Cosolvent Flushing and Enhanced Bioremediation at a Dry Cleaner Site

By

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Levine·Fricke·Recon

Florida DEPARTMENT OF ENVIRONMENTAL PROTECTION

Project Team

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Brief Cosolvent Flushing History

- Before 1980 Cosolvents theory - Pharmaceuticals
- Mid 1980s Cosolvents used to study transport of hydrophobic compounds in soils
- Early 1990s Cosolvents investigated for remediation
- 1995 First Cosolvent Flood at Hill AFB (Florida)
- 1996 Second Cosolvent Flood at Hill AFB (Clemson)
- 1998 Cosolvent Flood at a Dry Cleaner Site (LFR, Sages)
- 1999 Cosolvent Flood at Dover AFB
- 2001 2nd Cosolvent Flood at Dover AFB (Clemson)
- 2002-3 Full-Scale Flood at Sages (Others?)

Sages Dry Cleaner Site Jacksonville, Florida

Pilot test at Jacksonville, FL (Sages):

- Dry Cleaner PCE source zone
- 8 to 9.5 m below ground surface
- 7 m long by 3 m wide
- Performanced based cores and tracers

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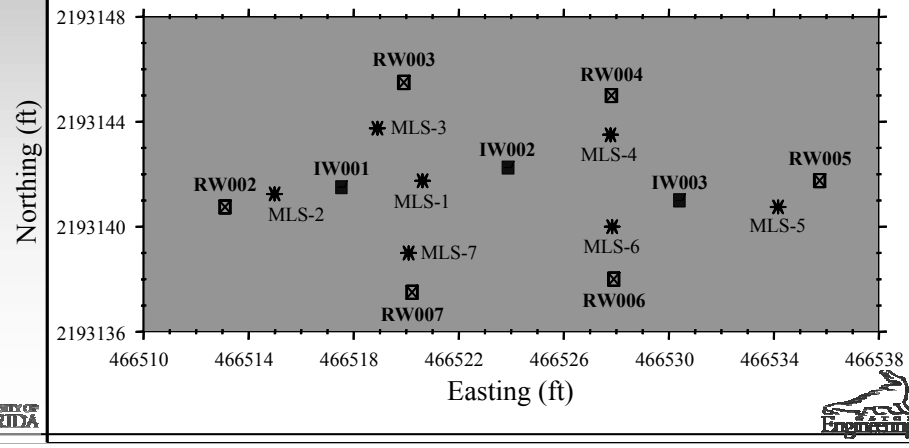
Sages Site

- 3 Injection Wells (IWs)
- 6 Recovery Wells (RWs)
- 7 Multi-Level Samplers (MLSs)



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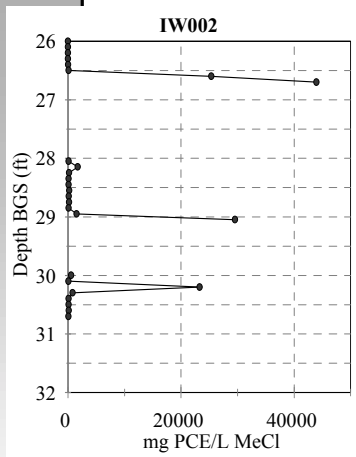
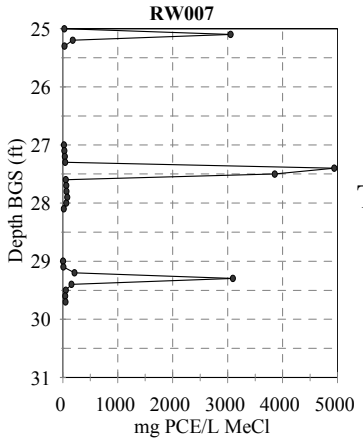
High Frequency Soil Sampling at Sages





