Phytoremediation of VOC's: Understanding Fate & Innovative Applications

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Acknowledgements

UMR: Graduate students Xingmao Ma, Garrett Struckhoff, Jeff Weishaar, Sally Breite

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Weston Solutions: Matt McCaughey, Bill Schneider

Univ. South Carolina: Lee Newman

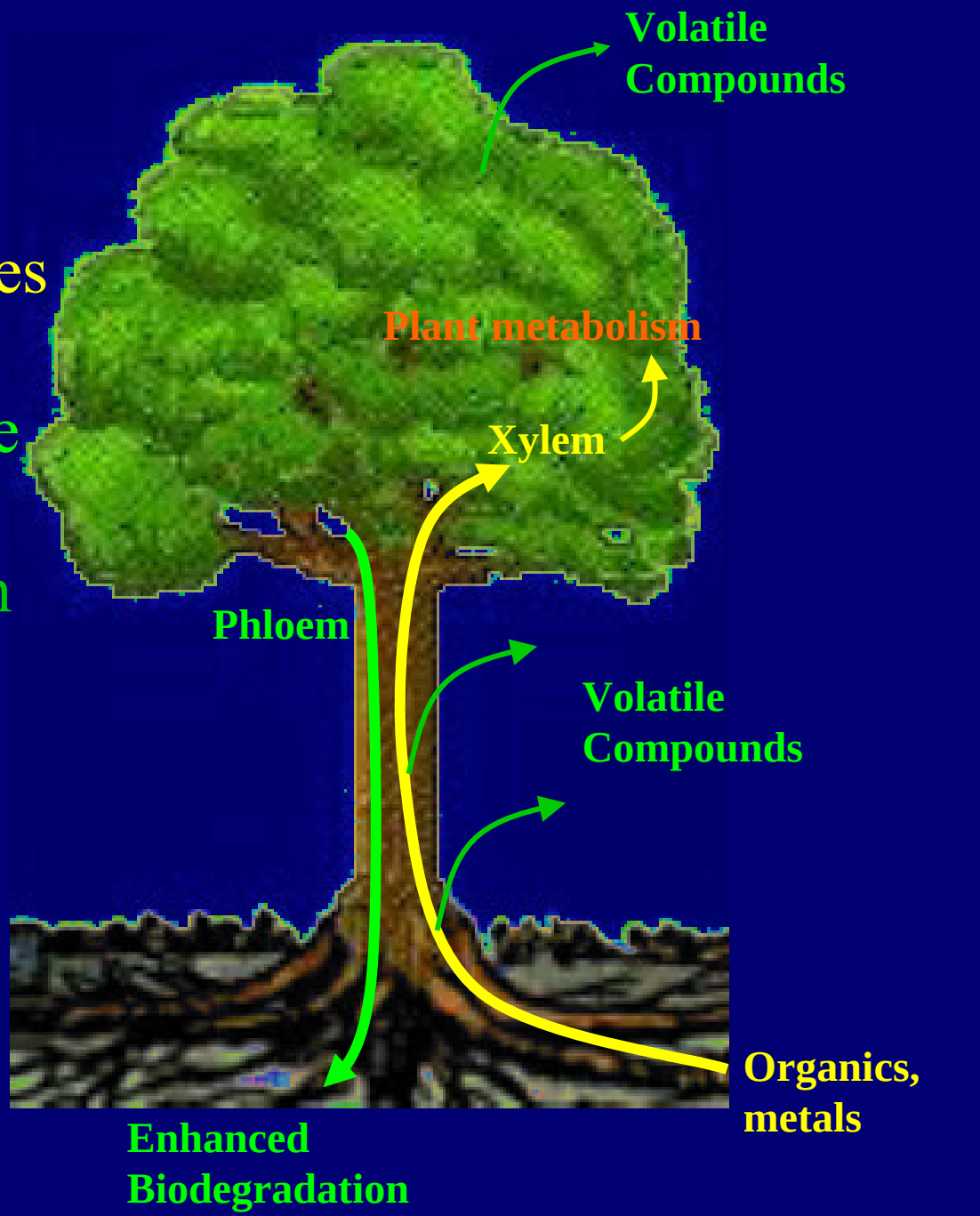
USGS

Weston Solutions

Phytoremediation Processes

Contaminant interactions

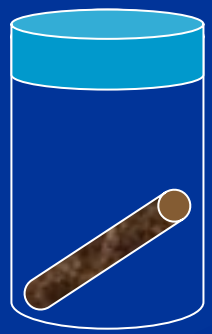
- VOC Uptake & Volatilize
- Plant Degradation
- Enhanced Biodegradation



Tree Coring

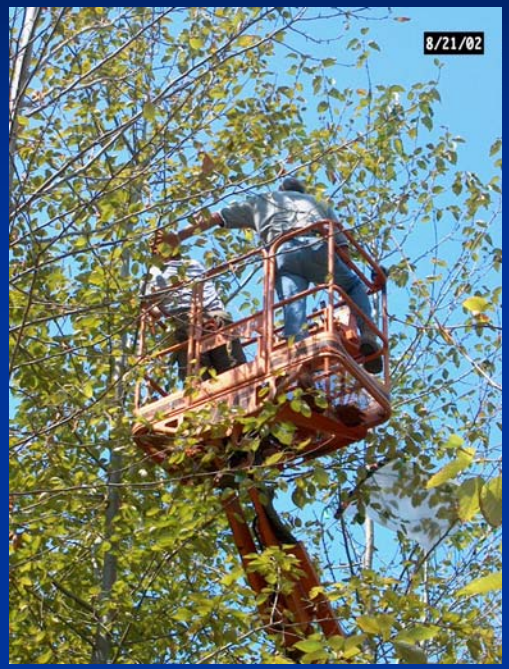
- Methods: D. Vroblesky
- Collect a core sample of the trunk/stem
- Core sample placed into vial
- After equilibration time headspace is analyzed via GC
- Partition coefficients used to determine initial concentrations

