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Linking Science, Practice and Decision Making
December 8-12, 2014 | Washington, DC

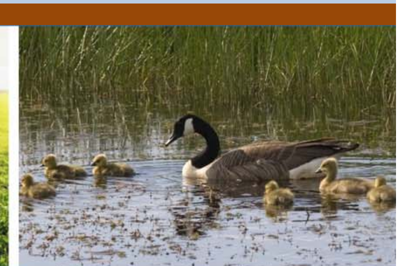
USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Drainage Water Management:
Optimizing nutrient use while managing risk

Presented by:
Rob Sampson
NRCS National Water Management Engineer

More Production

Less Risk



Cleaner Water

APS Crop Protection and Management Collection

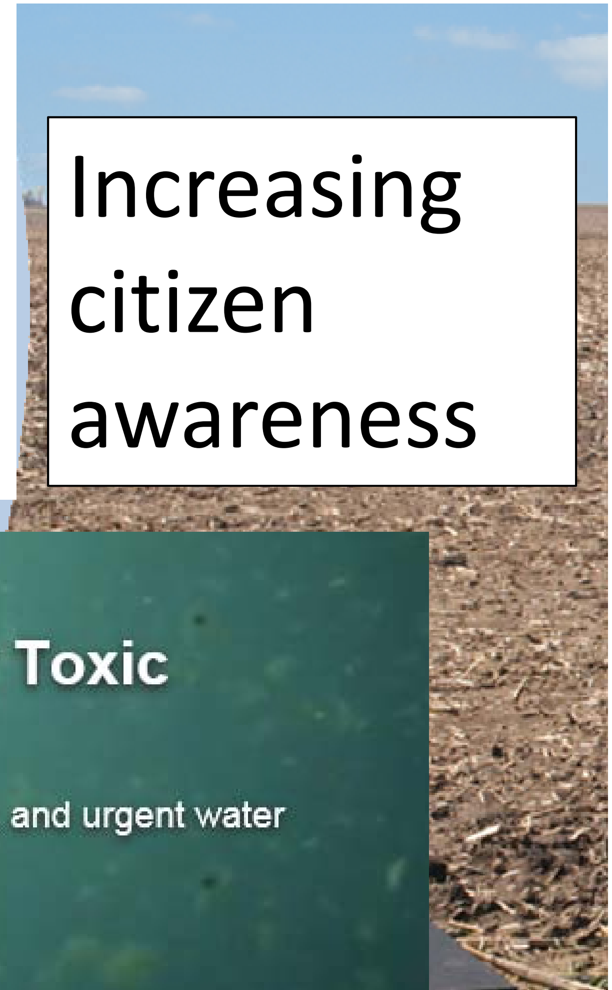
Plant Management Network

PMN Crop News Homepage

Posted 28 October 2014. PMN Crop News.

Tile Drains a Major Path for Phosphorus Loss, Studies Find

Source: American Society of Agronomy Press Release. www.agronomy.org



Increasing citizen awareness

Great Lakes Drinking Water Fouled by Toxic Algae

Years of inaction make green blooms the most unhealthy, unsightly, and urgent water quality problem in the world's largest source of fresh surface water

By Codi Yeager-Kozacek
Circle of Blue

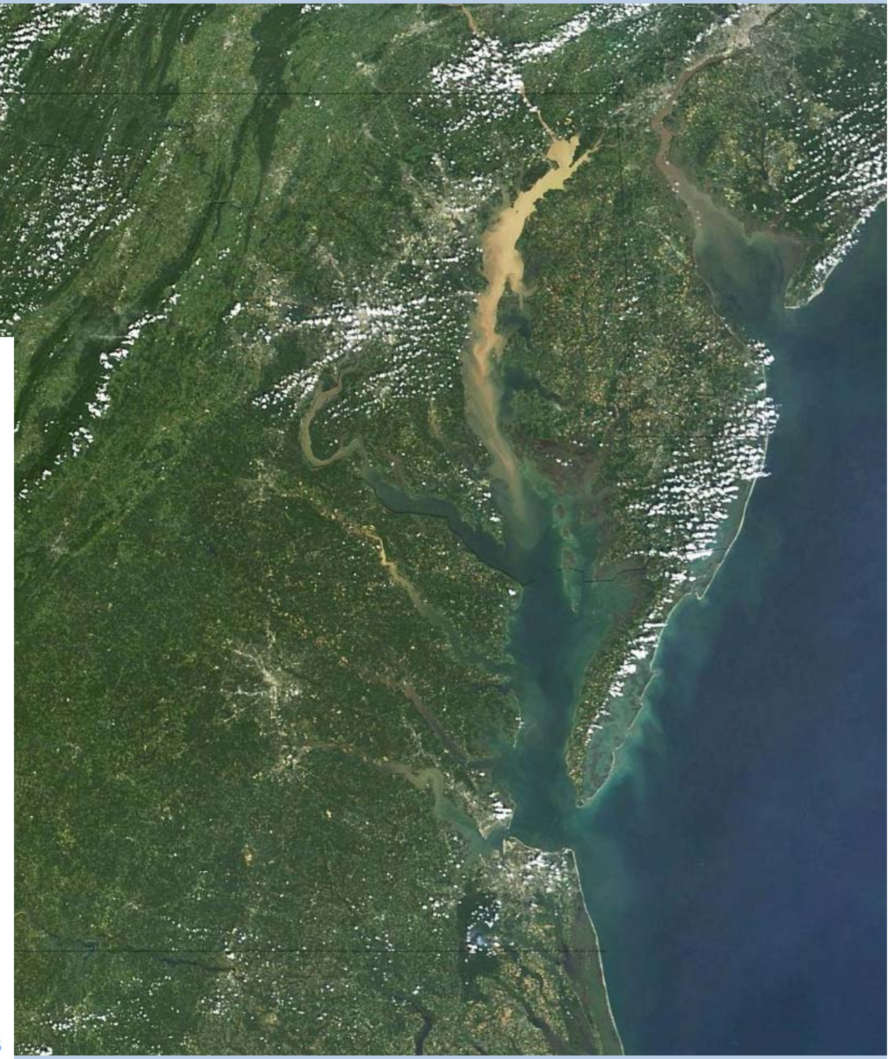
More Production

Orlan Love, The Gazette's outdoor writer since 1994, graduated from Marquette University in 1977 with a degree in journalism, after [...]

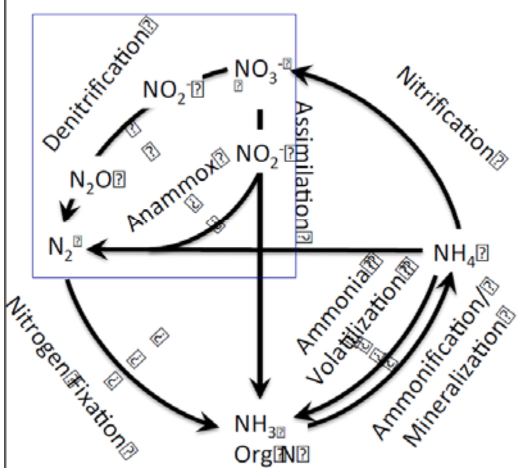
Updated: 4 August 2013 | 6:30 am in Local News, Statewide News

Farm fertilizer runoff wreaking havoc

'Nitrogen pulse' impacting Mississippi River, worsening Gulf of Mexico's dead zone



Denitrification



Microbially reduction of NO_3 to N_2. Carbon serves as an energy source for this redox reaction, and a nitrogen oxyanion (NO_3, NO_2) or oxide (NO, N_2O) serves as the terminal electron acceptor under anaerobic conditions

