Transforming Drainage to meet Tomorrow's Water Management Challenges

Jane Frankenberger, Professor
with Ben Reinhart, Project Manager
Agricultural & Biological Engineering

Indiana CCA Conference
Dec 17, 2019

PURDUE
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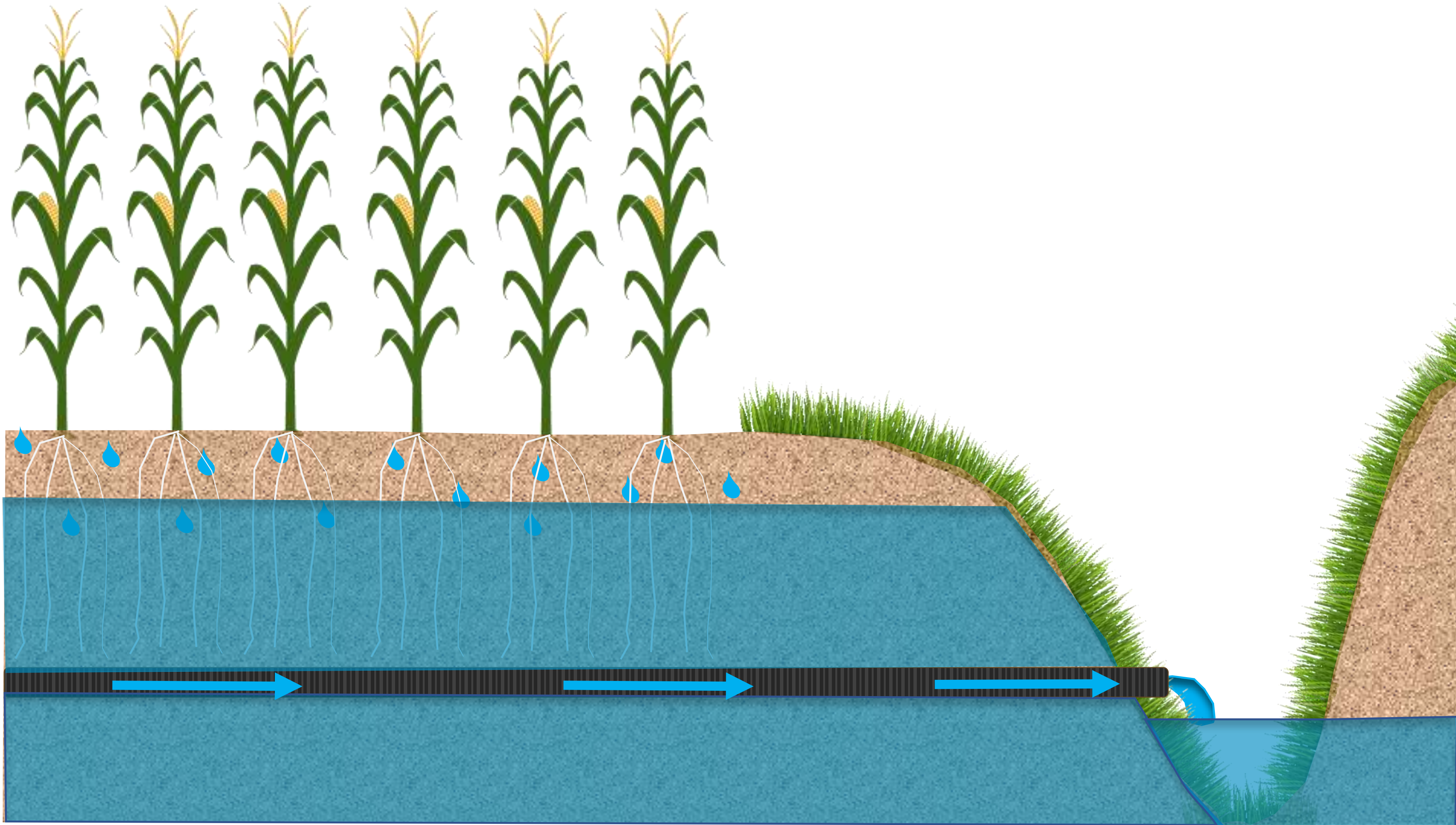
Artificial drainage is essential for crop production in much of Indiana

Drainage lowers the water table (replaces water by air in pores) below the root zone.



Drainage provides oxygen needed for plant growth, and allows roots to grow deep.

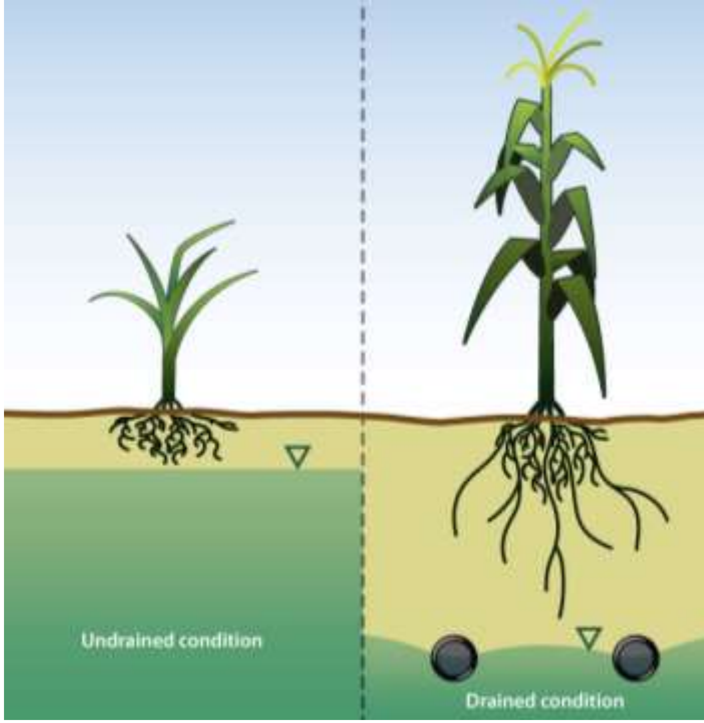


Image: Larry Brown, The Ohio State University

Drainage provides trafficable conditions for field operations.


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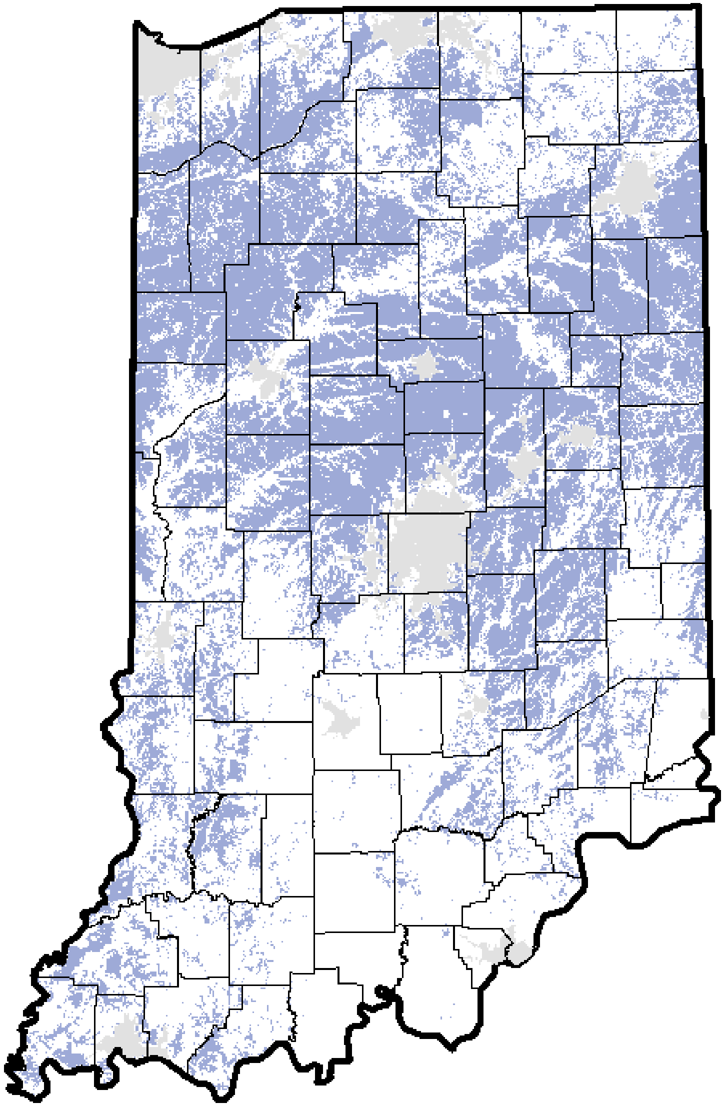
Photo: Gary Sands

About 45% of Indiana soils are naturally poorly drained.

Poor drainage due to:

- Restricting layers in the soil profiles
- Flat topography
- Lack of an outlet for natural drainage

Estimate of drained crop land



Indiana’s drainage infrastructure is designed to get rid of water as quickly as possible

Getting rid of water as quickly as possible leads to several issues.

Issue 1: Downstream flooding

Photo: FEMA Photo Library

Issue 2: Nitrogen and phosphorus in drainage water causes algae blooms downstream

Water from Lake Erie during toxic algae bloom

Photo: Tom Bridgeman

Issue 3: Lack of water during dry periods can reduce crop yields and streamflow.

What about tomorrow's challenges?

All 3 issues are becoming worse, exacerbated by the changing climate, and will become more extreme.

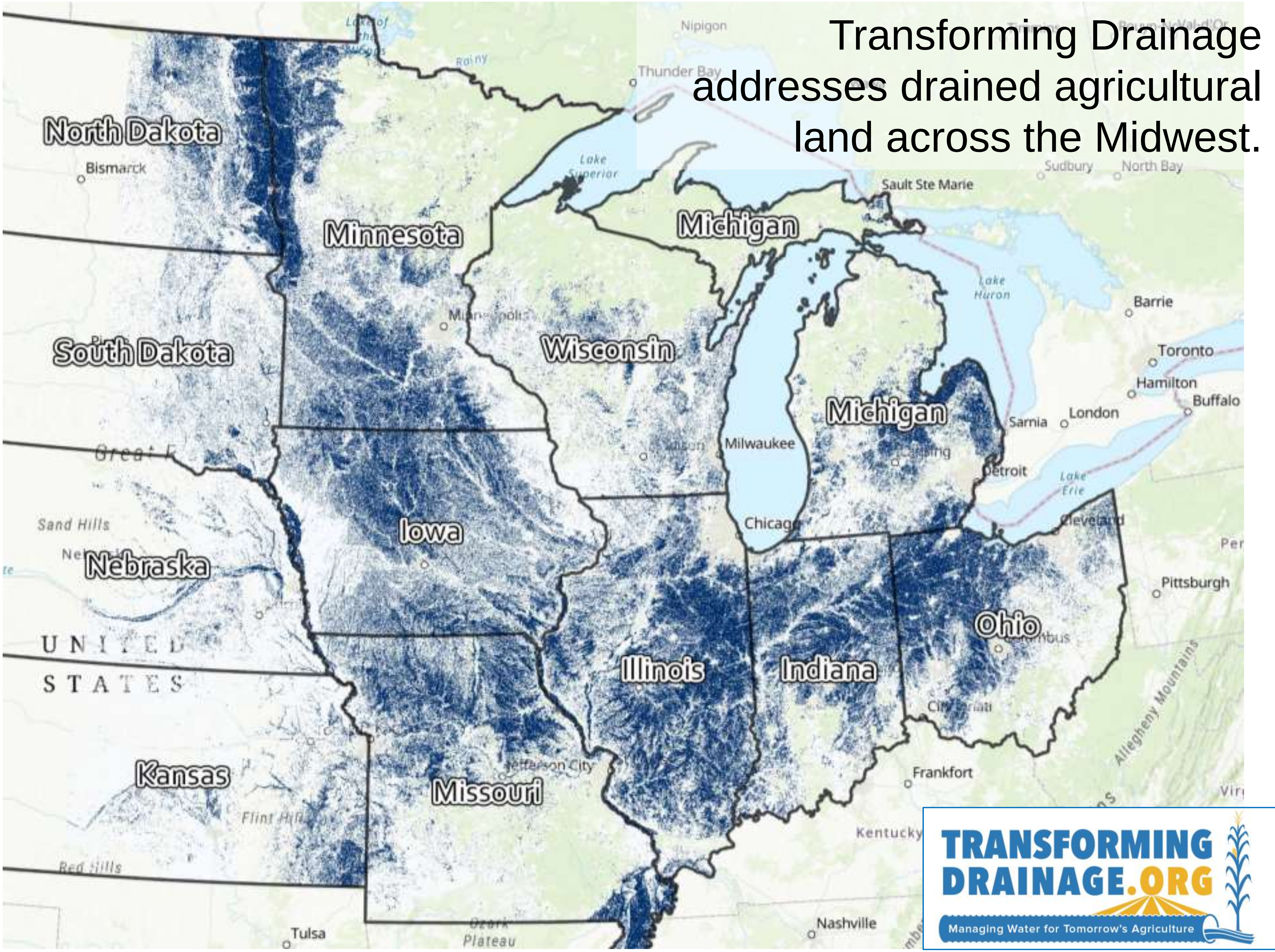
- **Winter and spring are becoming wetter**, leading to (1) increased flooding and (2) increased nutrient loss
- **Summers are becoming hotter with more intense rainfall,** (3) increasing drought potential.

Photo: Wikimedia Commons
Photo: Tom Bridgeman

What can we do? **Storing drained water in the landscape** addresses all these issues.

Our vision: The process of designing and implementing agricultural drainage will be **transformed** to include water storage and even water recycling.

Transforming Drainage addresses drained agricultural land across the Midwest.

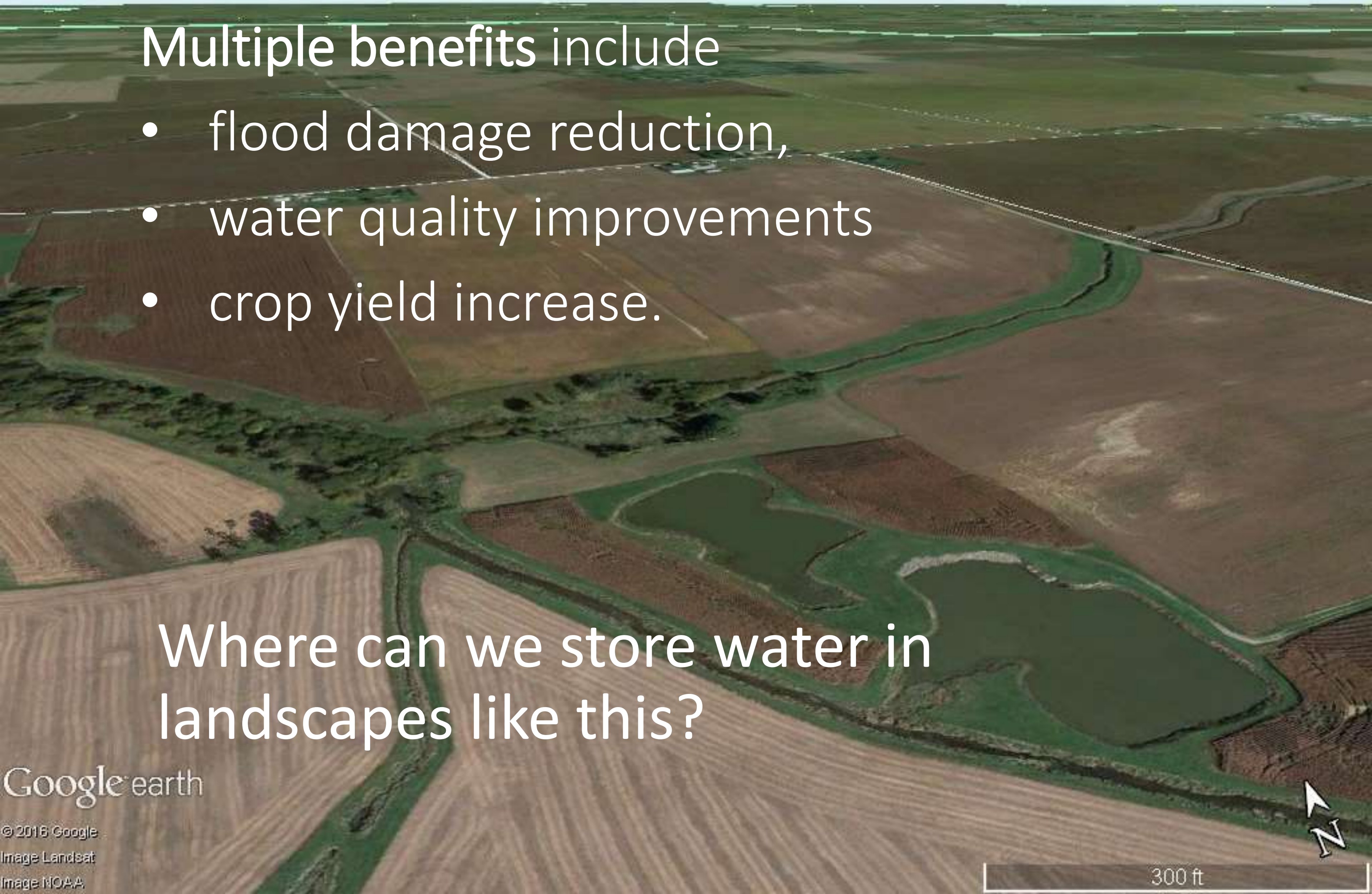


Storing drained water in the landscape can address all these issues

Multiple benefits include

- flood damage reduction,
- water quality improvements
- crop yield increase.

Where can we store water in landscapes like this?



Storing water in the soil: Soil health may increase water storage capacity of soils.

- Increasing soil organic matter increases water holding capacity.

