Modeling Hydrologic & Geochemical Effects of Rapid Infiltration of Wastewater

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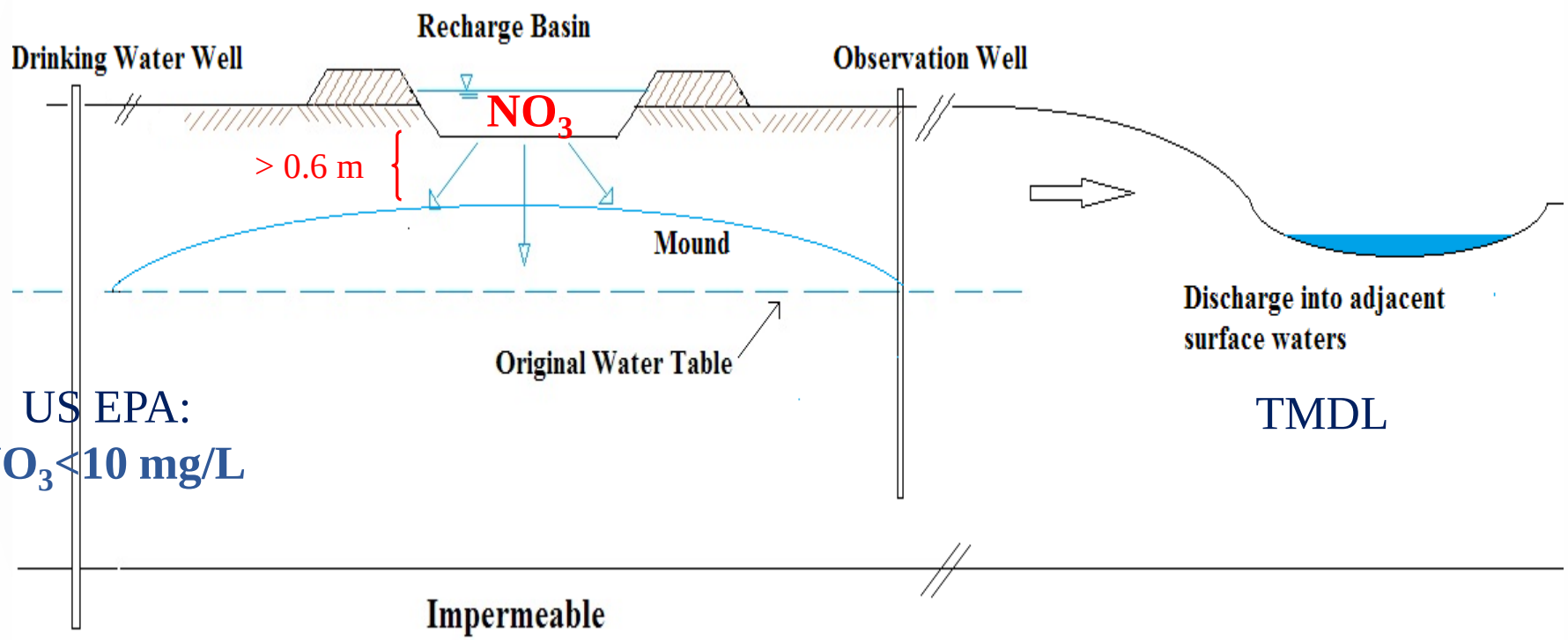
February 26, 2014

RIBS: Rapid Infiltration Basin System

Soil Aquifer Treatment (SAT)



US EPA:
NO_3<10 mg/L

TMDL

Objectives

1. Evaluate effects of
   - Non-uniform distribution of wastewater
   - Operating conditions (hydraulic loading cycle, application rate)
   - Subsoil properties

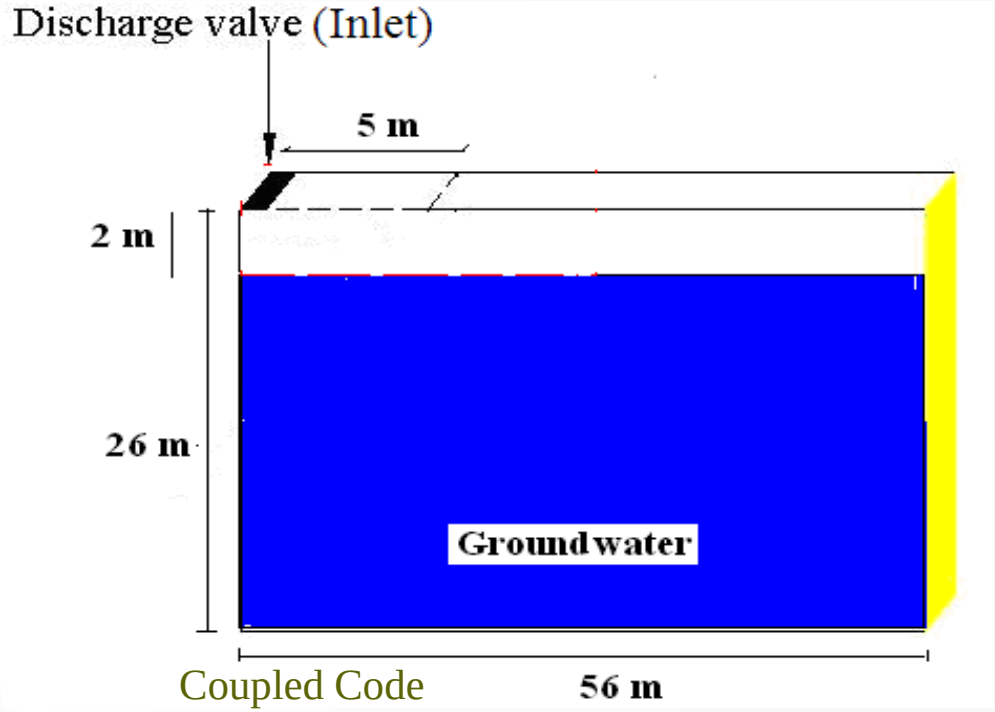
   on hydraulic and chemical (NO_3 removal) performance

