The Impact of Subsurface Drainage Design on Water Quality

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BIOSYSTEMS & AGRICULTURAL ENGINEERING

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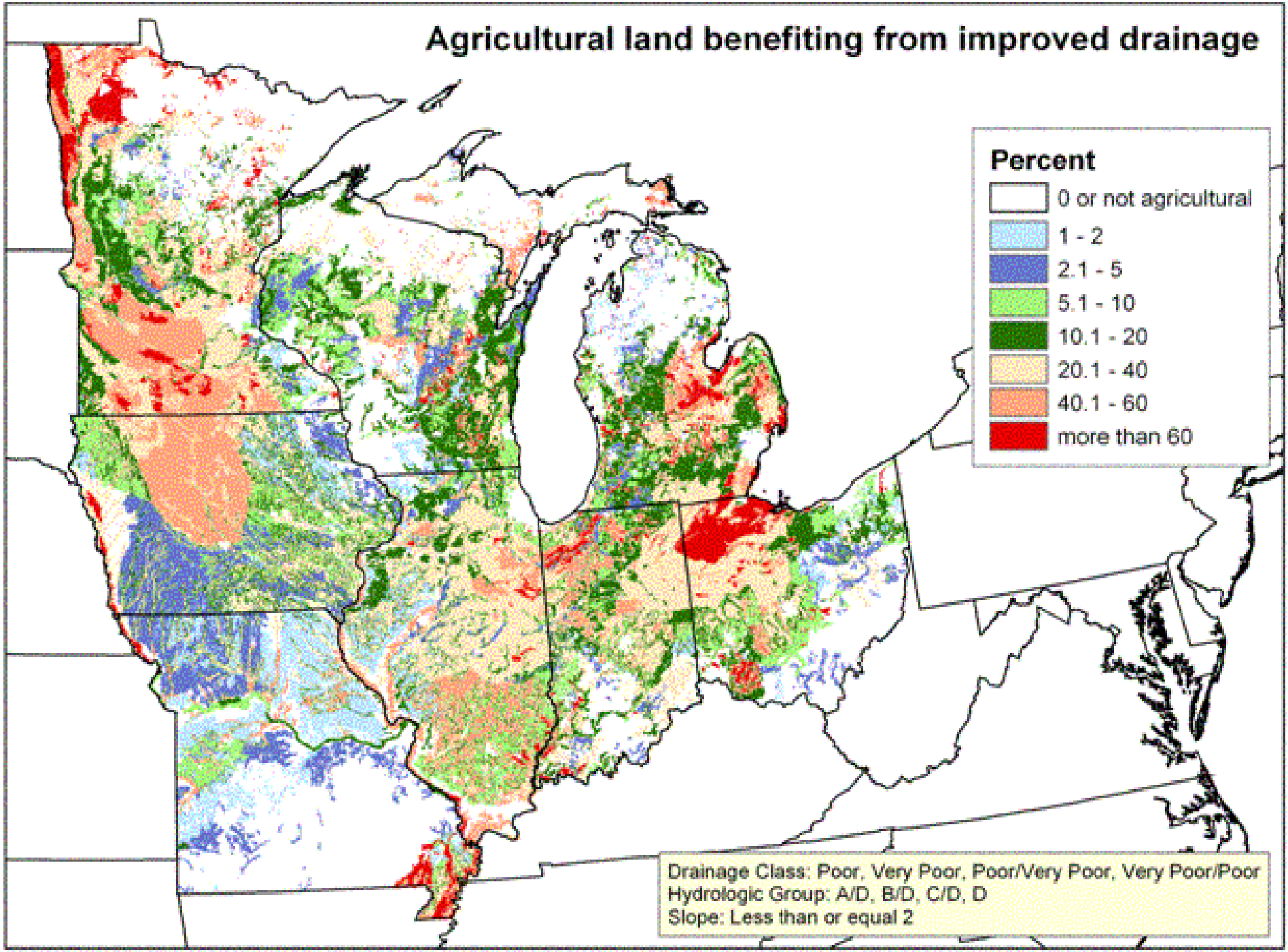
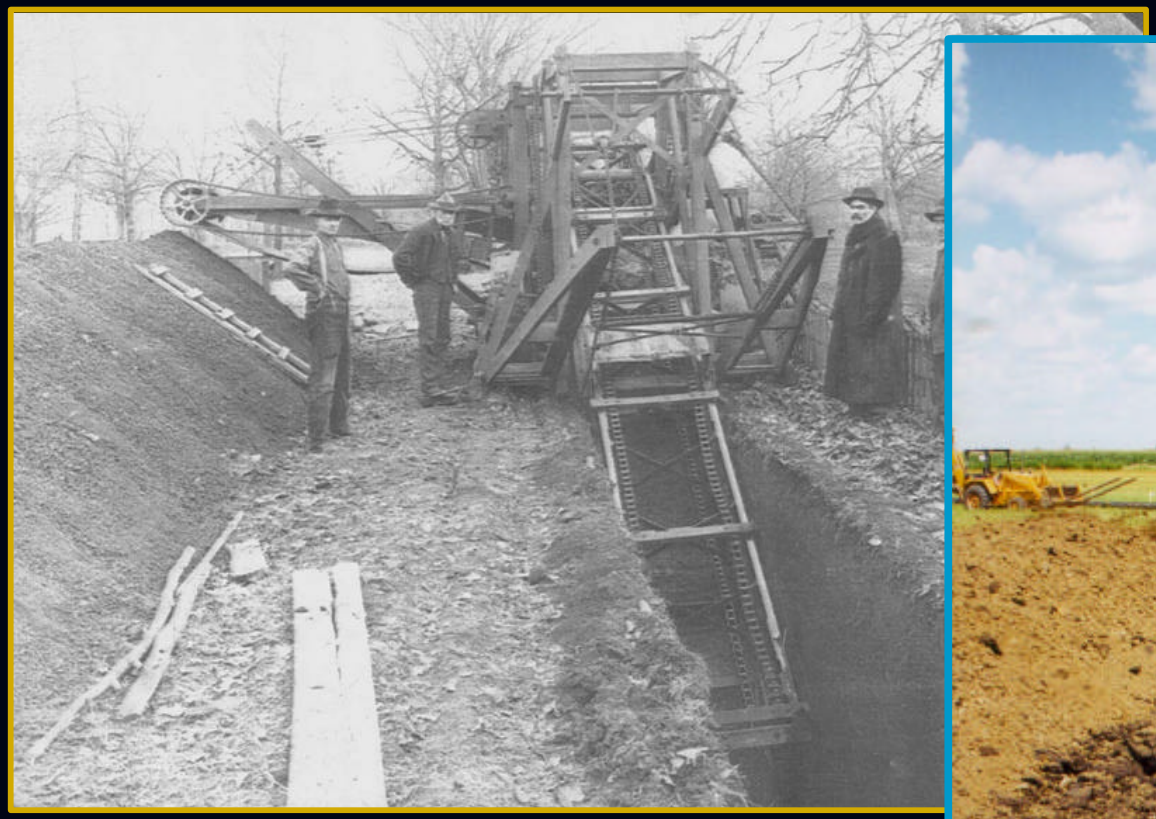
Background


Agricultural land benefiting from improved drainage
Percent
0 or not agricultural
1 - 2
2.1 - 5
5.1 - 10
10.1 - 20
20.1 - 40
40.1 - 60
more than 60
Drainage Class: Poor, Very Poor, Poor/Very Poor, Very Poor/Poor
Hydrologic Group: A/D, B/D, C/D, D
Slope: Less than or equal 2