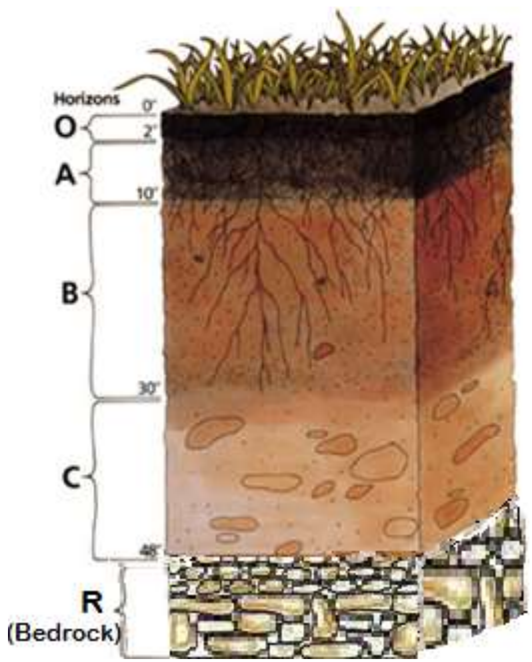
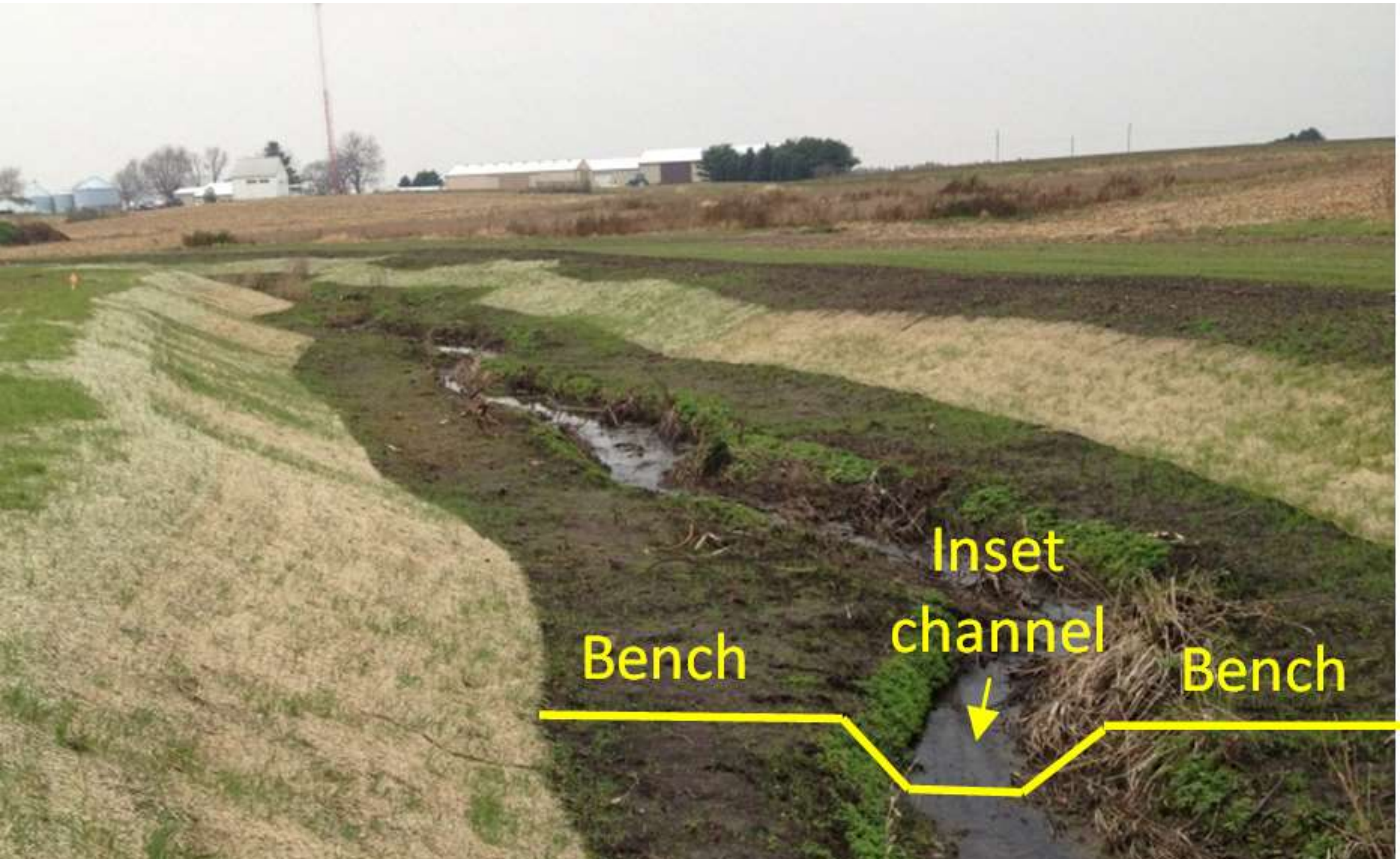


Image: Wikimedia Commons, Wilsonbriggs

- Cover crops and similar practices may help.

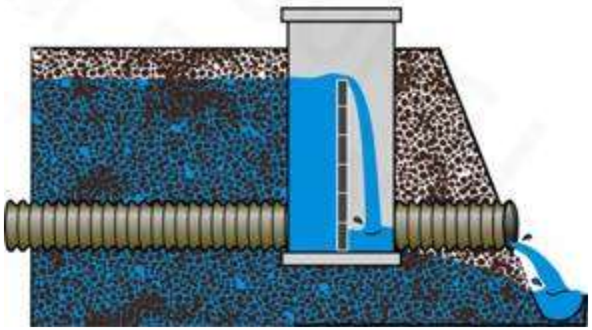
Image: NRCS

Storing water in wider ditches: Two-Stage Ditches



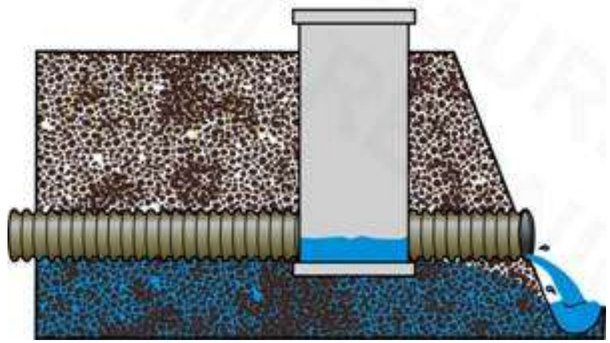
Storing water in the field: Drainage Water Management, also known as Controlled Drainage

After harvest



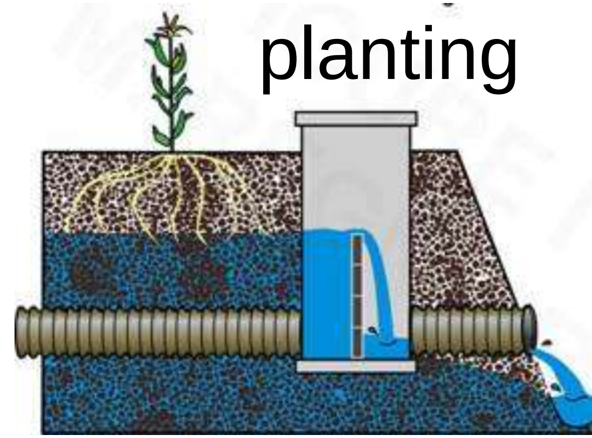
The outlet is raised after harvest to reduce nitrate delivery.

Before planting or harvest



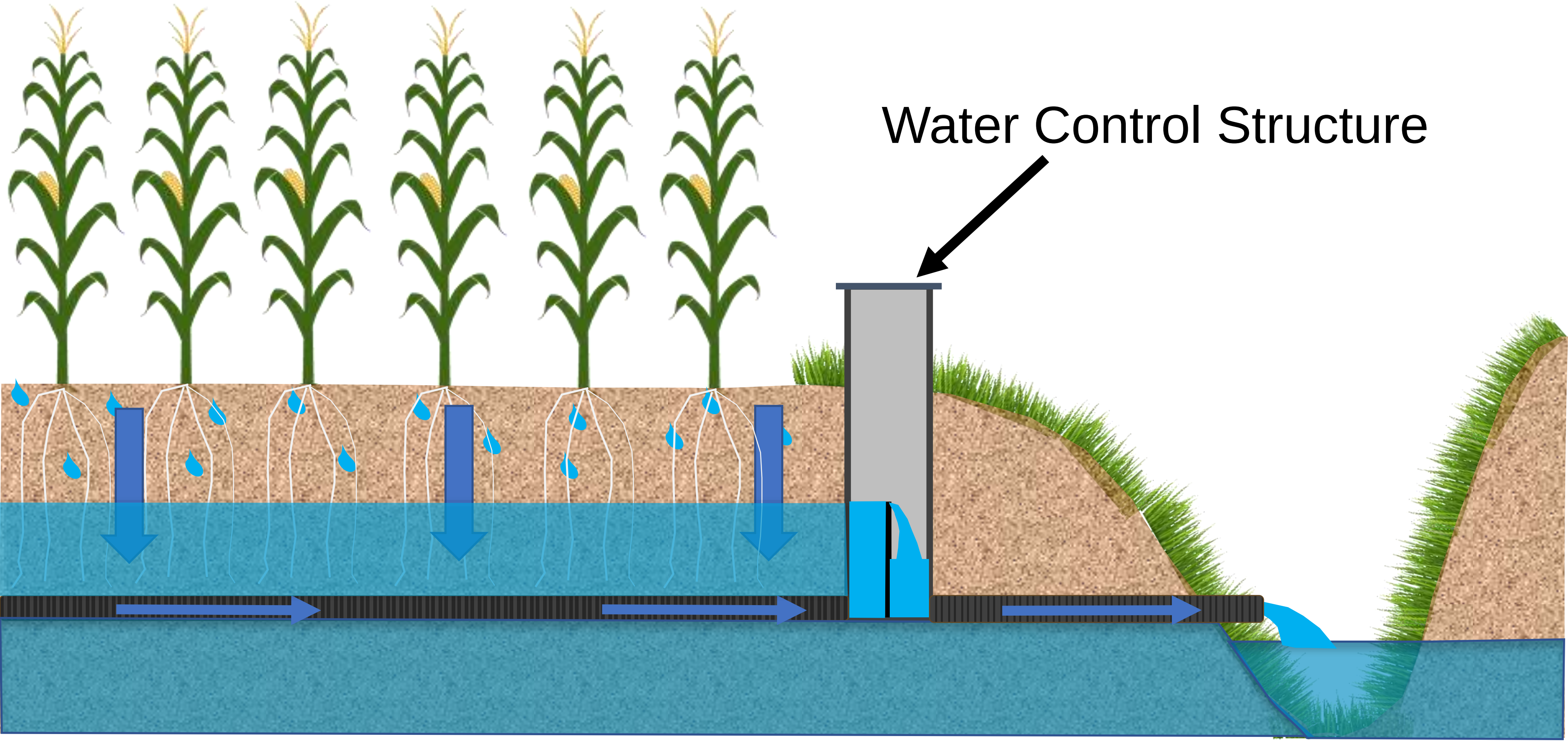
The outlet is lowered a few weeks before planting and harvest to allow the field to drain more fully.

After planting



The outlet is raised after planting to potentially store water for crops.

Controlled drainage holds water in the soil, potentially storing water for crops and to reduce nutrient loads.

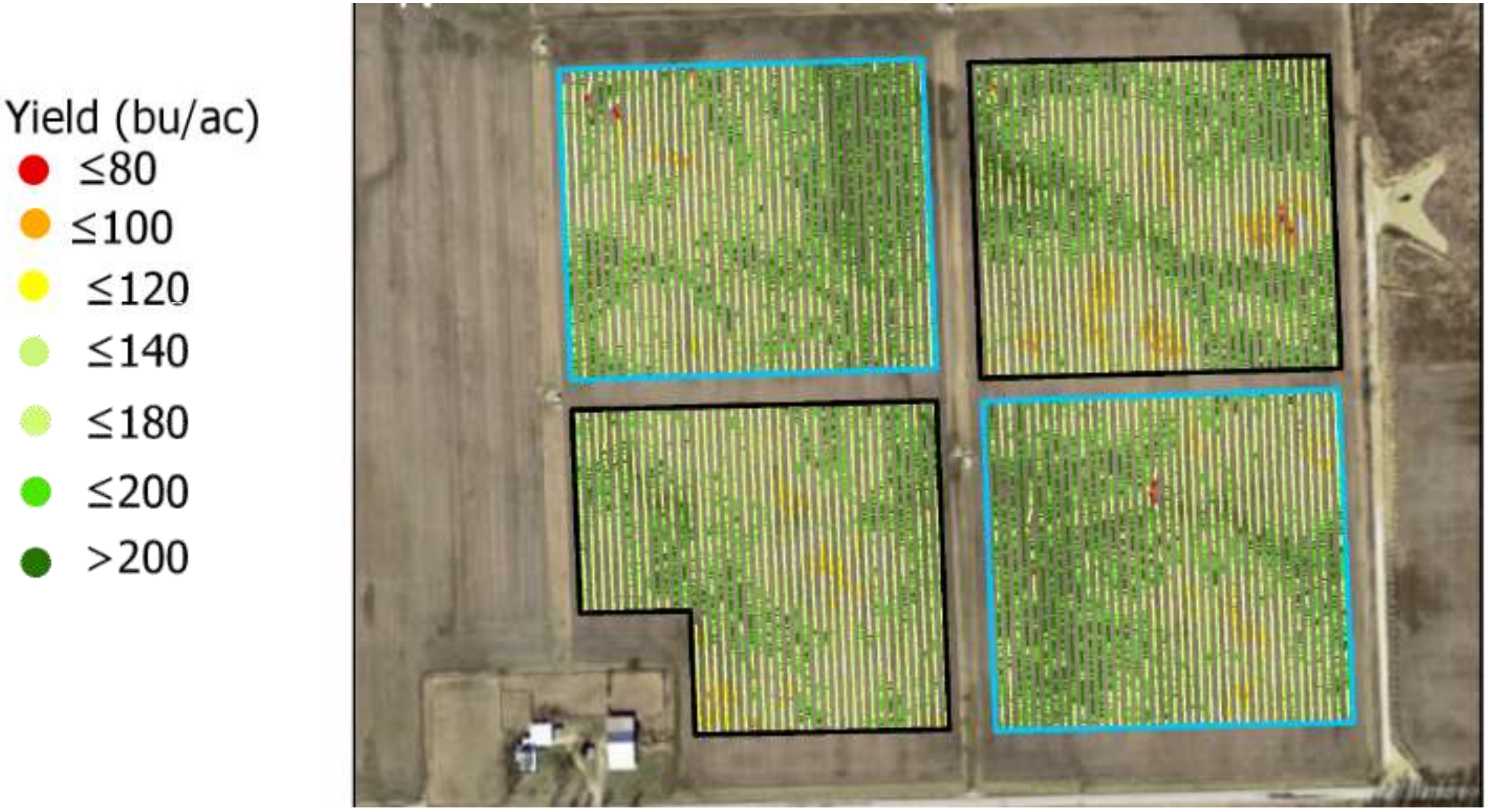


We evaluated drainage water management for 13 years at Davis Purdue Agriculture Center (DPAC) in Randolph County

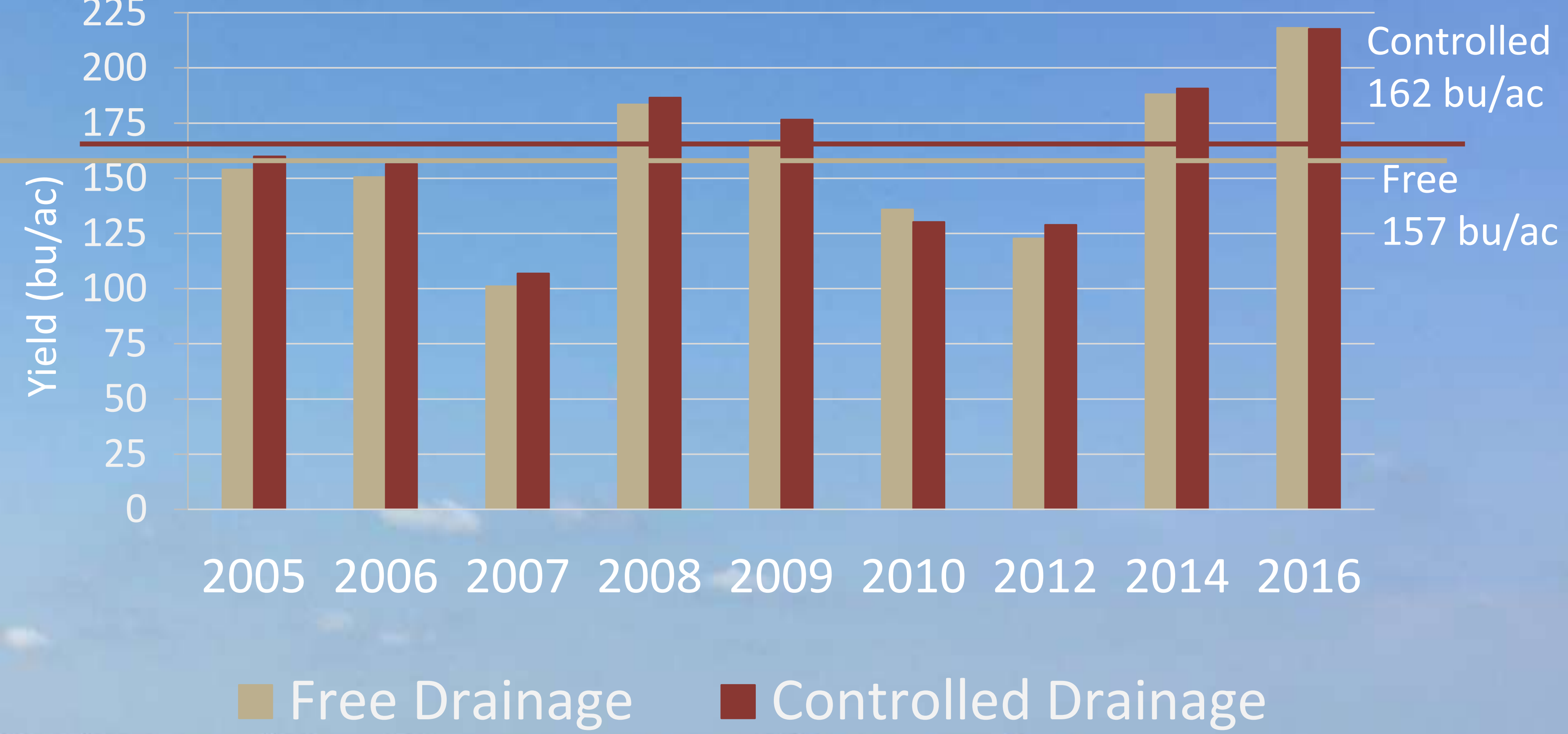
40 acre field divided into
2 controlled and
2 free draining quadrants

