

Conservation Drainage and Water Management for Tomorrow's Agriculture

Dr. Jane Frankenberger,
Professor
Agricultural & Biological
Engineering



My work on Conservation Drainage and Agricultural Water Management

Professor and Extension Ag Engineer for 29 years at Purdue University



Project Director for **Transforming Drainage** Multistate Project

<https://transformingdrainage.org/about-us/the-project-team/>

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Helping Water for Tomorrow's Agriculture

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Transforming Drainage Team

Purdue University	Iowa State University
<p>Jane Frankenberger, Project Director, is an Extension Agricultural Engineer with expertise in drainage and water quality. In addition to providing overall leadership for the project, she will serve as the lead in developing project networks and co-lead Extension activities.</p>	<p>Matt Helmers, is an Extension Agricultural Engineer with expertise in drainage and water quality. He currently manages controlled drainage sites and will serve as the lead in data synthesis as well as participate in Extension activities.</p>
<p>Ben Reinhart, Project Manager, is a Watershed Specialist with experience on conservation project development and implementation with local, state, and federal partners. He will provide coordination among Team Members across project objectives and develop project networks.</p>	<p>Lori Abendroth, is an Agronomist with experience in research database management, project management, and crop production. She will be involved in developing project networks and establishing a research database encompassing the experimental sites involved in the project.</p>
<p>Eileen Kladvik, is a Soil Physicist with expertise in soil health, drainage and water quality. She will participate in research data collection and synthesis related to controlled drainage as well as the application of results through</p>	<p>Giorgi Chighladze is a Data Manager and Analyst with experience soil sensing systems and environmental monitoring. He is involved in</p>

Led the formation of the **Conservation Drainage Network**

<https://conservationdrainage.net>

CONSERVATION DRAINAGE.NET
Network for agricultural drainage and water quality

Home Our Network Meetings and Events NCEEA-217 Resources

Save the Date for the 2025 Annual Meeting April 1-3, Champaign, IL

2025 CONSERVATION DRAINAGE NETWORK ANNUAL MEETING

A network for agricultural drainage and water quality

ABOUT THE CONSERVATION DRAINAGE NETWORK	NETWORK PARTICIPANTS AND MEMBERS	MEETINGS OF THE NETWORK: UPCOMING AND PAST
<p>The Conservation Drainage Network is a national partnership with the goal of improving drainage practices to meet future demands of crop production while reducing adverse environmental impacts of ...</p> <p>Read more...</p>	<p>The Conservation Drainage Network is made up of individuals from many agencies and organizations interested in advancing strategies to reduce negative environmental impacts from drained agricultural ...</p> <p>Read more...</p>	<p>The Conservation Drainage Net holds a meeting each year to which members are invited. Information upcoming and past meetings is included below. This meeting is together drainage ...</p> <p>Read more...</p>

Managing water is key for successful agriculture.



Most years we have too much; sometimes too little.



Spring: Runoff and nutrient loss



Summer: Drought, crop yield loss

In the Midwest, we have an impressive drainage infrastructure designed to get rid of water as quickly as possible.



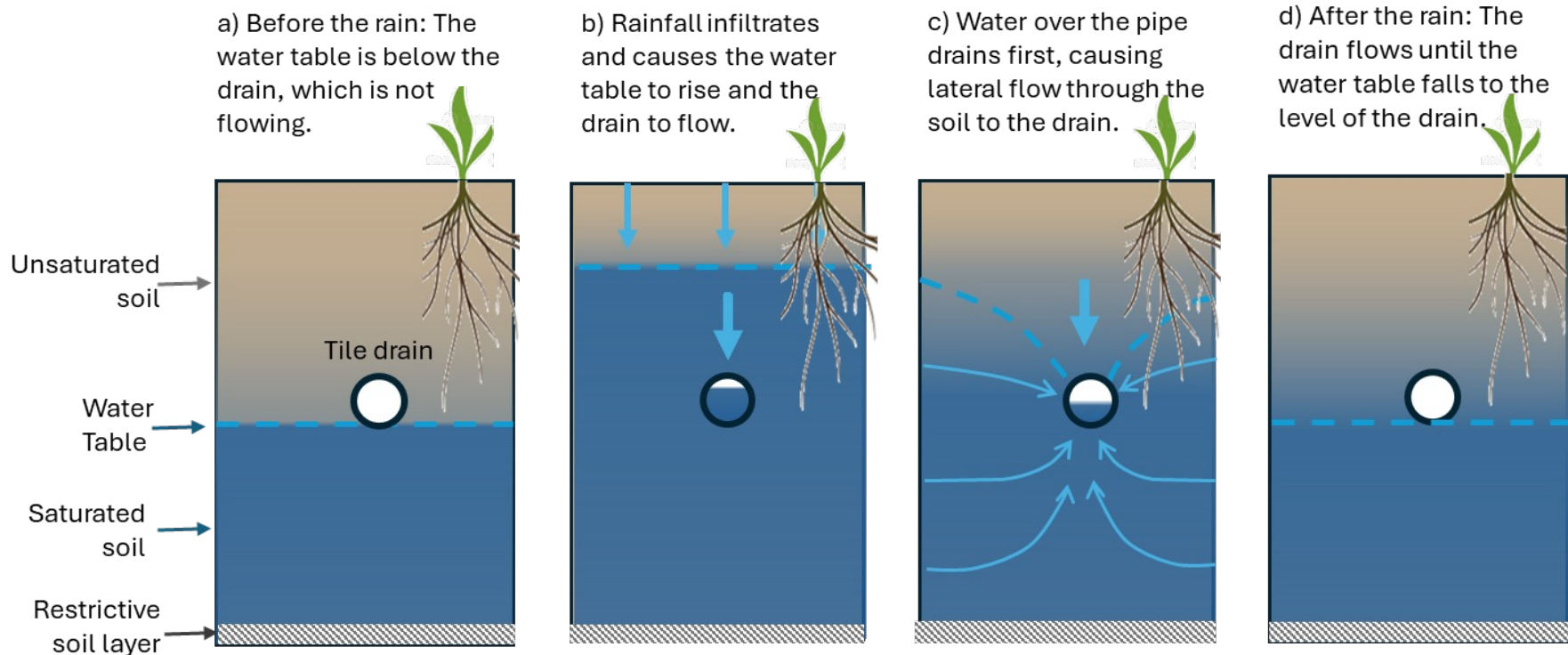
Subsurface tile drains



Surface drains (ditches)

Drainage lowers the water table to increase aeration.

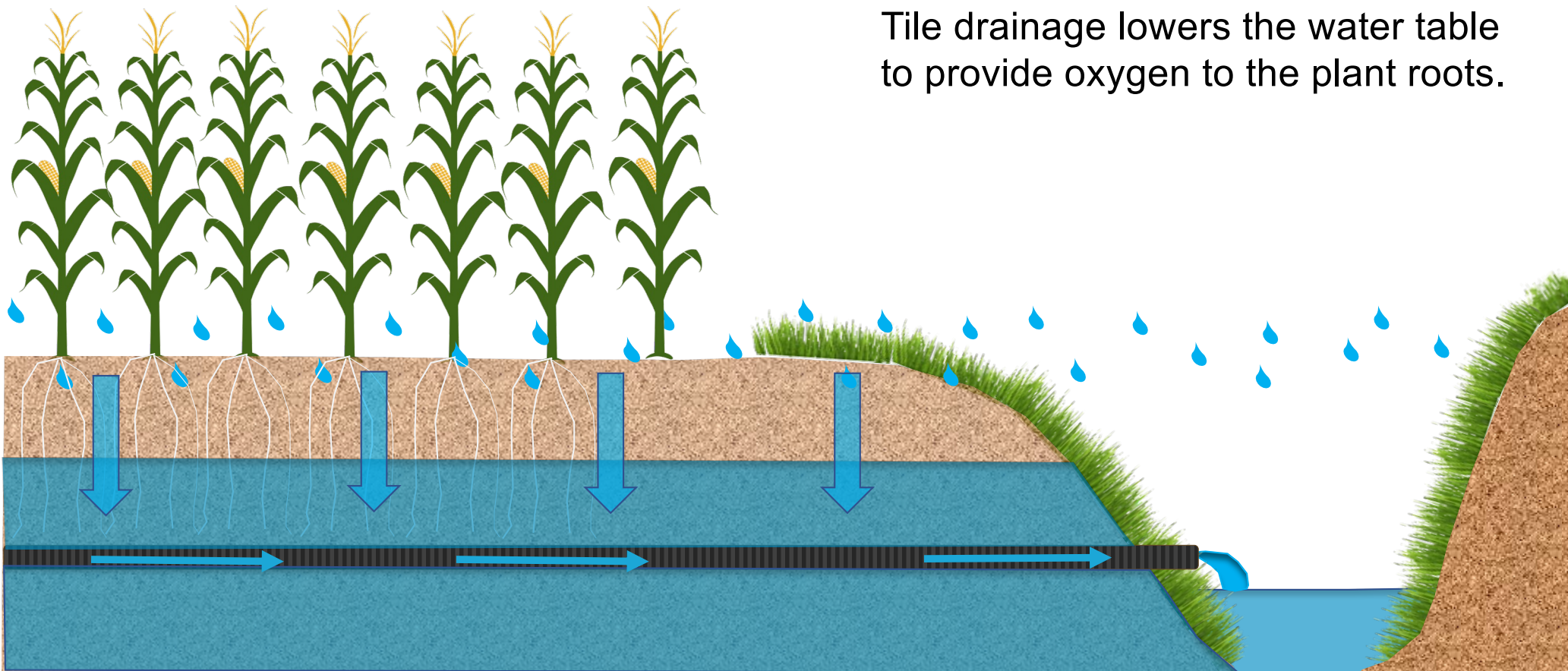
The **water table** divides the saturated zone (where all pore space is filled with water), from the unsaturated zone above (pore space includes air).



Drainage lowers the water table to increase aeration.

Rainfall infiltrates and raises the water table.

Tile drainage lowers the water table to provide oxygen to the plant roots.

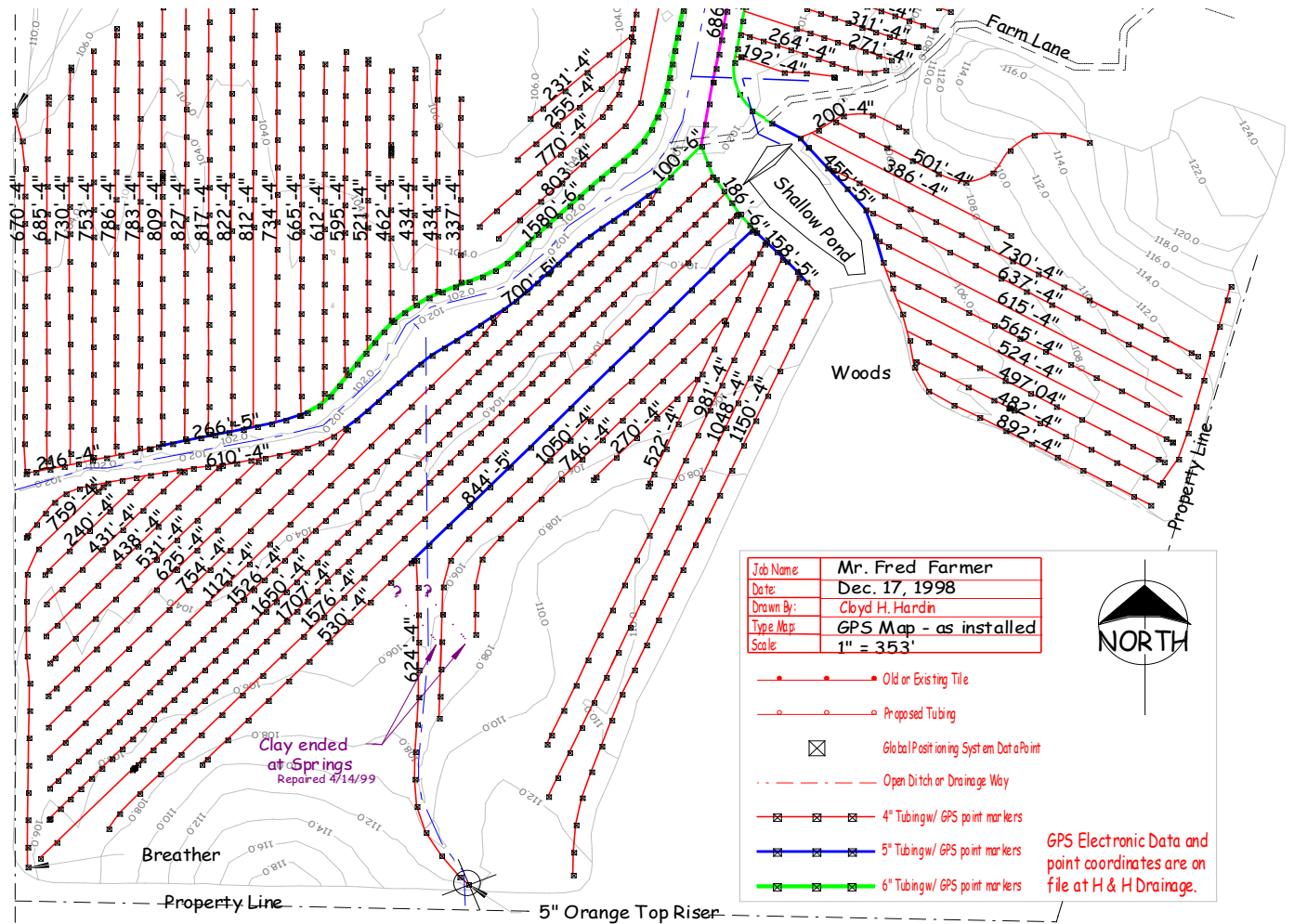




Video clips from Davis Purdue Agricultural Center Field Day, courtesy of Jeff Boyer, Superintendent

Tile Drainage Systems

The drains are spaced at a distance that allows drainage at a rate adequate to support crop growth, usually 20 to 100 feet apart.



Recently tiled field.



Photo from Gary Sands

Most years we have too much; sometimes too little.
Both intensifying as **extreme weather increases**.



Spring: More runoff and
nutrient loss



Summer: More drought
and crop yield loss



In the Midwest, we have an impressive drainage infrastructure designed to get rid of water as quickly as possible.



Subsurface tile drains



Surface drains (ditches)

But is today's agricultural water management systems adequate to address tomorrow's needs?



Subsurface tile drains



Surface drains (ditches)

Issue 1: Nutrient loss from tile drainage is causing issues of national concern.

- Tile drains greatly increase loss of **nitrate** to streams.
- Recent research is showing more clearly that **phosphorus** also moves through tiles.



Nitrate



Phosphorus

Water from Lake Erie during toxic algae bloom



Photo: Tom Bridgeman

Issue 2: Despite excess water in spring, yields are often limited by lack of water in late summer.



Some years we have excess water and water shortage in the same year.