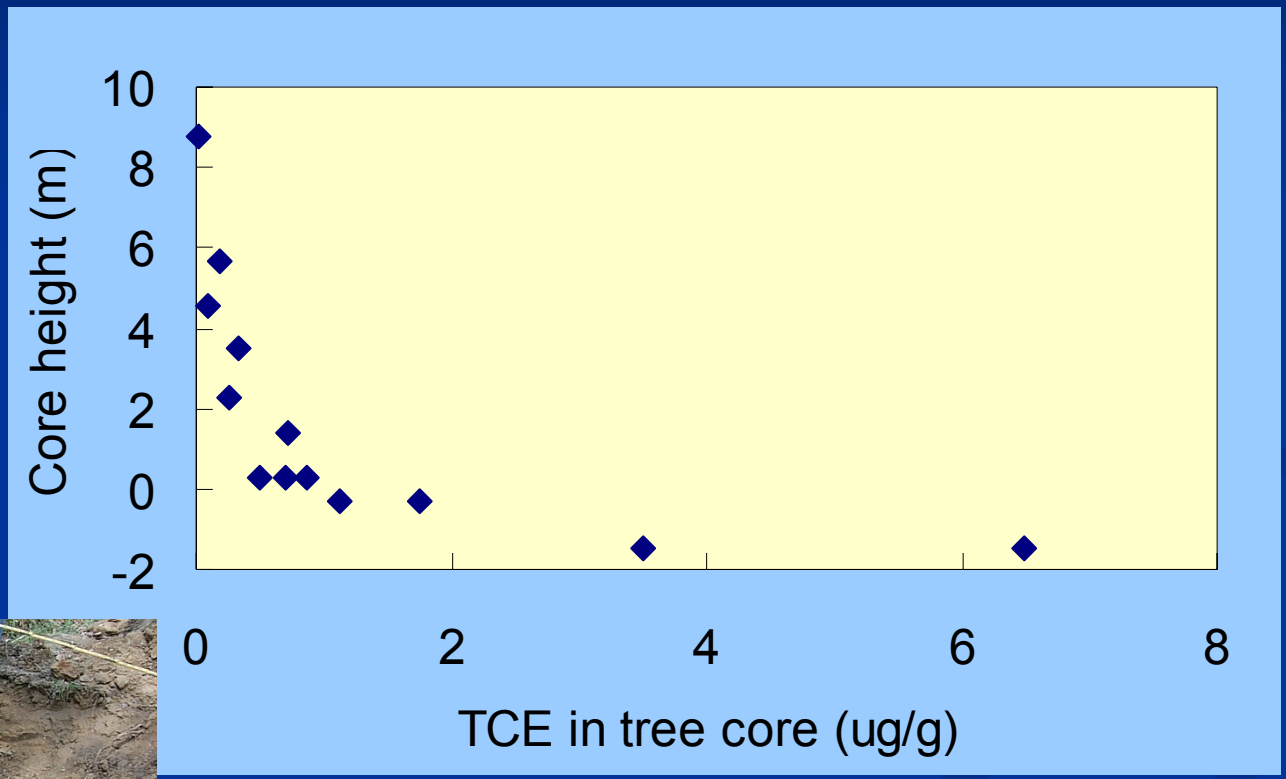
Headspace Analysis



USGS

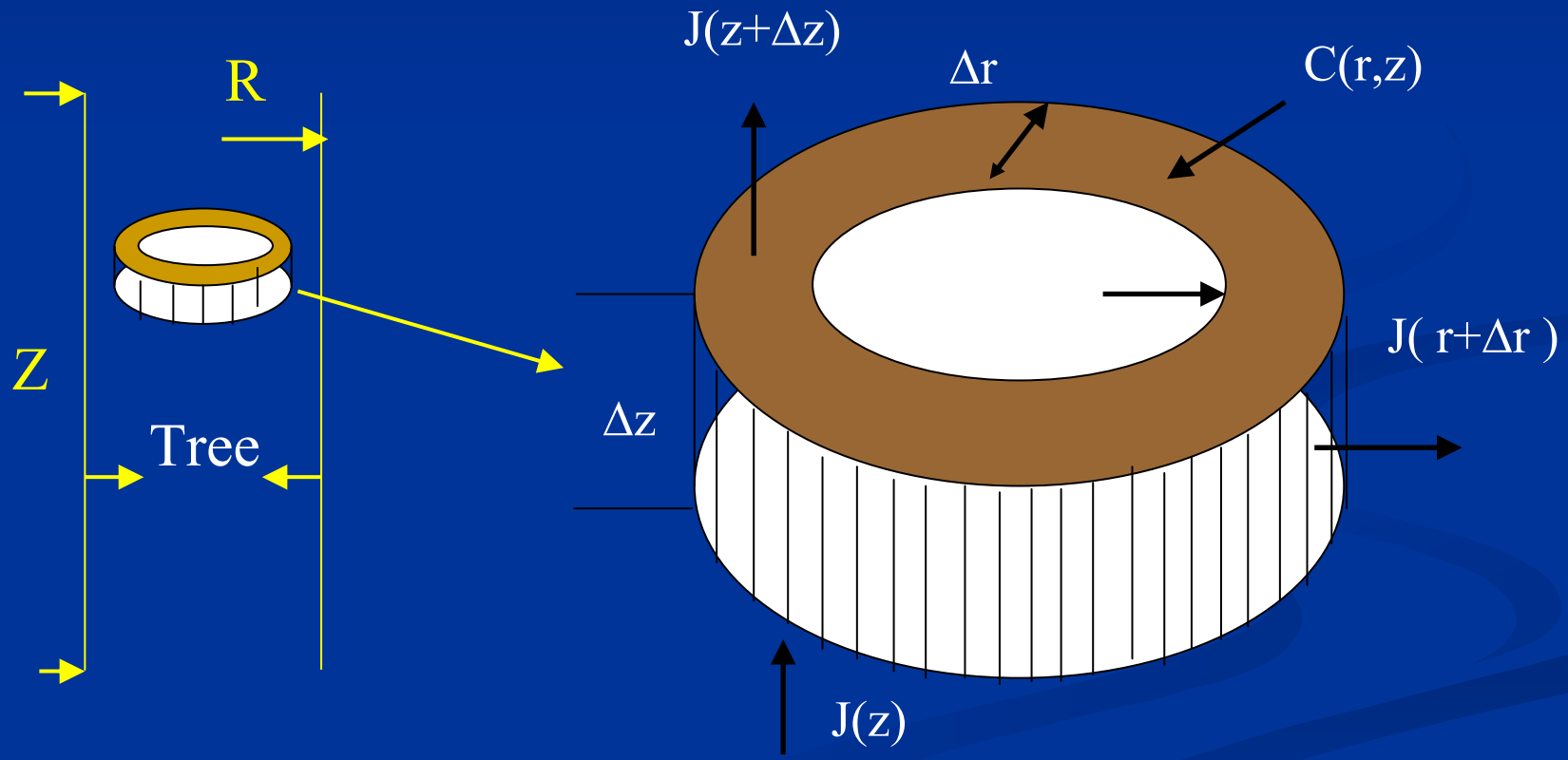
Concentration in Biomass vs. height





Concentration decreased exponentially with elevation up the trunk

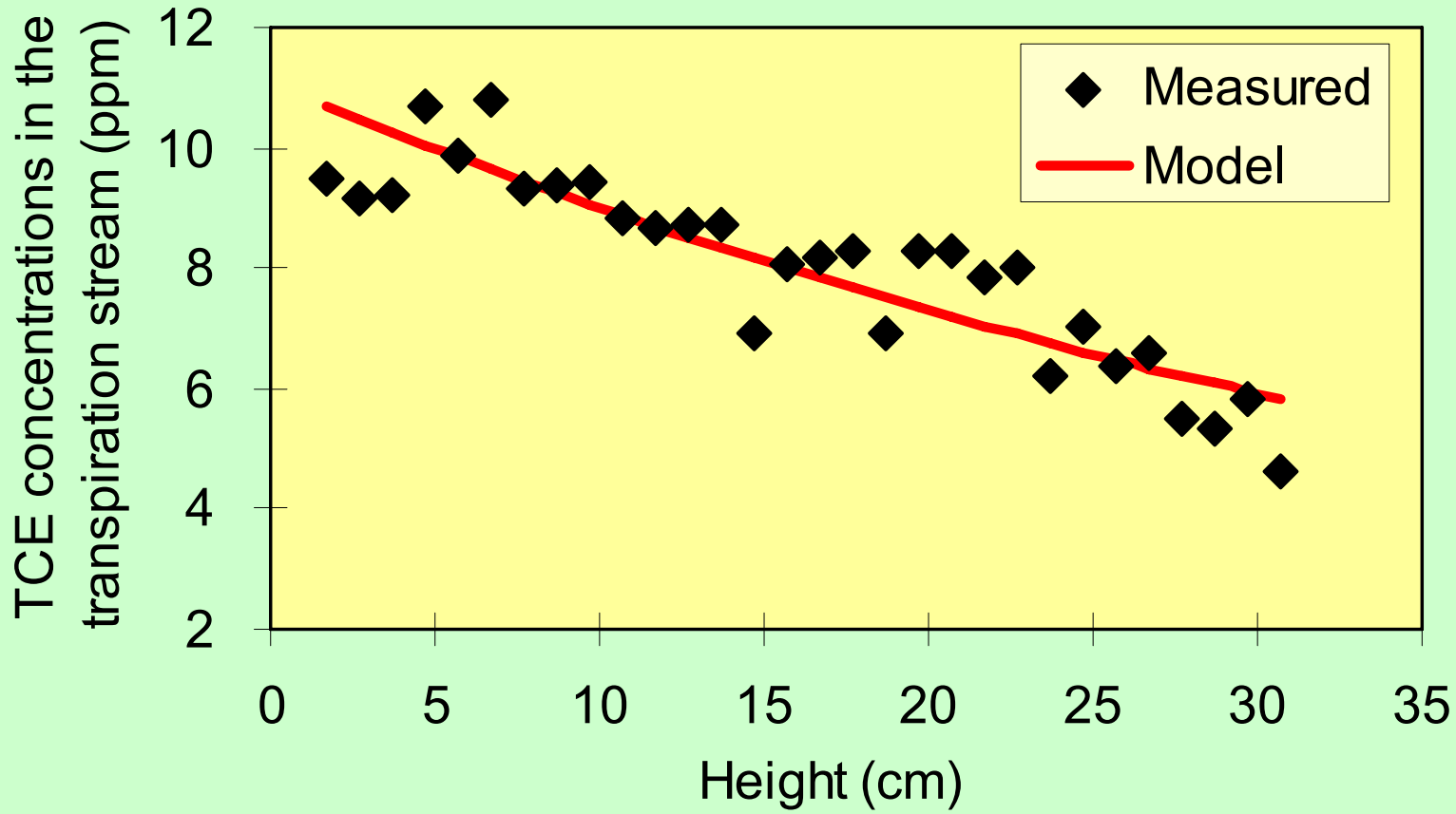