Thin lenses of DNAPL on minor permeability contrasts

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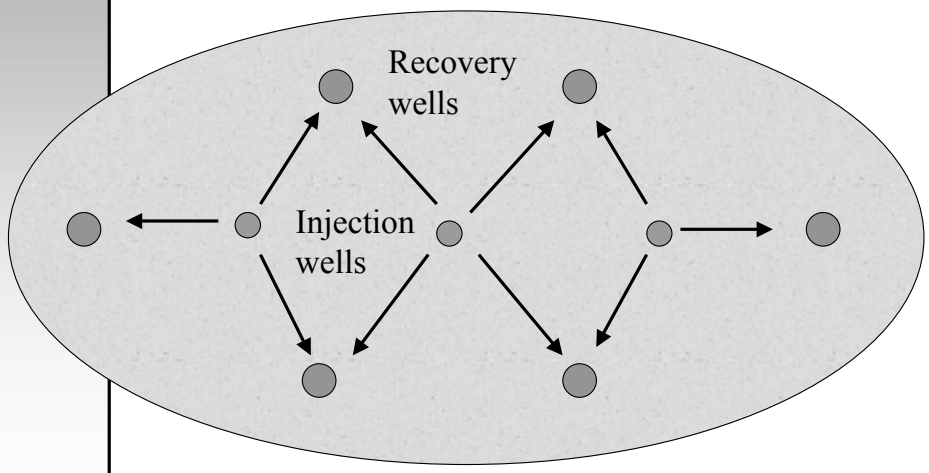
Sages Well Layout

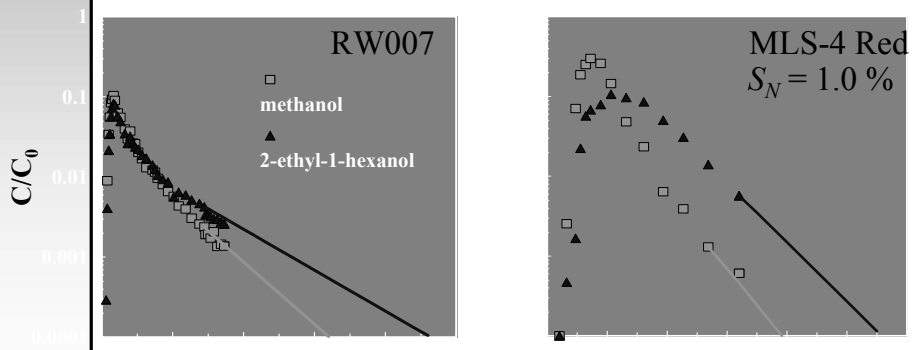


Sages Site

Partitioning Tracer Test:

S_N = 0.26 %

V_{PCE} ≈ 50 L



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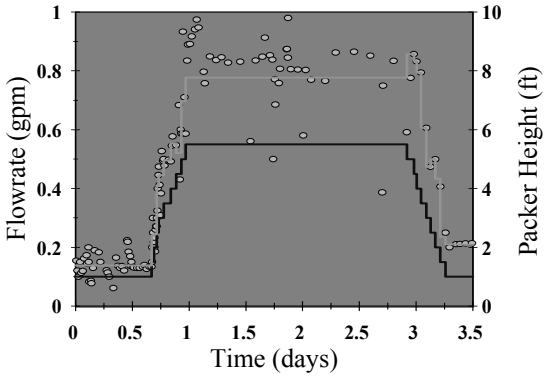
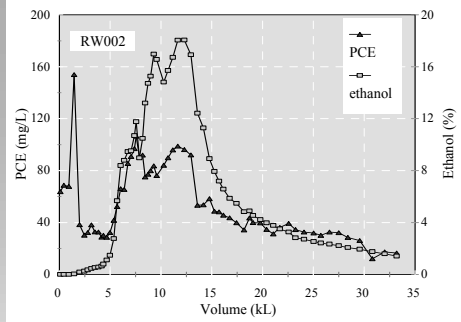
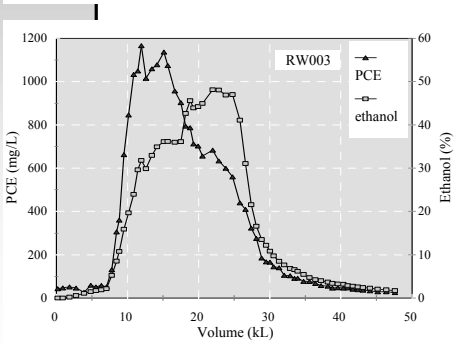
Sages Site

