A Presentation of the

December 2, 2008

IOWA STATE UNIVERSITY
University Extension

UNIVERSITY OF MINNESOTA
EXTENSION

Drainage Water Management: Drainage, Crop Yield, and Nutrient Loads

IA-MN Drainage Forum

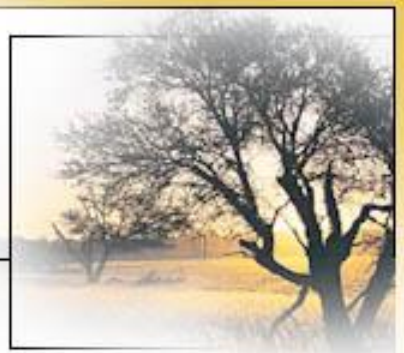
2 December, 2008

Owatonna, MN

Jeff Strock, Stacey Feser, and Gary Sands

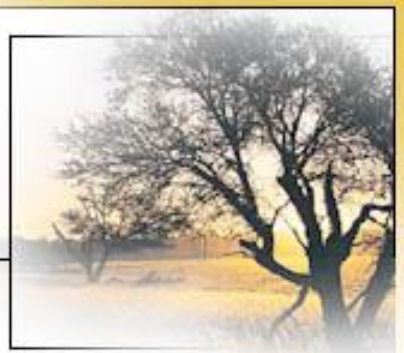
University of Minnesota

Acknowledgements

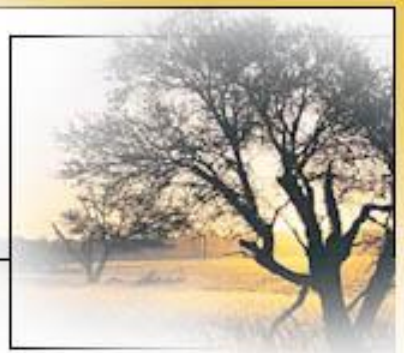


- Brian Hicks - cooperator
- Sara Olsen & Lynn Lendt – summer interns
- Bill VanRyswyk – MDA
- RCRCA – AgriDrain structures
- MN Ag. Fertilizer Research & Education Committee – Funding

Conclusions



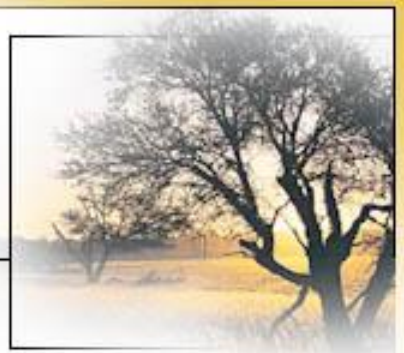
- Controlled drainage is a valuable system for mitigation of nitrate from tile drainage water.
- Controlled drainage has been shown to increase yield.
- Controlled drainage ***could*** constitute a problem with regard to phosphorus loss to surface water.



- OVERVIEW

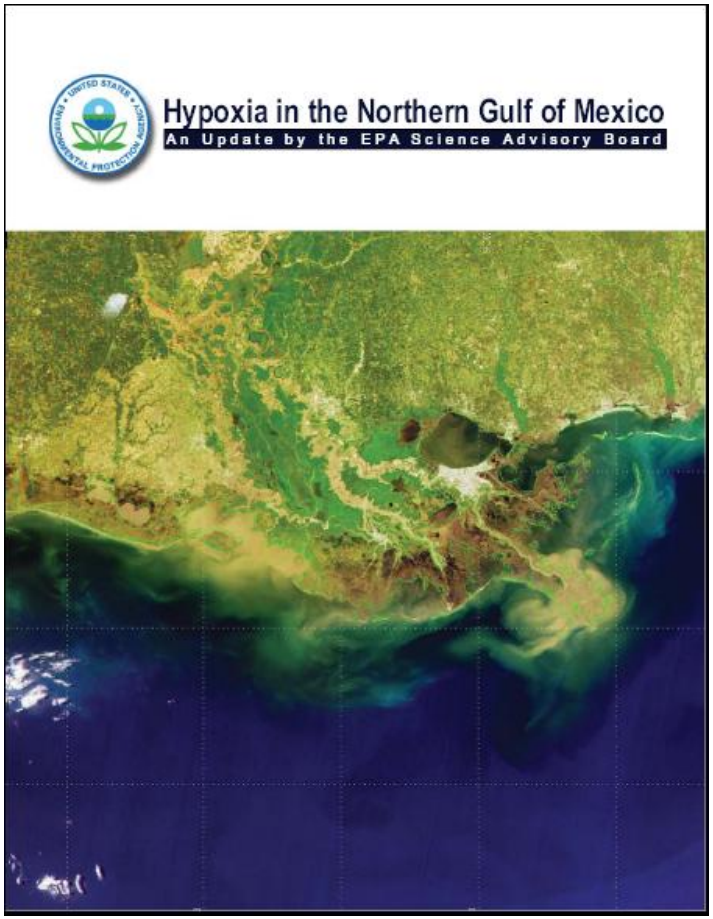
- Objectives
- Background
- Nitrogen and Phosphorus
- Field Experiment

Objective



- Understand the mechanisms and processes affecting N and P loss under tile drainage systems, specifically controlled drainage.