Too much (June)



Then too little (July)

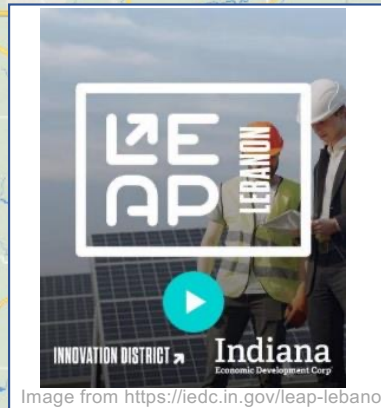


The LEAP district in Lebanon lacks water, so the Indiana Economic Development Commission has proposed a 40-mile pipeline from Tippecanoe County.

Proposed wells near
Granville Bridge



40 mile
pipeline
(probable
route)



This has caused great controversy, but no current state law addresses.



Pipeline location from
<https://www.clintoncountytoday.com/state-to-pump-water-through-clinton-county-to-boone-county/>

Background map: <https://maps.bing.com>

Two issues; both are expected to be become more severe due to future extreme weather

- **Excess nutrients in spring will increase** as winter and spring becomes warmer and wetter



Photo: Tom Bridgeman

- **Water availability in late summer will decrease** with warmer summers and increased flashiness of precipitation



Storing drained water in the landscape addresses both these issues.

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**CONSERVATION
DRAINAGE.NET**

Network for agricultural drainage and water quality



Feedback Form
on Conservation
Drainage



Typically, farmers' goal is to get rid of excess water as quickly as possible.



But can we instead store water in drained landscapes like this?

In the field?

In the buffer?

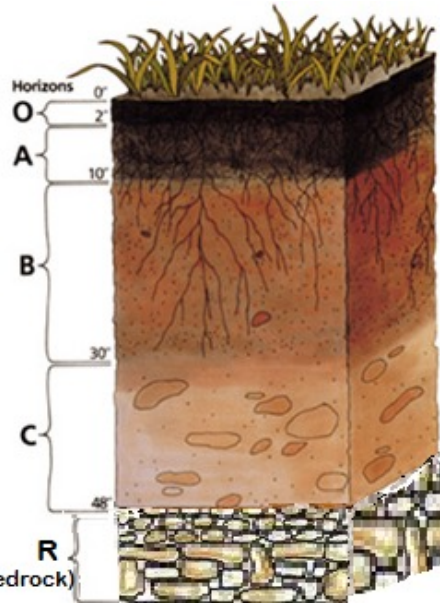
In the ditch?



Photo: Dan Jaynes

Conservation Agriculture: Storing water in the soil Increasing soil health.

- Increasing soil organic matter can increase water holding capacity.



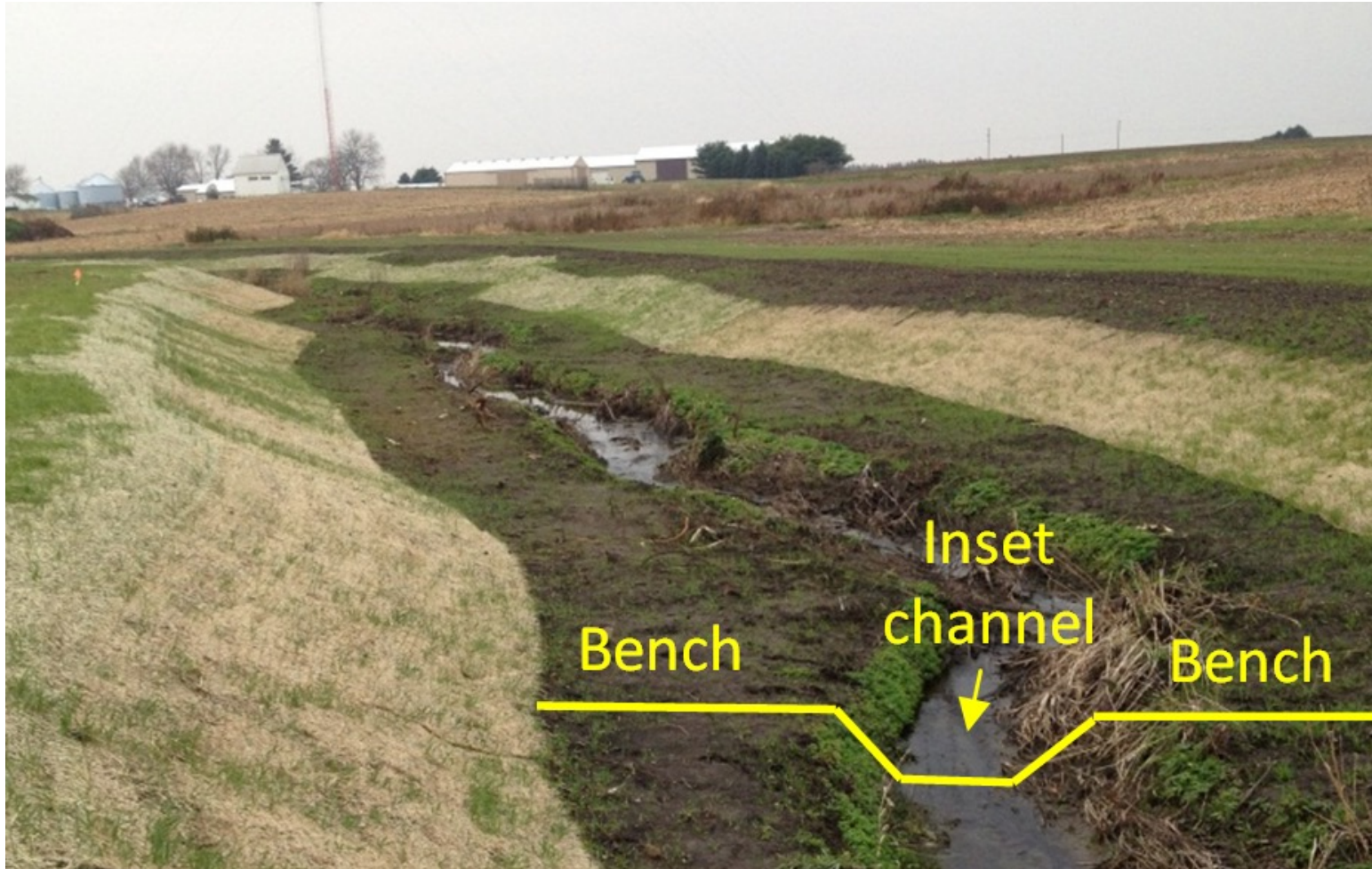
- Bu

Image: Wikimedia Commons, Wilsonbriggs



Image: NRCS

Conservation Drainage: Storing water in wider ditches:
Two-Stage Ditches

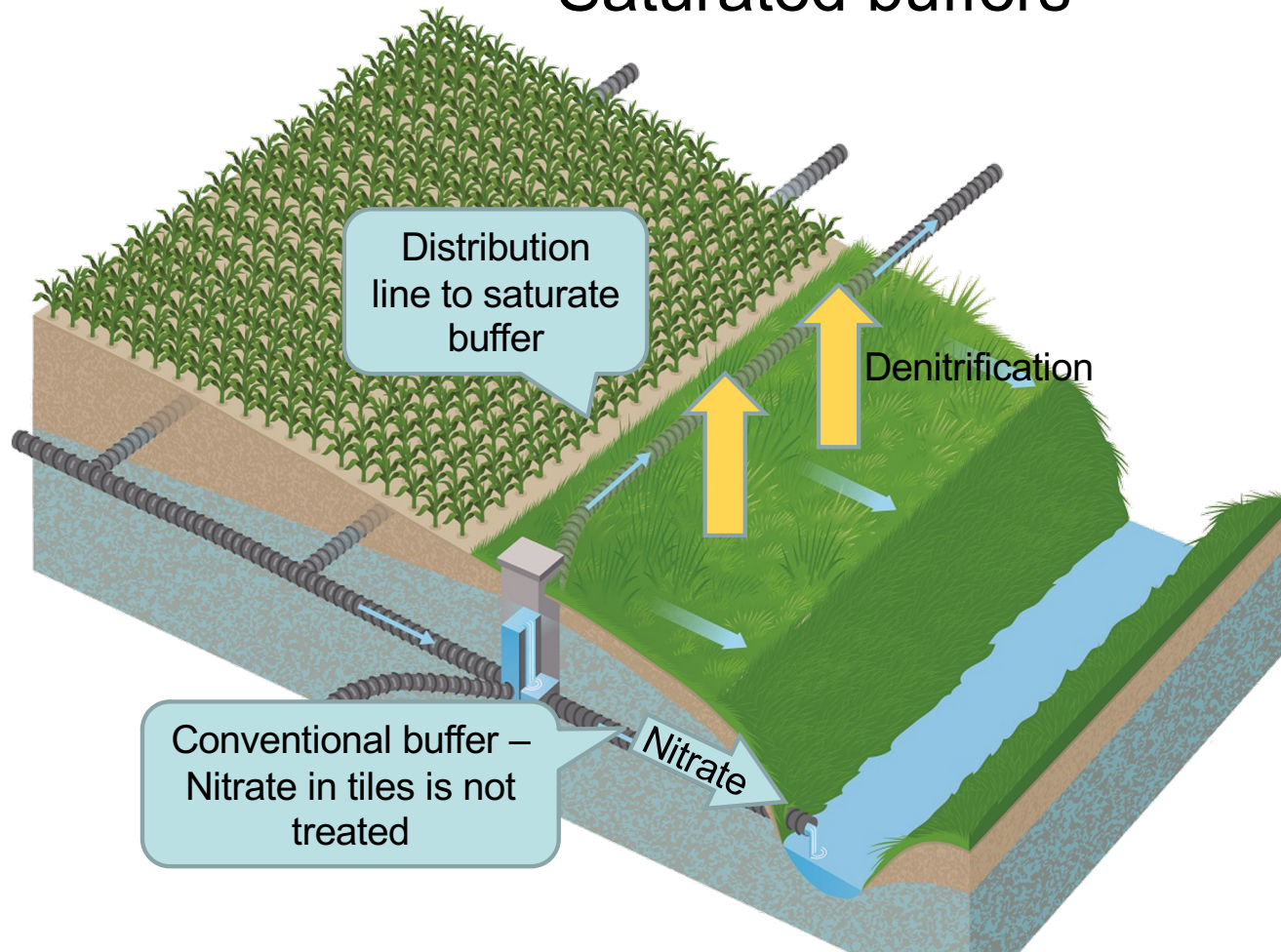


Trapezoidal ditches were once the only standard, but they can be modified to store water and support aquatic ecosystems.



Photo from A. Ward, Ohio State

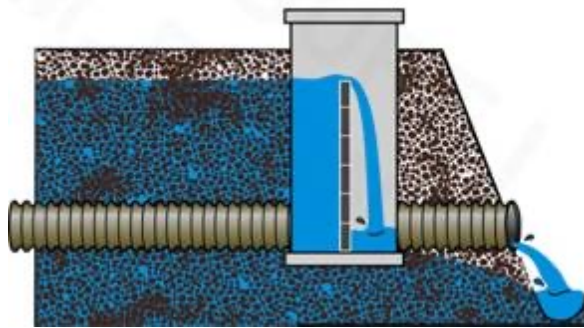
Conservation Drainage: Storing water in buffers: **Saturated buffers**



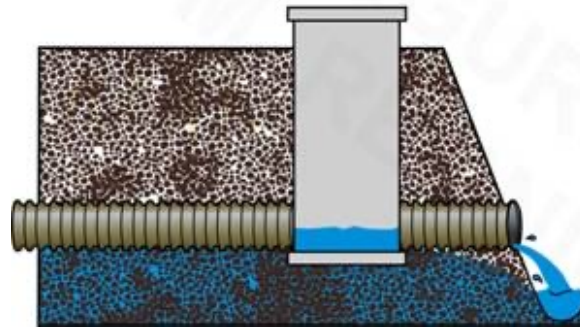
Conservation Drainage: Storing water in the field:
Drainage Water Management, also known as Controlled Drainage