Cosolvent Flushing



95 % consumable grade ethanol





Cosolvent Flushing

Total PCE
Removed
67.4 kg
41.5 L

Sages Site

Waste Treatment:

- Air Stripping
- Macro Porous Polymer (MPP)

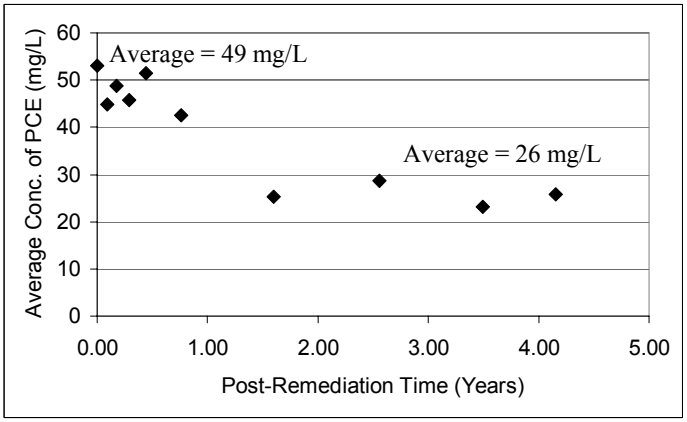
Trailer-mounted MPP system

PCE recovered from effluent

Summary Results

Cosolvent Extraction:
43 L PCE Removed (Mass Recovery)
~63 % PCE Removed (Partitioning Tracer)
65% Removal based on Soil Core Data

Concentration (or Flux) Reduction in the Source Zone



Mass Reduction = 64% : Flux Reduction = 47%
n = 35 sampling locations

Solvent Extraction Residual Biotreatment (source management)

- Remove more accessible fraction of DNAPL, lower dissolved concentrations/flux. Reduce time/distance needed to meet GW quality objectives.
- Activate reductive bio-transformations in high redox environments.
- Insure supply of e- donor, accelerate process and reduce uncertainty.
- Meet regulatory requirements.

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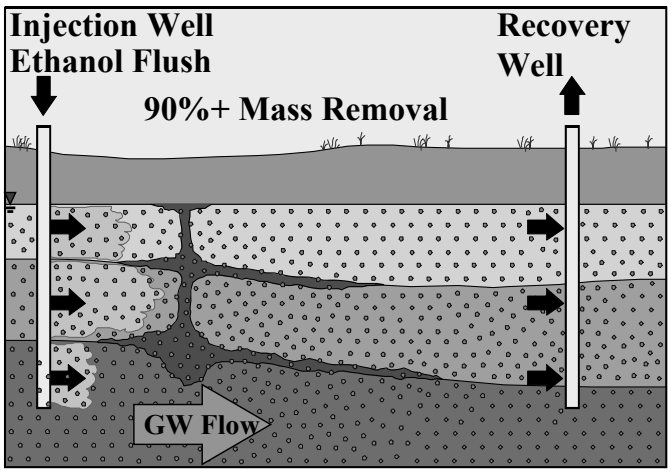
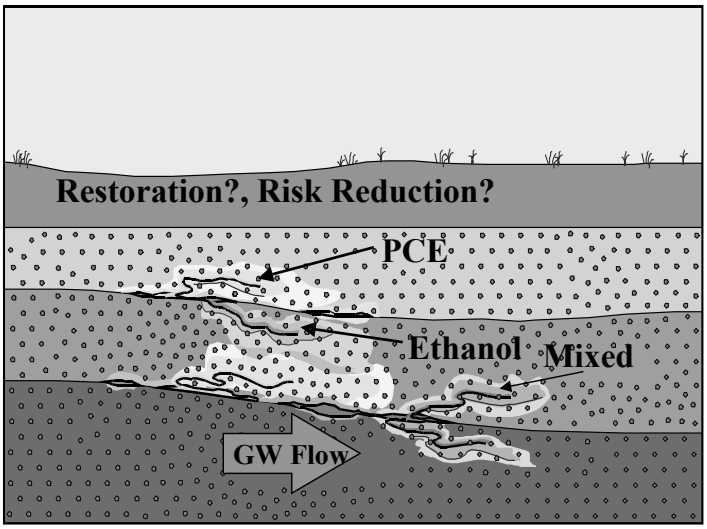
Pre-Cosolvent Flush Site Characterization