Watershed Science and Engineering Group

Lassiter and Easton 2013

More Production

Less Risk

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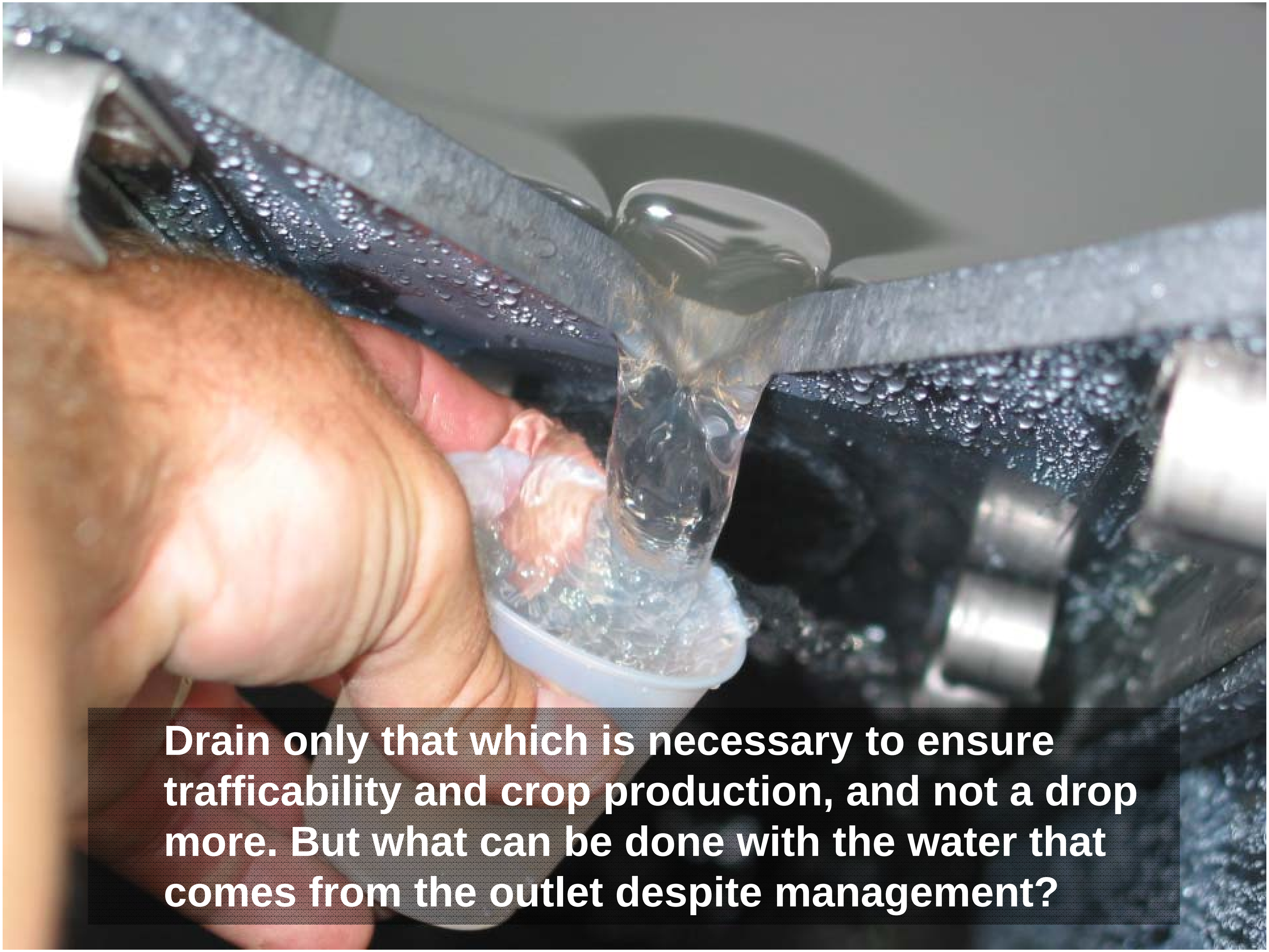

Drain only that which is necessary to ensure trafficability and crop production, and not a drop more. But what can be done with the water that comes from the outlet despite management?

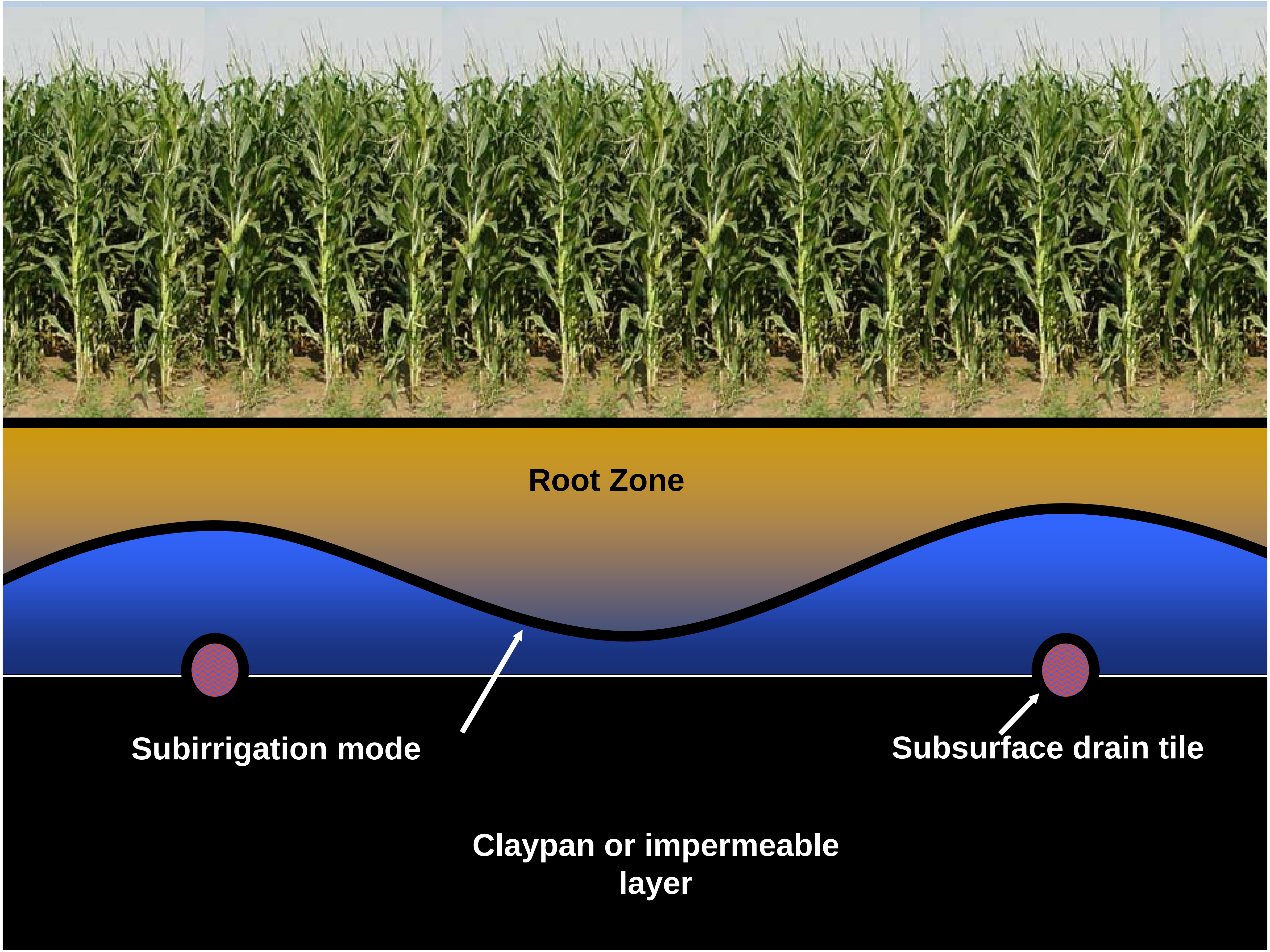
Drainage Water Management – Subirrigation