Modeling configuration



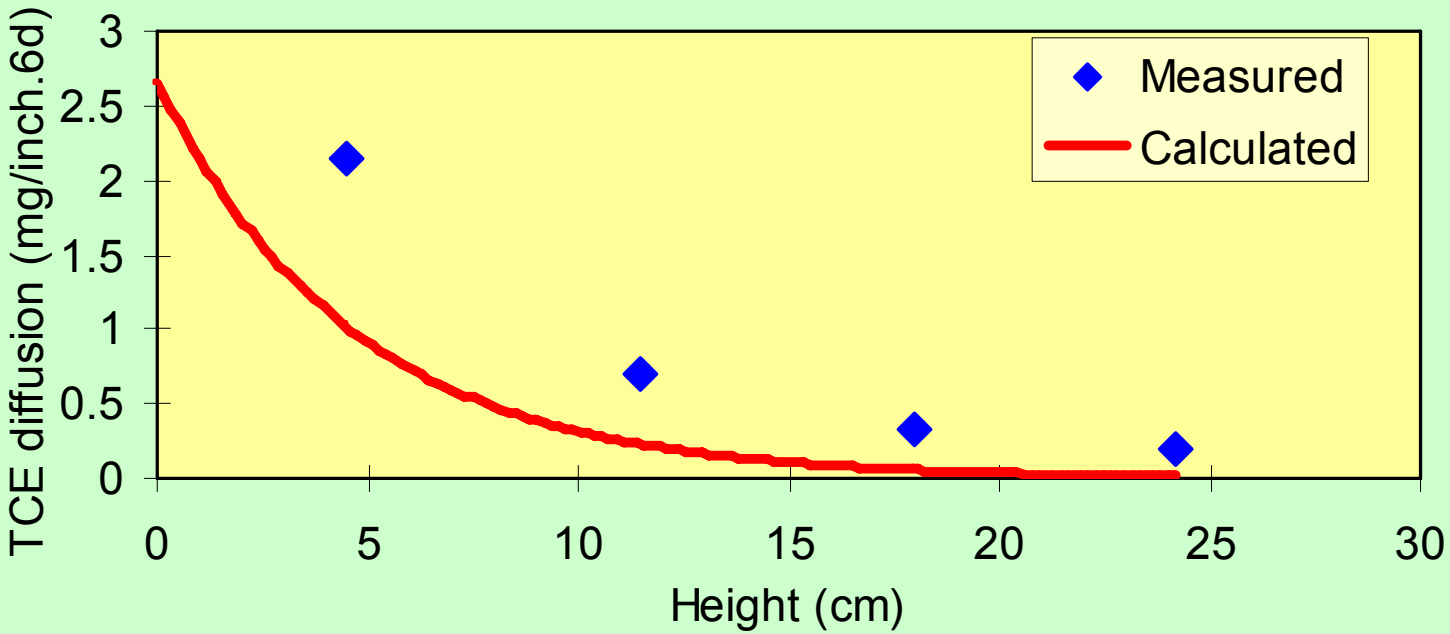
Processes involved in the model

- Chemical transport upward in xylem
- Chemical transport downward in phloem
- Sorption/desorption
- Diffusion
- Metabolism

