Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Advance Tile Drainage Topics

BIOSYSTEMS & AGRICULTURAL ENGINEERING
UNIVERSITY OF MINNESOTA

UNIVERSITY OF MINNESOTA Extension SERVICE

Canada

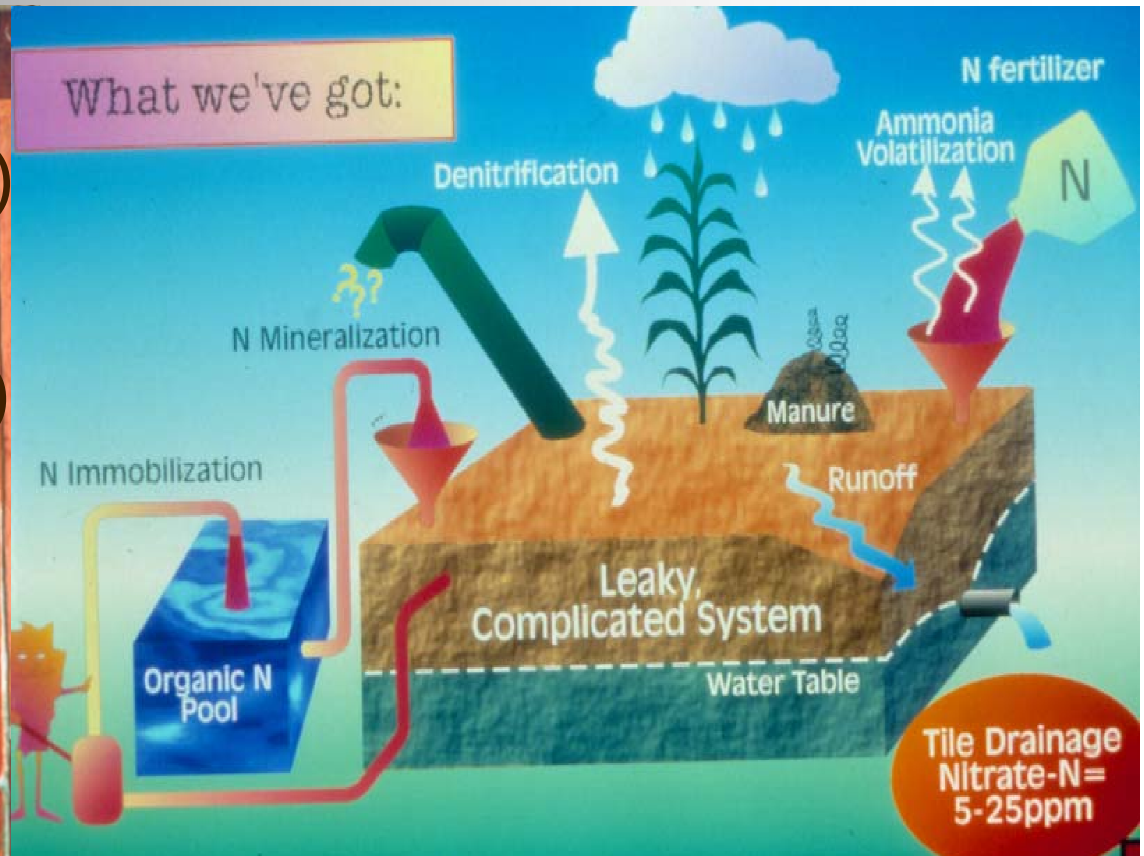
Nitrate Moves with Water

Water Quality Issues – Nitrates
1996 Site A - Manitoba

Nitrate-N

Max. Conc.
43.5 ppm (Apr. 24)

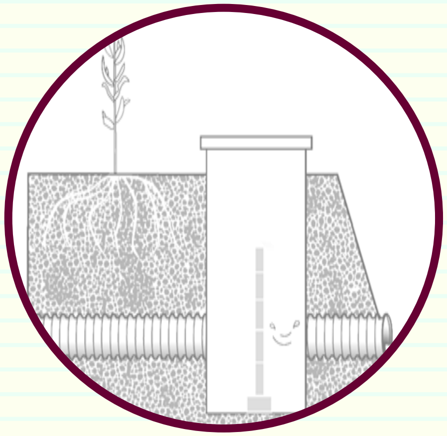
Min. Conc.
28.5 ppm (July 25)



“Conservation Drainage”

1. Drain just enough water to ensure trafficability and crop growth…. *and not a drop more*!

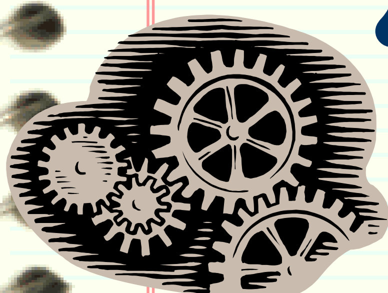
2. Adopt best practices where appropriate to improve water and N use efficiency—while maintaining productivity.



Conservation Drainage Strategies

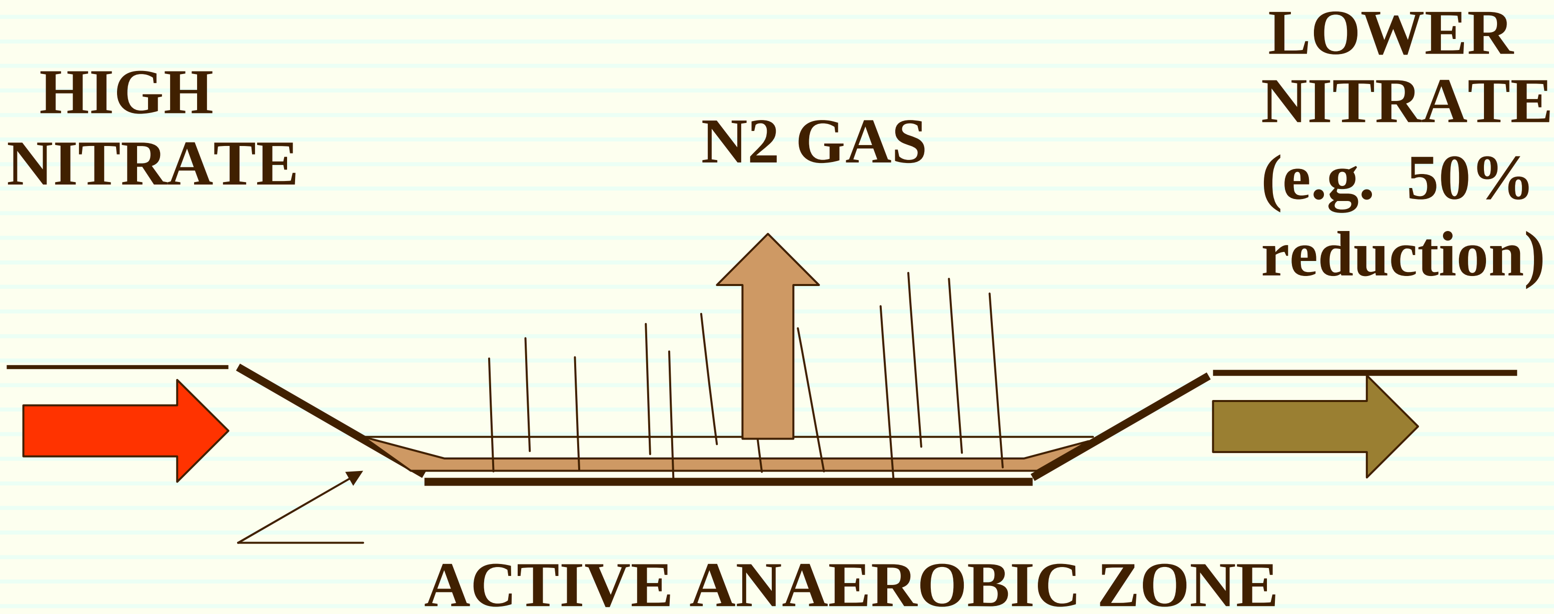
- Agronomic approaches
  - Nutrient, crop, tillage management
  - Cover crops, scavenger crops

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

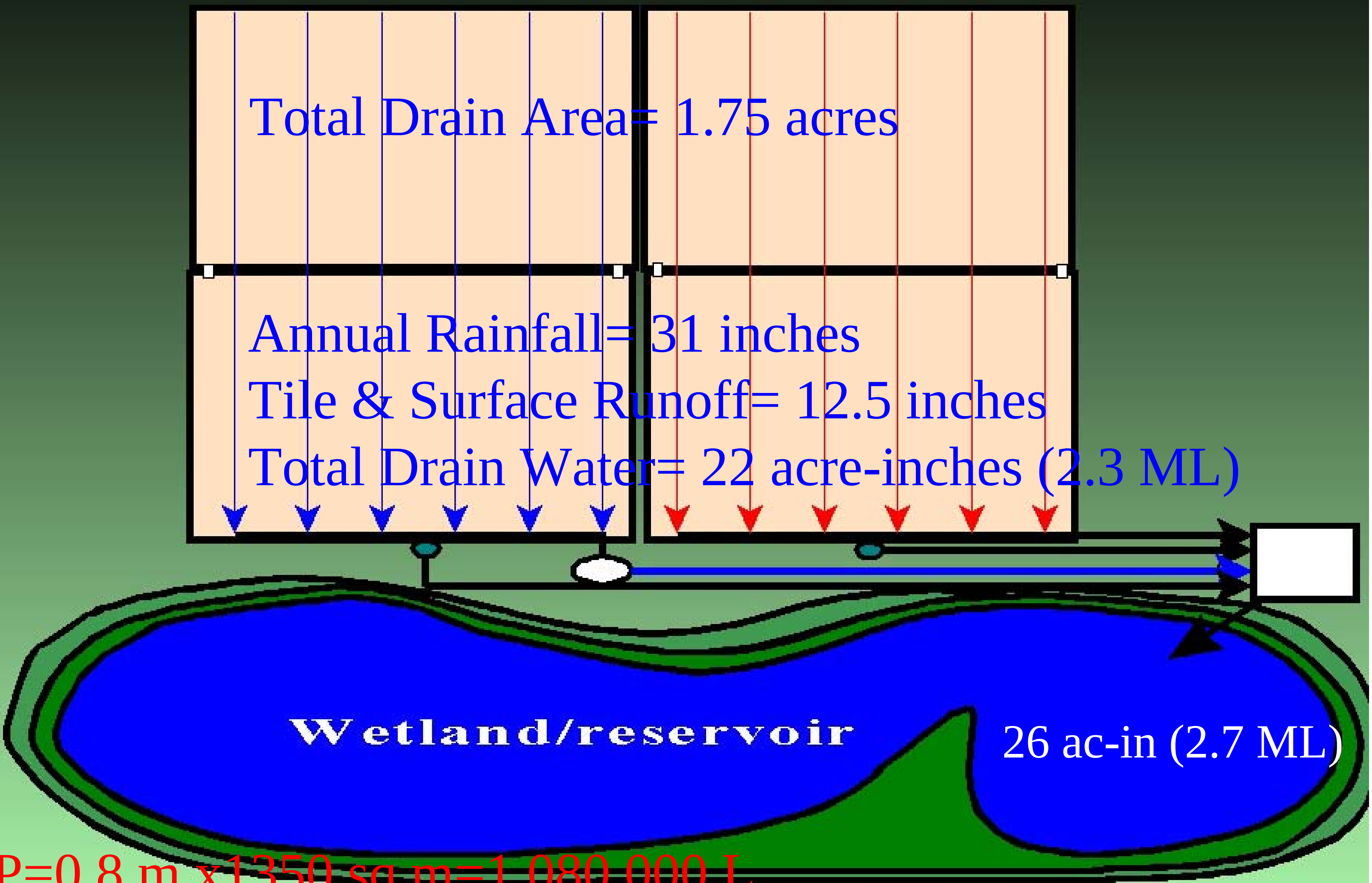


- Engineering approaches
  - Drainage design & management
  - Ditch modification/management
  - Bio-reactors
  - Recycle tile water

WETLANDS


HIGH NITRATE
N2 GAS
LOWER NITRATE (e.g. 50% reduction)
ACTIVE ANAEROBIC ZONE

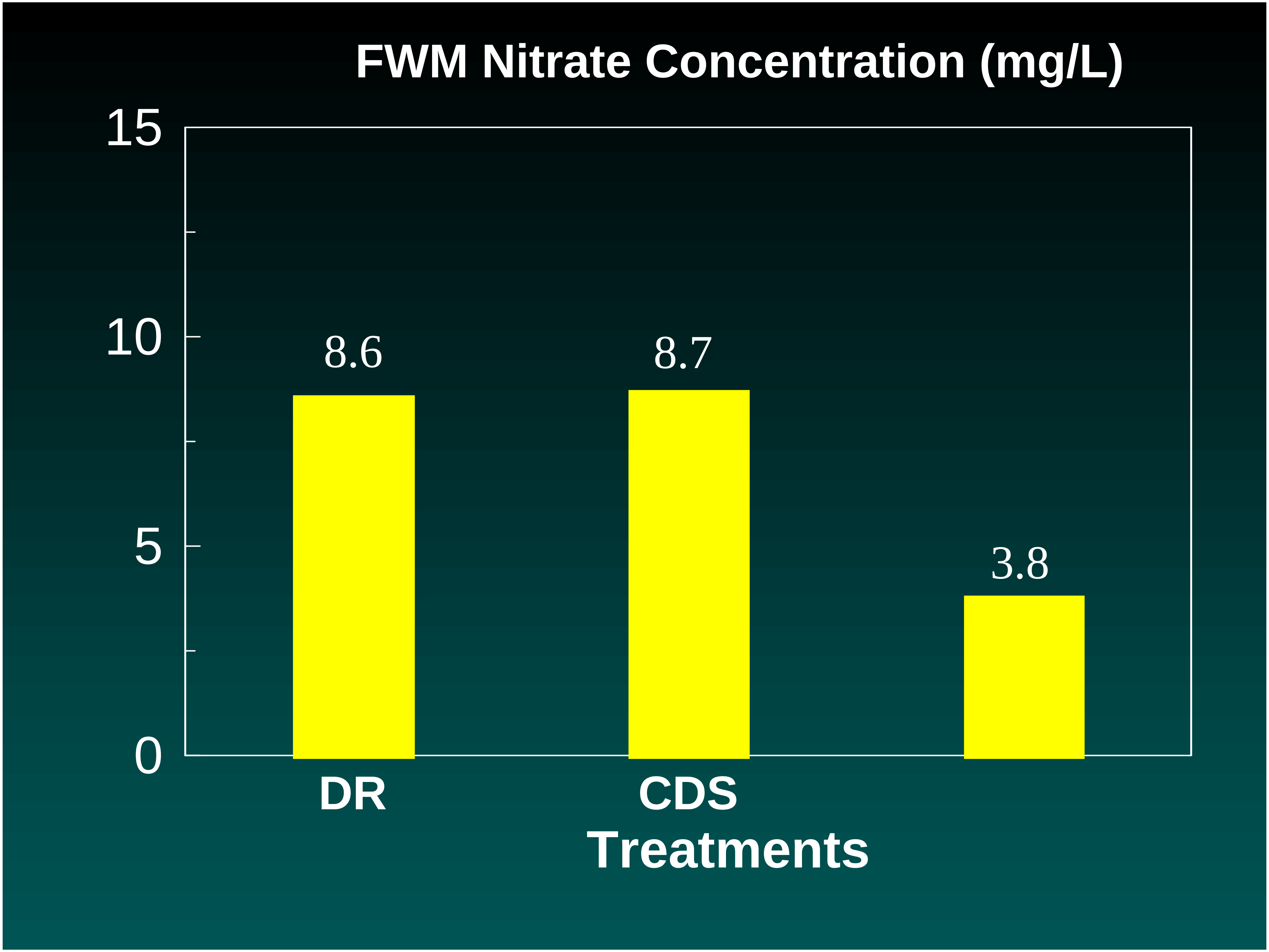
Plot Layout



P=0.8 m x1350 sq m=1,080,000 L

ET=0.007m x1350 sq m x 120=1,134,000 L

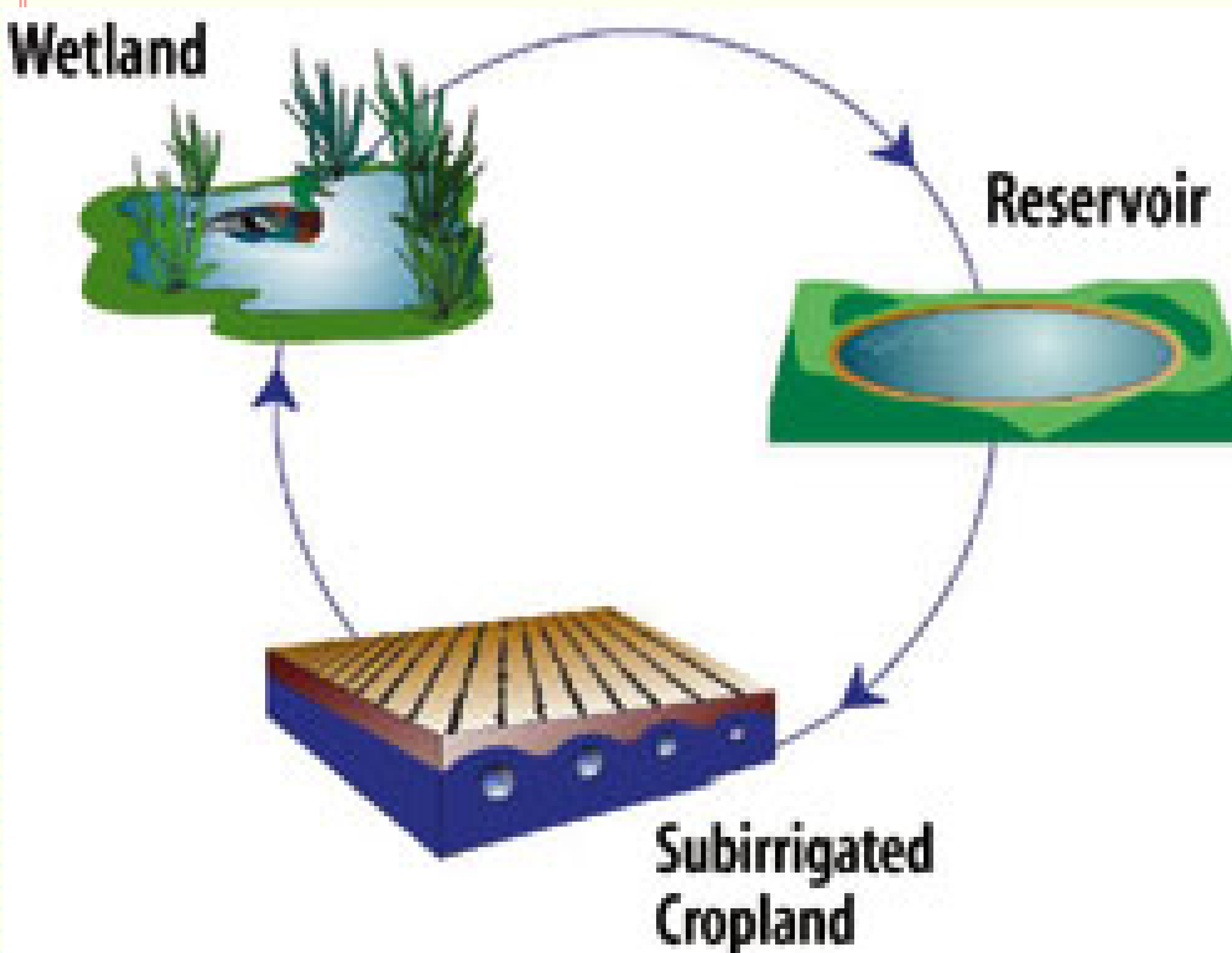

Wetland During the Summer & Fall, 2000
Area=1350 sq m
Depth~1.5 m
~2,025,000 litres


