Modeling of Downgradient Reverse Diffusion Effects

Tom Sale – Colorado State University*
Tissa Illangasekare- Colorado School of Mines

Presented at

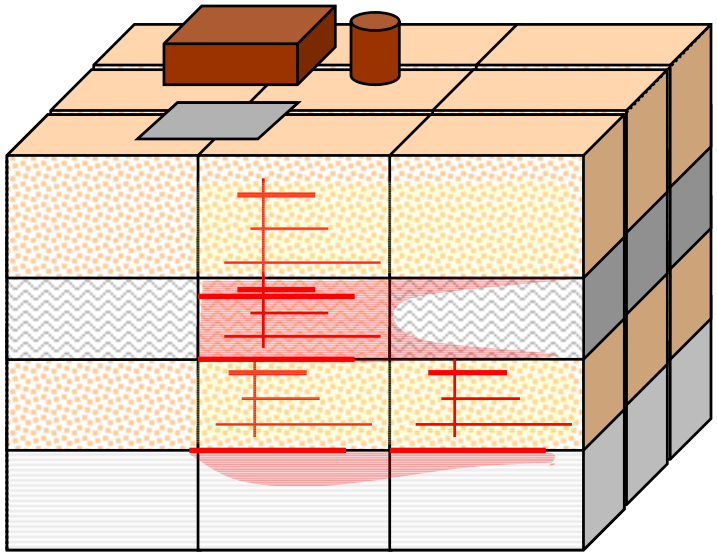
RTDF/PRB Meeting, Niagara Falls, October 2003

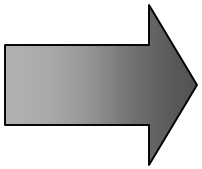
Presentation

- Problem Statement
- Laboratory Studies
- Analytical Models
- Comparisons to Field Data
- Implications

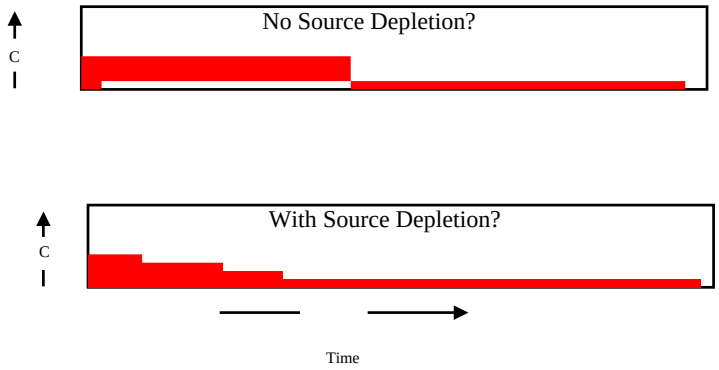
Problem Statement

A Priori Analysis of the Benefits of Source Treatment



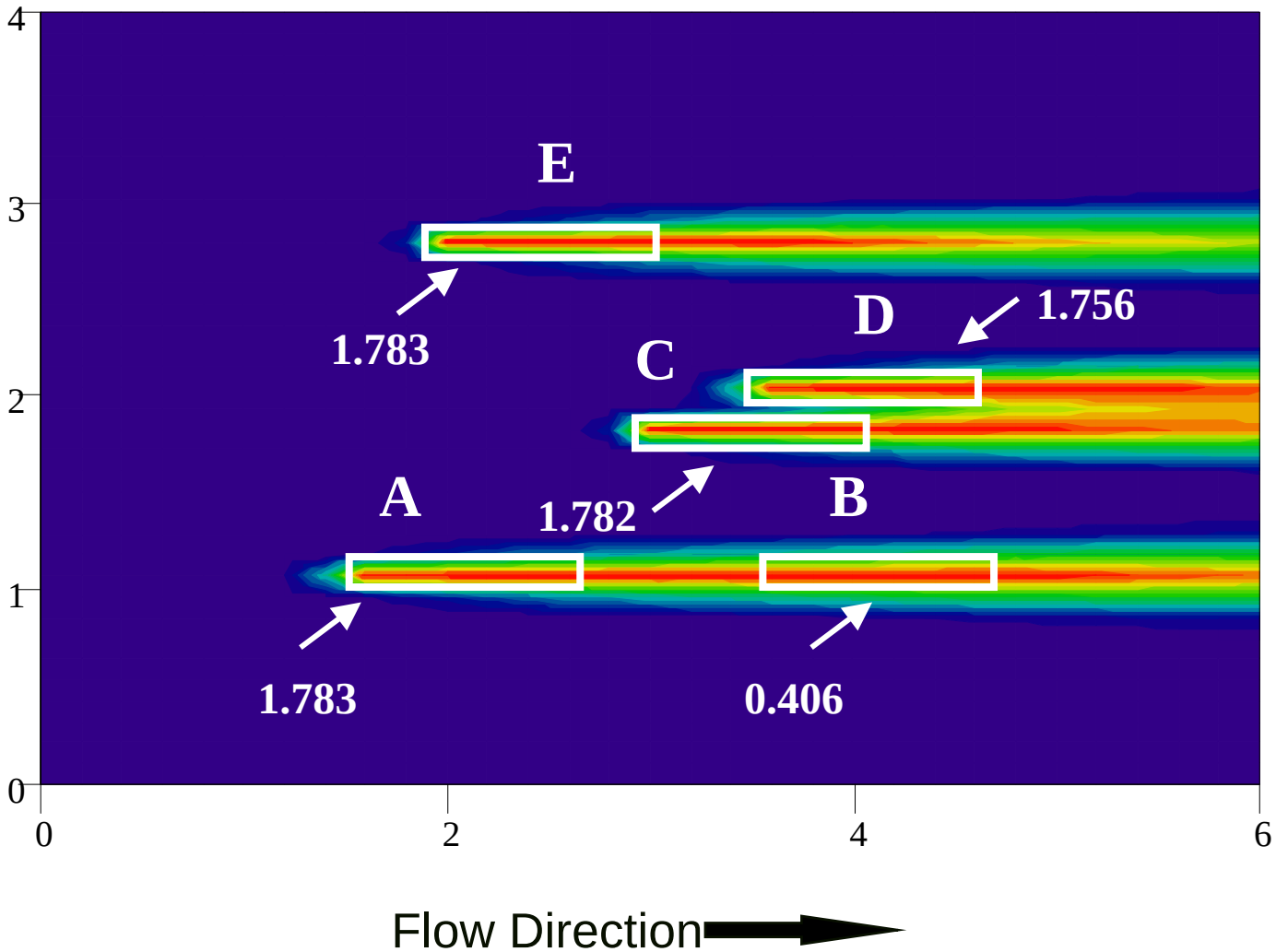


Given an investment what is the net change in the emission function

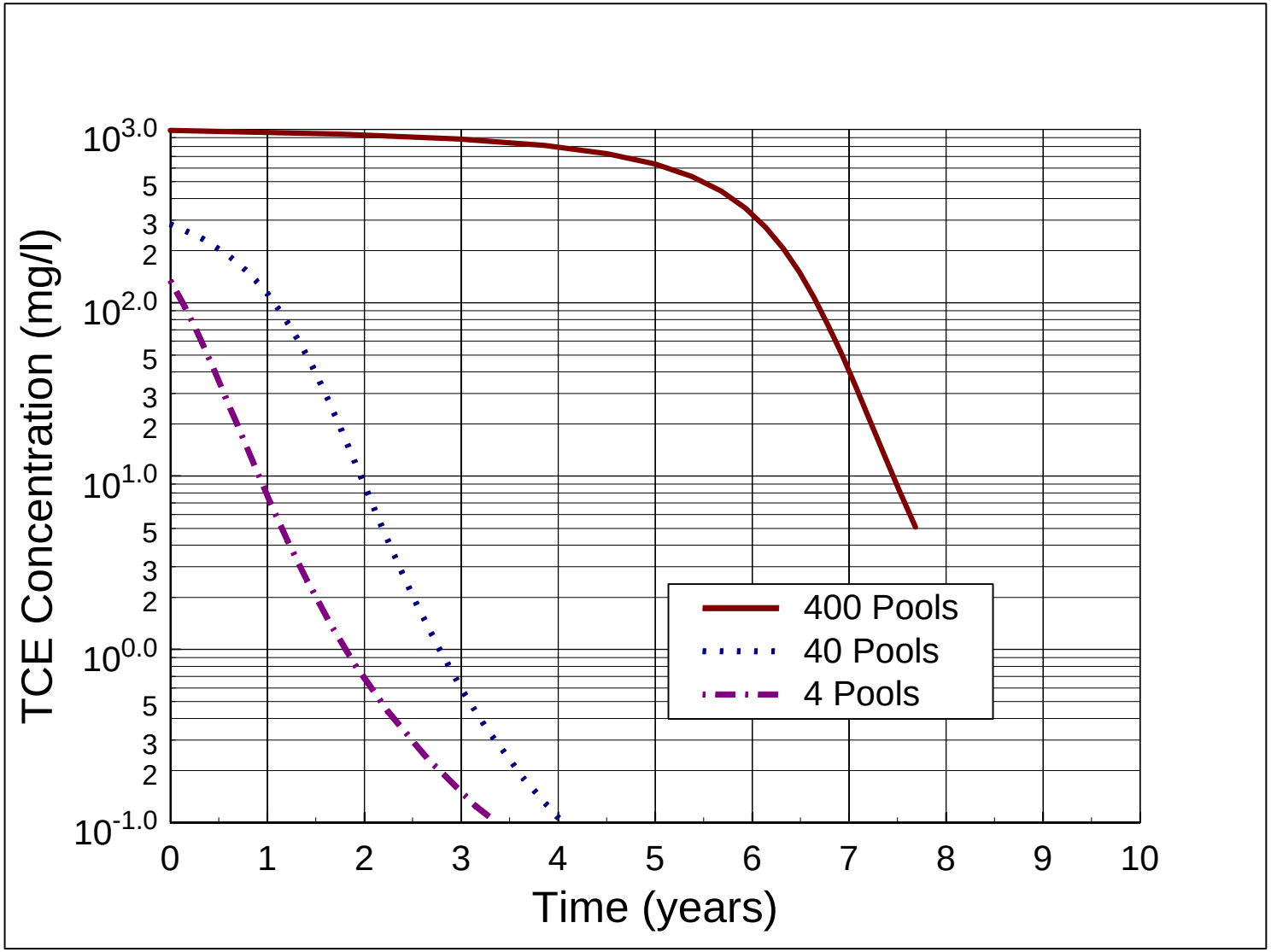


Mass Discharge from multiple DNAPL pools in a source zone

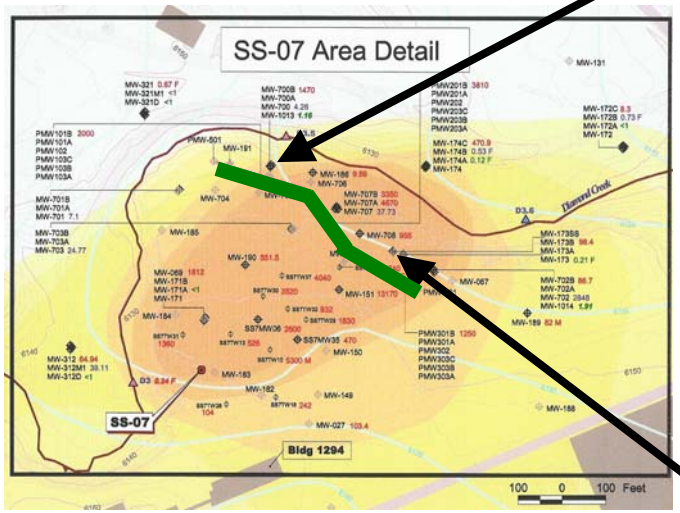
(Sale and McWhorter, WRR, 2001)