Nitrogen Losses to the Miss

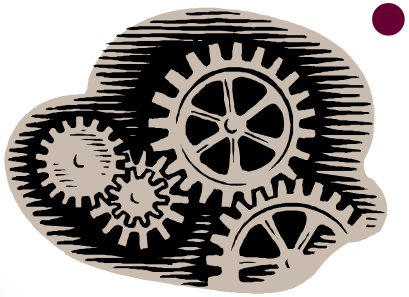
Hydrologic Impacts



Mitigation Strategies

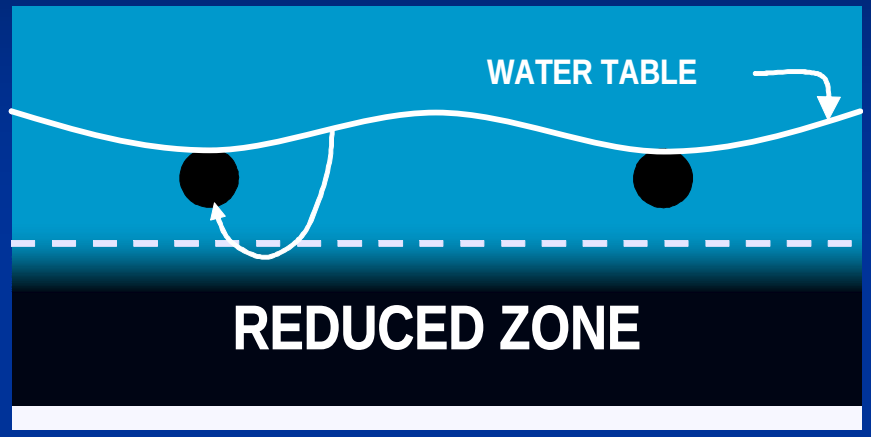
- Agronomic approaches
  - Nutrient, crop, tillage management
  - Cover crops, scavenger crops

- Ecological approaches
  - Wetlands as kidneys
  - Ditch modification/management

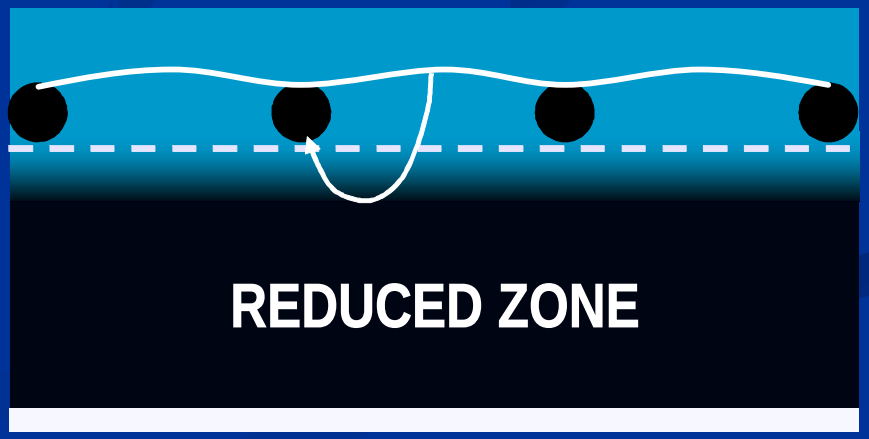


- Engineering approaches
  - Drainage design & management
  - Ditch modification/management
  - Bio-reactors

Hypothesis by Skaggs, et al. (1998)