FWM Nitrate Concentration (mg/L)
15
10
5
0
8.6
8.7
3.8
DR
CDS
Treatments

Wetland Design Standards

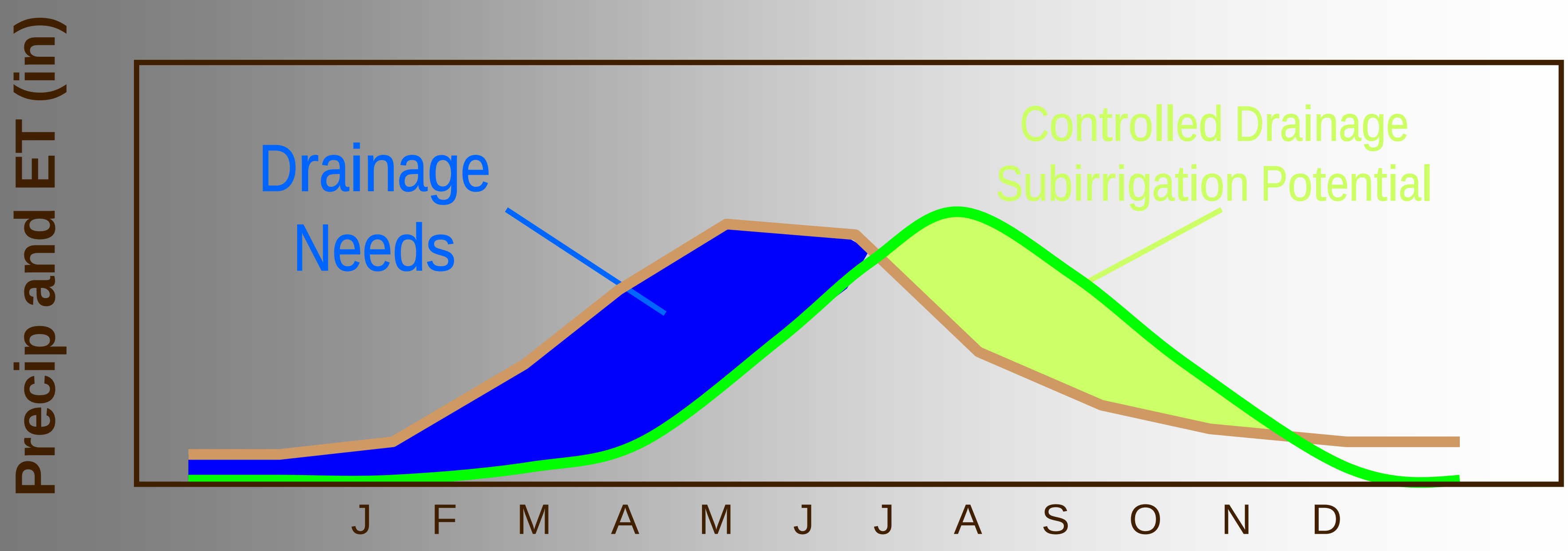
- Wetland restoration – rehabilitation of a degraded wetland or a hydric soil area that was previously a wetland (NRCS Practice Standard 657)
- Wetland enhancement – improvement, maintenance, and management of existing wetlands for a a particular function or value (NRCS Practice Standard 659)
- Wetland creation – conversion of a non-wetland area into a wetland where a wetland never existed (NRCS Practice Standard 658)
- Constructed wetland – specifically design to treat both non-point and point sources of water pollution (NRCS Practice Standard 656)

Conservation Drainage Strategies

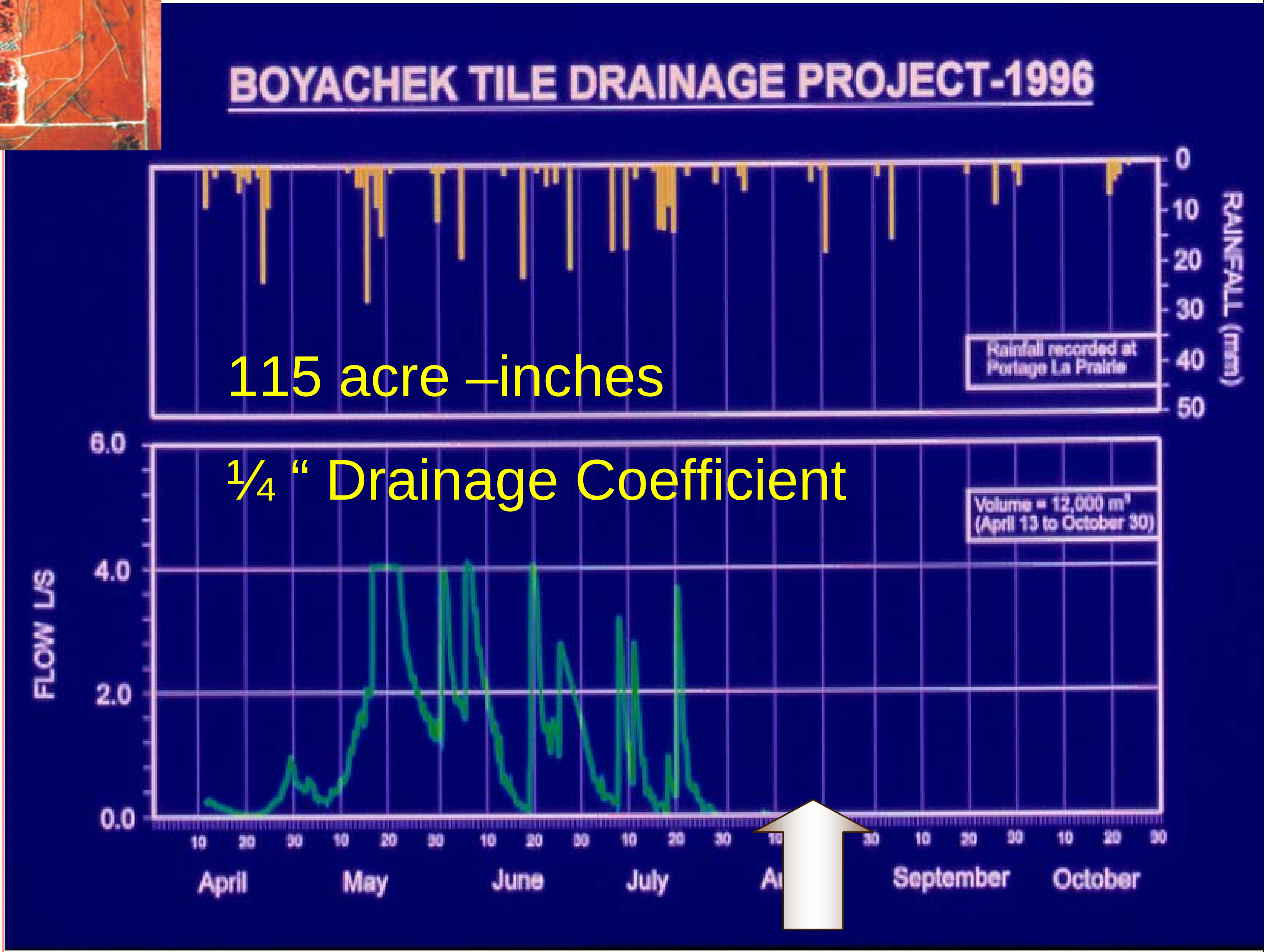


- **Recycle tile water**

Water Management Need/Potential

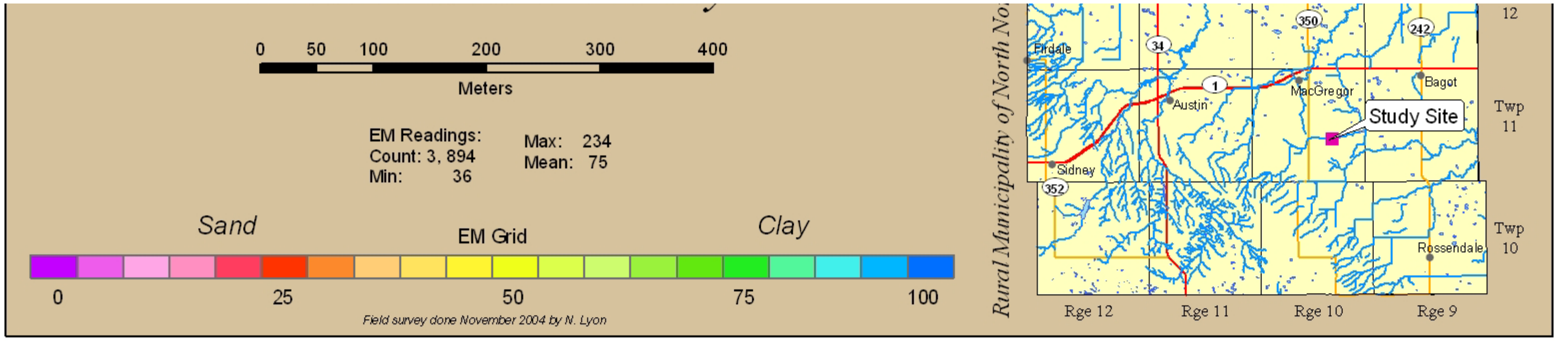


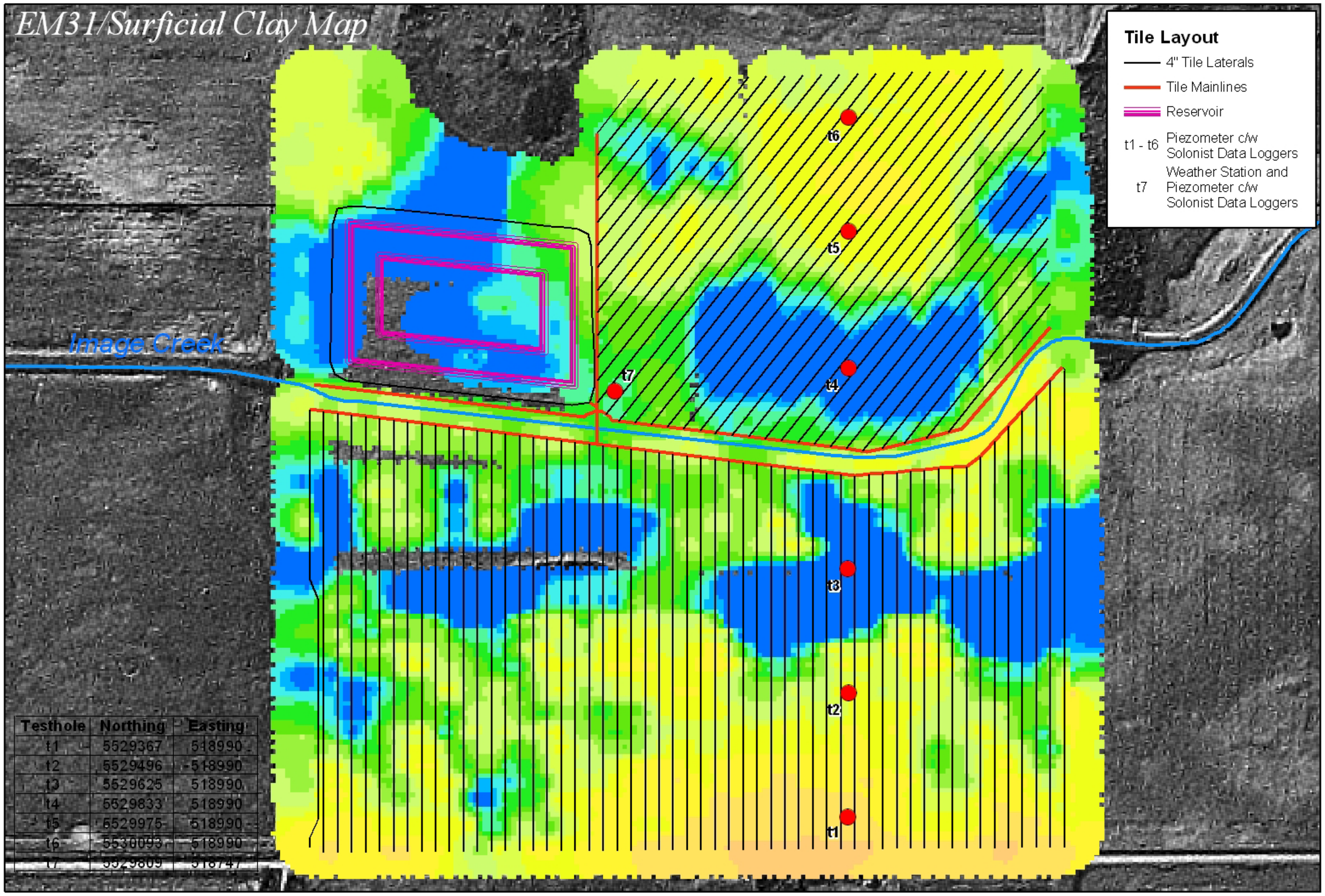
Site A - 1996



115 acre –inches

¼ " Drainage Coefficient





Testhole	Northing	Easting
t1	5529367	518990
t2	5529496	518990
t3	5529625	518990
t4	5529833	518990
t5	5529975	518990
t6	5530093	518990
t7	5529809	518747

File Reference: G:\AV_2005\Misc\Tour_June_14_05\Tour_Hulme.mxd

Map Revised: June 6, 2005

Figure 1: Typical Manitoba Tile Recycle Project (Kroeker Farms)

Hulme Tile Recycling Objectives:

1. Monitor water table, tile flow rate, precipitation, soil moisture, and ET.
2. Calibrate DRAINMOD with 3 years of field data.
3. Run DRAINMOD to simulate multi-year operation of tiles to recycle water.
4. Compute frequency versus volume of tile effluent for use in supplying irrigation system.
5. Monitor tile water quality, especially nutrient loads.
6. Determine impacts on reservoir, soils and environment of recycled tile water quality.