- Aerobic Conditions
- Low levels of daughter products (TCE)
- DNAPL contamination identified at 26 to 31 ft. bgs

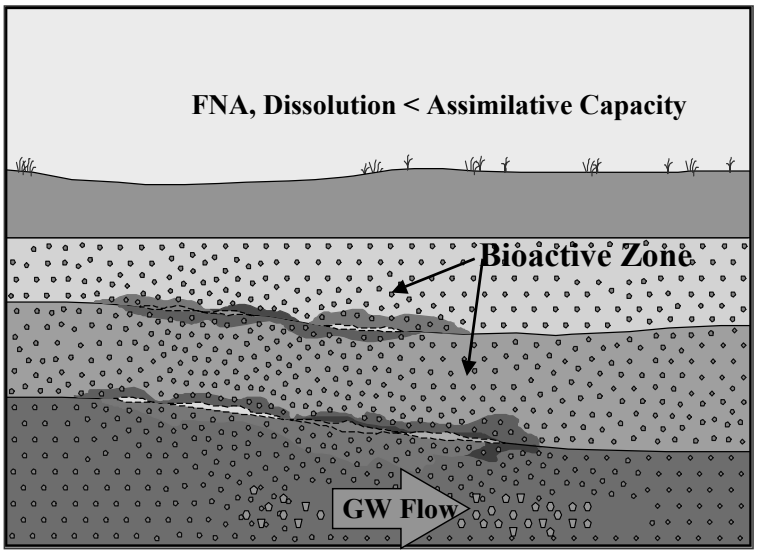
Cosolvent Extraction



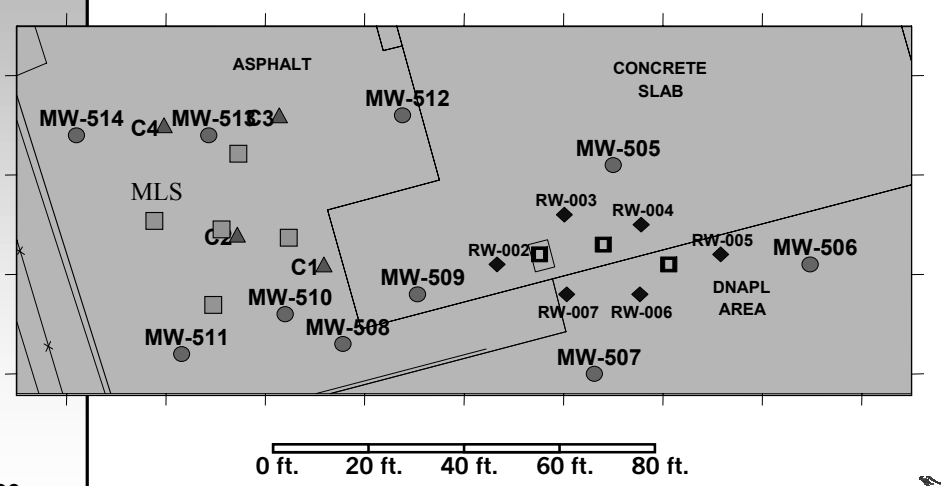
Residual Contaminants



Bioremediation



Sage's Dry Cleaner Site