We analyzed 9 years of corn yield and 4 years of soybean yield

- Yield measured with yield monitor each year, cleaned and processed. Example for 2009:



Corn Yield at DPAC

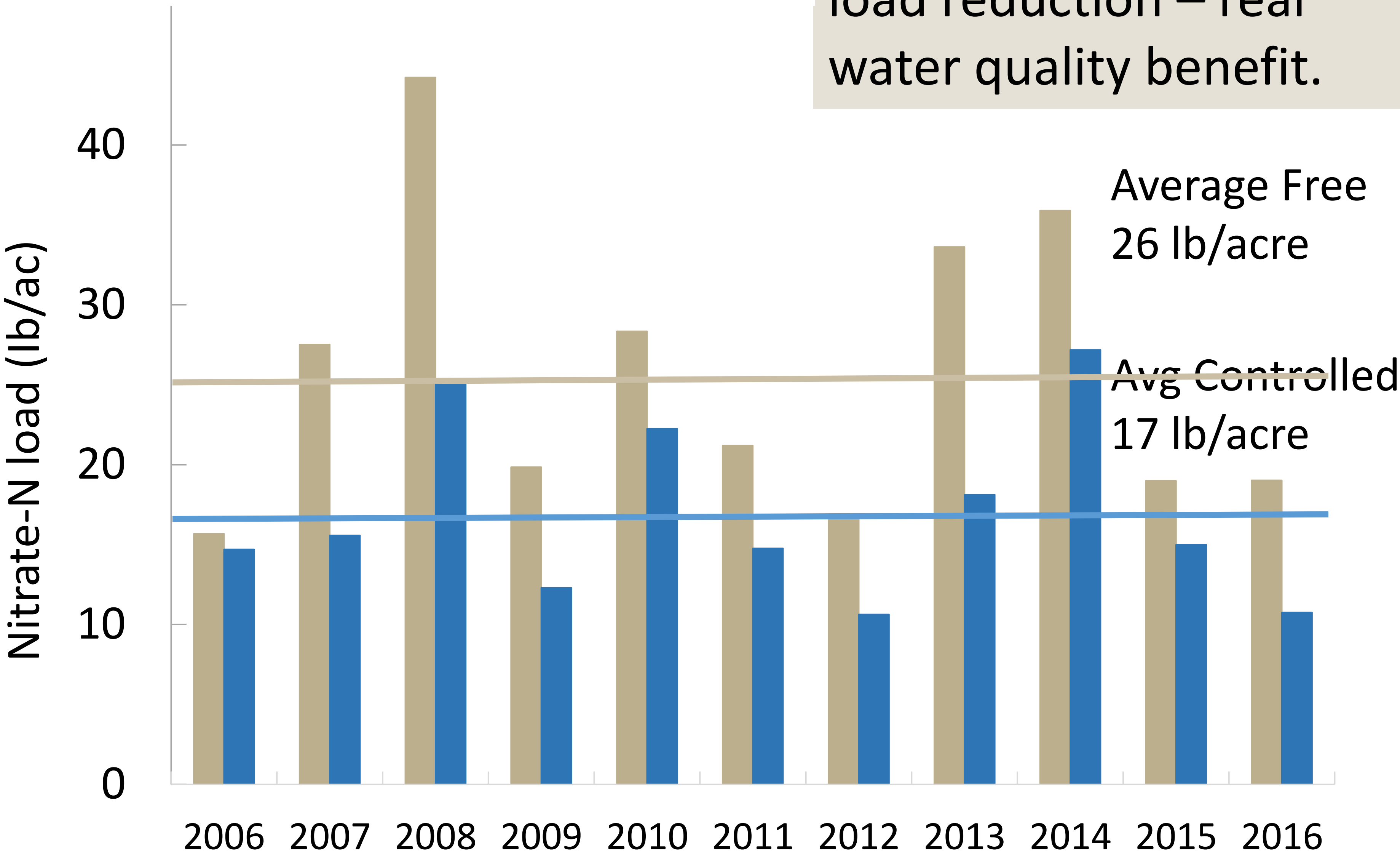


Average increase of 5 bu/acre with controlled drainage

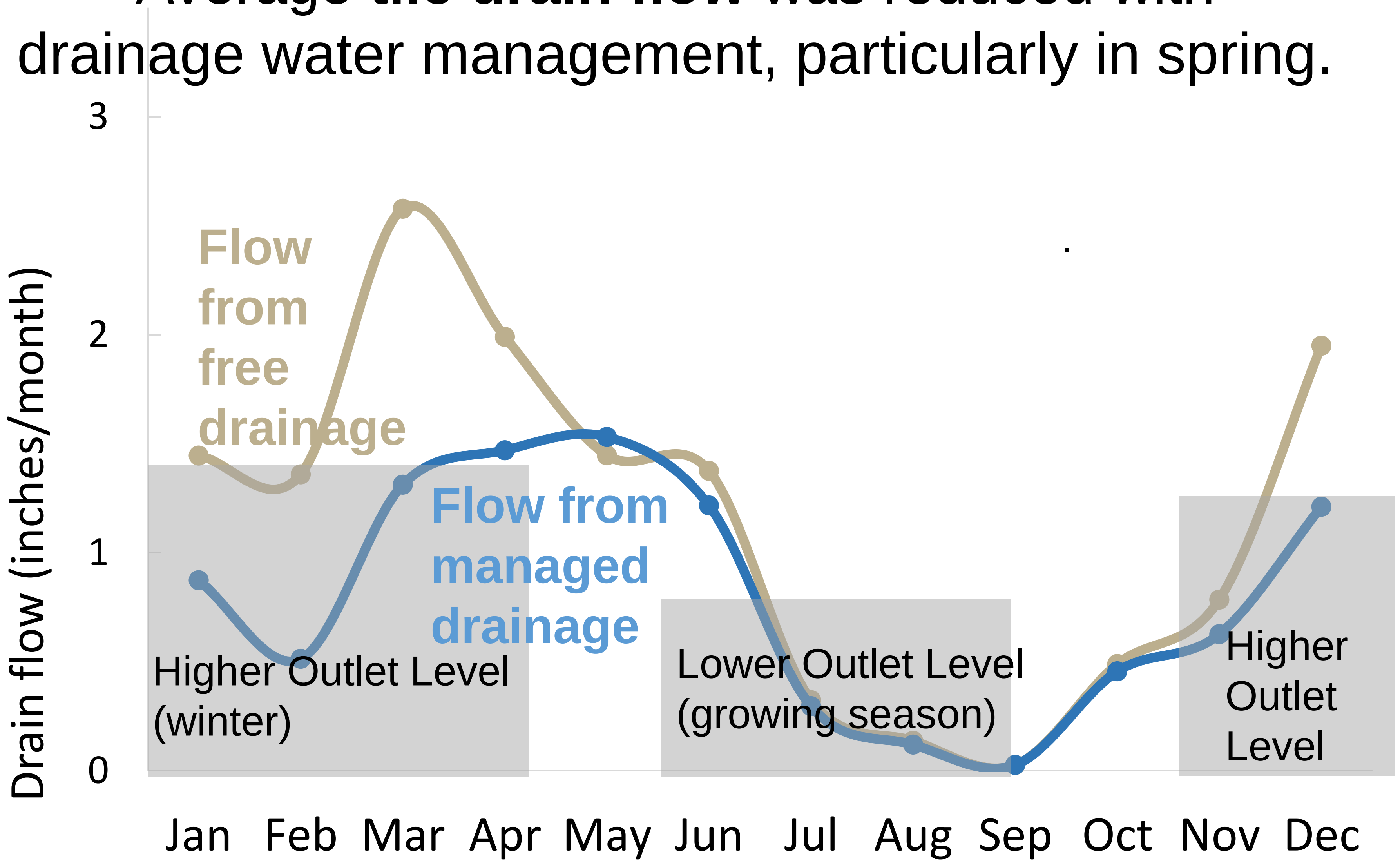
Drain flow, nitrate, and phosphorus concentrations were monitored in each quadrant.

Average **nitrate load** (lb/acre)

9 lbs/acre = 35% nitrate load reduction – real water quality benefit.



Average **tile drain flow** was reduced with drainage water management, particularly in spring.



Scaling up – How can this work across the Midwest?

A $5 million USDA NIFA-funded Coordinated Agricultural Project

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NC STATE UNIVERSITY

UNIVERSITY OF MINNESOTA

NDSU NORTH DAKOTA STATE UNIVERSITY

IOWA STATE UNIVERSITY

USDA United States Department of Agriculture

SOUTH DAKOTA STATE UNIVERSITY

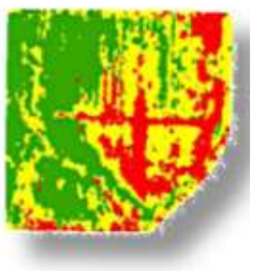
University of Missouri

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2015-68007-23193, "Managing Water for Increased Resiliency of Drained Agricultural Landscapes", http://transformingdrainage.org. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

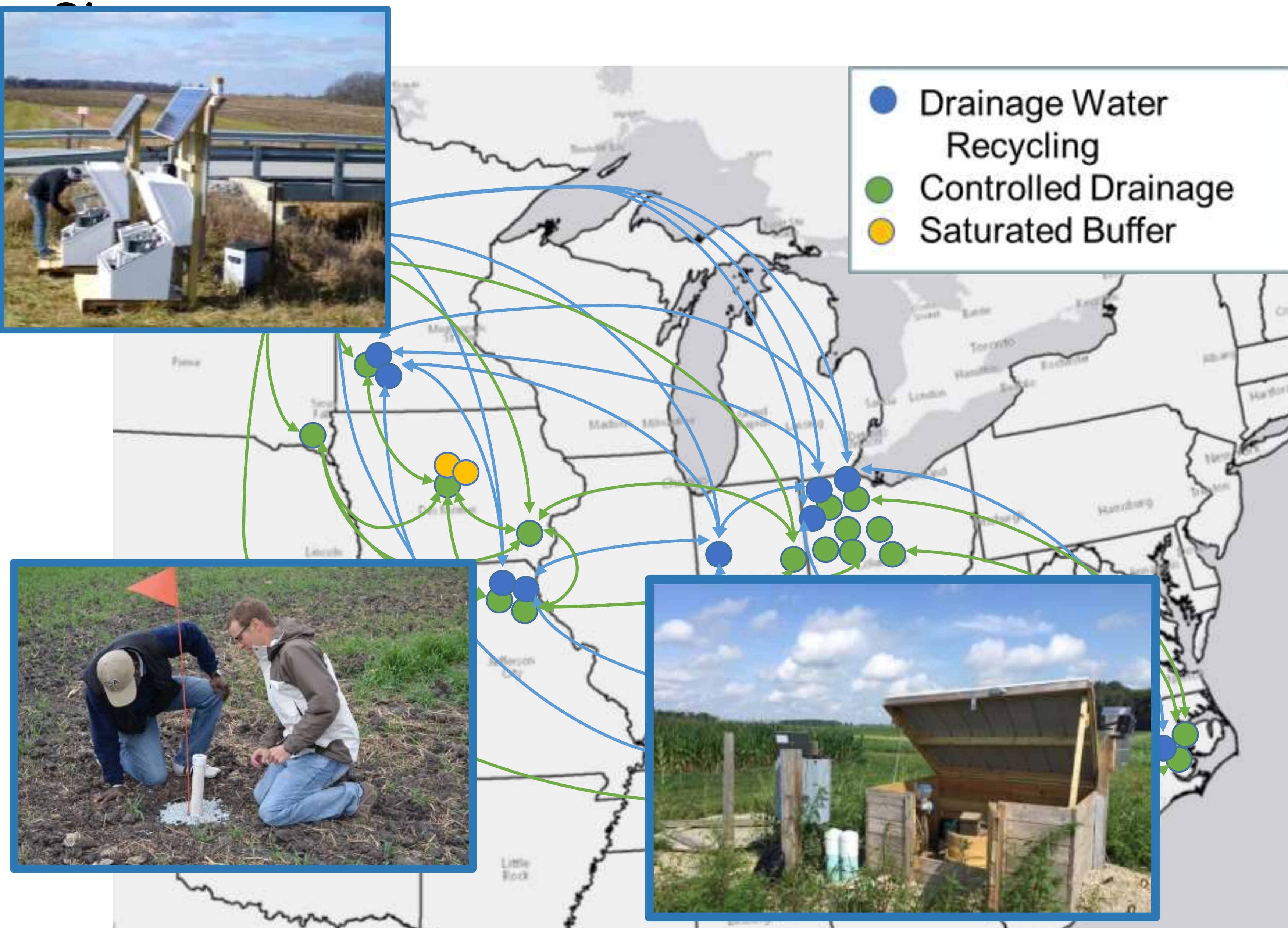
An integrated project to transform drainage

Field Research

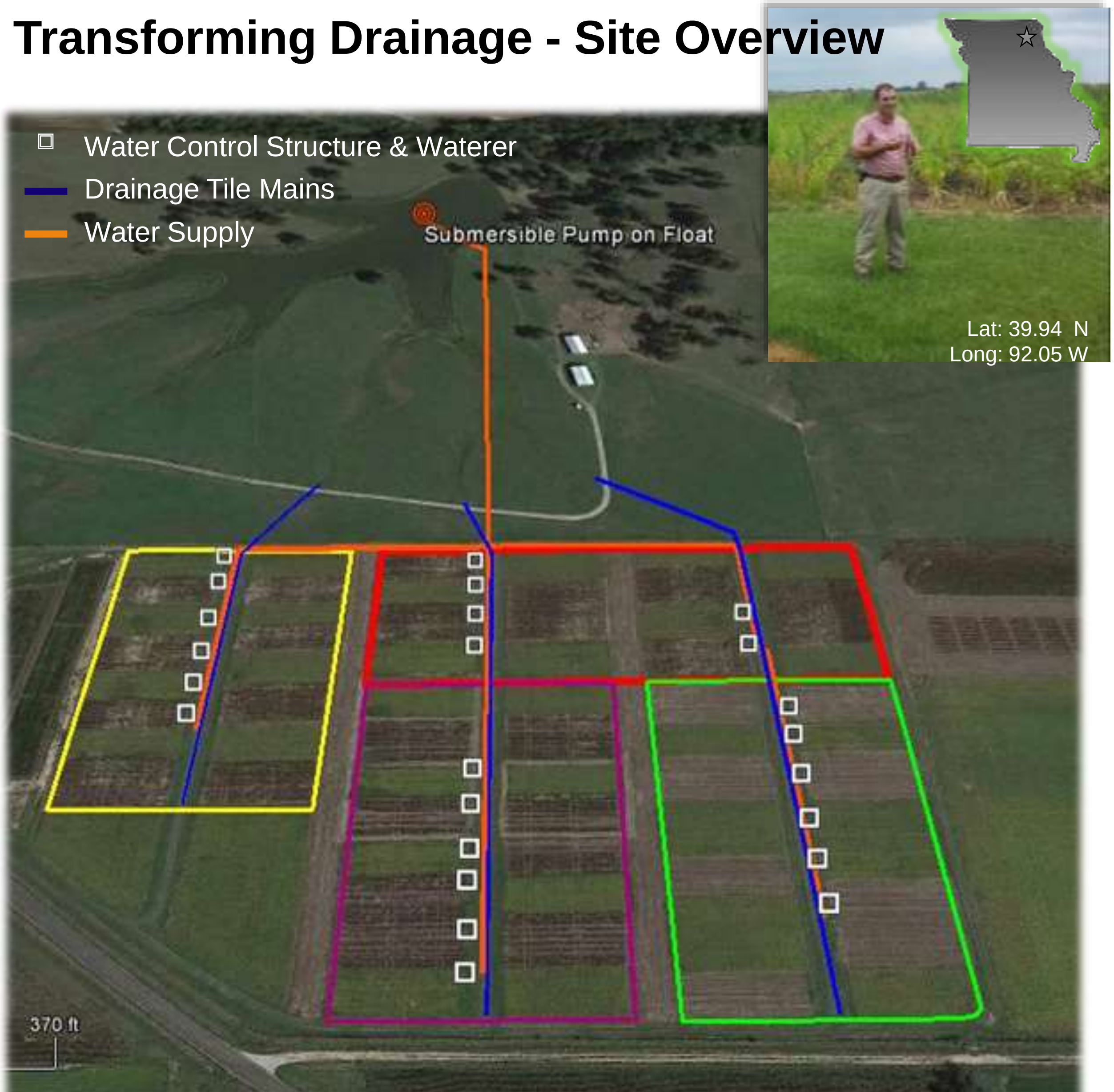


Strengthen and Broaden the Network
(Researchers, Industry, Contractors, Agencies)

Field Research – Existing, New, Historical



Transforming Drainage - Site Overview



Missouri Site

Research Leader: Kelly Nelson,
University of Missouri

Landscape:

- Claypan at approx. 24”

Water Management Practices:

1. Controlled Drainage, Subirrigation
   - 20’ & 40’ spacing
2. Conventional Drainage, No Irrigation
   - 20’ & 40’ spacing
3. No Drainage, Overhead Irrigation
4. No Drainage, No irrigation

Experimental Design:

- Split-Plot Design with 4 replications
- Main plots: water management treatment (150’ x 60-80’ depending on drain spacing)
- Subplots: crop (corn, soybean) with cultivars and fertilizer treatments (30’ x 20-40’)

Measurements:

- Crop yield – 2002 to 2014
- Rainfall/Irrigation water use – 2002 to 2013
- Soil organic matter – 2002 to 2012
- Soil NO_3 , NH_4, temperature, water content, soil water NO_3 (various depths) – 2004 to 2005
- Soil N_2O Flux – 2004 to 2005
- Grain nitrogen – 2006 to 2007