Conventional Drain Depth

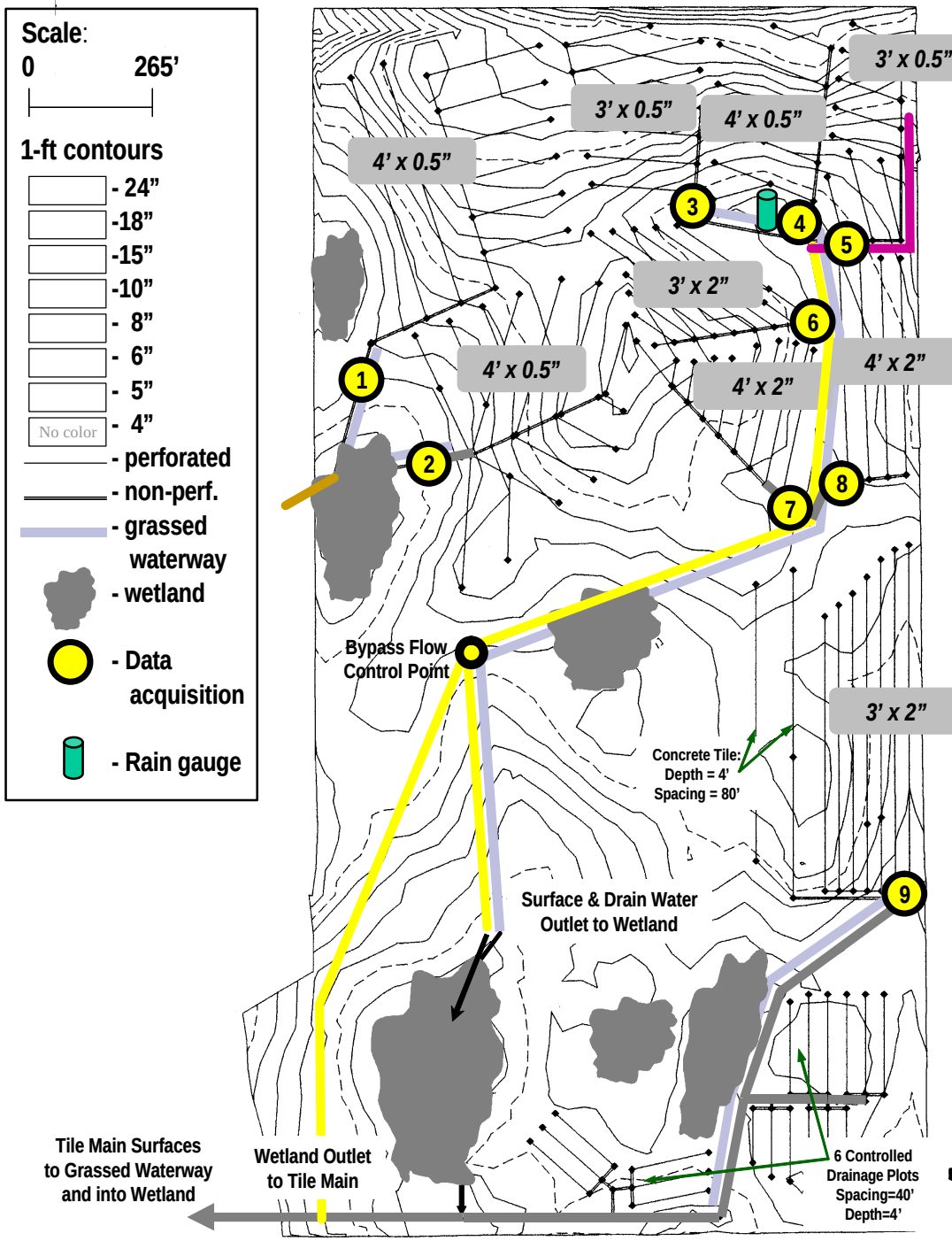


Shallow Drainage

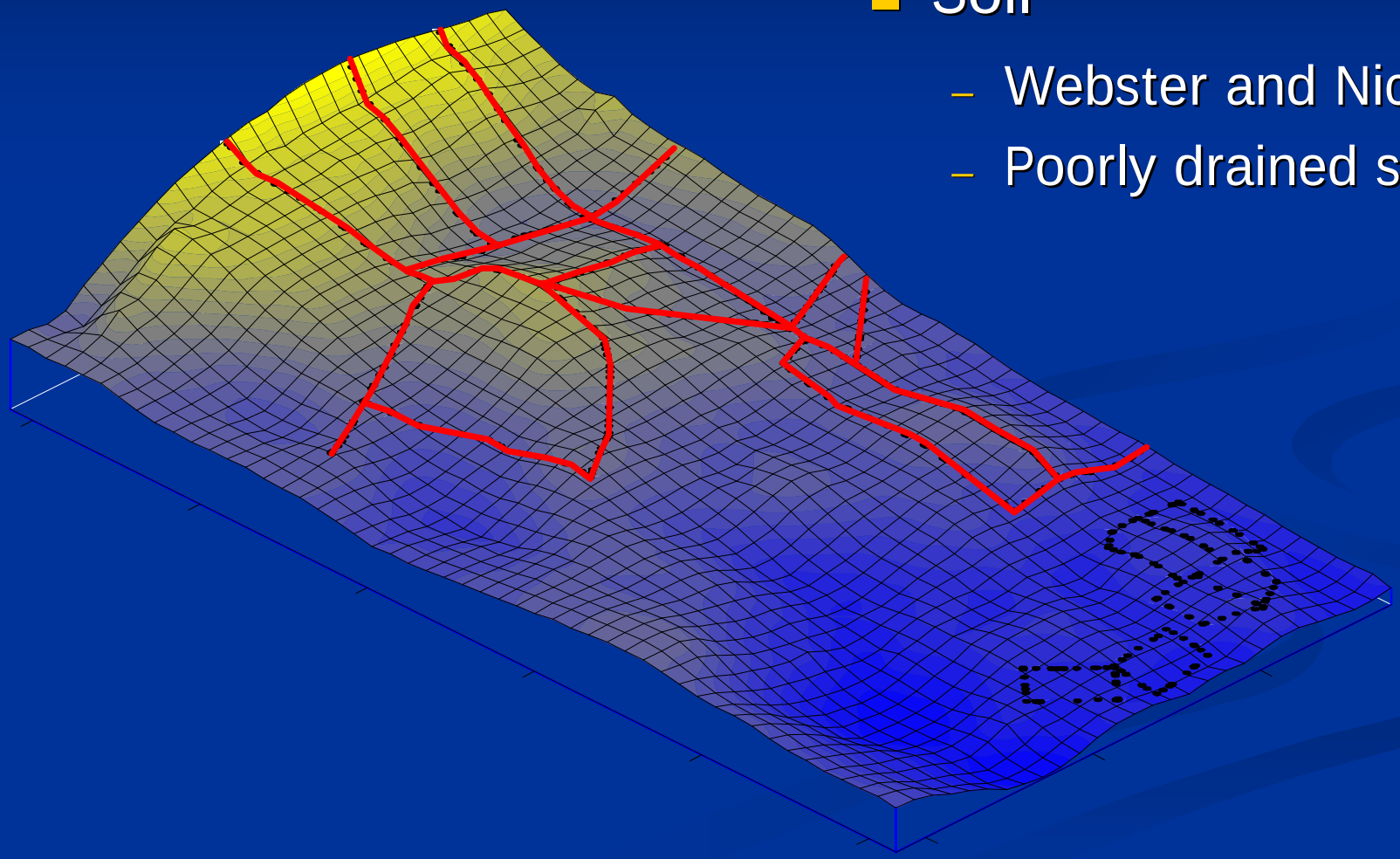
Site Layout

- Data Collection
  - 15-min flow (t. bucket)
  - Nitrate conc. (auto sample)
  - Rainfall