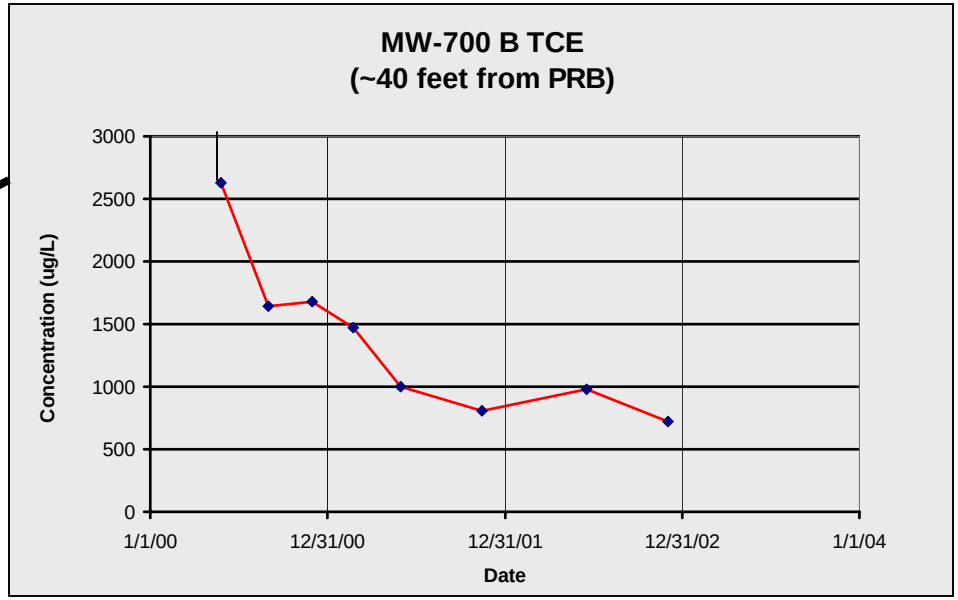


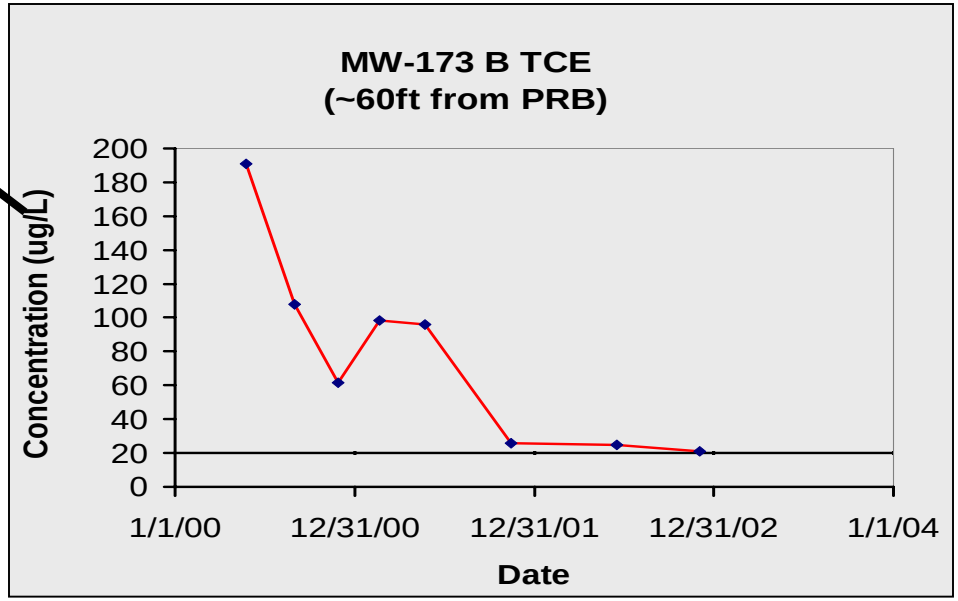
DNAPL – Source Emission Functions



F.E. Warren
Spill Site 7 PRB

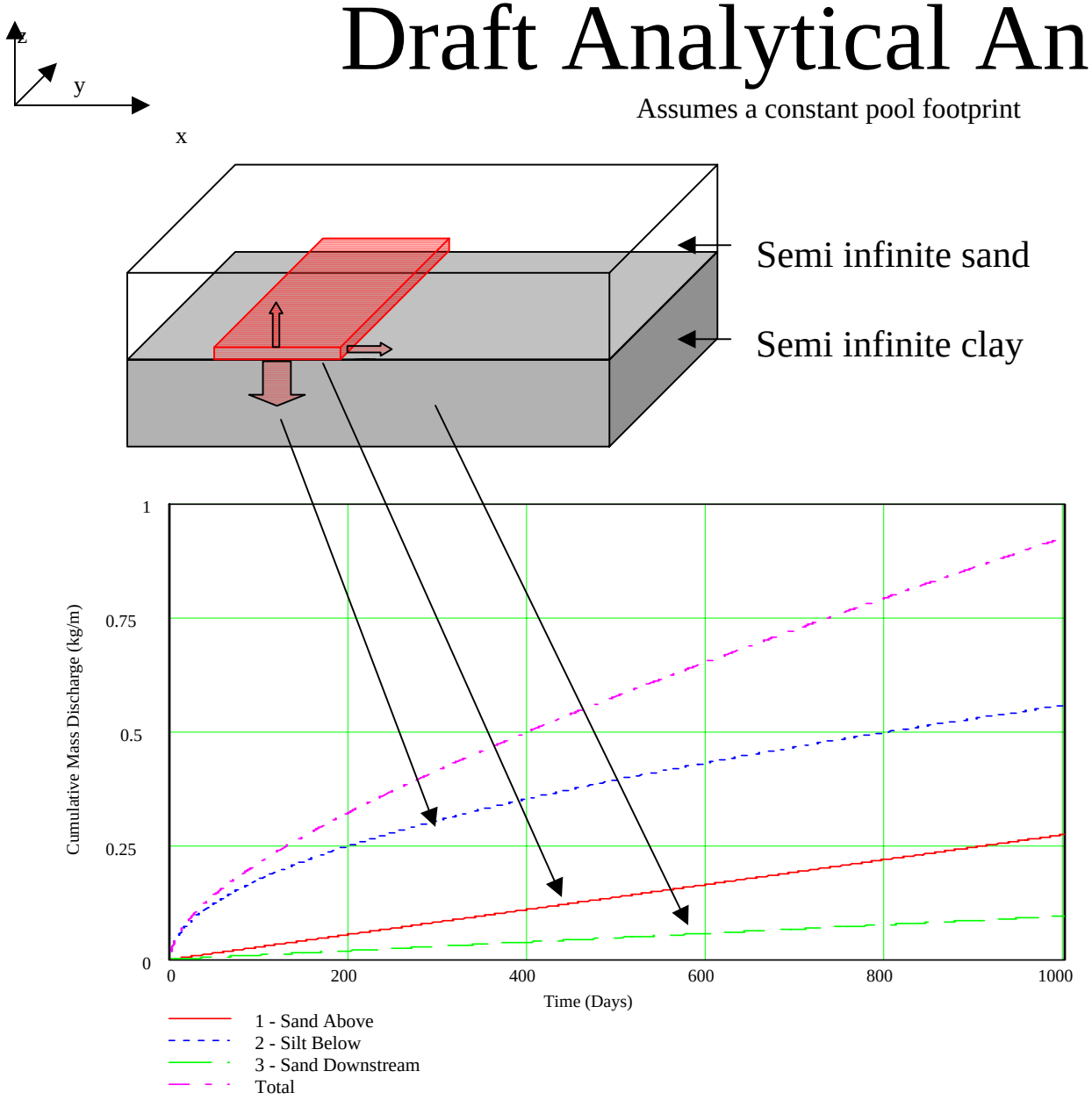




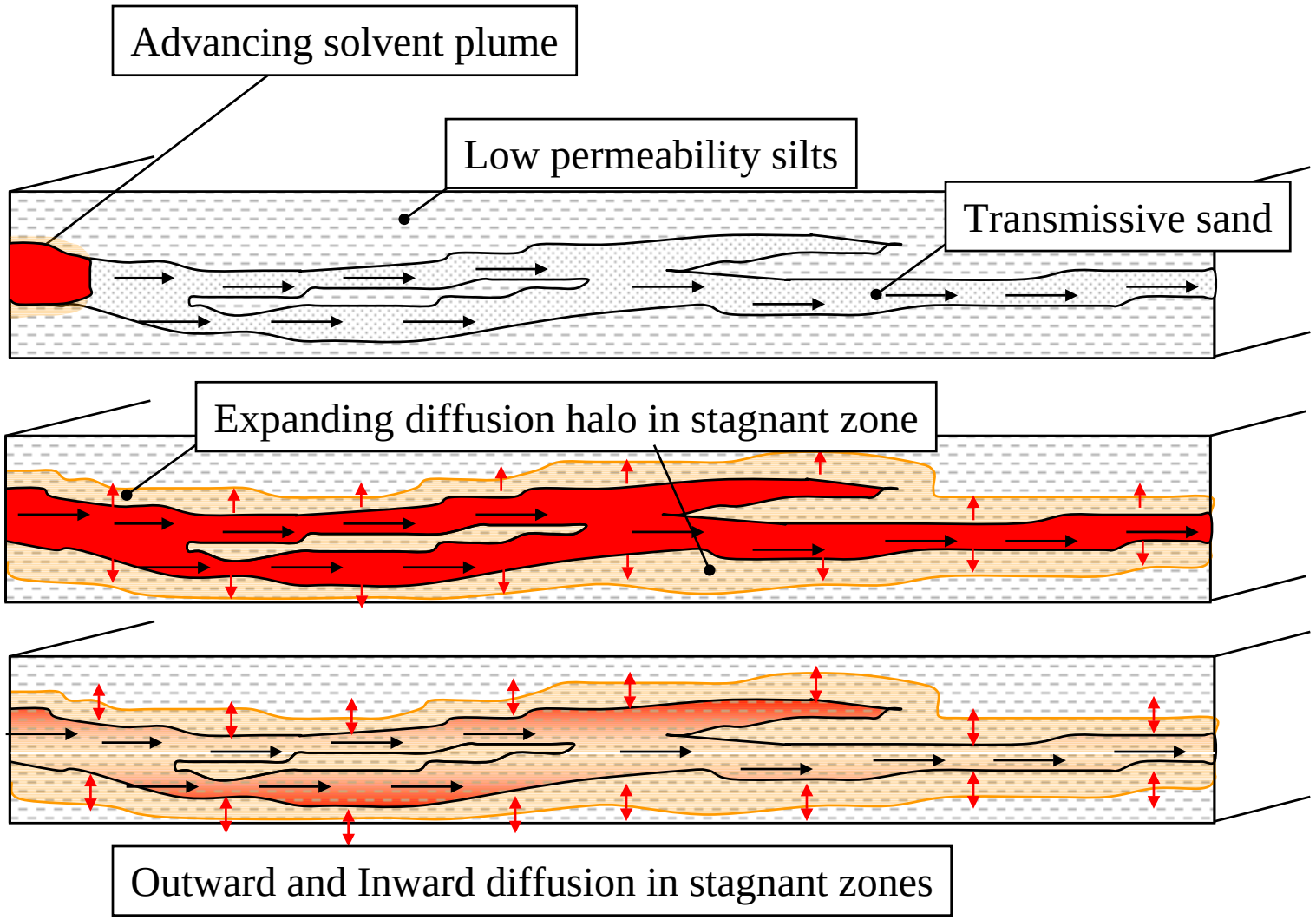


Draft Analytical Analyses

Assumes a constant pool footprint



Plume Attenuation/ Plume Replenishment by Matrix Diffusion - (after Sudicky et al., 1985; Parker et al.,1994 and 1997)