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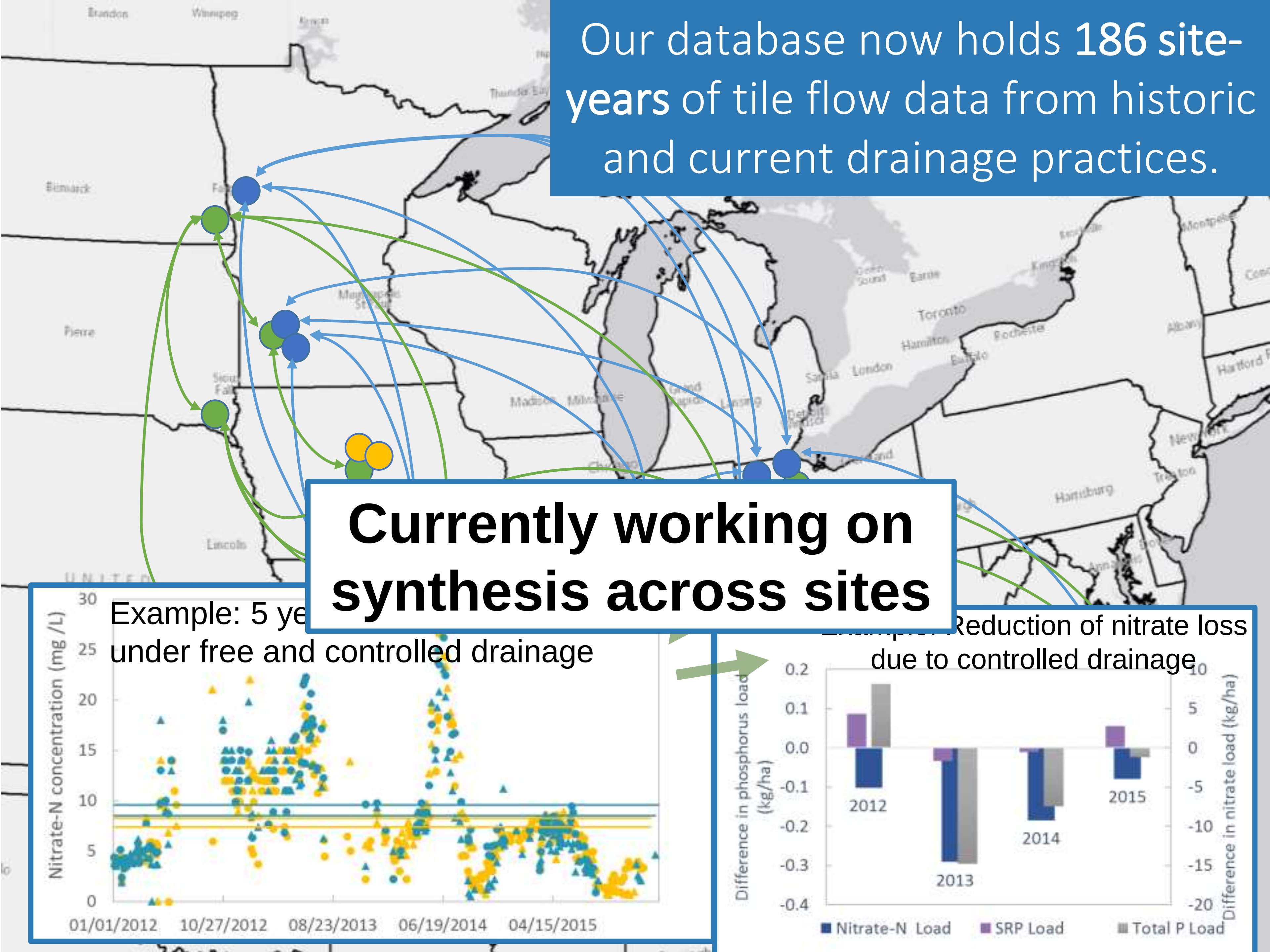
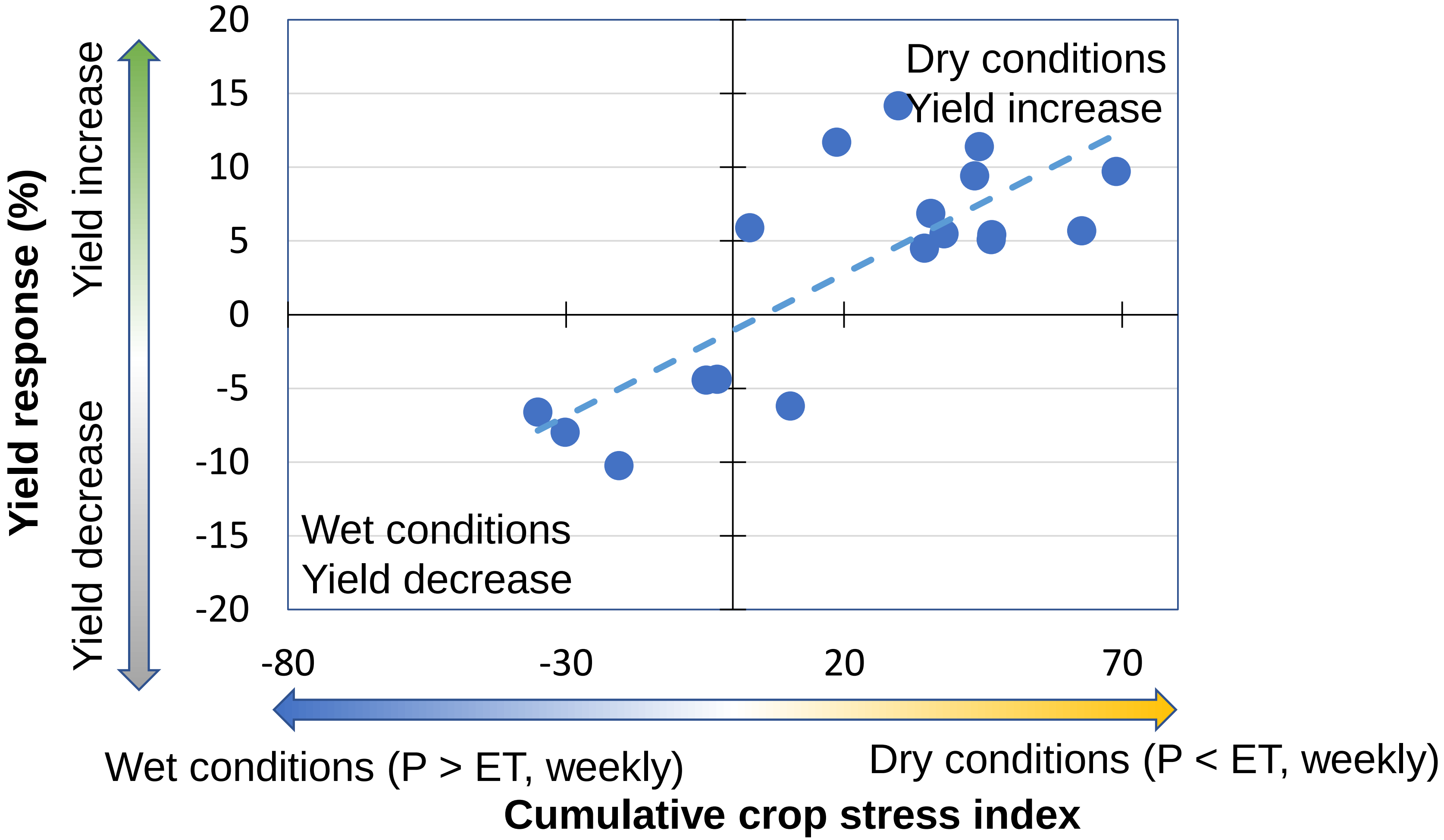
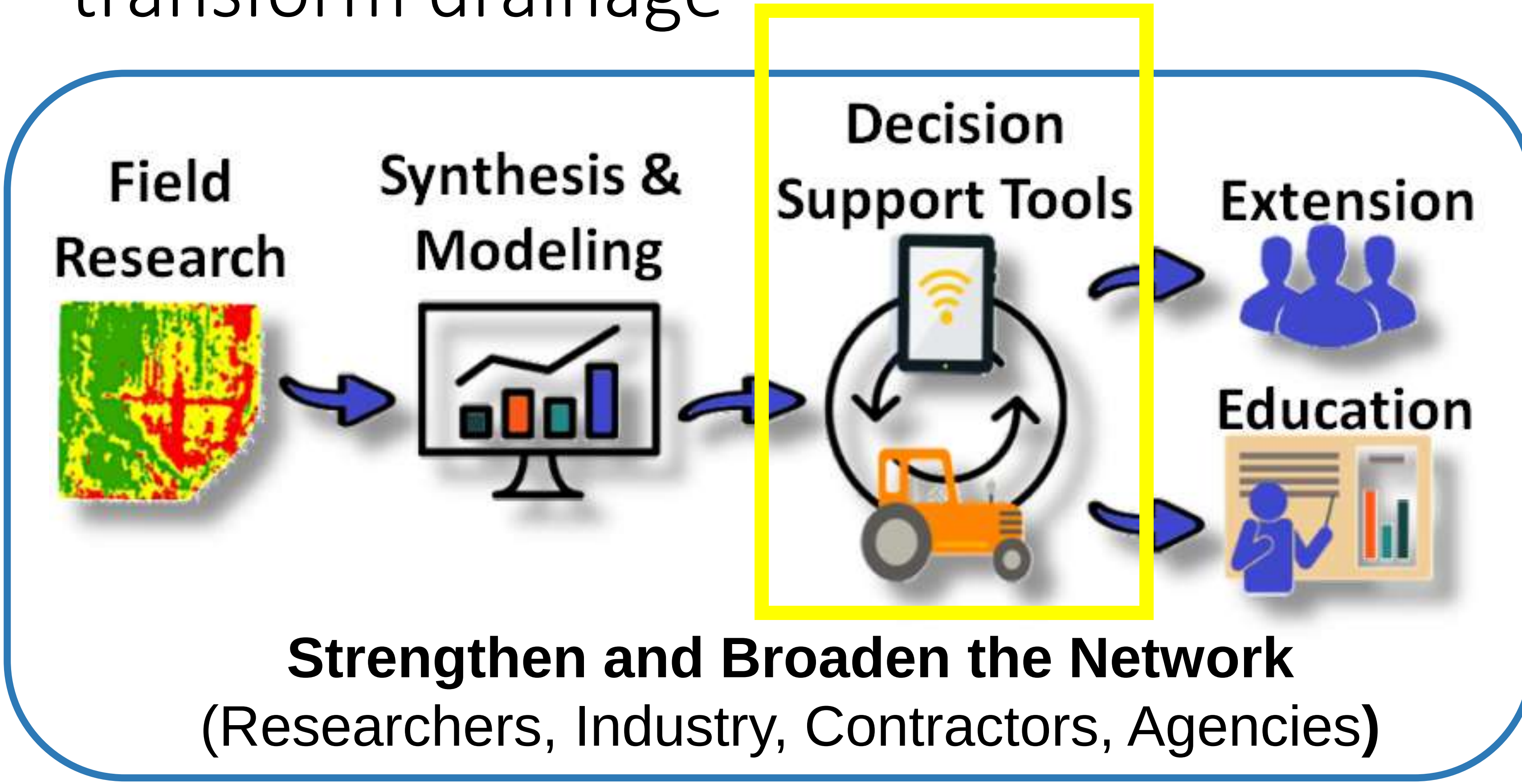

Our database now holds 186 site-years of tile flow data from historic and current drainage practices.
Currently working on synthesis across sites
Example: 5 ye
under free and controlled drainage
Nitrate-N concentration (mg /L)
30
25
20
15
10
5
0
01/01/2012
10/27/2012
08/23/2013
06/19/2014
04/15/2015
Example: Reduction of nitrate loss
due to controlled drainage
Difference in phosphorus load (kg/ha)
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
2012
2013
2014
2015
10
5
0
-5
-10
-15
-20
Difference in nitrate load (kg/ha)
Nitrate-N Load
SRP Load
Total P Load
Bismarck
Pierre
Lincoln
Madison
Milwaukee
Toronto
Hamilton
London
Rochester
Albany
Harrisburg
Trenton

Yield analysis of 8 controlled drainage sites spanning IN, OH, MN, MO, IA, and NC and representing 18 unique site-years



Result: Statistically significant yield increase in dry years.

An integrated project to transform drainage



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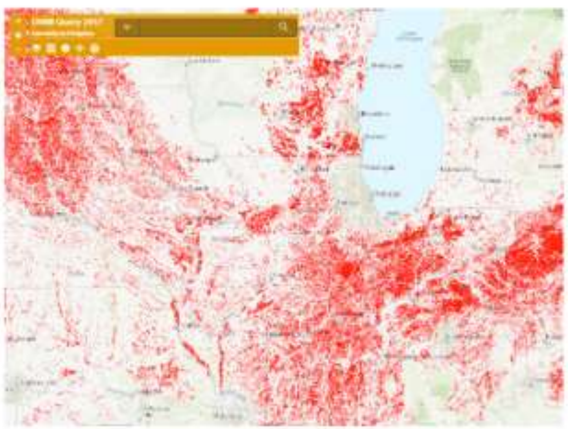
Tools Overview

Controlled Drainage Suitability Tool

This map identifies land in Midwest that has a high probability of being suitable for controlled drainage.

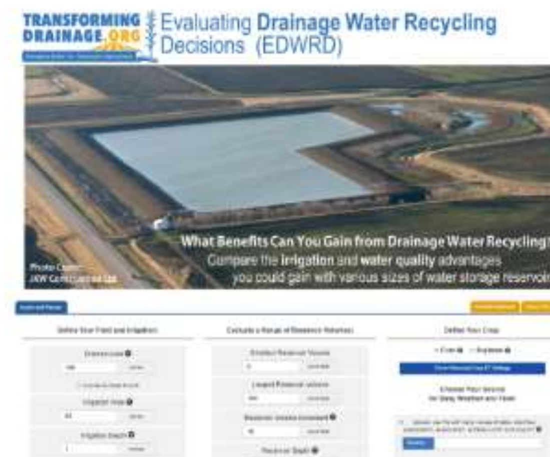


Subirrigation Site Suitability Tool

This web mapping application identifies land in the Midwest that has a high probability of being suitable for subirrigation

Evaluating Drainage Water Recycling Decisions (EDWRD)

This tool provides estimates of the potential irrigation and water quality benefits from drainage water recycling.



Transforming Drainage Project – Decision Support Tools

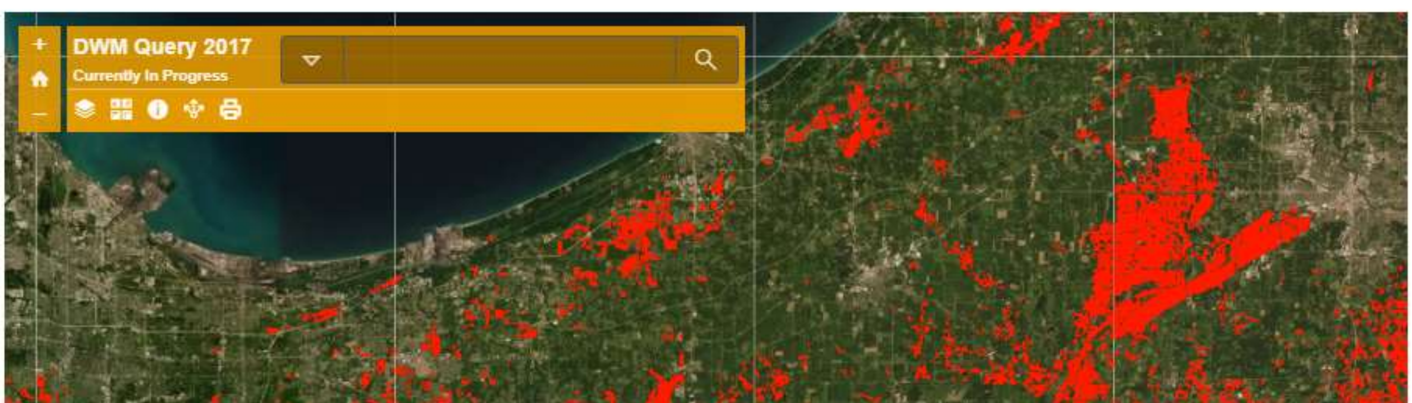
Controlled Drainage Suitability Tool

This map identifies land in the Upper Midwestern United States that has a high probability of being suitable for **controlled drainage** (CD). The soils have been identified as likely to be or have been drained for crop production. And for economic feasibility, the identified land is relatively flat to maximize the spatial area controlled by each water control structure. The data sources are the United States Department of Agriculture: 2017 gSSURGO data from the Natural Resources Conservation Service (USDA-NRCS) and the 2015 Cropland Data Layer from the National Agricultural Statistics Service (USDA-NASS).

The NRCS query that is mapped represents the following:

- Flat topography (1% slope or less)
- Soils that have a seasonal high water table (saturated to within 18 inches (46 cm) of the surface during the growing season)
- Cropland land use
- 15 acres or more of contiguous surface area (to represent economic feasibility)

This map is designed to give a broad picture of the locations in the region that are likely to be involved in CD activities to a greater extent. The map does not take into account property boundaries, and the fact that land owners and managers on neighboring properties may have different goals and objectives that may not include CD. Also, areas that are not identified in this map may actually be suitable for CD, depending on the site specific topography, drainage system layout, and other factors. The map utilizes data that are intended for use at a broad scale, rather than a site specific scale, so field verification of the suitability of any site is still needed when evaluating potential projects.



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This map identifies the potential suitability for subirrigation of land in the Upper Midwestern United States. It identifies agricultural land that has a restricting layer that causes the water table ...

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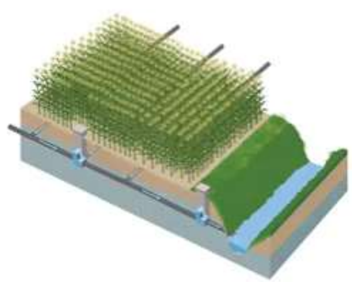

Controlled drainage, also known as drainage water management, is the practice of using a water control structure to raise the depth of the ...