WS #	AREA (ha)
1	2.43
2	2.14
3	1.34
4	1.13
5	0.85
6	1.01
7	0.77
8	1.09
9	1.54

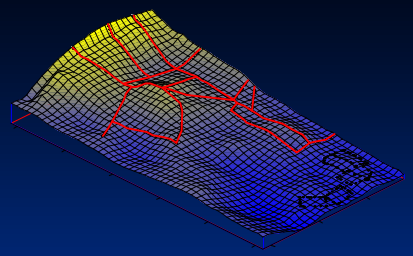


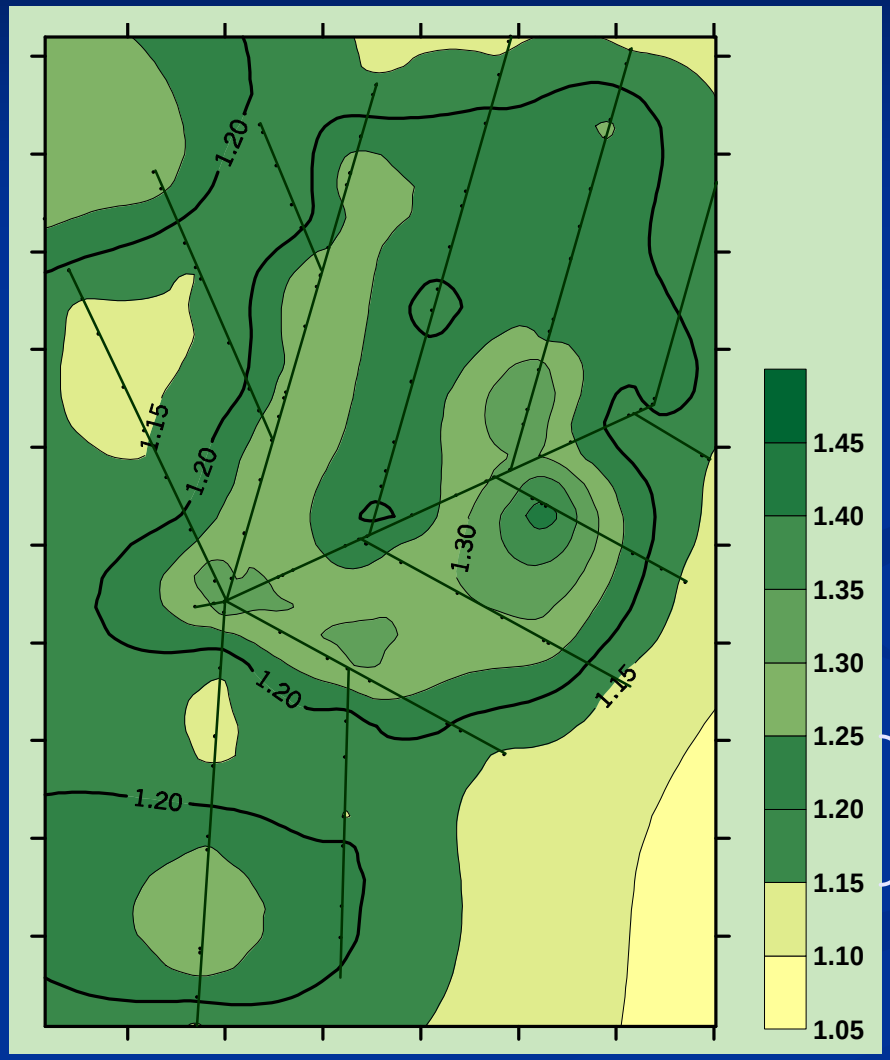
Watersheds Delineated by Topo

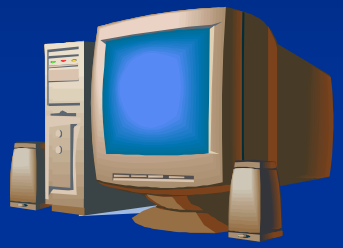


- Soil
  - Webster and Nicollet soil
  - Poorly drained soils

Drainage Designs by CAD



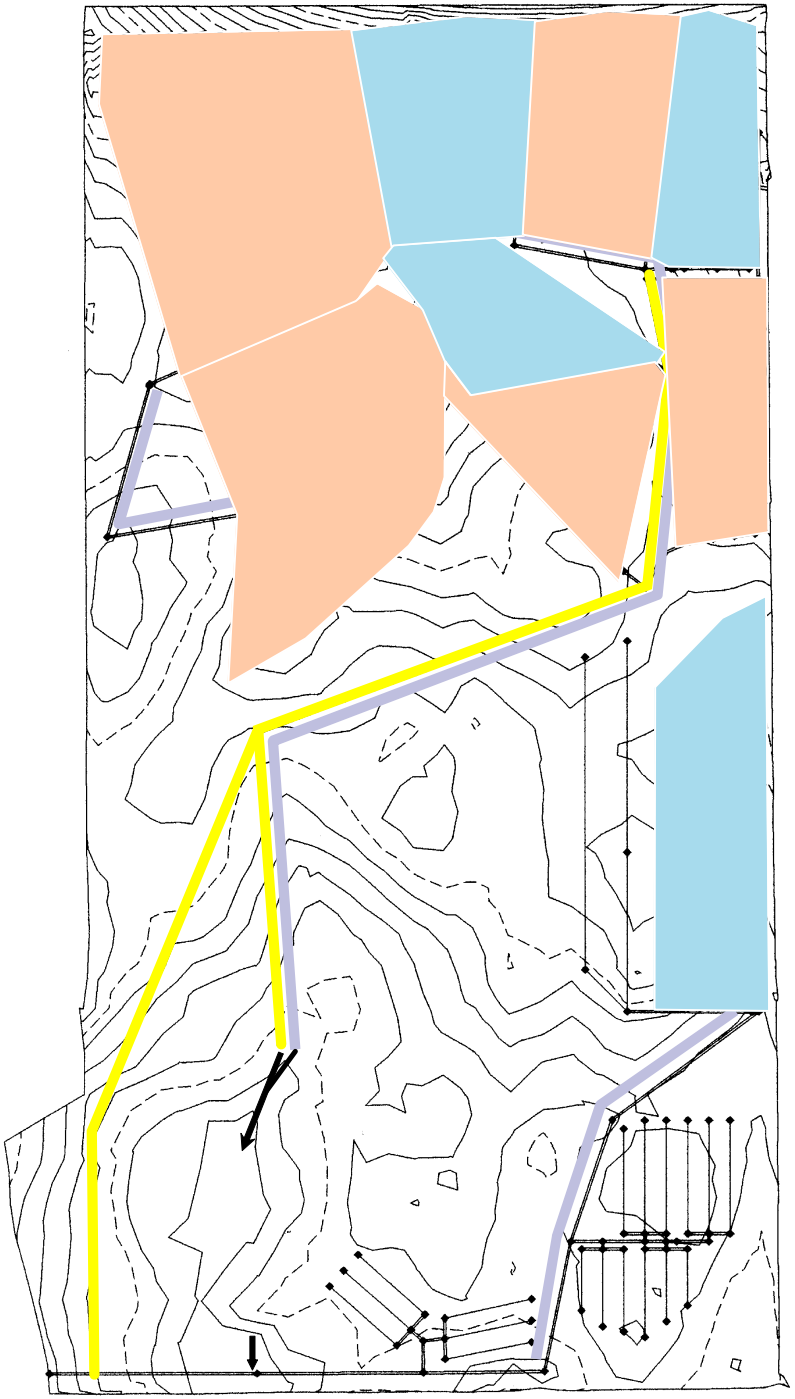




design depth
± 7cm

Experimental Design

- 2 Factorial design with drain depth & *intensity*
  - Depth: 90 & 120 cm avg
  - Intensity: 13 & 52 mm/day
- Data collection since 2001



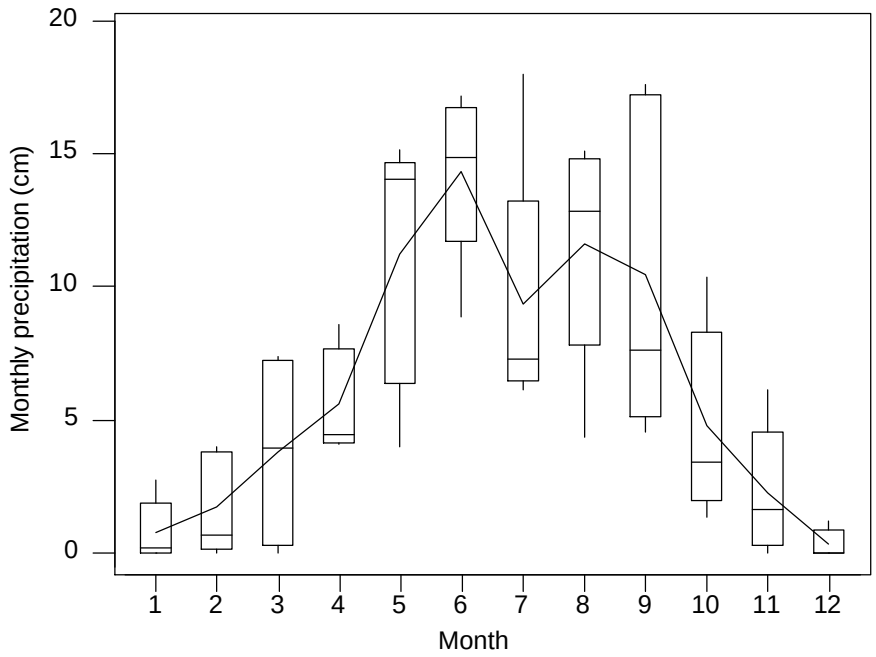
ANOVA

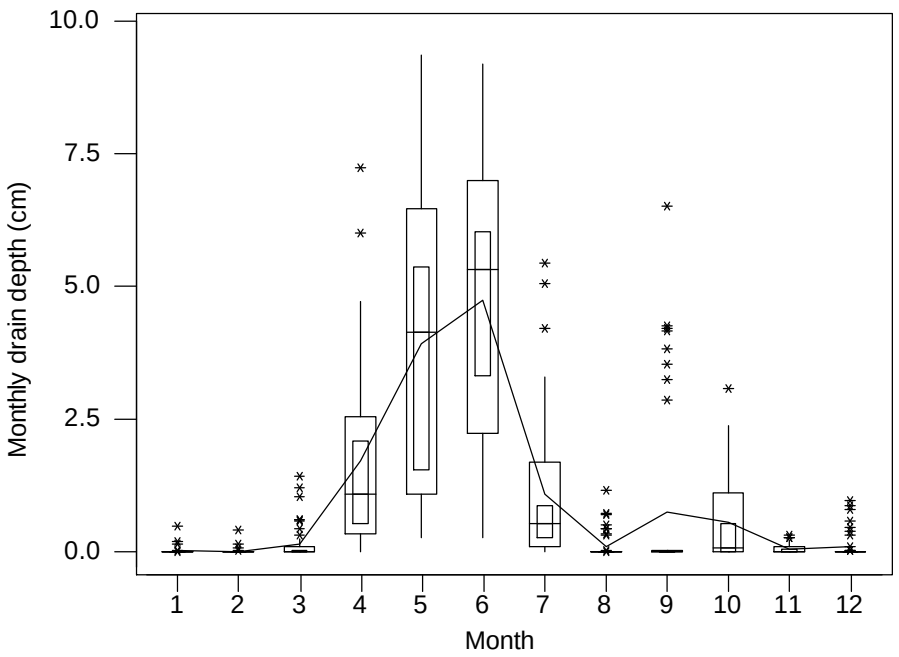
- Annual drainage volume
- Flow-weighted NO_3-N concentration
- Annual NO_3-N loss
- Results both by year and aggregated