Figure 2: Typical Tile Drainage Installation by Plow (McCutcheon Farm Drainage)

Figure 3: Hulme Tile Outlet Manhole

Figure 4: Hulme Outlet Piping - Reservoir or Creek

Figure 5: Weather Station - Watchdog

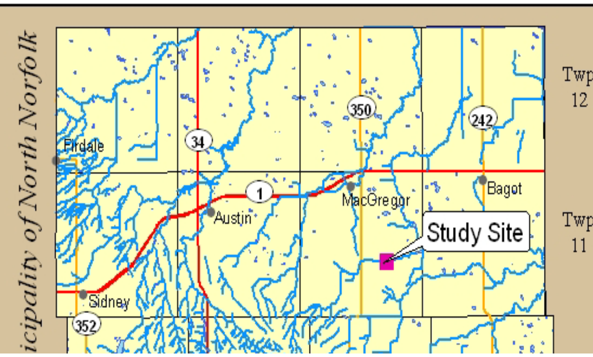
Hulme: EM31 Survey

0 50 100 200 300 400

Meters

EM Readings:
Count: 3, 894
Min: 36

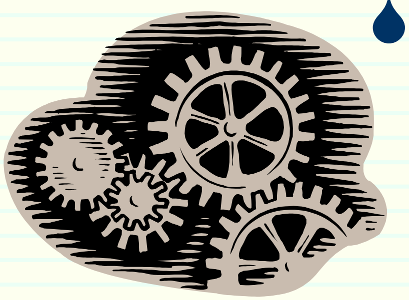
Max: 234
Mean: 75



Conservation Drainage Strategies

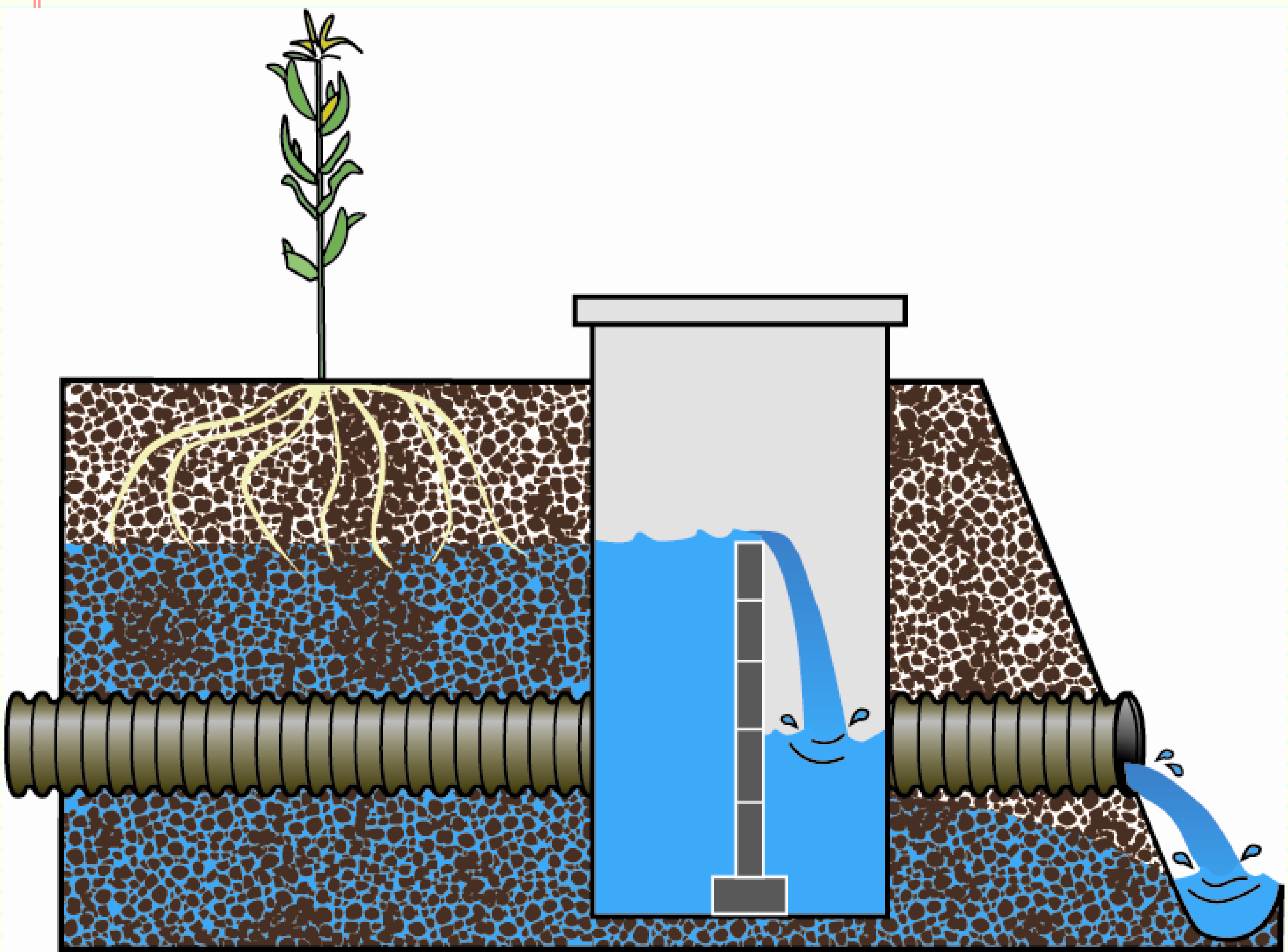
- Agronomic approaches
  - Nutrient, crop, tillage management
  - Cover crops, scavenger crops

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



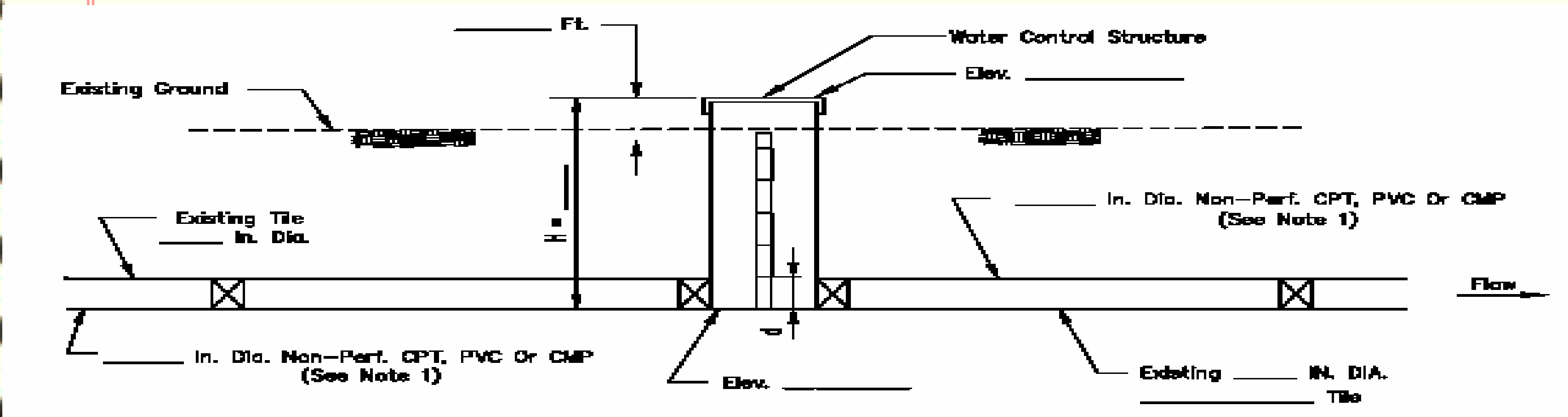
- Engineering approaches
  - **Drainage design & management**
  - Ditch modification/management
  - Bio-reactors
  - Recycle tile water

Managed Drainage ("Controlled" Drainage)

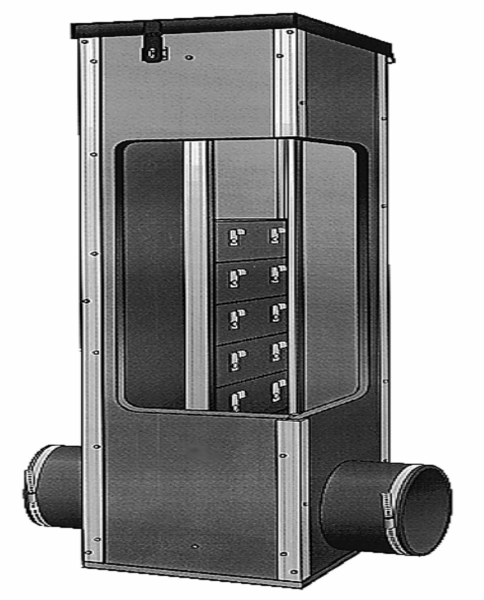


NRCS Practice 554

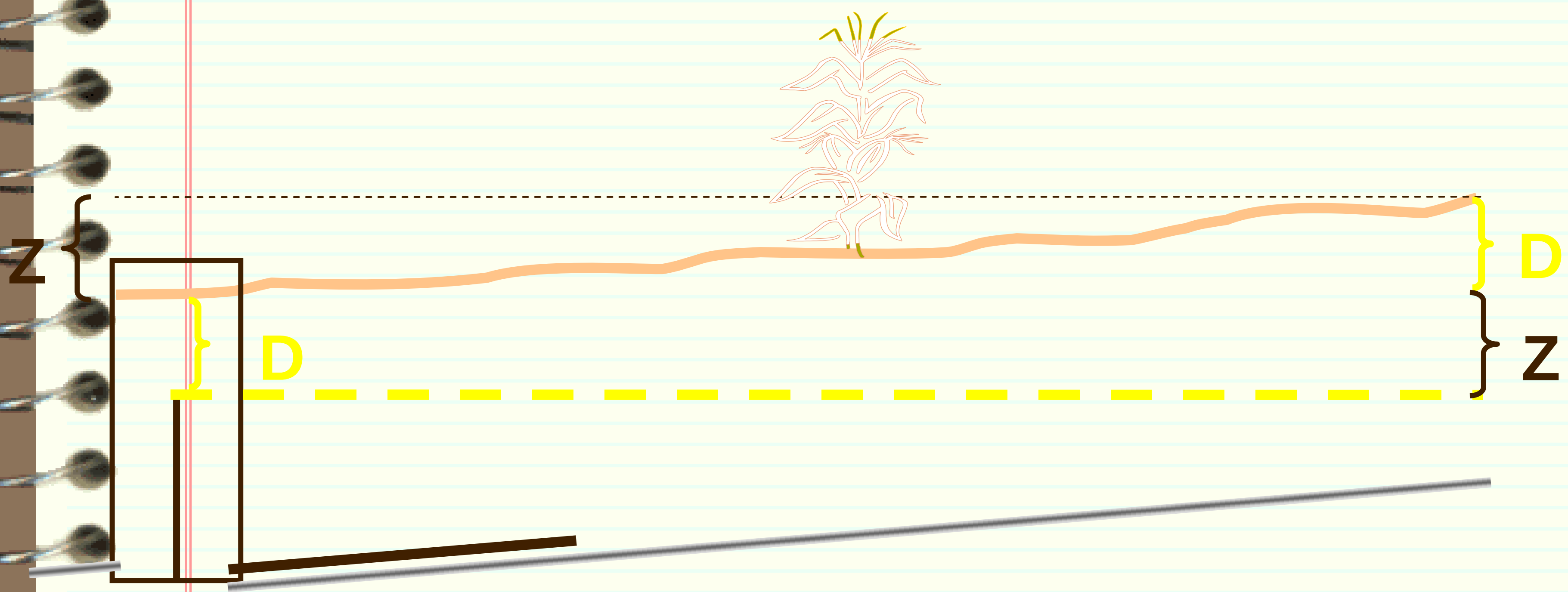
Drainage Water Management



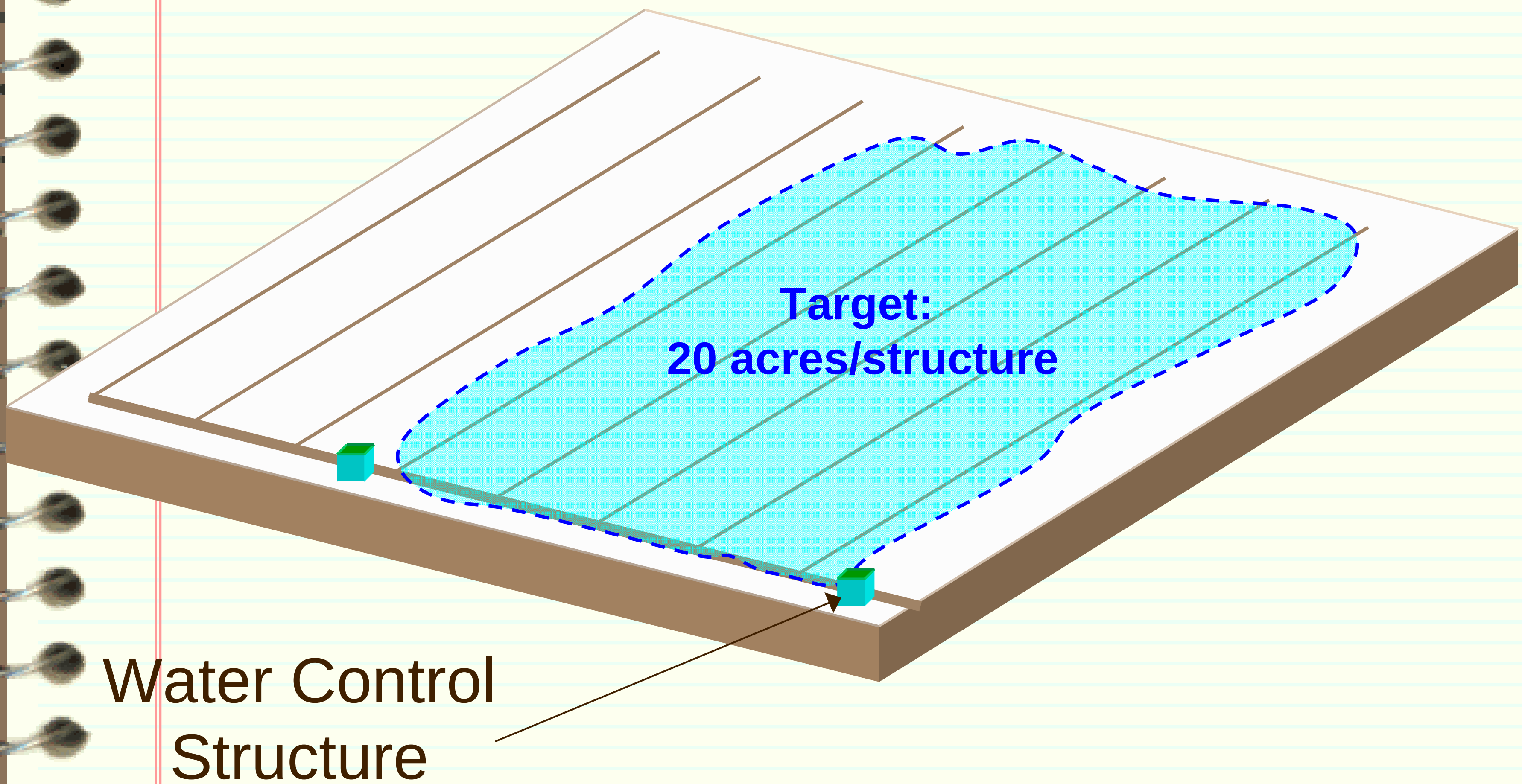
- 20 acres or more per control structure
- 2-ft contour "zone" maximum
- 20-ft of non-perf at structure



Why Limit Topography?



How to Do it: Control "Zones"



Water Control Structures

Image courtesy of Agri Drain Corp.

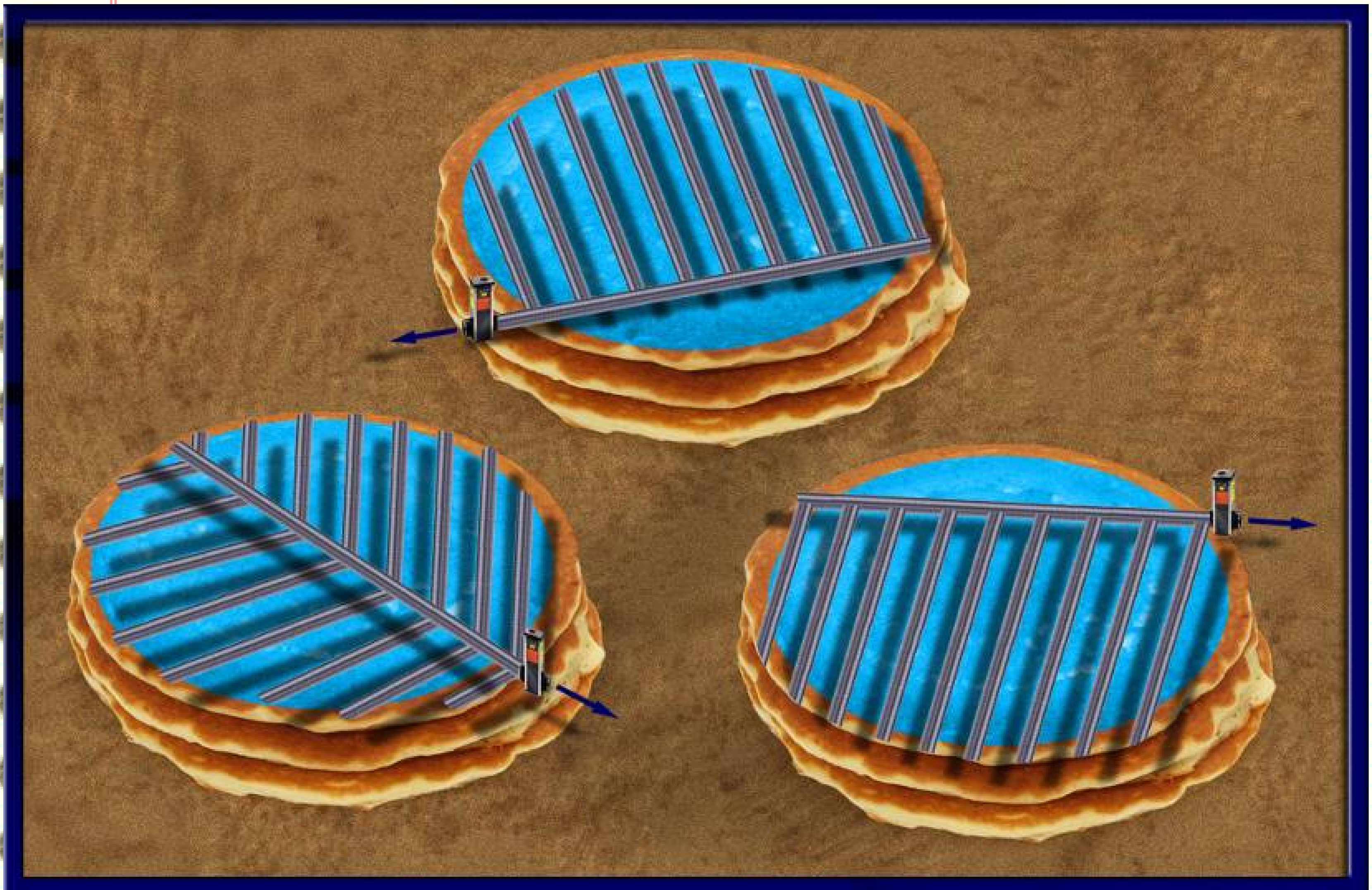


Image courtesy of Agri Drain Corp.