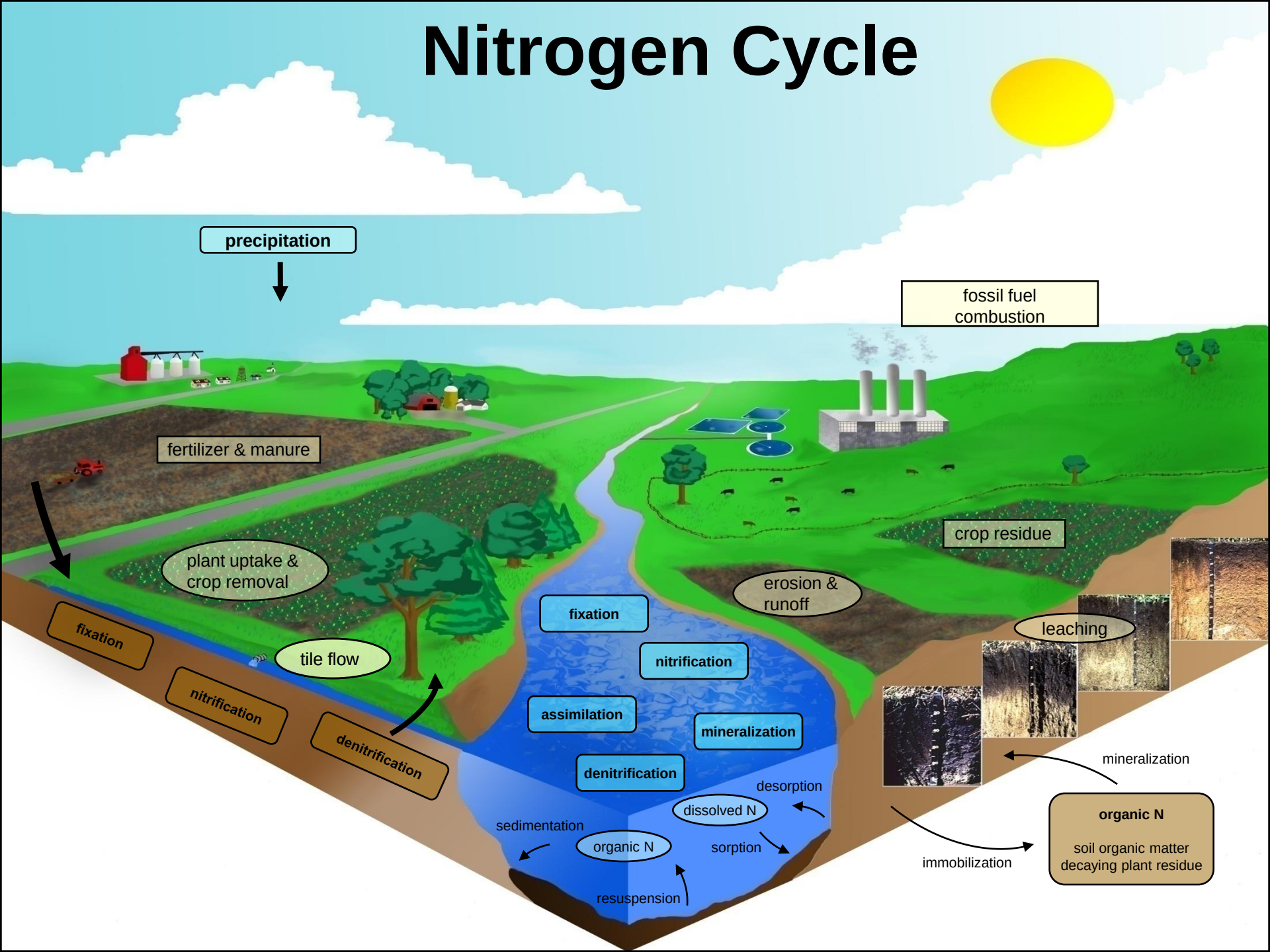
Background



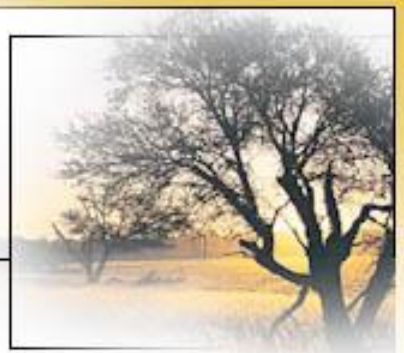
- The EPA Science Advisory Board 2008 report noted that the Mississippi River is disproportionately enriched with nitrogen and phosphorus during the spring (**April, May, and June**).