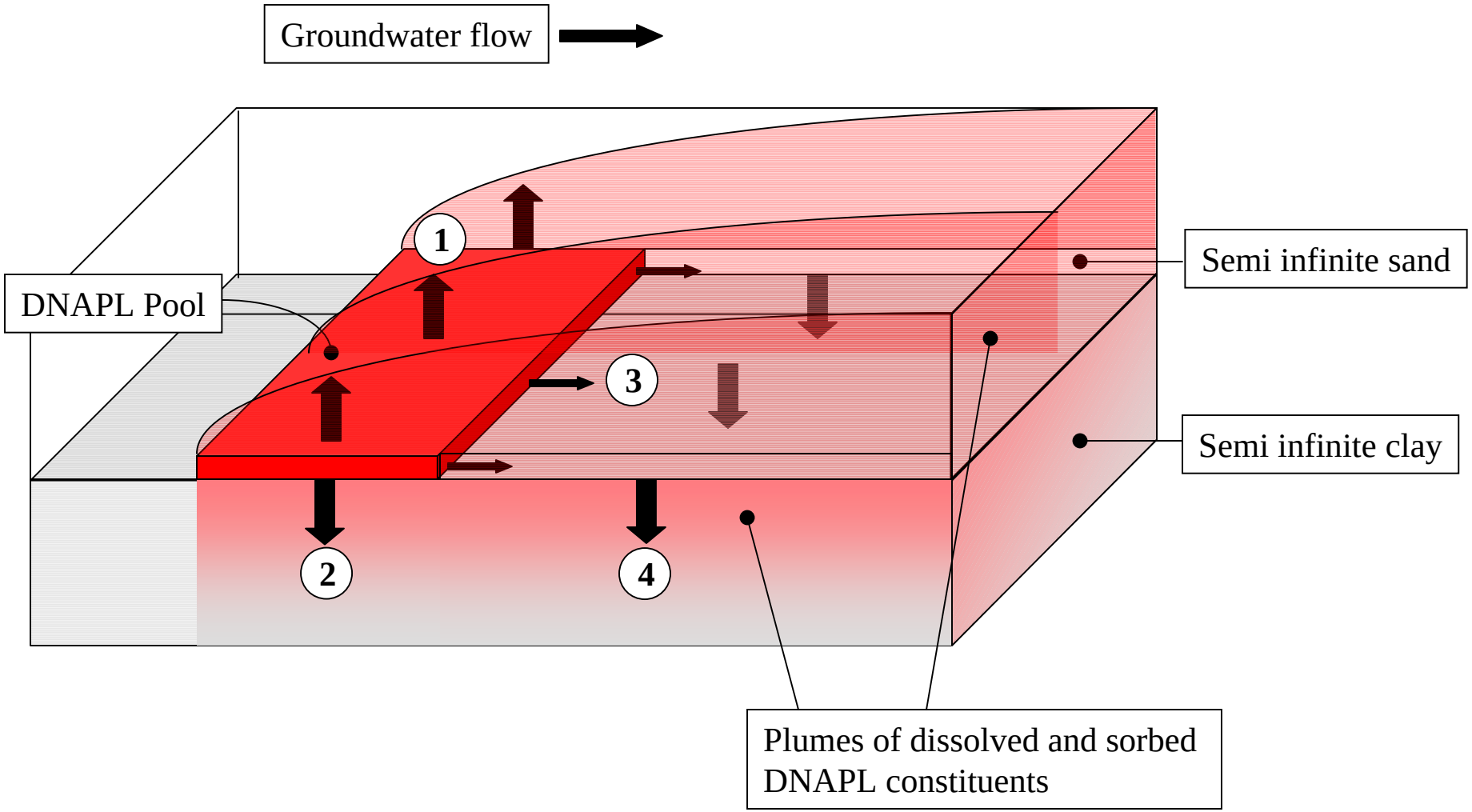


Laboratory Studies

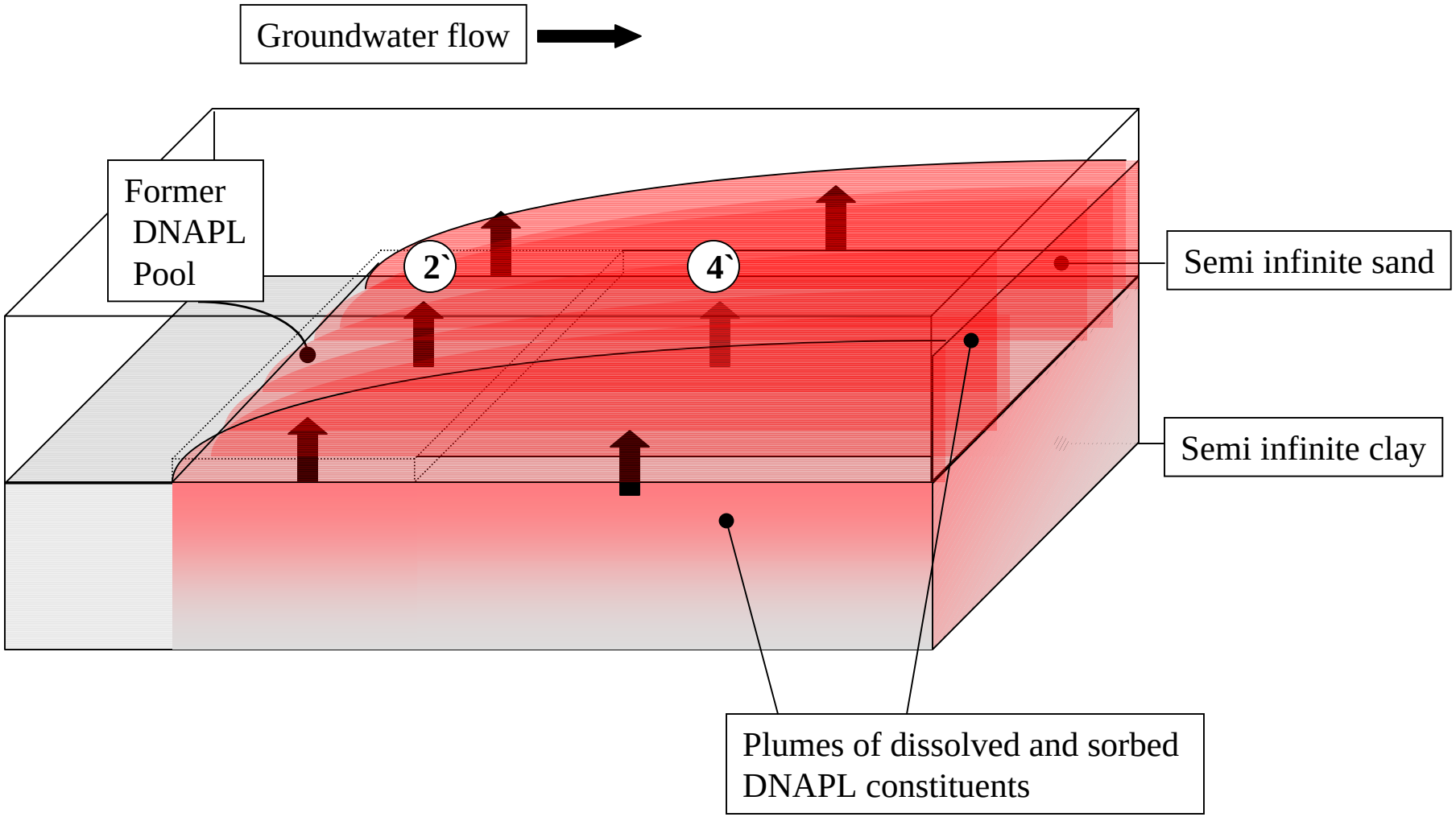
AFCEE Source Zone Initiative

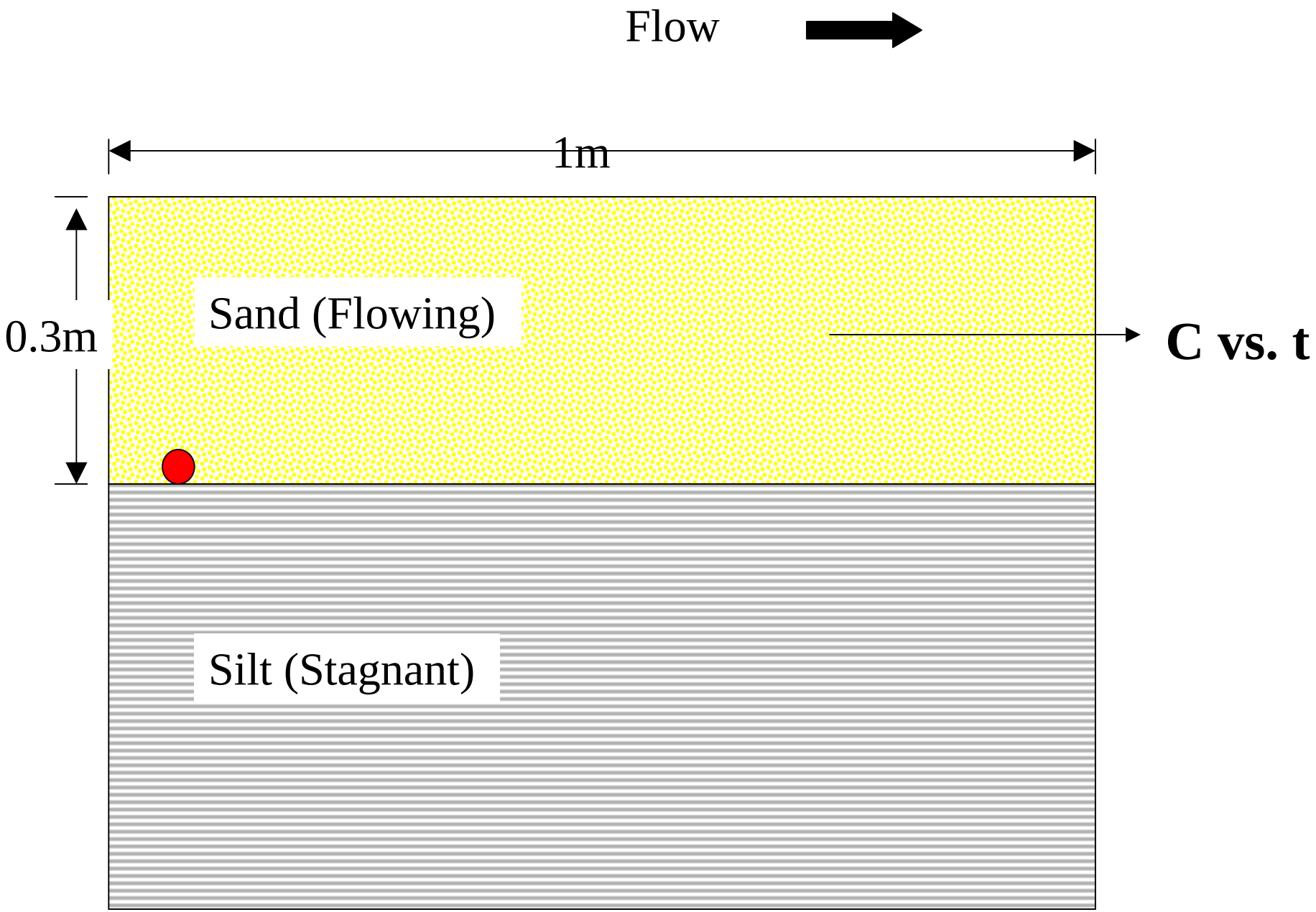
Colorado State University
and
Colorado School of Mines

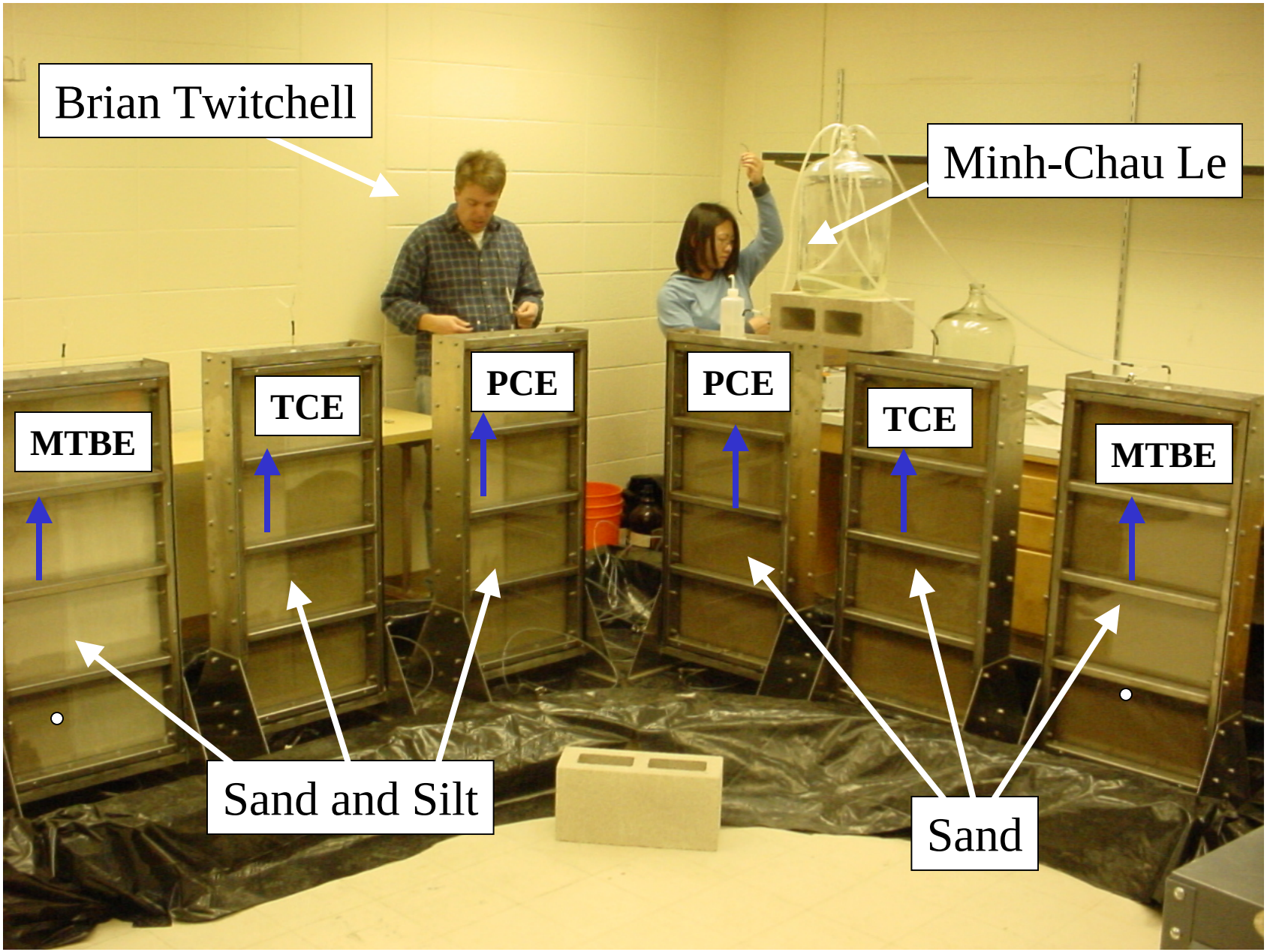
Simple Case


Groundwater flow
DNAPL Pool
1
2
3
4
Semi infinite sand
Semi infinite clay
Plumes of dissolved and sorbed DNAPL constituents