Jacksonville, Florida



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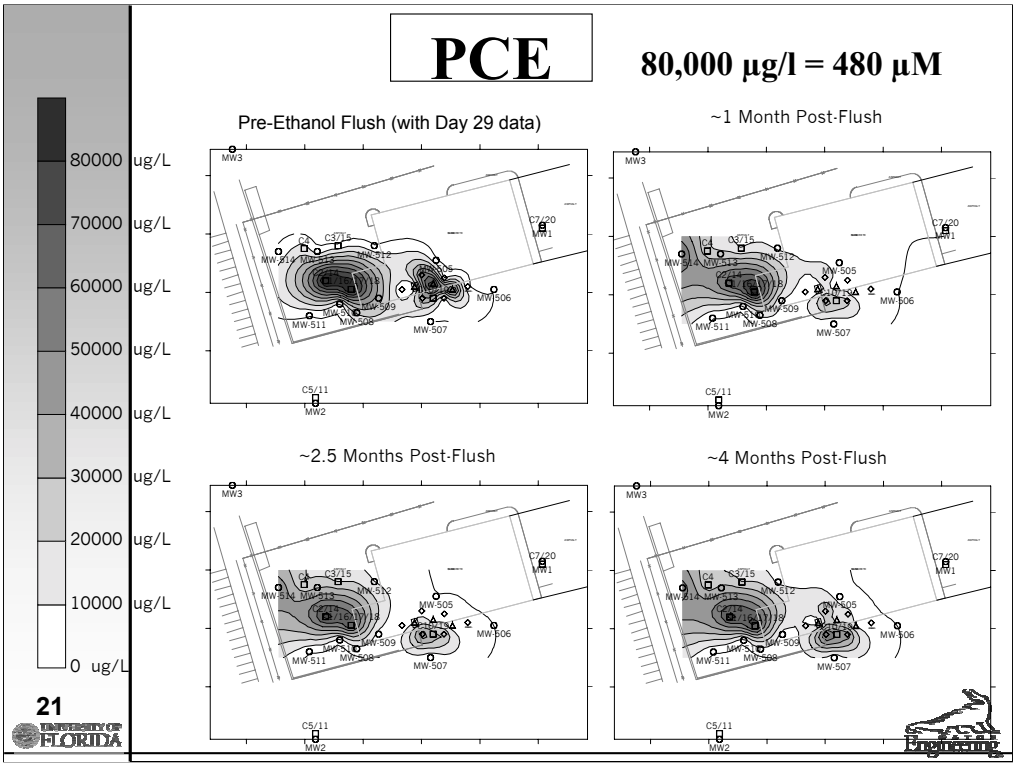
PCE
80,000 µg/l = 480 µM
Pre-Ethanol Flush (with Day 29 data)
~1 Month Post-Flush
~2.5 Months Post-Flush
~4 Months Post-Flush
80000 ug/L
70000 ug/L
60000 ug/L
50000 ug/L
40000 ug/L
30000 ug/L