Water control structure added in a main drain

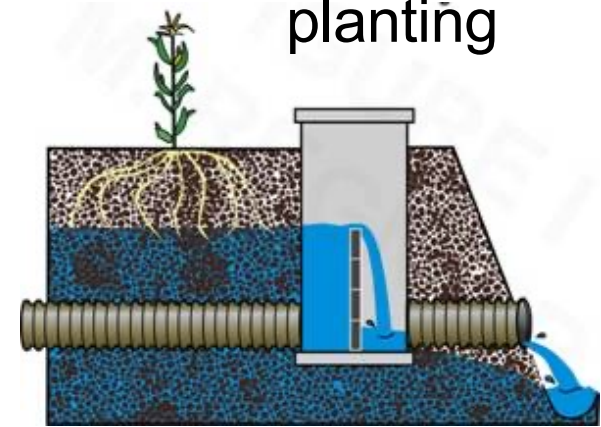
After harvest



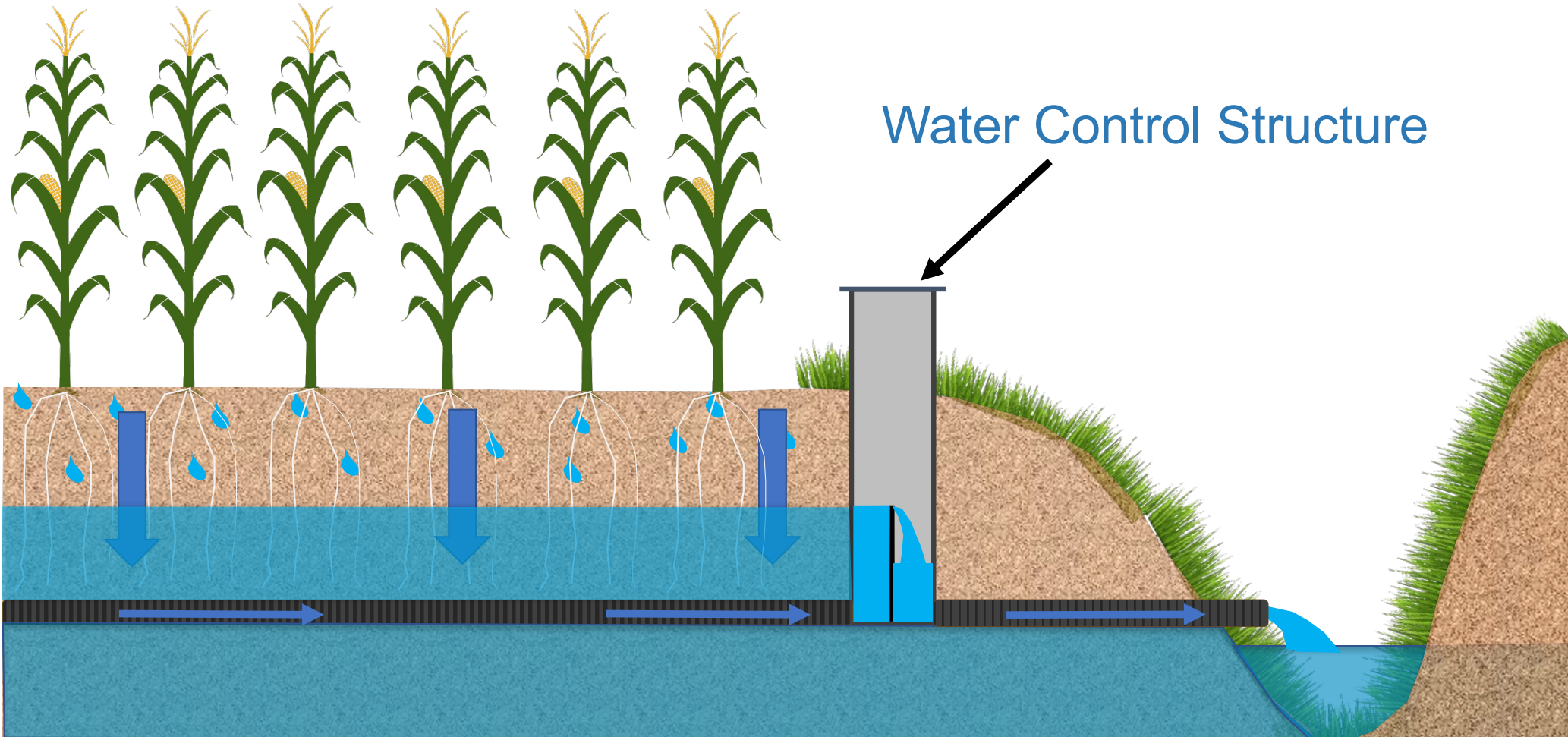
Before planting
or harvest



After
planting



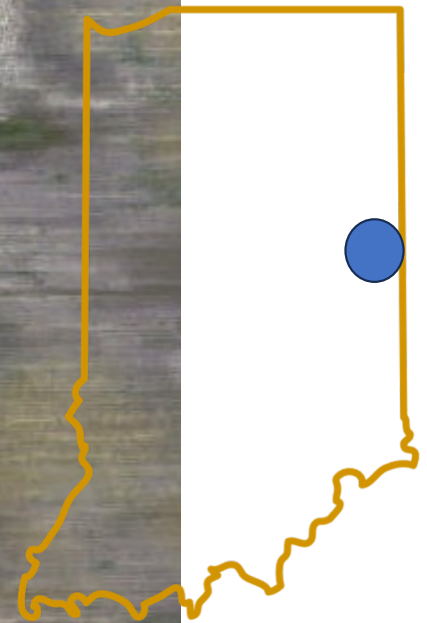
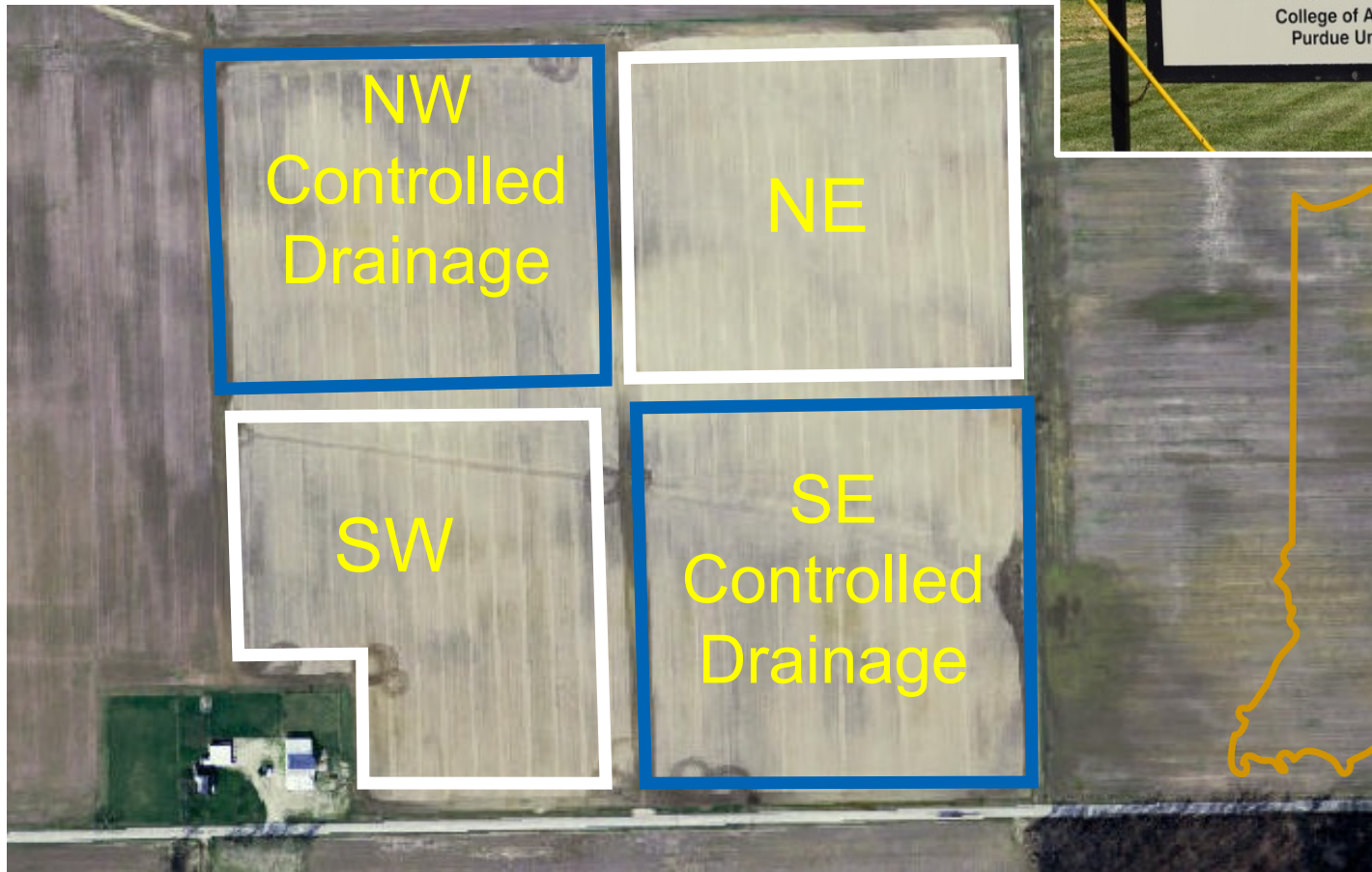
Storing water in the field: Controlled drainage



Controlled drainage research at Davis Purdue Agriculture Center in Indiana



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

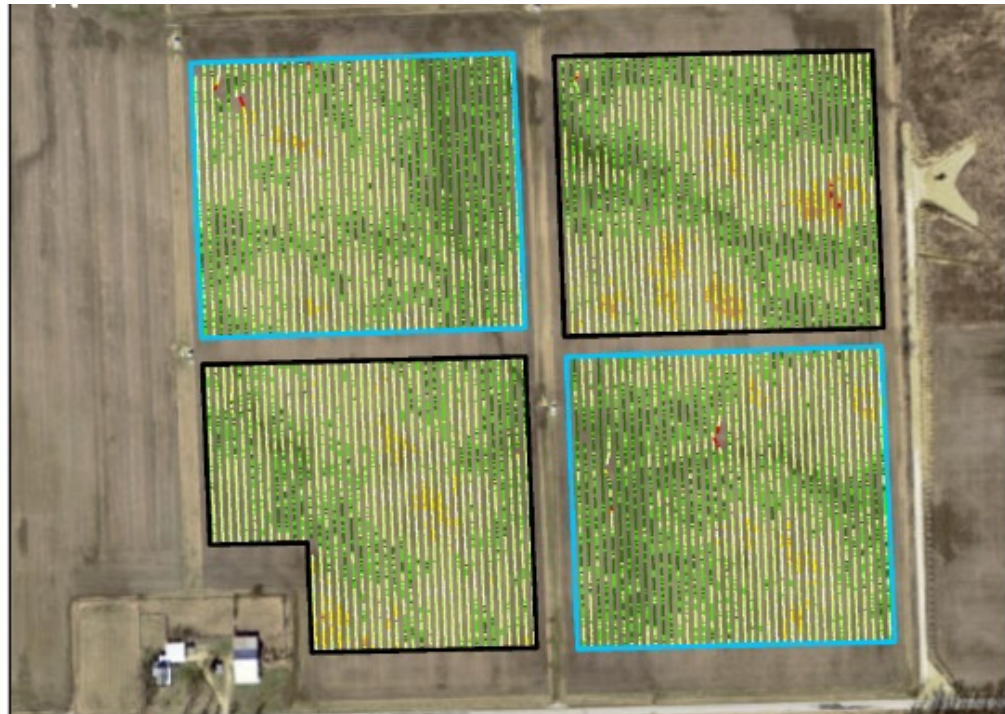


Corn yield over 9 years increased slightly with controlled drainage

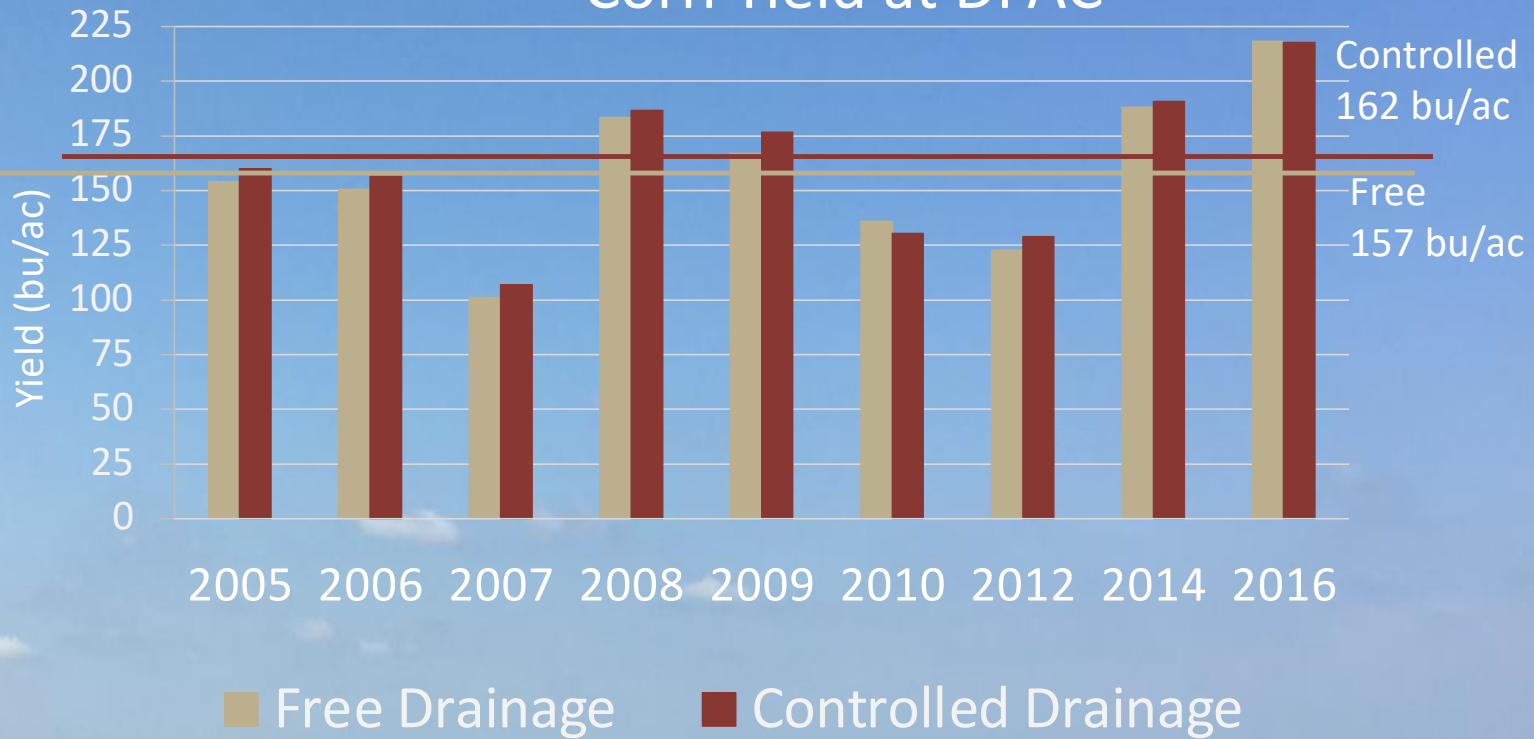
- Yield measured with yield monitor each year, cleaned and processed. Example for 2009:

Yield (bu/ac)