2. Evaluate a surface organic enrichment layer- a denitrification (DNF) layer - on RIBS performance

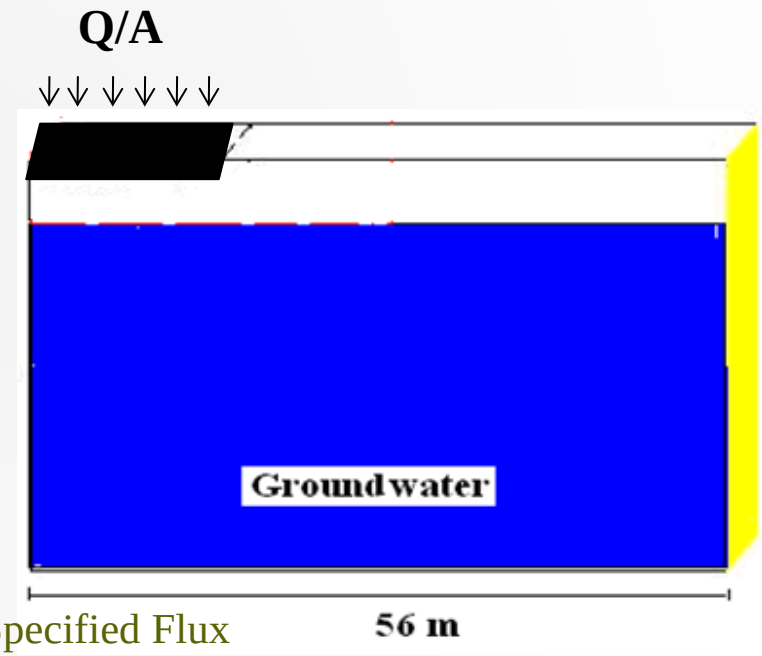
Methods

- Develop computer model of overland water flow, subsurface water and air movement, and nitrogen cycling
- Confirm model accuracy with field data from other published studies
- Use model to answer questions, for example:
  - Can RIBS operations be designed to improve dentrification?
  - Effect of water table depth and soil heterogeneity?
  - DNF layer - will it work?