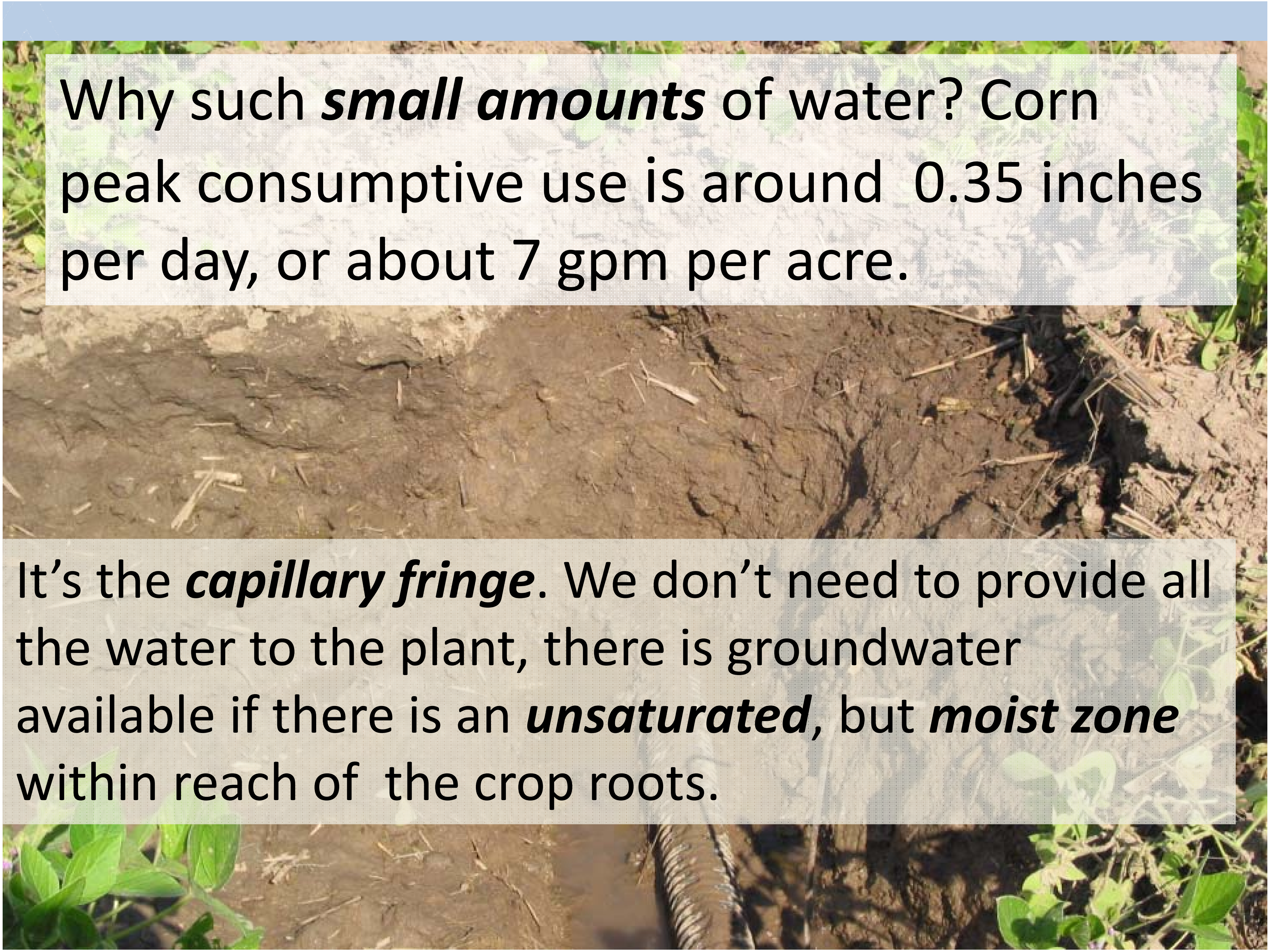
Subirrigation through subsurface controlled drainage systems: ***Drainage Water Management in Reverse.***

Pump a relatively ***low volume*** of water up and into the control structure, backing the water up the drain tile and forcing exfiltration into the soil for crop water use.

Low flow volumes, of ***1 – 4 gpm per acre***, compared to 5 – 12, gpm per acre for an sprinkler system.

Cleaner Water


Root Zone
Subirrigation mode
Subsurface drain tile
Claypan or impermeable layer


Why such ***small amounts*** of water? Corn peak consumptive use is around 0.35 inches per day, or about 7 gpm per acre.
It's the ***capillary fringe***. We don't need to provide all the water to the plant, there is groundwater available if there is an ***unsaturated***, but ***moist zone*** within reach of the crop roots.

Managing subsurface water is about managing the free water table AND the capillary fringe.

Does subsurface irrigation make a difference?

Missouri's first Drainage-Subirrigation System			John and Jeff Lorberg Cape Girardeau County	Installed: Spring 2004
Average corn yields, bushels per acre (more recently in wheat)				
Average for years prior to system	2004	2005	2006	2007
110	201	201	192	211

Cost: $608 per acre (cost of tile and water control structures with no grading).
Maintenance cost: Negligible.
Life span: 20 years. Installation cost recovery in two years with $4 corn.

Mark Nussbaum Photo

"We're seeing more interest recently because of more people realizing they needed water during a drought, and because they saw some people being successful with the system. Some are also able to invest with higher corn prices," Nussbaum says.

Corn Response to an Integrated Water Management System

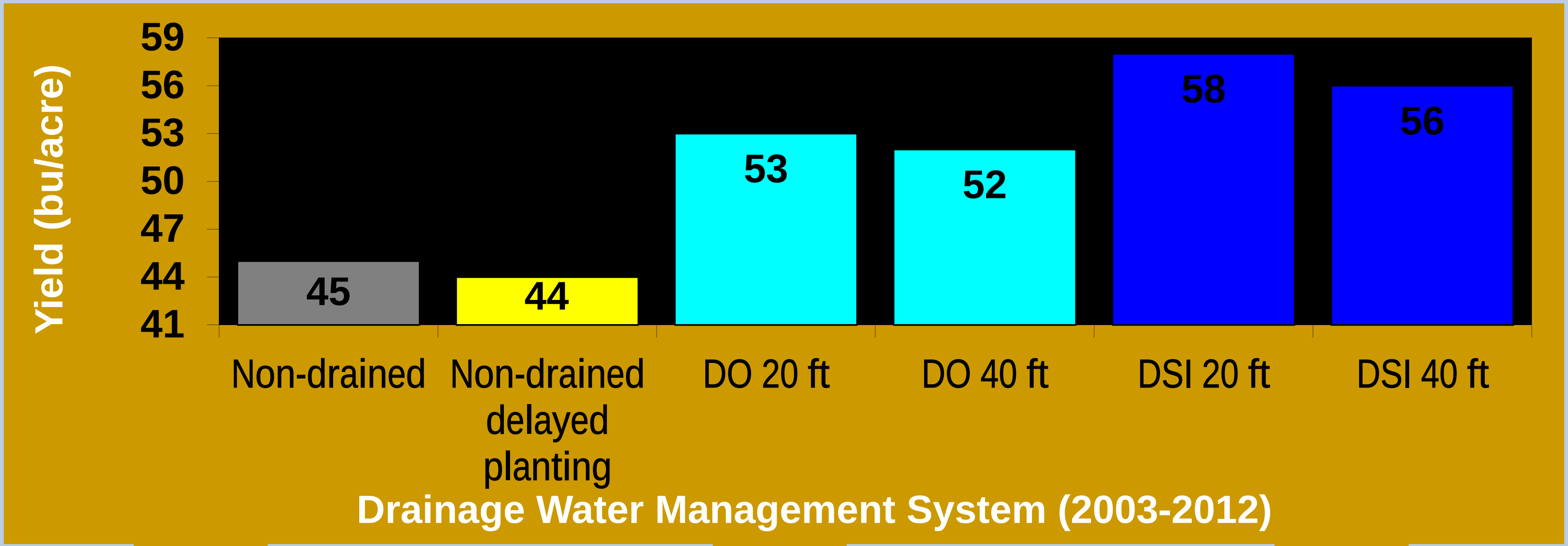
Year(s) and Environment	Yield increase DO 20’	Yield increase DSI 20’	Yield increase DO 20’	Yield increase DSI 20’
	---Bu/acre---		--------%--------	
06: Dry-Moderate	8	72	6	55
02,05,12: Wet-Dry	15	74	35	172
03,07: Wet-Moderate	26	56	25	48
04,08,09,10,11: Wet-Wet	35	31	25	22
Average	21	58	23	74

2004-2005: PCU, Irrigation, Drainage on NU and Yield.
Nelson et al., 2009. Agron. J.

2006-2007: N Source & Drainage on Yield
In review. App. Eng. In Agric.

2008-2010: Drainage and High Yield Hybrids
Nelson et al., 2012. Intl. J. Agron.