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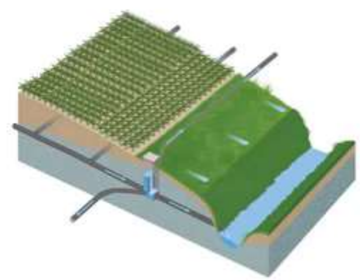
SATURATED BUFFERS



Saturated buffers store water within the soil profile of field buffers, by diverting tile water into shallow laterals that raise the water ...

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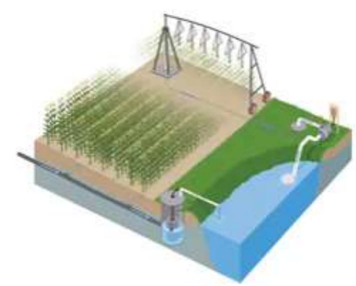
DRAINAGE WATER RECYCLING



Drainage water recycling is the practice of capturing excess water drained from fields, storing the drained water in a pond, a reservoir, or ...

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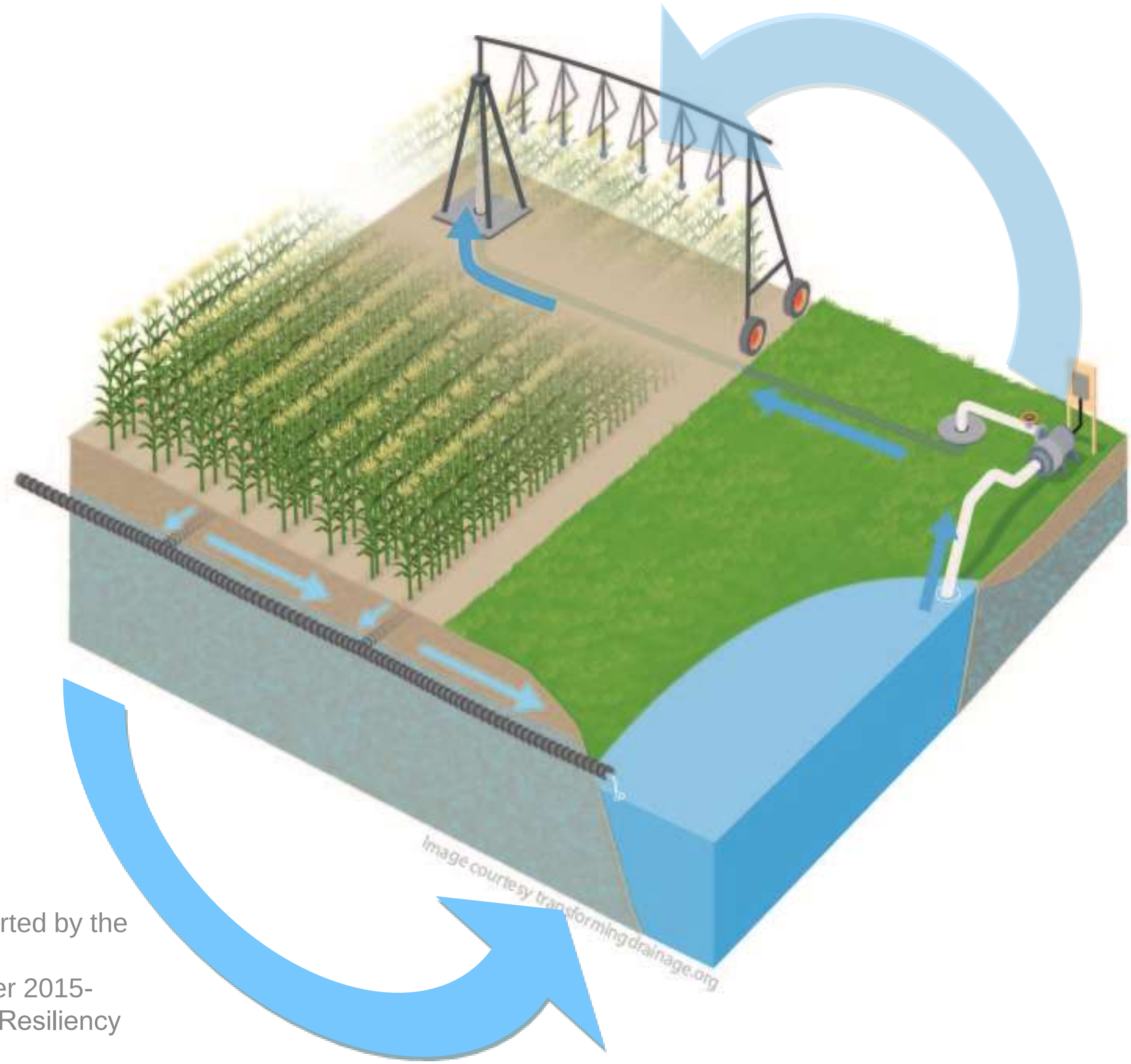
Storing water in a pond or reservoir, then recycling drainage water back onto fields

New concept: Irrigating nutrient-rich drainage water back onto crops

Drainage Water Recycling



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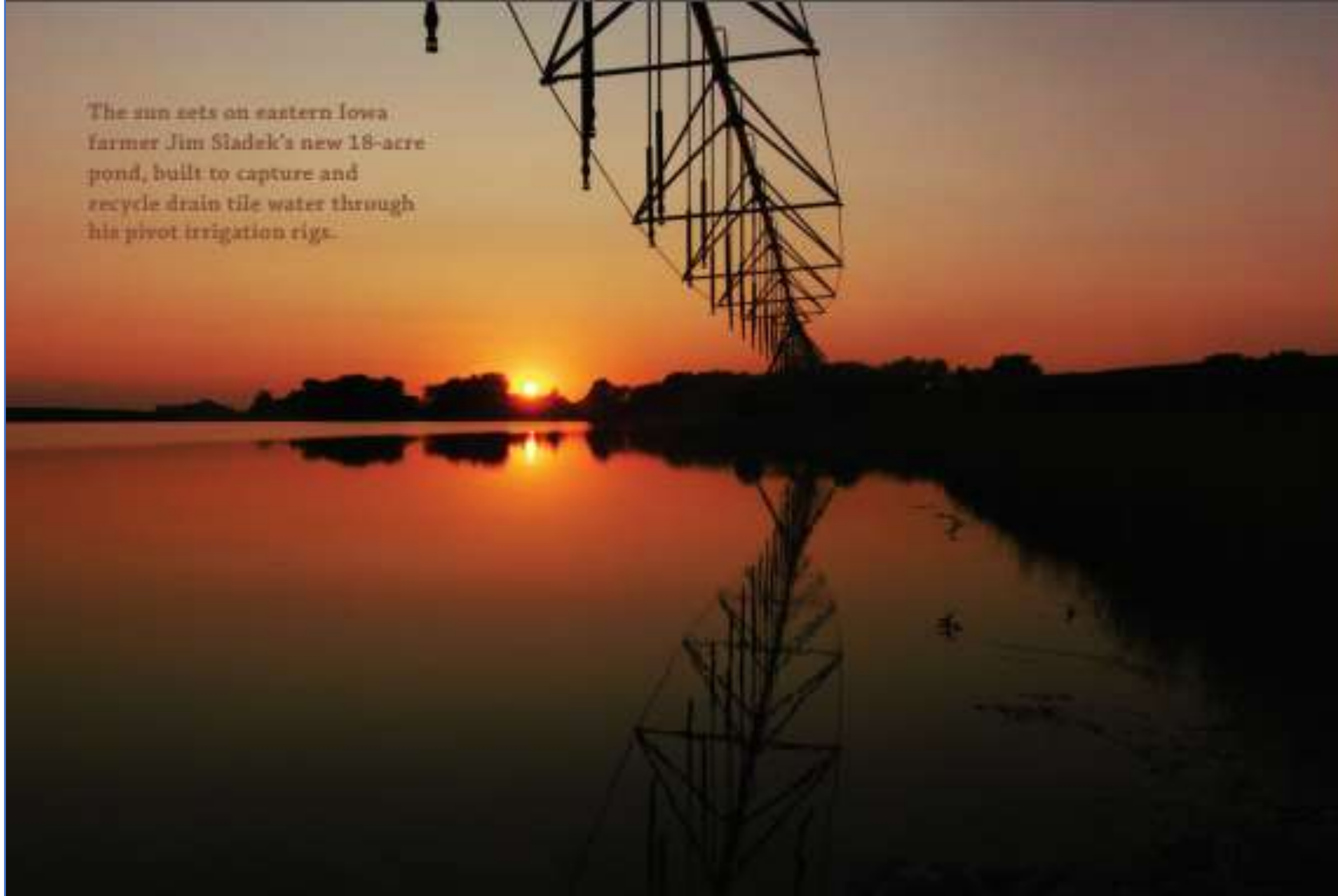
This practice is rare, but there are a few examples.

Corn and Soybean Digest



The sun sets on eastern Iowa farmer Jim Sladek's new 18-acre pond, built to capture and recycle drain tile water through his pivot irrigation rigs.

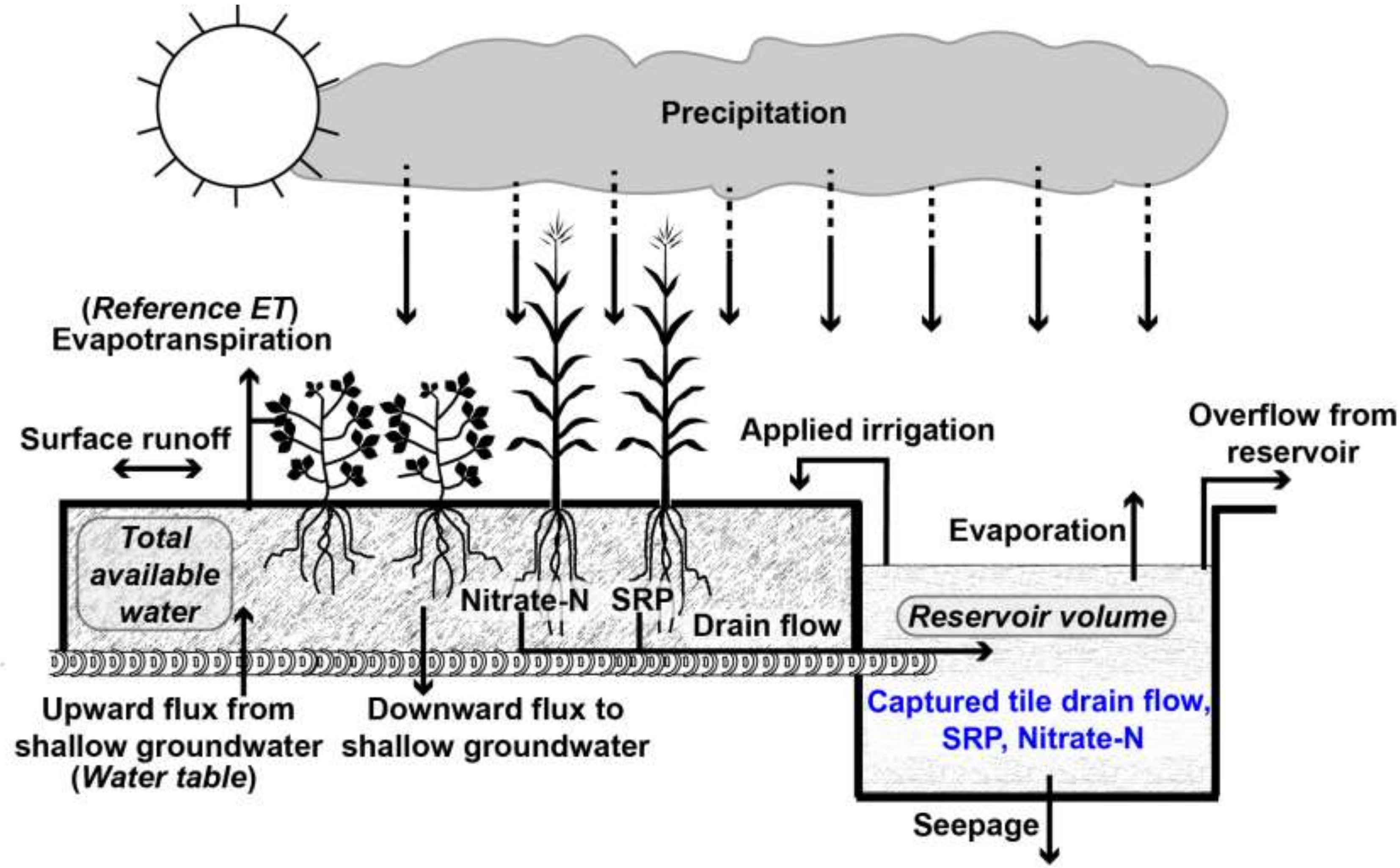
New farm pond recycles drainage water

Iowa farmer builds profitable pond to capture excess

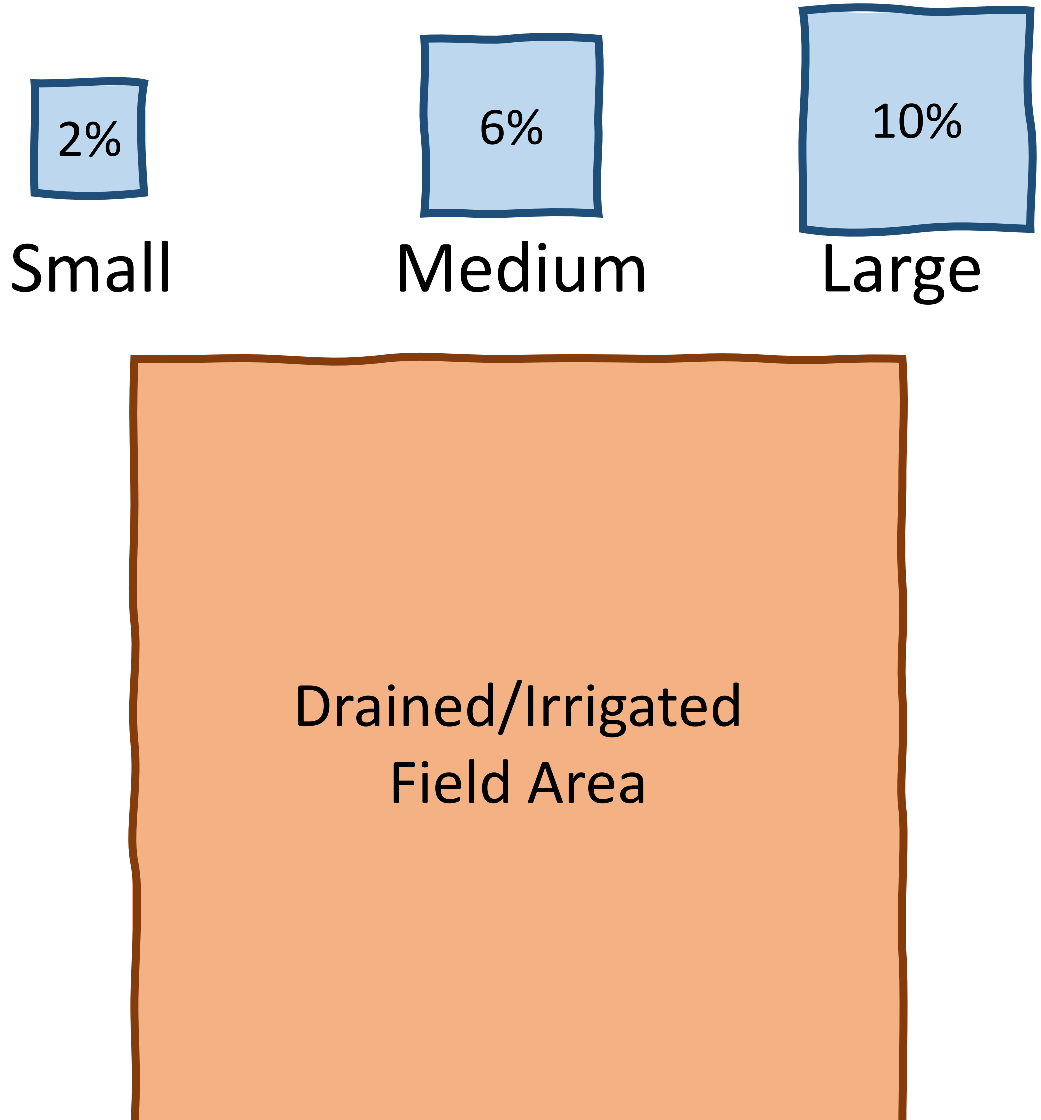
about irrigation. With the installation of an 18-acre pond in mid-December 2014, the eastern Iowa grower married the two passions. By April 1, the pond was full, ready and waiting for

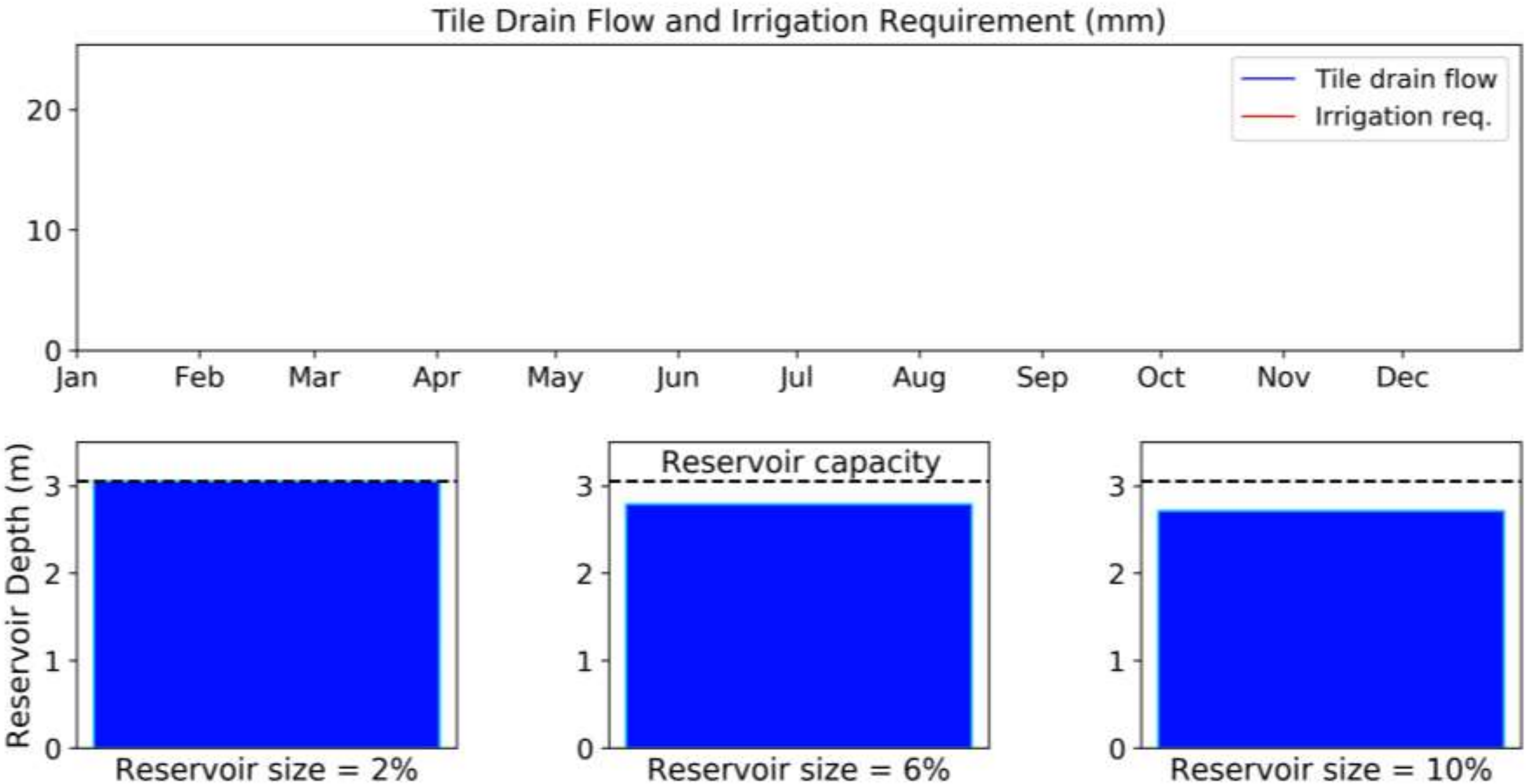
the water in a 10-foot-deep, 10-acre pond could average $50,000 per year," says Sladek. "That's a net return of $5,000 per acre."

