TREATMENT OF TRICHLOROETHENE (TCE) IN LOW PERMEABILITY ZONES OF AQUIFERS USING CARBON SEQUESTRATION

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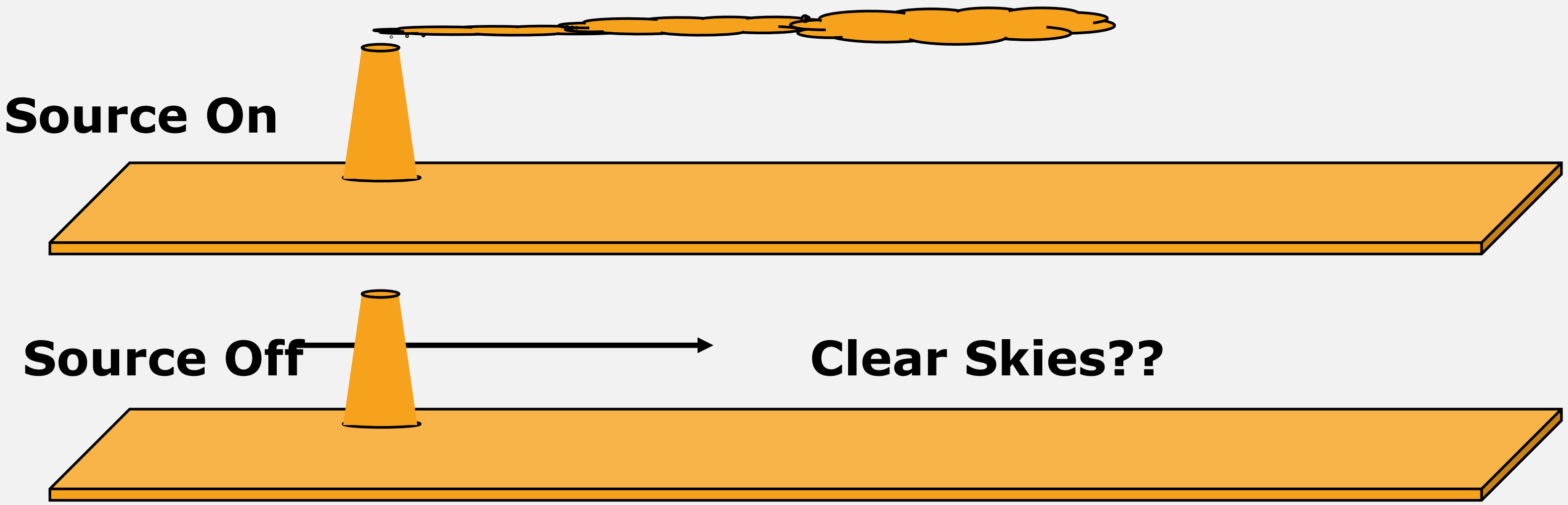
SPONSORS

- DuPont & GE
- University Consortium for Field-focused Groundwater Remediation
- DoD's SERDP program

ROAD MAP

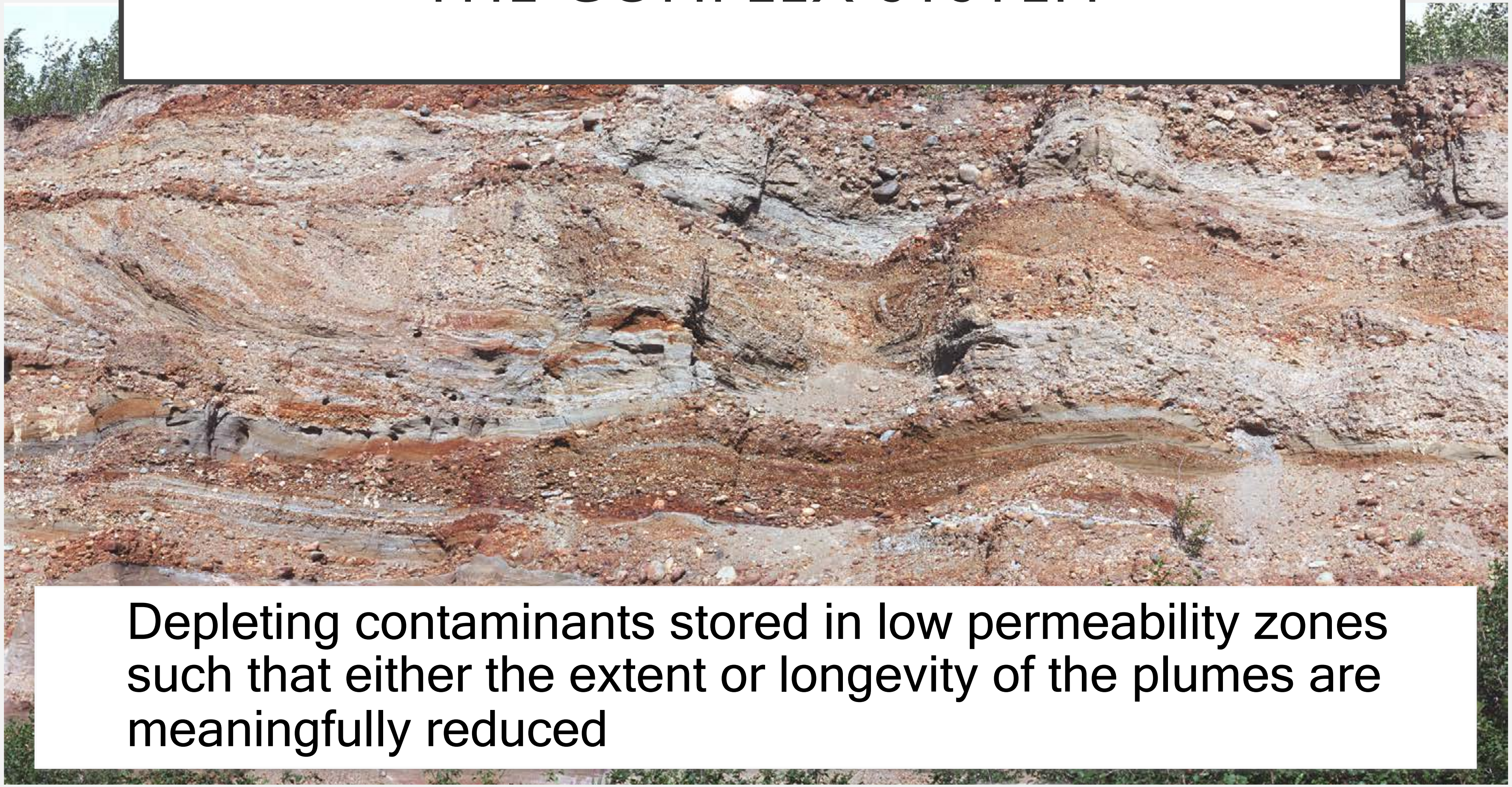
- Introduction: Contaminant removal from low-k zones of aquifers
- Research objectives: 1) Delivery, 2) Redox poise
- Methods: 1) Column studies, 2) Batch studies
- Results
- Future work

INTRODUCTION



Contaminants stored in low permeability zones can sustain plumes in groundwater for extended periods