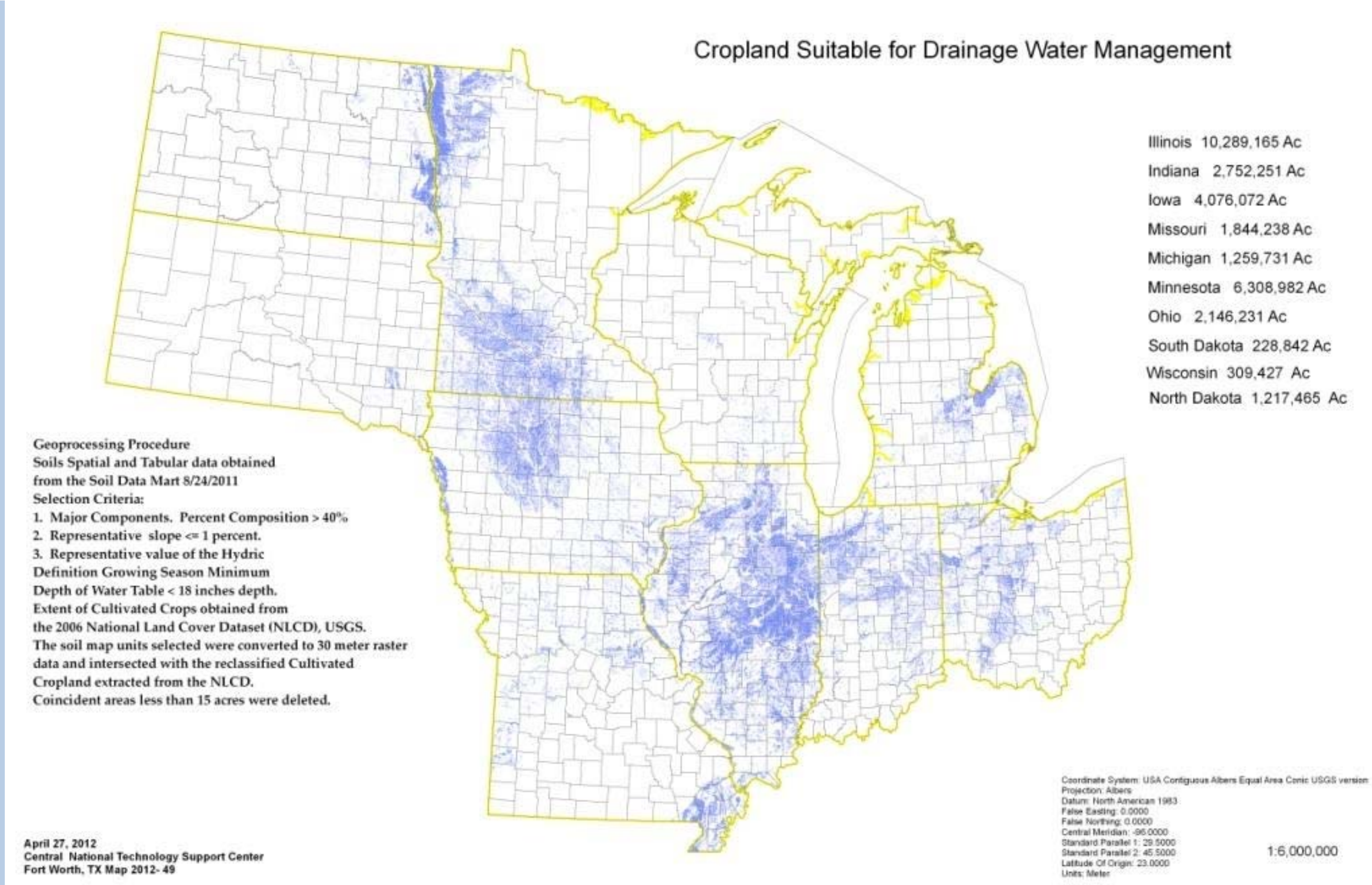
Soybean Response to Integrated Water Management Systems



2003-2006: Yield Response to DWM.
Nelson et al., 2011. Agron. J.

2007 & 2008: High Yield Cultivars and DWM.
Nelson et al., 2012. Crop Management.

2009 & 2010: IWMS & Fungicide Management.
Nelson et al., 2011. Agron. J.



DWM Suitability – where is subirrigation possible?

More Production ✓ Less Risk ✓ Cleaner Water ✓

Table 4

Soil	Optimal Spacing (ft)	Optimal Subirrigation Rate (gpm)	Projected Yield (bushels)	Projected Profit ($/acre)
86074 Adler	45	2	219	$280
82010 Amagon	15	2	216	$174
86001 Calhoun	15	2	215	$167
73381 Captina	20	2	170	$43
66000 Moniteau	30	2	216	$242
86048 Roellen	15	2	217	$175
86057 Sharkey	15	3	154	$-54
66110 Sandessein	15	3	212	$145
54005 Twomile	25	2	214	$215
66024 Wilbur	30	2	212	$219

Soils from SE Missouri and optimal tile spacing, subirrigation flow rate and profit. Results from DRAINMOD.

Nussbaum et. al, 2014, in review.

Subirrigation and Drainage Water Management: Constraints and Challenges:

1. The drainage system heeds to be installed with Subirrigation in mind:
   I. Generally flatter, more uniform slopes.
   II. Soil surface parallel to the drain profile. Land Leveling?
   III. Water source, and if needed, water right.

2. Soil must have a restrictive layer – however if drainage was required, it may be a safe bet that the layer exists.

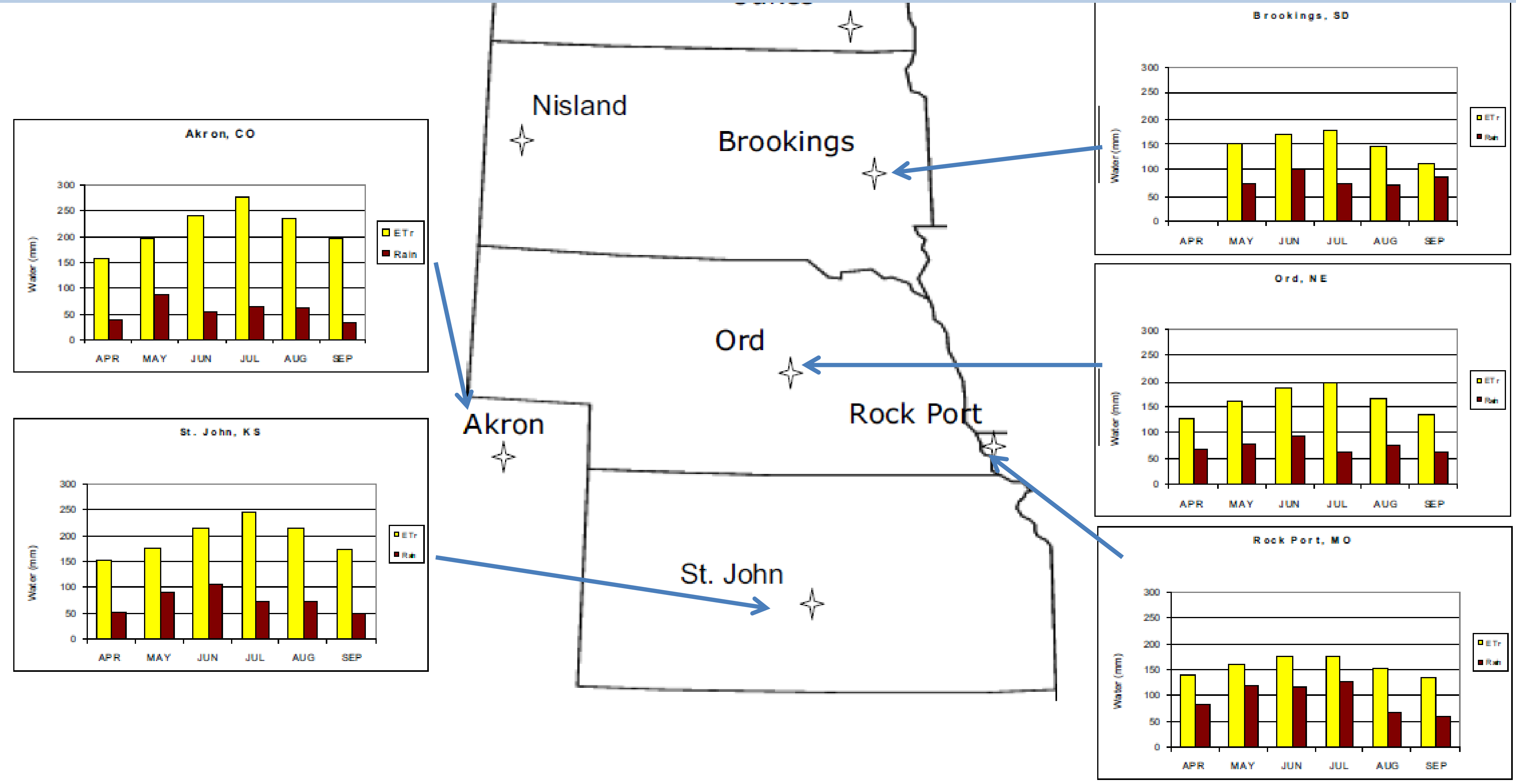
3. Tile spacing might be closer. Perhaps up to twice the tile length compared to controlled drainage alone.