NITROGEN & PHOSPHORUS

Nitrogen Cycle

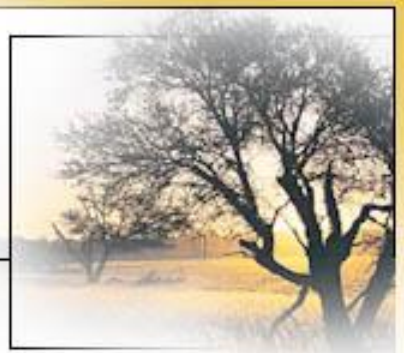


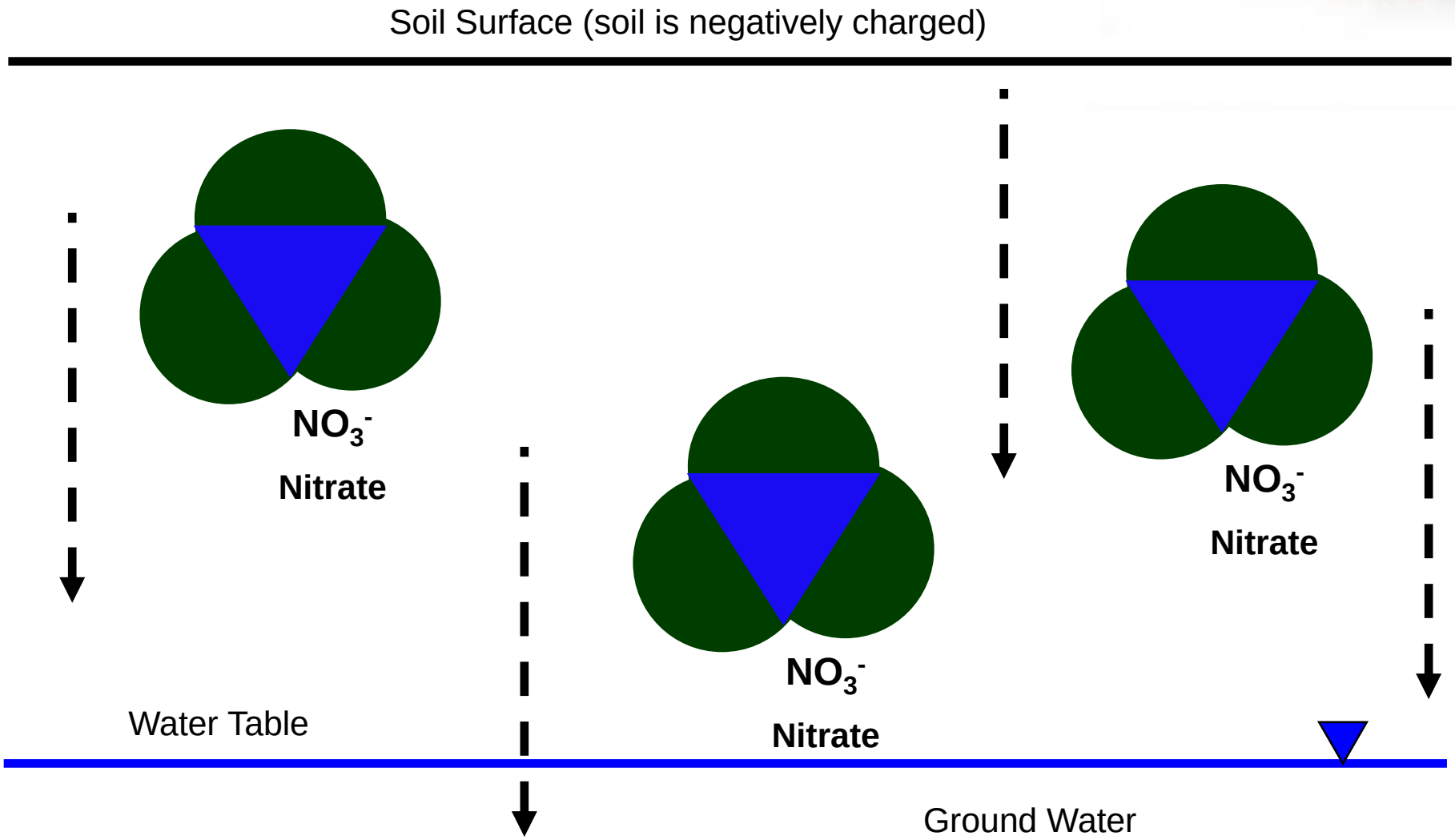
N in Freshwater Systems



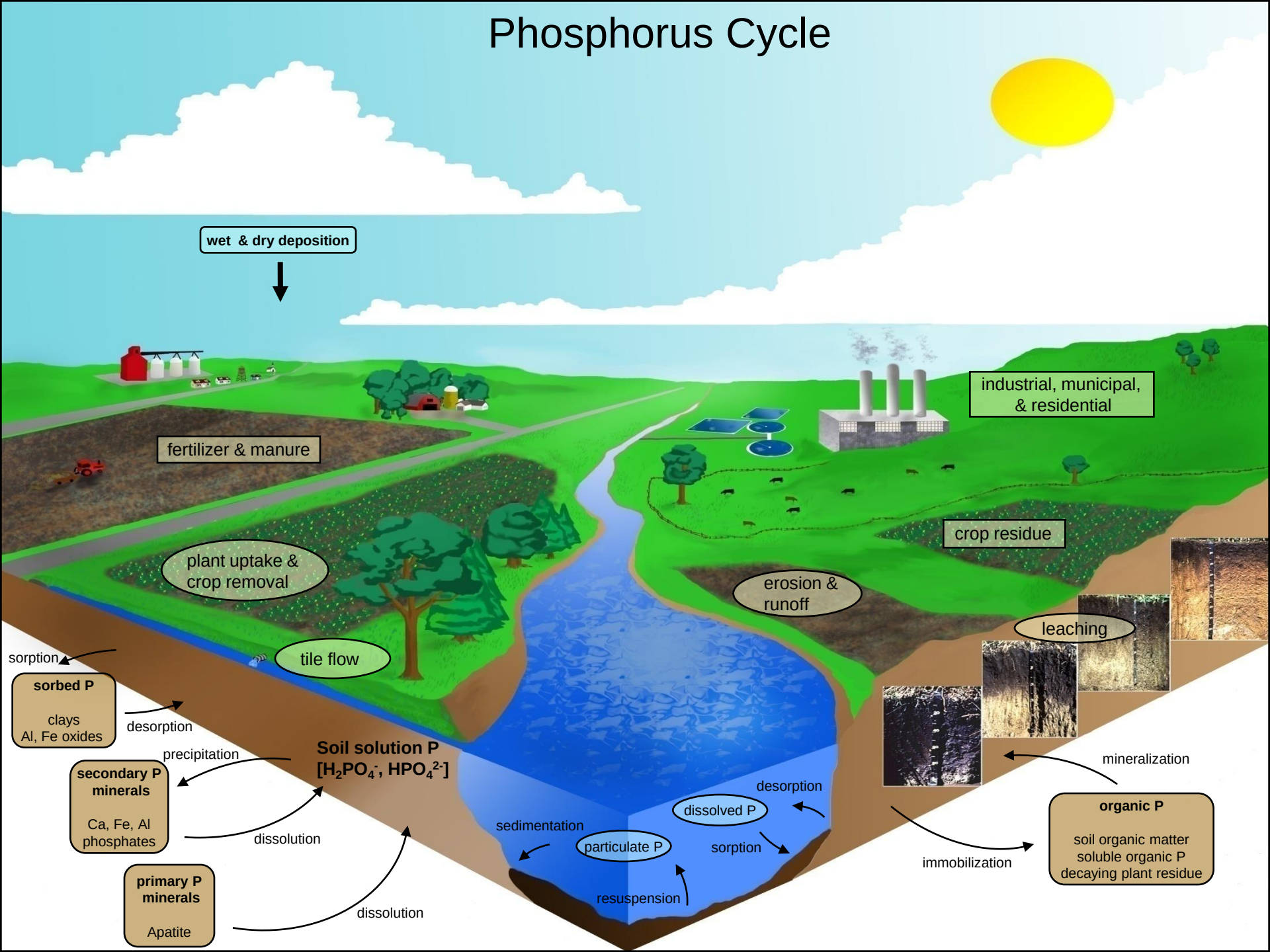
- Nitrogen is abundant in freshwater systems and occurs in water as N_2, NO_2, NO_3, NH_4, and in diverse organic forms. It may be derived from precipitation and soils, but its availability is usually regulated by microbial processes. Nitrogen occurs in relatively short supply relative to biological demand.
- Nitrogen may also limit algal growth in some freshwater systems, particularly when phosphorus levels have been increased.