We developed a model to evaluate drainage water recycling benefits, by combining soil water balance and reservoir water balance.

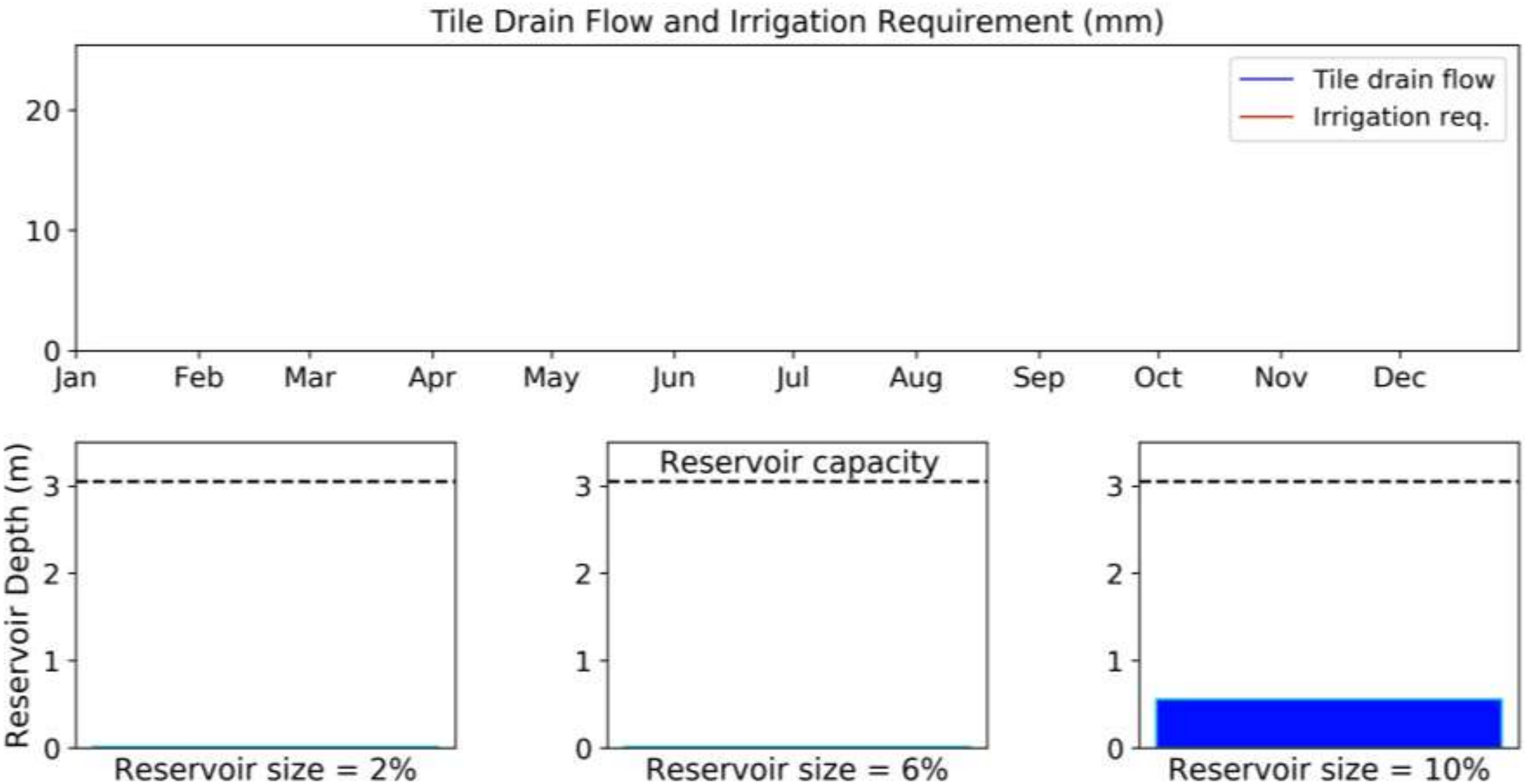


We evaluated 3 reservoir sizes, average depth 10 feet, using drain flow data we measured at Davis Purdue Ag Center.



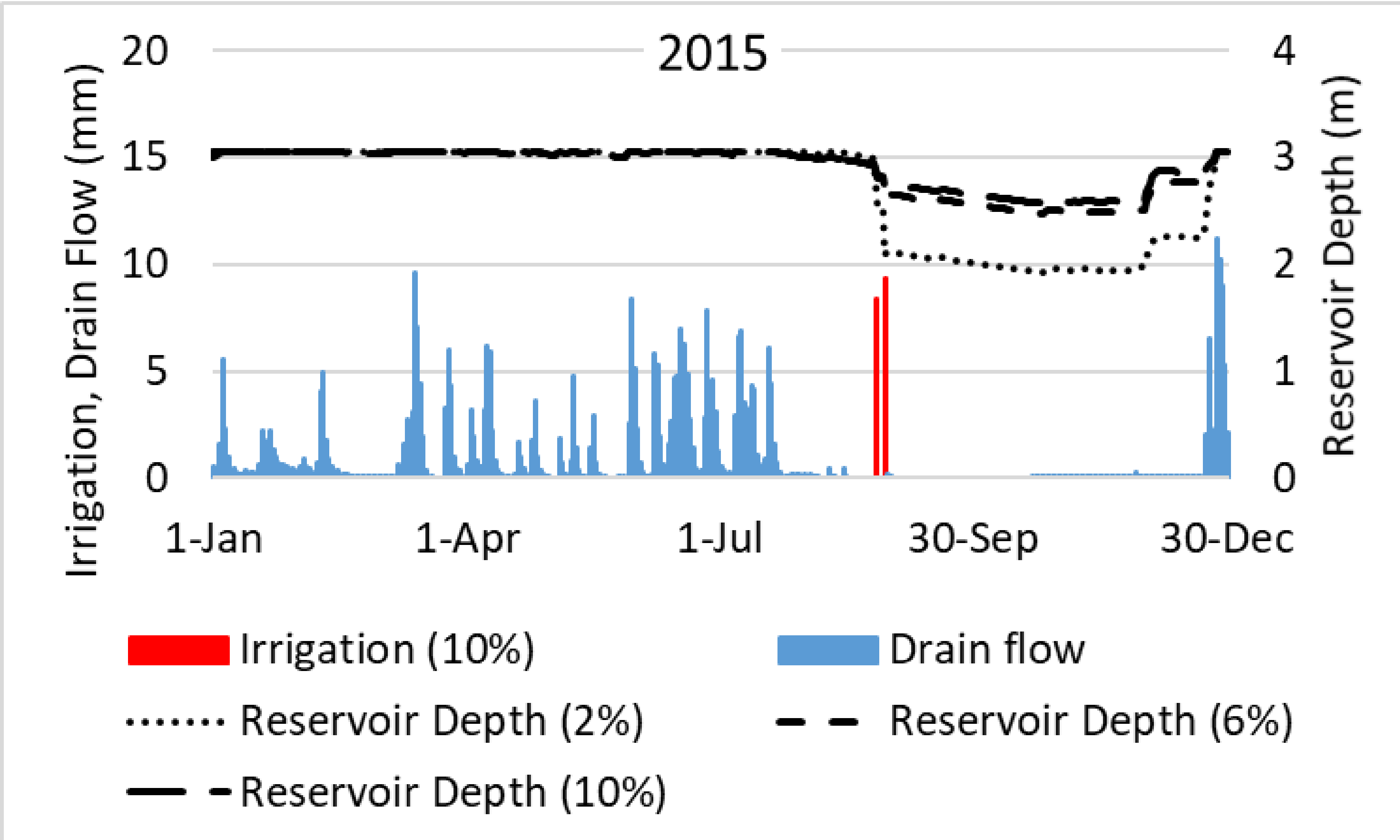


Larger reservoir can provide more irrigation water (needed in some years). (Animation by Ben Reinhart)

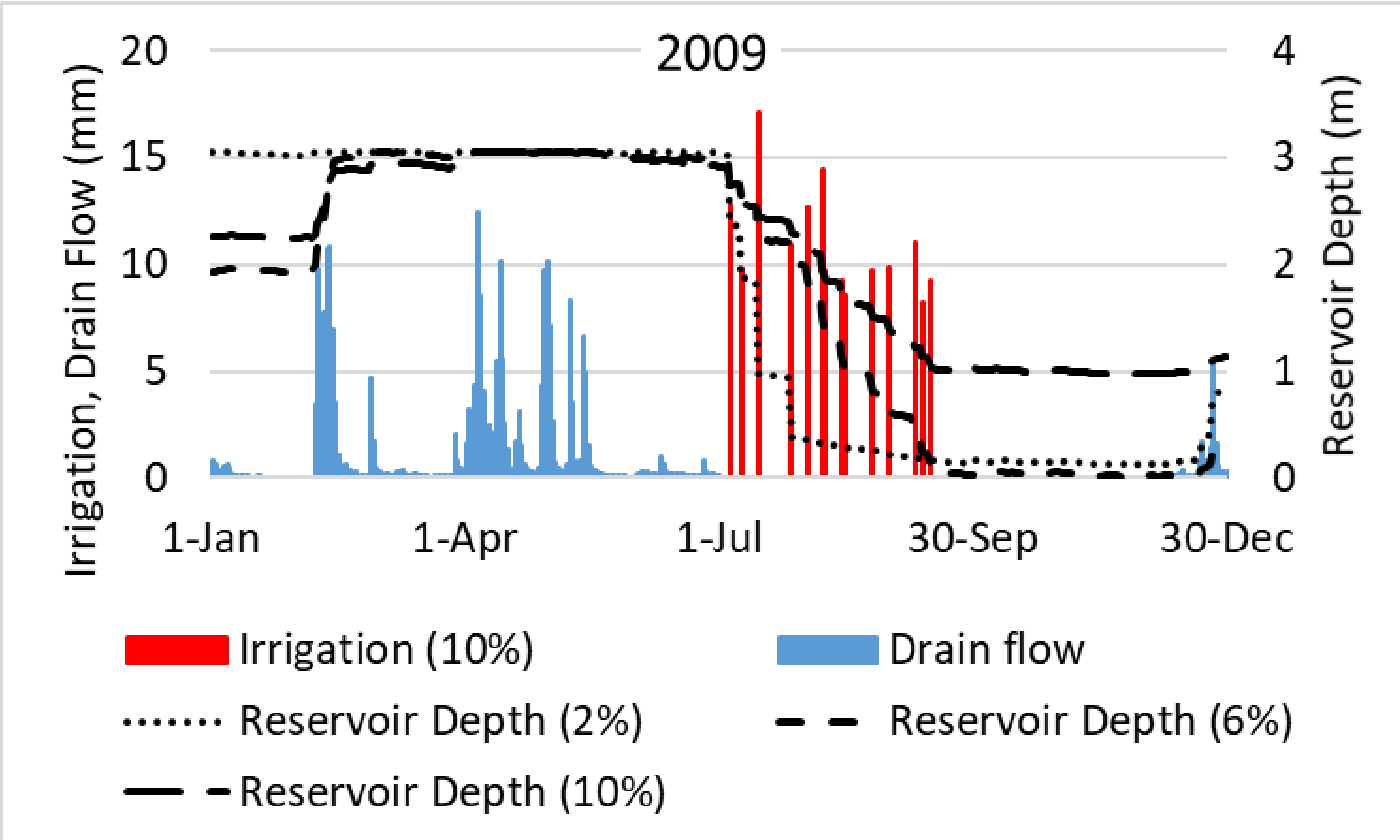


Reservoirs capture nutrient loads (keeping nutrients out of waterways), especially after a dry year

Water flows at the DPAC – Wet year



Water flows at DPAC – Dry year



Performance of drainage water recycling evaluated using two metrics

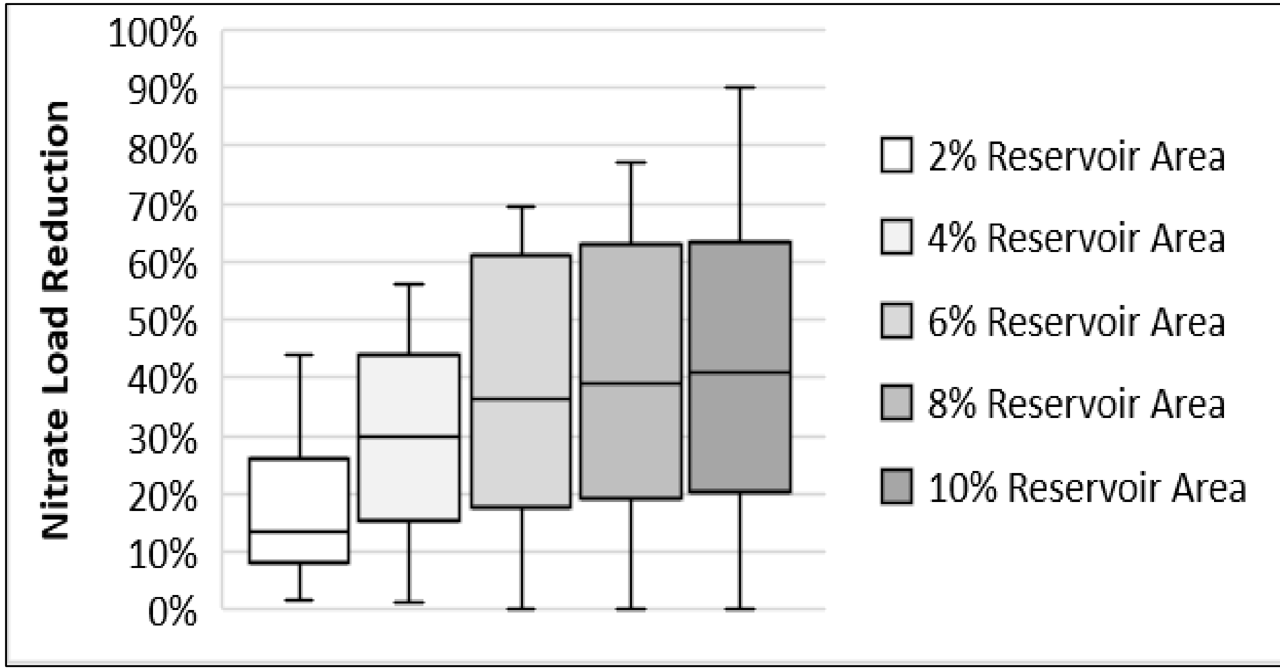
Nutrient loss reduction

- Percent reduction of annual N or P lost from the field

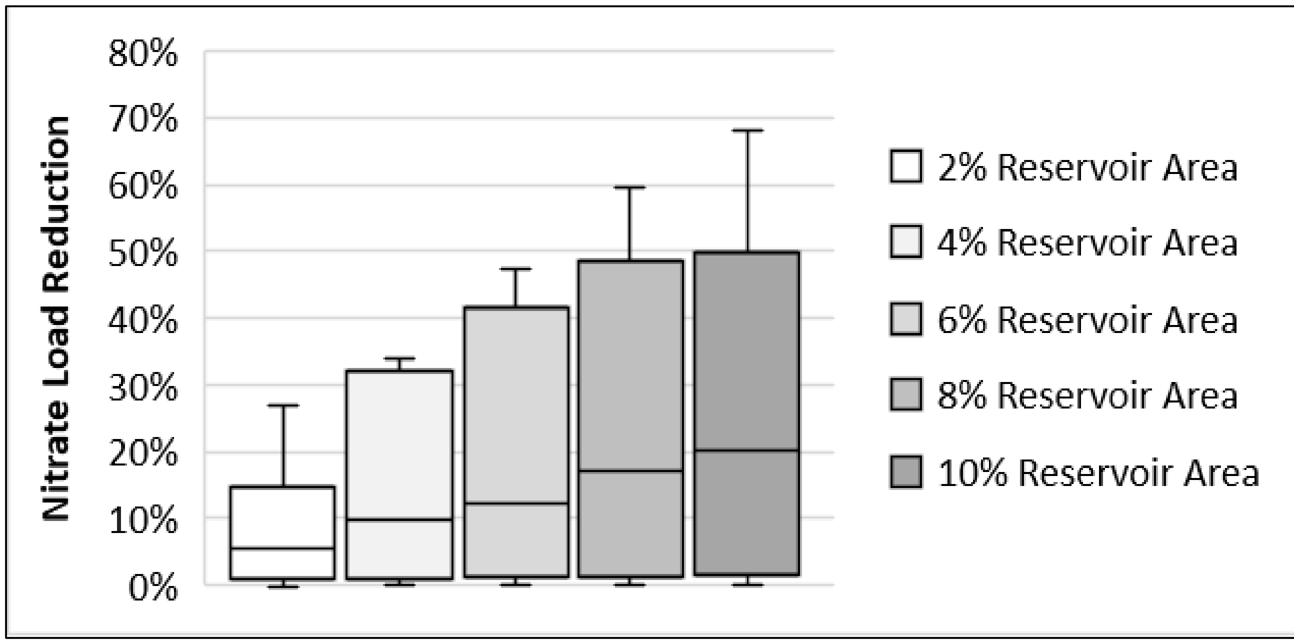
Irrigation

- mm of water applied
- Percent of irrigation demand ("desired irrigation") that was available.