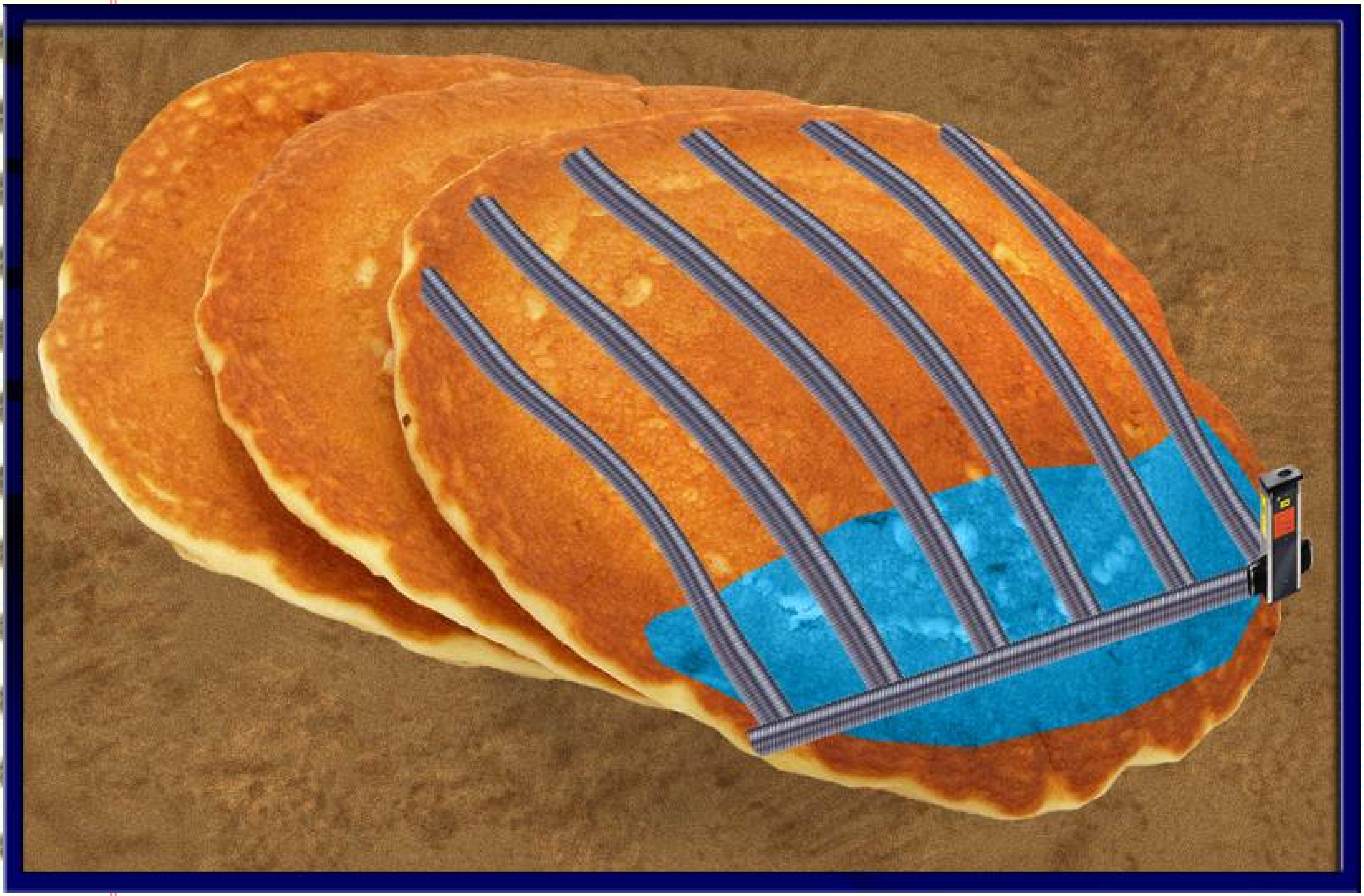


Image courtesy of Agri Drain Corp.

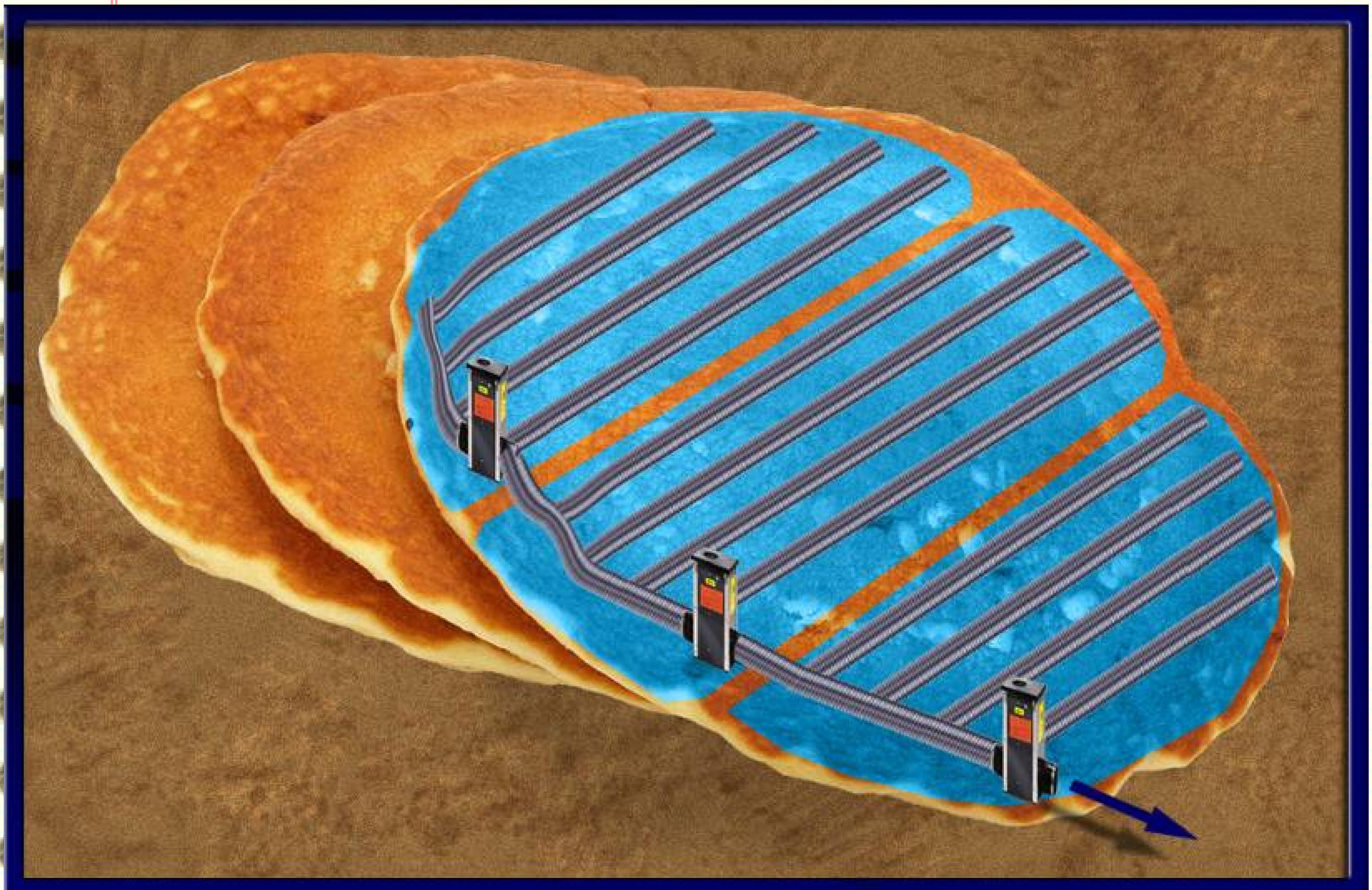


Image courtesy of Agri Drain Corp.

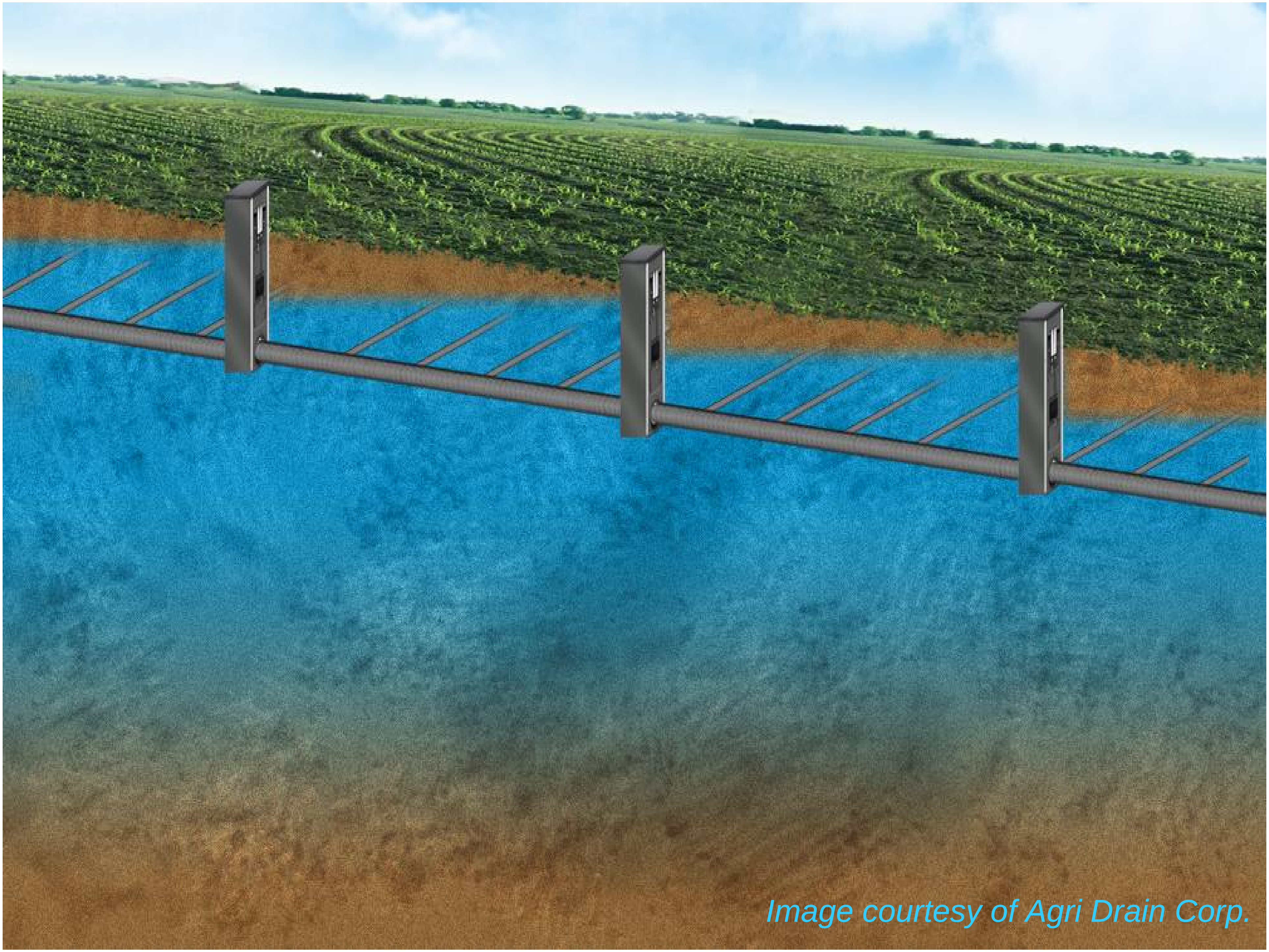
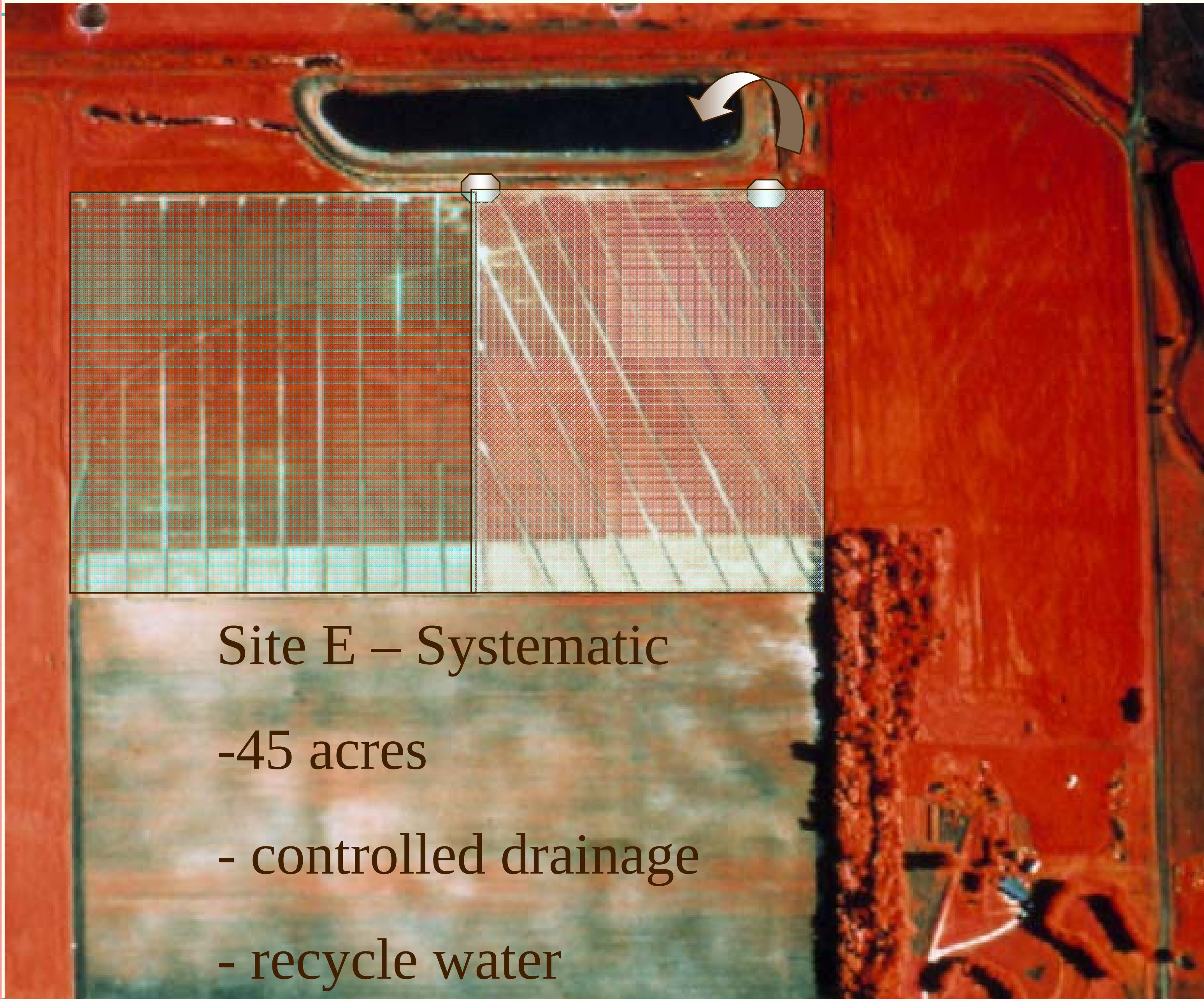


Image courtesy of Agri Drain Corp.