N is mobile in soil

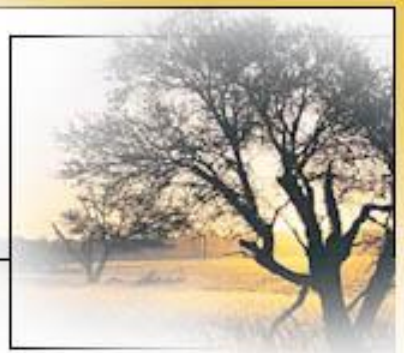




Phosphorus Cycle



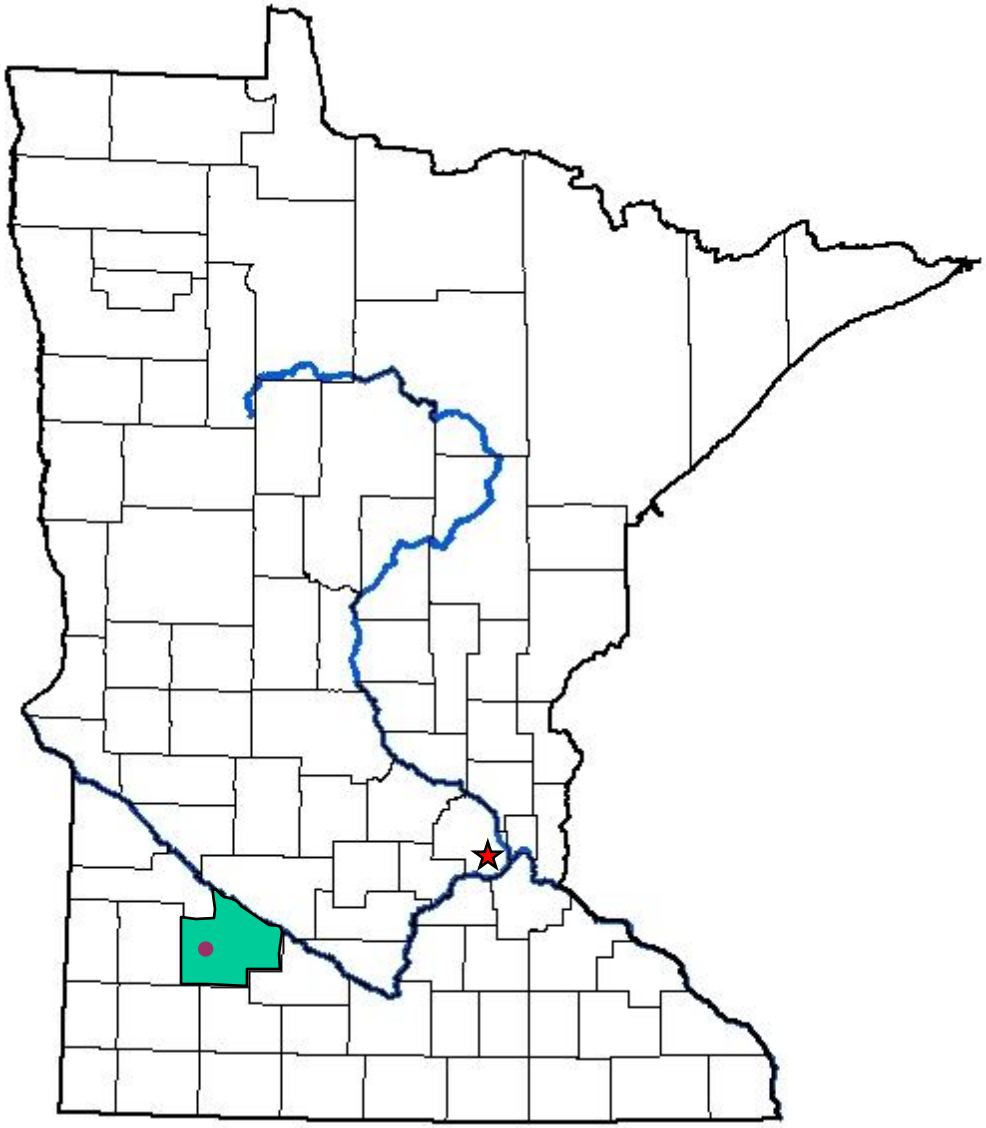
P in Freshwater Systems



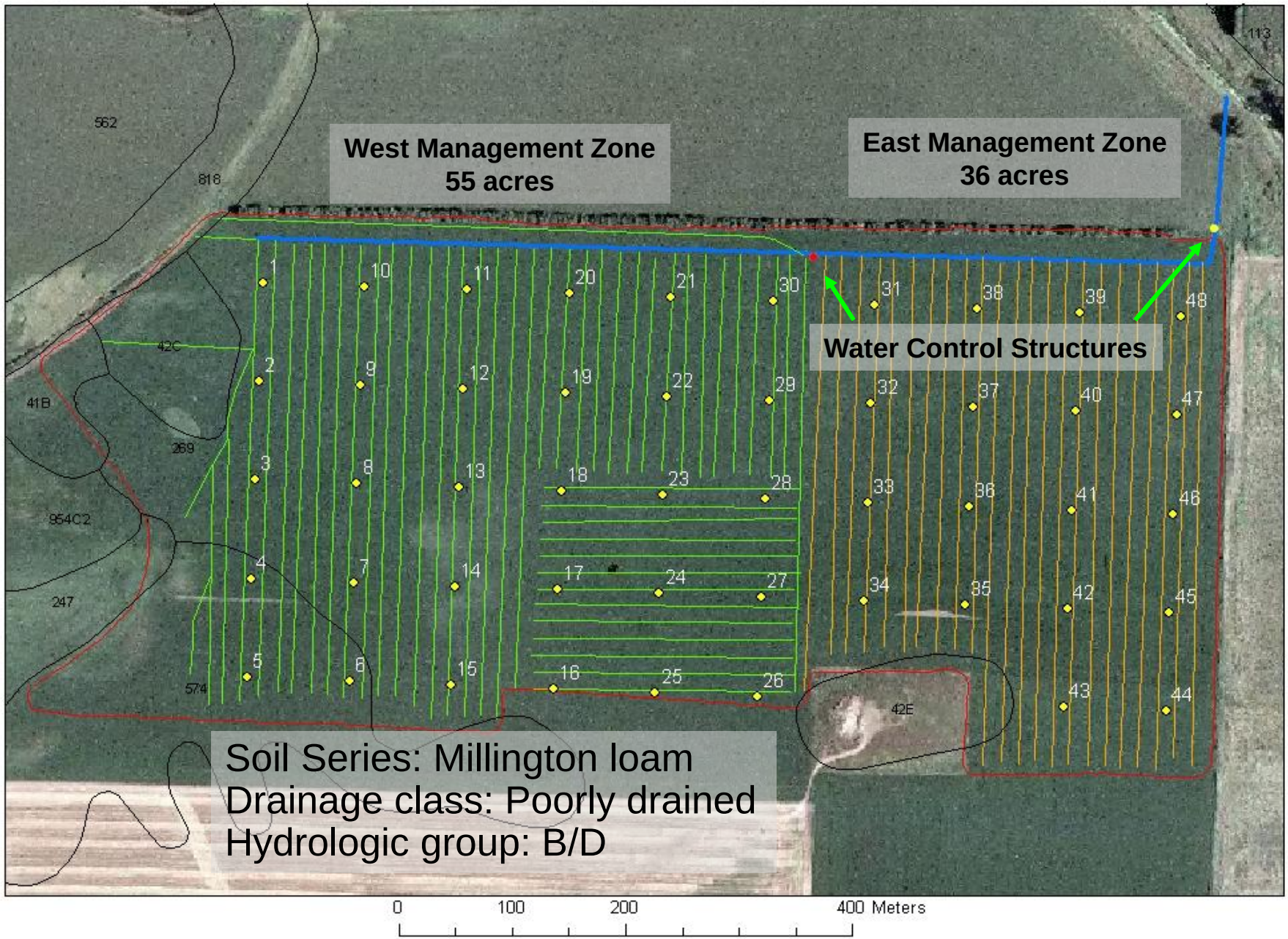
- Freshwater systems are generally phosphorus-limited. Generally, a phosphate concentration of 10 ug/L will support plankton, while concentrations of 30 to 100 ug/L phosphate or higher will likely trigger blooms (USEPA, 1986; Dunne and Leopold, 1978).
- A high availability of P does not always indicate continued algal production because the system may become nitrogen limited.