- ≤ 80
- ≤ 100
- ≤ 120
- ≤ 140
- ≤ 180
- ≤ 200
- > 200



Corn Yield at DPAC



Average increase of 5 bu/acre
with controlled drainage

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



Above: Water samples from the automated sampler

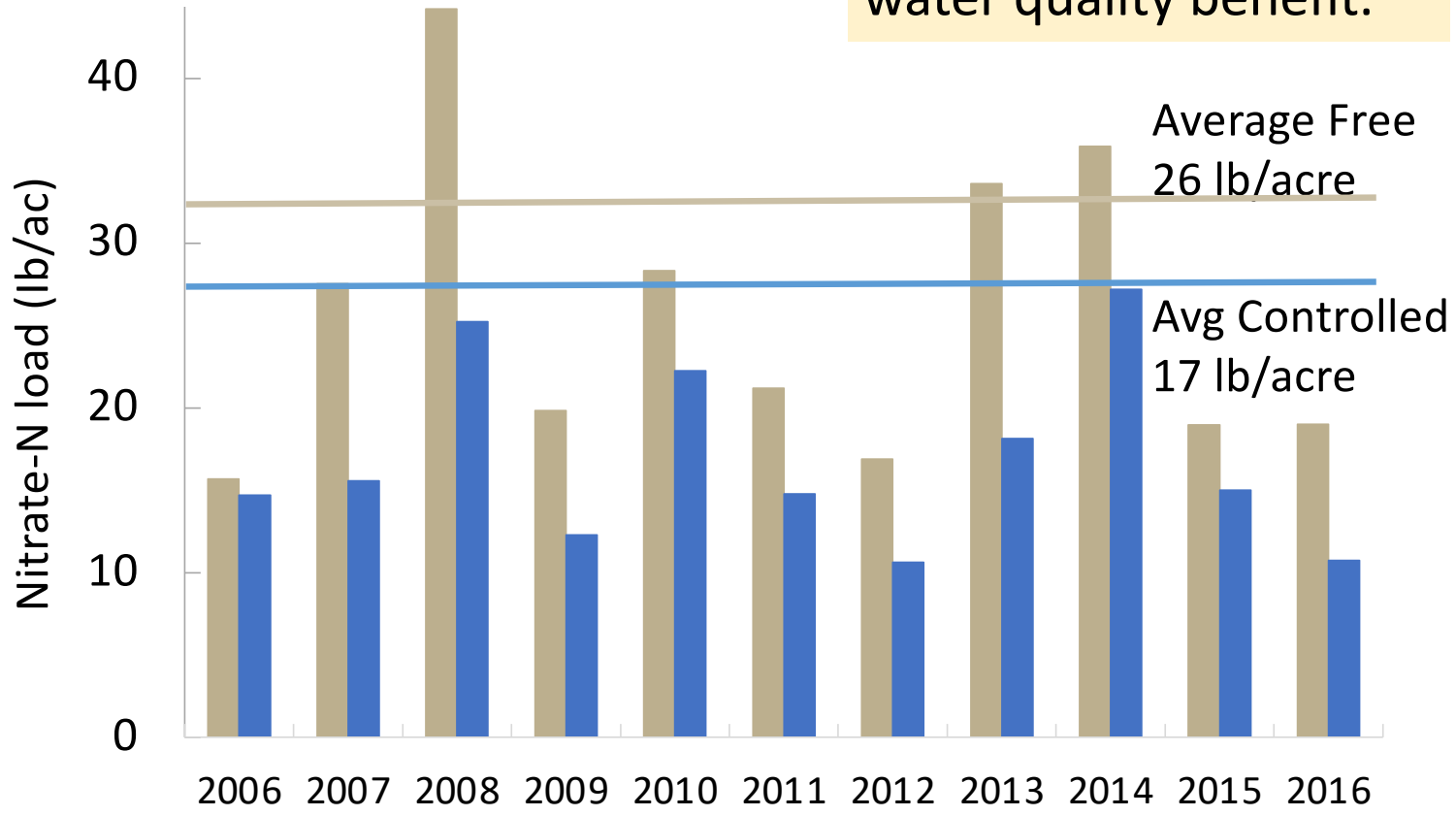


Right: Analyzing samples in the lab; Inline flow meter



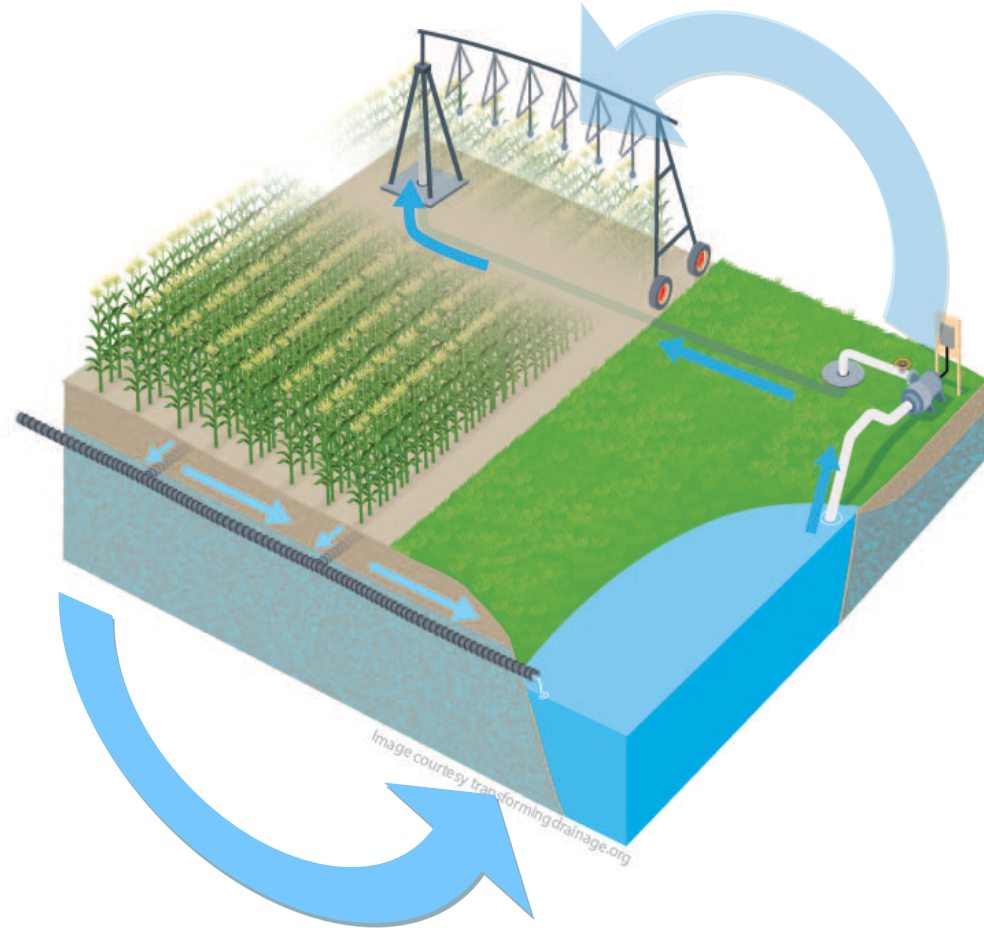
Nitrate load (lb/acre) was reduced by 9 lb/acre on average

35% nitrate load reduction – a significant water quality benefit.

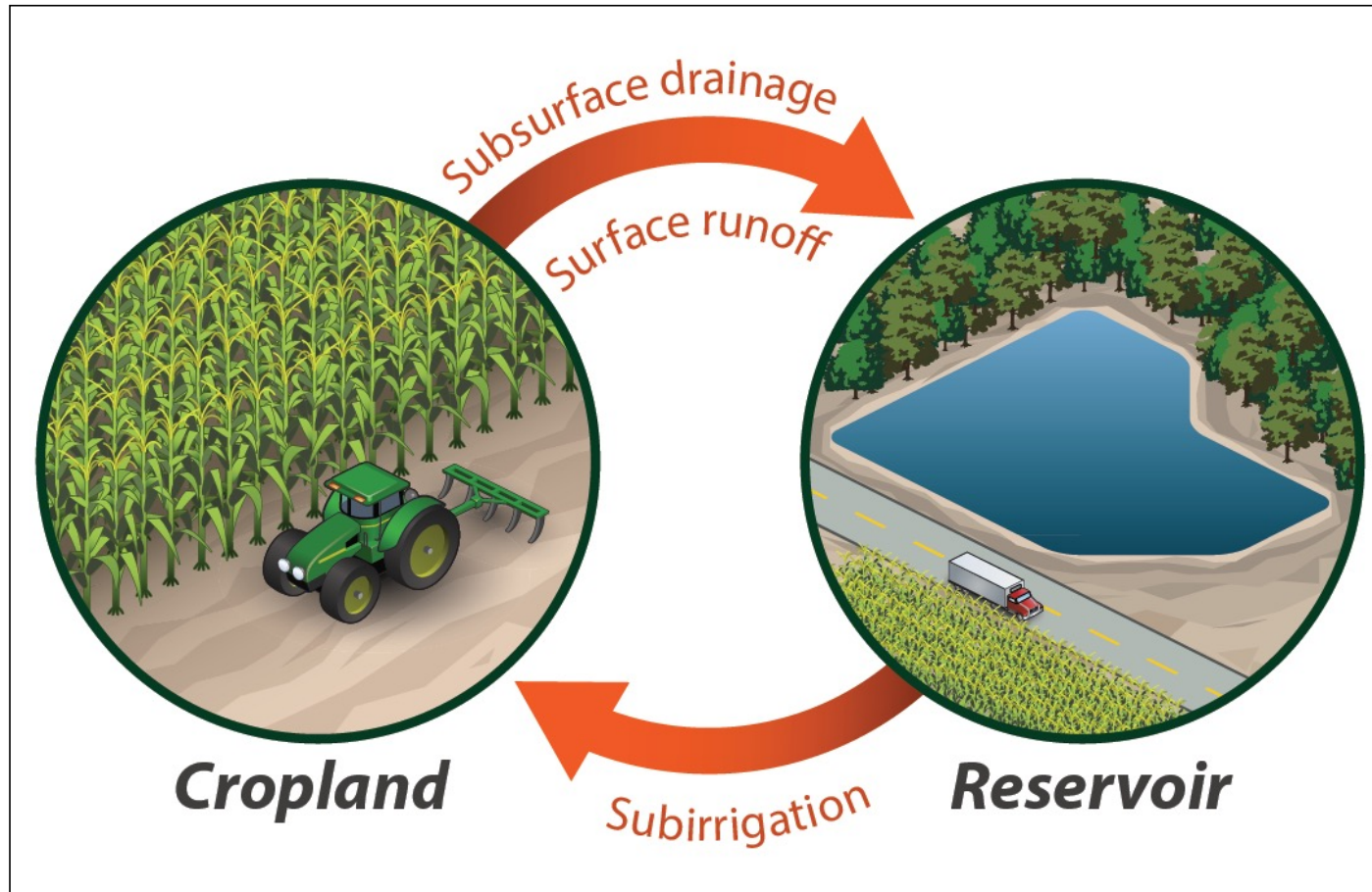


Conservation Drainage: Storing drained water, and irrigating nutrient-rich drainage water back onto crops