Results

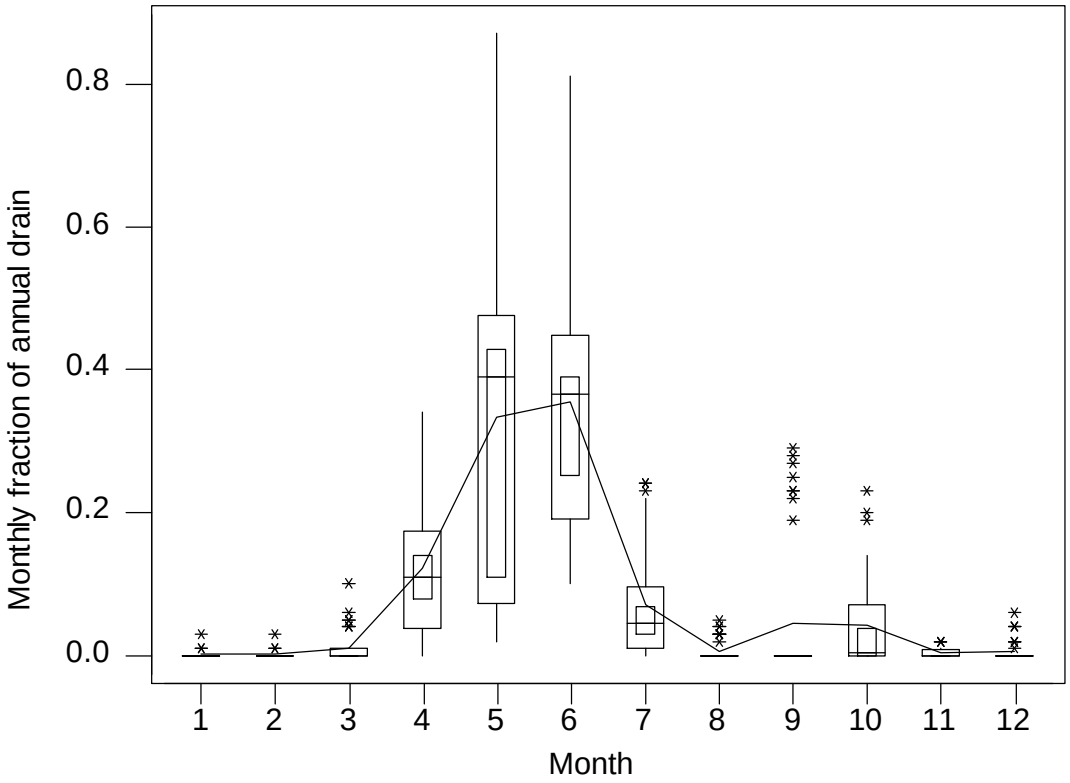
2001 - 2005

Monthly Distributions of Precipitation and Drainage

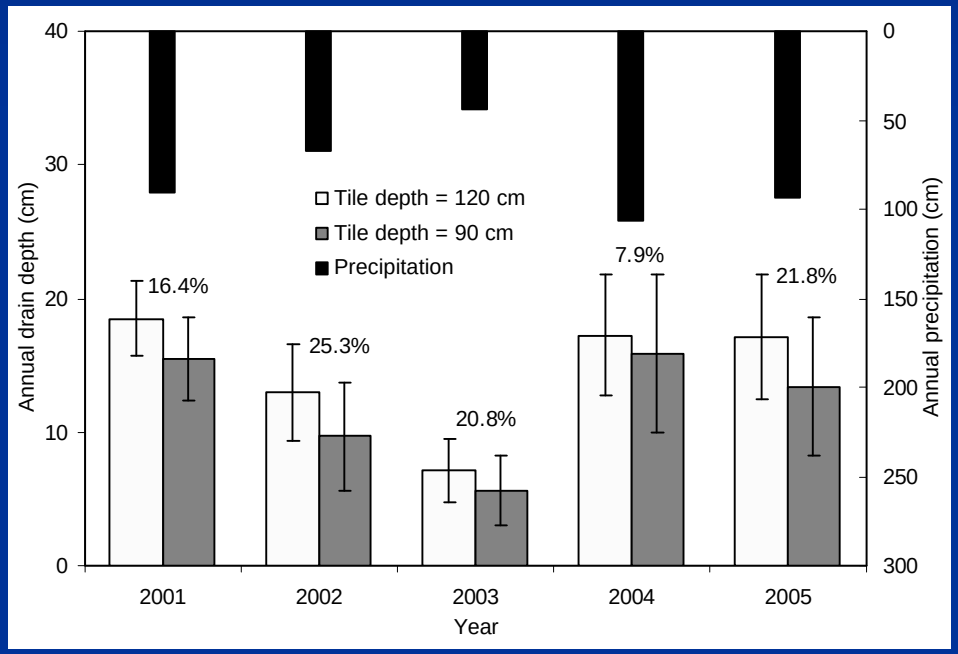




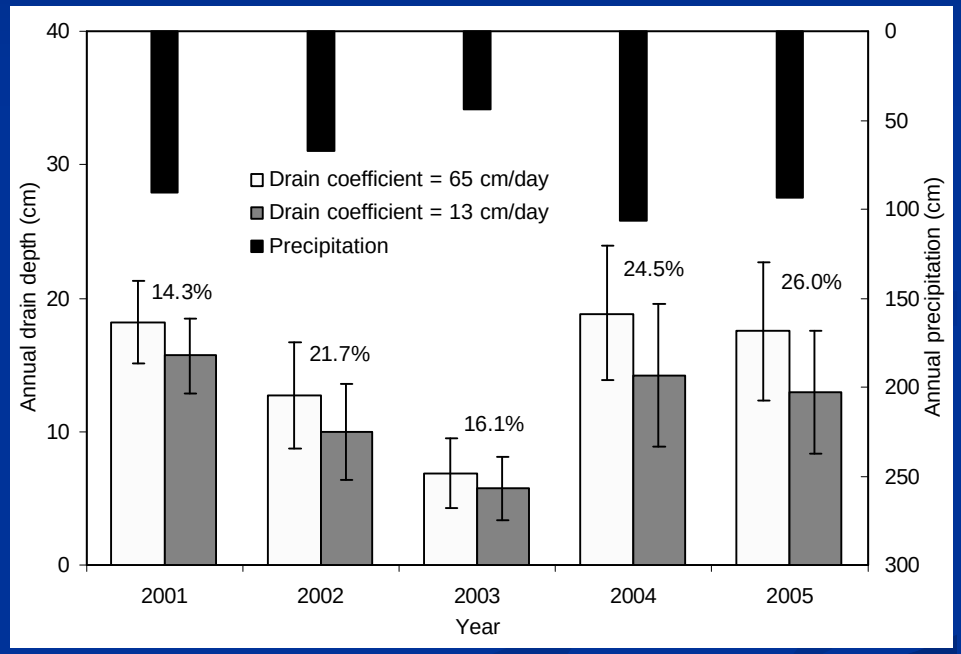
Fractional Distribution of Annual Drainage