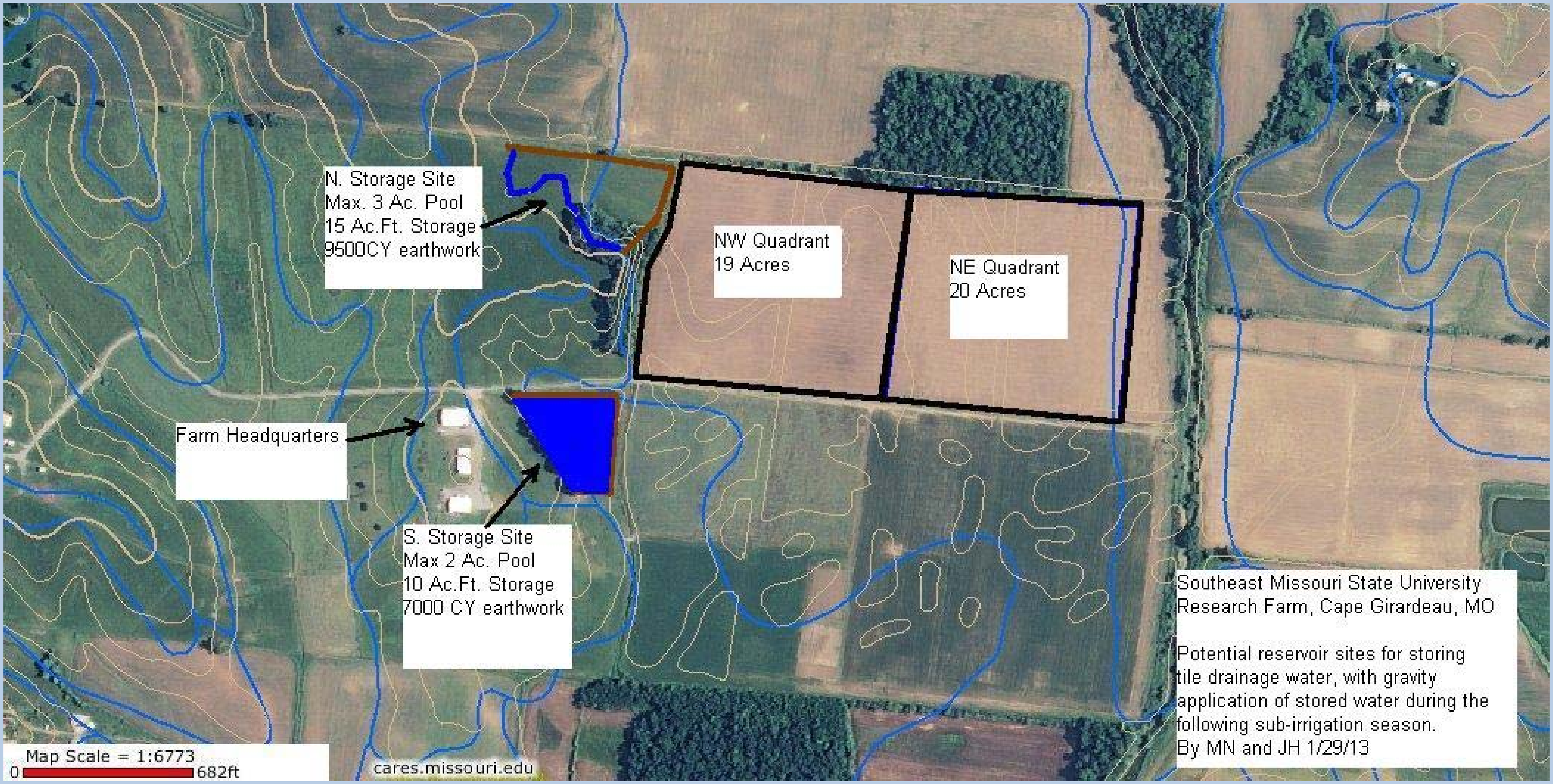
More Production More Production

Less Risk

Cleaner Water

Corn Water Use Compared to Average Precipitation: Value of subirrigation depends on timing of precipitation compared to crop stage.





Potential storage sites for winter and spring drainage water capture for use as irrigation water later in the season.

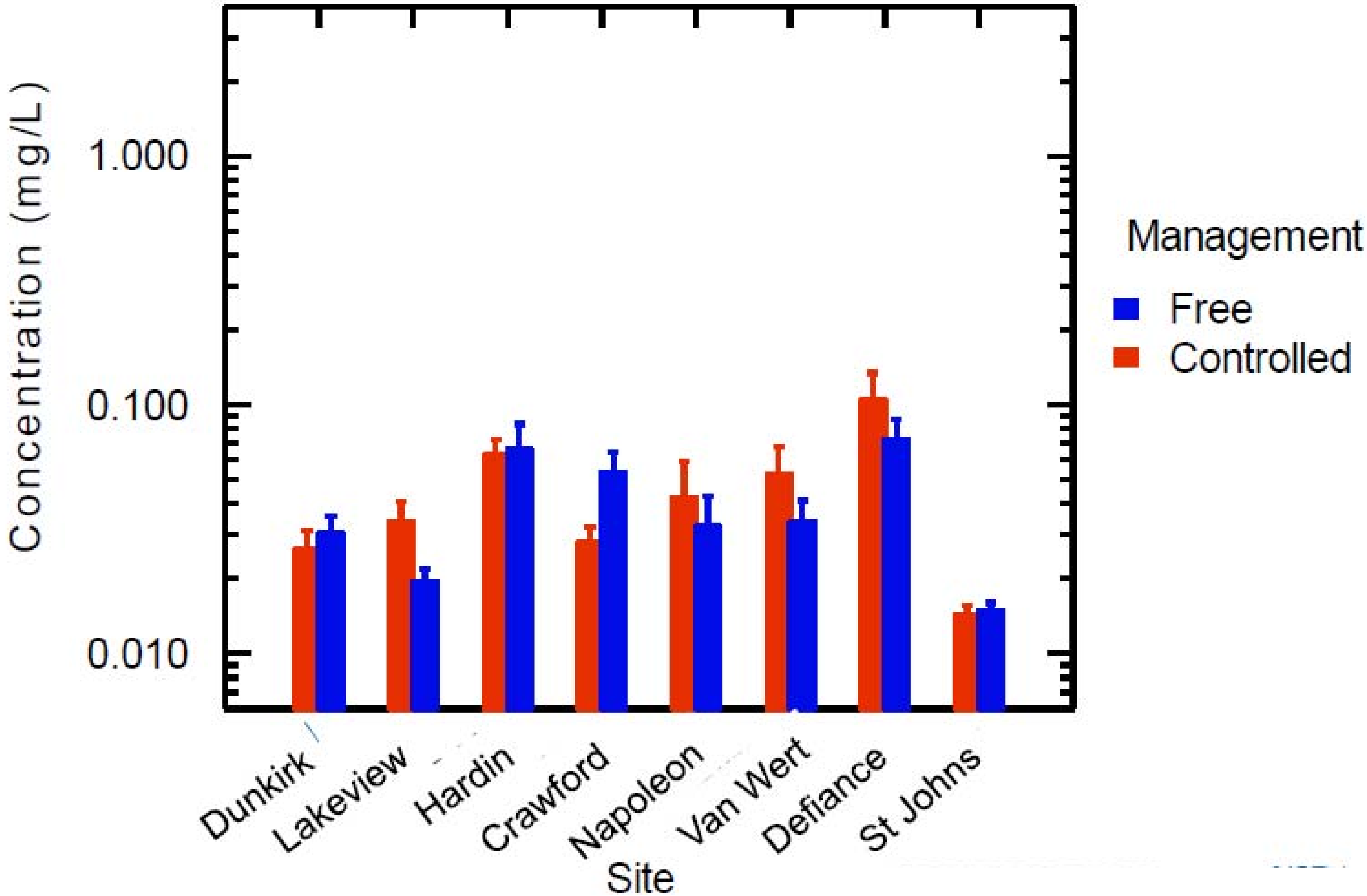
Thoughts on Markets Around Controlled Drainage, Drainage Water Management and Subirrigation:

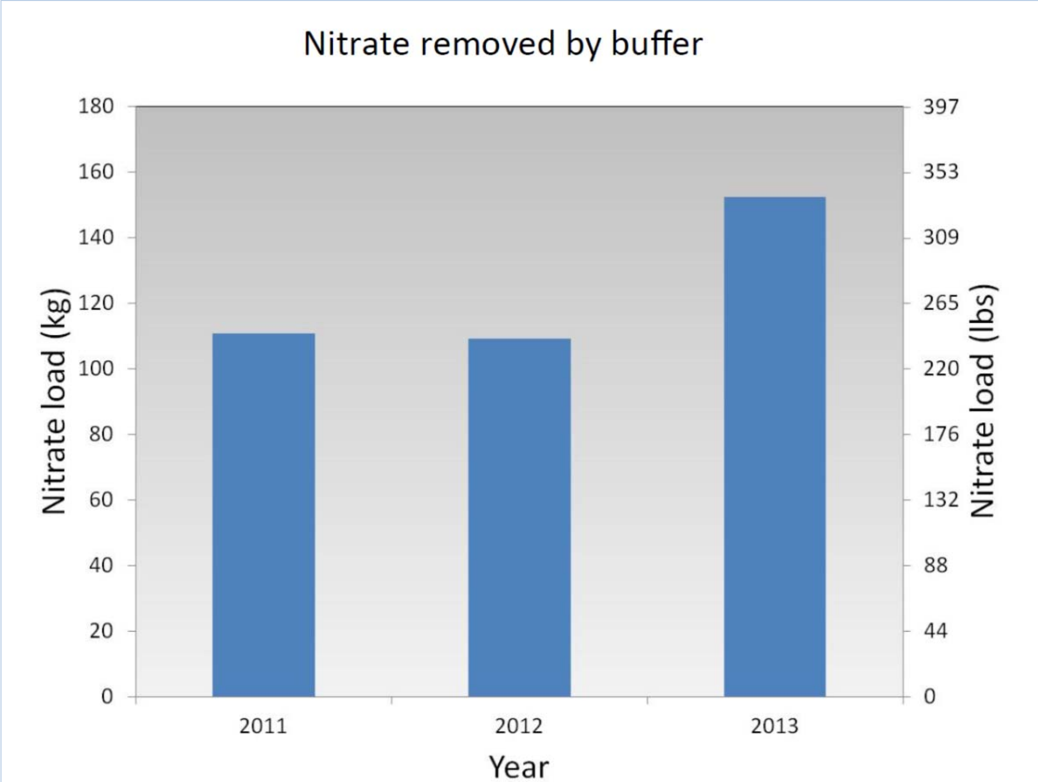
- There is adequate research in reduction of N, P_{sol}, and water volume to predict impacts within some error ~ 20 to 50%.
- Impacts will vary with year, crop and management style. Dry years may show the most crop gain, and the least downstream benefit.

Thoughts on markets around Controlled Drainage, Drainage Water Management and Subirrigation (con't):

- ***Verification*** in any quantitative sense will require water flow measurement and water quality sampling, Can be automated, but the number of moving parts increases very quickly with an increased complexity of drainage system.
- ***Controlled drainage alone*** provides reduced nutrient export, but less (if any) monetary gain for the farmer. Addition of subsurface irrigation will increase yield and decrease risk.
- No foolproof method to ***guarantee results***. Change in crop prices, ownership, or water availability (change in water rights) can nullify and even reverse all benefits.

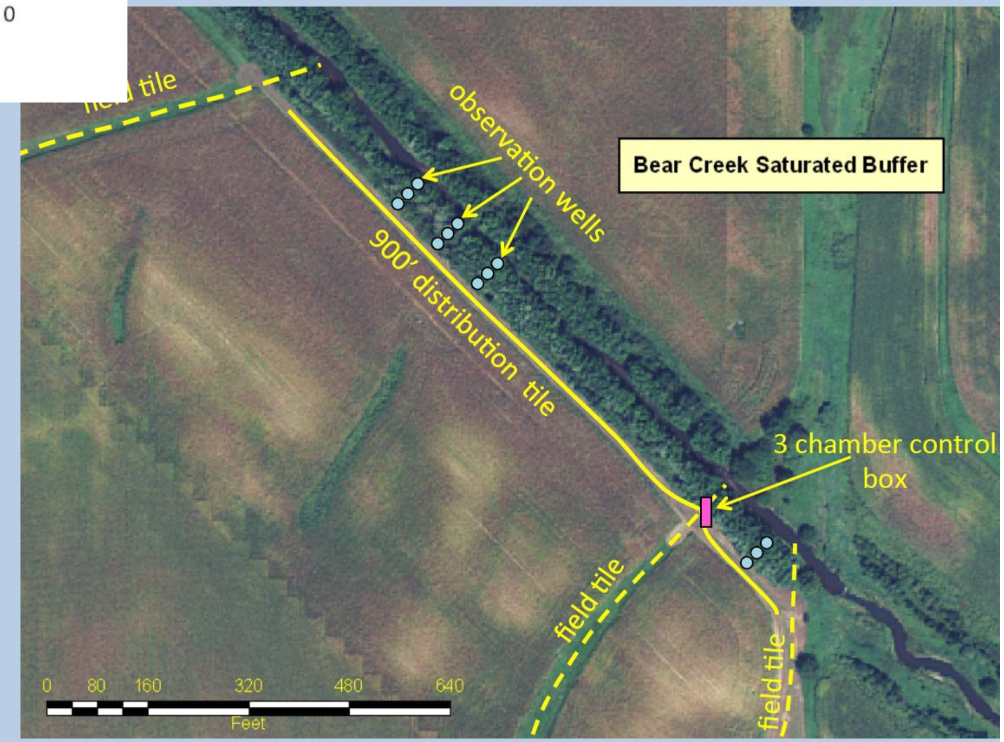
Avg. Phosphate-P Concentrations (+SE) from 2010-2013