Model Prediction: distribution

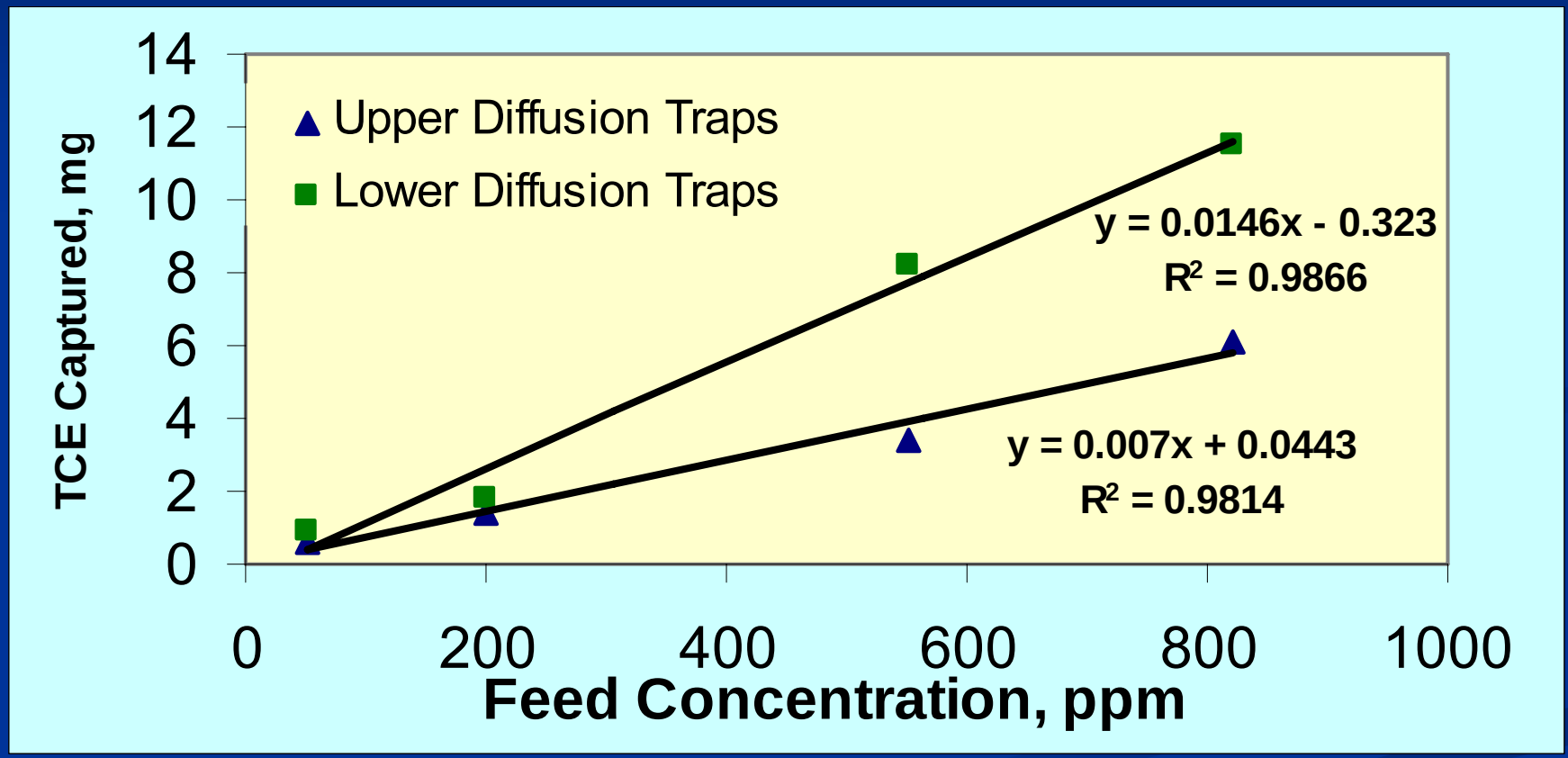


Model Prediction: Diffusion



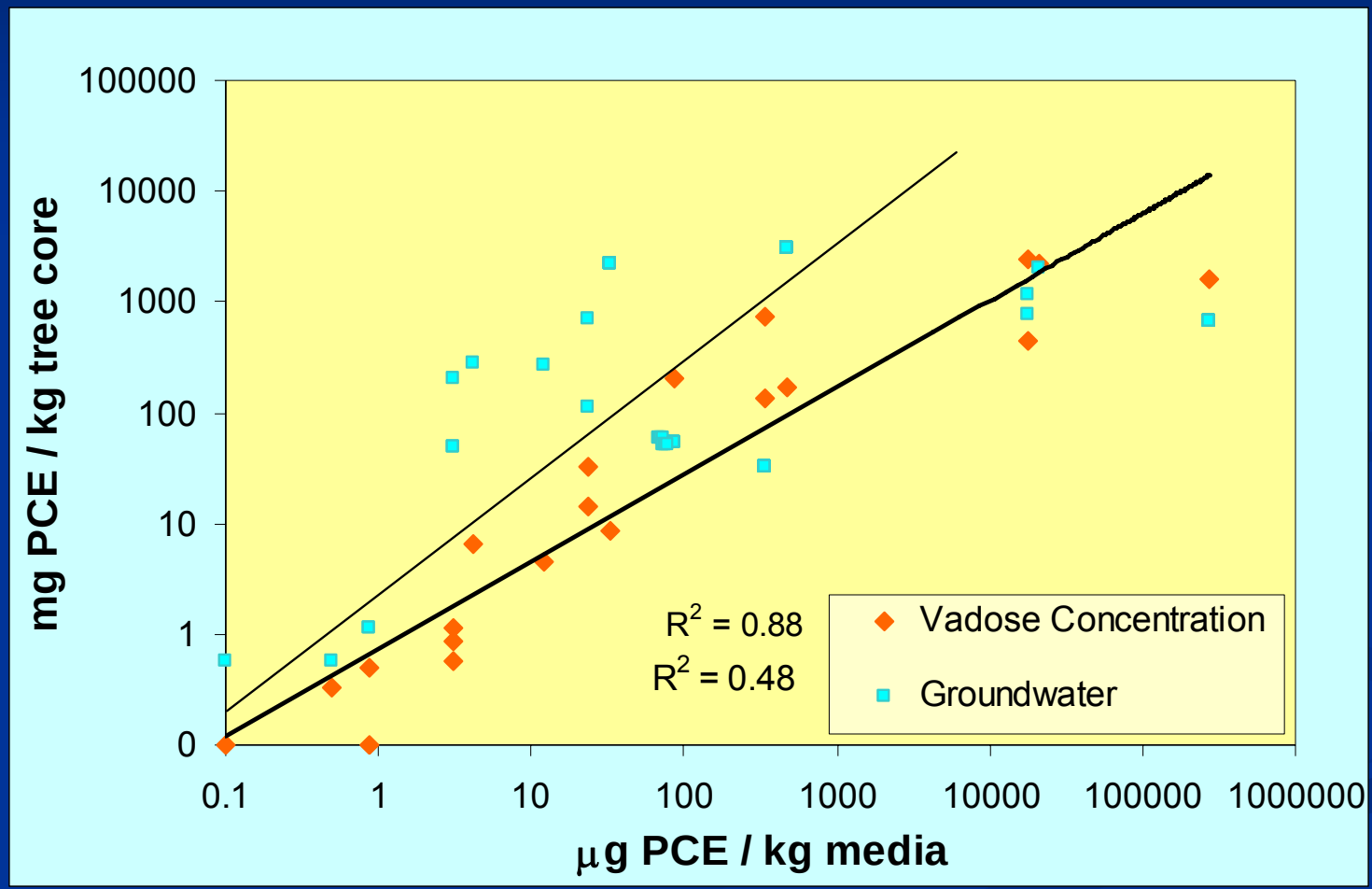
Effective Diffusivity was 0.4 – 2.5 x 10^{-6} cm^2/s