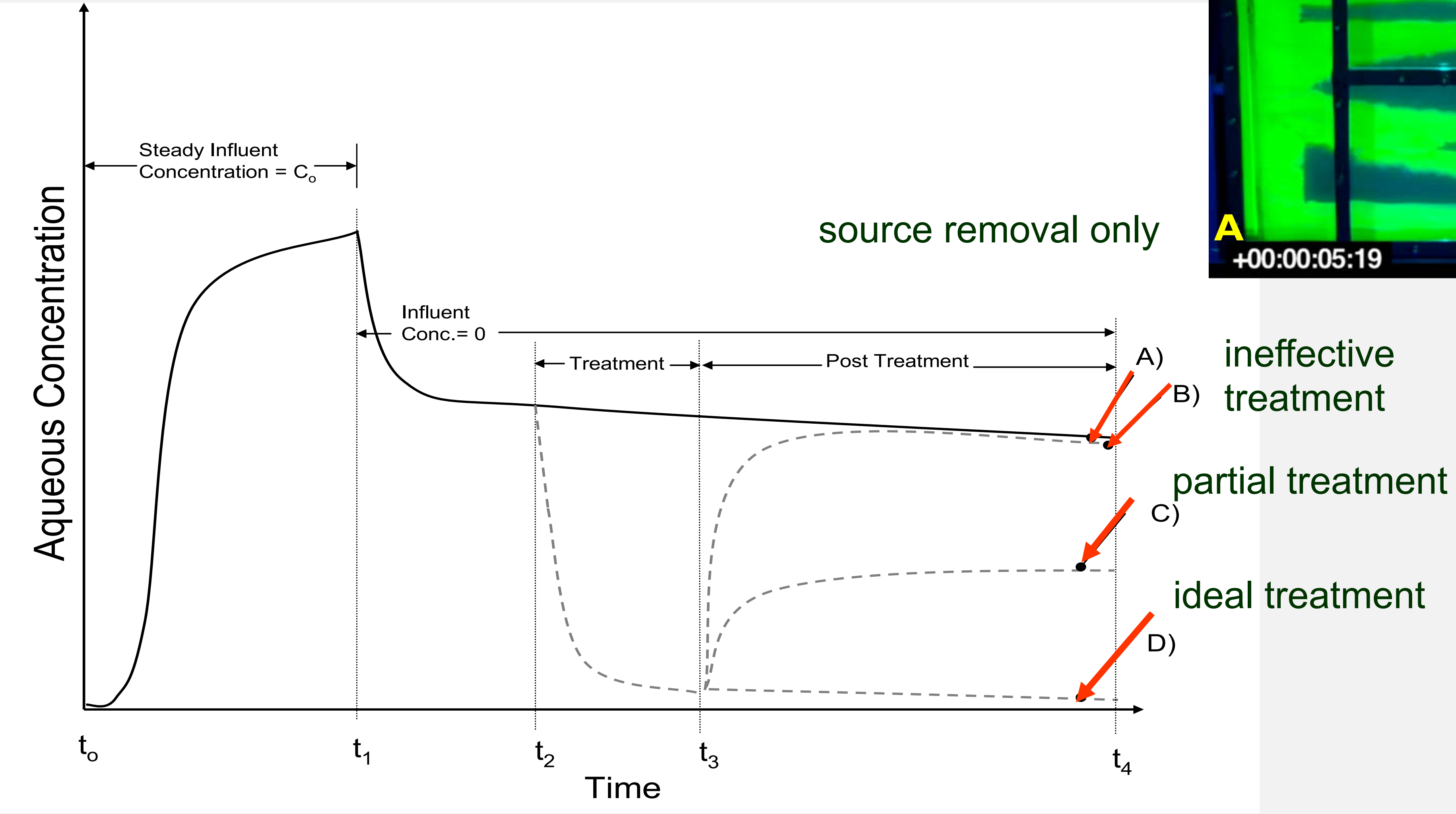
THE COMPLEX SYSTEM

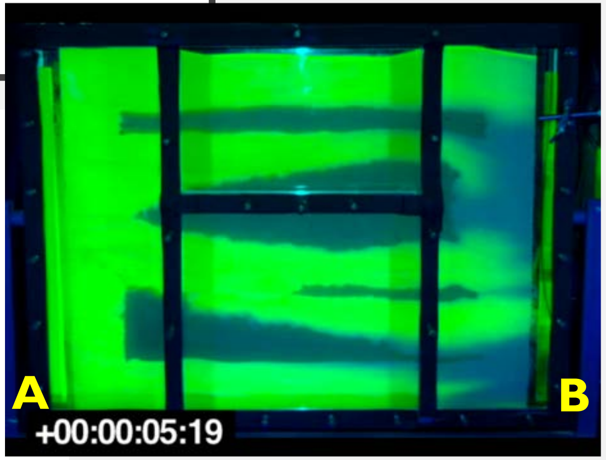


Depleting contaminants stored in low permeability zones such that either the extent or longevity of the plumes are meaningfully reduced

BACK DIFFUSION VIDEO

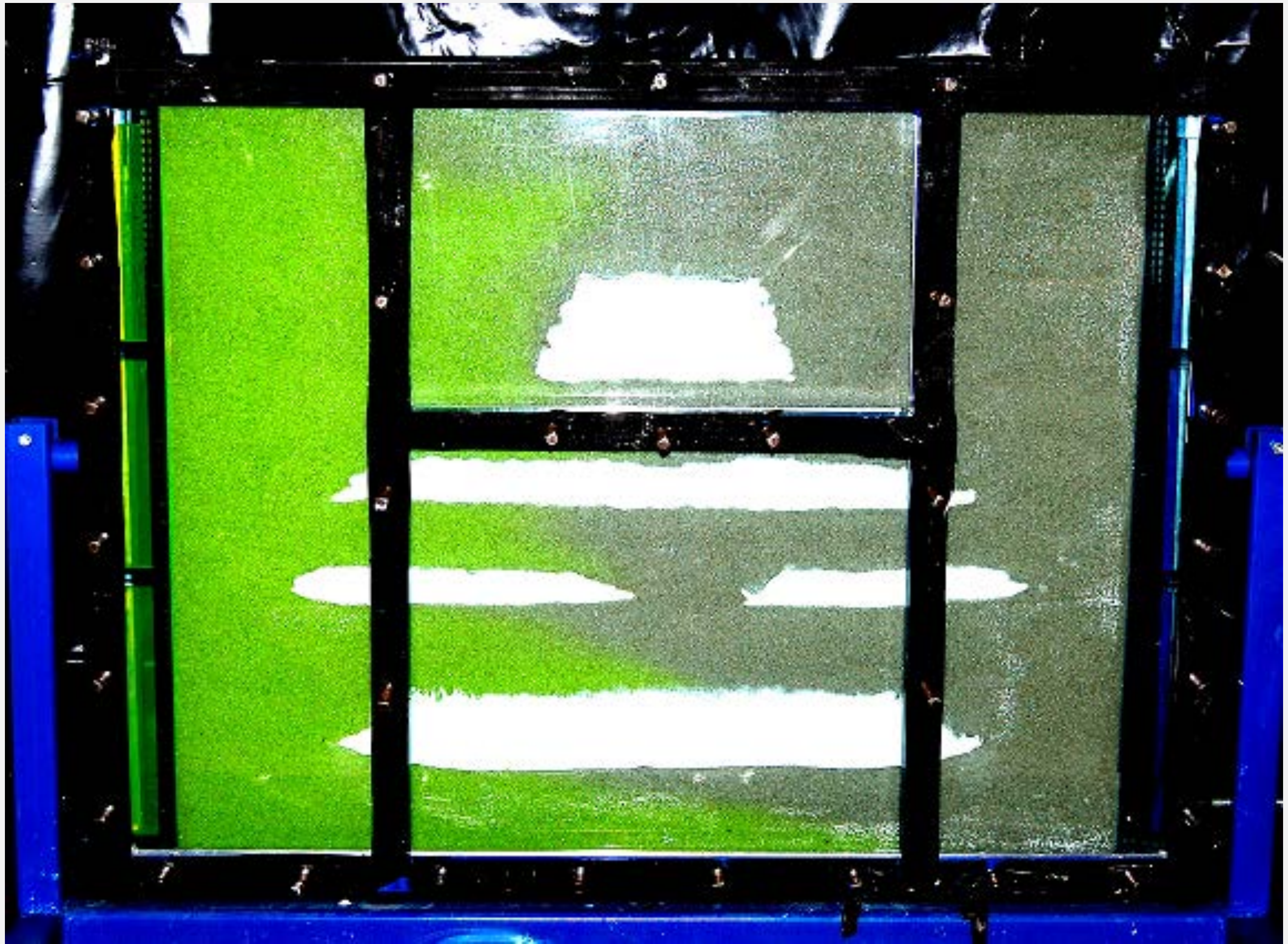
HYPOTHETICAL RESPONSES TO PLUME TREATMENT





