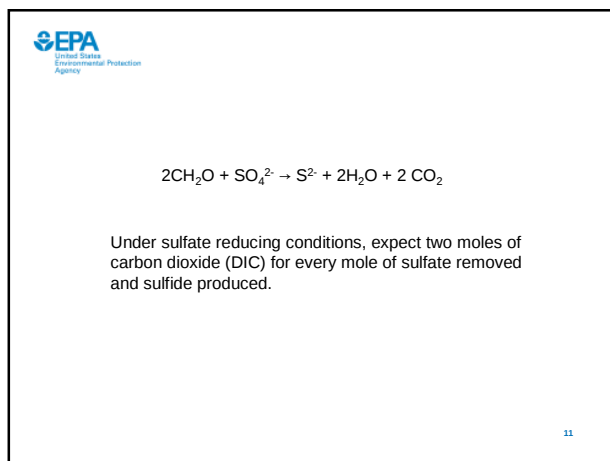
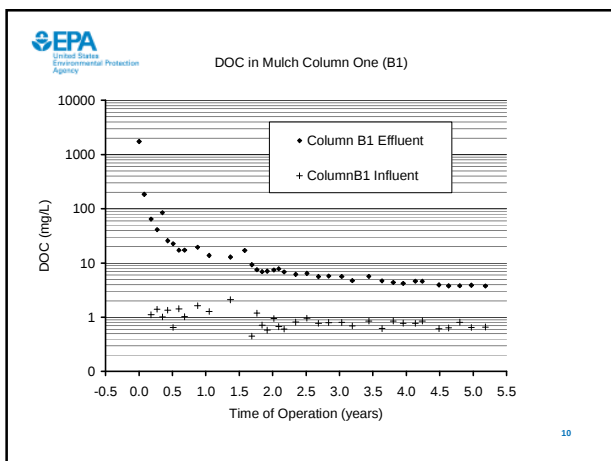
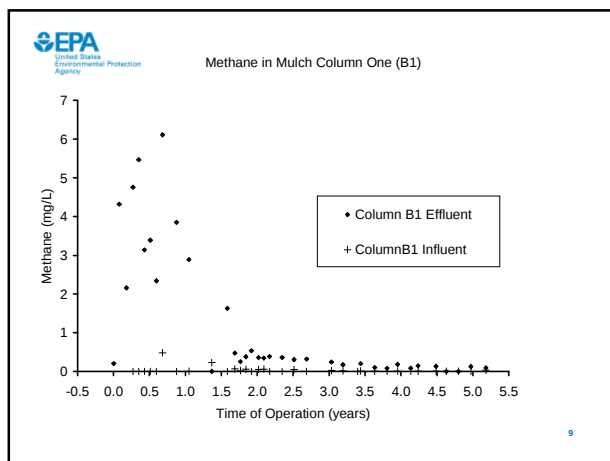
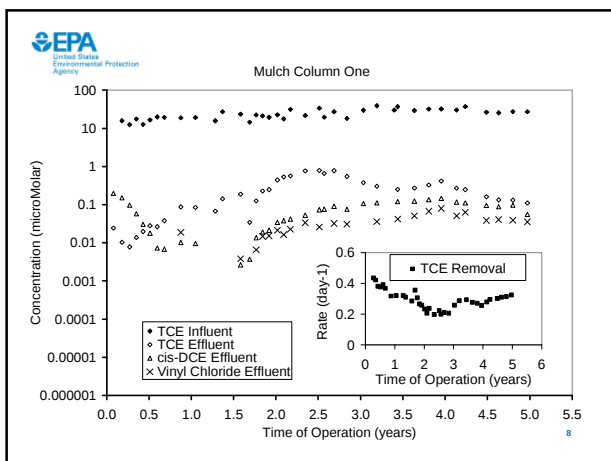
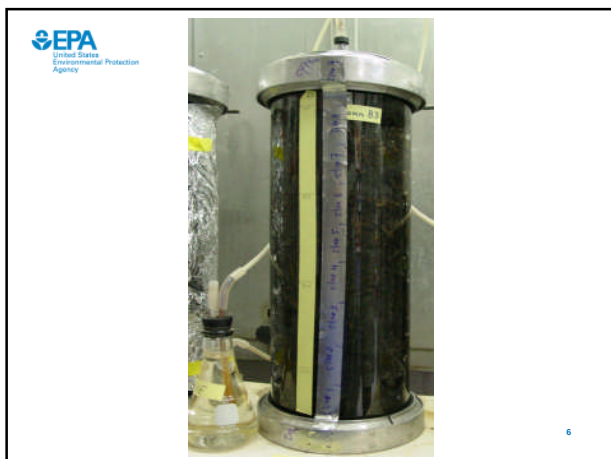