Total diffusion mass vs. influent



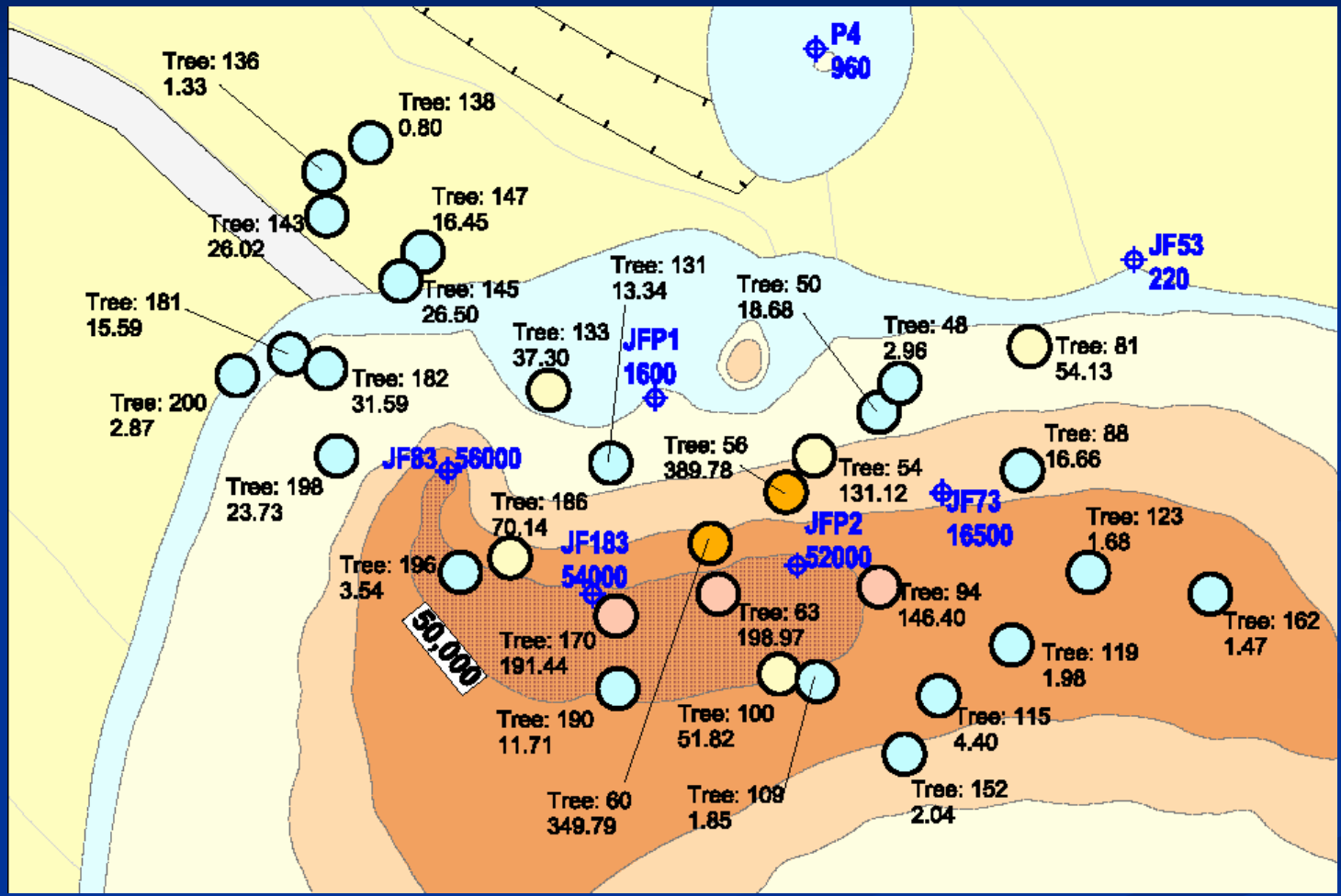
Accumulative Diffusion mass, 28 day dose period