Back Diffusion

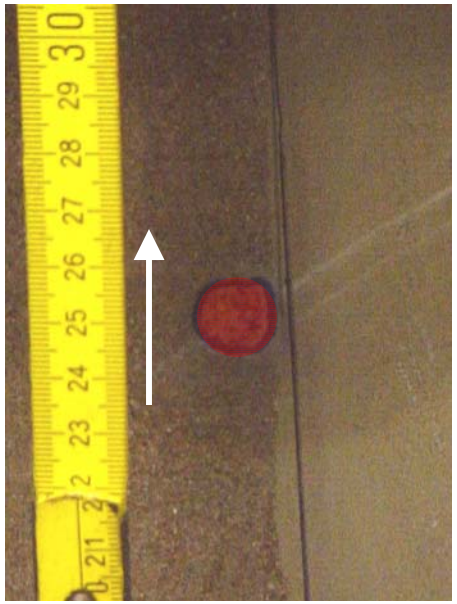


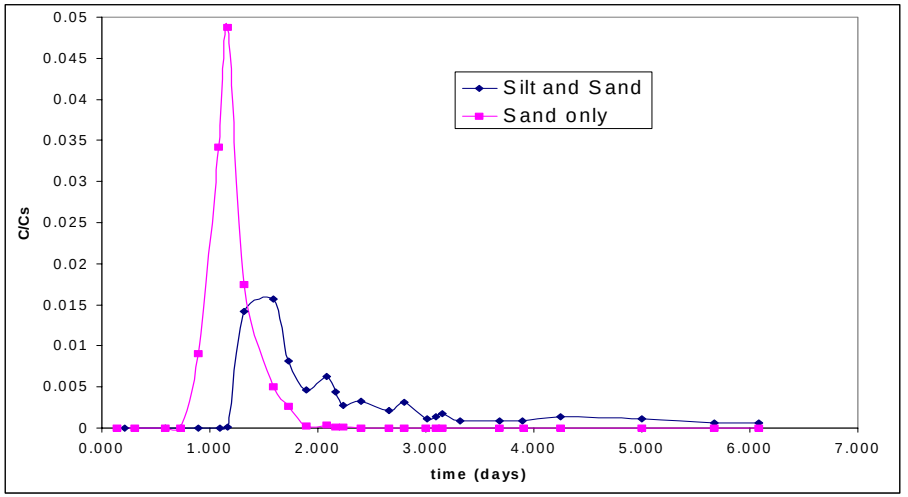

Flow
1m
0.3m
Sand (Flowing)
C vs. t
Silt (Stagnant)

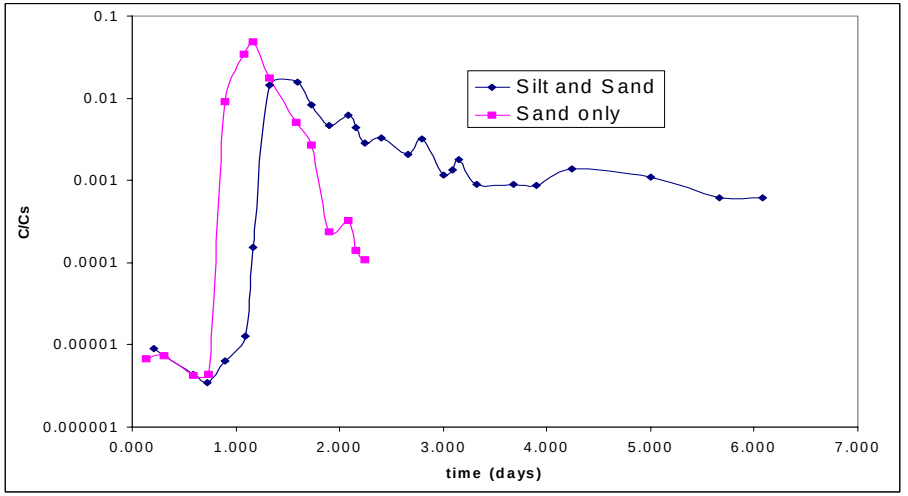

Brian Twitchell
Minh-Chau Le
MTBE
TCE
PCE
PCE
TCE
MTBE
Sand and Silt
Sand

Small Tank Studies - Preliminary Results – Brian Twitchell, Minh Chau Le and Tom Sale Colorado State University (2003)