Annual Drainage Volume

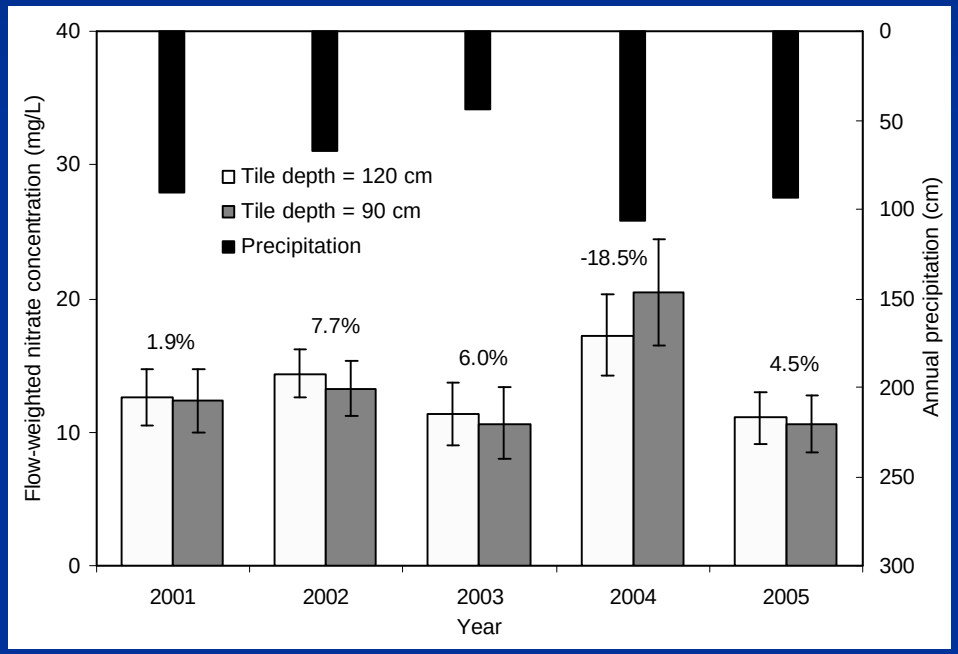


Drain depth

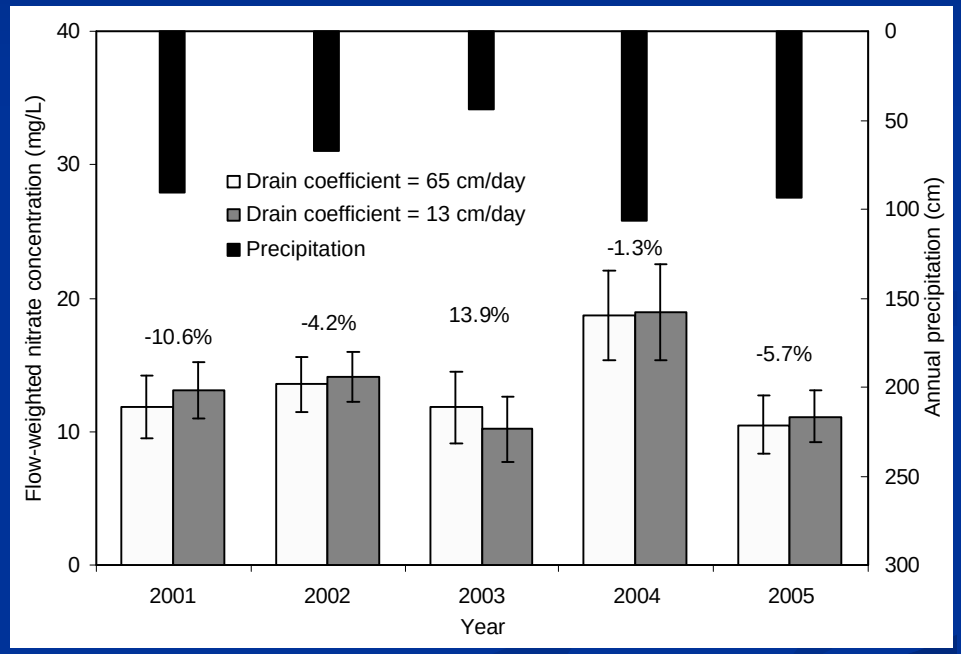


Drainage Intensity

Flow-Weighted NO_3-N Conc

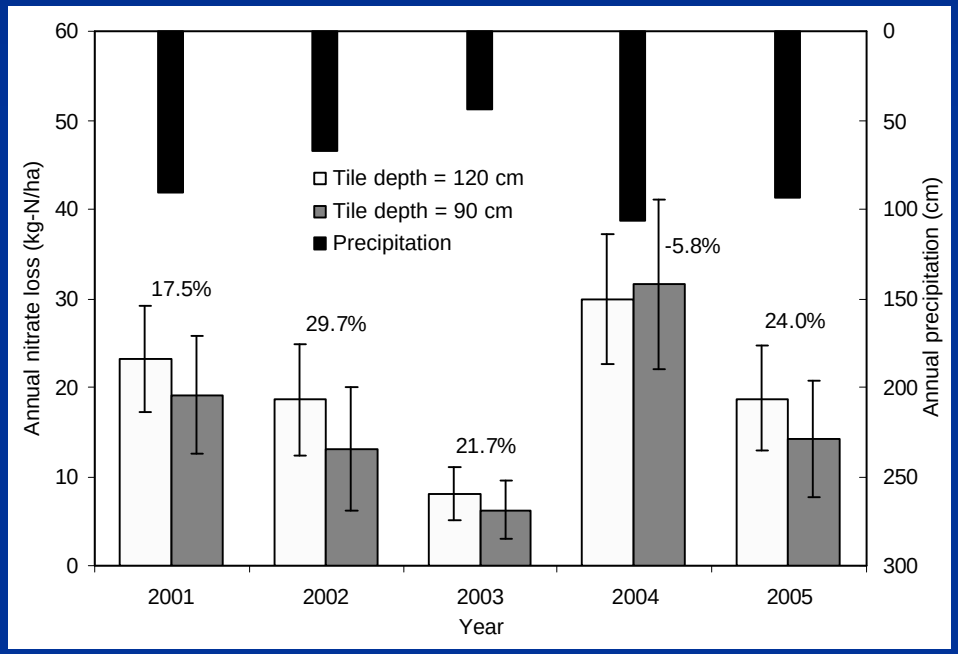


Drain depth

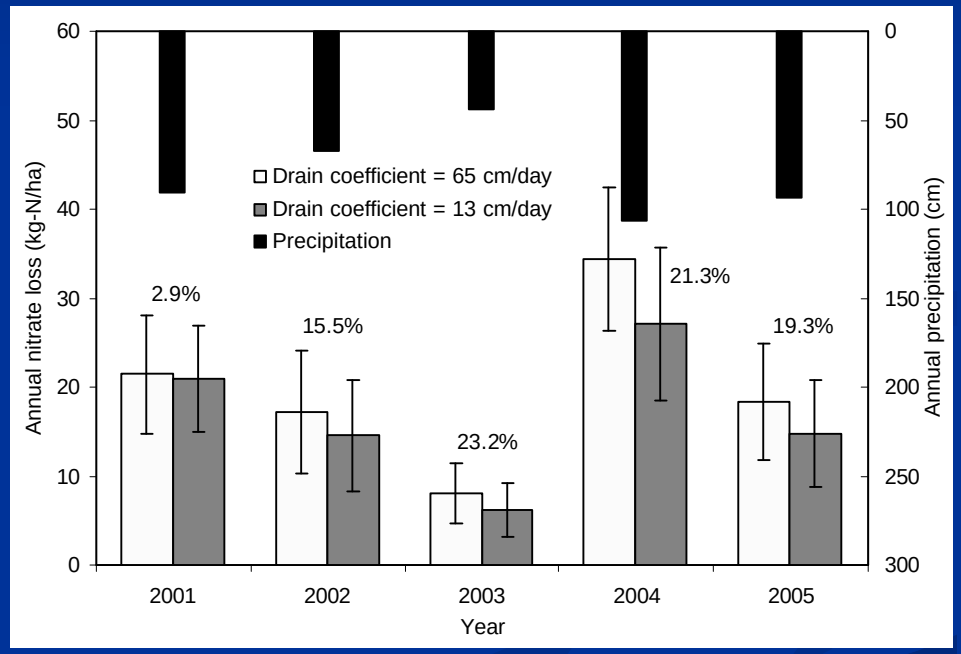


Drainage Intensity

NO_3-N Mass Loss (Load)