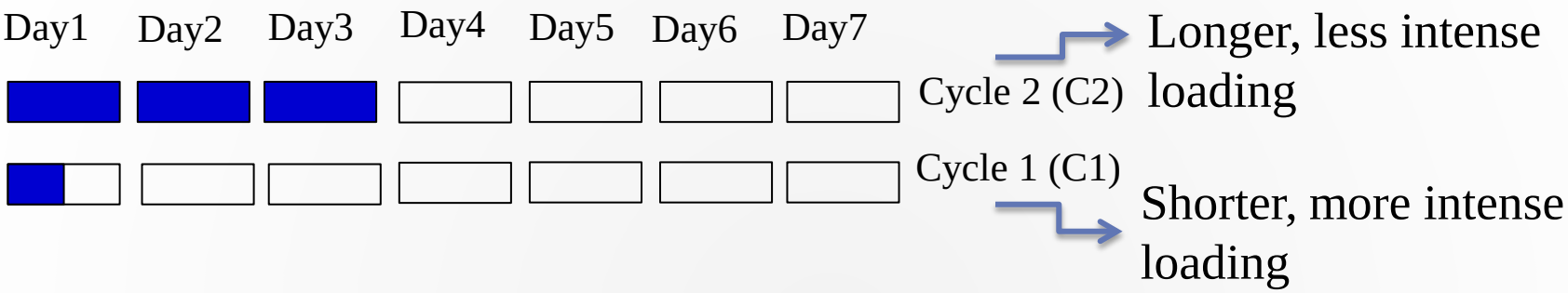
Model Domain



Coupled Code

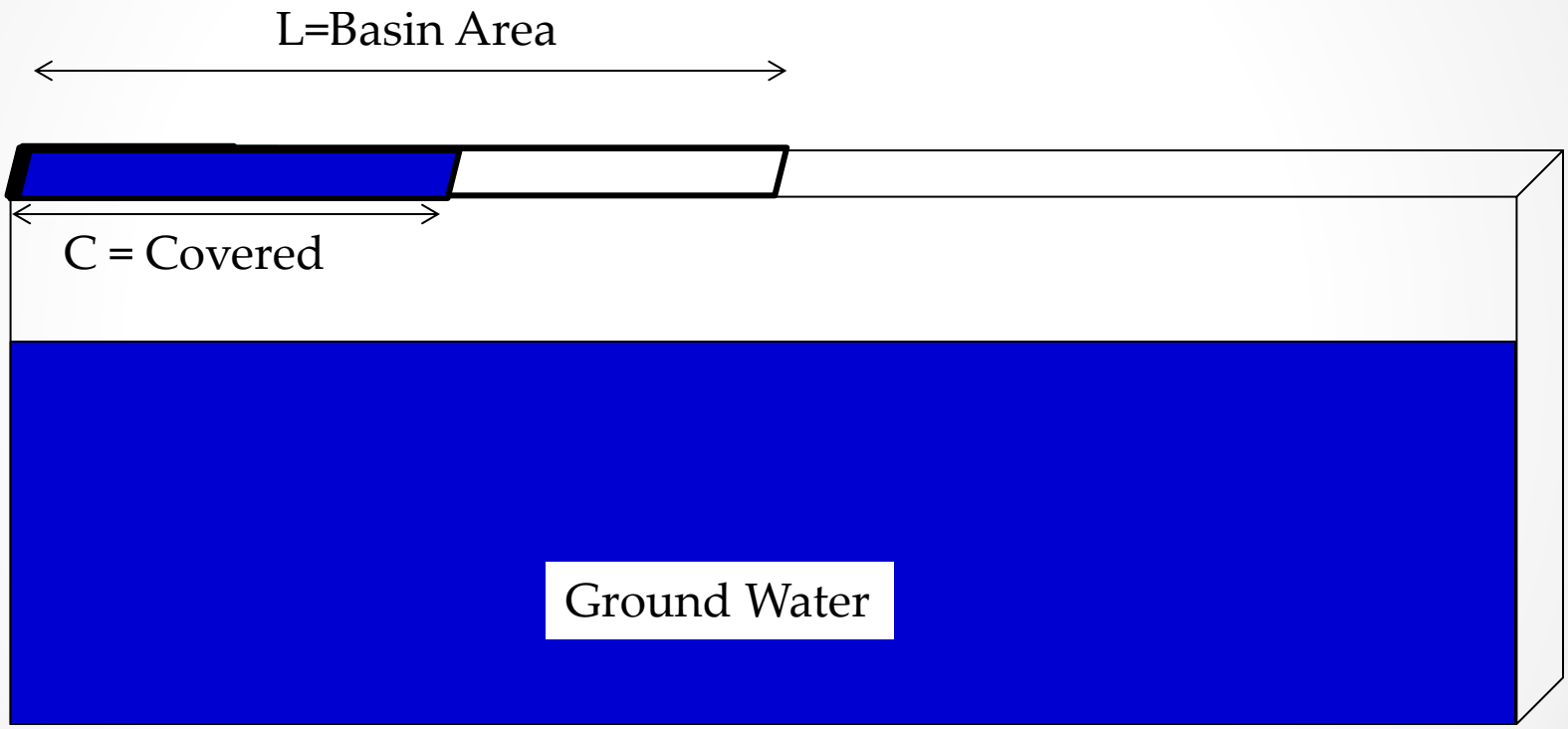


Specified Flux



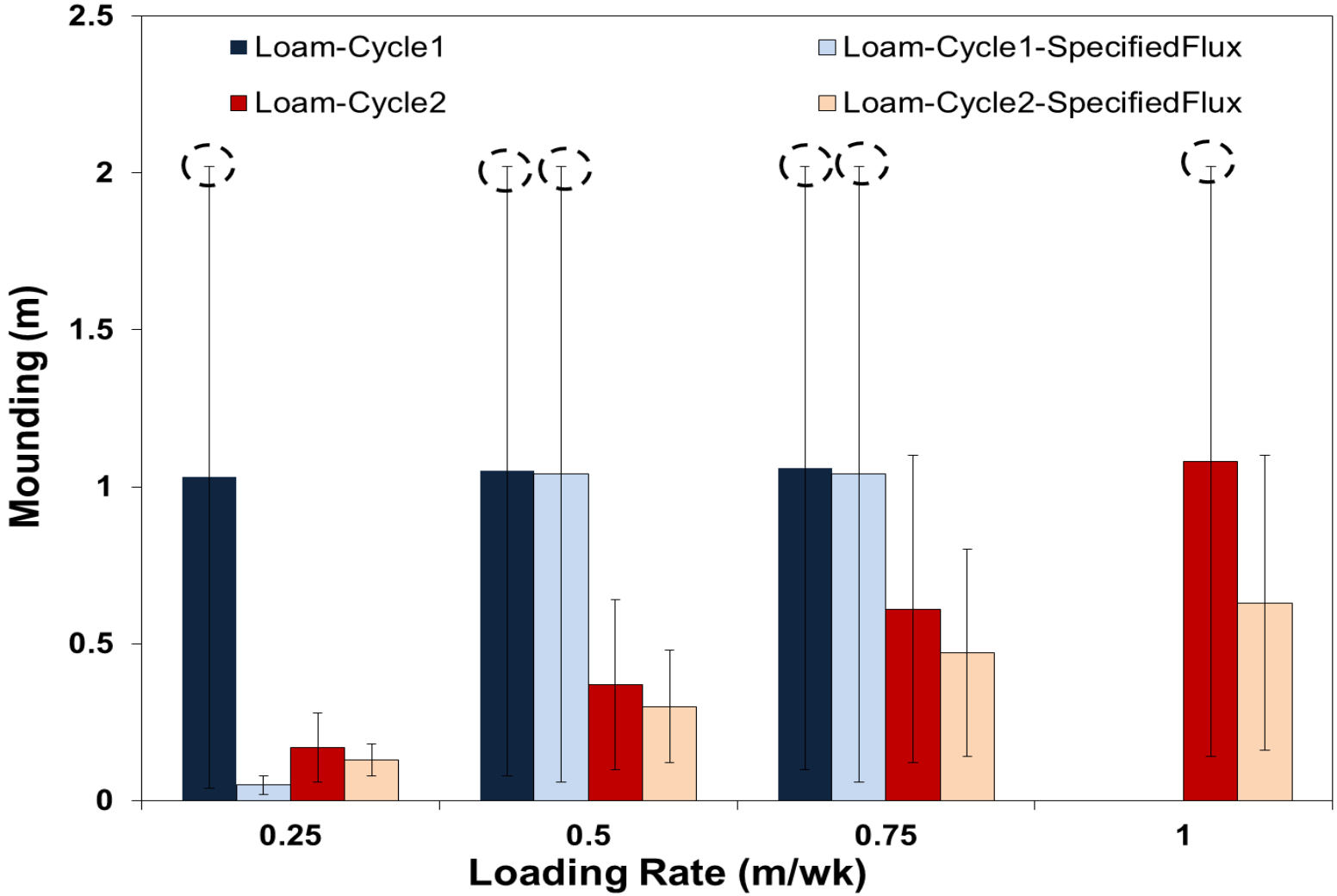
	Loading Rate (m/wk)
Cycles 1 & Cycle 2	L1 = 0.25
	L2 = 0.50
	L3 = 0.75
	L4 = 1.00