20000 ug/L
10000 ug/L
0 ug/L
MW3
C7/20
MW1
C4
C3/15
MW-514
MW-513
MW-512
MW-505
C2/14
C1/13
C6/18
C7/19
C8/16
C8/17
MW-509
MW-506
MW-511
MW-508
MW-507
C5/11
MW2
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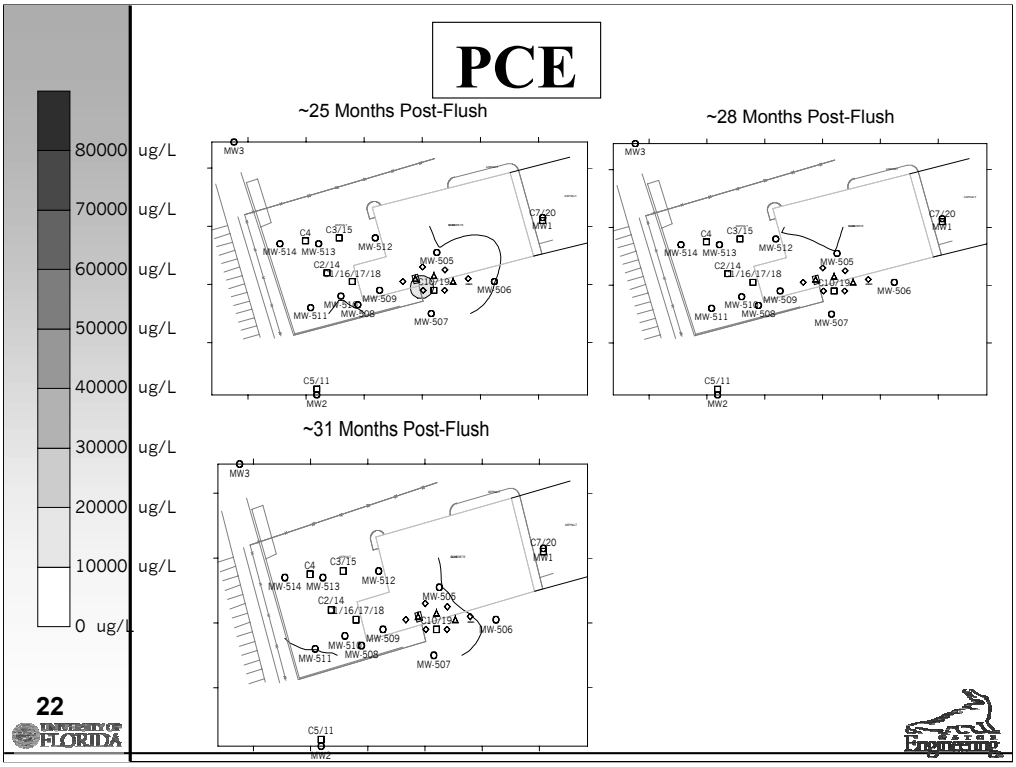
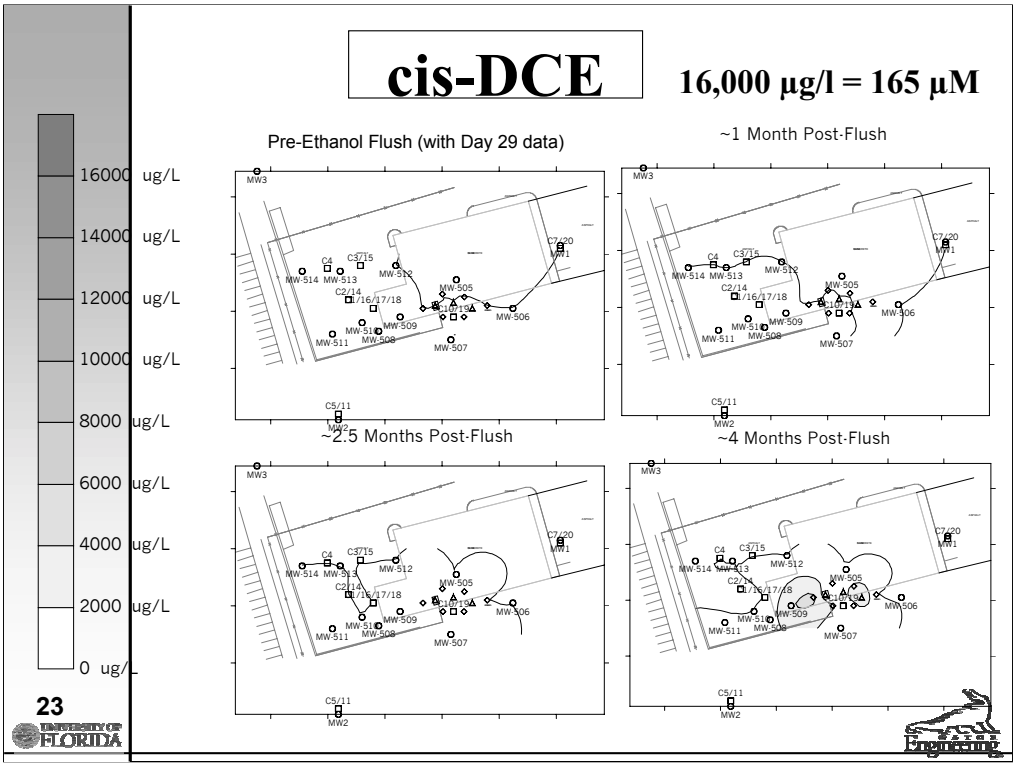