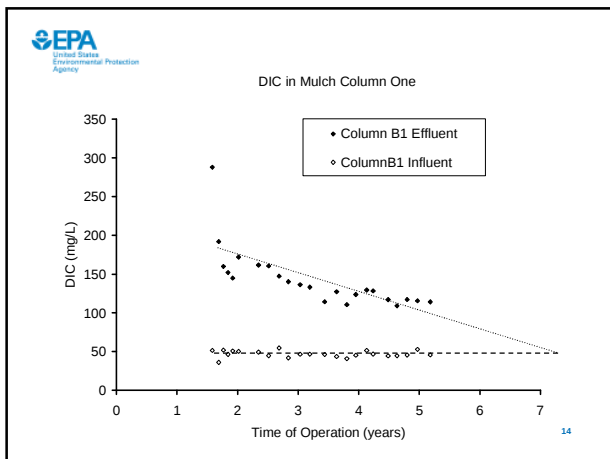
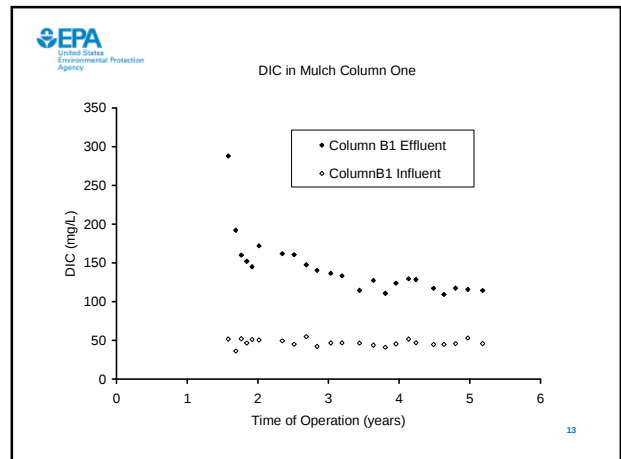
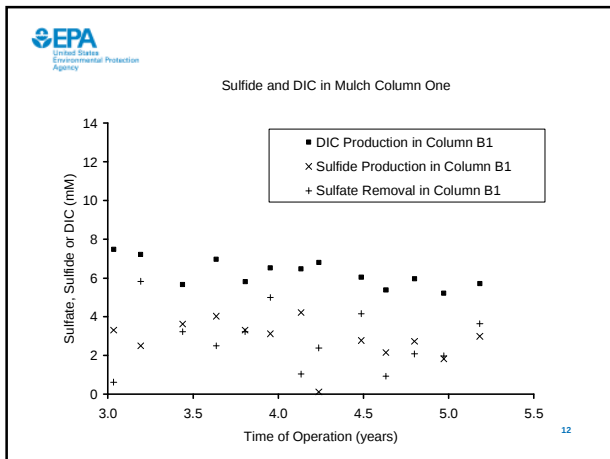
Sustainability in a Laboratory Column that Simulates the Mulch Biowalls.

4



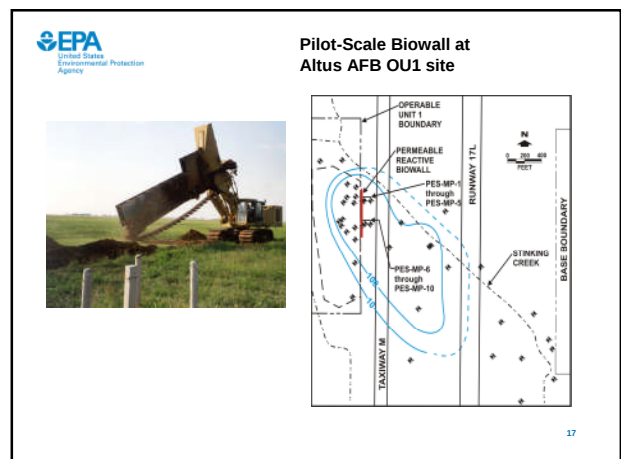
5





Based on behavior in the laboratory, TCE degradation has been sustained for at least five years, and might last for a few more years. After two years, most of biodegradation is sulfate reduction. This is important because the sulfide that is produced can produce or sustain iron sulfide minerals (FeS) in the biowall, which will provide an abiotic component of TCE removal.