Water Progress Over the Basin

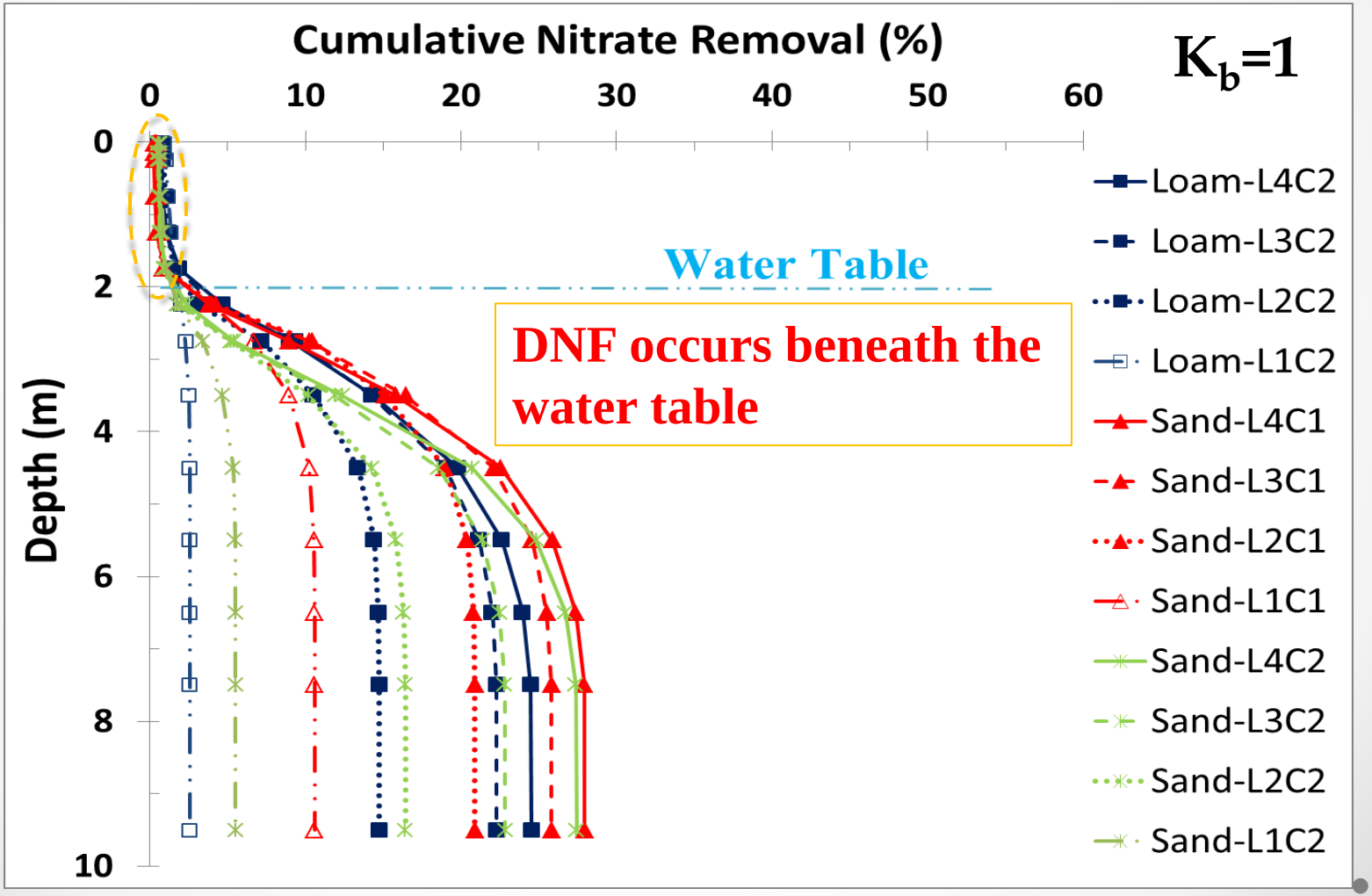


Mounding height in loamy sand for two application cycles & two boundary conditions

neglecting overland flow can result in significant under-prediction of groundwater mounding