Drainage
Water
Recycling

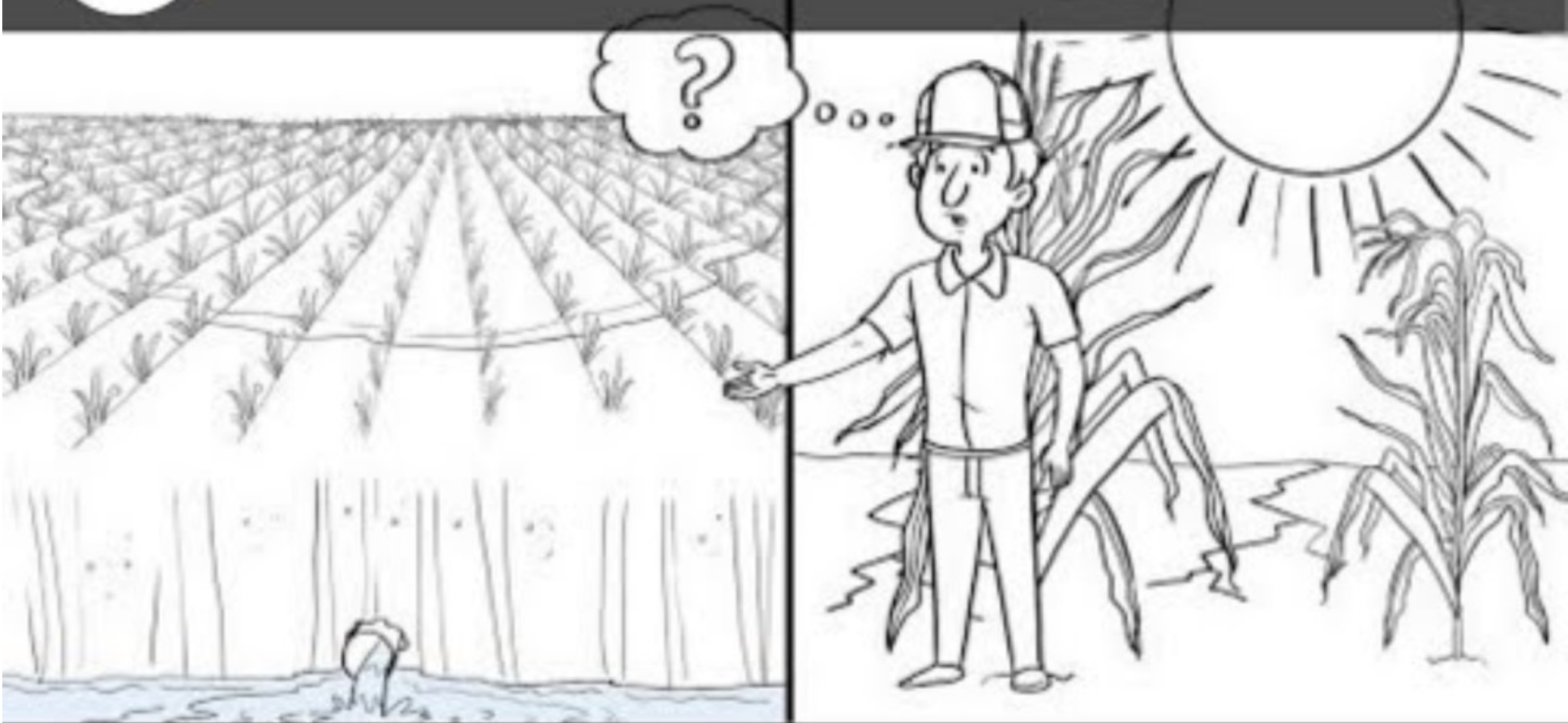


Storing water, and applying it when needed = **Recycling**





Benefits of Storing Drainage Water



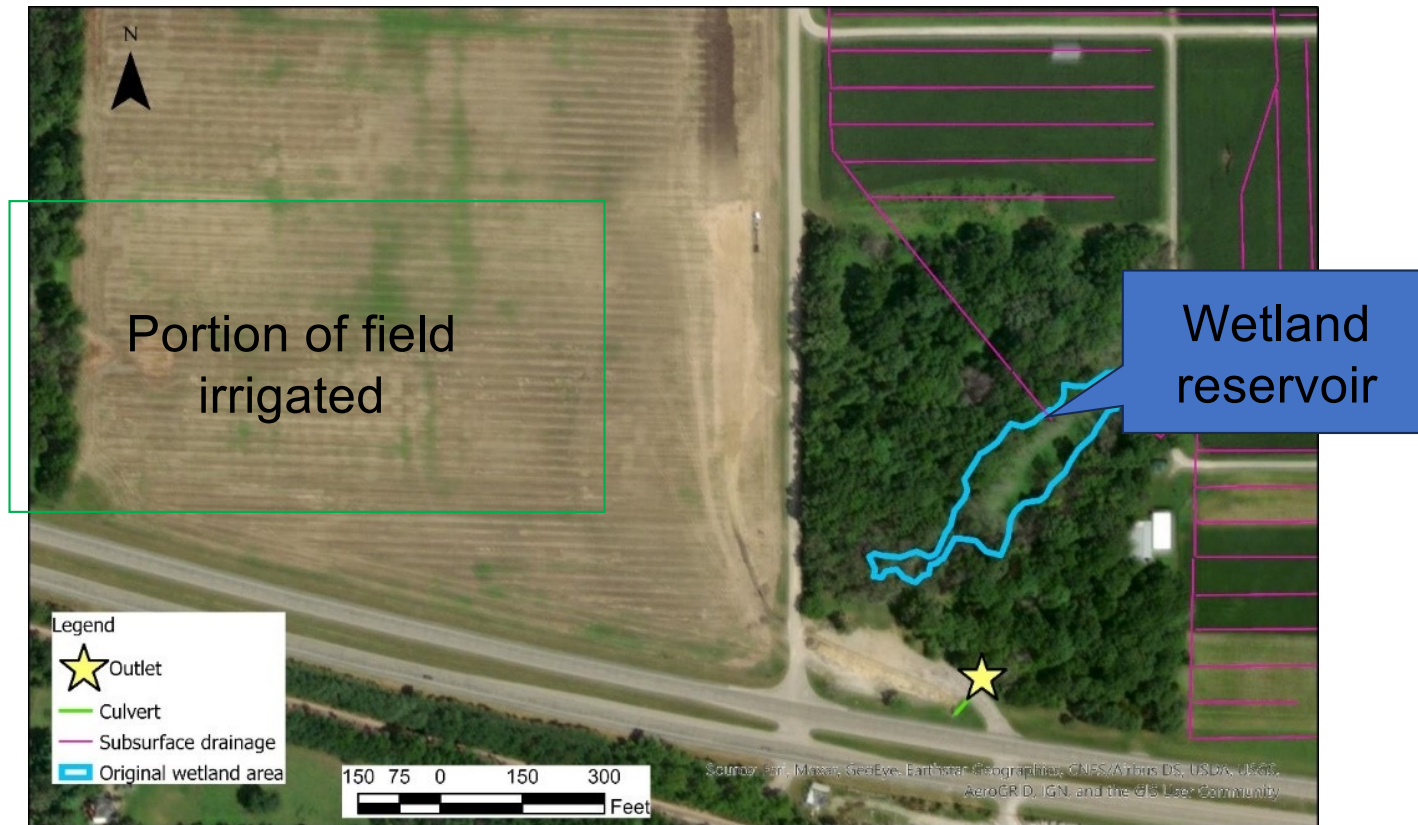
Feedback
Form on
Conservation
Drainage





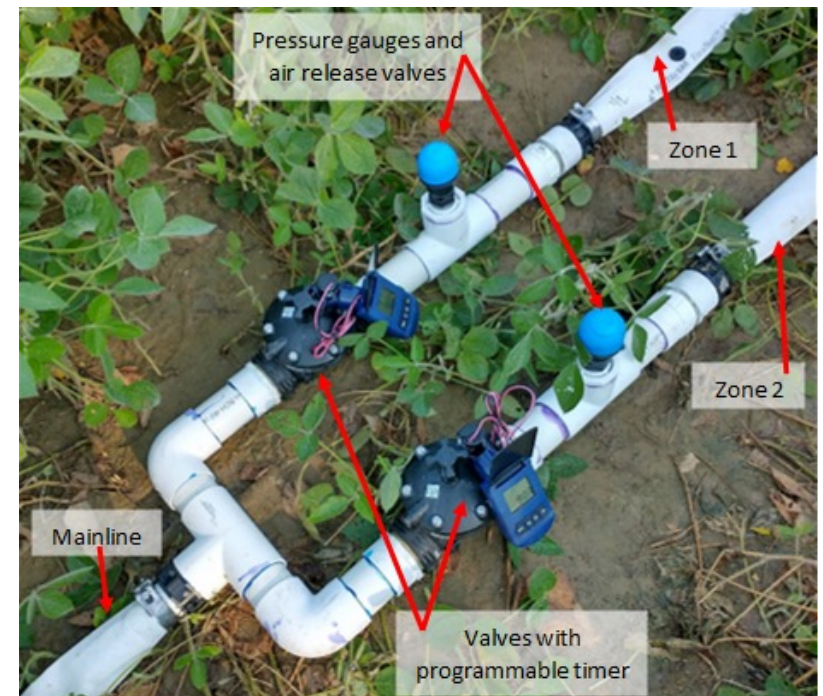
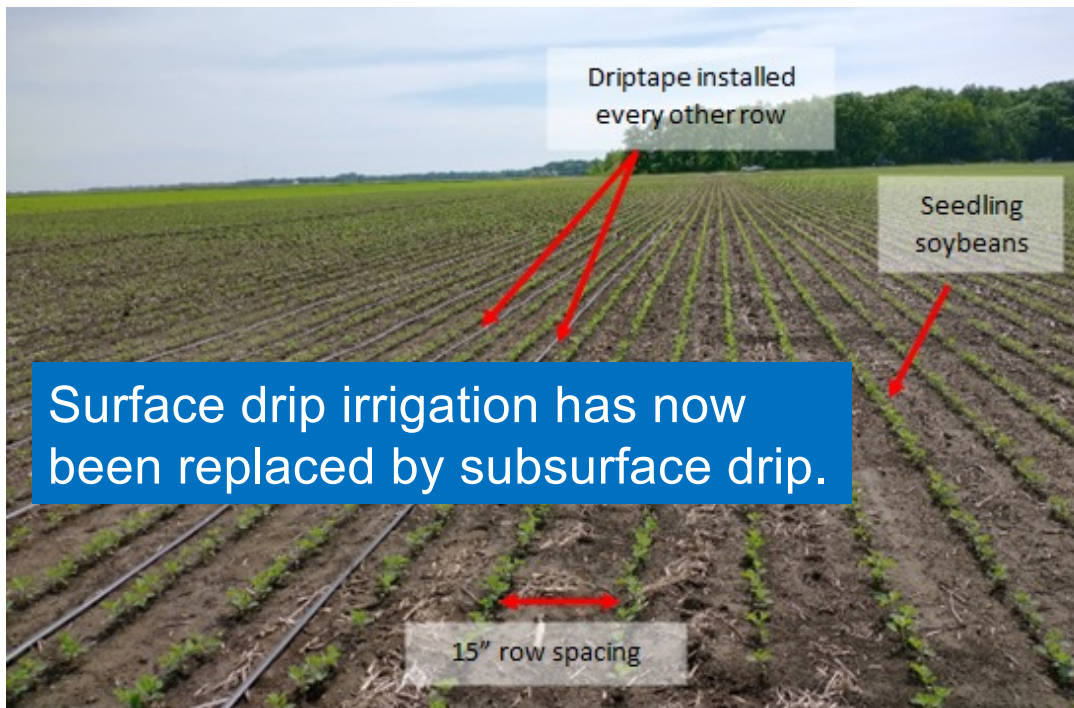
Drainage Water Recycling study at Purdue Agronomy Center for Research and Education (ACRE)

led by Laura Bowling, Keith Cherkauer, Shawn Casteel, Dan Quinn, Juan Sesmero



Drip irrigation in corn & soybeans, including fertigation

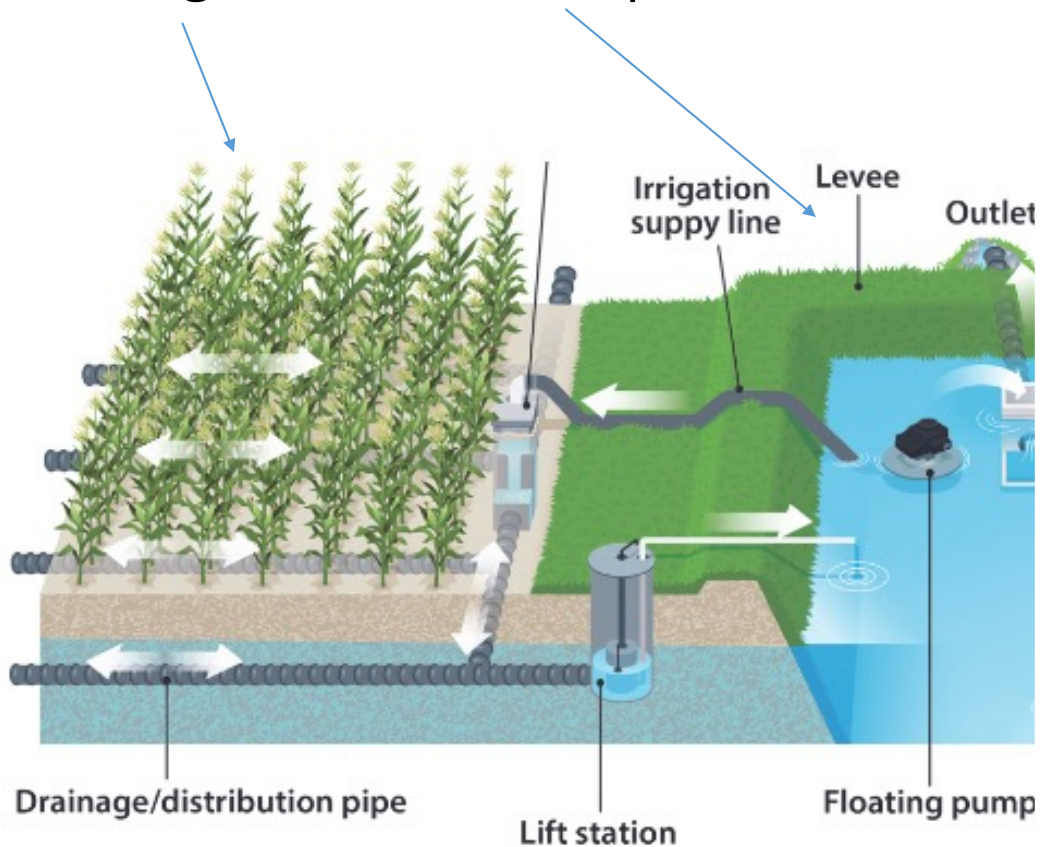
Will provide information on crop yield, leaching, and water use impacts of drainage water recycling.



(Talk with Shawn Casteel or Dan Quinn for more info.)

Drainage water recycling: Multiple options for implementation

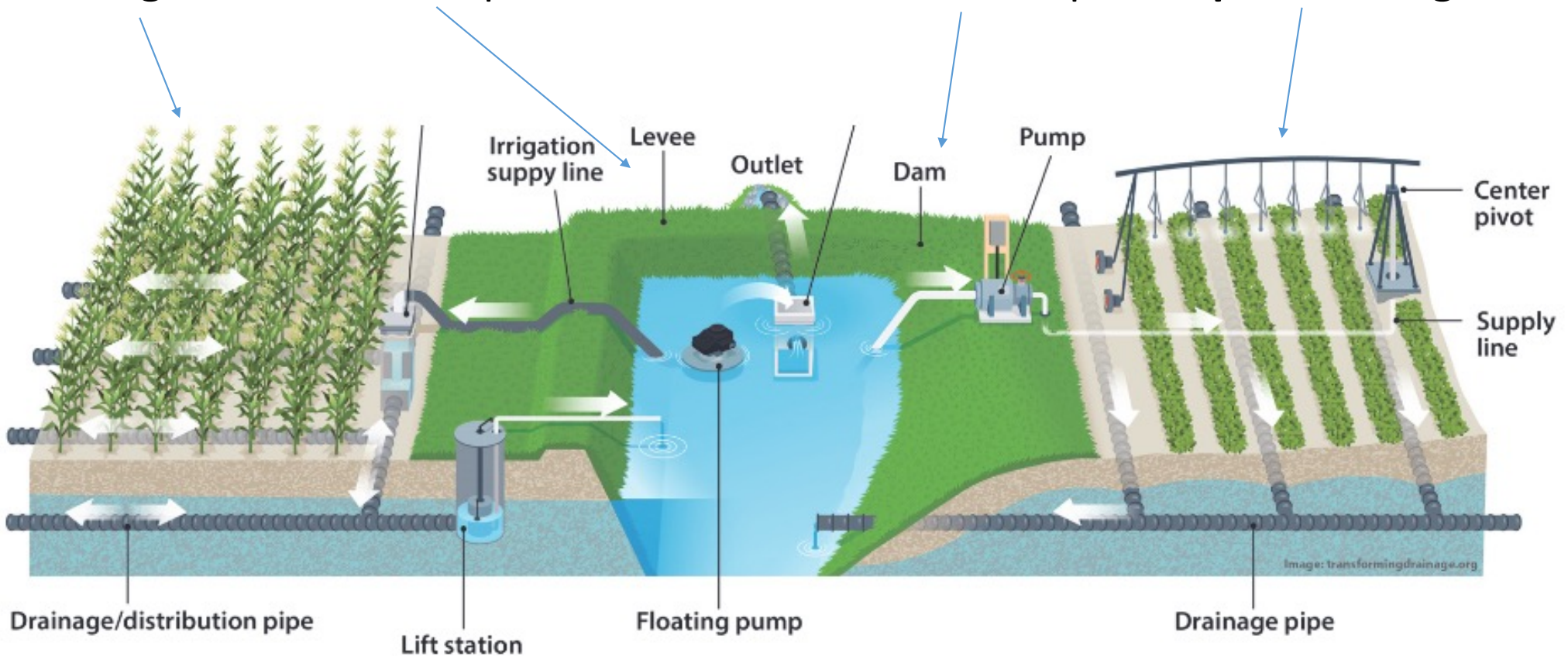
Subirrigation, Excavated pond



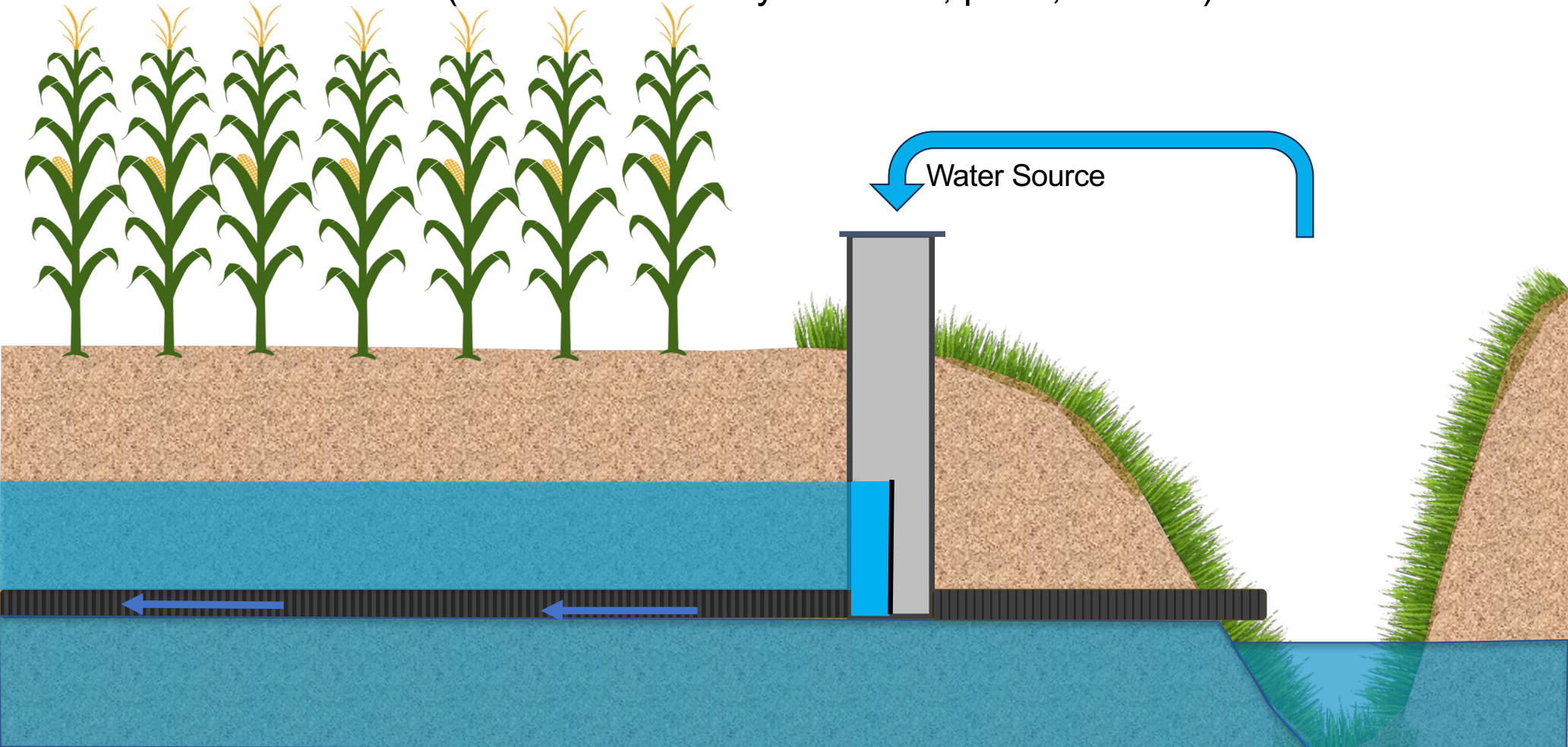
Drainage water recycling: Multiple options for implementation