Sustainability at field scale in the OU-1 Mulch Biowall at Altus AFB.





Constructed June 2002

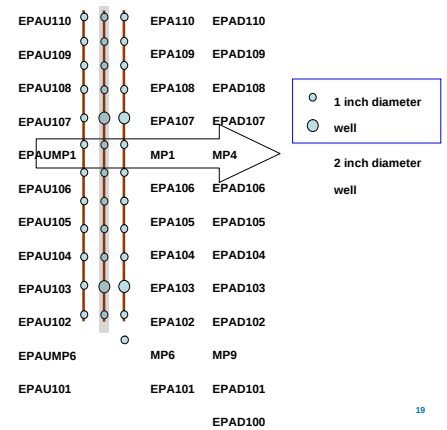
455 feet long, 24 feet deep, 1.5 feet wide

300 cubic yards tree mulch

60 cubic yards composed cotton gin trash

265 cubic yards sand

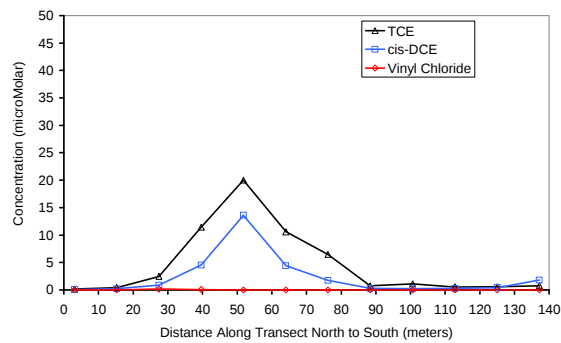
18



19



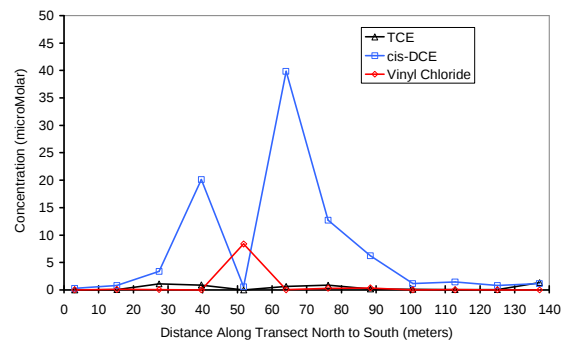
Up Gradient January 2005 after 2.6 Years of Operation



20



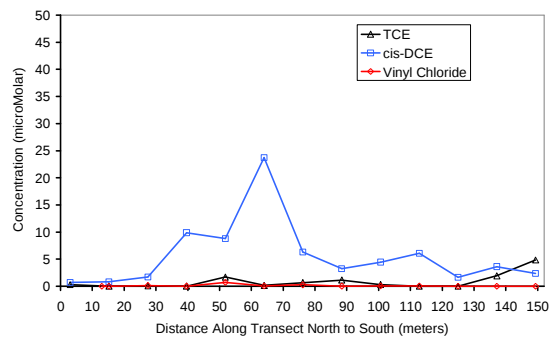
In Biowall January 2005 after 2.6 Years of Operation



21



Down Gradient January 2005 after 2.6 Years of Operation



22



TCE 2004-2006

Location	Up Gradient	In Biowall	Down Gradient	Fraction Remaining
Meters North to South on Transect	ug/L	ug/L	ug/L	
64	1273	52	110	0.086
51	1171	17	101	0.086
39	1197	8	132	0.11