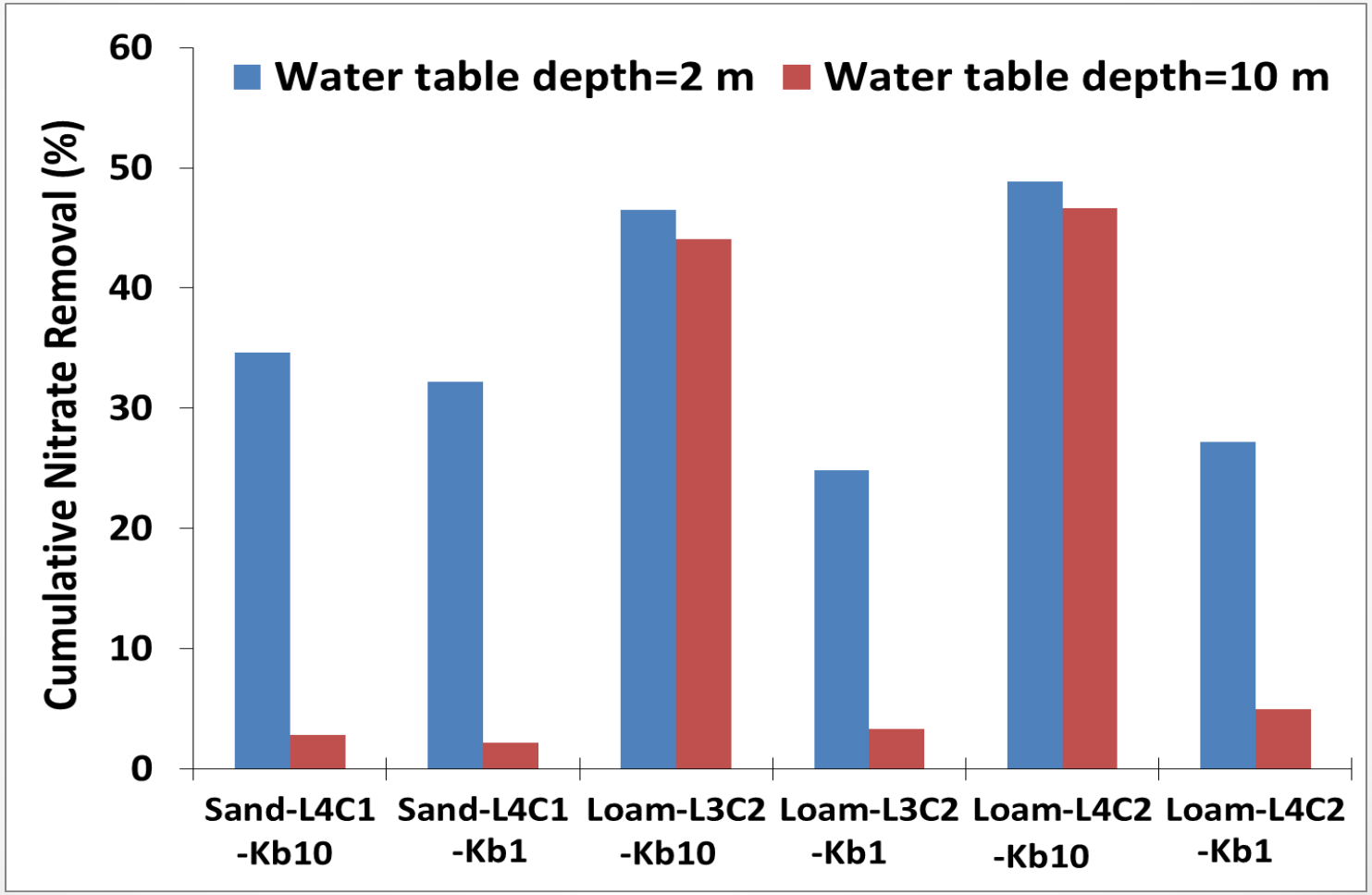


Cumulative Percent NO_3 Removal Over Depth

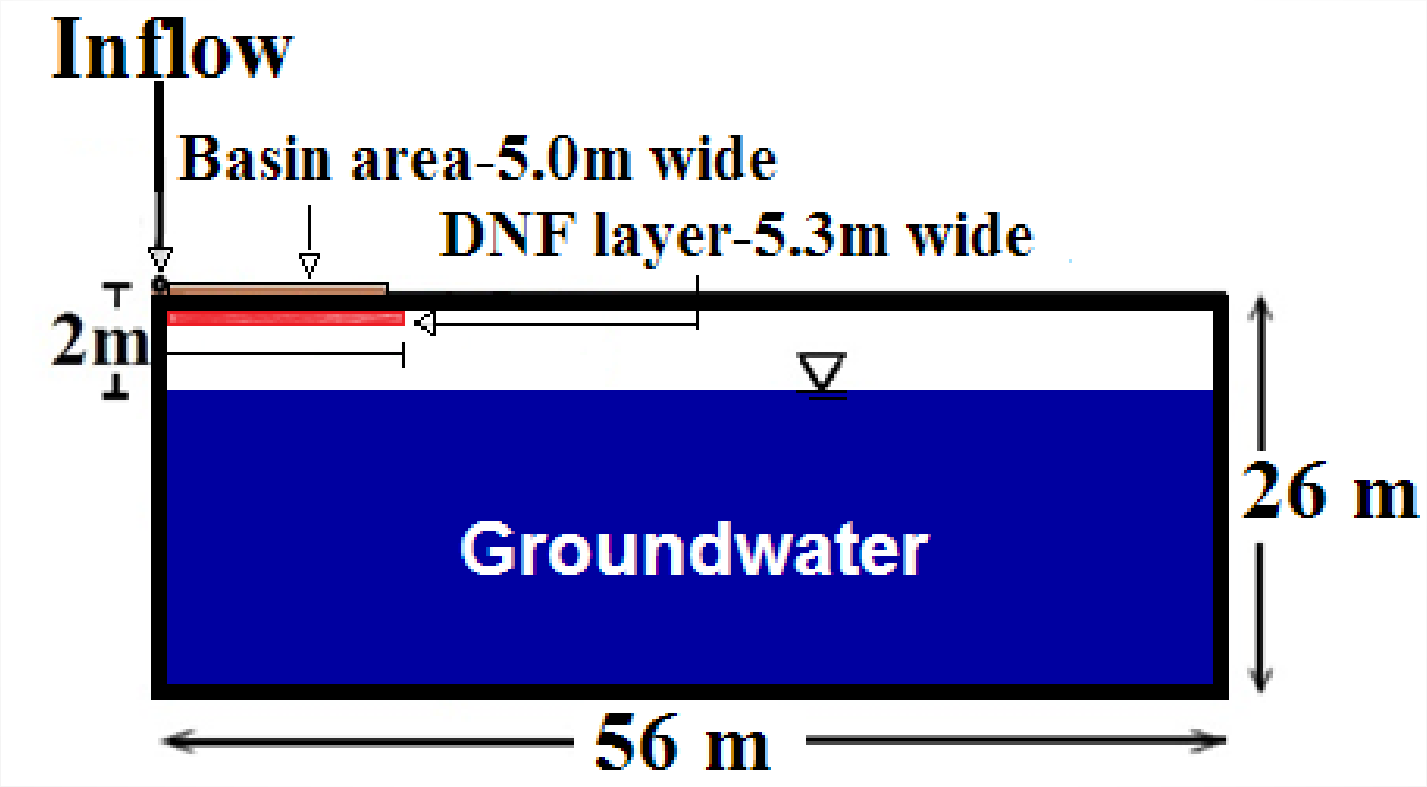


Cumulative NO_3 Removal for Various Water Table Depths