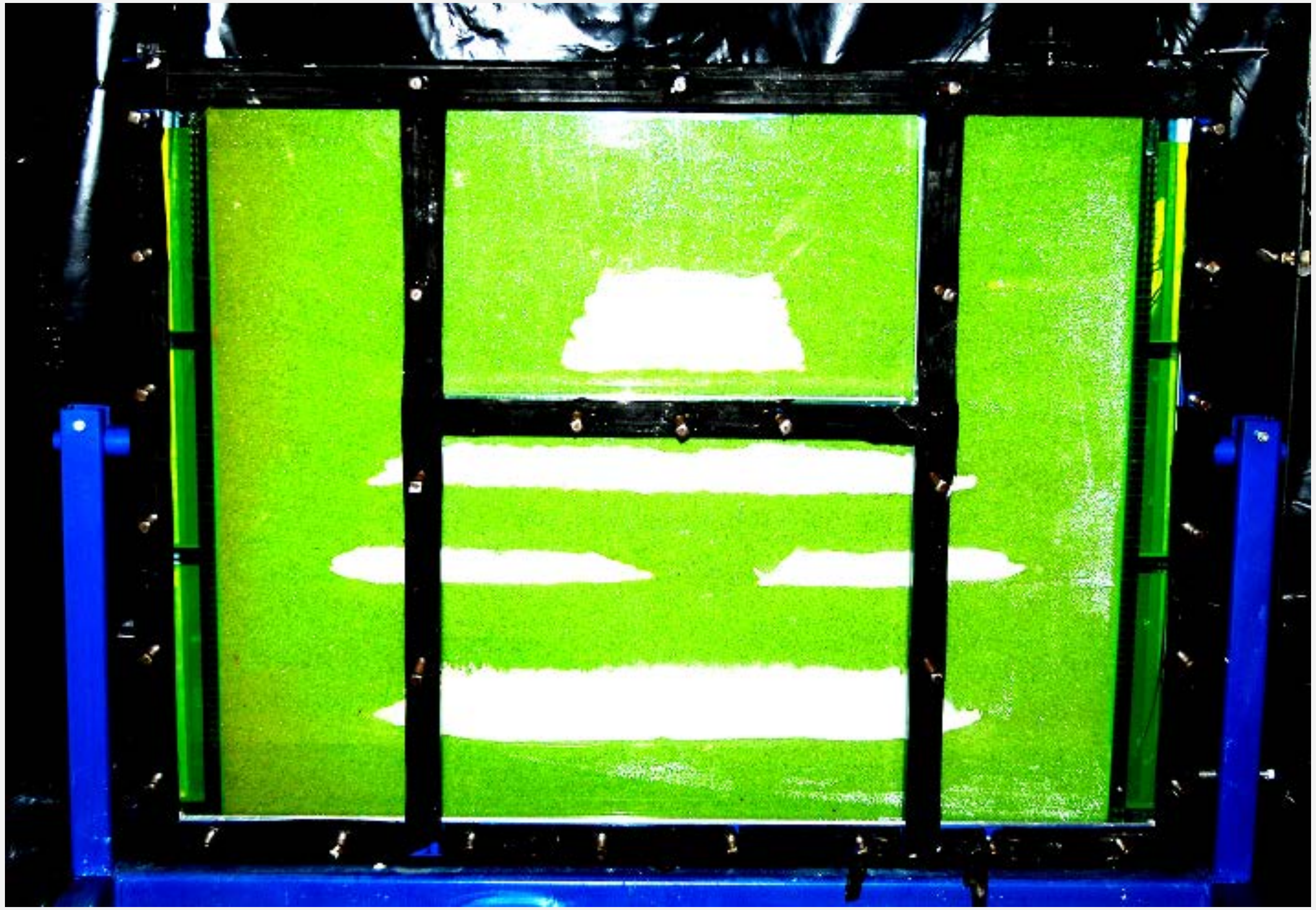
ALKALINE ACTIVATED PERFULFATE

Day 4: flushing Fluorescein



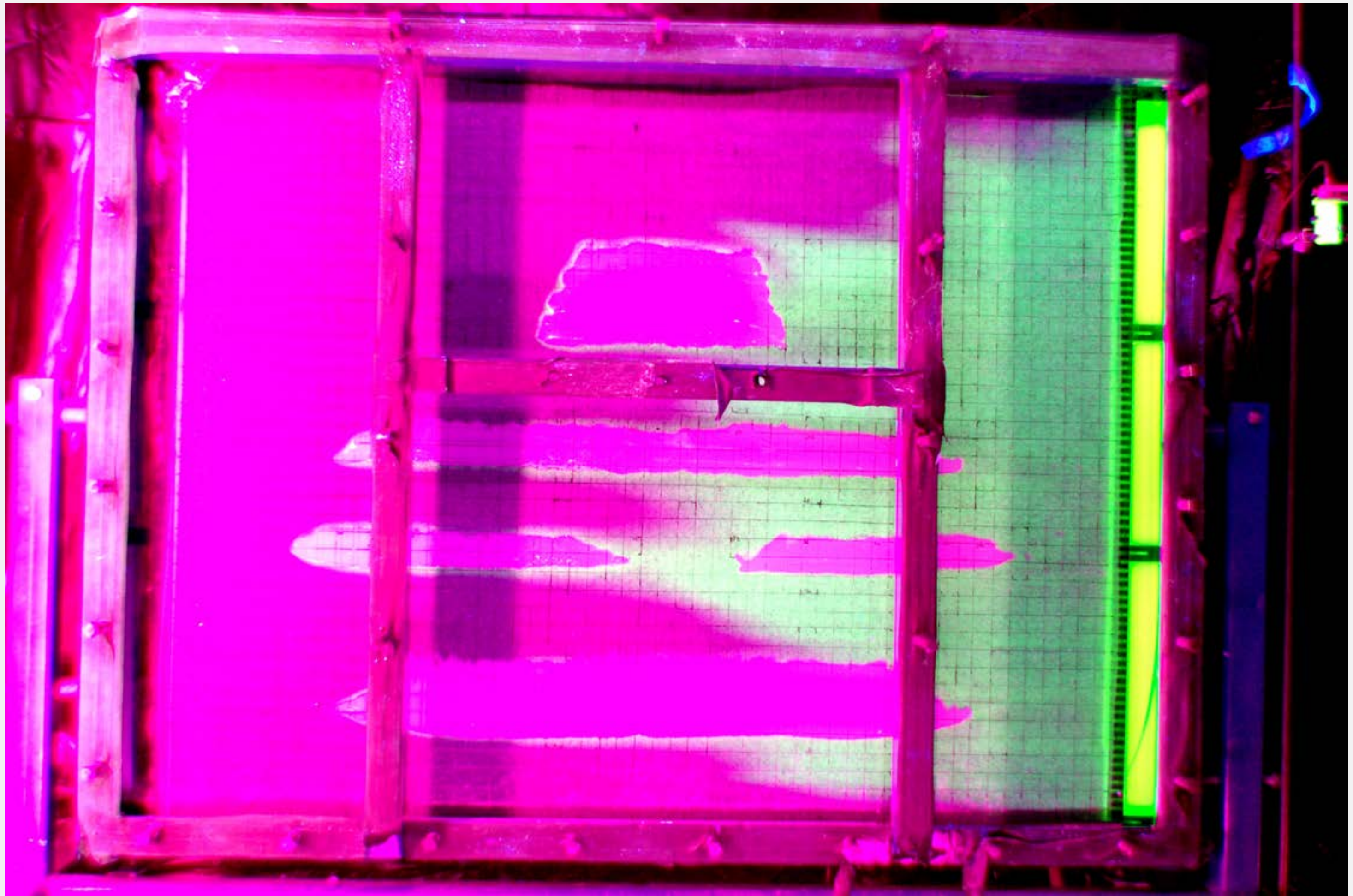
ALKALINE ACTIVATED PERFULFATE

Day 91: one day before flushing water



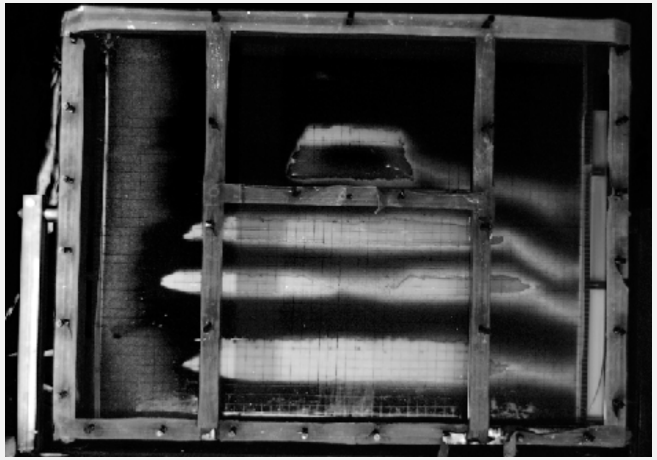
ALKALINE ACTIVATED PERFULFATE

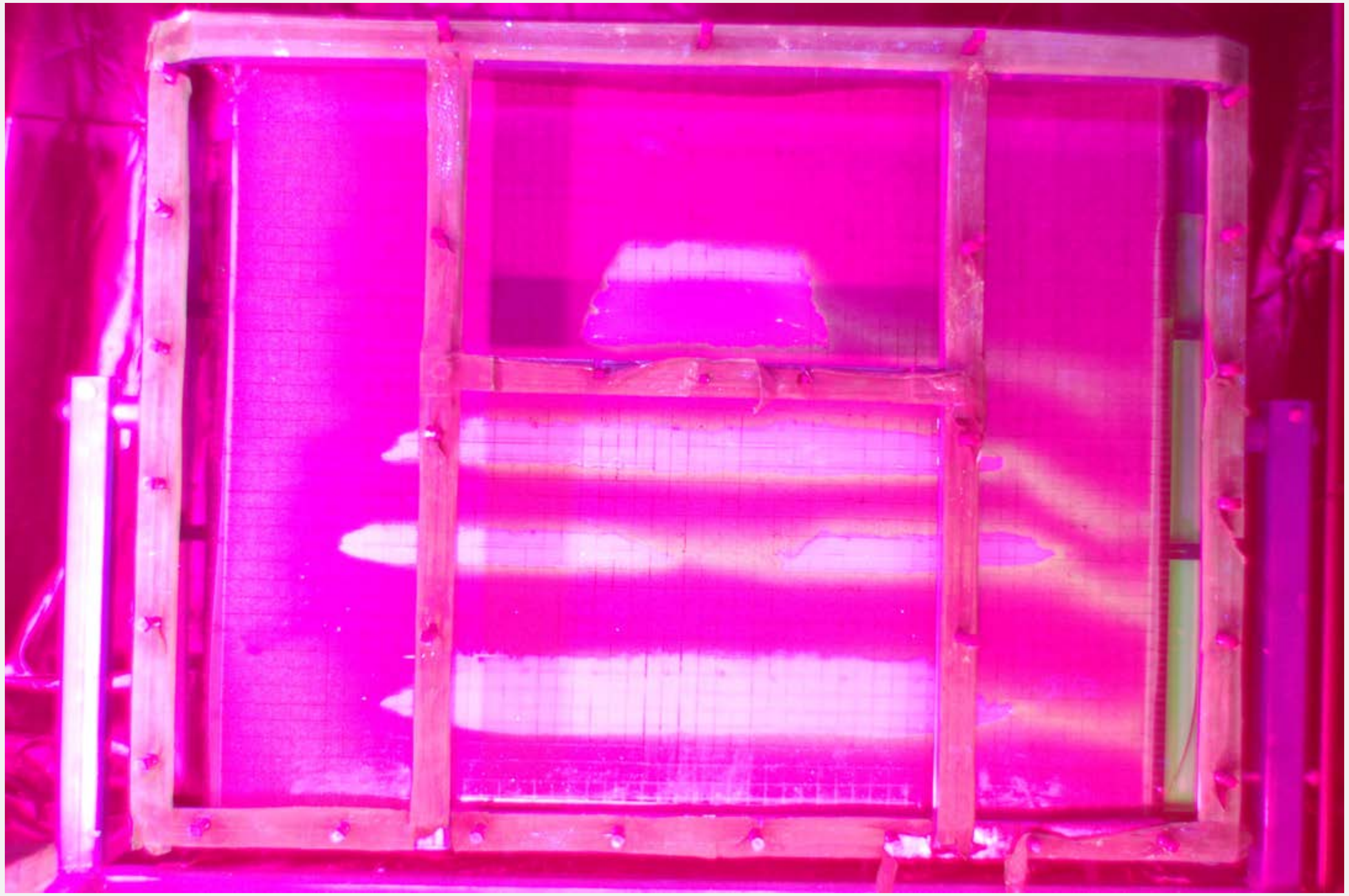
Day 99: water only



ALKALINE ACTIVATED PERSULFATE

Day 132: one day before flushing persulfate





TREATING TCE IN LOW PERMEABILITY ZONE

- Generally well understood:
  - water flushing
  - multiple PRBs
  - chemical oxidation
  - addition of biodegradable carbon

- Might work but, poorly understood:
  - carbon sequestration