23

Hydraulic Gradient 0.003
Hydraulic Conductivity 8 to 20 feet per day

Estimate of Darcy Flow
0.024 to 0.06 feet per day

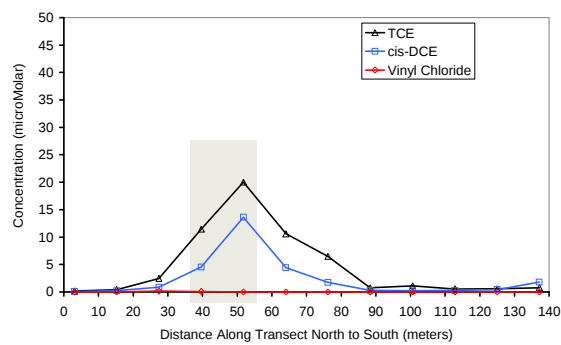
24

Bromide Tracer Test

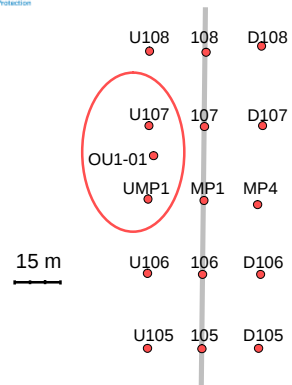
- Identify groundwater flow patterns around the biowall;
- Estimate hydraulic parameter values;
- Obtain TCE attenuation rate constant in the biowall.

25

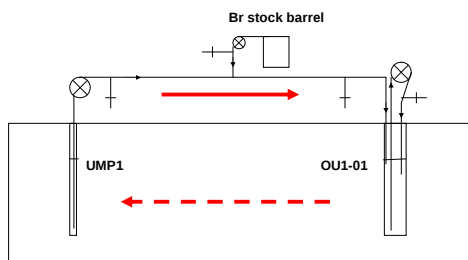
Up Gradient January 2005 after 2.6 Years of Operation