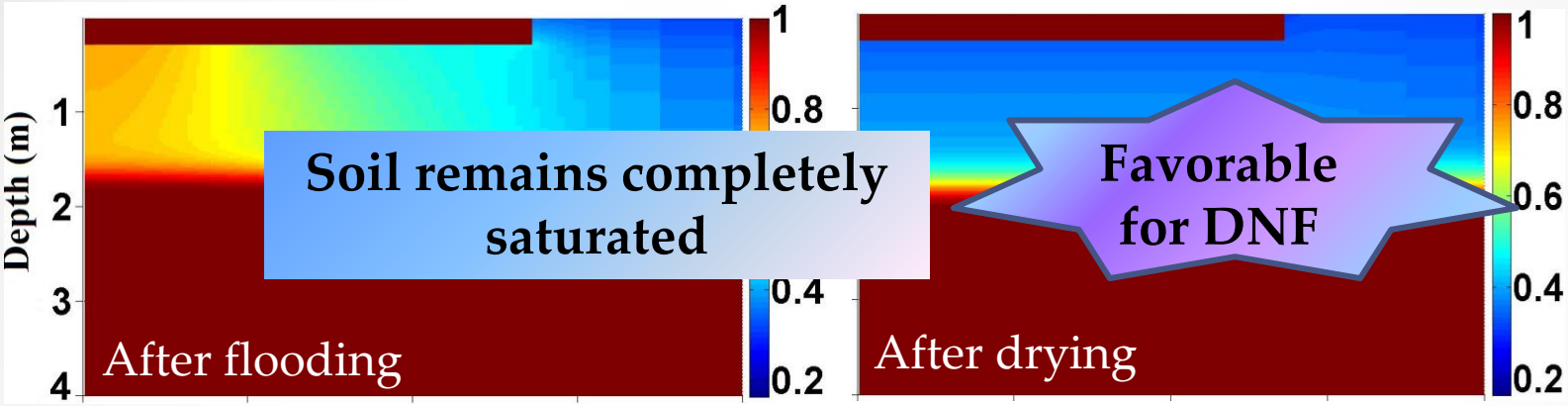
Water table depth has a significant impact on DNF if the RIBS is underlain by a permeable medium