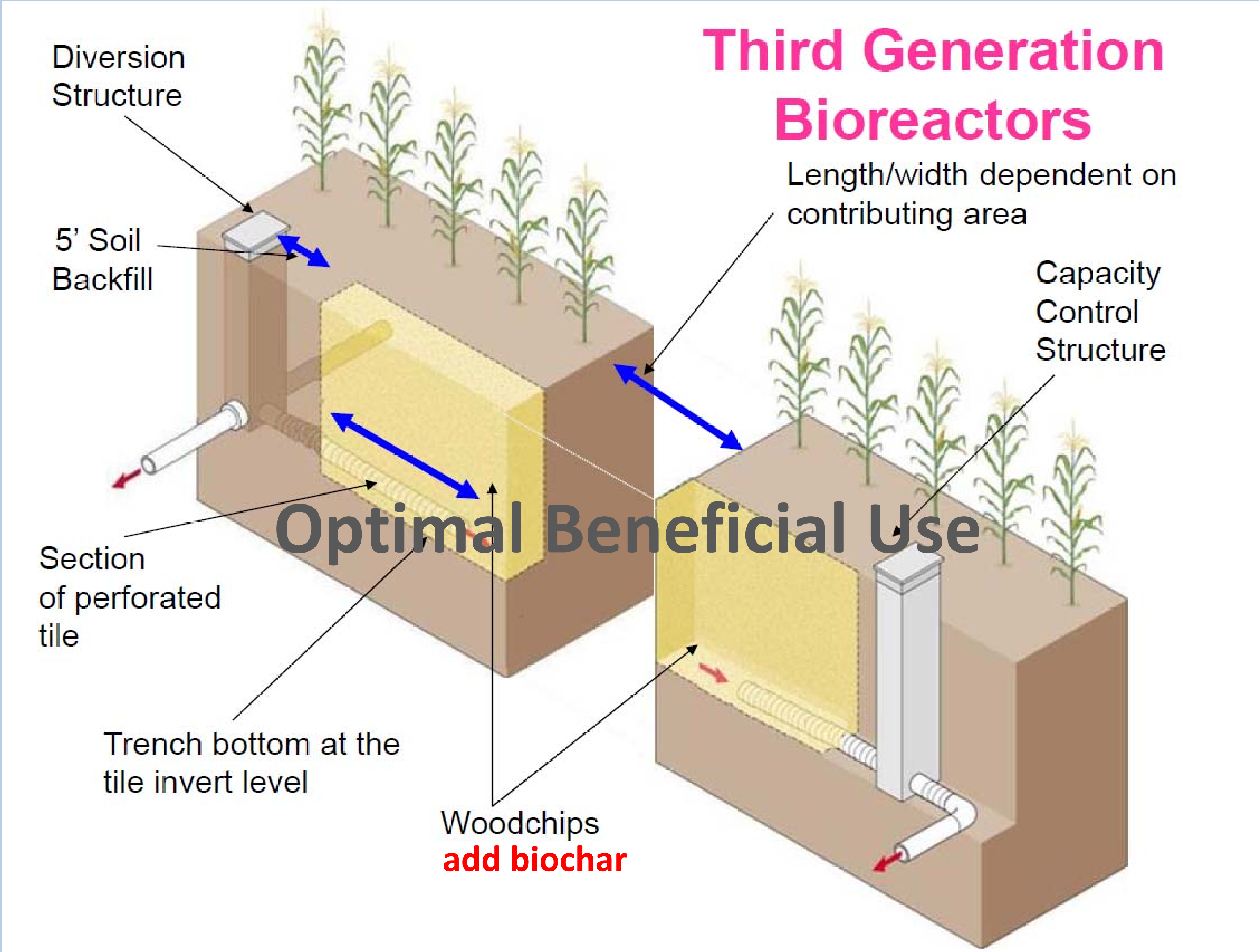




Saturated Buffer impacts on Nitrate

Jaynes and Eisenhart, 2014.





Schematic of a Bioreactor.

Cooke and Bell, 2010

Interesting take home messages

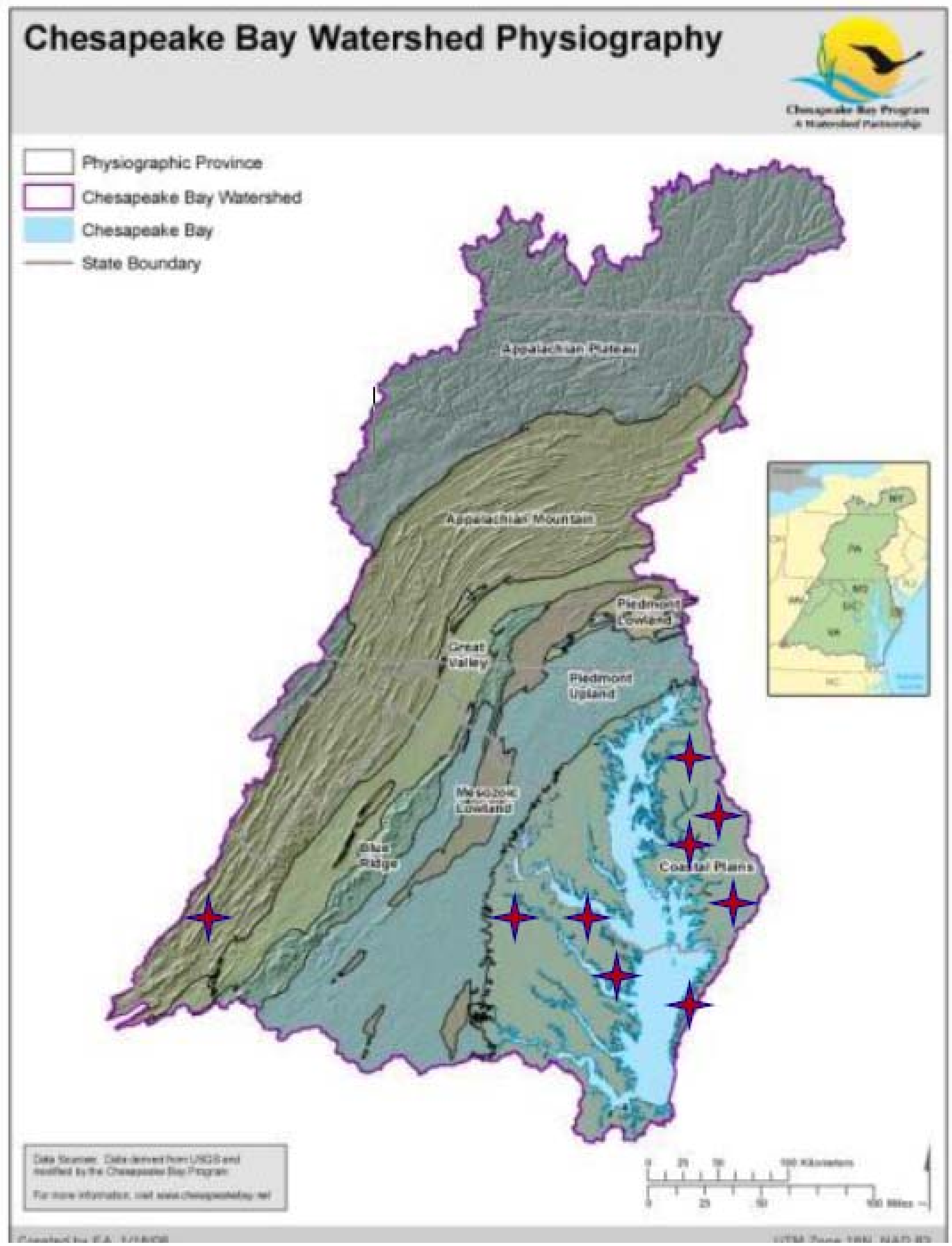
- Enhanced P removal over woodchips alone (4.5 mg P L^{-1}) was due to two factors
  - Sorption
  - Precipitation
- Nitrate removal times decreased dramatically (72 down to 18 hrs for 90% removal)
  - Implications for bioreactor designs (e.g., treat larger volume, reduce reactor size/residence time)

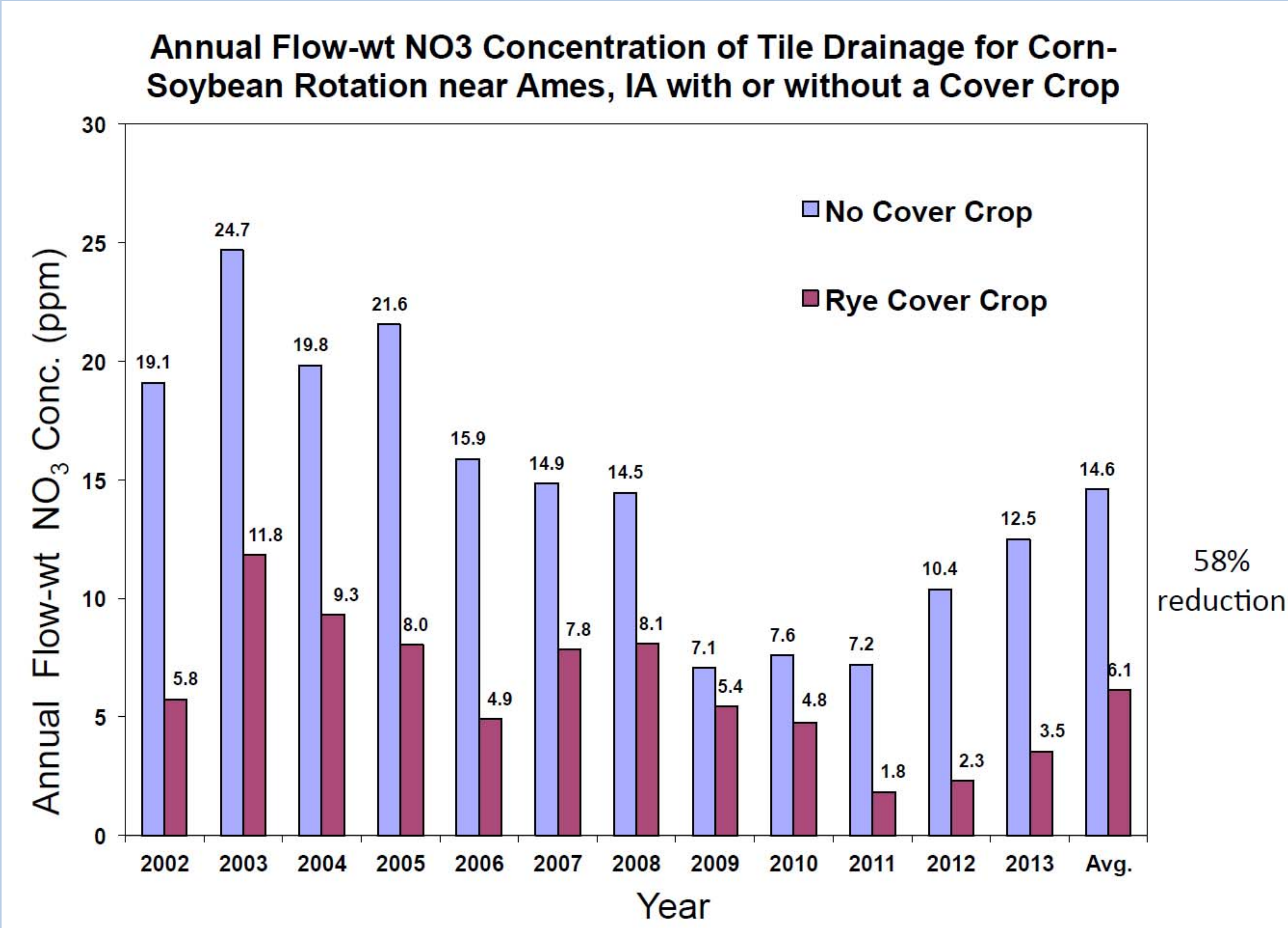
Lassiter and Easton, 2014 Biochar addition to wood chips in denitrifying bioreactor

National Cooperative Extension Research (NCERA)

Virginia Tech, using an NRCS CIG grant, is conducting further field scale research around Chesapeake Bay.