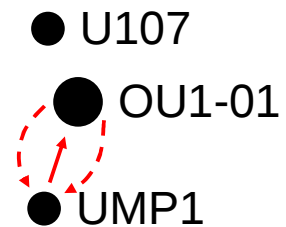
26



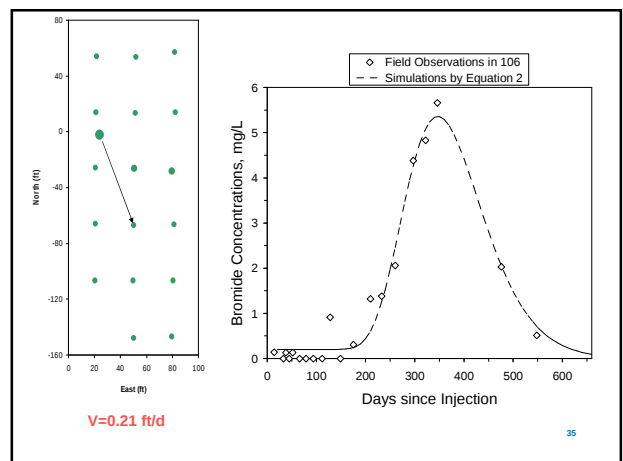
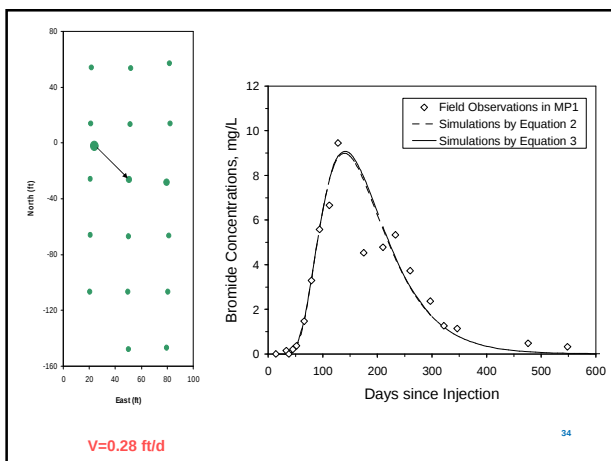
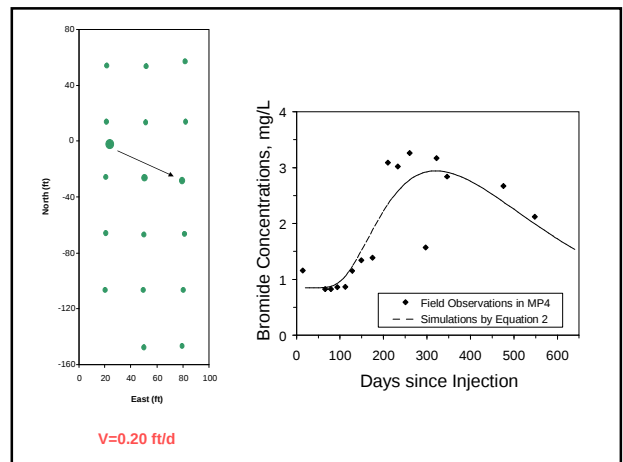
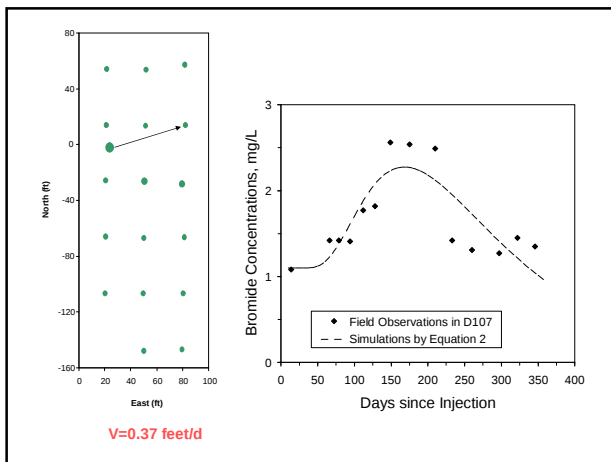
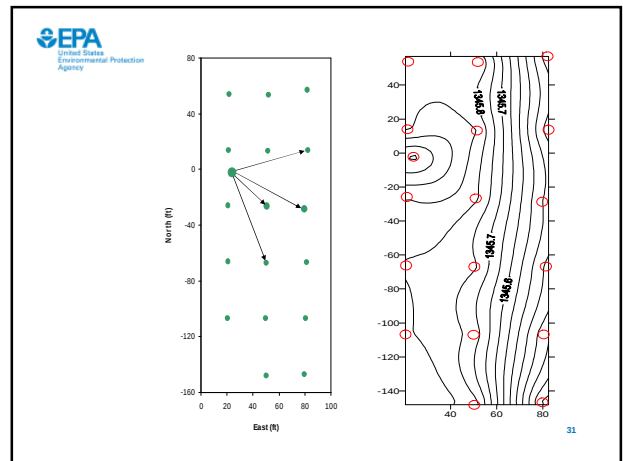
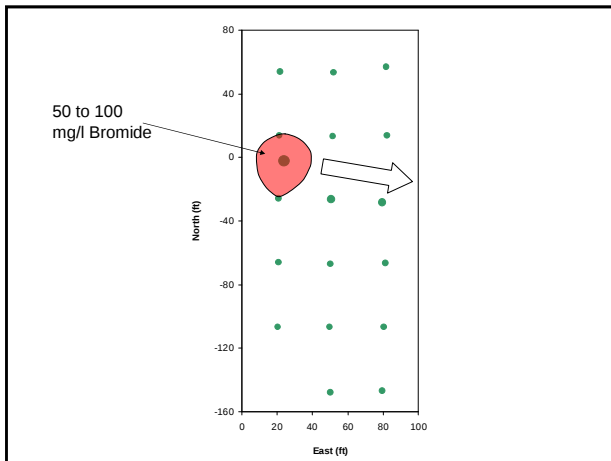
27



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Hydraulic Gradient 0.003
Hydraulic Conductivity 8 to 20 feet per day
Effective Porosity 0.15

Estimate of Darcy Flow
0.024 to 0.06 feet per day

Estimate of Seepage Velocity
0.16 to 0.40 feet per day

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*Estimate of Seepage Velocity from Slug Test and
Hydraulic Gradient*

0.16 to 0.40 feet per day

Measured Seepage Velocity
0.20, 0.21, 0.28, 0.37 feet per day

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Measured Seepage Velocity
0.20, 0.21, 0.28, 0.37 feet per day
Assume 0.29 feet per day as best estimate.