Relationship to Vadose zone Soil 1.2 m deep



Re: Garrett Struckhoff

Aberdeen Proving Ground J-Field



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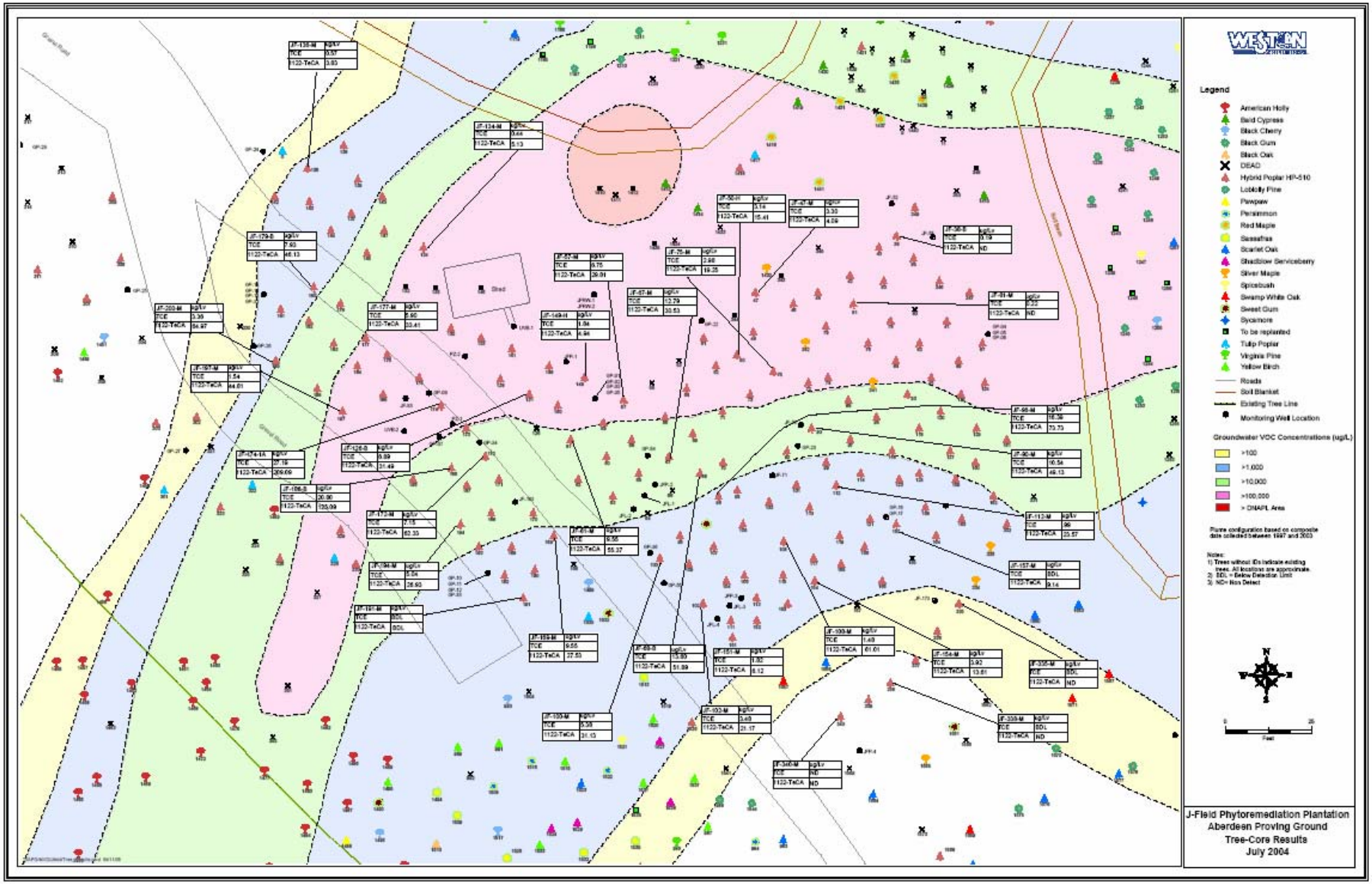
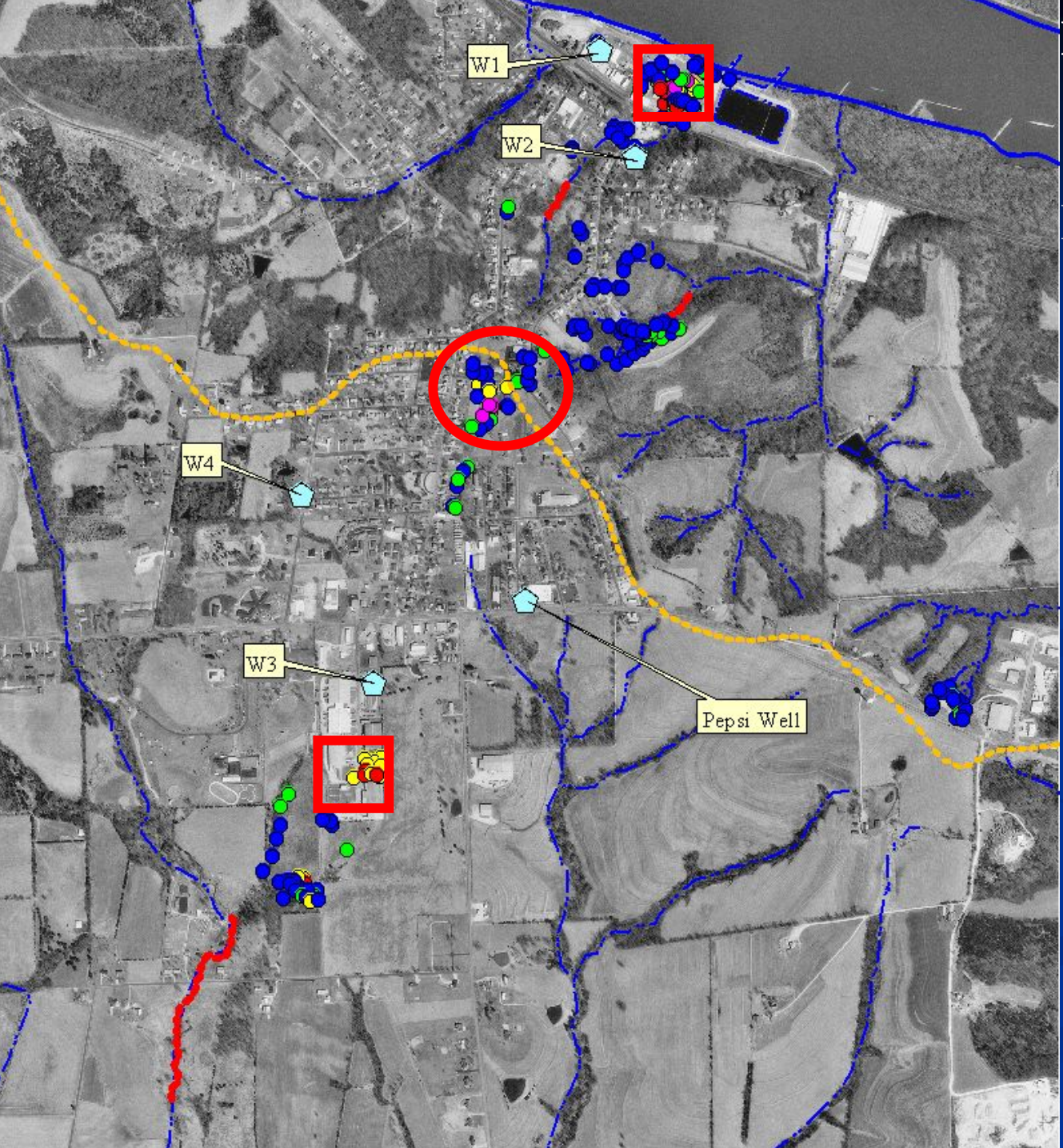