PCE
80000 ug/L
70000 ug/L
60000 ug/L
50000 ug/L
40000 ug/L
30000 ug/L
20000 ug/L
10000 ug/L
0 ug/L
~25 Months Post-Flush
~28 Months Post-Flush
~31 Months Post-Flush
MW3
C7/20
MW1
C4
C3/15
MW-514
MW-513
MW-512
C2/14
MW-505
C1/16/17/18
MW-509
MW-506
MW-511
MW-508
MW-507
C5/11
MW2
22

cis-DCE

16,000 µg/l = 165 µM



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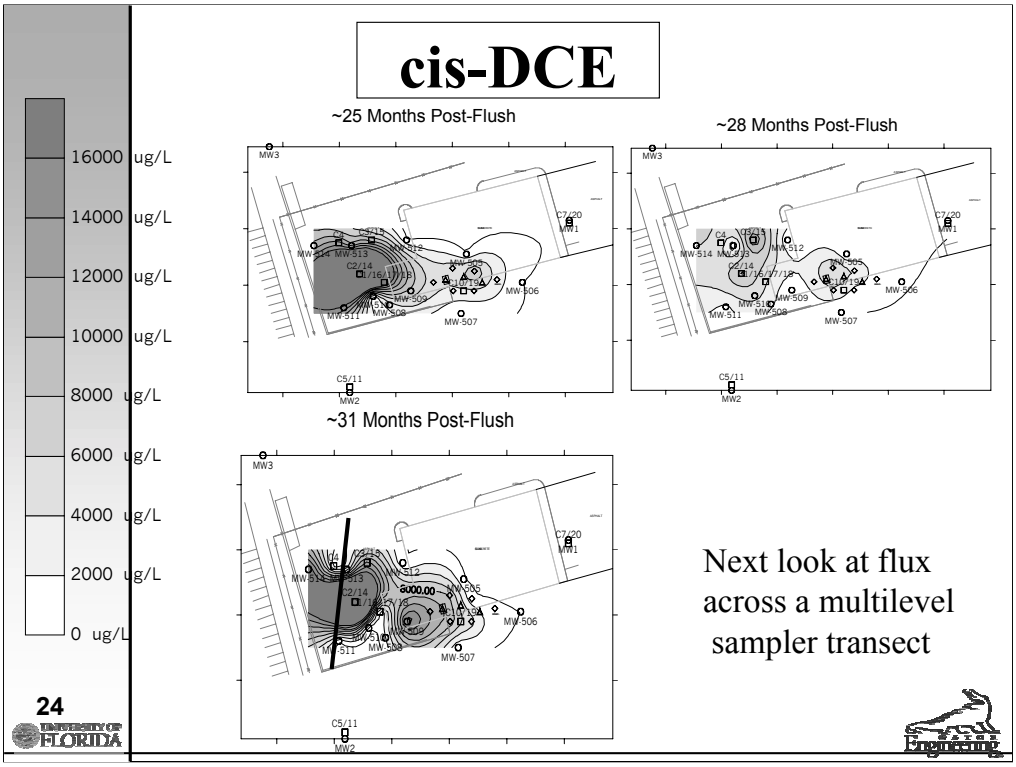
cis-DCE