If the effective porosity is 0.15,

Best estimate of Darcy Flow
0.044 feet per day

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The mulch averages 71% solids and 29%
water filled porosity.

At a Darcy Flow of 0.044 feet per day, the
seepage velocity would be 0.15 feet per day.

The biowall is 1.5 feet wide.

The residence time is 10 days.

39

$$C / C_o = e^{-kt}$$

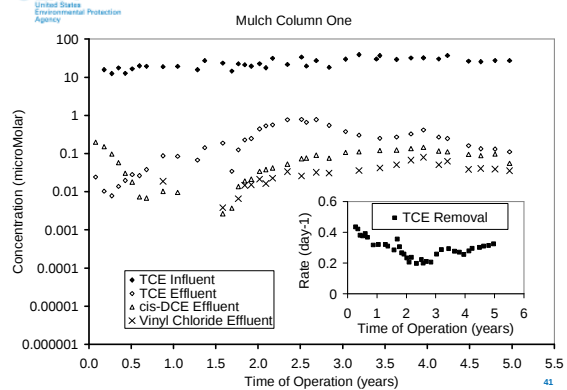
$$k = -\ln(C / C_o) / t$$

$$C/C_o = 0.11$$

$$t = 10 \text{ days}$$

$$k = 0.2 \text{ per day}$$

40



41

The initial rate of TCE removal in the field scale biowall was similar to the removal in the laboratory column that simulated the biowall.

How did that performance hold up over time at field scale?

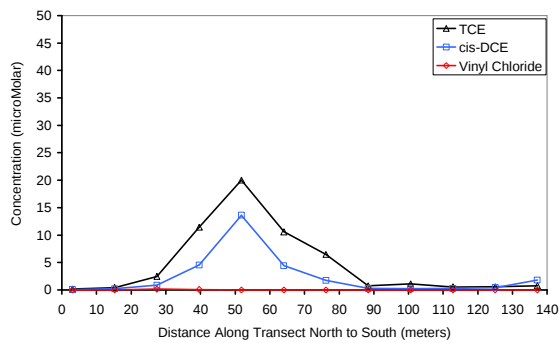
42

Measured Seepage Velocity
0.20, 0.21, 0.28, 0.37 feet per day

Travel time from up gradient wells to Biowall = 0.3 year.
Travel time from Biowall to down gradient well = 0.3 year.