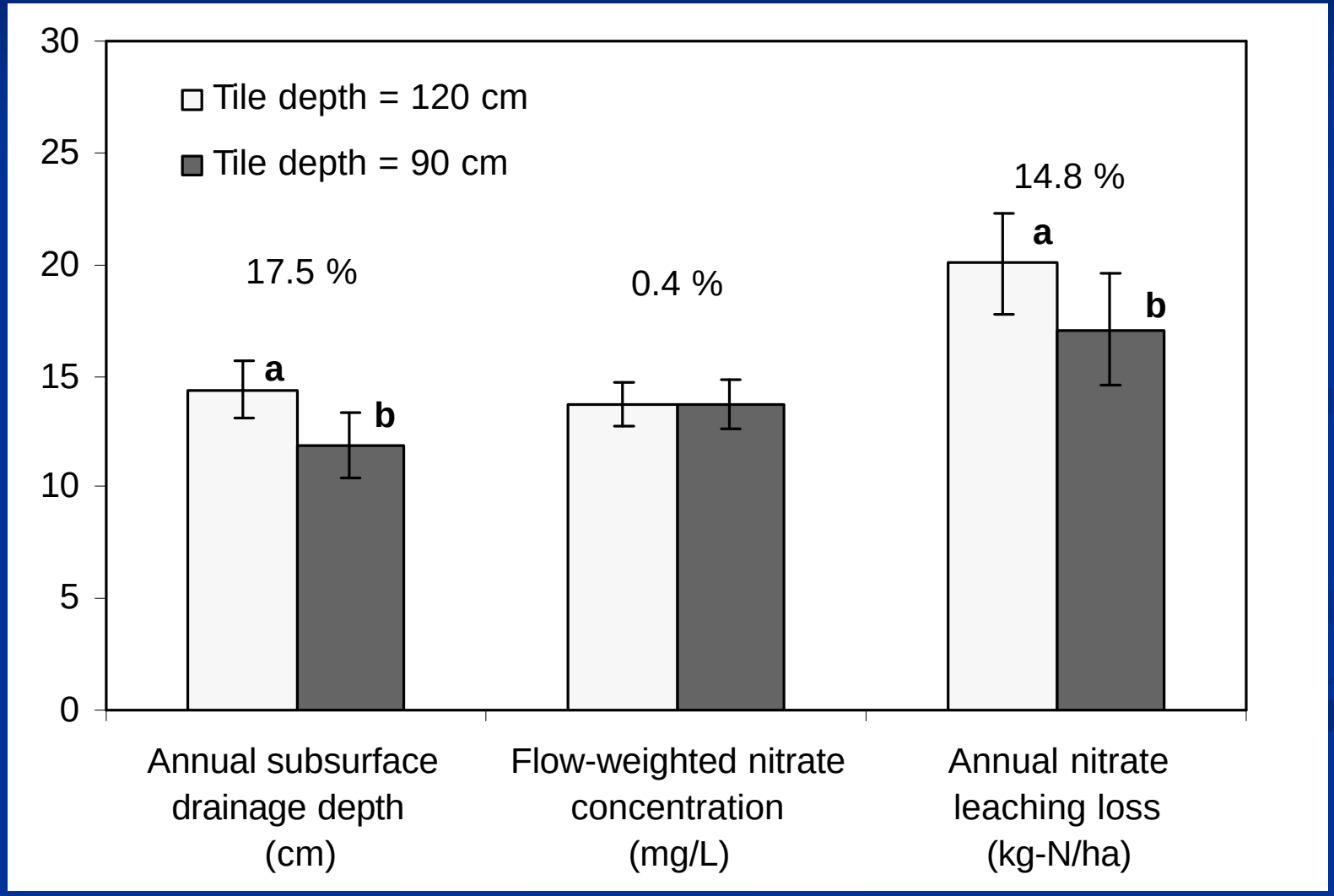


Drain depth



Drainage Intensity

Aggregated Results by Drain Depth



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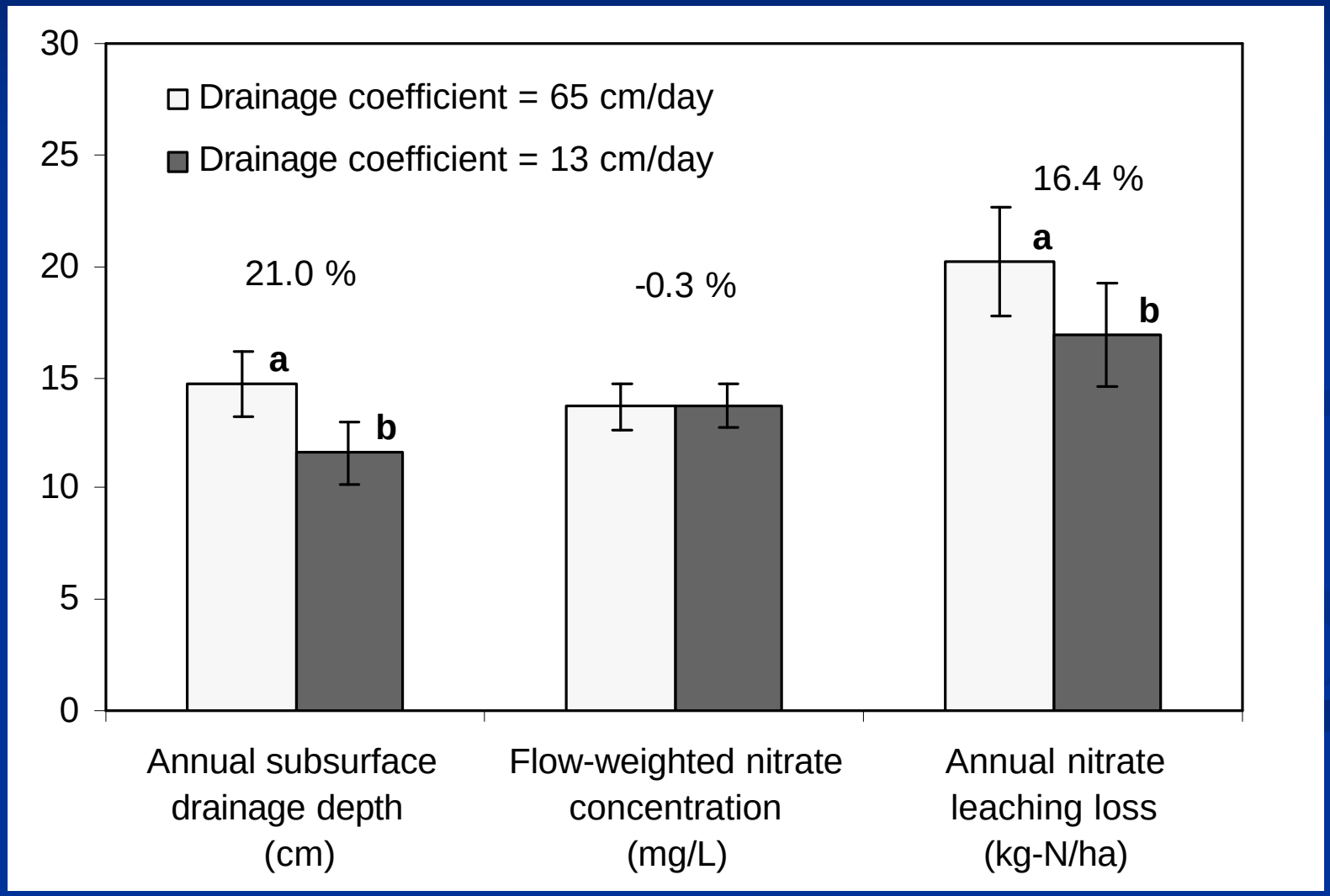
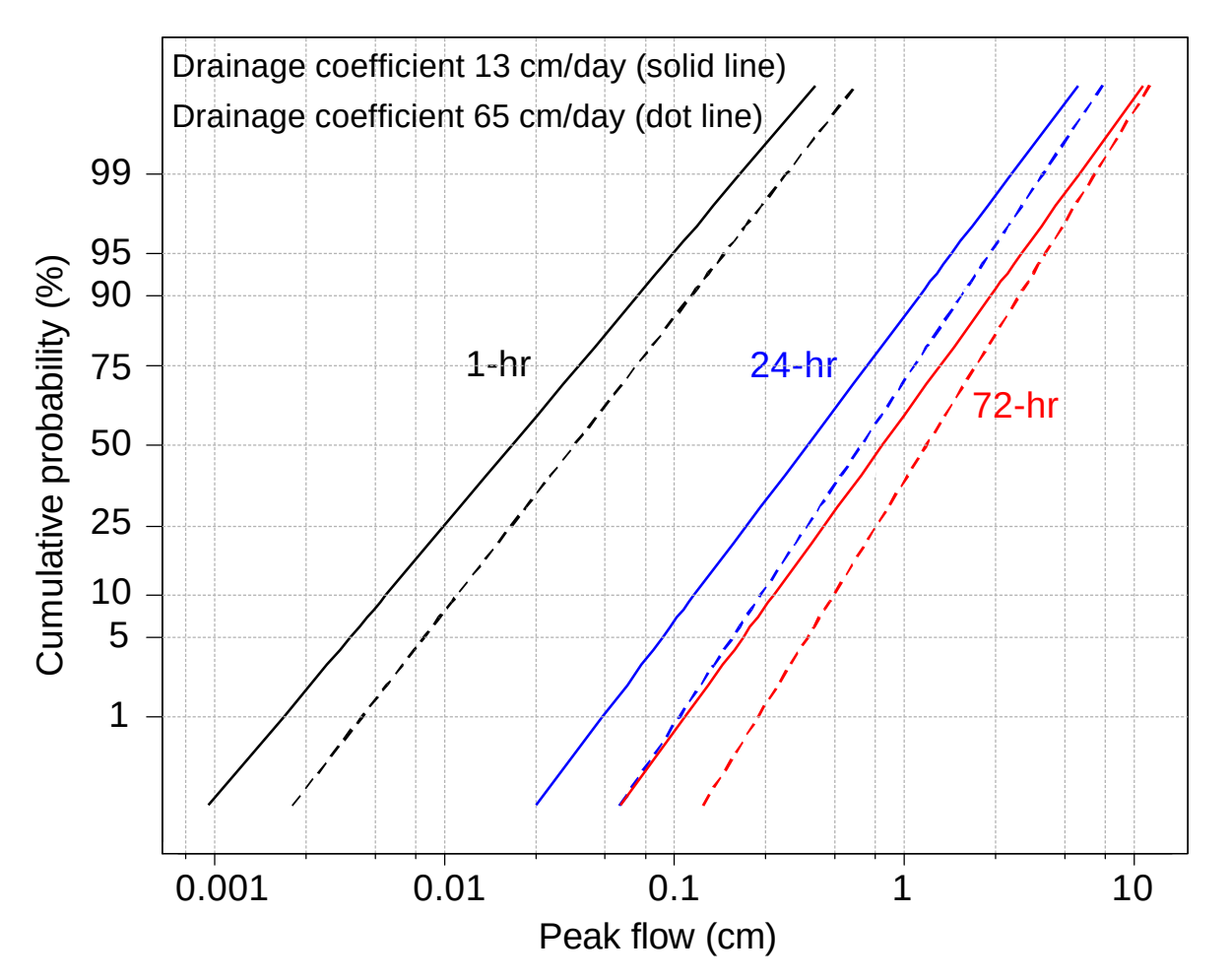