Tile Layout - Controlled Drainage



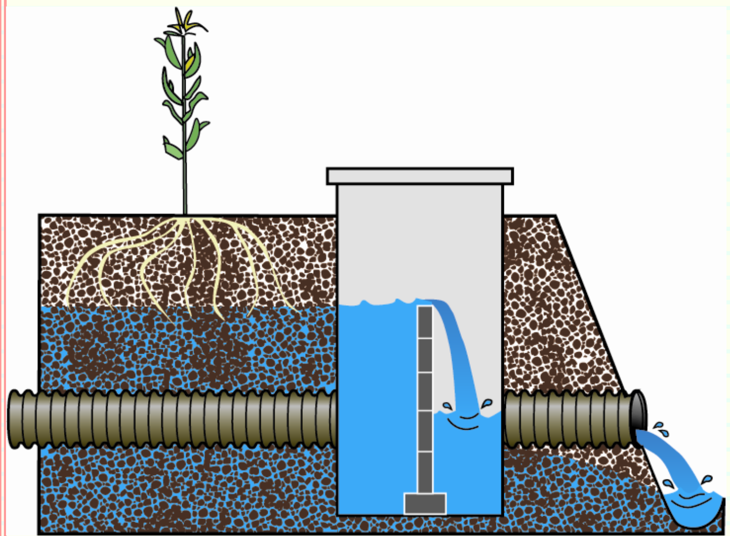
Site E – Systematic

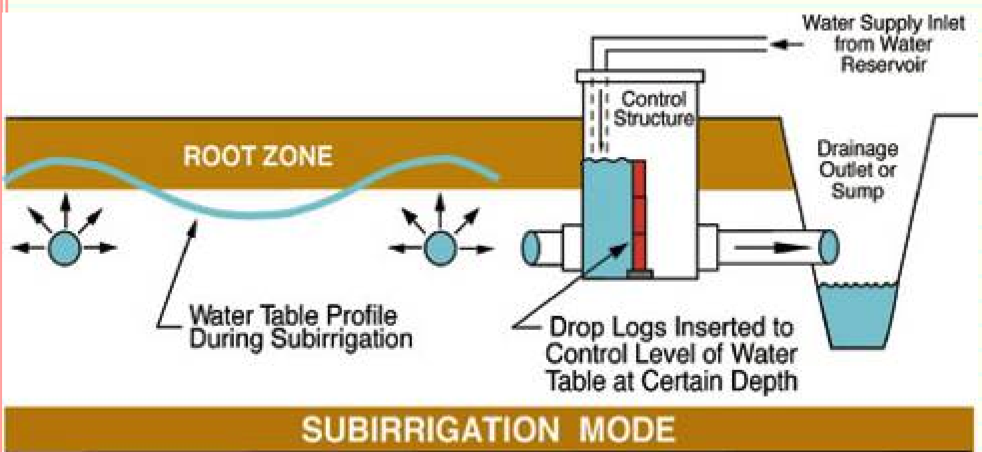
-45 acres

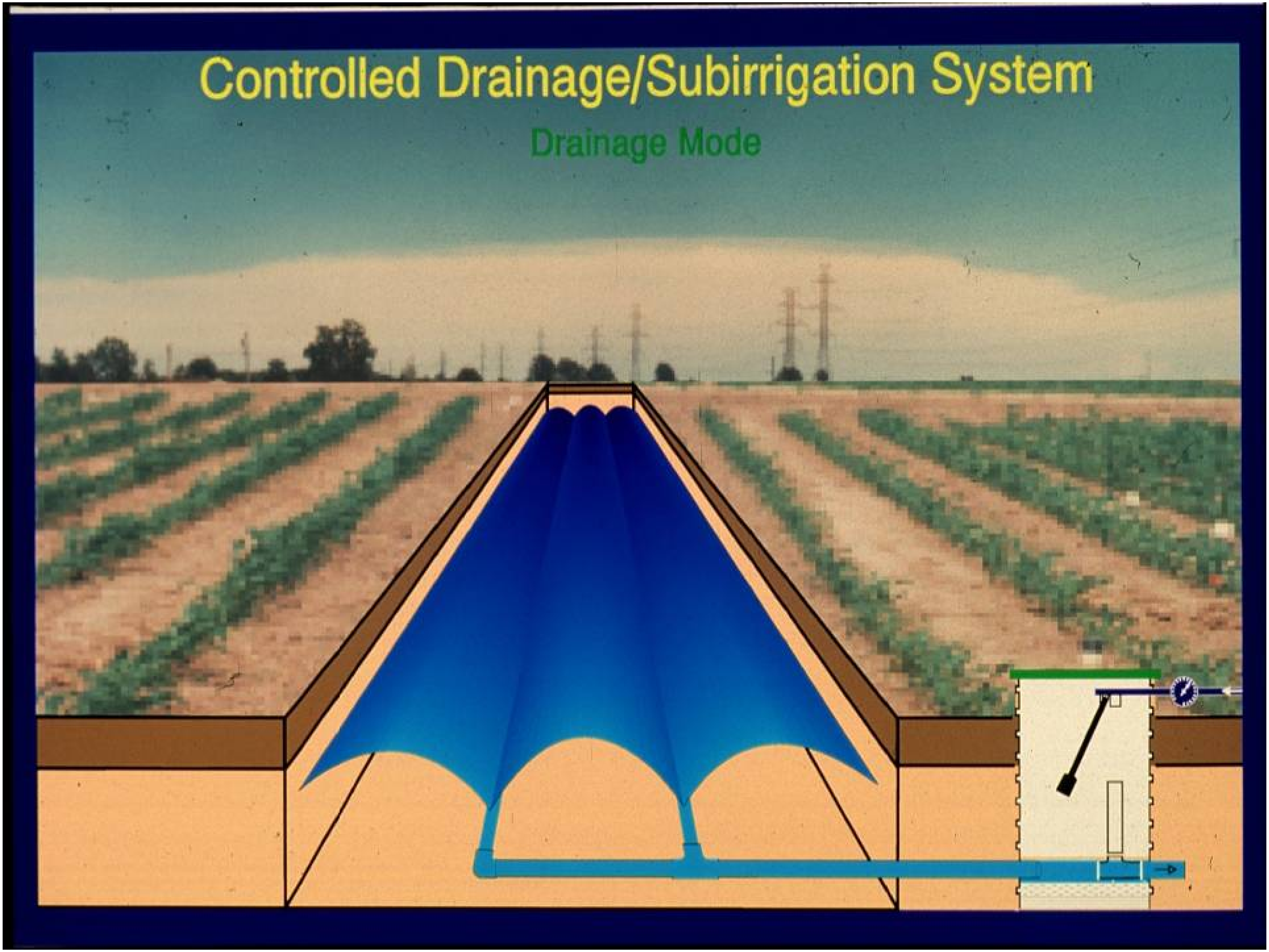
- controlled drainage

- recycle water

4. Subirrigation

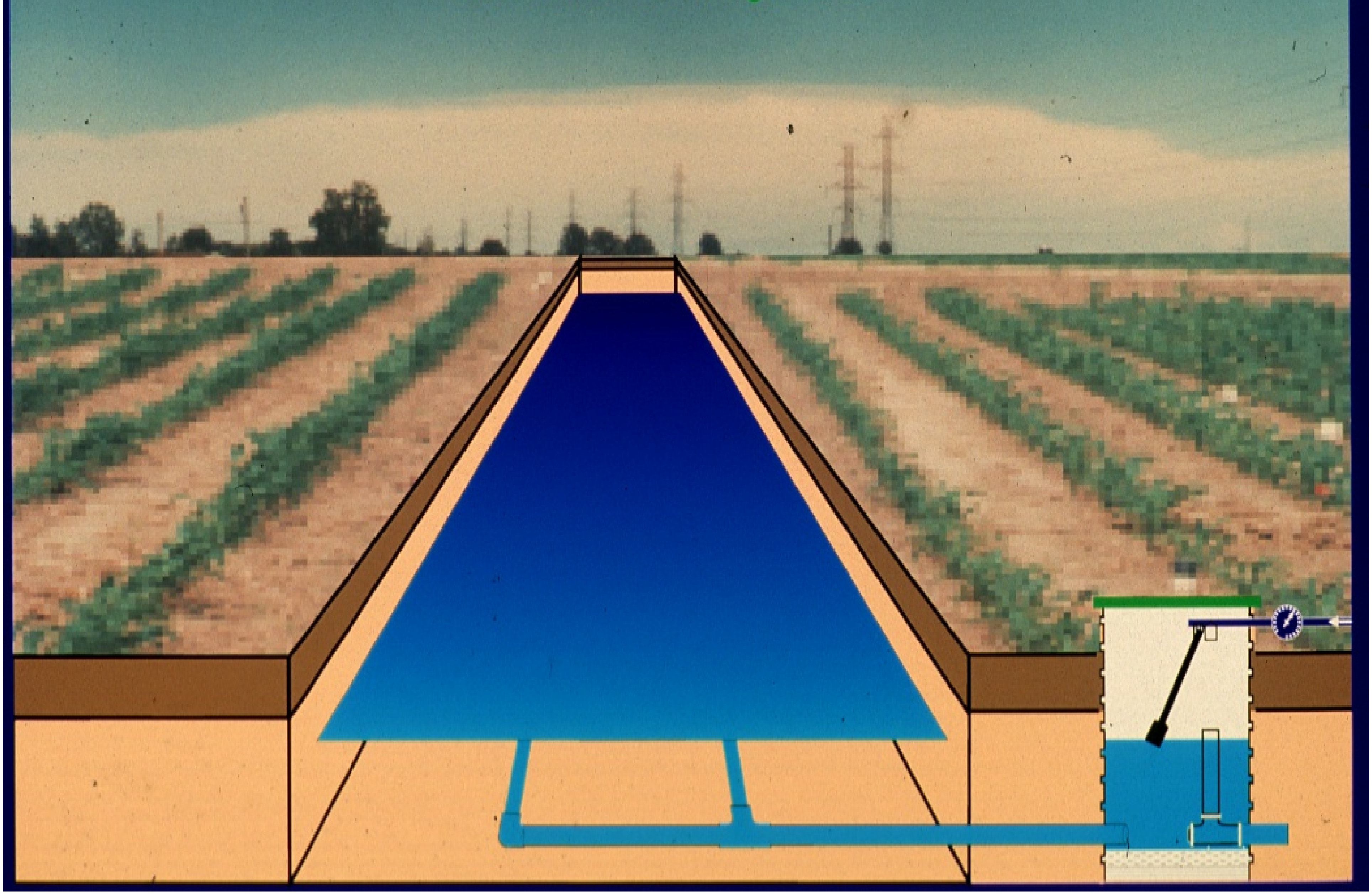


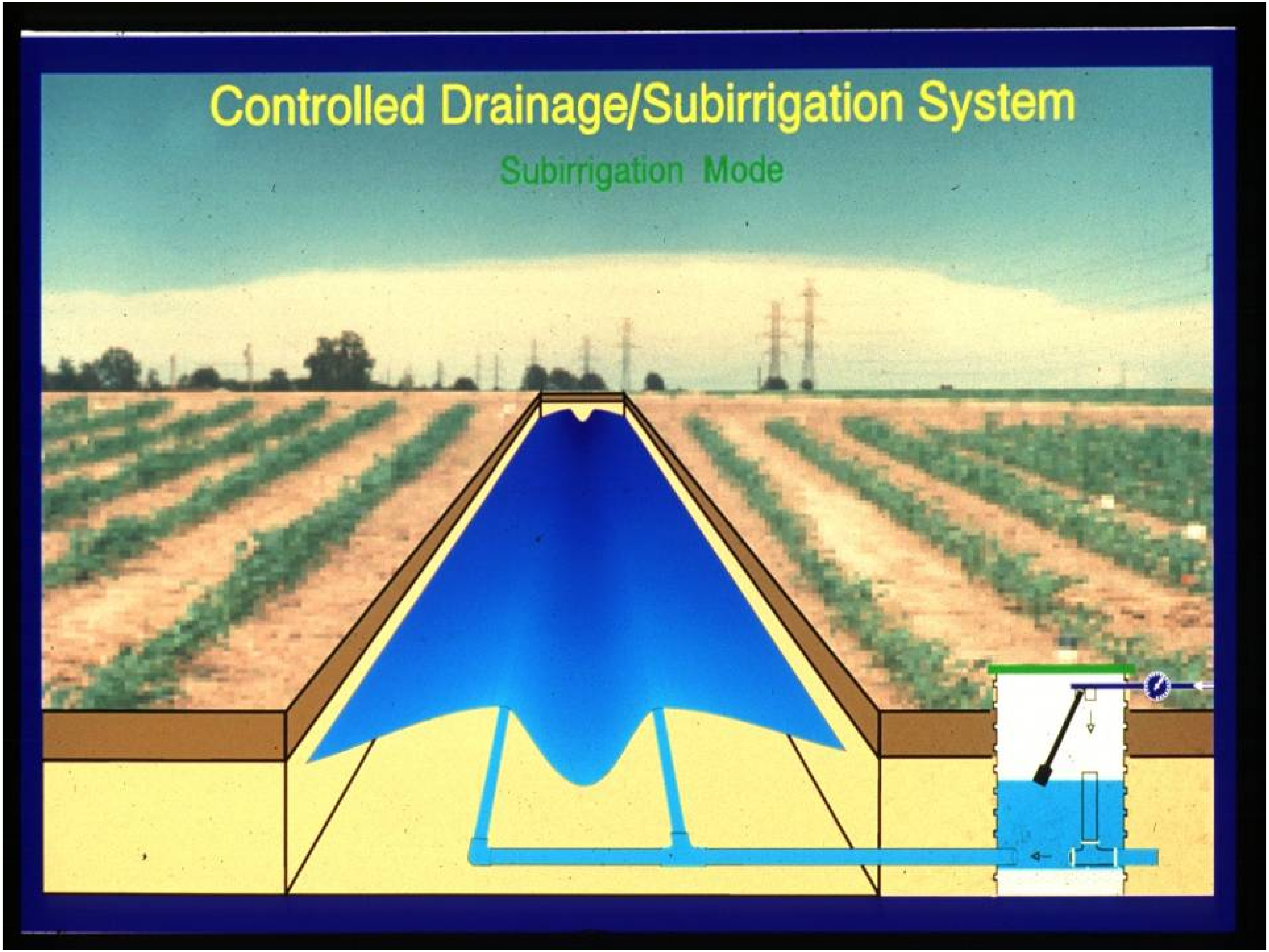



Controlled Drainage/Subirrigation System
Drainage Mode

Controlled Drainage/Subirrigation System

Controlled Drainage Mode



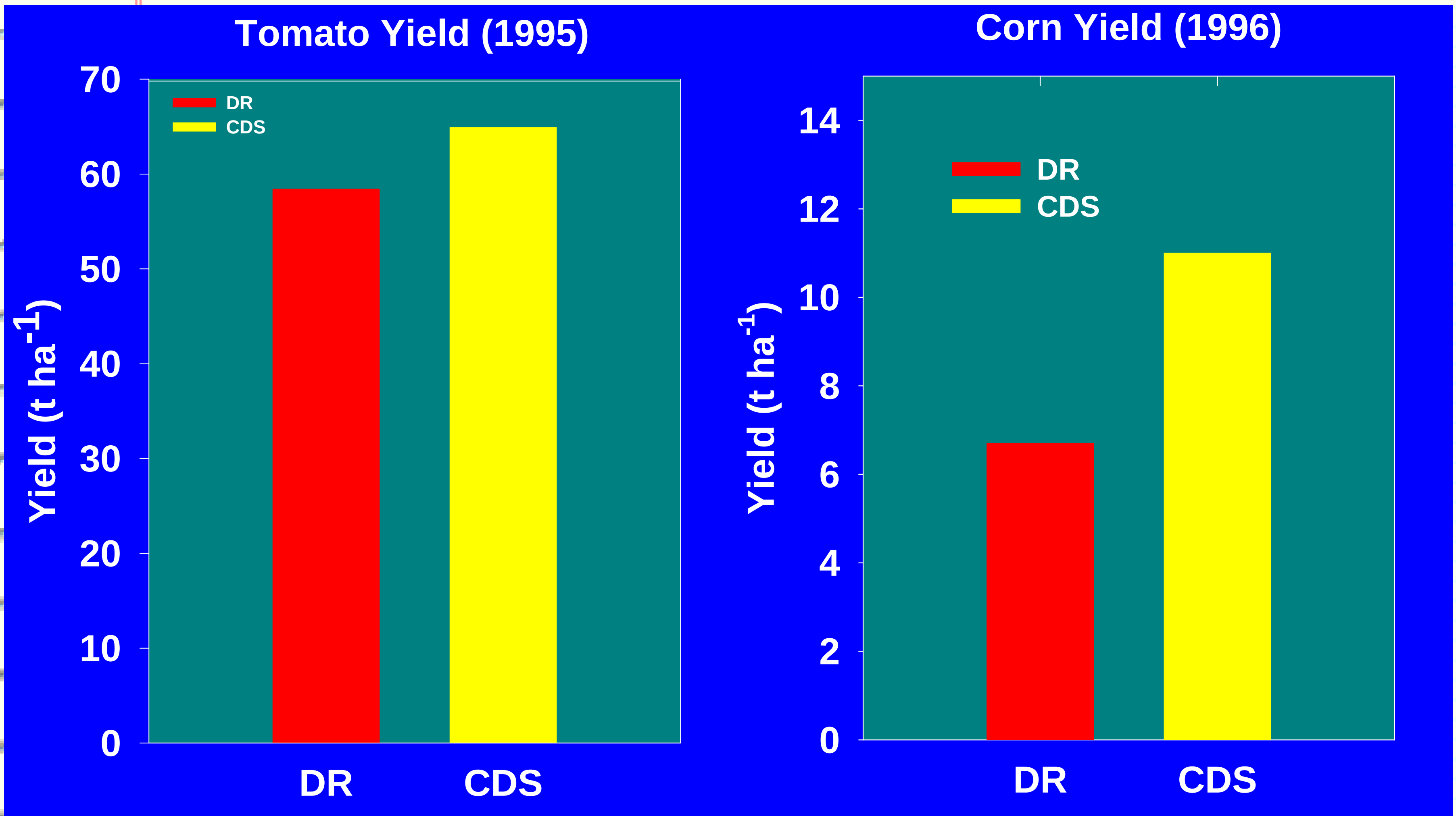


Controlled Drainage/Subirrigation System
Subirrigation Mode

Farm-Scale Field Site (SW Ontario)

- 4-ha area on Berrien Sandy loam soil
- Two plots each 67 m wide by 284 m long, each plot contained 10 subsurface drains with spacing 6 m between drains at an average depth of 0.6 m
- Two water table management treatments controlled drainage with sub-irrigation (CDS); Free outlet tile drainage (DR)