MTBE Tank Experiments

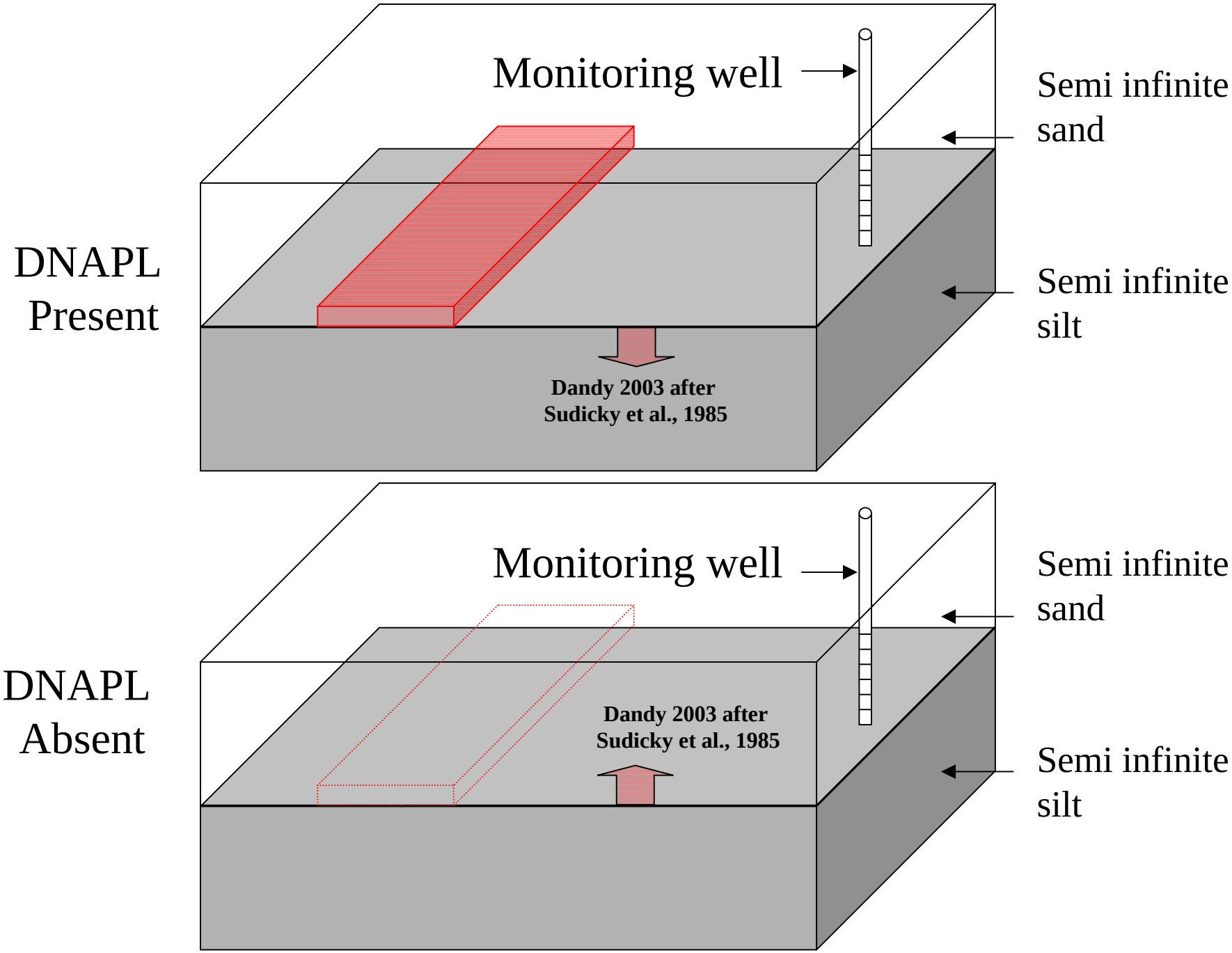






Analytical Models

AFCEE Source Zone Initiative


DNAPL
Present
Monitoring well
Semi infinite
sand
Semi infinite
silt
Dandy 2003 after
Sudicky et al., 1985
DNAPL
Absent
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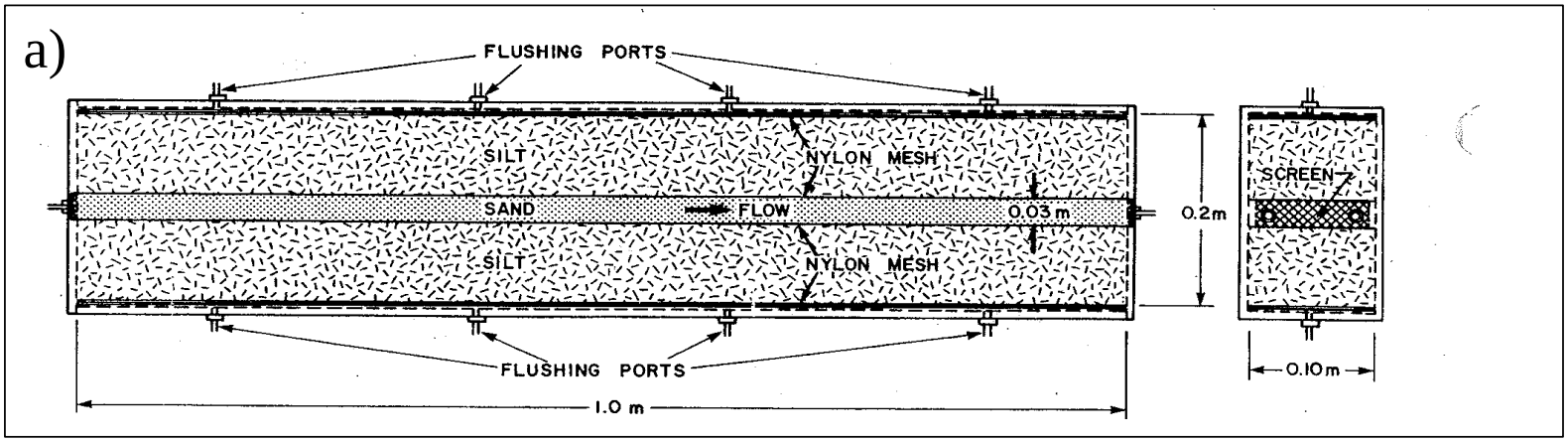
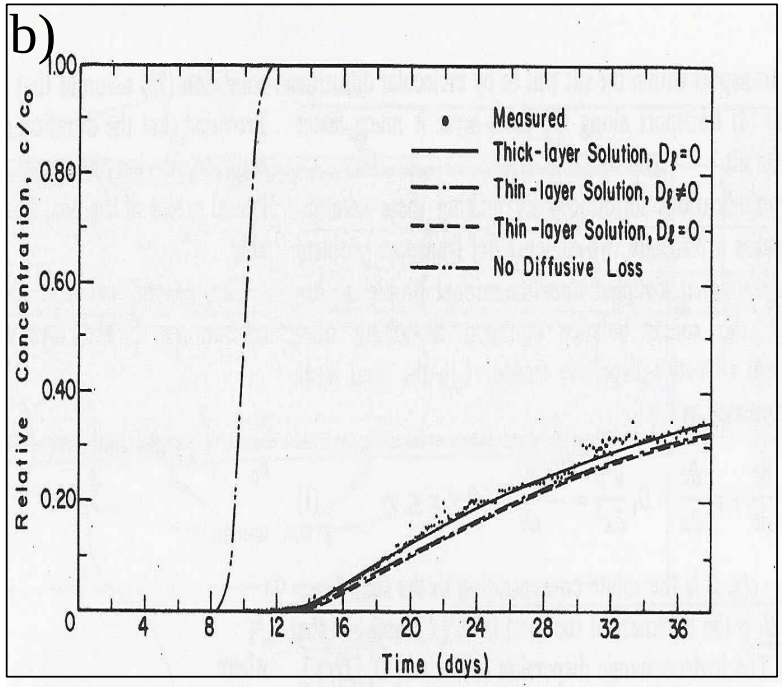
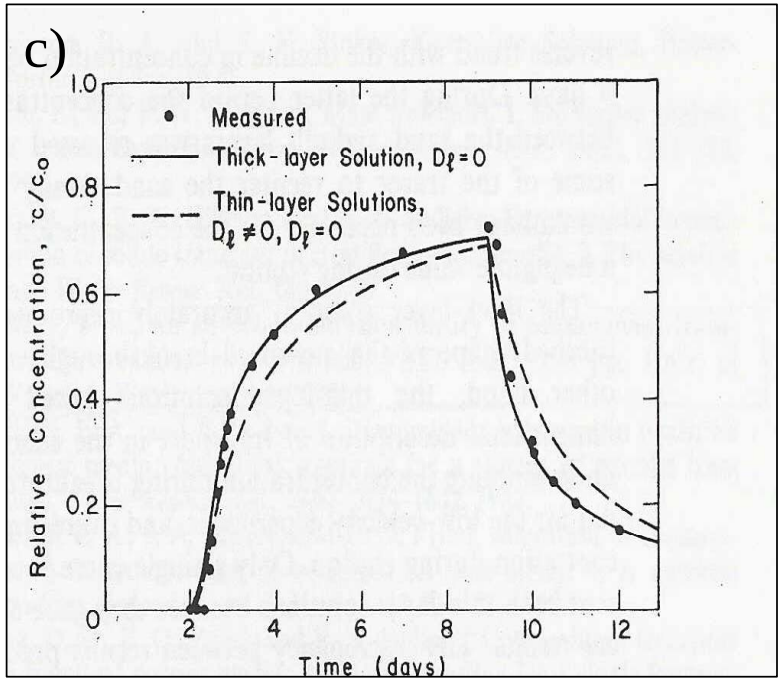
Excerpt from Sudicky Gillham and Frind, WRR 1985