  - sonication
  - emplacement of reactive iron-sulfide minerals

CARBON SEQUESTRATION

Hypothesis – Solid carbon phase emplaced in transmissive zones can adsorb contaminants and create a redox poise that favors reductive de-chlorination, and/or provides a favorable substrate for microbes that facilitate in situ treatment.

OBJECTIVE

- explore deliverability of carbon black, activated carbon, and charcoal into porous media
- evaluate the redox poise imposed by each carbon types

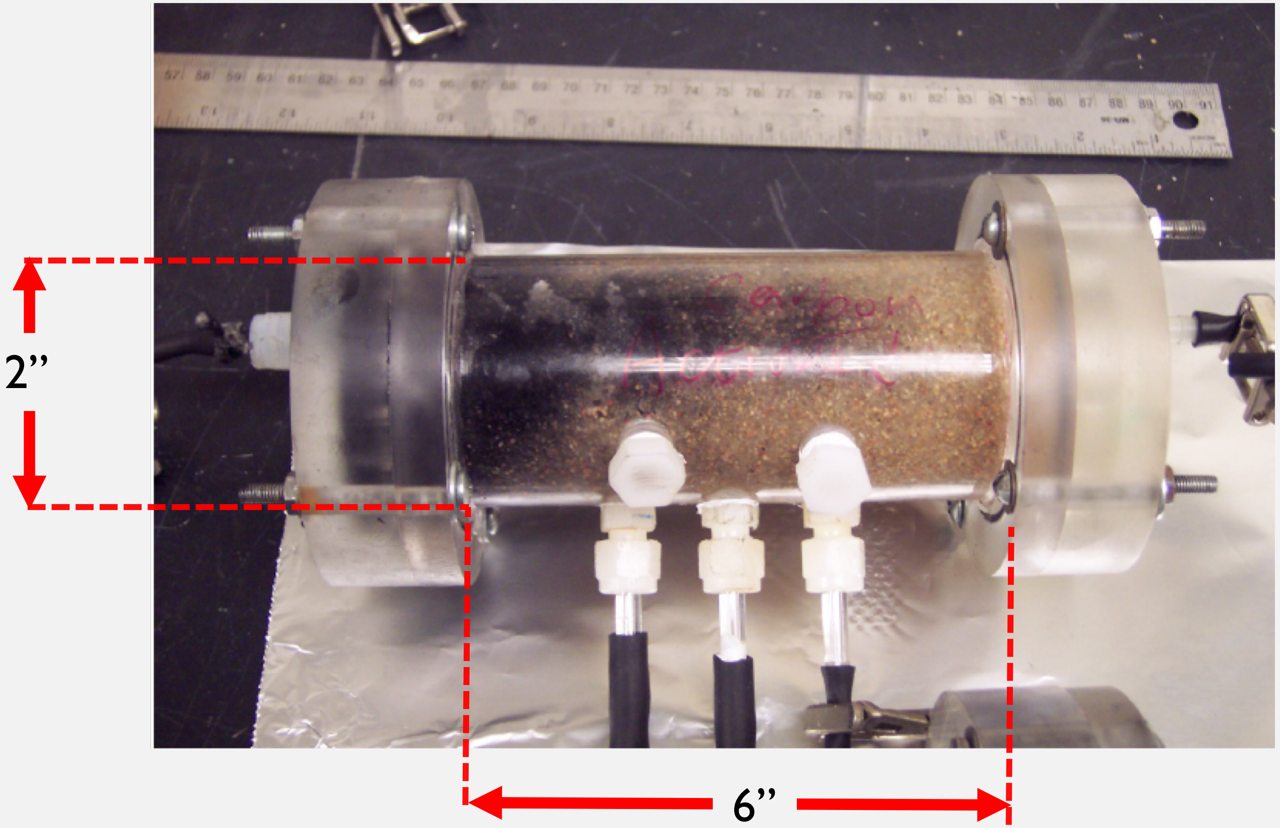
CARBON TYPES

- activated carbon (Fisher Scientific)
- carbon black (Columbian Chemicals Company)
- charcoal (ACROS ORGANICS)

Size:

- ground into a fine powder and passed through a #200 sieve

DELIVERY OF CARBON



medium to coarse quartz-feldespar sand

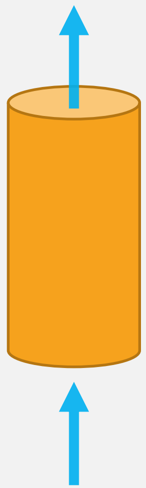
porosity: 0.345

hydraulic conductivity: 0.035 cm/s

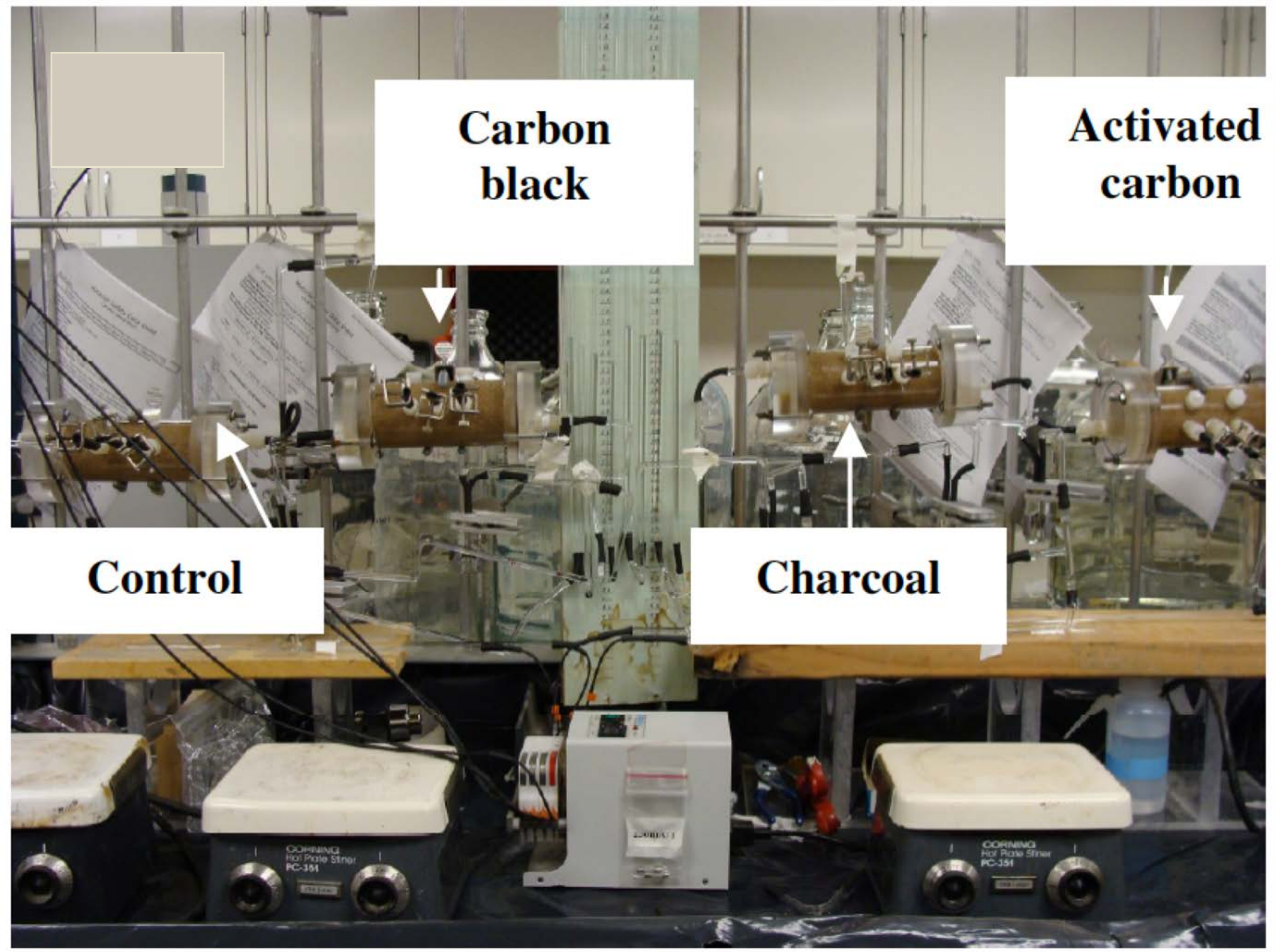

250mA/T
CORNING
Hot Plate Stirrer
PC-351
CORNING
Hot Plate Stirrer
PC-351

Influent:

- Deionized water
- 80 mg/L Na_2SO_4
- 20 mg/L Na_2HPO_4

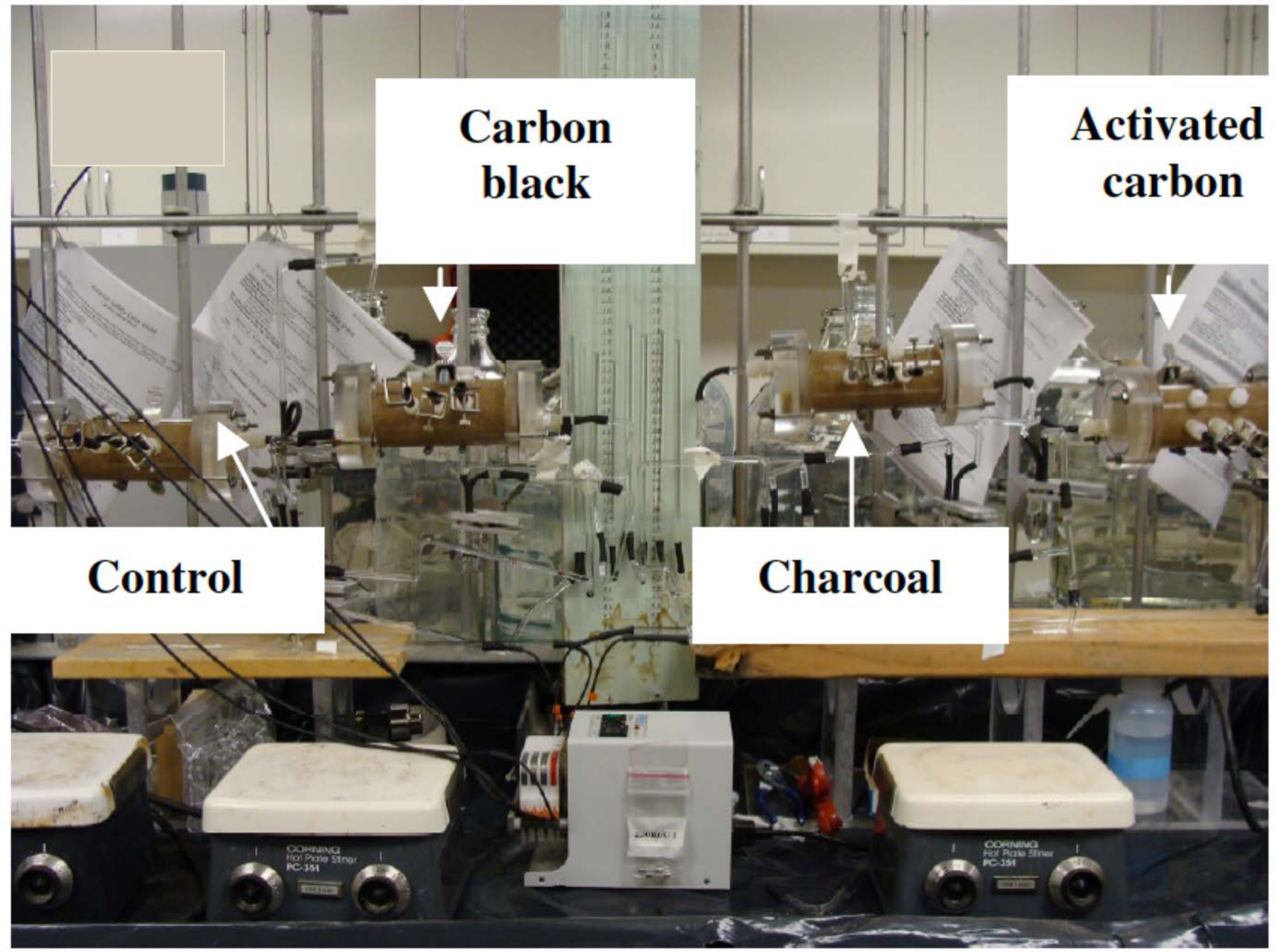


seepage velocity of 1 ft/day



Slurry: 4% carbon by weight

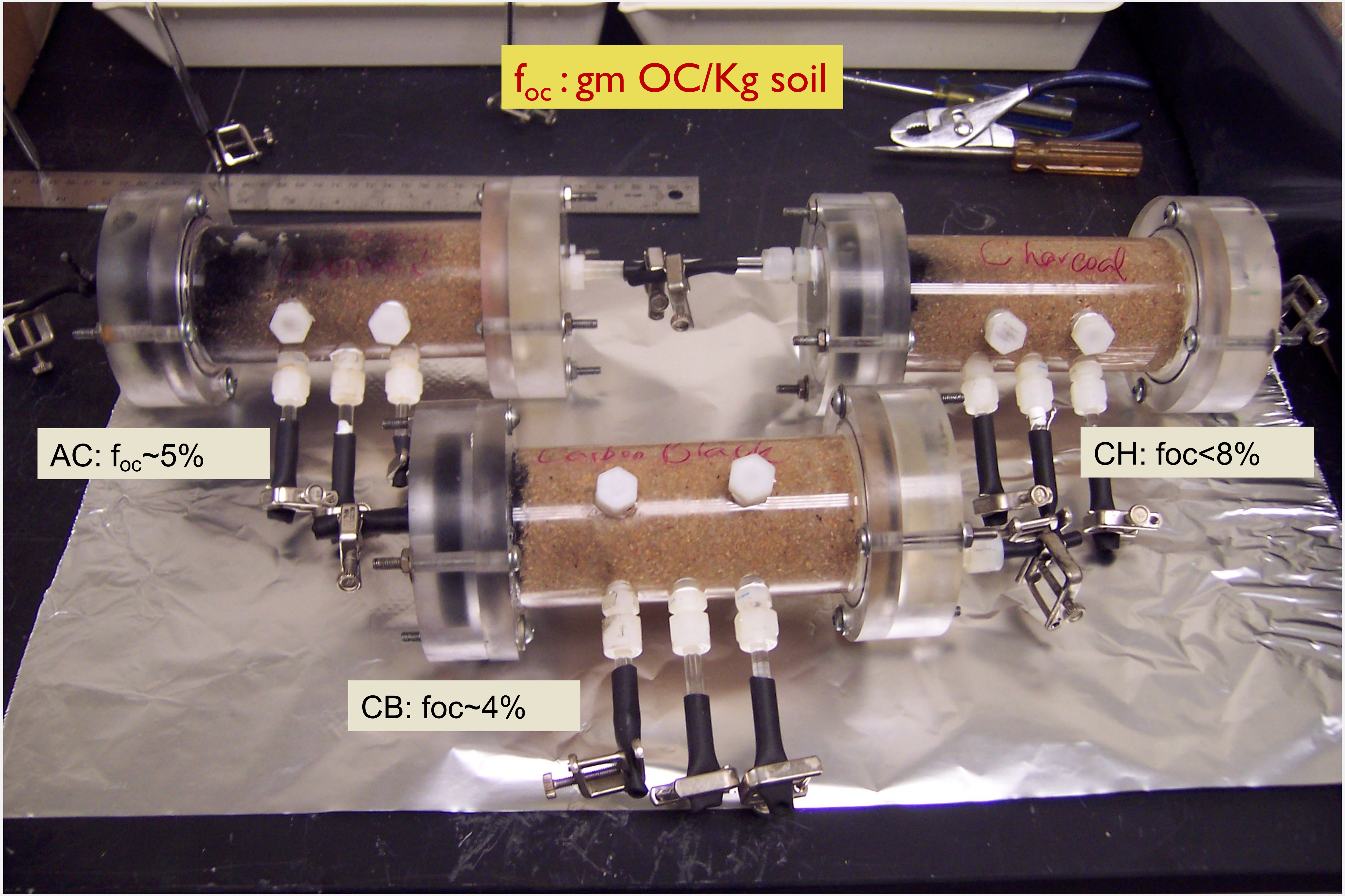
Seepage velocity: 20 ft/day



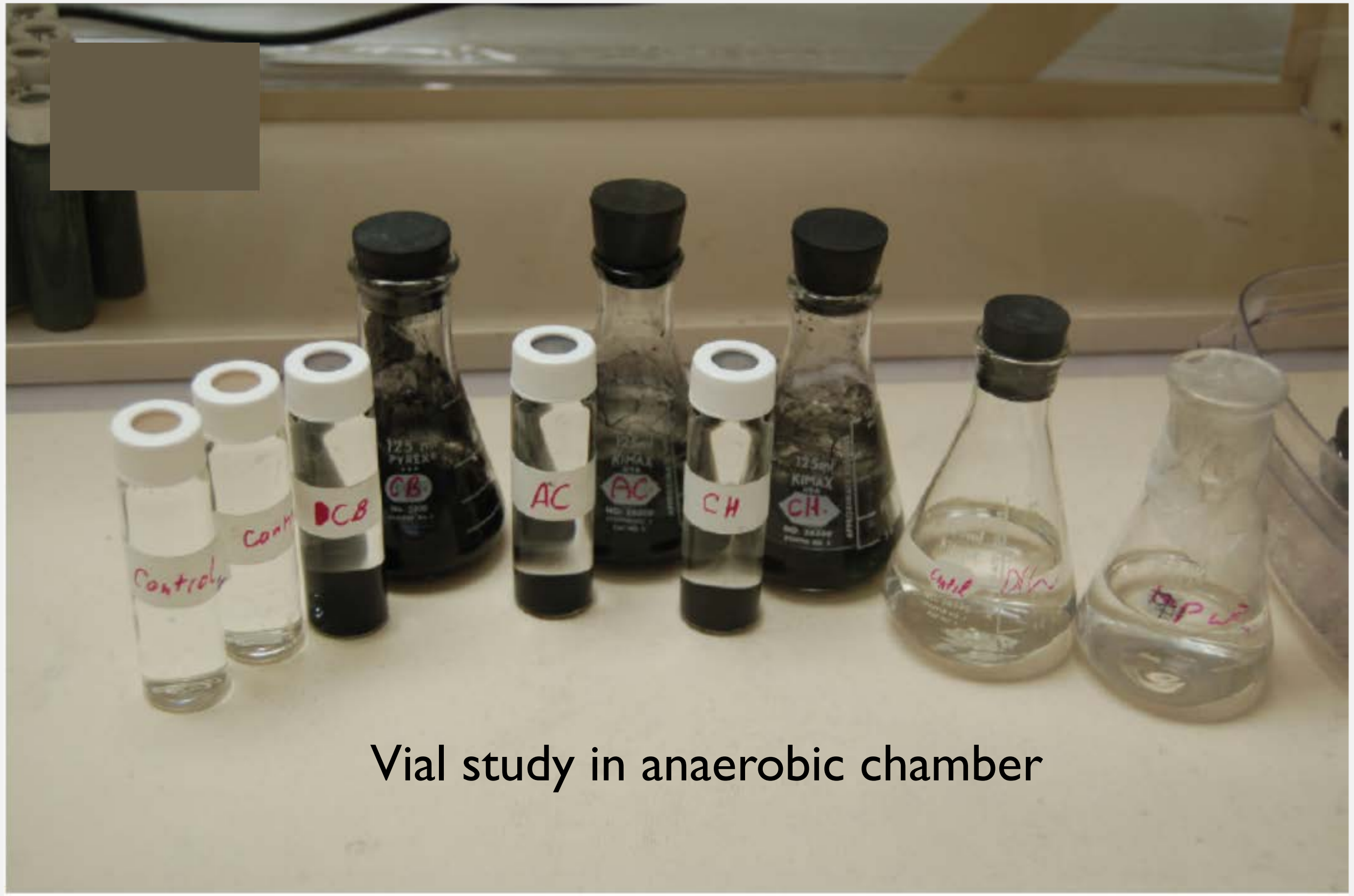
CARBON CONTENT CALCULATION

- Columns disassembled, content emptied onto #80 sieve
- Content washed with DIW to separate the carbon from sand
- Carbon-water was pour into a porcelain Buchner funnel (equipped with a pre-weighted 0.45 micron filter paper wetted with DIW) connected to a side-arm flask with a tube leading to a vacuum pump
- The liquid was drawn through the perforated plate by vacuum suction leaving carbon particles on top
- Filter papers were dried in the oven for 24 hours and weighted