Subirrigation, Excavated pond

Embankment pond, Sprinkler irrigation

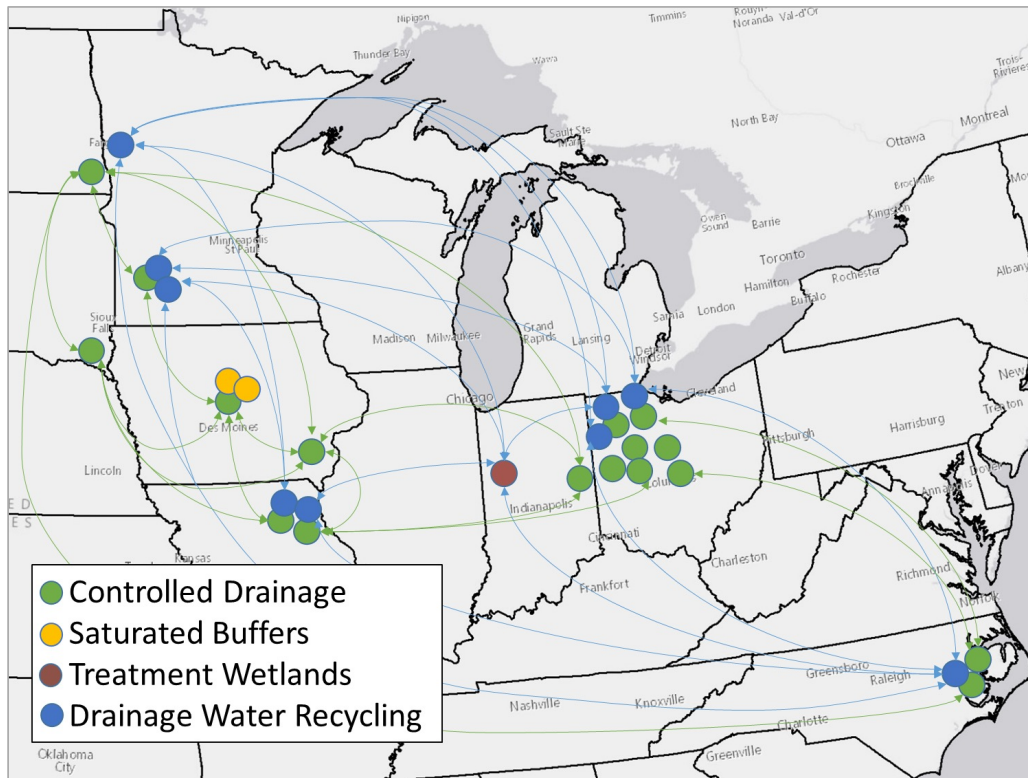


Subirrigation: Adding water to the soil through the tile line.
(Water source may be a well, pond, or ditch)



Transforming Drainage Project

Multistate drainage research, extension, and education (project now completed)



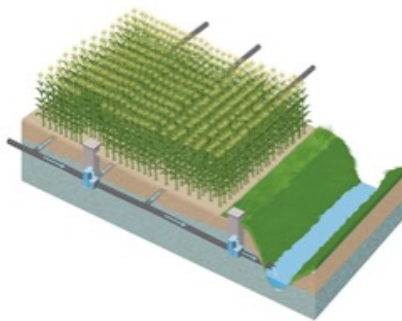
Project Outcome: Extension publications were co-authored by teams of Transforming Drainage researchers, peer-reviewed by experts, and are available online. ...

[Read more](#)

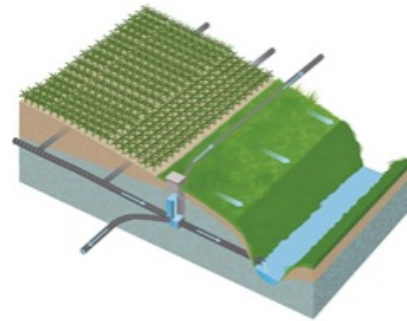
Researching findings were made available to producers, drainage contractors, and conservation agencies through **nine Extension publications.** *“Questions and Answers about Drainage Water Recycling for the Midwest”* won an **ASABE Blue Ribbon Award.**



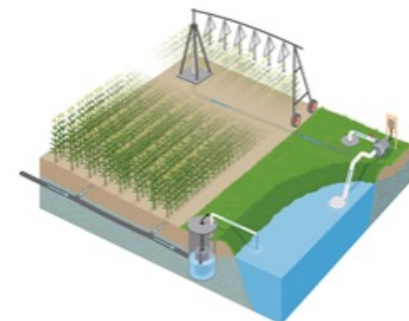
CONTROLLED DRAINAGE



SATURATED BUFFERS



DRAINAGE WATER RECYCLING

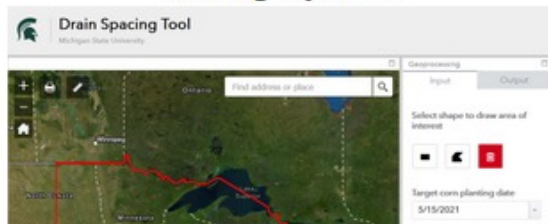


Tools Overview

A variety of tools were developed as part of the Transforming Drainage project to help with planning, evaluating, and exploring subsurface tile drainage systems and practices that can be implemented to improve water management.

Drain Spacing Tool

The Drain Spacing Tool estimates the optimum drain spacing that maximizes economic return on investment in the drainage system.



Drainage Rate Calculator

This tool calculates the three standard coefficients (drainage rates) for characterizing hydraulic properties of subsurface drainage systems.



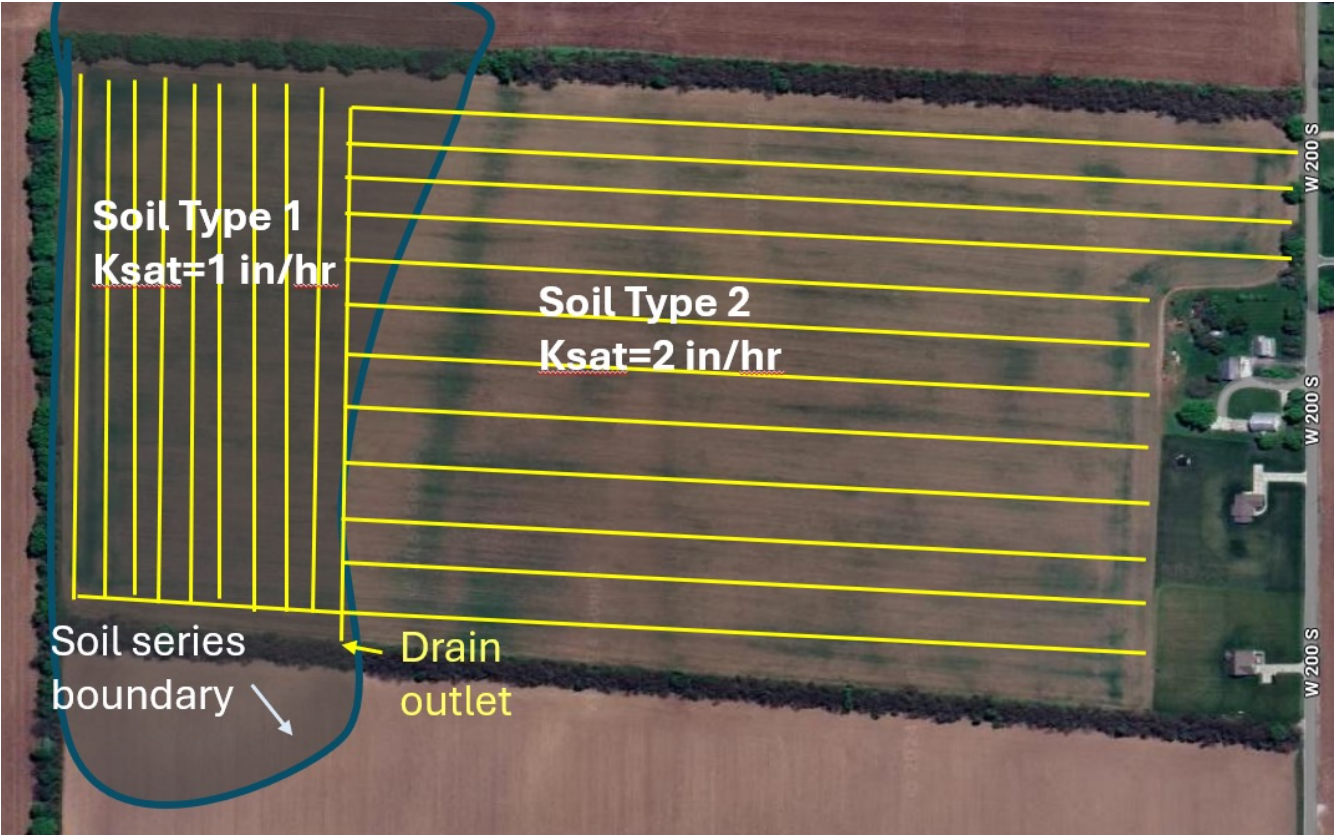
Likely Extent of Agricultural Drainage

This tool identifies agricultural areas that are likely to have been drained for crop production in the Midwestern USA.

Likely Extent of Agricultural Drainage

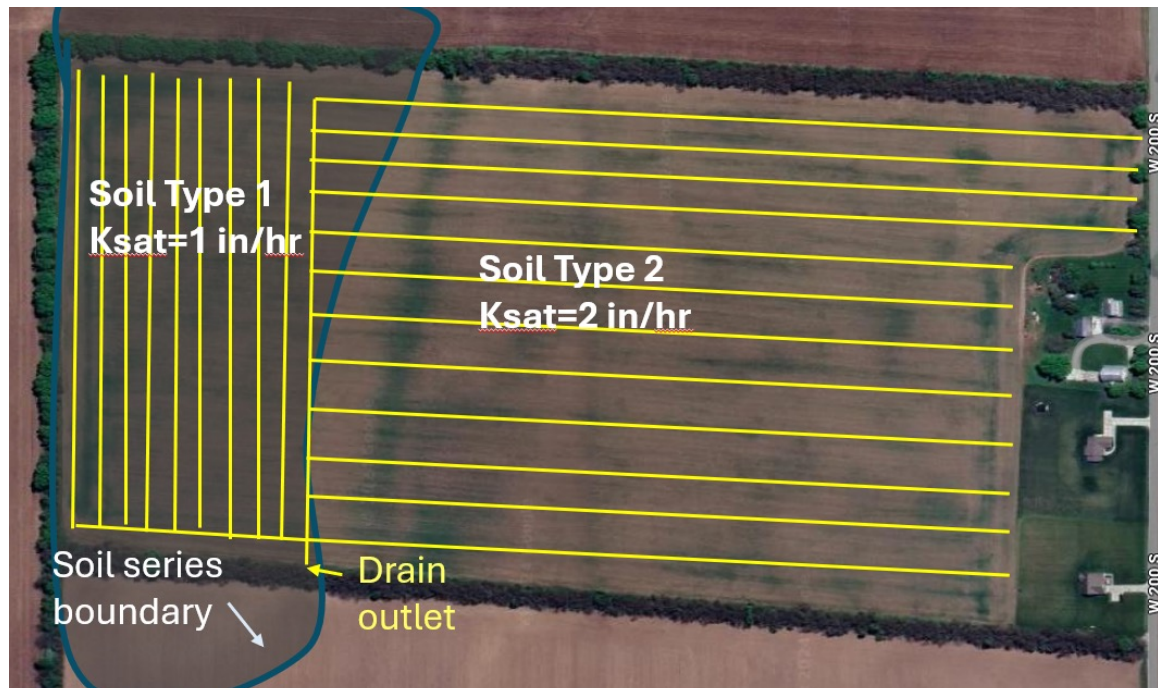


Tools for deciding on drain spacing



Optimal Tile Spacing Depends on Soil

- Optimal spacing depends on the soil hydraulic conductivity and the depth to a restricting soil layer.
- Narrower spacing is needed in soils with low soil hydraulic conductivity or a shallow depth to the restricting layer.



Find out about
soils at any
location through
the Soil Survey

The screenshot shows a web browser window with the address bar displaying `websoilsurvey.sc.egov.usda.gov/App/HomePage.htm`. The page features a header banner with the USDA logo, the text "United States Department of Agriculture" and "Natural Resources Conservation Service", and a large "Web Soil Survey" title. Below the banner is a navigation menu with links for "Home", "About Soils", "Help", and "Contact Us". The main content area includes a search box with a "Go" button, a "Browse by Subject" sidebar with a list of categories, and a central section titled "Welcome to Web Soil Survey (WSS)" which contains a photograph of people in a field and a "START WSS" button. To the right of the main content are two sidebars: "I Want To..." with a list of links and "Announcements/Events" with a link to "Web Soil Survey 3.0 has been released!".

Web Soil Survey - Home x

← → ↻ `websoilsurvey.sc.egov.usda.gov/App/HomePage.htm` ☆ ☰

USDA United States Department of Agriculture
Natural Resources Conservation Service

Web Soil Survey

Home About Soils Help Contact Us

You are here: Web Soil Survey Home

Search

Enter Keywords

All NRCS Sites ▾

Browse by Subject

- Soils Home
- National Cooperative Soil Survey (NCSS)
- Archived Soil Surveys
- Status Maps
- Official Soil Series Descriptions (OSD)
- Soil Series Extent Mapping Tool
- Geospatial Data Gateway
- eFOTG
- National Soil Characterization Data
- Soil Geochemistry Spatial Database
- Soil Quality

The simple yet powerful way to access and use soil data.

START WSS

Welcome to Web Soil Survey (WSS)

Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.

Soil surveys can be used for general farm, local, and wider area planning. Onsite investigation is needed in some cases, such as [soil quality assessments](#) and certain conservation and engineering applications. For more detailed information, contact your local [USDA Service Center](#) or your [NRCS State Soil Scientist](#).

Four Basic Steps

I Want To...