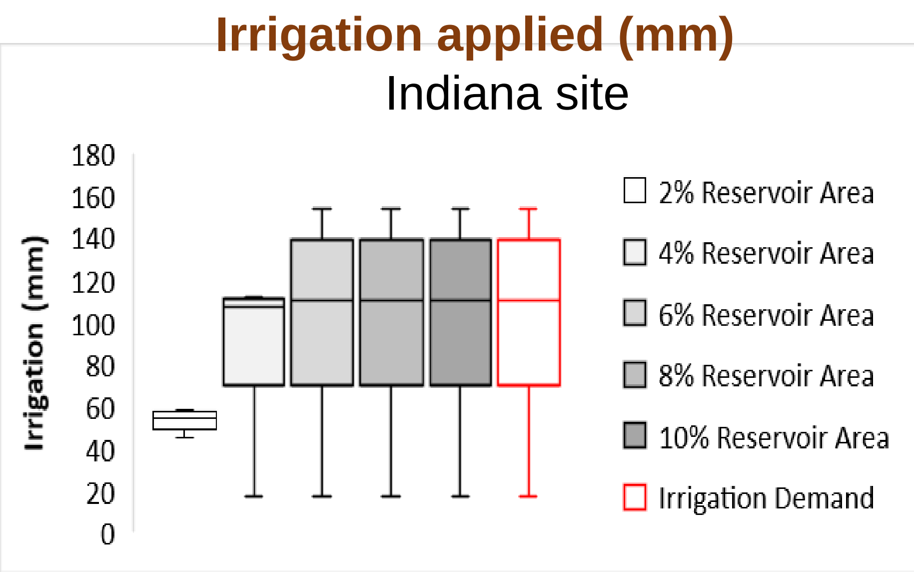
- Nitrate load reduction – Indiana site (DPAC)

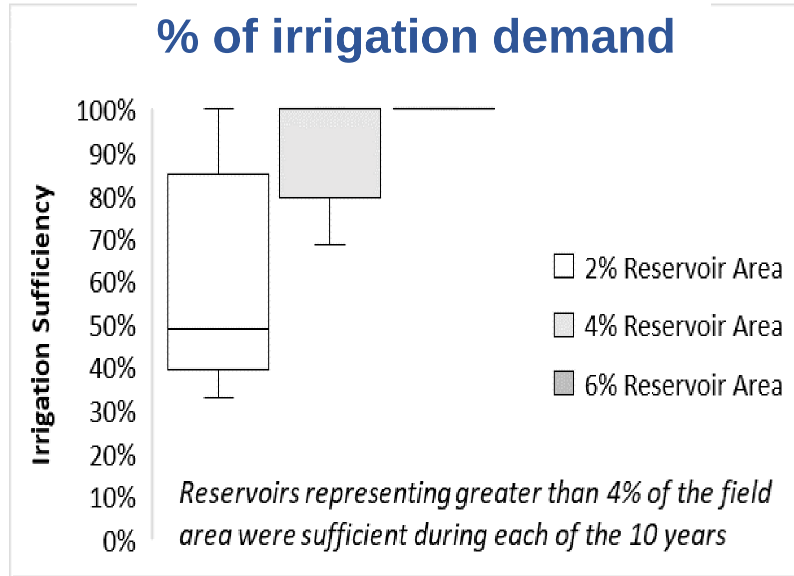


- Nitrate load reduction – Iowa site

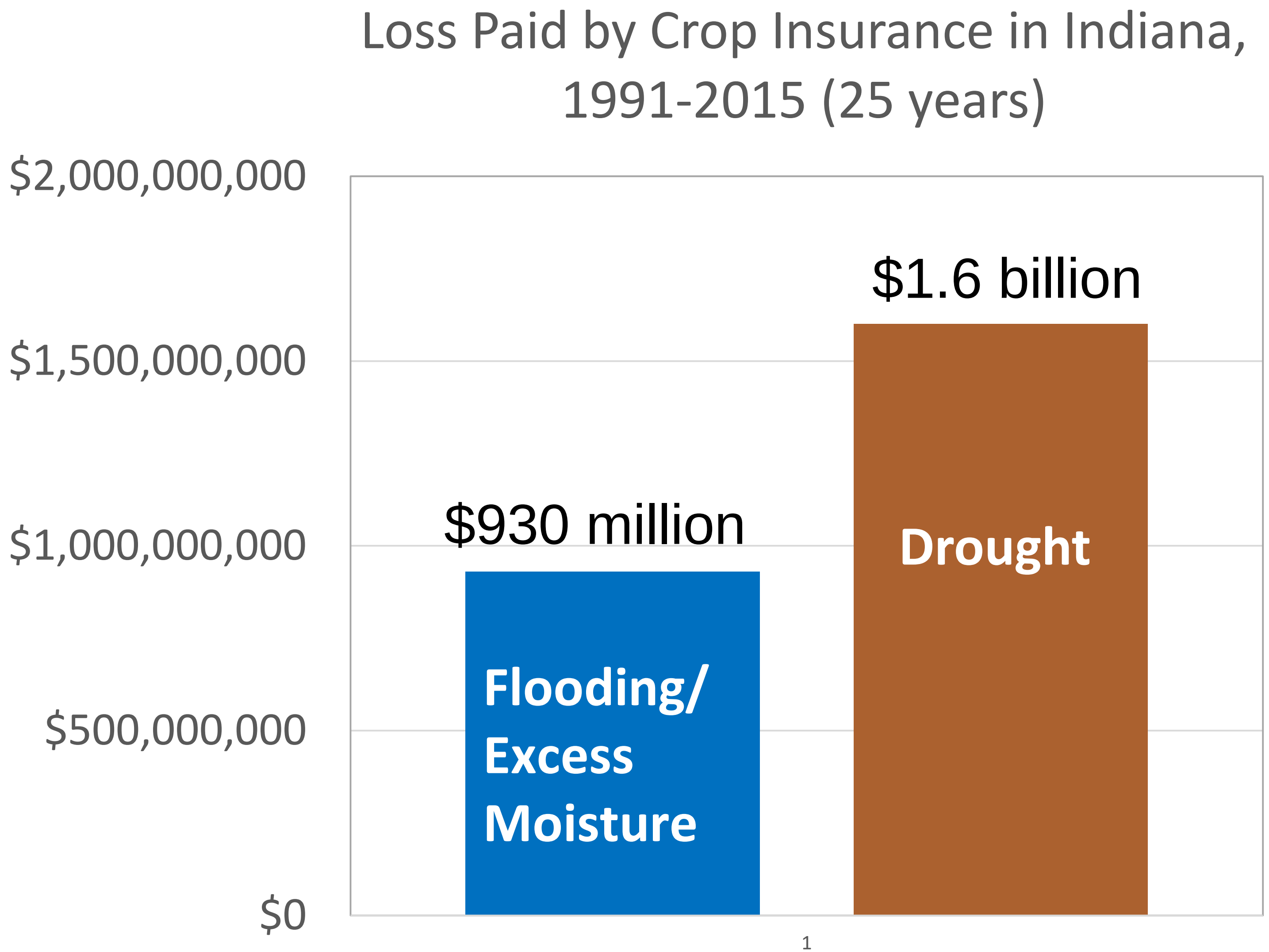


Looking longer term: 10 years of drain flow data



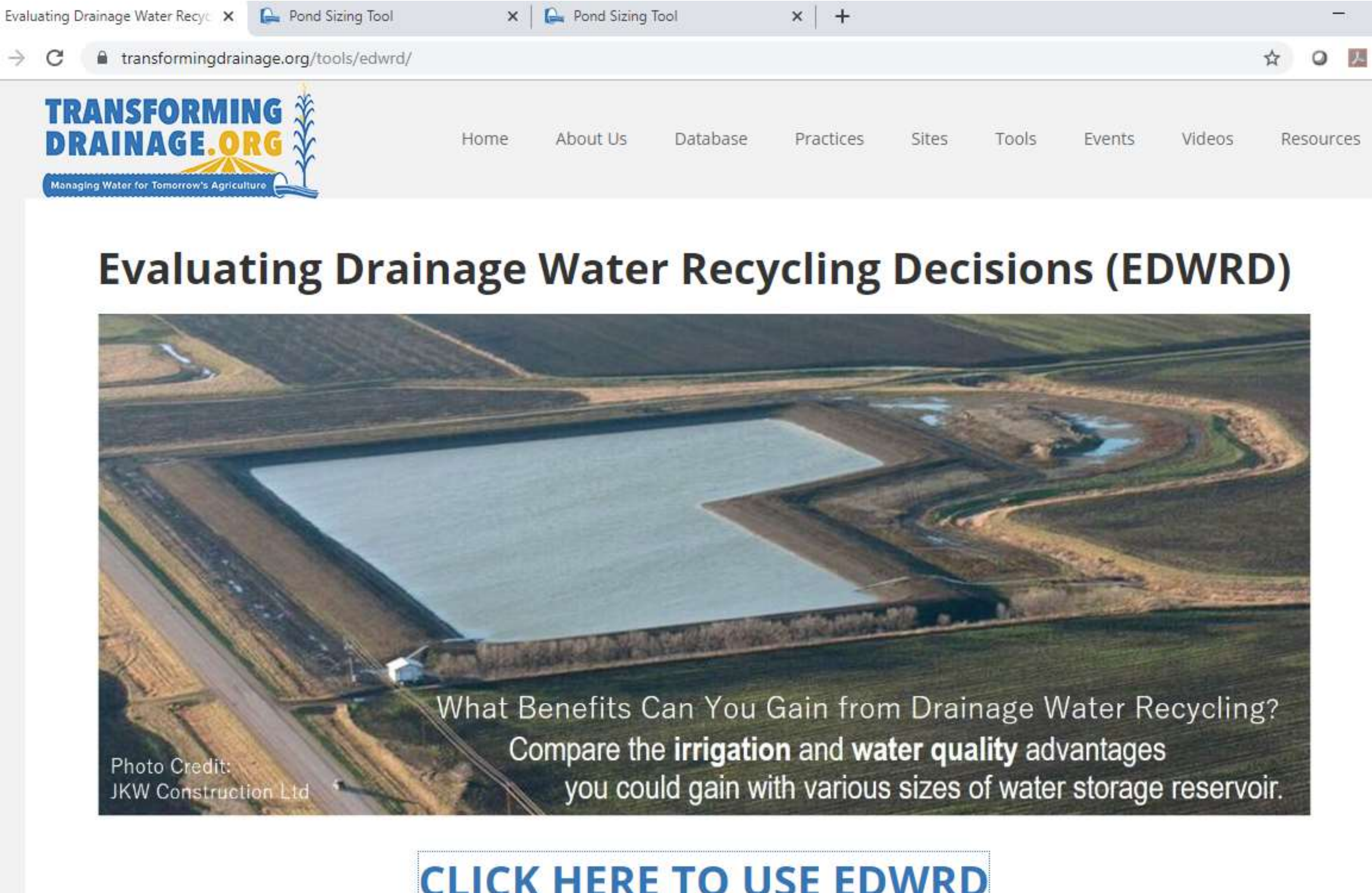


Will it pay?



Analysis by Ben Reinhart

Analysis is freely available in an online tool.



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Nick Hermanson of Story City has been utilizing drainage water recycling on his farms for several years. Drainage recycling utilizes ponds that hold water during the spring and early summer. The water ...

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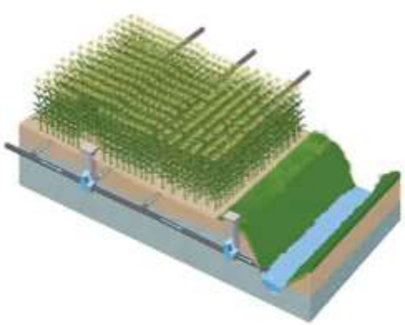

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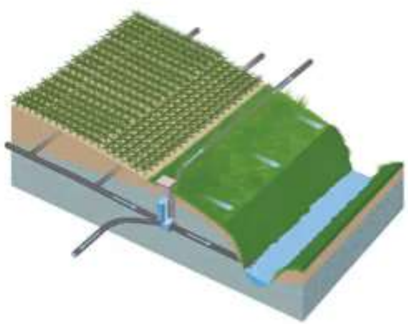
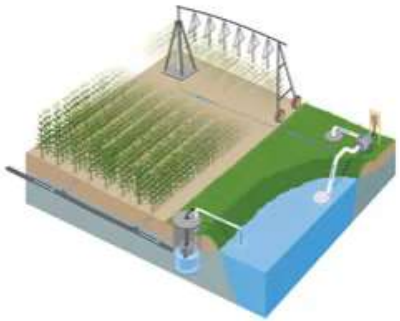
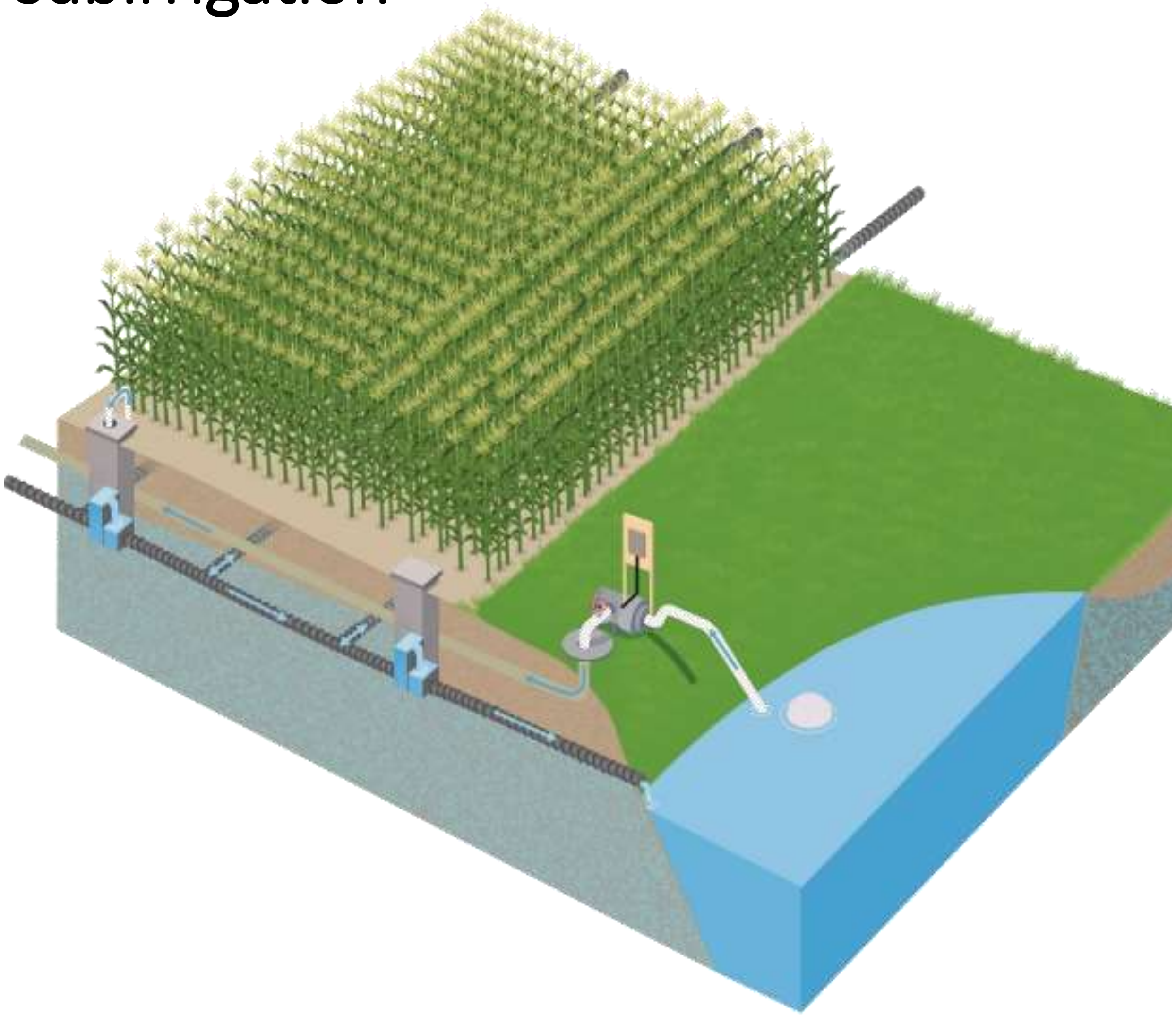