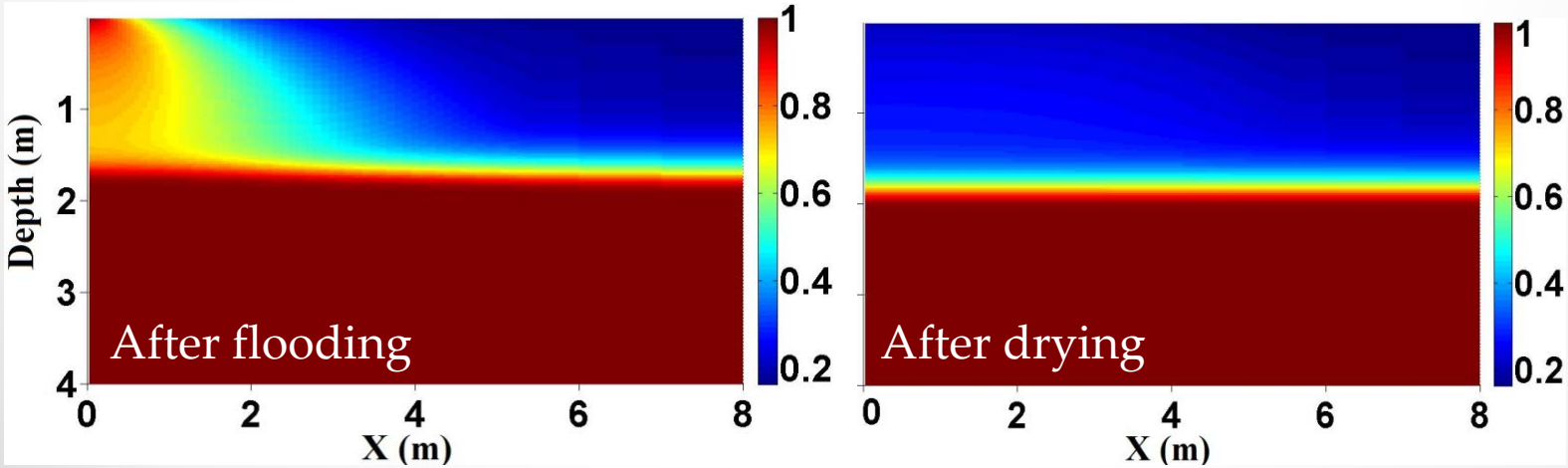
Evaluation of DNF Layer



Water Saturation Contours

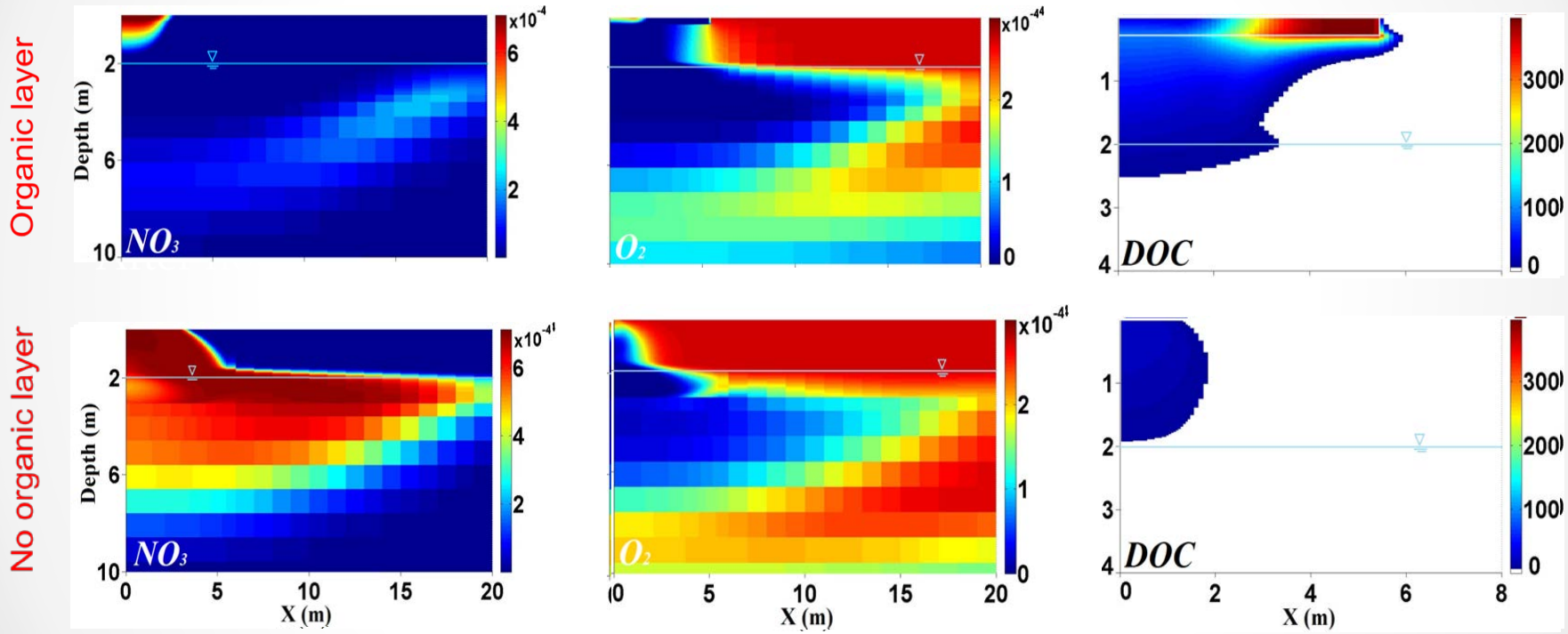


With DNF layer



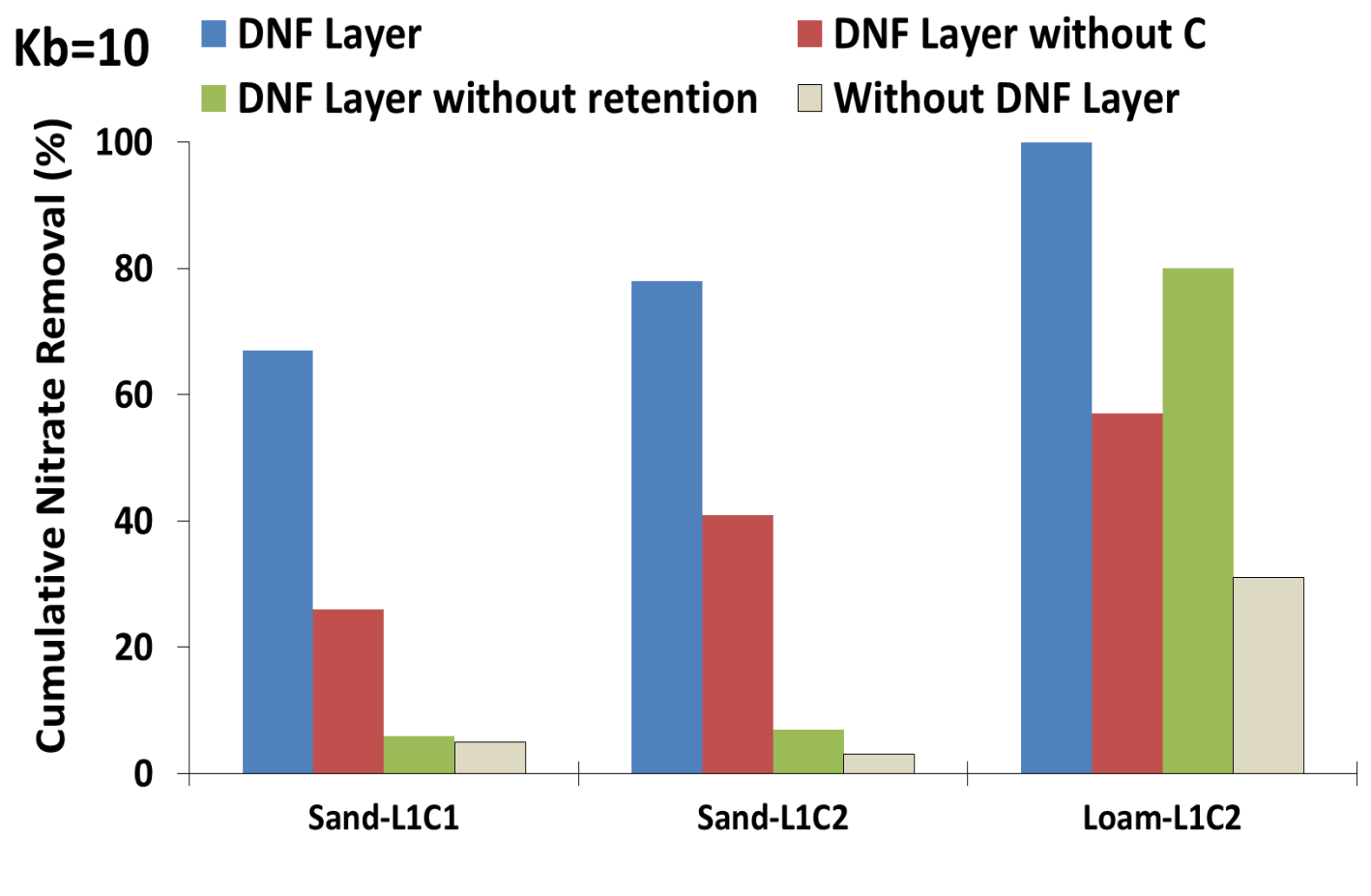
Without DNF layer

Chemical Contours



DNF layer enhances anaerobic zone and limited organic carbon – more denitrification

Cumulative NO_3 removal



Summary & Conclusions

- ✓ Model(s) matched data trends from limited field data – verifying modeling approach.
- ✓ Denitrification can be enhanced by modifying operating conditions: cycling of wastewater, adding organic carbon to wastewater, etc.
- ✓ Environmental conditions affect denitrification rates:
  - ✓ Soil type
  - ✓ Subsurface heterogeneity
  - ✓ Water table depth – shallower better

Summary & Conclusions

- ✓ Surface organic layer (denitrification layer) can substantially increase denitrification
  - ✓ Addition of limited organic carbon
  - ✓ Creation of anaerobic zones

- ✓ Modeling can be used to
  - ✓ Guide monitoring requirements
  - ✓ Suggest operating conditions to enhance denitrification
  - ✓ Evaluate new proposed design features – denitrification layers