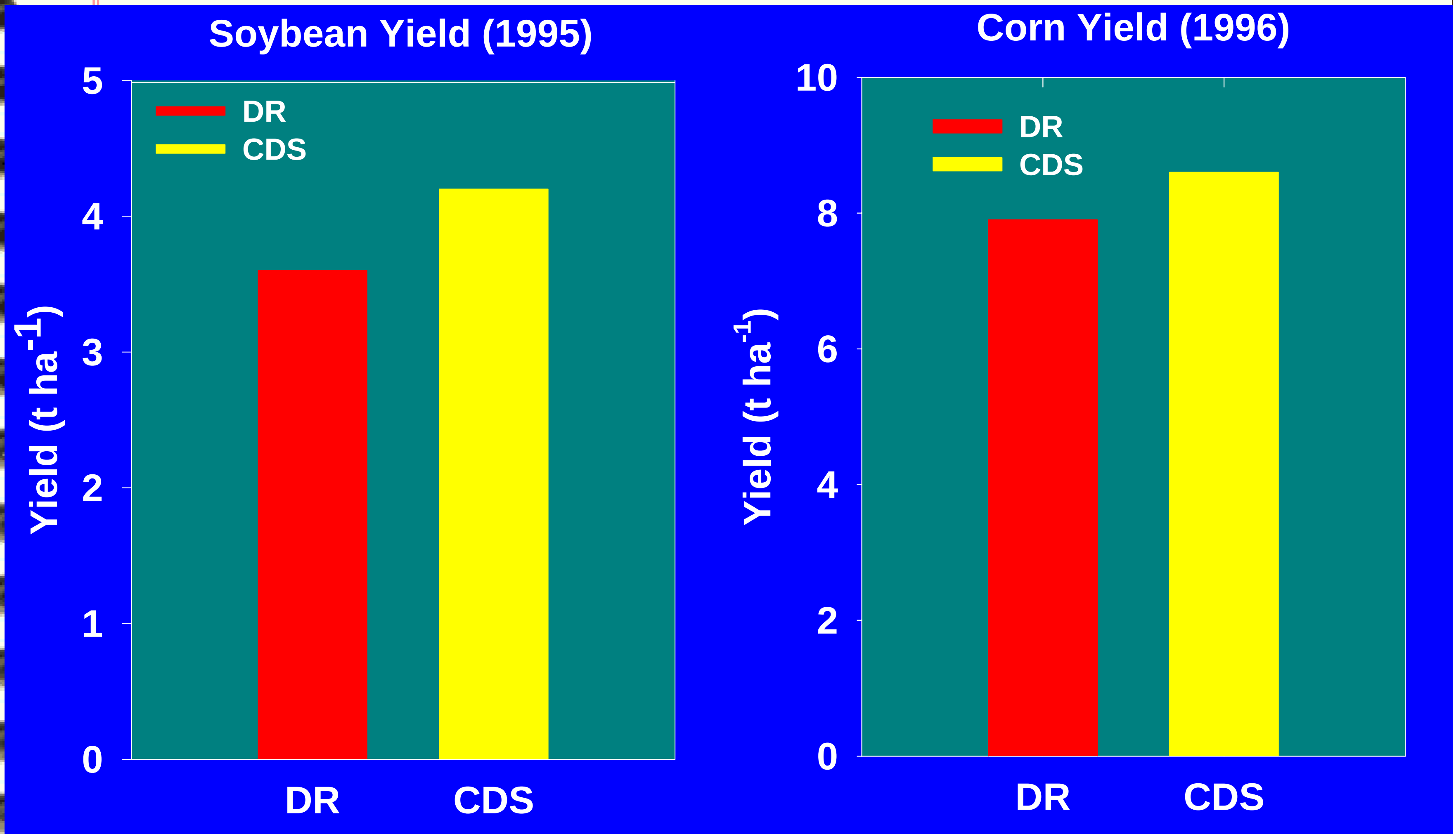
Yields (Farm-Scale Field)



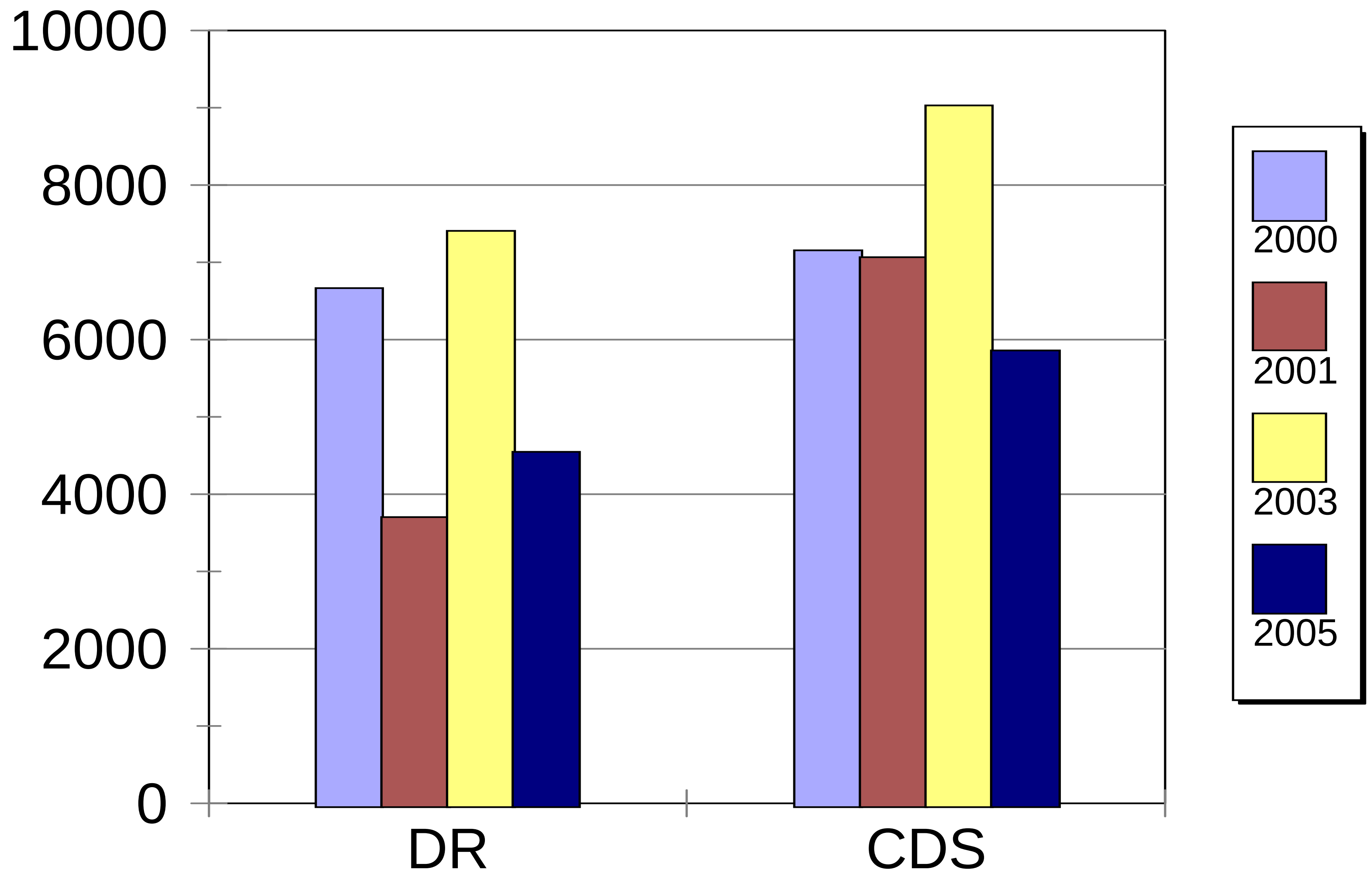
Plot-Scale Field Site (SW Ontario)

- 0.4-ha area on Brookston clay loam soil
- Four plots each 15 m wide by 67 m long, each plot contained 2 subsurface drains with spacing 8 m between drains at an average depth of 0.6 m
- Two water table management treatments controlled drainage with sub-irrigation (CDS); Free outlet tile drainage (DR)

Yields (Plot-Scale Field)

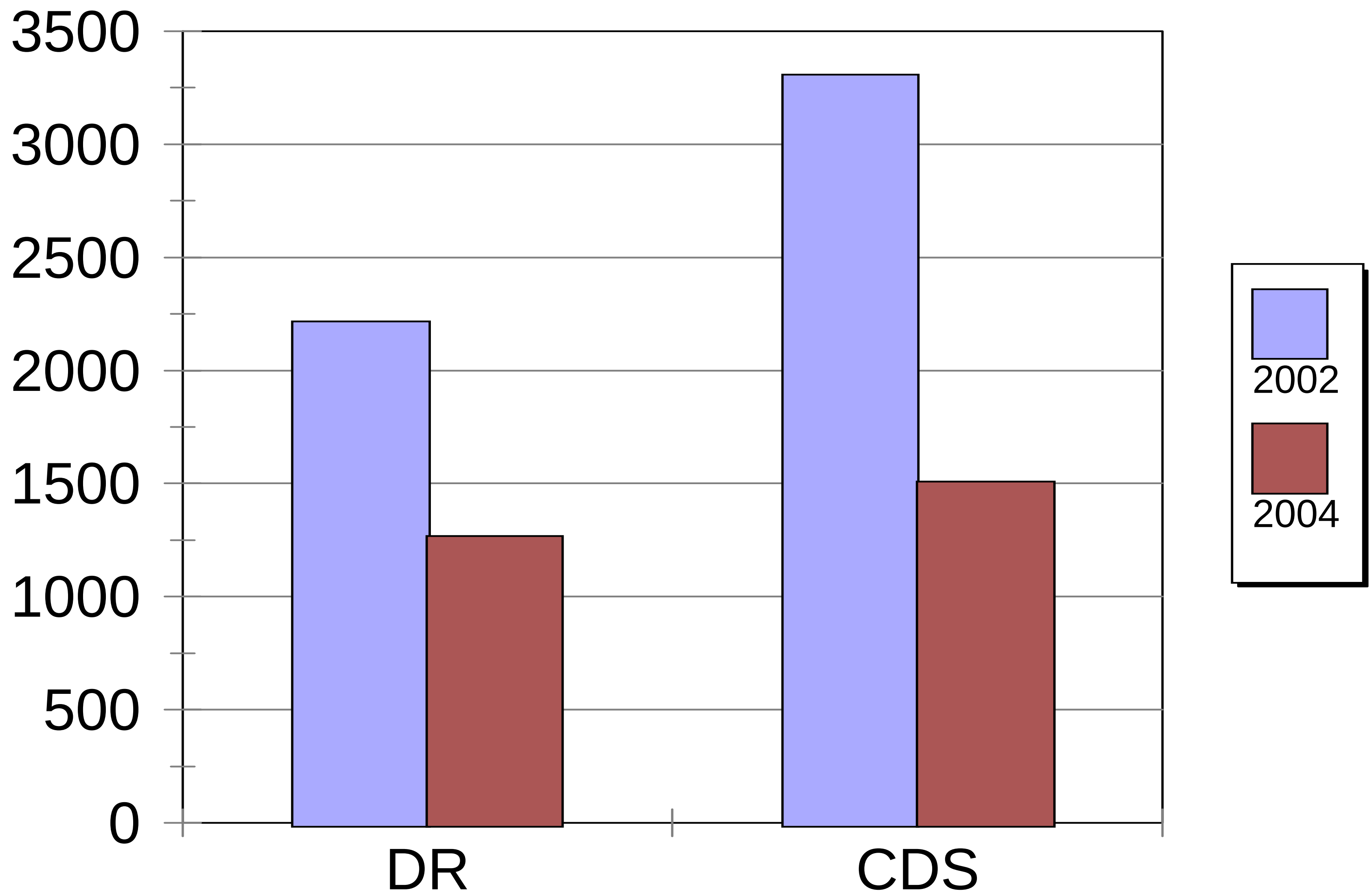


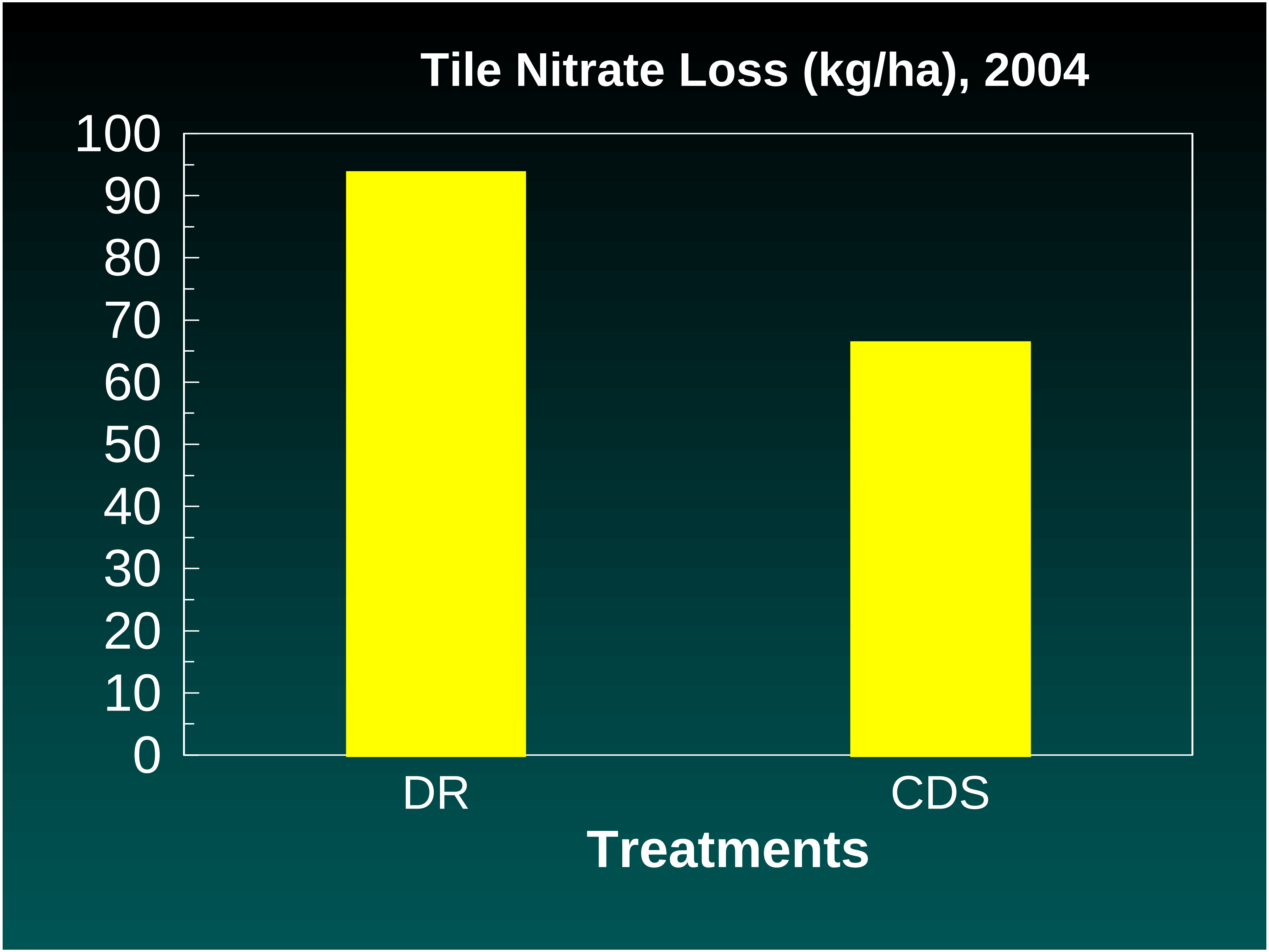
Corn Yields (kg/ha)



Controlled Drainage/Irrigation/Wetland Demonstration Project

Soybean Yields (kg/ha)




Tile Nitrate Loss (kg/ha), 2004
100
90
80
70
60
50
40
30
20
10
0
DR
CDS
Treatments

Conclusions (Farm-Scale)

- CDS system reduced FWM nitrate concentration by 37 % relative to DR system
- CDS system reduced total nitrate loss by 38 % relative to DR system
- CDS system increased tomato yields by 11-25 %, increased corn yield by 64 % relative to DR system

Conclusions (Plot-Scale)

- CDS system reduced drainage volume by 50 % relative to DR system
- CDS system reduced FWM nitrate concentration by 32 %, reduced total nitrate loss by 38 % relative to DR system
- CDS system increased soybean yields by 17 %, increased corn yield by 9 % relative to DR system

Planning Considerations

- Field Topography:
  - 0-1% grades
  - 0-0.5% better!
  - More grade, higher cost
- Controlled Drainage
  - Goals: production? WQ?
- Subirrigation: Water Source
  - Dependability
  - Legality
  - Distance/cost
  - Power source for pumping
- Lateral spacing may be closer ($$)
- What type of control structure & devices to use?