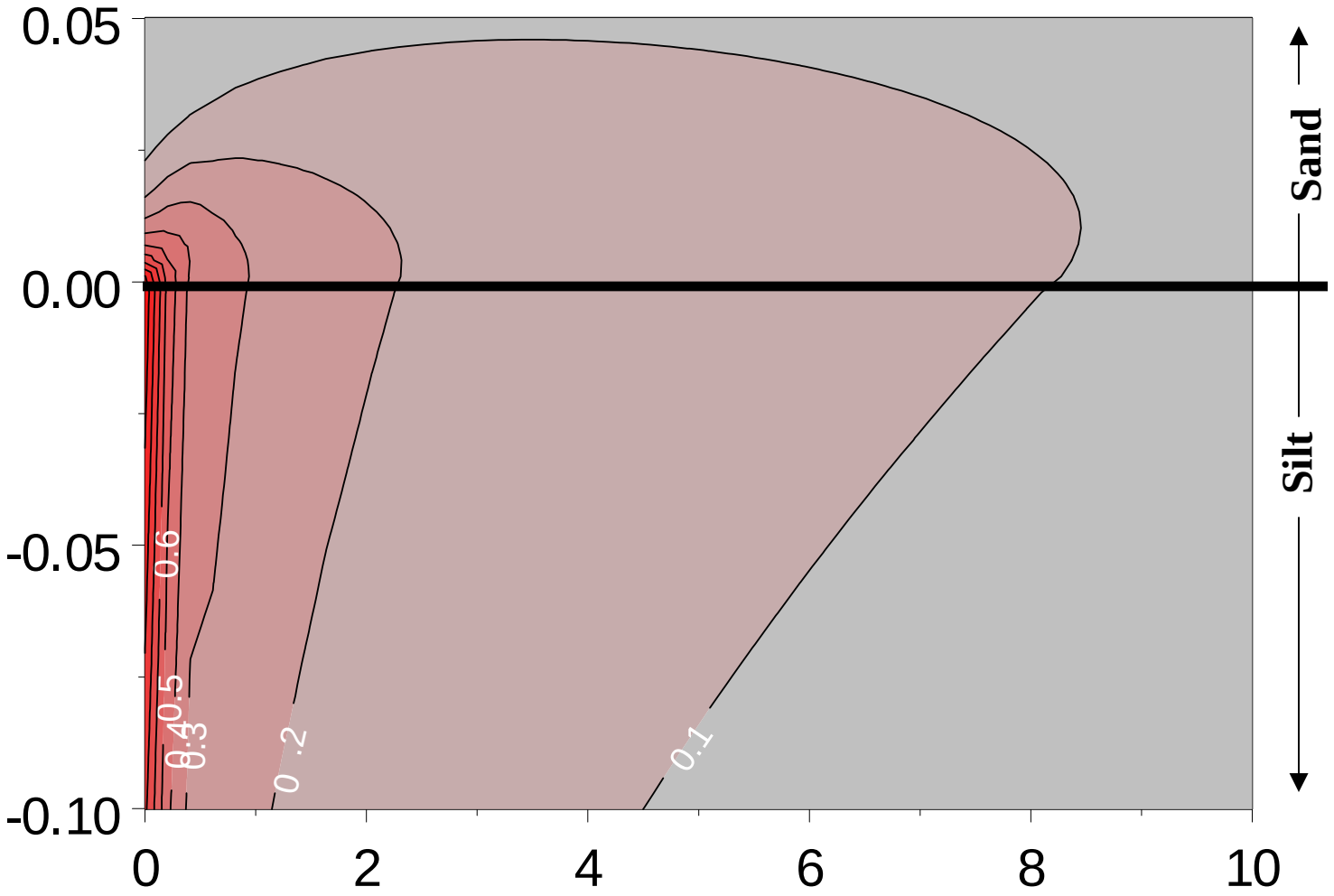


Analytical Models for Downstream Processes

- Sudicky et al. 1995
- Dave Dandy/ Colorado State University / 2003
  - Discrete source at interface
  - Solves for concentration in sand and silt layers
  - Enhanced computation speed and reliability

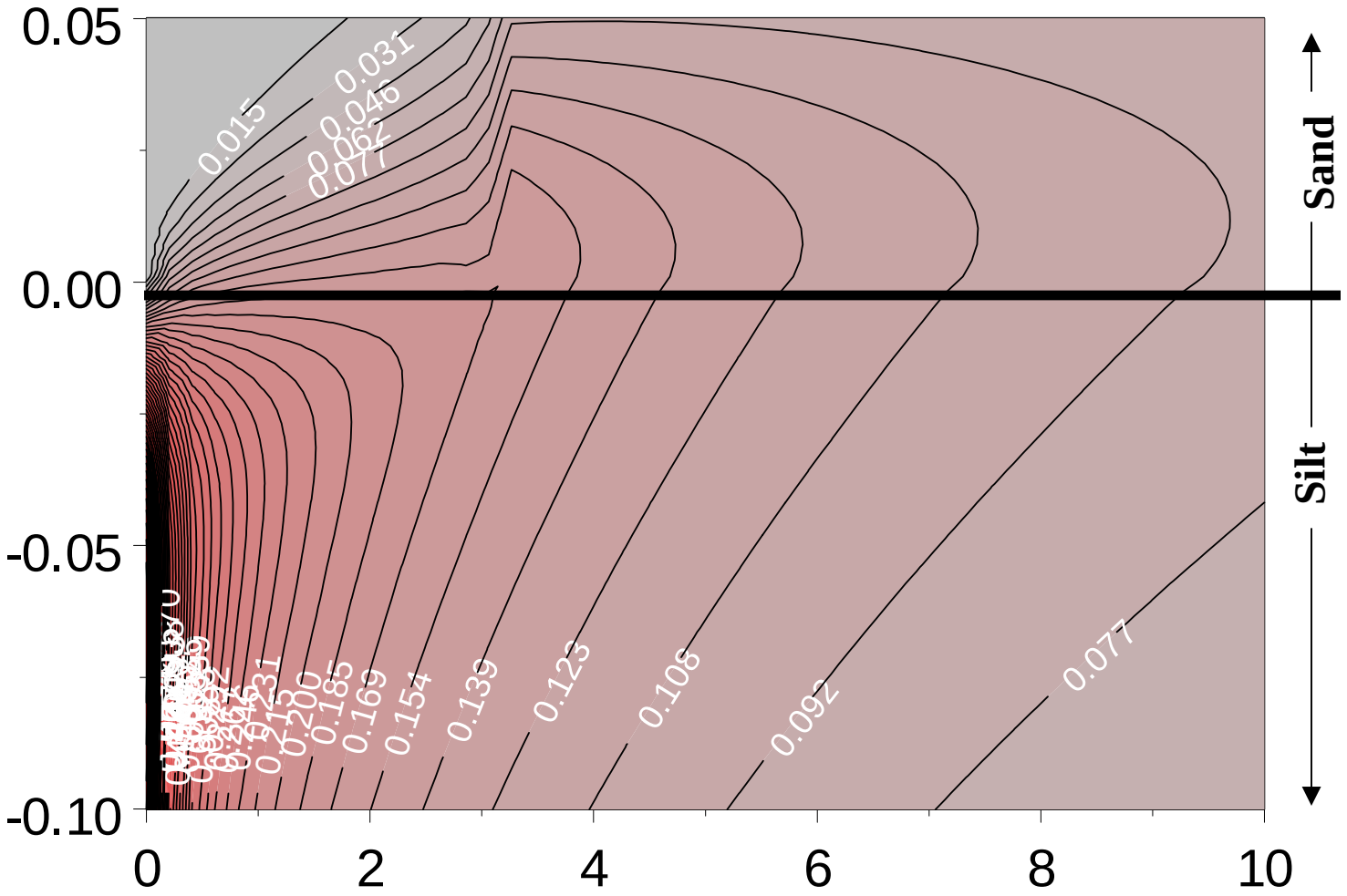
Elapsed Time = 1000 days – Source on for 1000 days

V_w = 0.3m/day, R=1, Dimensions in m



Elapsed Time = 1010 days – Source off for 10 days

V_w = 0.3m/day, R=1, Dimensions in m



Elapsed Time = 1100 days – Source off for 100days

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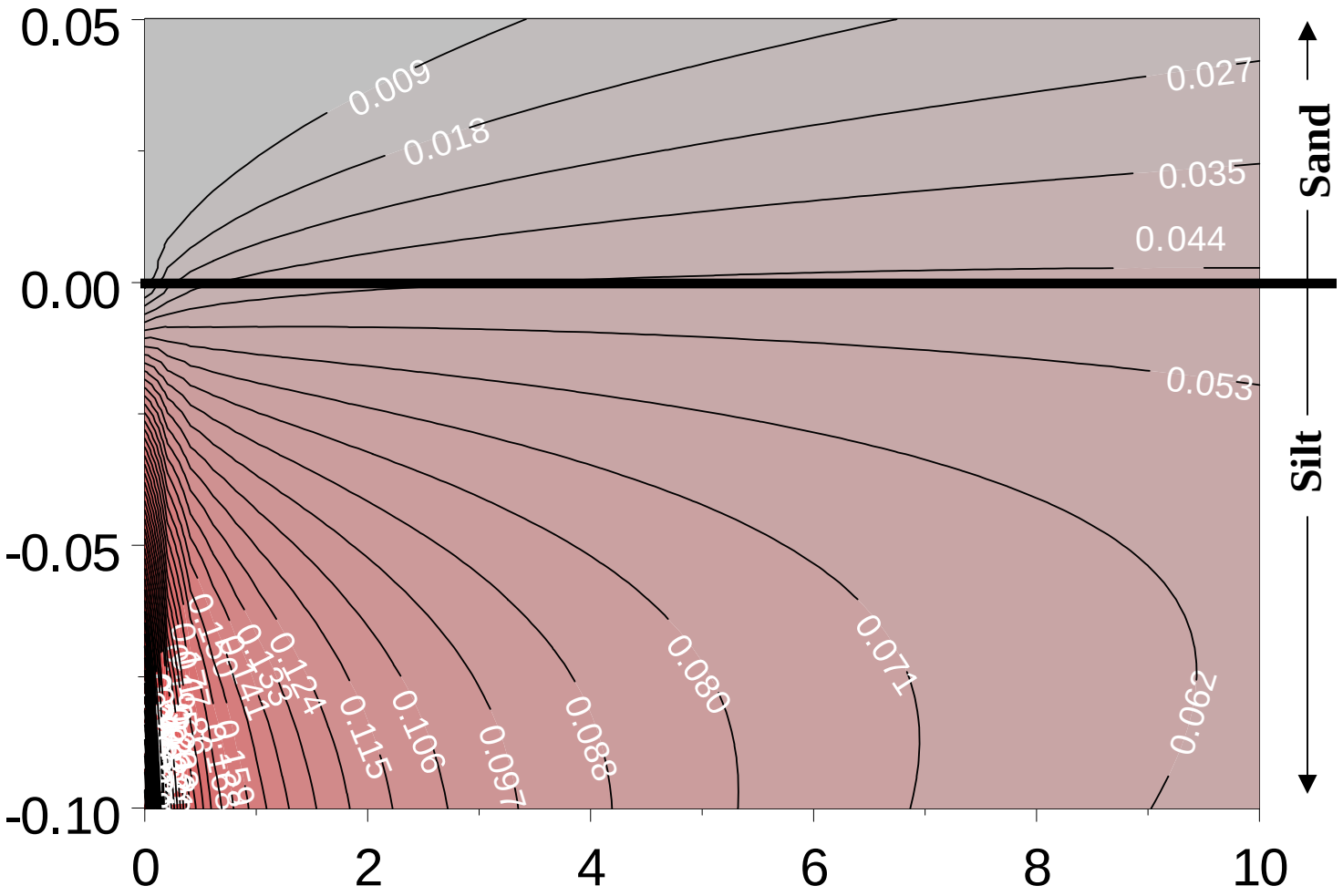