FIELD EXPERIMENT

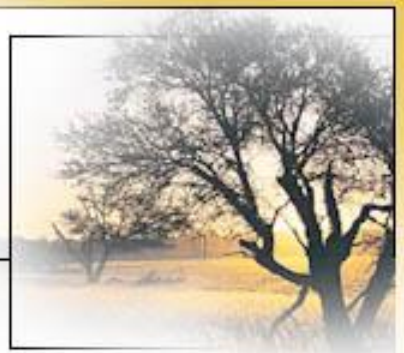
Redwood Co. Farm



Hicks Family Farm - Controlled Drainage Site

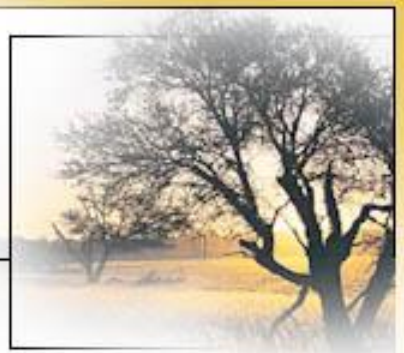


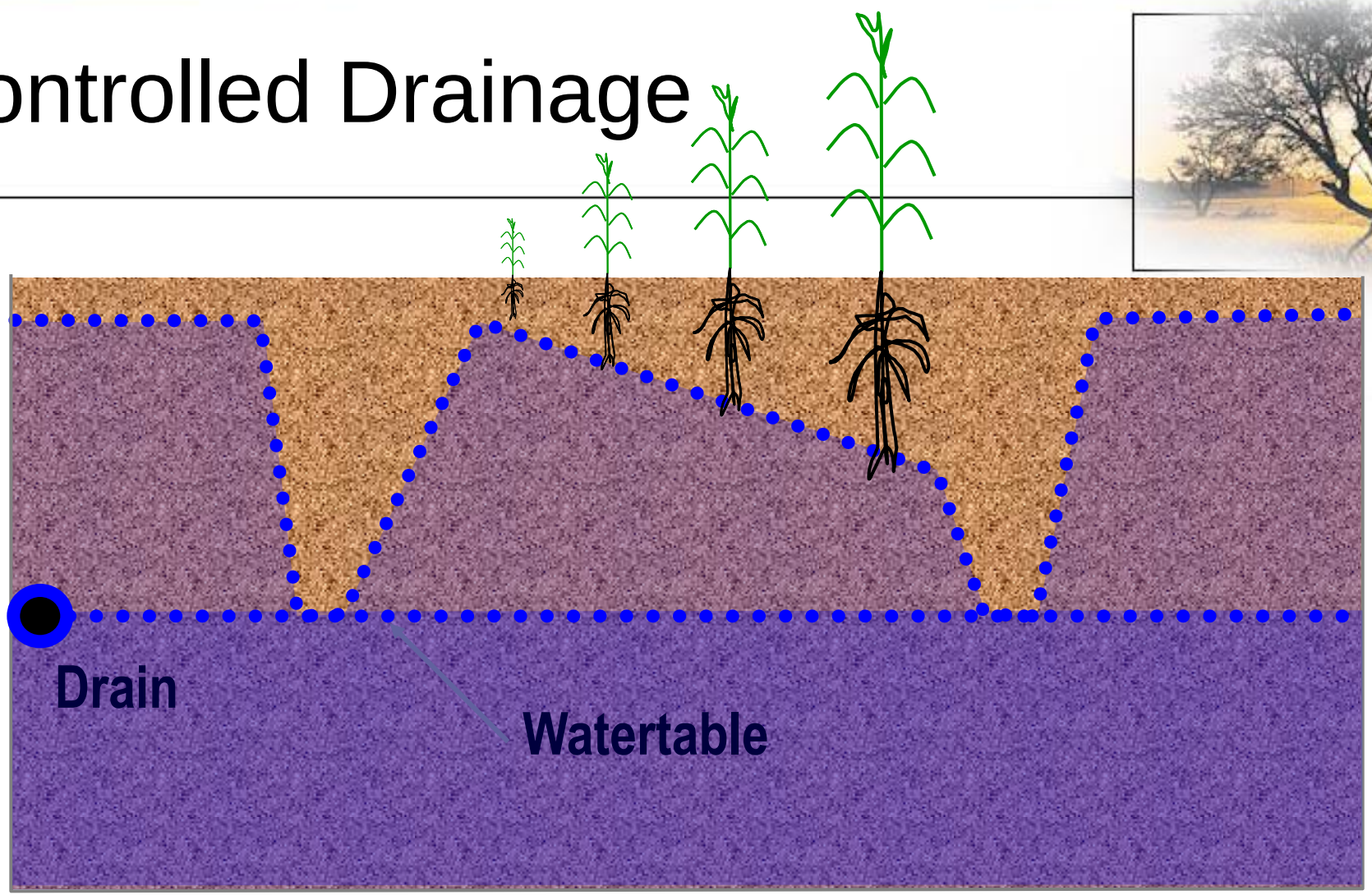
Drainage System Layout



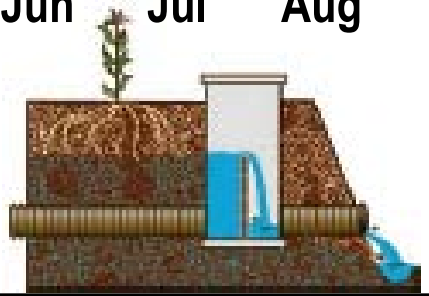
- Drain depth: 4 ft
- Drain spacing: 50 ft
- No previous history of drainage before 2005
- 2006
  - Both halves manage conventionally
- 2007
  - Both halves managed in controlled drainage mode
- 2008
  - East managed in controlled drainage mode and West managed in conventional drainage mode.

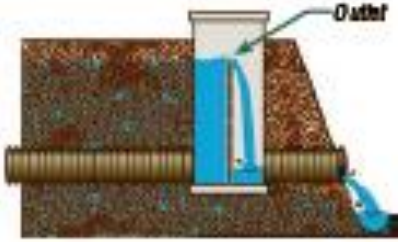
Controlled Drainage





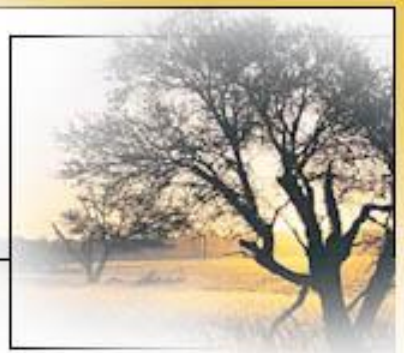
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec





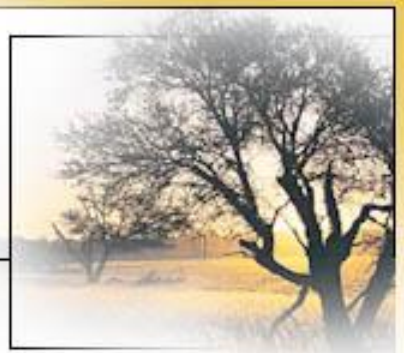
Sources: Gary Sands, and Purdue University