- Start Web Soil Survey (WSS)
- Know the requirements for running Web Soil Survey — will Web Soil Survey work in my web browser?
- Know the Web Soil Survey hours of operation
- Find what areas of the U.S. have soil data
- Know how to hyperlink from other documents to Web Soil Survey

Announcements/Events

- Web Soil Survey 3.0 has been released! [View description of new features.](#)
- Web Soil Survey Release History

I Want Help With...

- Getting Started With Web Soil Survey
- How to use Web Soil Survey
- How to use Web Soil

Another option for the Soil Survey: SoilWeb Apps

<http://casoilresource.lawr.ucdavis.edu/gmap/>



California Soil Resource Lab x

casoilresource.lawr.ucdavis.edu/soilweb-apps

UC DAVIS CALIFORNIA SOIL RESOURCE LAB

HOME SOILWEB APPS

HOME » SOILWEB APPS

SoilWeb Apps

Our online soil survey can be used to access USDA-NCSS detailed soil survey data (SSURGO) for most of the United States. Please choose SoilWeb:

SoilWeb

Explore soil survey areas using an interactive Google map. View detailed information about map units and their components. This app runs in your web browser and is compatible with desktop computers, tablets, and

SoilWeb Earth

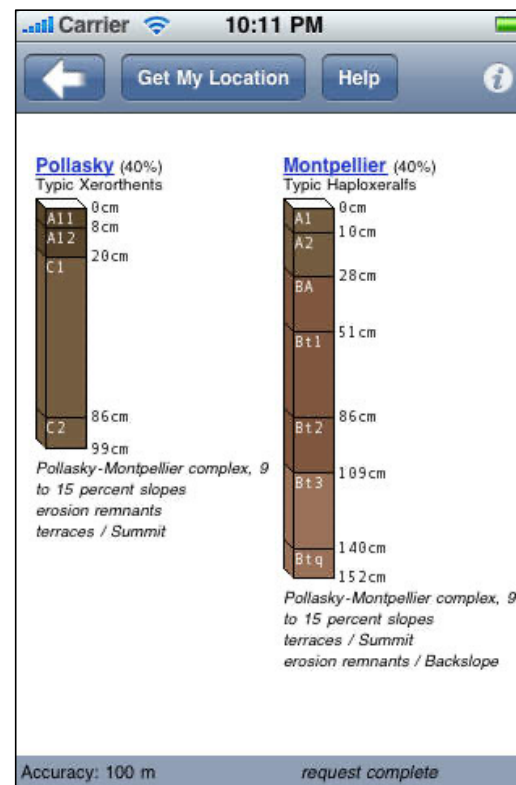
Soil survey data are delivered dynamically in a [KML](#) file, allowing mapped areas in a 3-D display. You must have [Google Earth](#) or some means of viewing KML files installed on your desktop computer, table

Use it in a web browser, or get the app for your phone or tablet. (Google Play Store for Android; iTunes for iPhone or iPad)



Download the app for iPhone or Android: SoilWeb App (from California Soil Resource Lab)

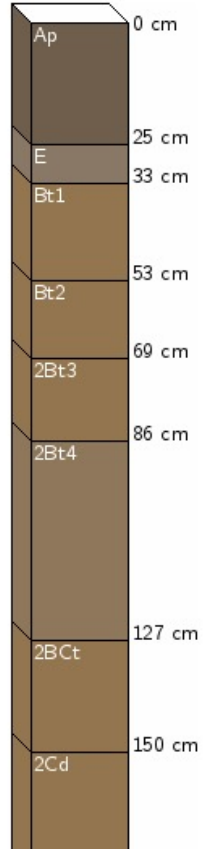
Google Play Store for Android;
iTunes for iPhone or iPad



Map Unit Name: **Starks-Fincastle complex, 0 to 2 percent slopes** Symbol: **SwA**
Component Name: **Fincastle**
Component Key: 11977785
[Soil Data Explorer](#) | [Series Extent Explorer](#)
[Official Series Description](#)

▲ Soil Profiles

- Typical Profile >
- Org. Matter
 - Clay
 - Sand
 - Ksat
 - pH
 - Kr Factor
 - EC
 - SAR
 - CaCO₃
 - Gypsum
 - CEC @ pH7
 - Linear Ext.



Soil hydraulic conductivity by depth shows why this soil is poorly drained.

Typical Profile

Org. Matter Clay

Sand

K_{sat} ? >

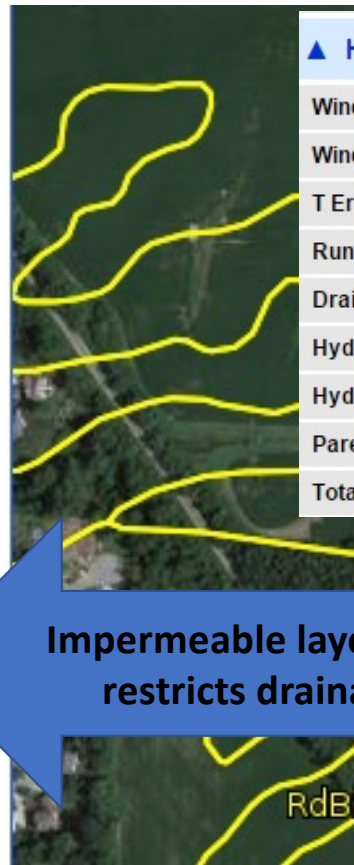
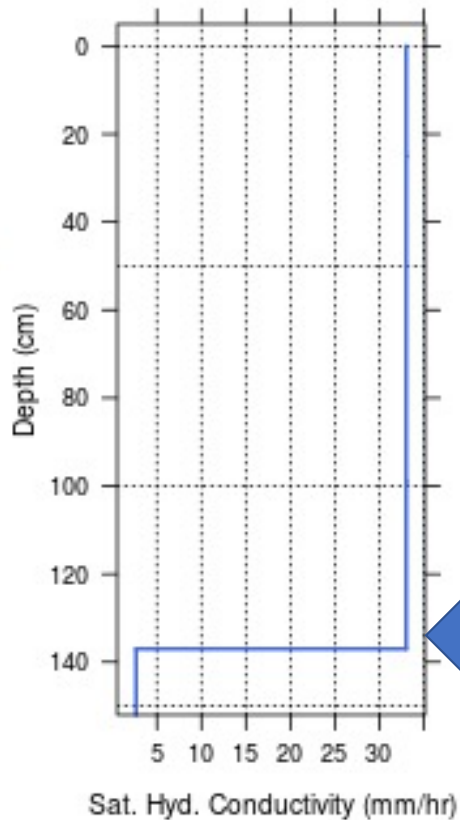
pH K_f Factor

EC SAR

CaCO₃ Gypsum

CEC @ pH7

Linear Ext.



▲ Hydraulic and Erosion Ratings

Wind Erodibility Group: 5 ?

Wind Erodibility Index: 56 ?

T Erosion Factor: 4 ?

Runoff: Low

Drainage: Somewhat poorly drained

Hydric Rating: No ?

Hydrologic Group: Group B/D ?

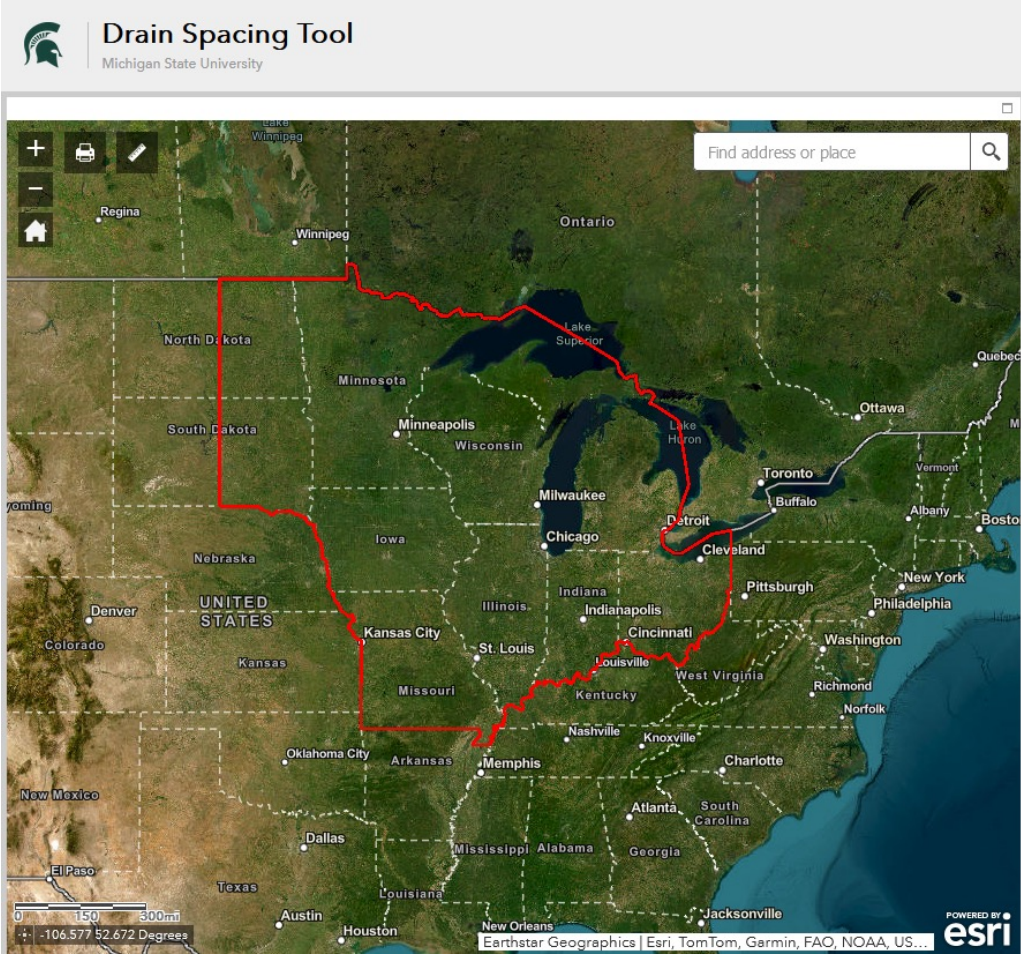
Parent Material: loess over loamy till

Total Plant Available Water (cm): 25.08



Impermeable layer that restricts drainage

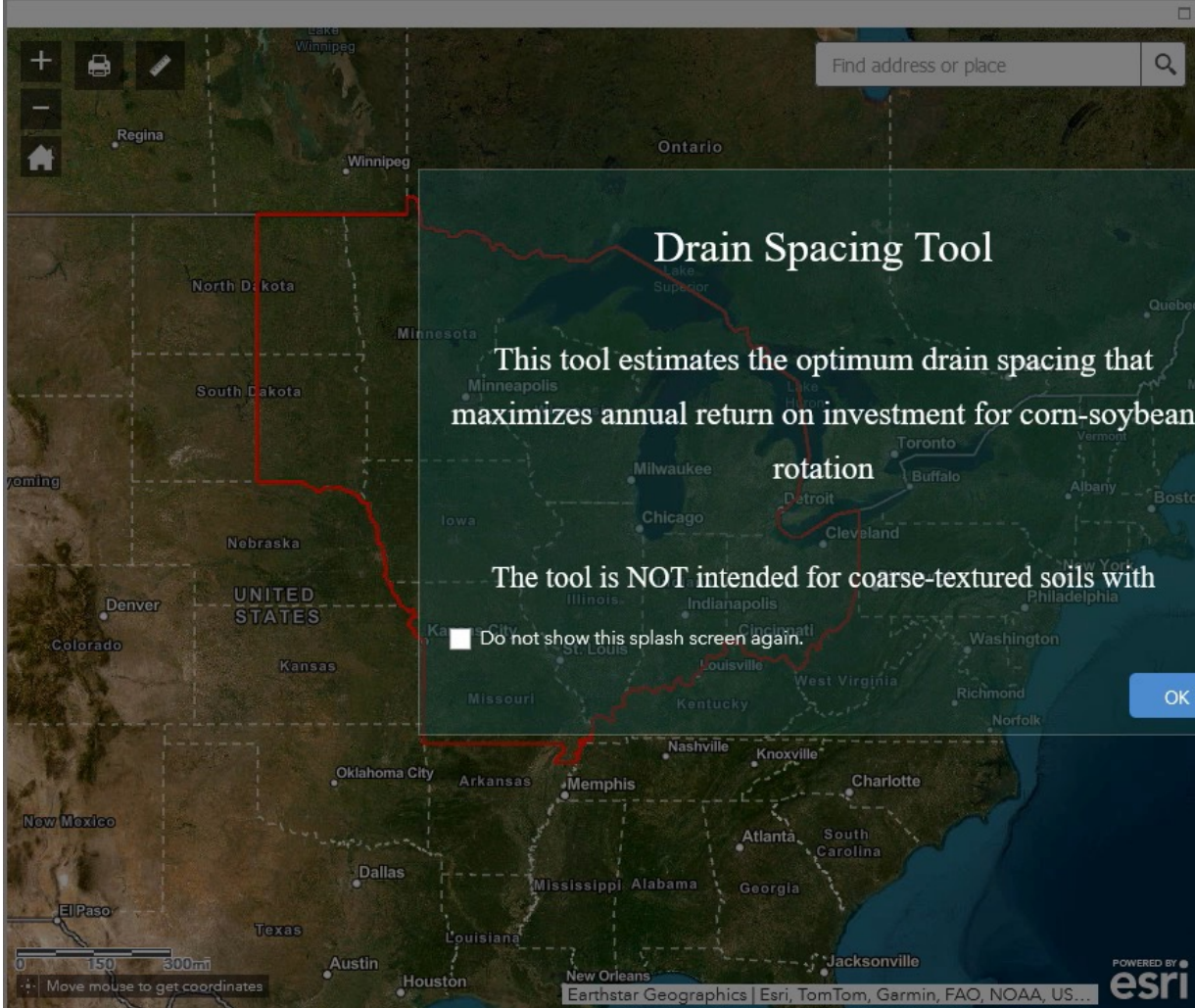
Drain Spacing Tool – Michigan State University





Drain Spacing Tool

Michigan State University



Drain Spacing Tool

This tool estimates the optimum drain spacing that maximizes annual return on investment for corn-soybean rotation

The tool is NOT intended for coarse-textured soils with

Do not show this splash screen again.