DRAINAGE WATER RECYCLING



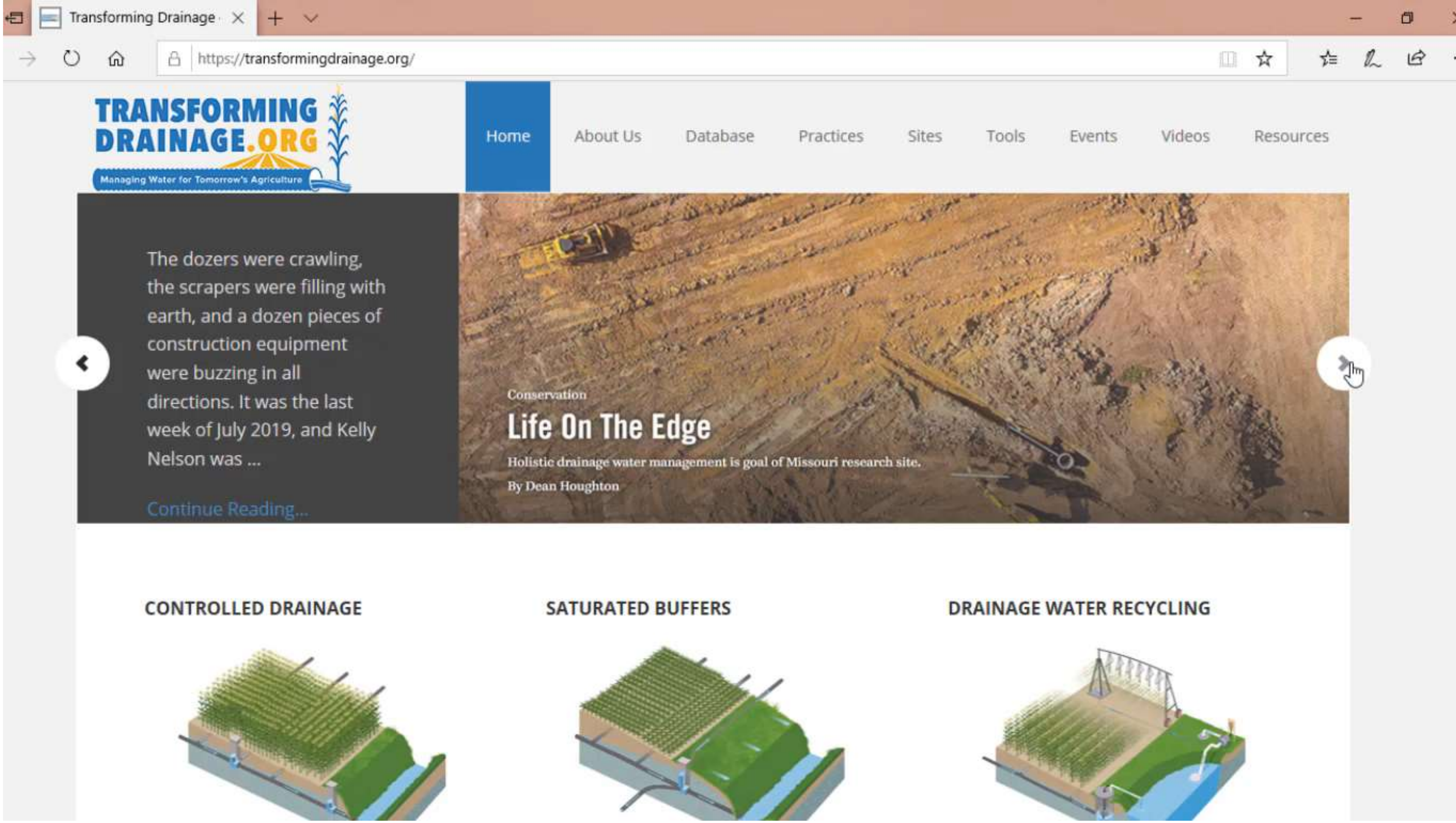
Irrigation can be through a sprinkler, or **subirrigation**



But specific site properties needed:

1. High hydraulic conductivity
2. Very low slope
3. Impermeable layer that holds up the water

Where are these found?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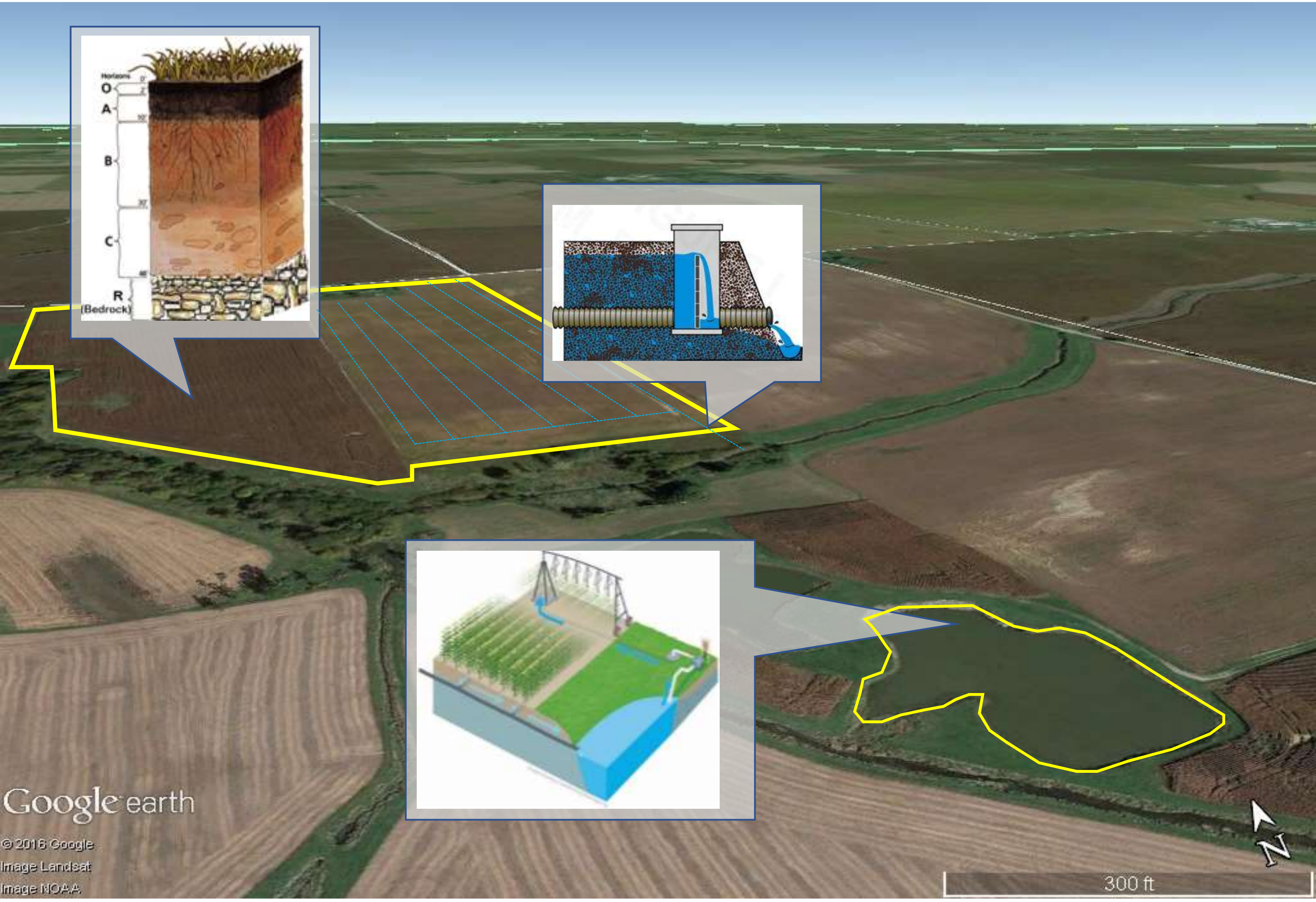
The dozers were crawling, the scrapers were filling with earth, and a dozen pieces of construction equipment were buzzing in all directions. It was the last week of July 2019, and Kelly Nelson was ...
Continue Reading...
Conservation
Life On The Edge
Holistic drainage water management is goal of Missouri research site.
By Dean Houghton
CONTROLLED DRAINAGE
SATURATED BUFFERS
DRAINAGE WATER RECYCLING

We need to use all these opportunities for water storage.

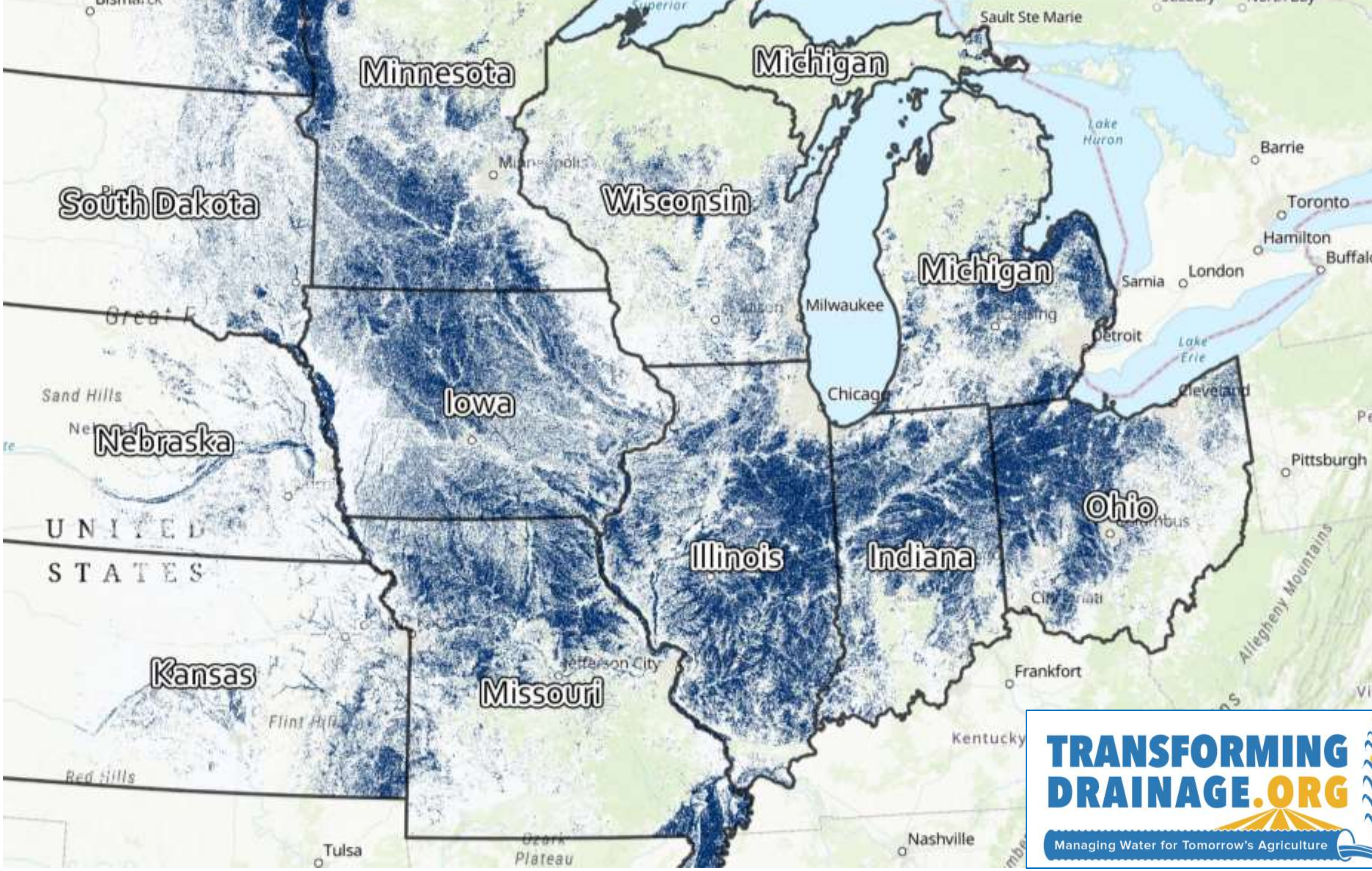


Benefits of Transforming Drainage

- Reduce uncertainty and risk related to water availability

- Reduce nutrient losses from agricultural fields

Transforming Drainage addresses drained agricultural land across the Midwest.



TRANSFORMING DRAINAGE.ORG

Managing Water for Tomorrow's Agriculture

Extension and Engagement to Transform Drainage

- Informative website

TransformingDrainage.org

- Links to all project outputs
- Practice descriptions
- Research site overviews
- Links to news and social media

- Regional Extension Publications

"Questions and Answers About Drainage Water Recycling for the Midwest"

TRANSFORMING DRAINAGE.ORG

EXPERT REVIEWED

ABE-156-W

Questions and Answers About Drainage Water Recycling for the Midwest

Jane Frankenberger, Ben Reinhart, Kelly Nelson, Laura Bowling, Chris Hay, Mohamed Youssef, Jeff Strock, Xinhua Jia, Matt Helmers, Barry Allred

WHAT IS DRAINAGE WATER RECYCLING?

Drainage water recycling is the practice of capturing excess water drained from fields, storing the drained water in a pond, a reservoir, or a drainage ditch, and using the stored water to irrigate crops when there is a water deficit. Relative to conventional drainage, drainage water recycling has two major benefits: (1) increased crop yield and (2) improved downstream water quality.

Figure 1: A drainage water recycling system consists of storing drainage water in a pond, which is then used for field irrigation. Irrigation methods vary with site conditions and may include overhead irrigation (left) or subirrigation (right).

Although precipitation in the Midwest is generally plentiful, the timing and amount do not always coincide with crop water needs. Drainage occurs mostly in the spring due to excess precipitation, while crop water use in mid- to late summer may result in periods when available water is insufficient. Storing drainage water can provide value to crops during periods when crop water needs exceed available soil water. The practice can also provide an opportunity for irrigation where certain limitations exist, such as inadequate water supplies or poor water quality.

Water quality also benefits from this system, because drained water, which typically contains nitrogen, phosphorus, and potentially other contaminants that can harm downstream water, is diverted into the water storage pond instead. Storing and recycling drainage water for beneficial use on crops prevents it from causing water quality problems, such as algae blooms in Lake Erie or hypoxia in the Gulf of Mexico.

Drainage water recycling can be a closed loop system where the drained water from a field is recirculated onto the same field, or water drained from one field can be used to irrigate a different field. Irrigation may be through subirrigation that raises the soil water table by adding water to the subsurface drain tiles, sprinkler irrigation systems, drip irrigation, or other technologies.

PURDUE EXTENSION ABE-156-W 1

- Field Days and other events throughout the region

https://cafnr.missouri.edu/2016/01/keeping-nutrients-in-the-field/

http://www.extension.iastate.edu/article/webinar-address-common-misconceptions-about-drainage-and-water-quality

Private Sector Partners in the Network

- Leadership by the drainage industry in saturated buffer research and outreach.

- Iowa Soybean Association and other commodity groups

SAVE THE DATE

Conservation Drainage Network Annual Meeting

(formerly Agricultural Drainage Management Systems Task Force)

June 3-4, 2020

Fort Wayne, Indiana

Courtyard by Marriott, Ft. Wayne Downtown at Grand Wayne Convention Center

In conjunction with

North Central Extension and Research Activity 217 – Drainage Design and Management Practices to Improve Water Quality and the Transforming Drainage Project (June 1-2)

This meeting brings together drainage and conservation professionals in industry, state and federal agencies, universities, and private organizations. All are welcome to hear the latest research as well as contribute to discussions about drainage management and water quality opportunities.

A new Conservation Drainage Network website will be released in 2020.
Annual meeting details can also be found at https://transformingdrainage.org/2020-annual-meeting/.

Transforming Drainage

Thank you! Questions?

Contact information:

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http://transformingdrainage.org

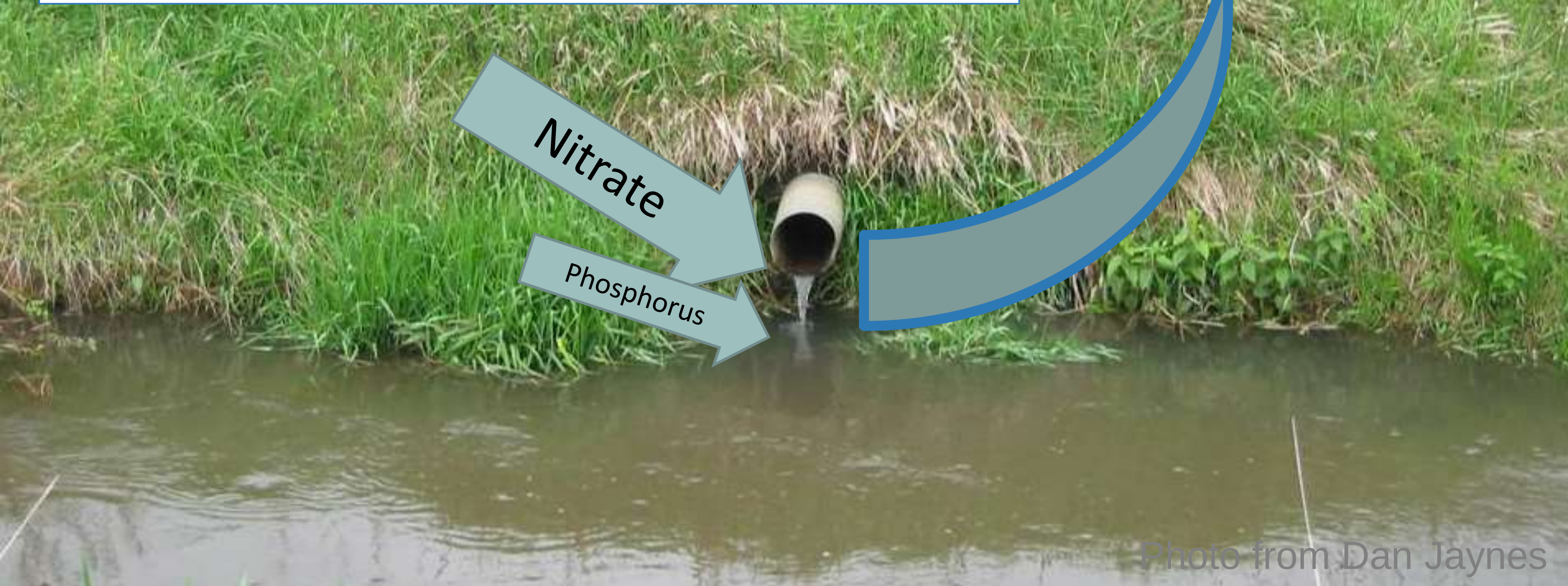

Photo from Dan Jaynes