Design Steps

- Determine spacing using both drainage and subirrigation
  - Drainage – water drained at a rate so as to move water table to desired depth in reasonable time
  - Subirrigation – irrigation water provided fast enough to replace water used by plants and lost through ET
- Drainage Coefficient
  - 0.25-0.5 in/day (sometimes higher)
- Subirrigation Coefficient
  - Max ET + 10% (fine soils)
  - Max ET + 12-20% (coarser soils)
- Select closest spacing for design, but NO CLOSER

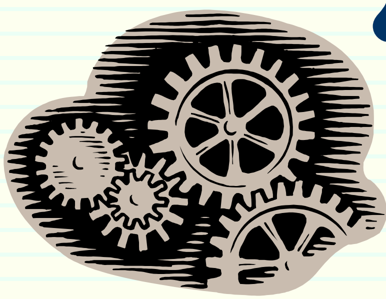
Comments from a Producer

I am far too scared of major rainfall events to consider sub irrigation, at least on that soil. Maybe on the Alamassippi sands it would be better where you have faster reaction times. Considering how little we need to irrigate in Manitoba, I am much less concerned about irrigation efficiency as I am about drainage efficiency.

Conservation Drainage Strategies

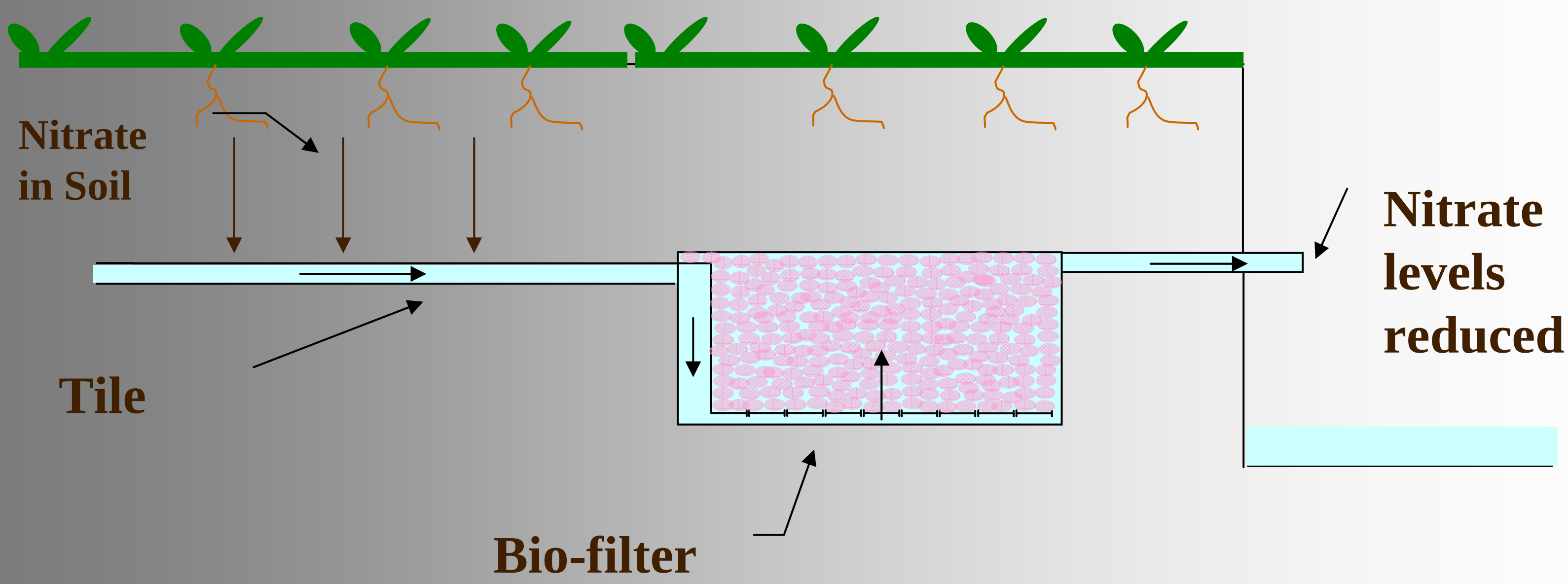
- Agronomic approaches
  - Nutrient, crop, tillage management
  - Cover crops, scavenger crops

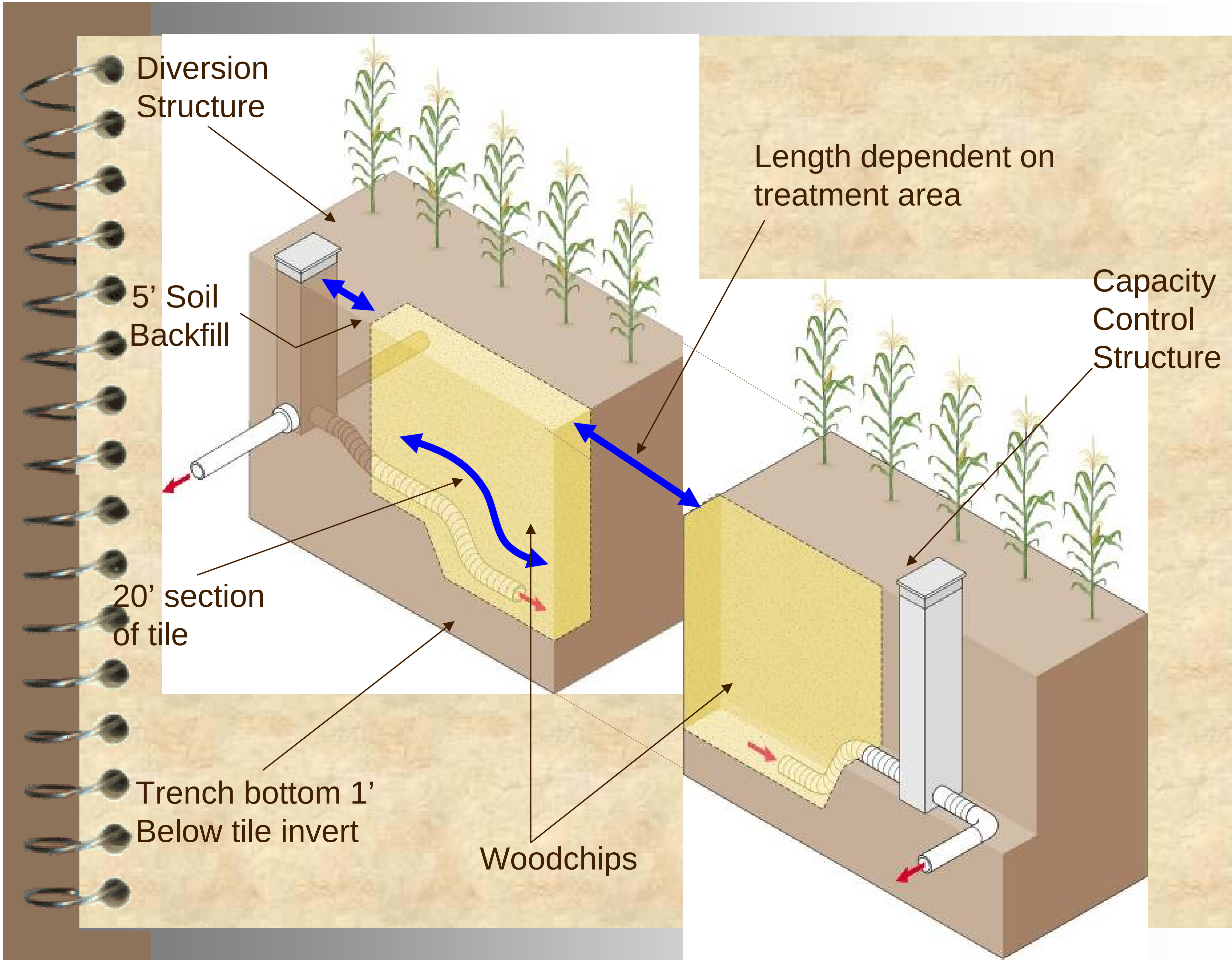
- Ecological approaches
  - Wetlands as kidneys
  - Ditch modification/management



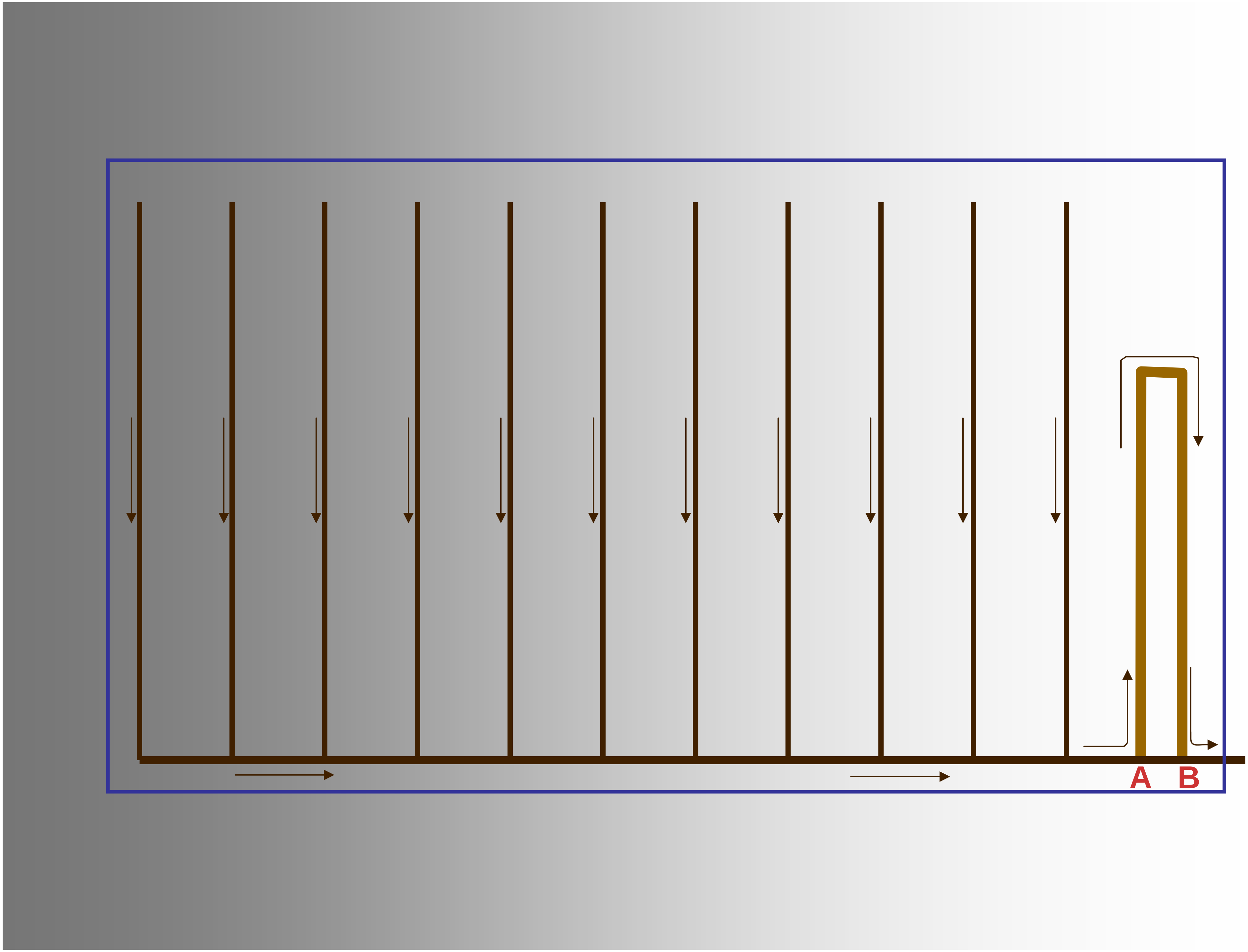
- Engineering approaches
  - Drainage design & management
  - Ditch modification/management
  - **Bio-reactors**
  - Recycle tile water

Subsurface Bio-filters

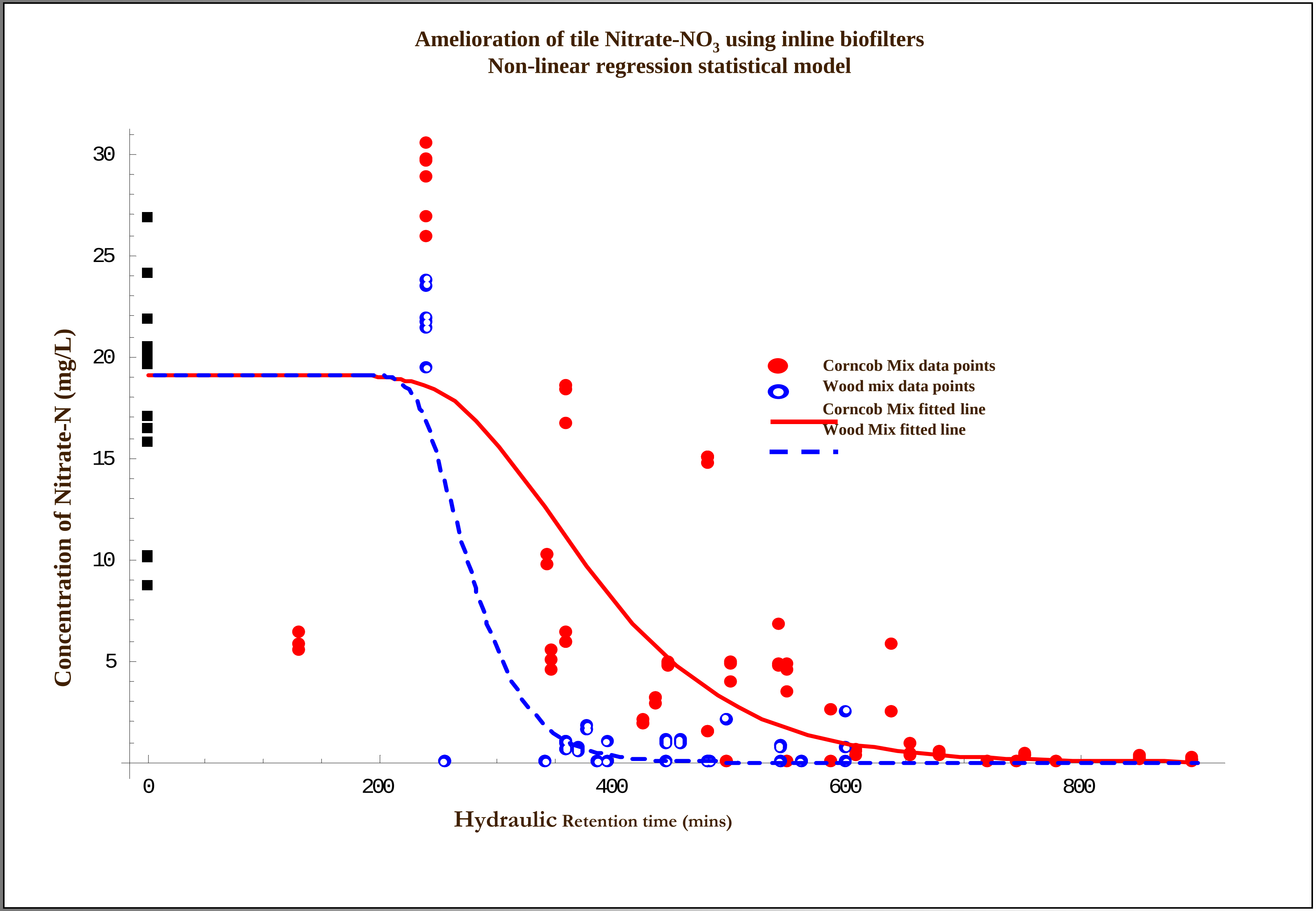




Diversion Structure
5' Soil Backfill
20' section of tile
Trench bottom 1' Below tile invert
Woodchips
Length dependent on treatment area
Capacity Control Structure


A
B


Diversion Structure
Wood Chips



Amelioration of tile Nitrate-NO_3 using inline biofilters
Non-linear regression statistical model
Concentration of Nitrate-N (mg/L)
30
25
20
15
10
5
0
200
400
600
800
Hydraulic Retention time (mins)
Corncob Mix data points
Wood mix data points
Corncob Mix fitted line
Wood Mix fitted line