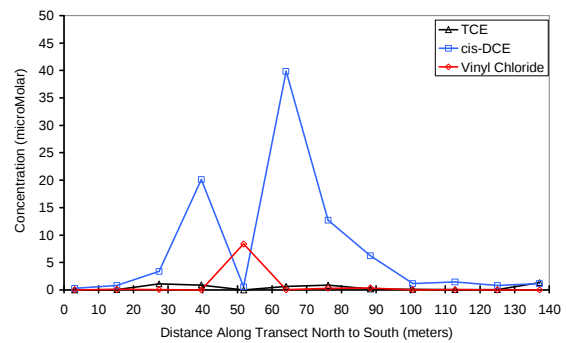
43

Up Gradient January 2005 after 2.6 Years of Operation



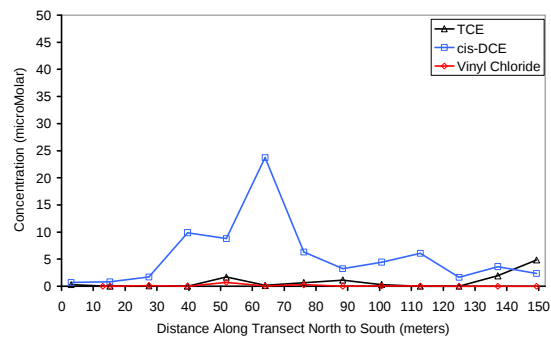
44

In Biowall January 2005 after 2.6 Years of Operation



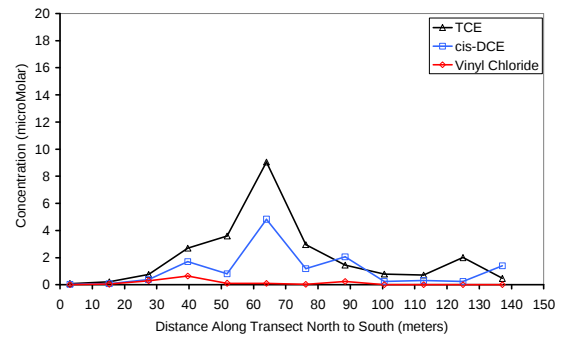
45

Down Gradient January 2005 after 2.6 Years of Operation

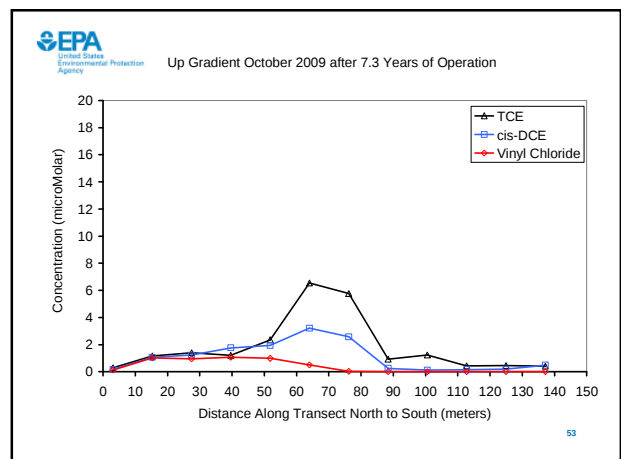
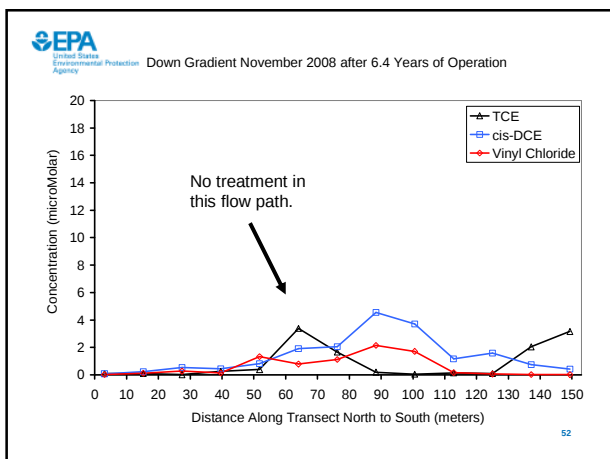
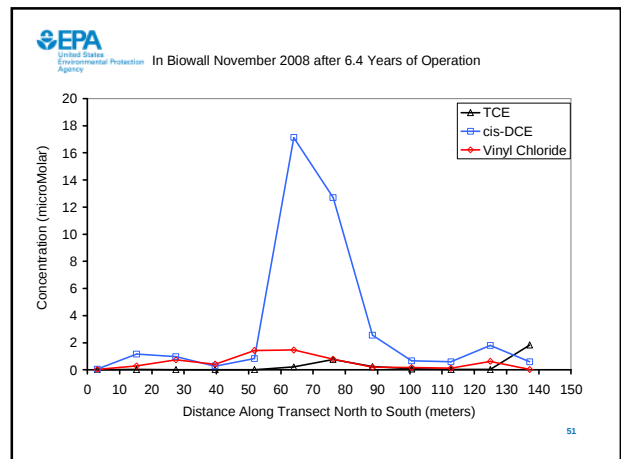
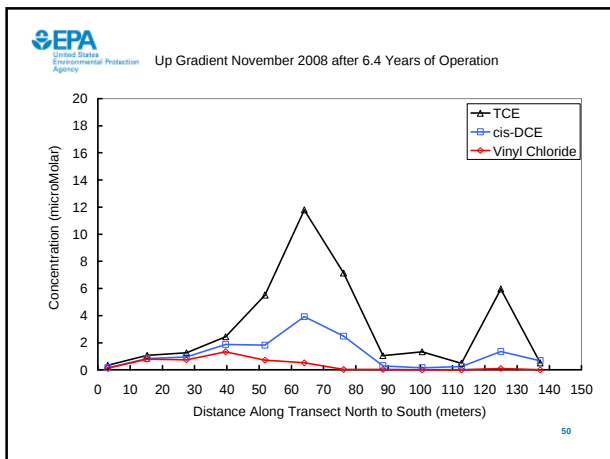
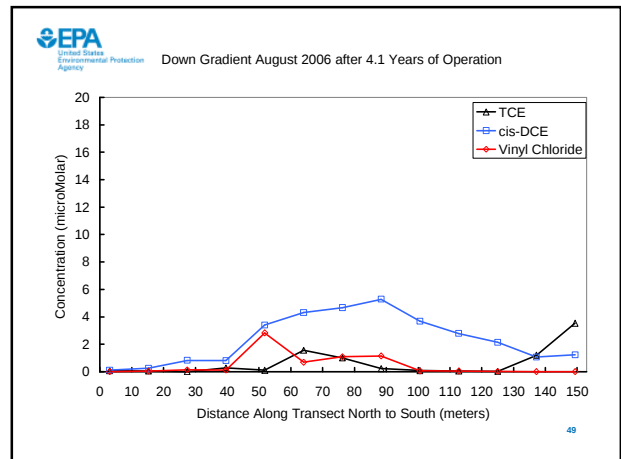
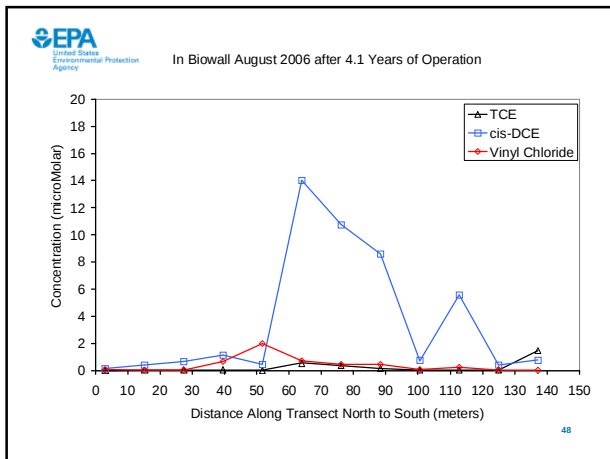