More Production





Effect of cover crop on NO3 concentration.

Jaynes and others, 2014.

Drainage Water Management

Denitrifying Bioreactor: Permanent Standard

Interim IA-747 - 1

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

DENITRIFYING BIOREACTOR

(Ac.)

INTERIM CODE 747

DEFINITION

A structure containing a carbon source installed to intercept subsurface drain (tile) flow or ground water, and reduce the concentration of nitrate-nitrogen.

Use a medium for the carbon source that is reasonably free from dirt, fines, and other contaminants.

This does not preclude the planned addition of inoculants to improve the function of the

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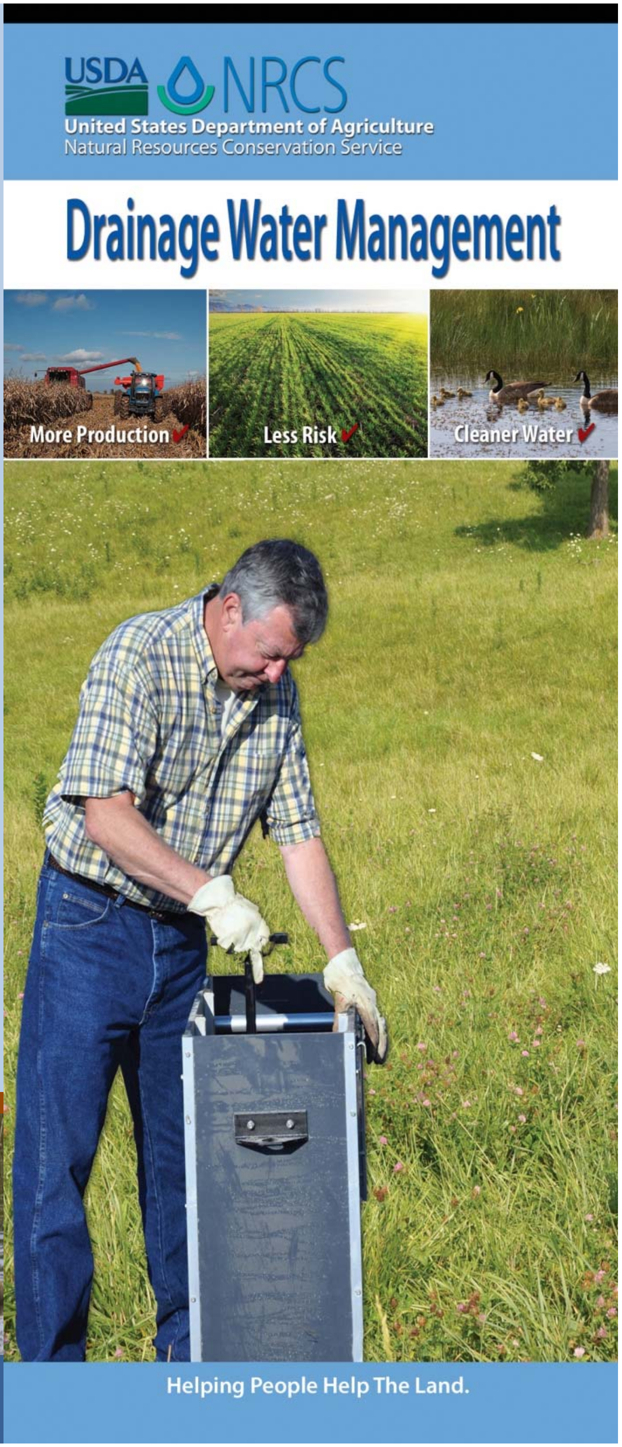

Drainage Water Management Standard Revision

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

DRAINAGE WATER MANAGEMENT

(Ac.)

CODE 554 – DRAFT 1-REVISED

DEFINITION

The process of managing the drainage volume and water table elevation resulting from a surface ~~and~~ /or subsurface agricultural drainage system.

PURPOSE

The purpose of this practice is to:

- Reduce nutrient, pathogen, and/~~or~~ pesticide loading from drainage systems

and Subs-Surface (Code 443) and Irrigation Water Management (Code 449).

The practice does not apply to the seasonal inundation~~flooding~~ of fields from overland surface runoff.

CRITERIA

General Criteria Applicable to All Purposes

Manage the drainage discharges and water

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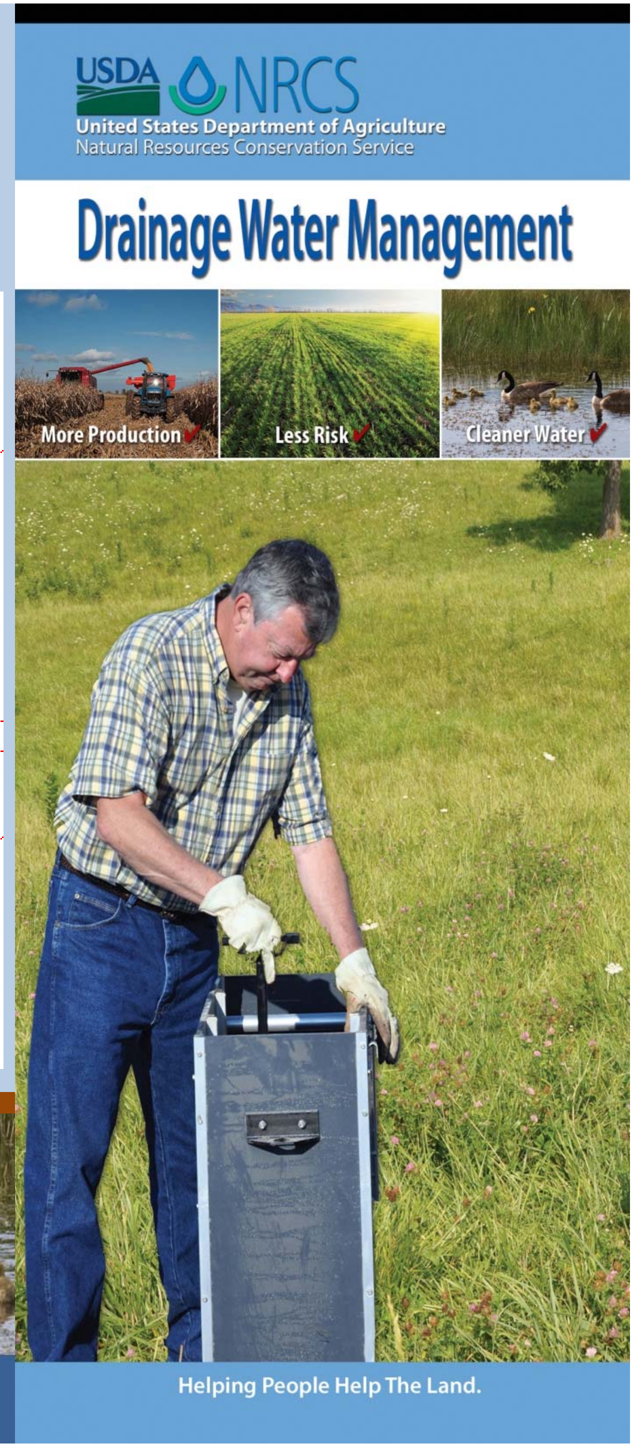
Less Risk

Cleaner Water



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