f_{oc} : gm OC/Kg soil



METHODS: REDOX POISE

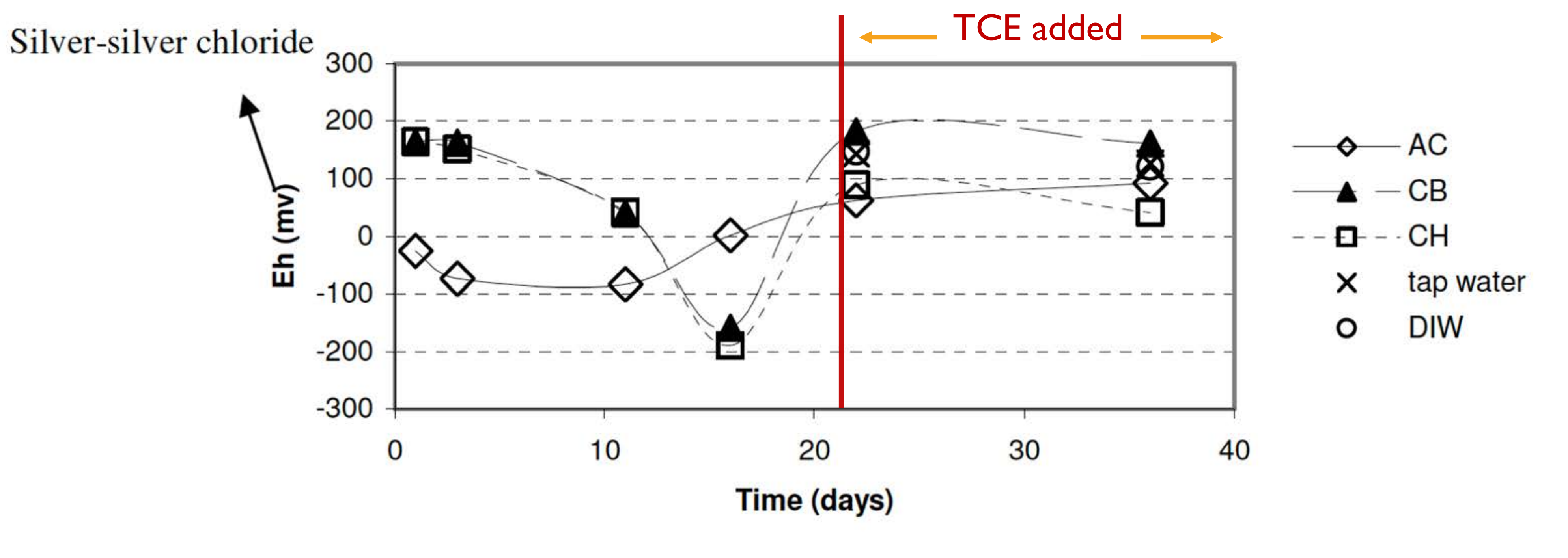


Vial study in anaerobic chamber

METHODS: REDOX POISE

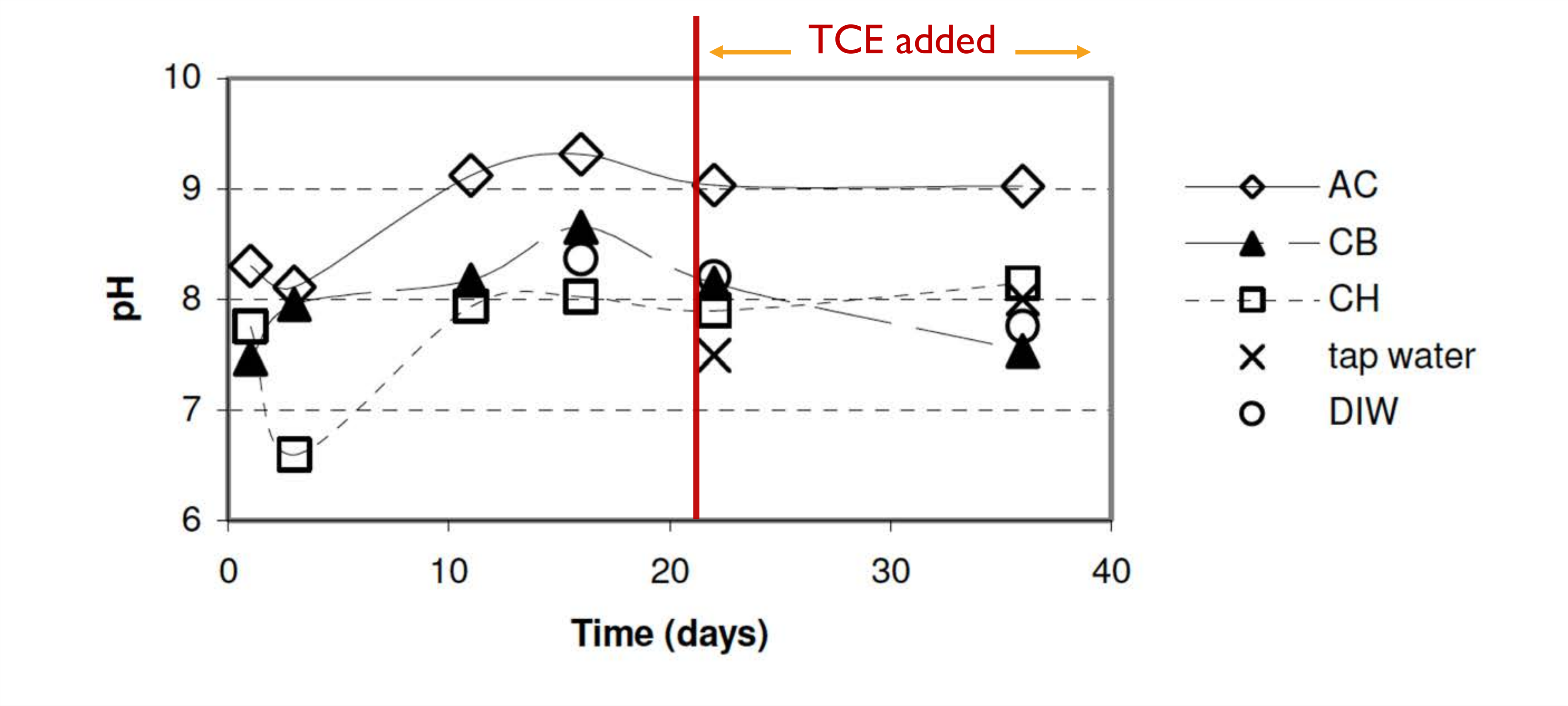
- Saturated TCE stock solution: non-aqueous TCE in DIW with 80 mg/L Na_2SO_4 and 20 mg/L Na_2HPO_4
- Test vials: 40 mL glass vials were filled with 20 mL of well-mixed carbon types topped off with 21 mL of TCE stock solution to minimize the head space
- Control vials: two 40-mL glass vials were filled up with the TCE saturated solution only.
- Eh and pH measurement: ORP probe through five weeks (three weeks before and two weeks after addition of the TCE stock solution).
- After a week of treatment, the vials were tested for TCE using a GC and chloride using a IC