Next look at flux across a multilevel sampler transect

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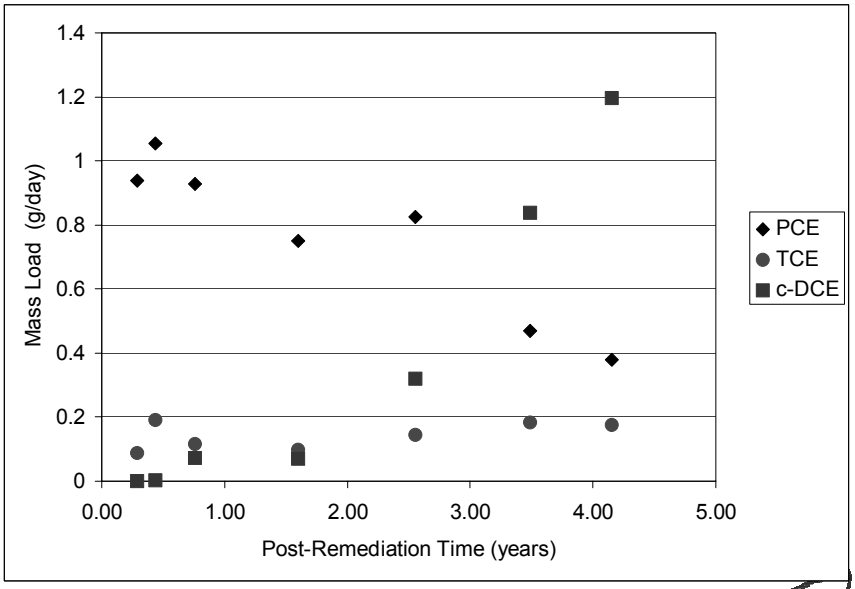
Total Plume Mass Load



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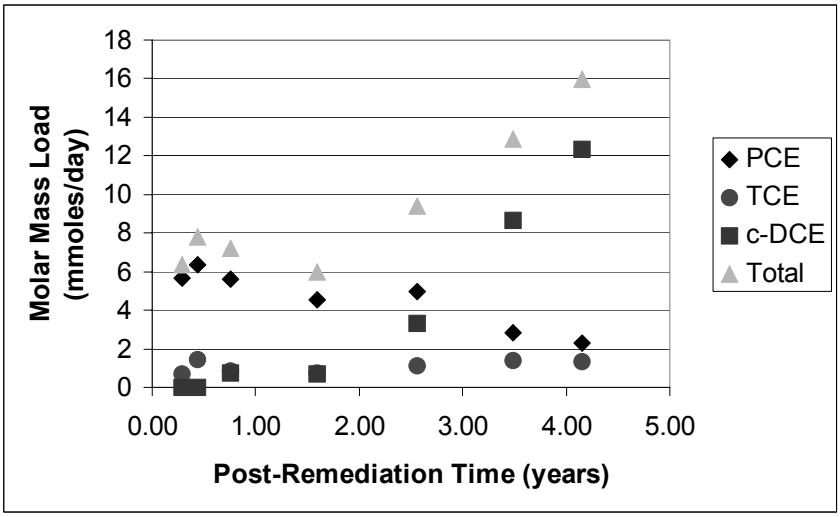
Molar Based Total Load



Increased mass flux caused by enhanced dissolution?

SUMMARY

Solvent Extraction:

43 L PCE Removed (Mass Recovery)

~64 % PCE Removed

Source Zone Flux

47% reduction in PCE concentration in the source zone multilevel sampler network

PCE Daughter Product Formation

Significant increase in *cis*-DCE mass

For additional indications of Biological Activity

See the Sages Poster

What's Next?

Full Scale Remediation at Sages (early 2003)

Monitoring Mass Flux from the Source Zone and in the Plume?