Elapsed Time = 2000 days – Source off for 1000 days

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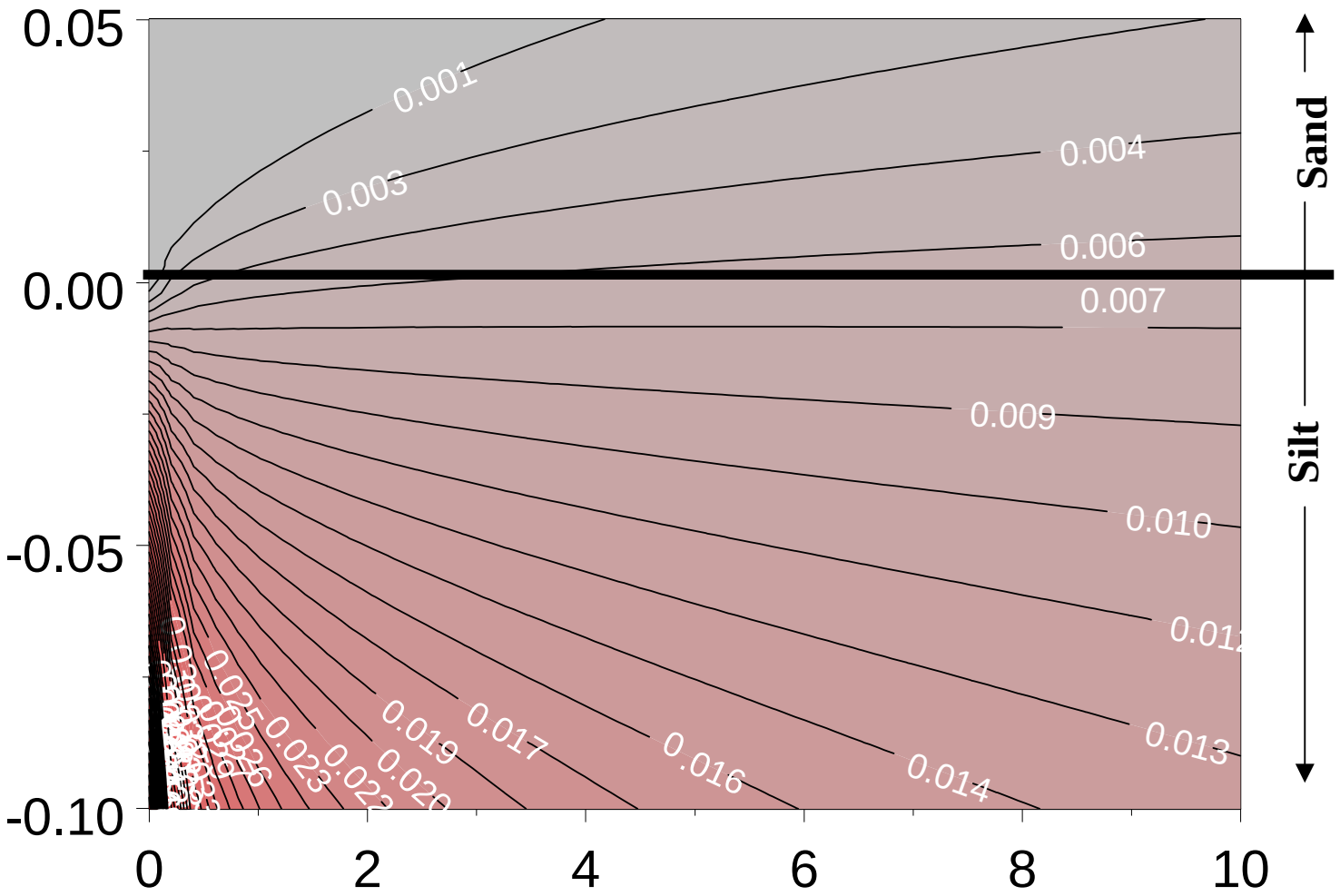

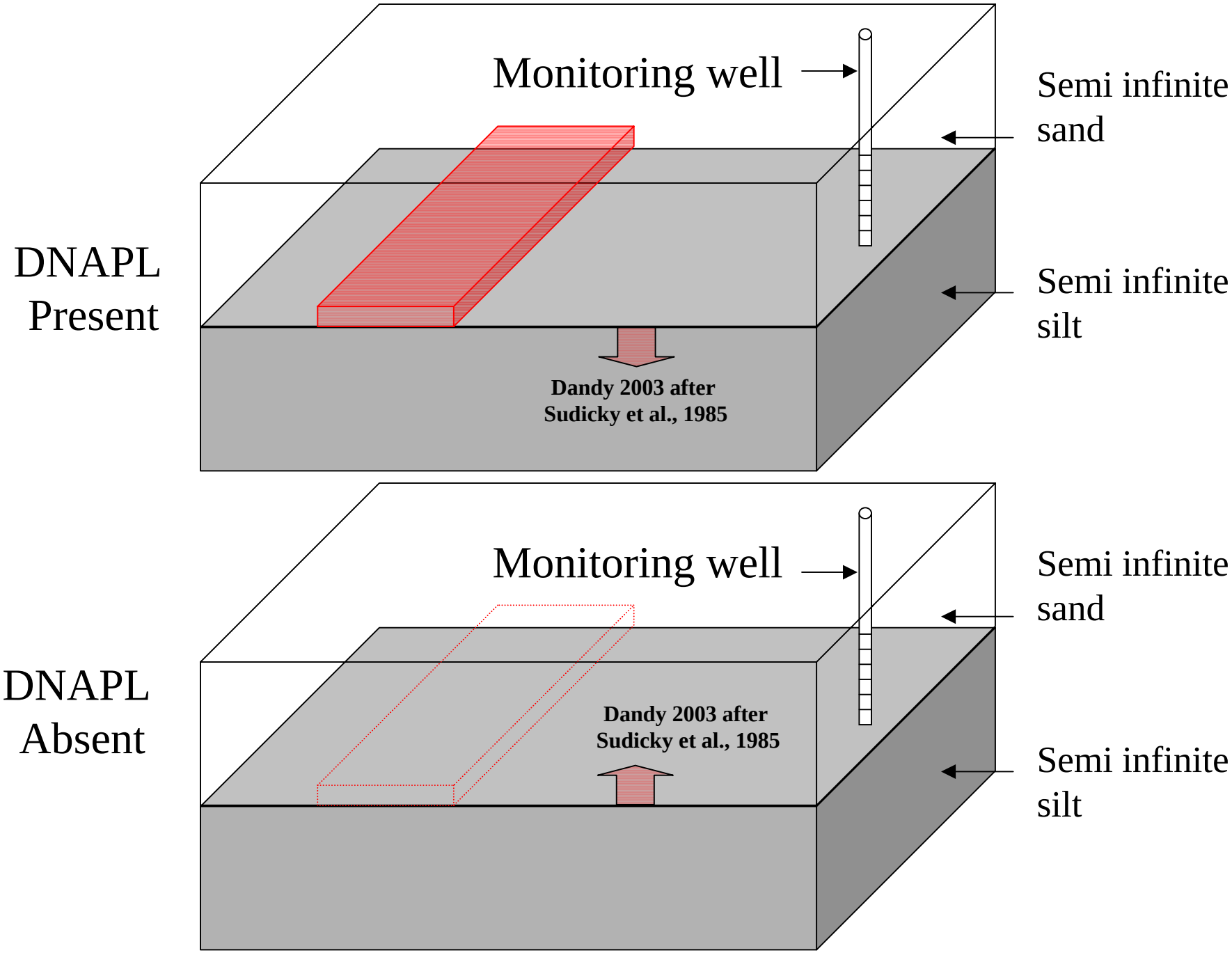
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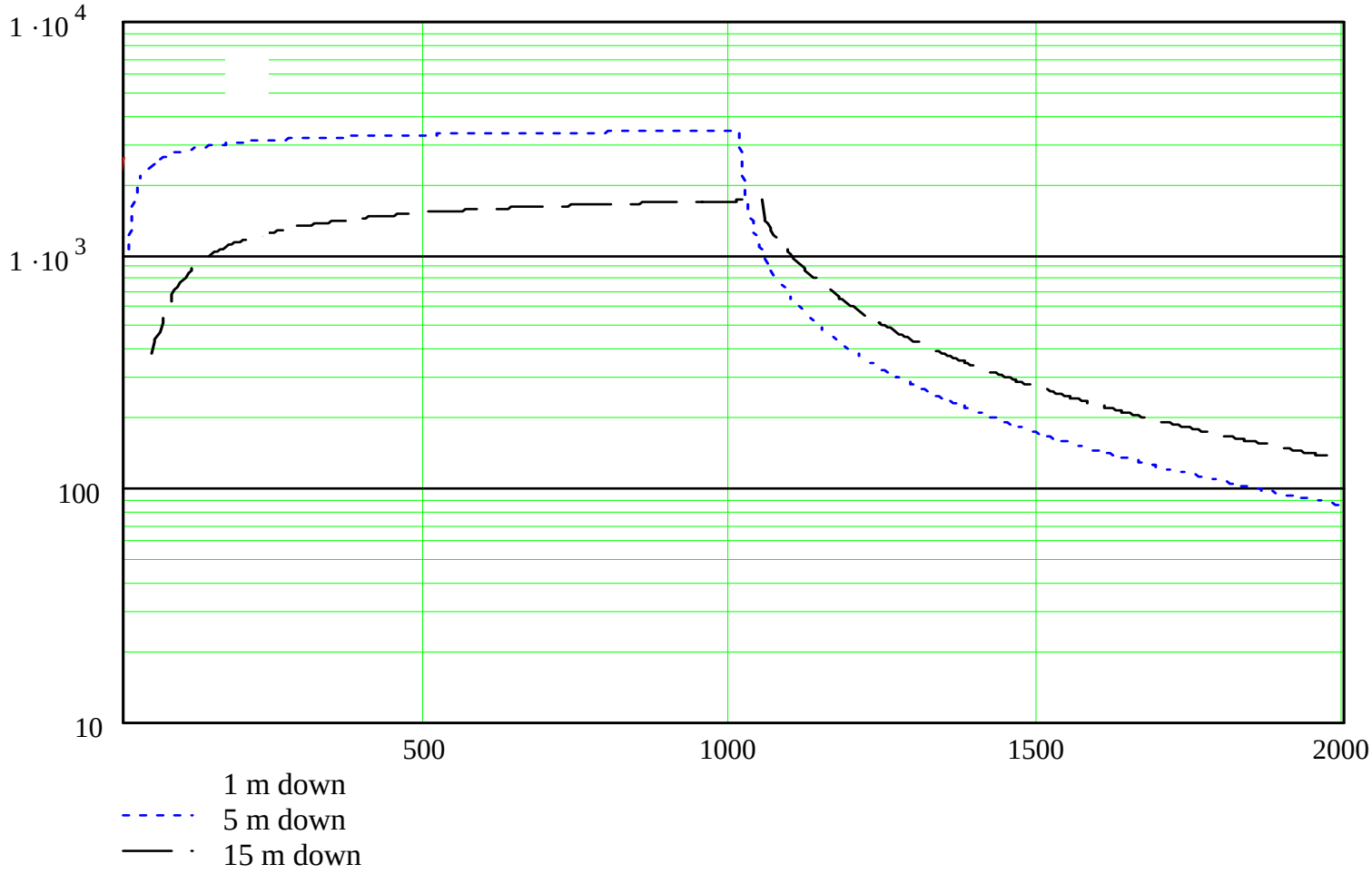
Concentration versus Time in an Analog Well