RESULTS: REDOX POISE



Eh data of carbon types vs. time

RESULTS: REDOX POISE

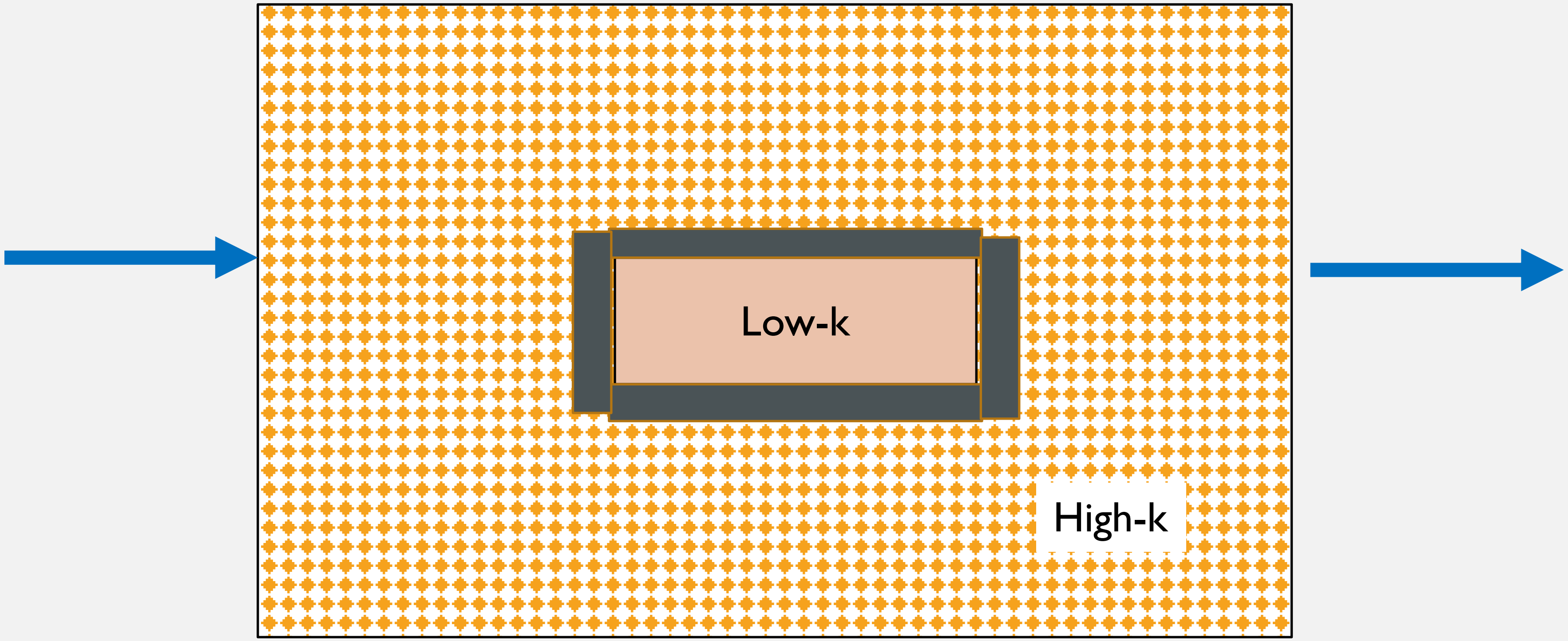


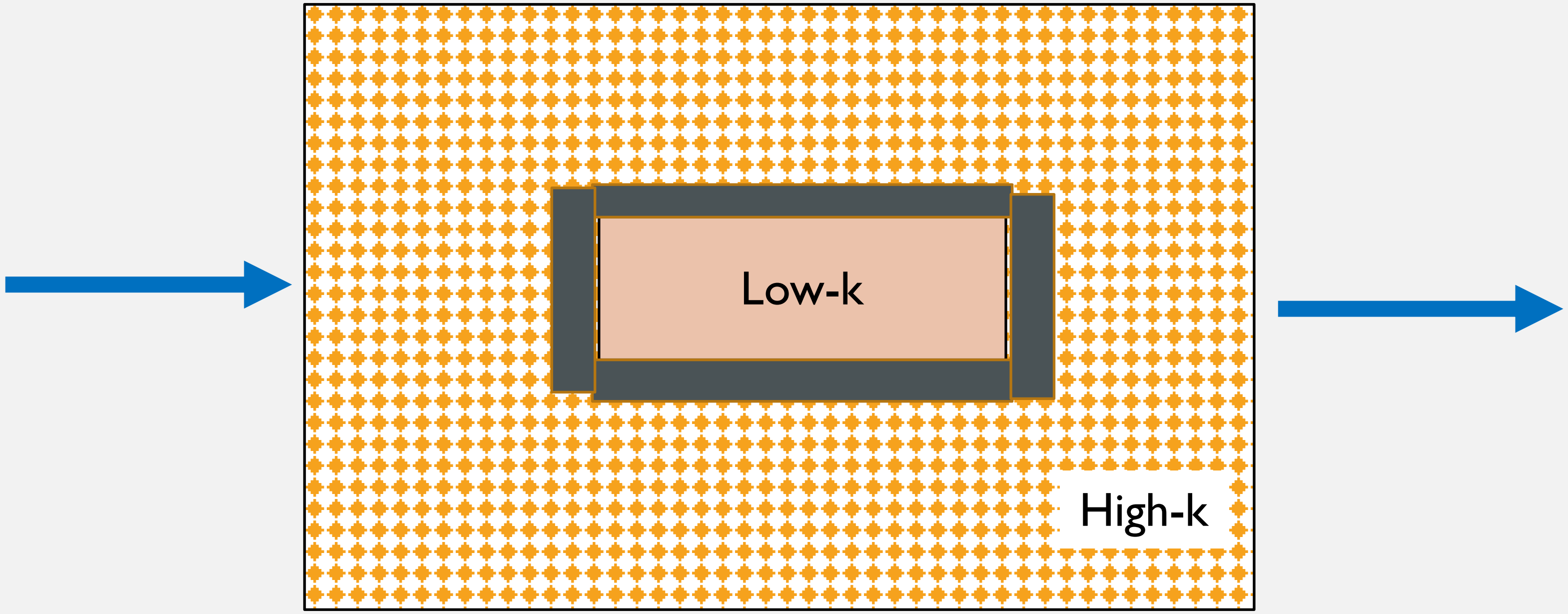
pH data of carbon types vs. time

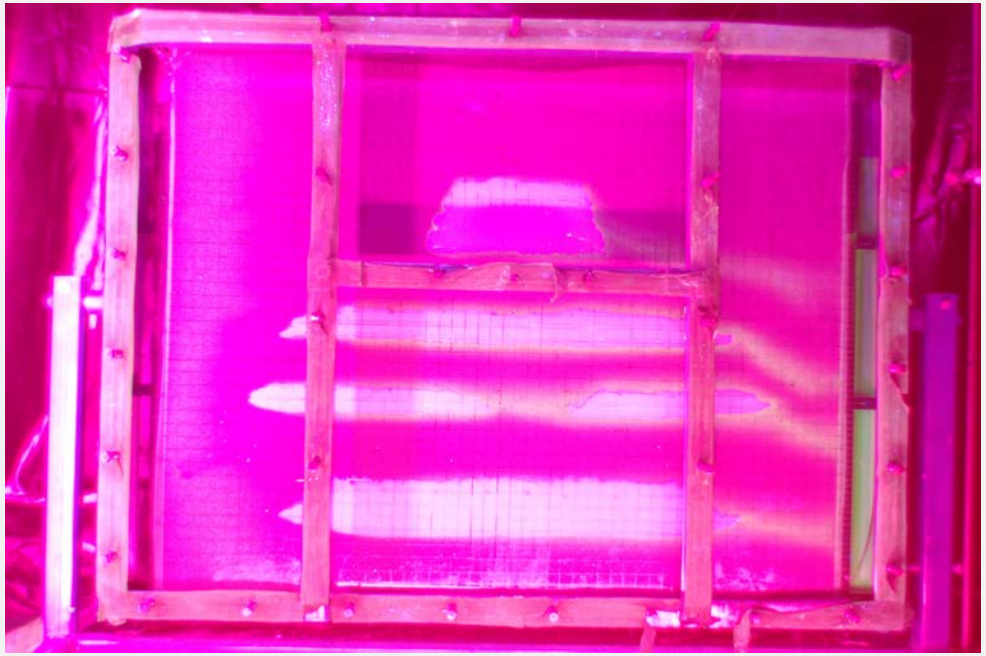
CONCLUSIONS

- Delivery issues to overcome
- Carbon sequestration for management of contaminants in low permeability zones seems to have limited feasibility

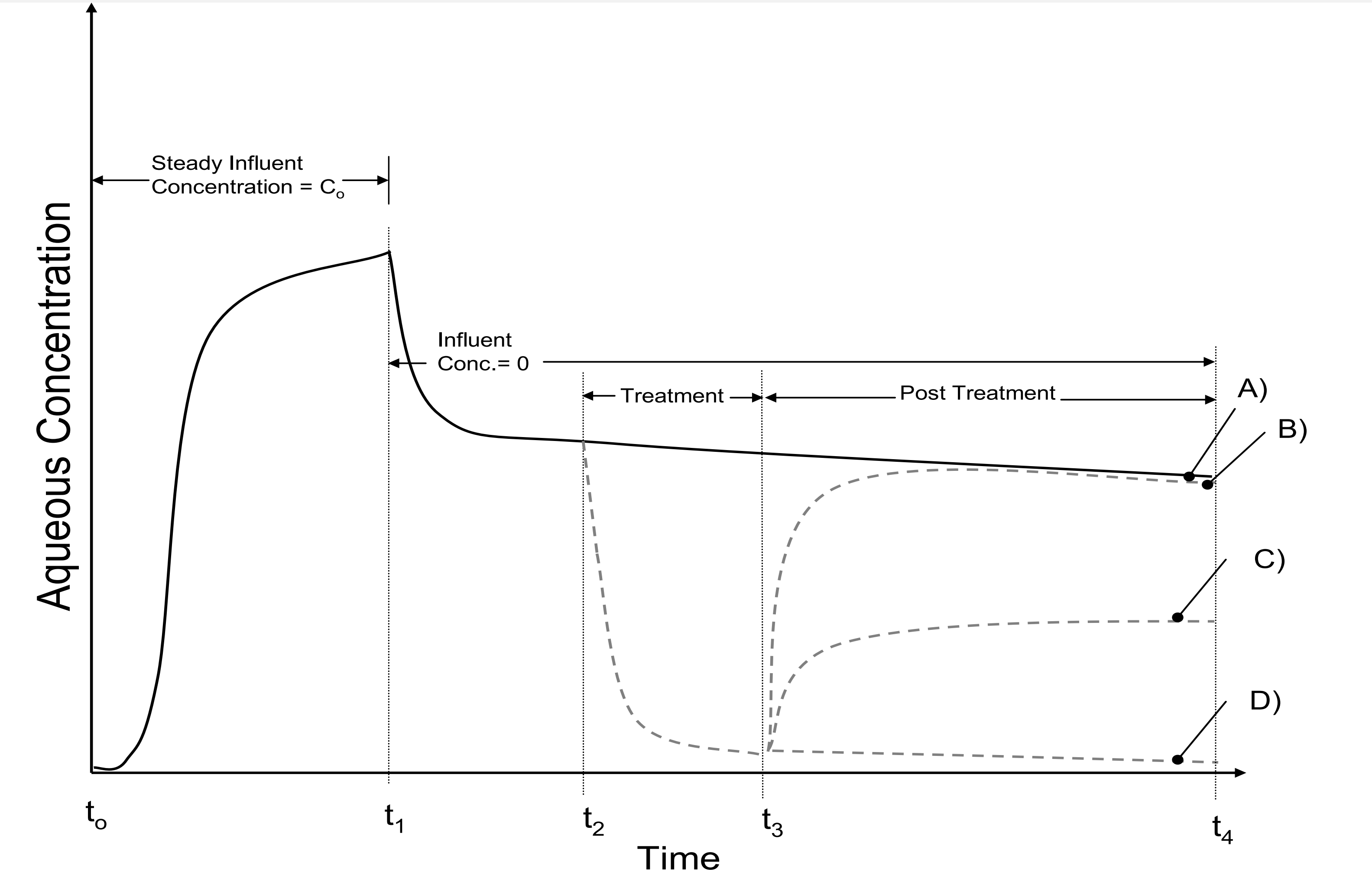
FUTURE PLANS




Low-k
High-k



HYPOTHETICAL RESPONSES TO PLUME TREATMENT



THANK YOU

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