OK

Geoprocessing

Input Output

Select shape to draw area of interest

Target corn planting date: 5/15/2024

Design drain depth (ft): 2.5

See Advanced Inputs

Calculate

[User Manual](#)

[Extension Bulletin](#)

[Video Tutorial](#)

Supplemental GIS Layers

Layers

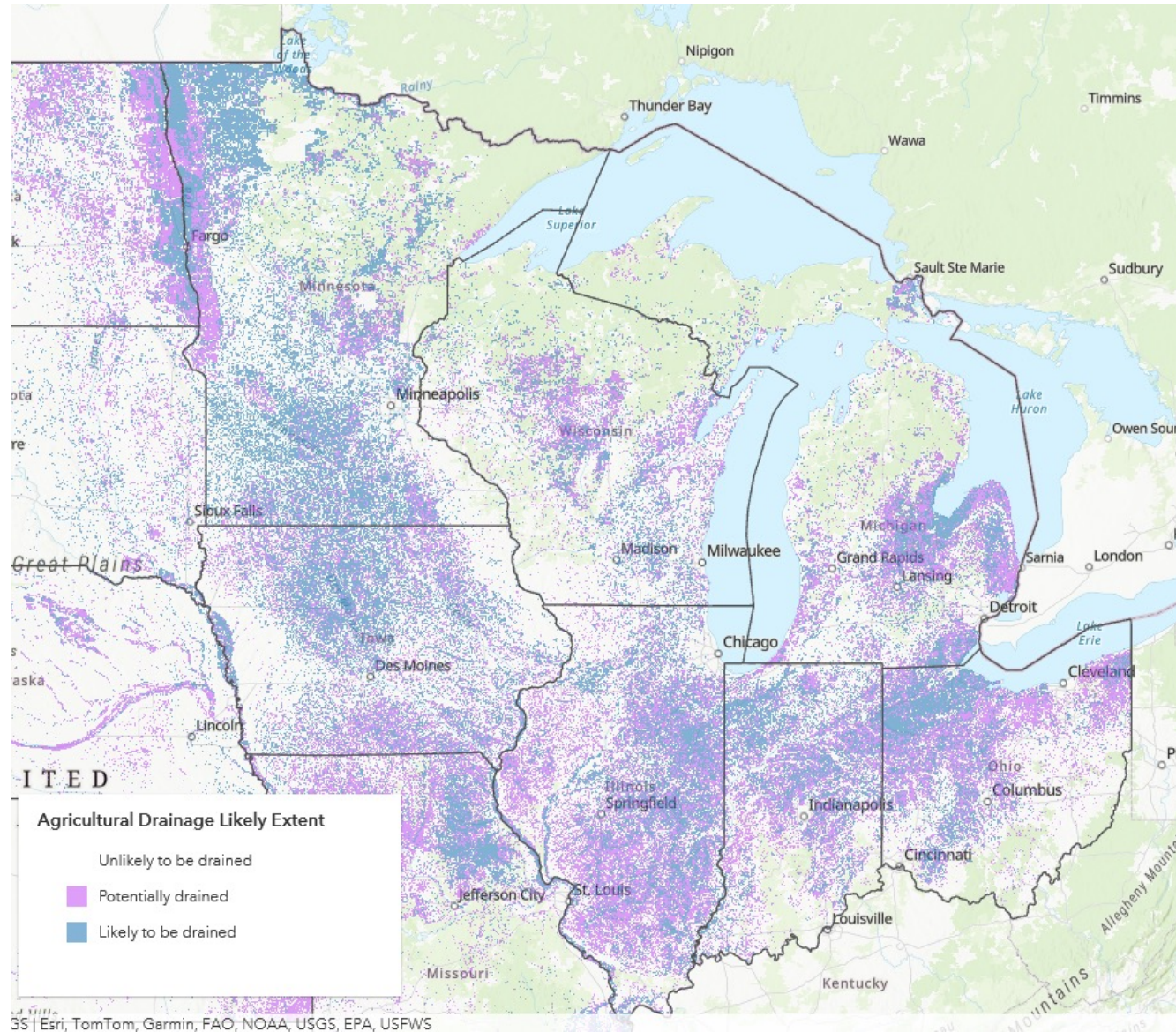
App State

Click to restore the map extent and layers visibility where you left off.



There is no definitive map of drained areas, but the **“Likely Drained Area Tool”** provides an estimate of likely drained areas in the Midwest

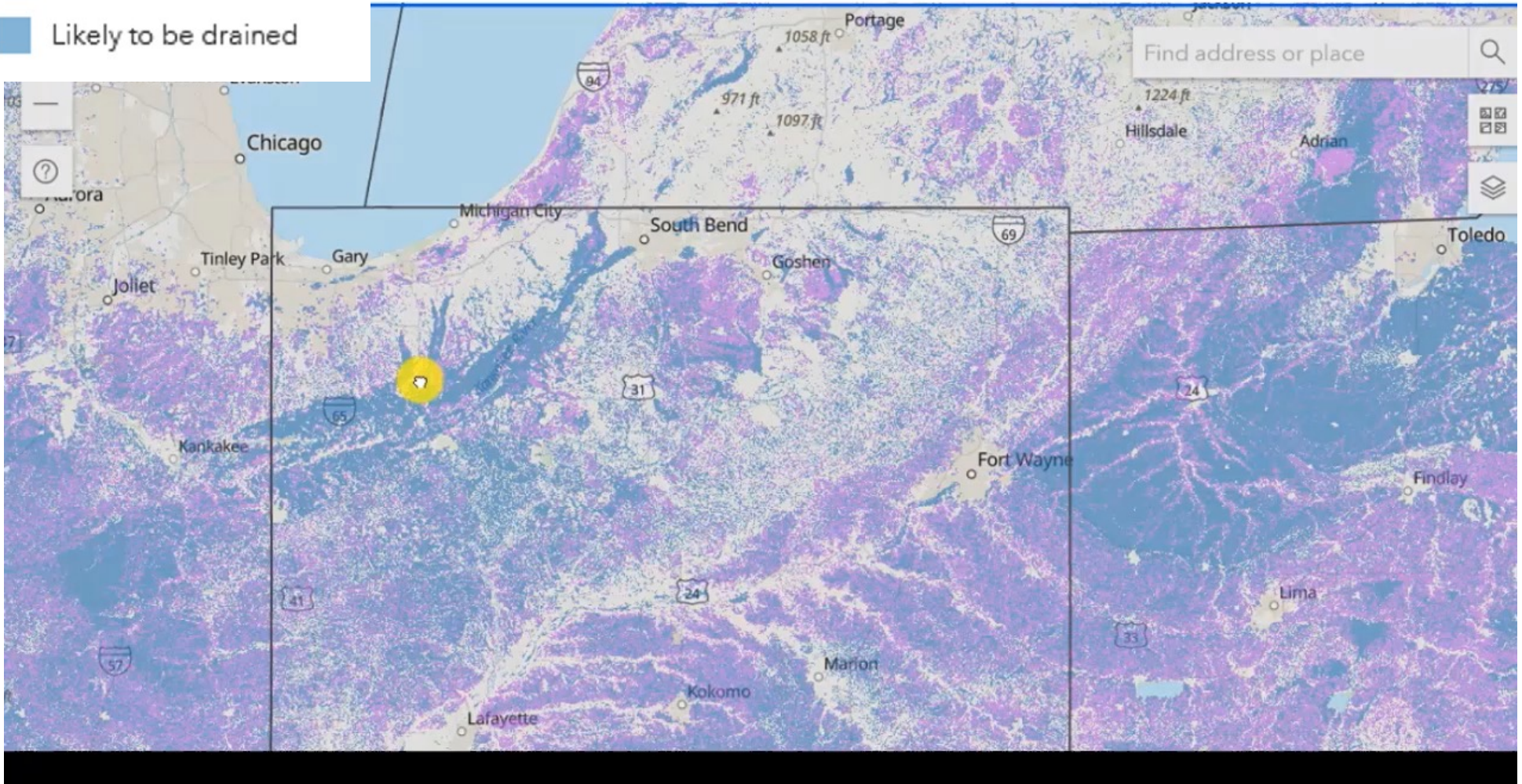
<https://transformingdrainage.org/tools/drainage-area-tool/>



Unlikely to be drained

Potentially drained

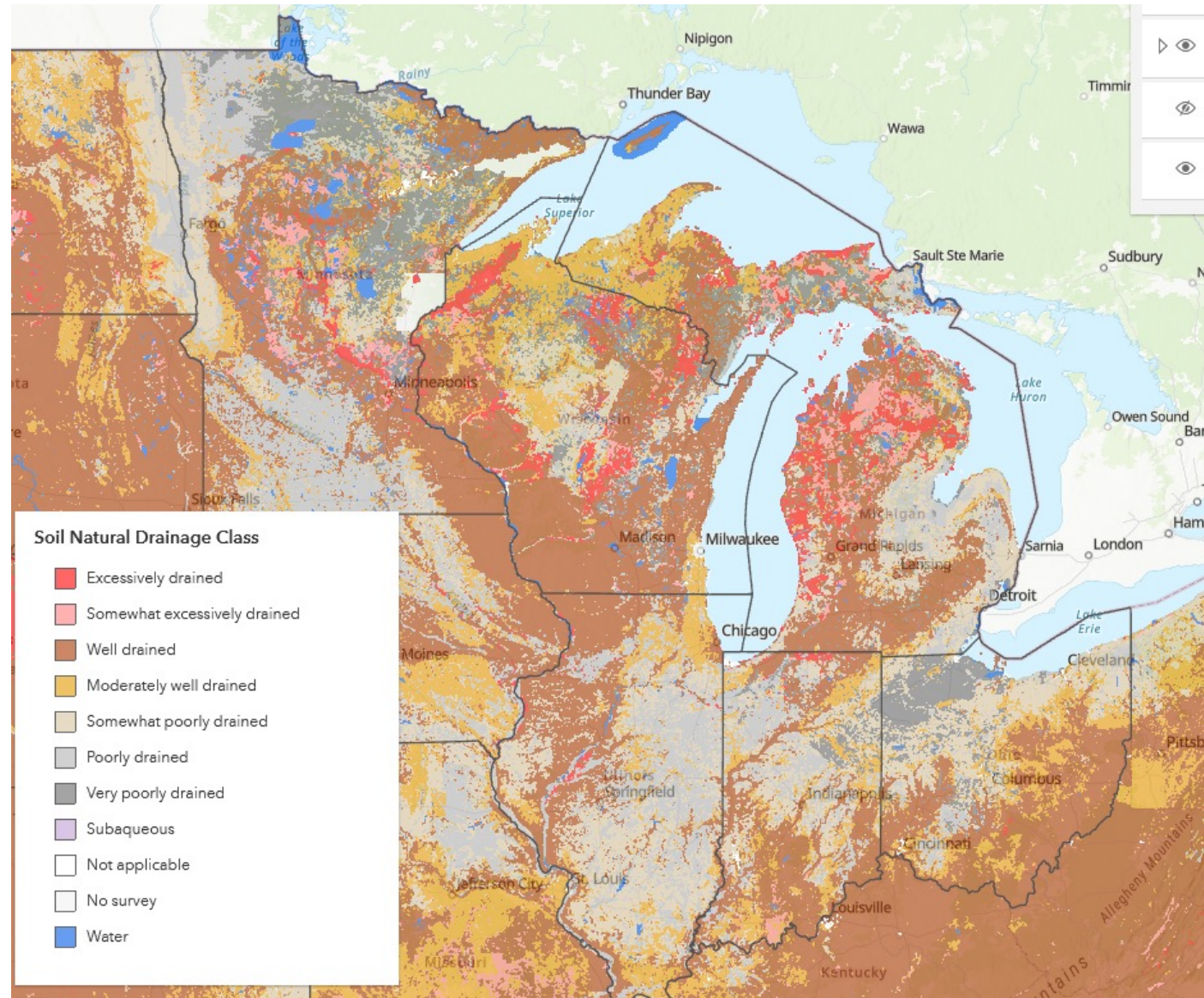
Likely to be drained



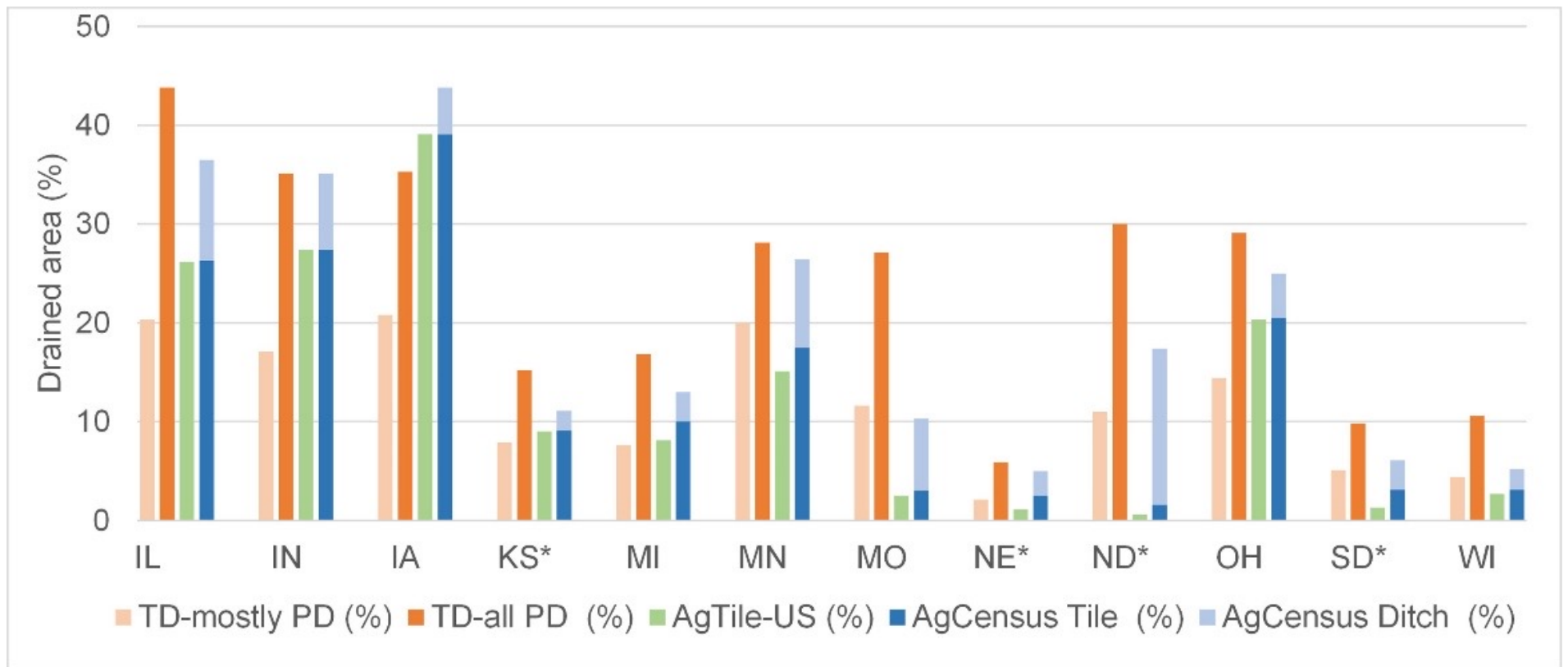
Based on **soil natural drainage class**, a property in the USDA NRCS Soil Survey

(Map from soilexplorer.net.

Grey means poorly drained, just like the soils themselves.)



Estimated drained land by state



Agricultural water management continues to be important.



We have the technology to expand our goals in drainage.



Goals as we plan drainage systems of the future

- Reduce uncertainty and risk related to water availability



- Reduce nutrient losses from agricultural fields





Questions?