Previous Management



- 2004 – Soybean
- 2005 – Small Grain
- 2006 – Corn
  - Planted: 4/21/06
  - Fertilized: 4/19/06
    - 155 lb N/A
    - 60 lbs P_2O_5/A
- 2007 – Corn
  - Planted: 4/27/07
  - Fertilized: 4/27/07
    - 160 lb N/A
    - 60 lbs P_2O_5/A
- 2008 – Soybean

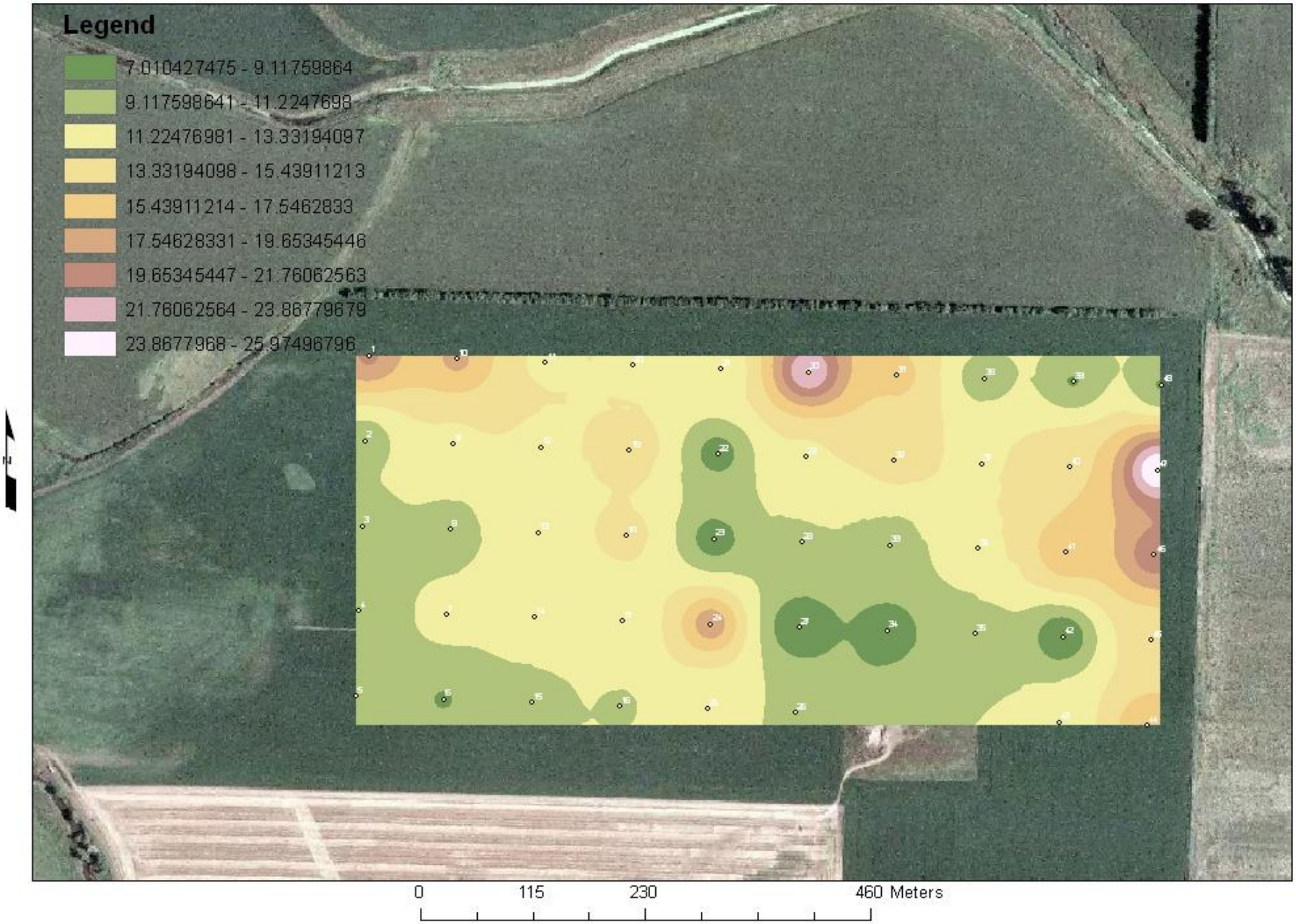
Summary of Select Soil Properties



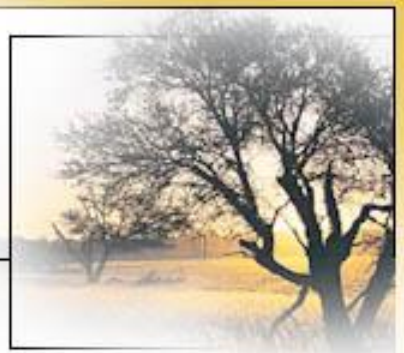
Variable	EAST			WEST		
	Mean	Min.	Max.	Mean	Min.	Max.
pH	7.6	7.3	7.8	7.6	7.3	7.8
Organic Matter (%)	5.0	3.8	6.7	4.9	3.2	5.8
Bray P1 (ppm)	21	3	40	17	4	44
Olsen P (ppm)	13	7	26	13	7	24
Available K (ppm)	139	89	189	155	98	258

Olsen P: v. low (0-3), low (4-7), med. (8-11), high (12-15), v. high 16+
Available K: v. low (0-40), low (41-80), med. (81-120), high (121-160), v. high 160+

Hicks Family Farm - Controlled Drainage Site



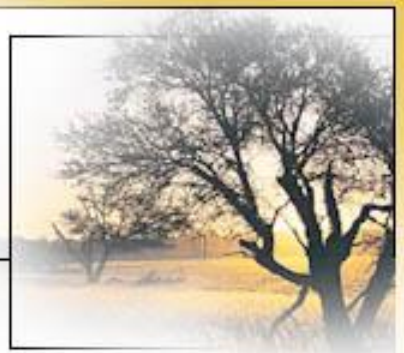
Soil Test Results



Loc.	Hor.	Depth	TP	WEP	Al	Ca	Fe	Mn
		m	----------	----------	mg/kg	----------	----------	----------
East	Apk	0-0.2	588.4	3.5	4274.7	4371.4	6626.9	322.7
	Ak1	0.2-0.46	462.0	1.0	3377.4	7791.5	5453.4	229.2
	Ak2	0.46-1.2	385.2	0.3	2774.2	7830.6	4658.2	197.4
West	Apk	0-0.24	650.2	1.8	3959.8	4899.0	6641.8	359.8
	Ak1	0.24-0.48	458.0	1.0	3133.1	8203.1	5383.3	289.9
	Ak2	0.48-1.2	426.9	1.0	4105.3	7161.8	6780.6	359.8

Method: EPA 3051

Yield results



paired-analysis design

		East	West	Undrained
	Year		bu/A	
control	2006 (corn)	193†	193	149
control	2007 (corn)	158	162	145
treatment	2008 (soybean)	22	19	46