RE: Jeff Weishaar

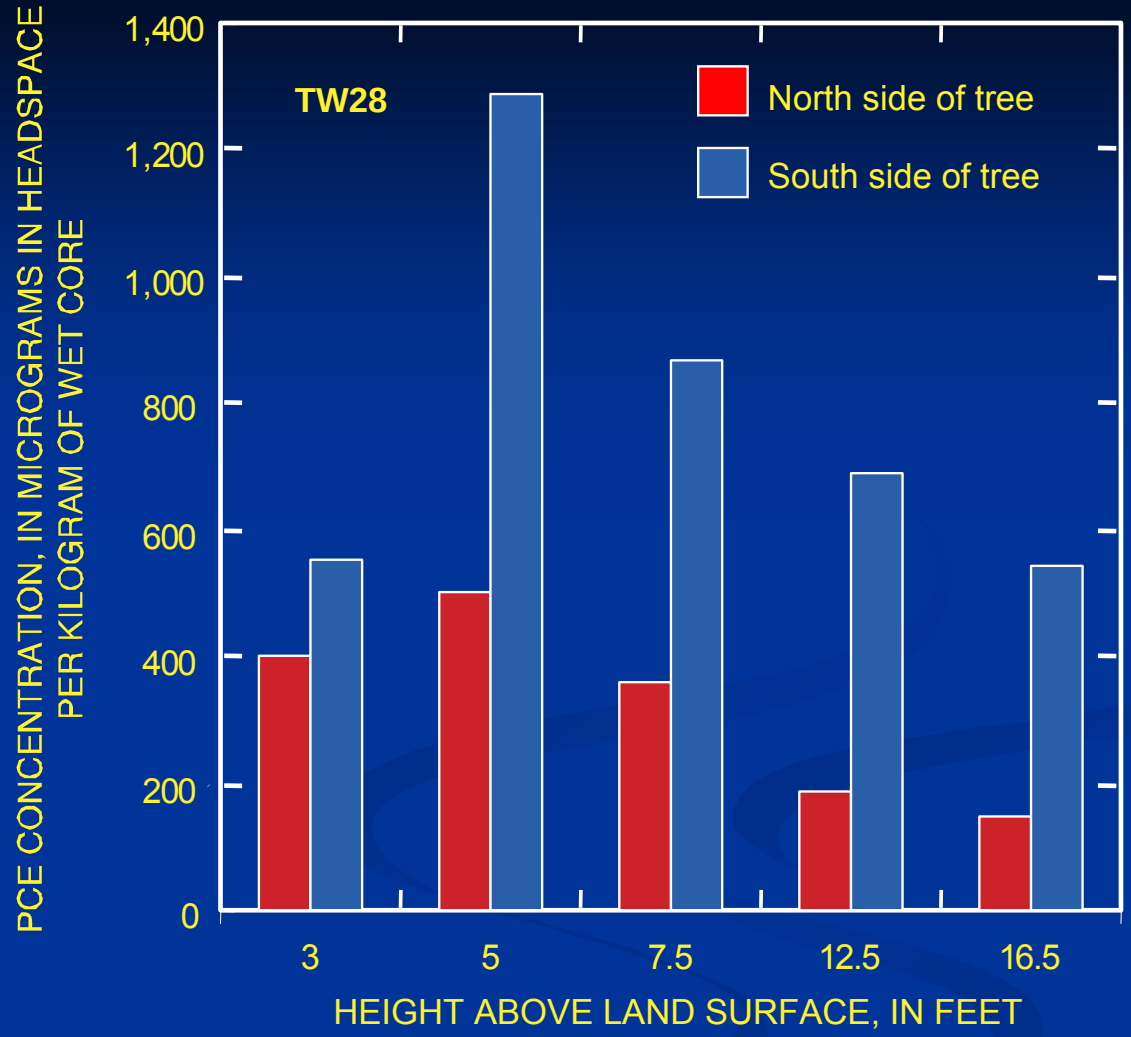
Weston Solutions



New Haven Missouri

Sampled by John Schumacher USGS Rolla Missouri

Perhaps – directional capability in a single tree?



Directional variability in tetrachloroethene (PCE) concentrations in core samples collected from tree TW28 on June 30, 2003.

From:U.S.G.S. Scientific Investigations Report 2004-5049,

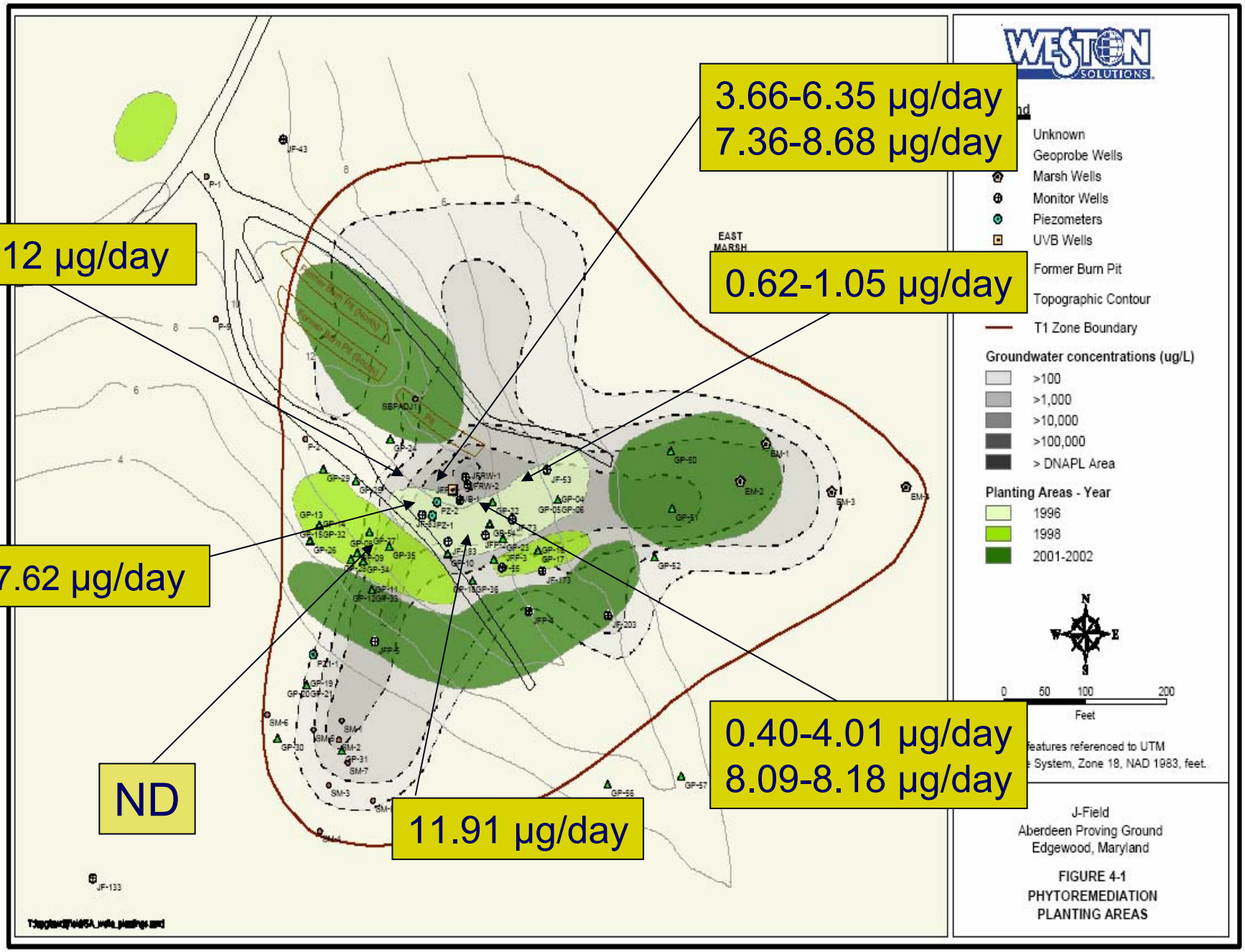
Recent Site Investigations

- 1,1,2,2-TeCA, APG West Canal area. Heavily Wooded area, contaminated aquifer @ 15-20'
- PCE in Urban Setting, much of New Haven Missouri (next slide)
- PAHs at Field site: Napthalene, Anthracene – 2 others
- Recent paper by Don Vroblesky, USGS *Groundwater Monitoring and Remediation, 2004* Multiple sites, bases

Mass Removal

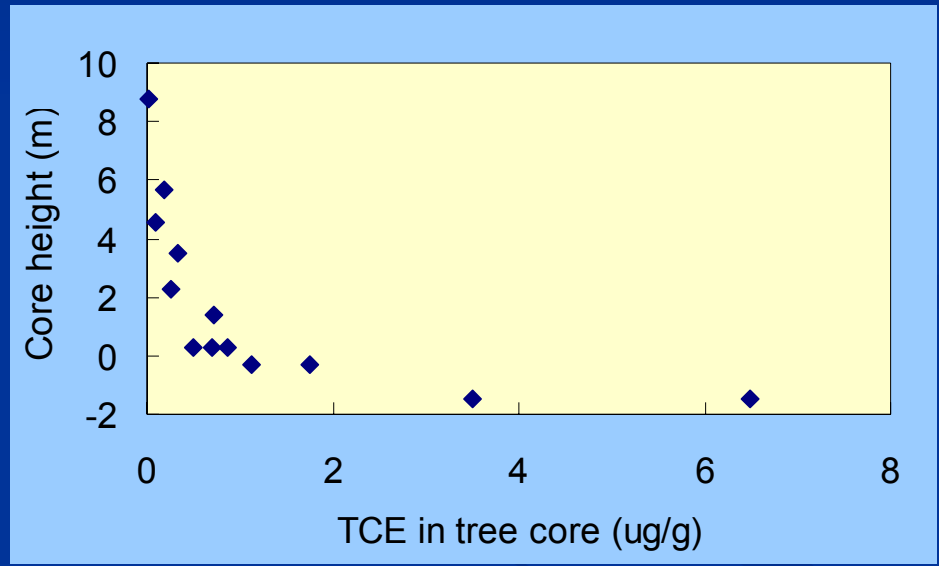
- Diffusion traps placed to collect VOCs
- Mass collection is related to eflux.
- Using transpiration rates of trees, mass removal from aquifer can be estimated (under way).