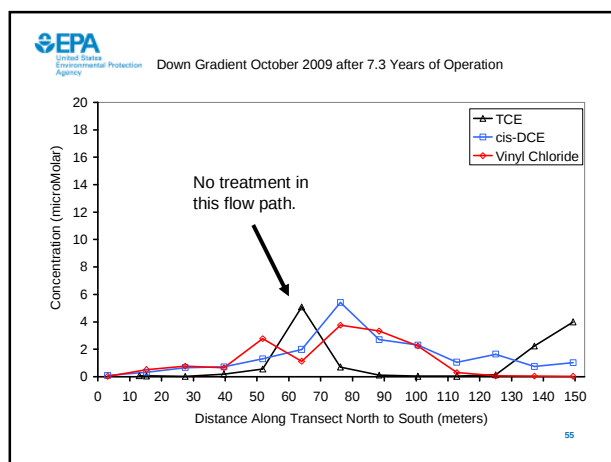
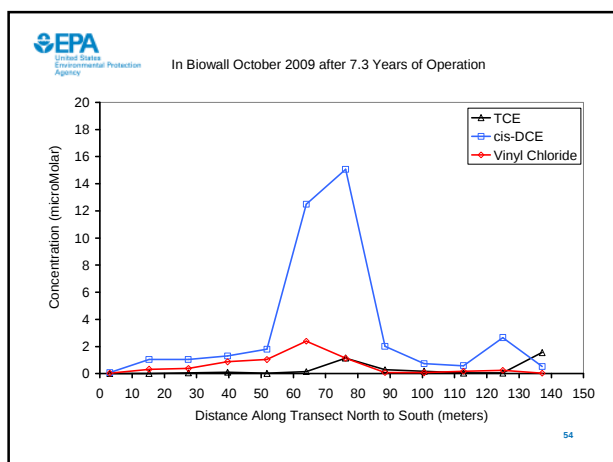
46

Up Gradient August 2006 after 4.1 Years of Operation



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EPA
United States
Environmental Protection
Agency

At field scale, treatment of TCE became ineffective along one flow path after 6 years of operation.

AFCEE, Parsons and Brown and Caldwell will evaluate the use of vegetable oil, soluble iron(II) and hematite to restore performance, starting sometime in 2010.

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