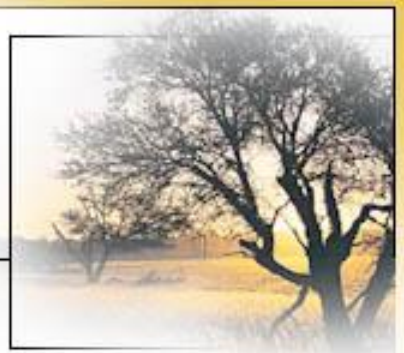
† Yield monitor data lost

treatment control

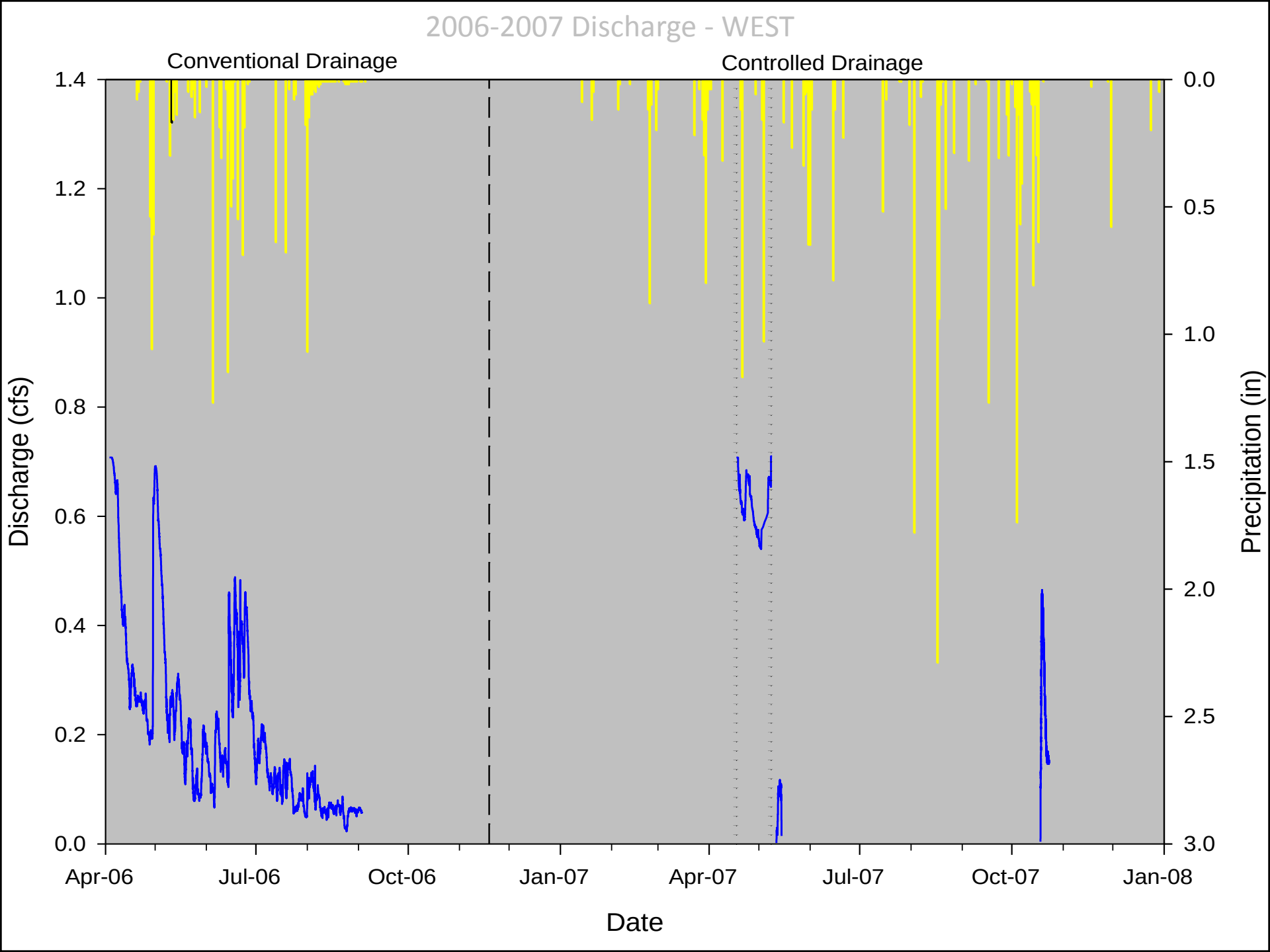
Water Quality Monitoring

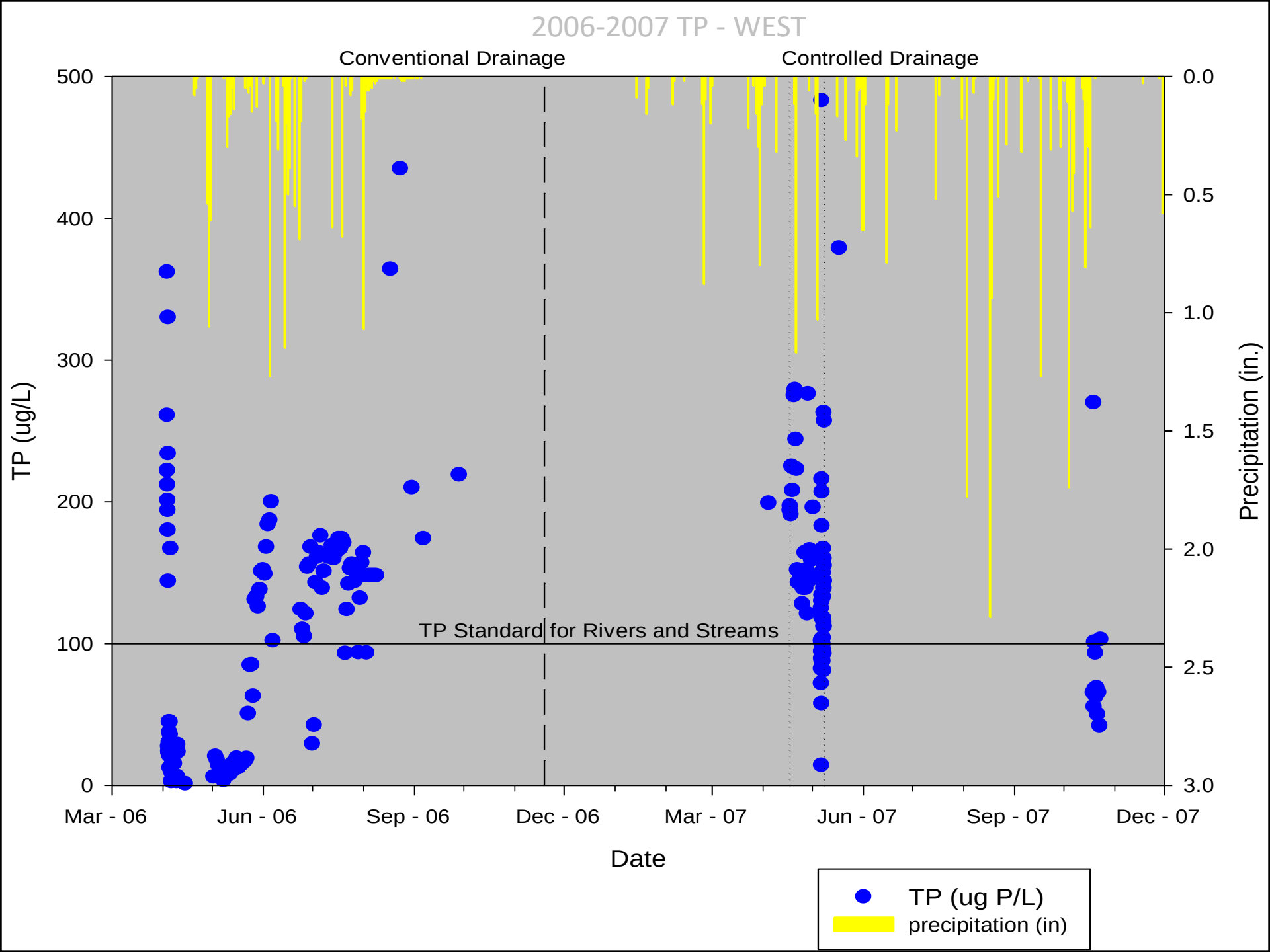
- Water samples analyzed for TN, NO_3-N, NH_4-N, TP, DRP.
- Flow
  - 2006
    - Time paced
  - 2007-present
    - Flow proportional method