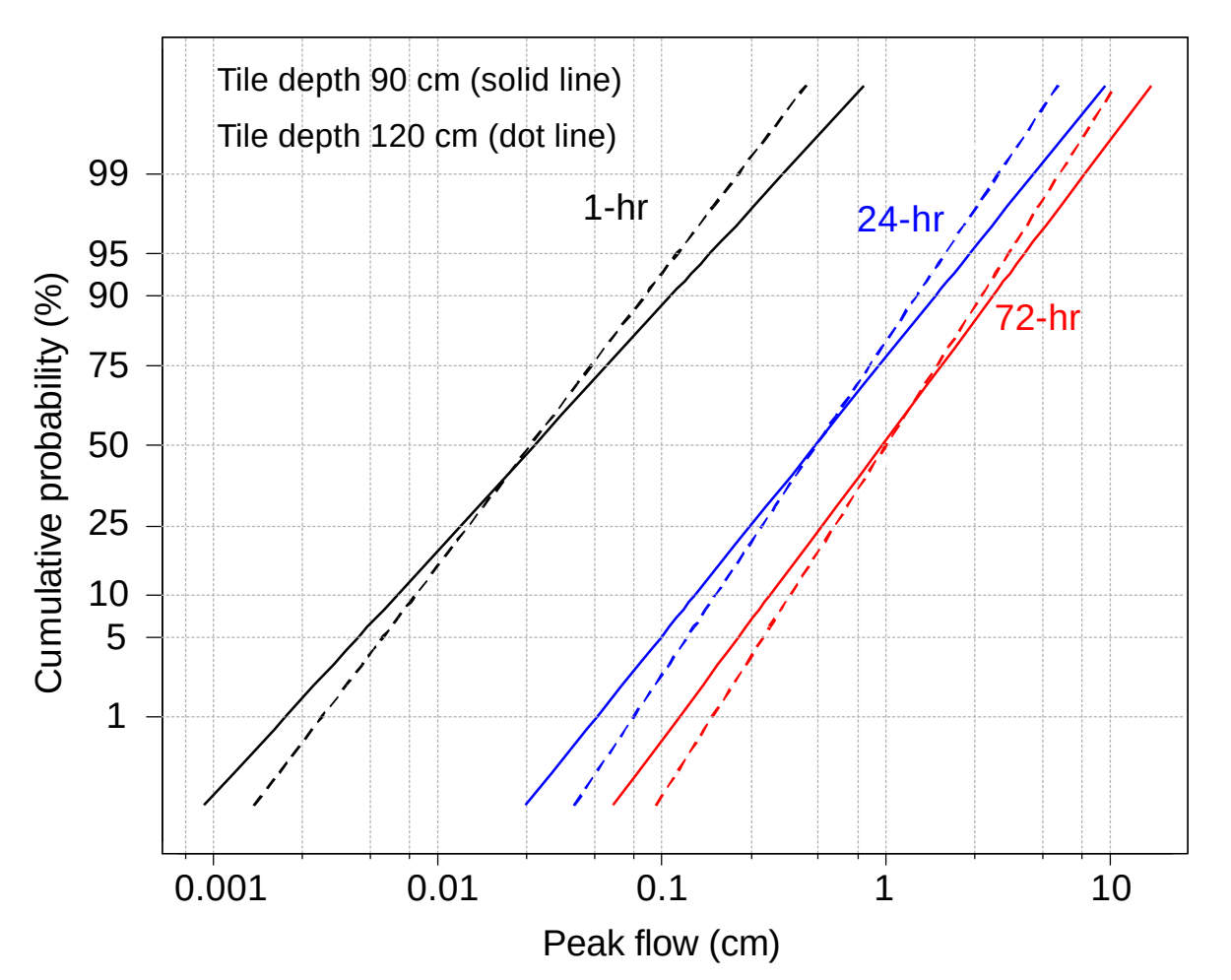
Peak Flow Analysis

- 1-, 24-, and 72-hr durations
- 5 years pooled
- lognormal distribution

Peak Flow & Drainage Intensity



Peak Flow and Drainage Depth



Summary

- Effects of subsurface drainage design (depth and drainage intensity) were evaluated
- Most of drain volume occurred from April through June
  - on average, approximately 80 % of annual drainage while 40 % rainfall occurred)

Summary – Flow

- Overall, about 16 % of rainfall resulted in drain flow
- A 1-ft shallower drain depth appeared to reduce annual drainage volume by 18 % as compared to conventional depth
- As expected, drainage intensity also increased annual drain volume by 21%
- Drainage intensity had a greater effect on peak flows than drain depth

Summary – Flow (cont)

- Reductions in drainage volume were not matched by increases in surface runoff
- Where does the water go?
- Subject of much discussion in research community

Summary – Nitrate-N Loss

- Nitrate concentration not significantly influenced
- A 1-ft shallower drain depth resulted in 15% decrease of annual N leaching loss
- Mechanism is volume reduction
- Intense drainage increased N losses by 16 %

Thank You!
Questions?