Benefits

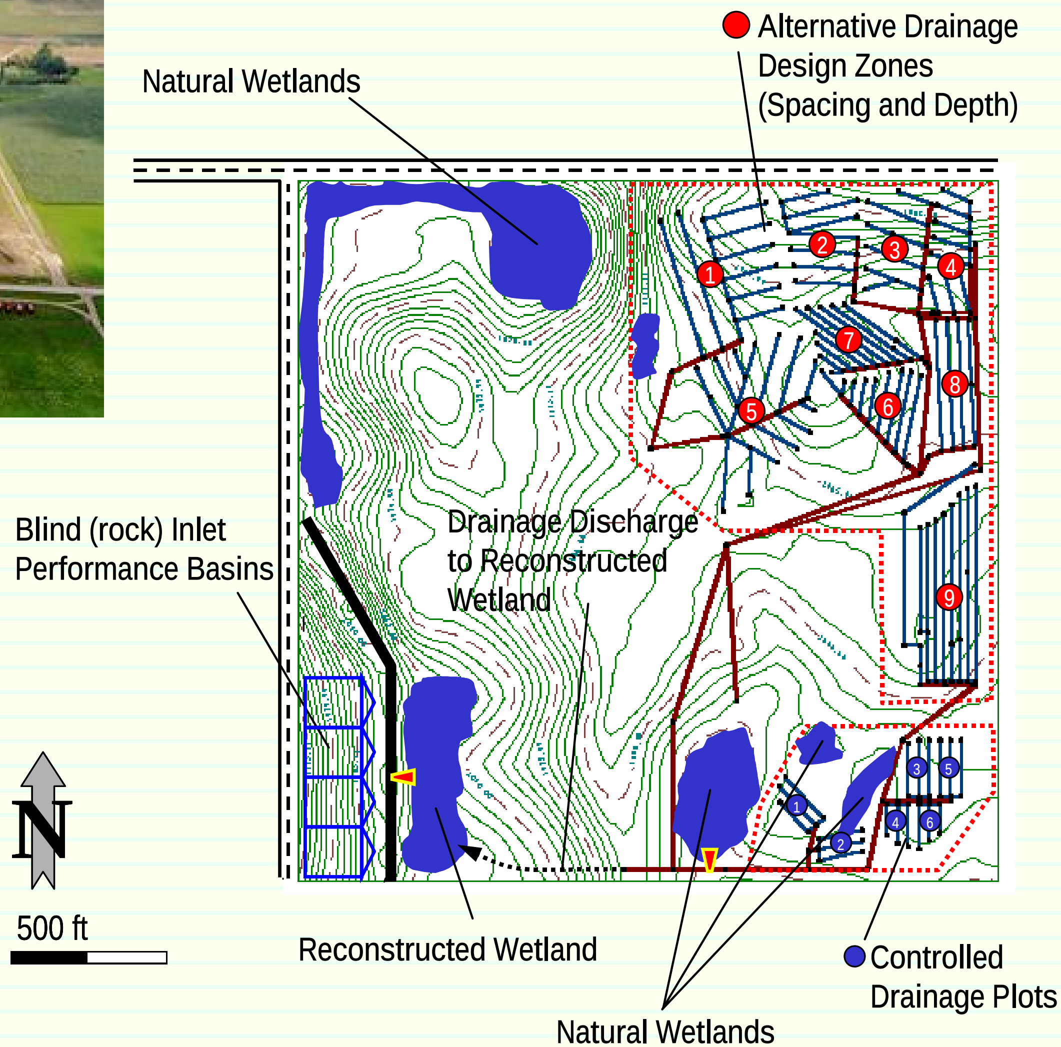
- Proven technology
- Requires no modification of current practices
- No land taken out of production
- No decrease in drainage effectiveness
- Very low maintenance
- Estimated life - 20 to 30 years
- ? 2 " of head required for inline installation

Summary

- Tile drainage IS a conservation measure!
- However nitrates leach
- Agronomy can help
- Other solutions are possible especially in flat areas with water deficits !
- Planning in advance easier than retrofit
- Look to the future of tile drainage in Manitoba – imagine 300,000 acres of tiled wet sands, then we can imagine the need for advance options

Drainage Research Facility

Southern Research & Outreach Center (Waseca, MN)



Water Table management

C. S. Tan, T. Q. Zhang, C. F. Drury, W. D. Reynolds

GPCRC, Agriculture & Agri-Food Canada, Harrow, Ontario, Canada

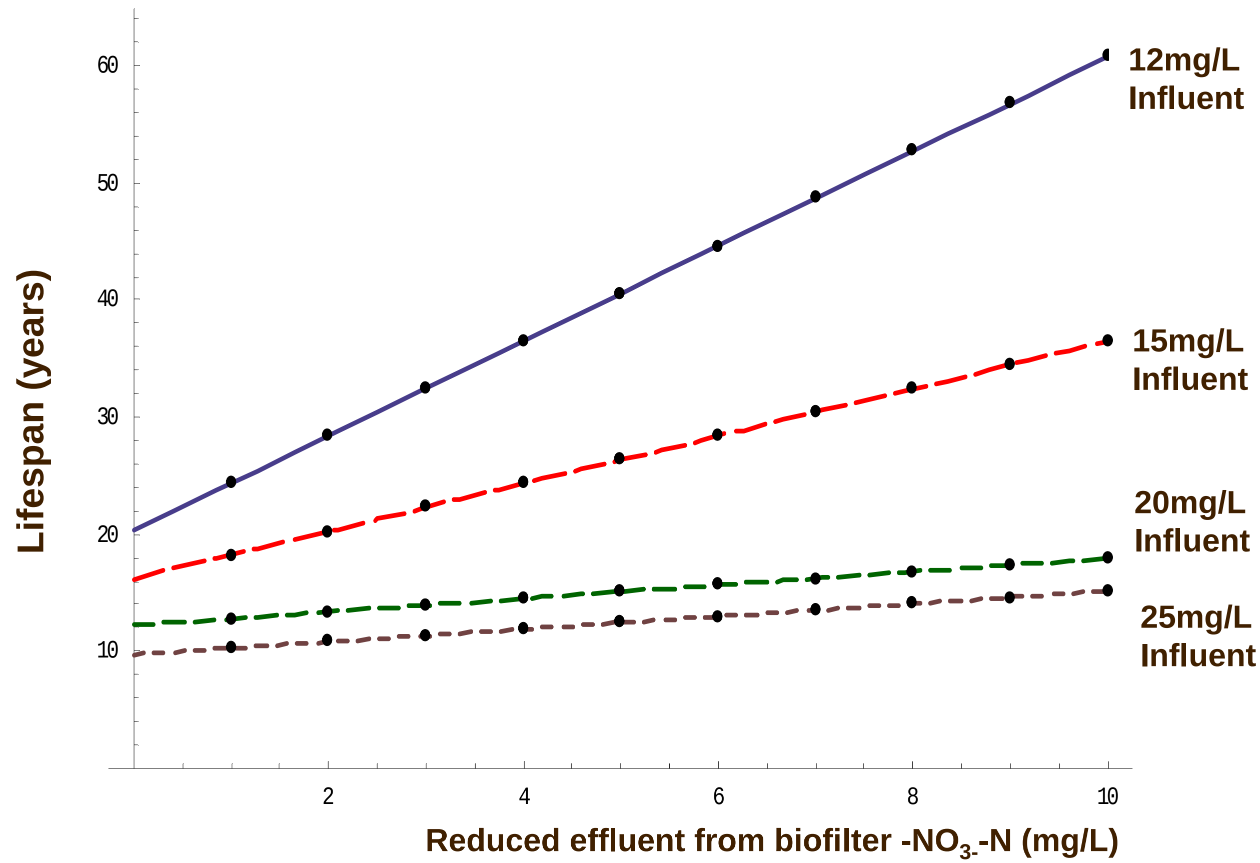
Presented at the 48th Convention

Land Improvement

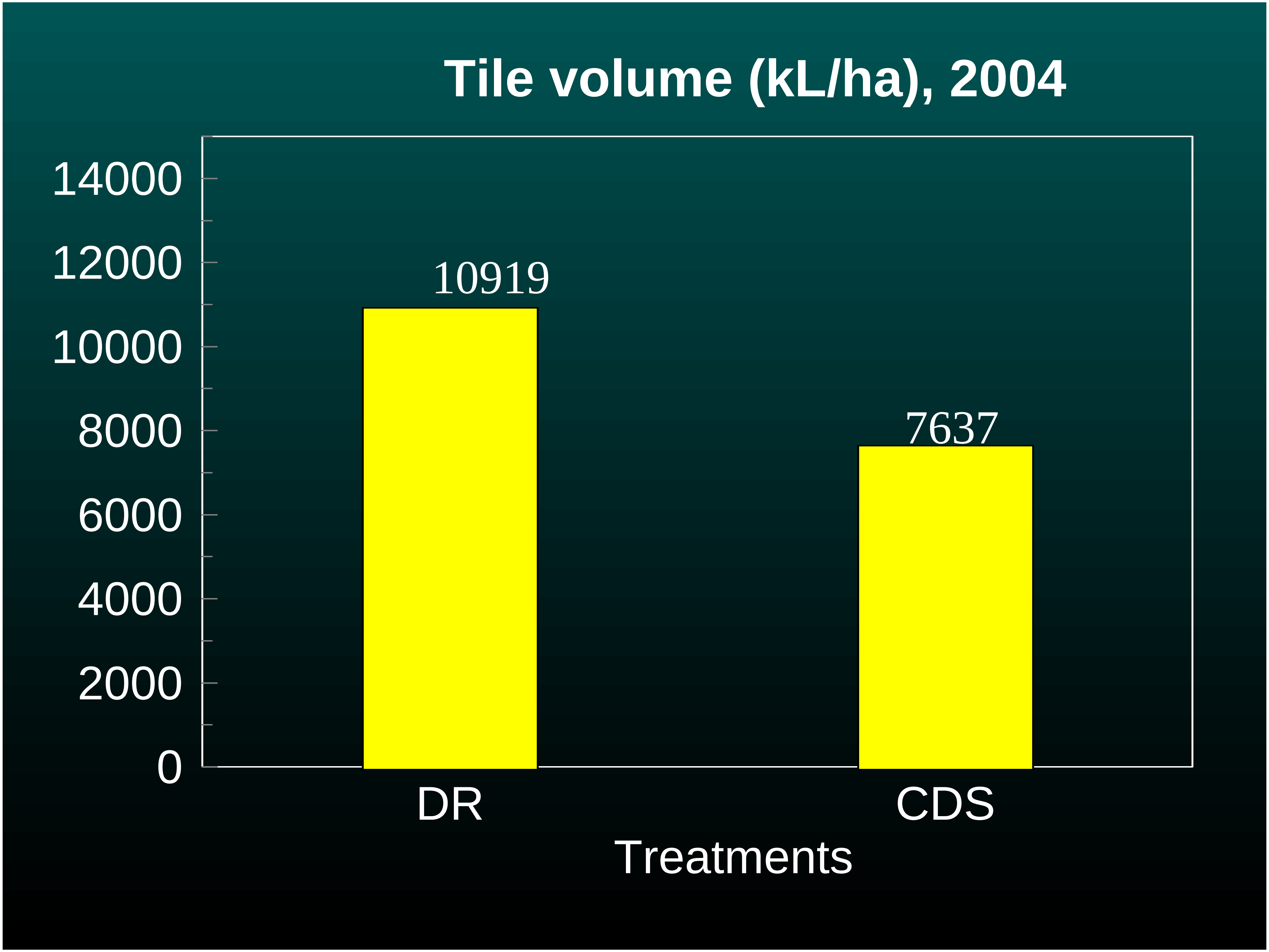
Contractors of Ontario

Joined by the Drainage Superintendents Association of Ontario

Thank You, GARY

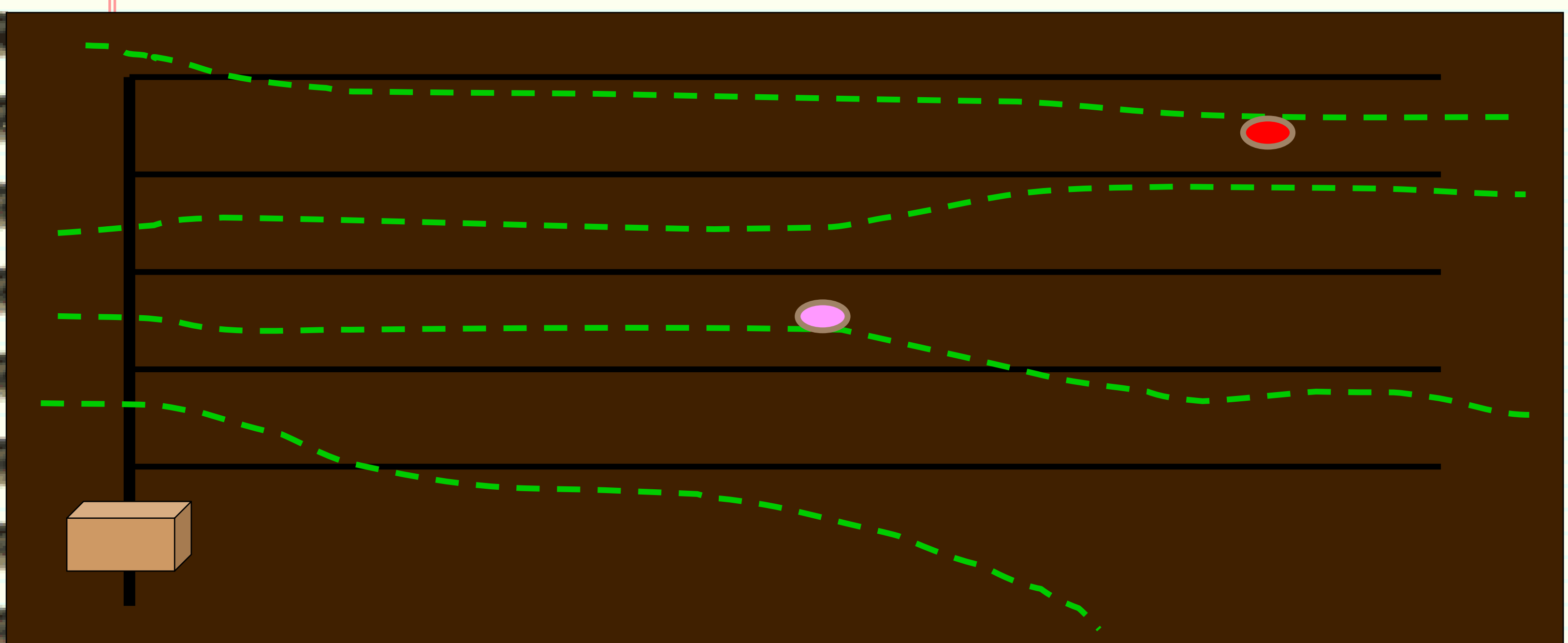


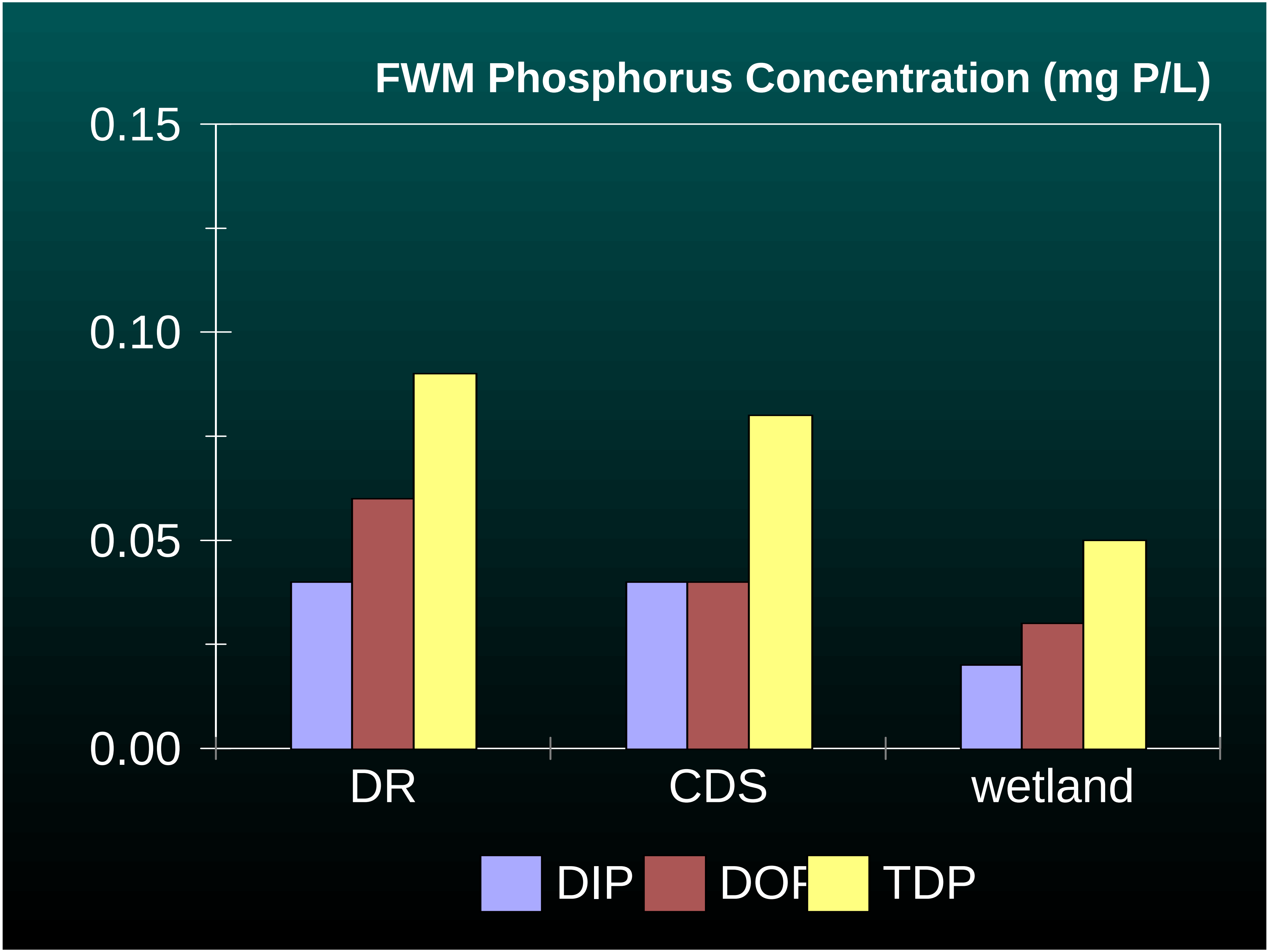
Lifespan (years)
60
50
40
30
20
10
2
4
6
8
10
Reduced effluent from biofilter -NO3--N (mg/L)
12mg/L Influent
15mg/L Influent
20mg/L Influent
25mg/L Influent


Tile volume (kL/ha), 2004
14000
12000
10000
8000
6000
4000
2000
0
10919
7637
DR
CDS
Treatments

Mgmt Considerations

- Locate, install, and use observation wells
  - 1-2 per management zone
  - Located between laterals
  - Upper end of zone




FWM Phosphorus Concentration (mg P/L)
0.15
0.10
0.05
0.00
DR
CDS
wetland
DIP
DOP
TDP