Comparisons to Field Sites

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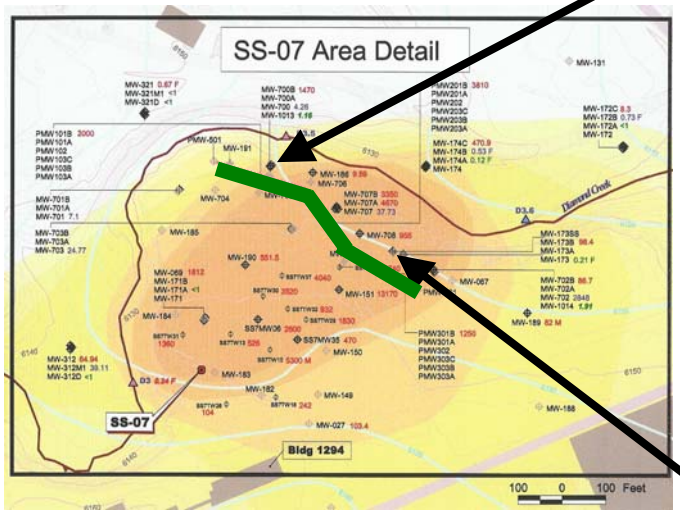
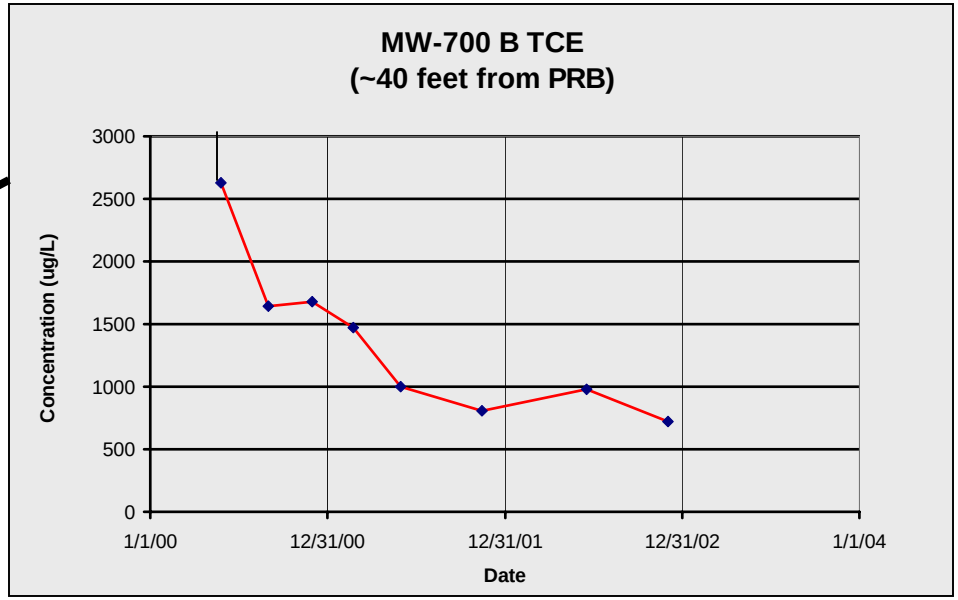
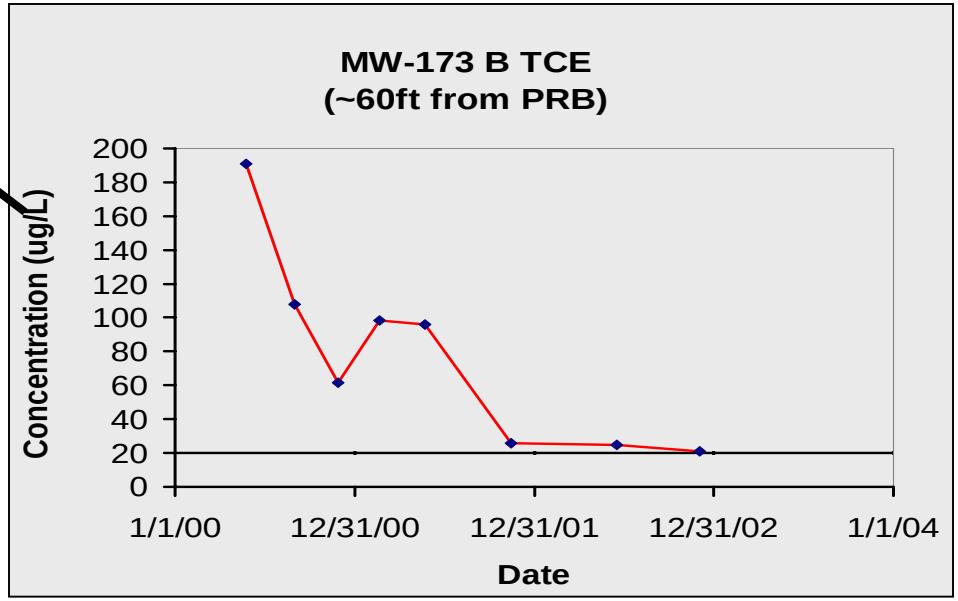
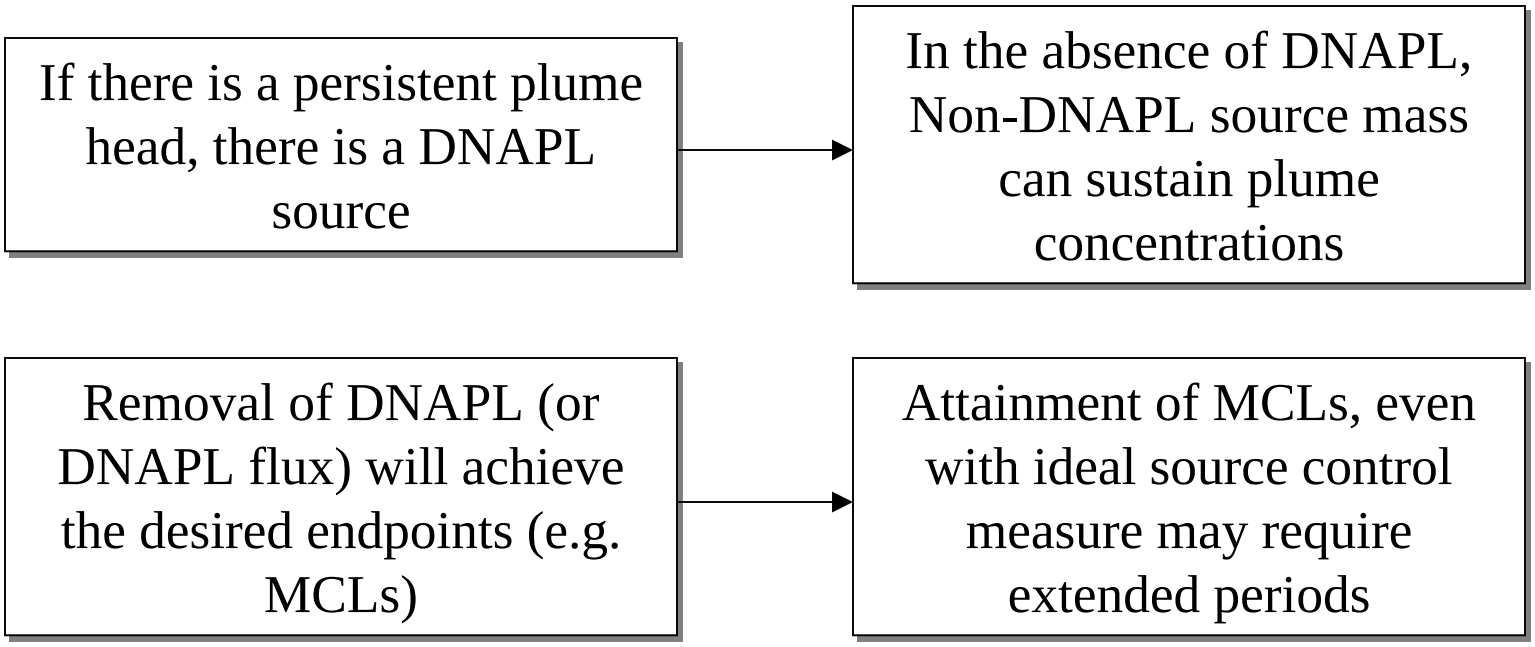
Spill Site 7 PRB







Implications



Resolutions – Observed plume concentrations, Source longevity, Difficulty of finding DNAPL, Limited water quality improvements with aggressive treatment, Rebound , Slow response in plumes