Annual Precipitation

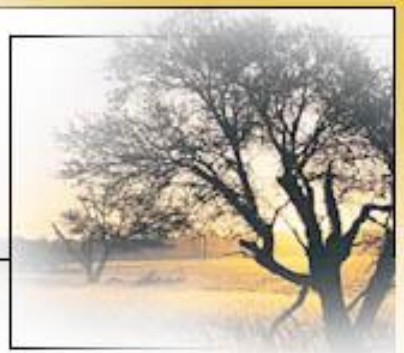


	2006	2007	30-yr. Avg.
January	0	0.4	0.64
February	0	0.93	0.56
March	1.83	1.58	1.81
April	4.36	1.95	3.09
May	2.28	2.48	3.61
June	4.47	2.31	4.10
July	1.4	0.58	3.09
August	4.54	5.58	3.32
September	2.94	1.81	3.27
October	0.29	6.54	1.94
November	0.74	0	1.53
December	1.58	0	0.71
Annual Total	24.43	24.16	27.74


2006-2007 Discharge - WEST
Conventional Drainage
Controlled Drainage
Discharge (cfs)
Precipitation (in)
Date
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Apr-06
Jul-06
Oct-06
Jan-07
Apr-07
Jul-07
Oct-07
Jan-08

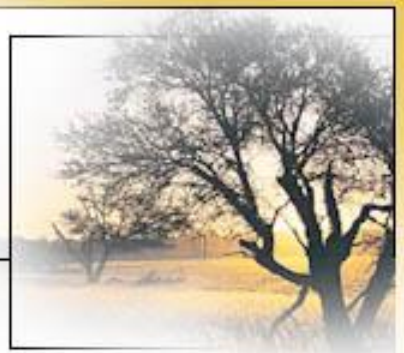

2006-2007 TP - WEST
Conventional Drainage
Controlled Drainage
TP Standard for Rivers and Streams
TP (ug/L)
Precipitation (in.)
500
400
300
200
100
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Mar - 06
Jun - 06
Sep - 06
Dec - 06
Mar - 07
Jun - 07
Sep - 07
Dec - 07
Date
TP (ug P/L)
precipitation (in)

Summary Data



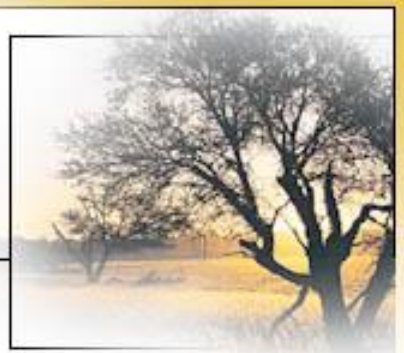
	2006	2007	% Reduction
Drainage (inches)	5.8	2.0	66%
TN (lbs/A)	41	3.8	91%
NO_3-N (lbs/A)	43	3.6	92%
NO_3-N Flow Weighted Mean Conc. (mg/L)	10.6	9.96	6%
TP (lbs/A)	0.249	0.062	75%
TP Flow weighted mean conc. (µg/L)	77	210	173% increase

Summary



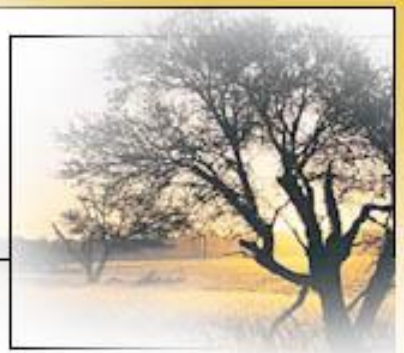
- Yield difference mainly due to crop rotation in 2006 & 2007. Yield increase of 3 bu/A in 2008.
- N loss from the drainage system was reduced when controlled drainage was implemented.
- N reduction was primarily due to a decrease in drain outflow; minor reduction in nitrate concentration.

Summary (continued)



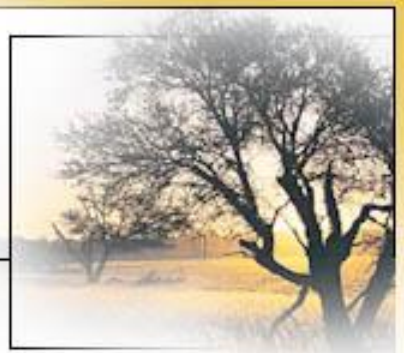
- Elevated P loss from drainage system; some plausible explanations:
  - Artifact of new tile drainage?
  - Preferential flow?
  - Reductive dissolution of P?
  - Mineralization of SOM?
  - Dissolution of P minerals?
  - Sorption/desorption of P from sediment in tiles?
  - Microbial reduction?

Summary (continued)



- This is a work in progress.
- Additional measurements
  - P sorption isotherms
  - EPC_0 (adsorption = desportion)
  - DPS (degree phosphorus saturation; Al_{ox} + Fe_{ox})
  - Dissolved Fe
  - DOC (dissolved organic carbon)

Conclusions



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- Controlled drainage has been shown to increase yield.
- Controlled drainage ***could*** constitute a problem with regard to phosphorus loss to surface water.

THANK YOU!

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