- Confirmed to date: PCE, TCE, CarbonTetrachloride, BTEX (Lab), Naphthalene & PAHs


3.66-6.35 µg/day
7.36-8.68 µg/day
12.12 µg/day
0.62-1.05 µg/day
7.62 µg/day
ND
11.91 µg/day
0.40-4.01 µg/day
8.09-8.18 µg/day
WESTON SOLUTIONS
Unknown
Geoprobe Wells
Marsh Wells
Monitor Wells
Piezometers
UVB Wells
Former Burn Pit
Topographic Contour
T1 Zone Boundary
Groundwater concentrations (ug/L)
>100
>1,000
>10,000
>100,000
> DNAPL Area
Planting Areas - Year
1996
1998
2001-2002
EAST MARSH
0 50 100 200
Feet
features referenced to UTM
System, Zone 18, NAD 1983, feet.
J-Field
Aberdeen Proving Ground
Edgewood, Maryland
FIGURE 4-1
PHYTOREMEDIATION
PLANTING AREAS

Potential: "VOC Lift"

- As VOCs translocate, potential exists to diffuse subsurface.
- Enhanced biodegradation of hydrocarbons
- Release with organic substrates for reductive dechlorination



Summary

- Tree coring for VOCs can provide site investigation, plume delineation for shallow GW
  - Quickly, inexpensively, in tight places, easily
- Diffusion of VOC in phytoremediation
- Soil, vadose zone VOCs are closely related to core concentrations
- Multiple compounds are applicable, SemiVOCs

Innovative approaches

- Vadose Zone, Vapor-phase Phytoremediation
- Monitoring & detailed delineation of plumes
- Groundwater management, controlling infiltration and promoting contaminated groundwater acquisition.

Thank you!

- Thanks for your valued time.

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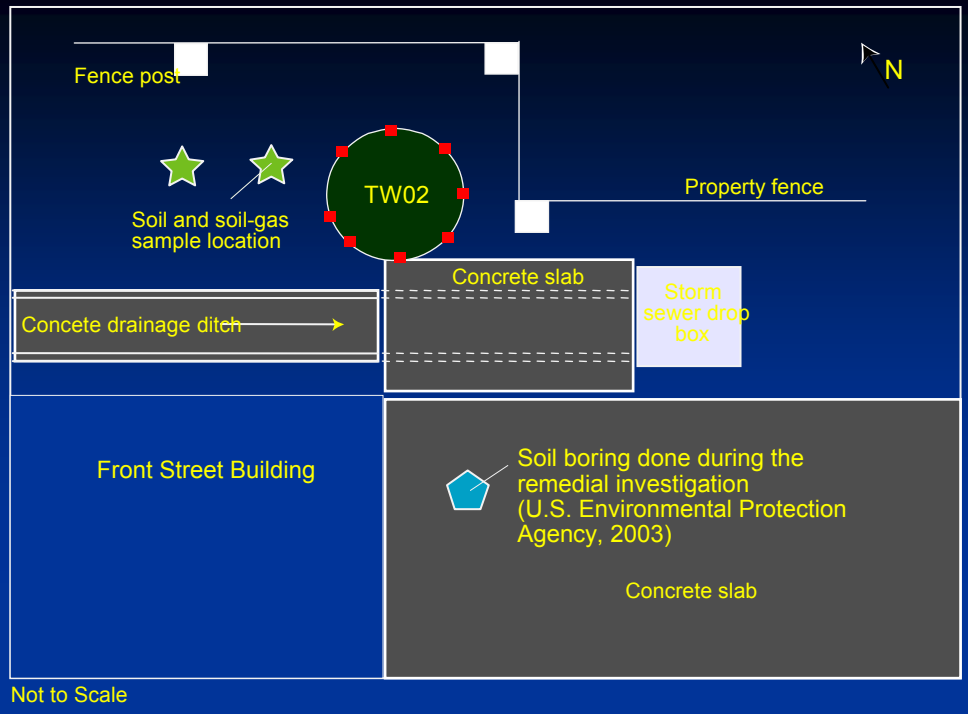
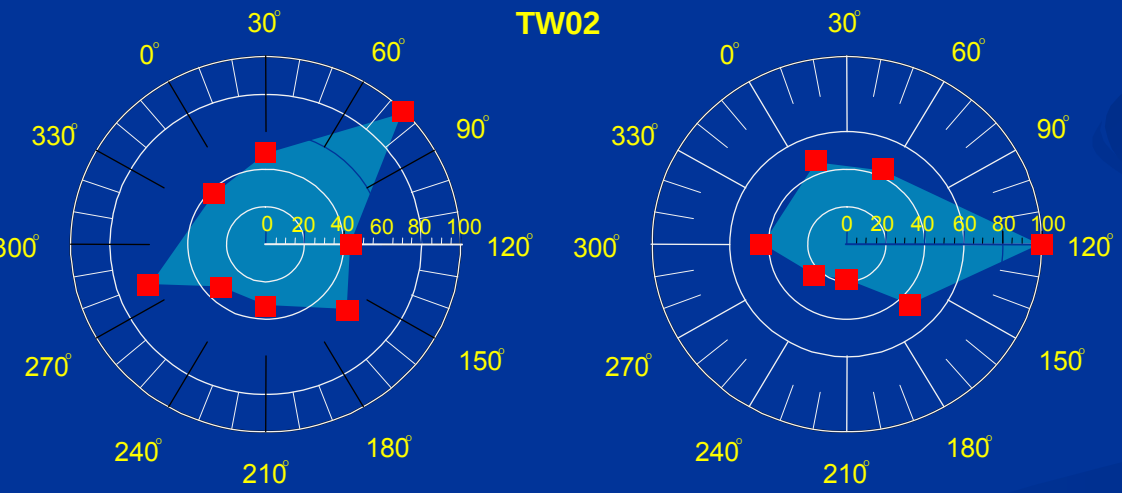
Collaborations

- BP (Amoco – Atlantic Richfield) – Petroleum and Chlorinated VOCs
- Virginia Tech – Creosote, napthalene
- US Army – Fort Leonard Wood & Aberdeen Proving Ground
- University of Washington – Chlorinated solvents
- Pro2Serve: DOE facility – Chlorinated Solvents

RADIAL VARIABILITY





1.5 FEET ABOVE THE LAND SURFACE

7.0 FEET ABOVE THE LAND SURFACE

PERCENTAGE OF THE MAXIMUM PCE CONCENTRATION DETECTED AT EACH HEIGHT. DIRECTION IN DEGREES FROM NORTH

USGS