Midwestern farmers are very concerned about getting rid of excess water.
Our drainage infrastructure: extensive, efficient, removes water year all year

Subsurface tile drainage  Surface drainage
Issue 1: Nutrient loss from tile drainage

- Tile drains greatly increase loss of nitrate to streams.
- Recent research is showing more clearly that phosphorus also moves through tiles.
Issue 2: Despite excess water in spring, yields are often limited by lack of water in late summer.
Crop yields are often reduced due to lack of water.

Loss Paid by Crop Insurance in Indiana, 1991-2015 (25 years)

Flooding/Excess Moisture: $930 million
Drought: $1.6 billion
Some years we have excess water and water shortage in the same year. In 2015…

Too much (June)  Then too little (July)
Two issues; both are expected to be become more severe due to climate change.

- Excess nutrients in spring will increase as winter and spring becomes warmer and wetter.
- 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.
The goal has been 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
Storing water in the soil
Increasing soil health.

- Increasing soil organic matter can increase water holding capacity.

Image: Wikimedia Commons, Wilsonbriggs
Image: NRCS
Storing water in wider ditches: Two-Stage Ditches
Storing water in buffers: Saturated buffers

Distribution line to saturate buffer

Conventional buffer – Nitrate in tiles is not treated

Denitrification
Storing water in the field: Controlled drainage

After harvest

Before planting or harvest

After planting
Controlled drainage holds water in the soil, potentially storing water for crops and to reduce nutrient loads.
Controlled drainage research at Davis Purdue Agriculture Center in Indiana
40 acre field divided into 2 controlled and 2 free draining quadrants
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
10-year average nitrate and phosphorus concentration: Highest in June; Approximately the same with free and controlled drainage.
Controlled drainage significantly reduced drain flow

Drainage volume in free-draining and controlled periods for FD and CD plots and number of days in each year that drainage was controlled. (From Saadat et al., in review)
Drain flow averaged all years was reduced particularly in spring.

Gray rectangles show when drainage was controlled.
Nitrate load (lb/acre) was reduced by 9 lb/acre on average.

35% nitrate load reduction

Average Free
26 lb/acre

Avg Controlled
17 lb/acre
Total Phosphorus load was not significantly changed with controlled drainage.

- Average Controlled: 0.53 lb/ac
- Average Free: 0.49 lb/ac
Corn yield over 9 years increased slightly with controlled drainage

• Yield measured with yield monitor each year, cleaned and processed. Example for 2009:
Average increase of 5 bu/acre with controlled drainage
Storing water in ponds or reservoirs:
Drainage water recycling
Storing water in ponds or reservoirs: Drainage water recycling
Few examples of drainage water recycling
Drainage water recycling ponds likely need to be both large and deep to be economical, approximately 20 ft in depth.
Drainage water recycling pond in Manitoba, Canada
Drainage water recycling pond in Manitoba, Canada
Few published drainage water recycling studies:
- Ontario, Canada;
- Missouri
- Ohio
Research need:
Quantify the potential benefits of a drainage water recycling system

- Crop yield benefits from irrigation
- Water quality benefits from capturing and recycling water and nutrients
Water balance in a Drainage Water Recycling System

- Given:
  1. Daily drain flow

- Track:
  2. Soil-crop water conditions
  3. Water level and volume
Water balance in a Drainage Water Recycling System

1. Pond Water Balance

2. Soil Water Balance

Root Zone

Total Available Water (TAW)

Maximum Capacity (V_max)

Precipitation (P)

Evaporation (E)

Irrigation (I)

Runoff (RO)

Deep Percolation (dp)

Upflux (UF)

Transpiring (ET)

Managing Water for Tomorrow’s Agriculture
1. Storage Reservoir
Water Balance

+ Drain flow (D)
+ Precipitation (P)
- Evaporation (E)
- Seepage (SP)
- Irrigation (I)

Daily Water Volume = $D + P - E - I - SP$

Monthly Evapotranspiration
2. Soil Water Balance

- Variables:
  + Precipitation (P)
  + Irrigation (I)
  - Runoff
  - Evaporation/Transpiration (ET)

*Deep percolation and capillary rise excluded

Depletion \( (D_p) = D_{p,i-1} - (P - RO) - I + ET \)
Irrigation – The connection

• Calculating crop water demand
• Identifying total available water (TAW)
• Where demand > readily available water (RAW) = stress

\[(K_s K_{cb} + K_e) ET_o = ET_{c,adj}\]
Tracking water in the storage reservoir

- As water is **added** to the system:
  1. Captured if available capacity > inflow
  2. Overflows if available capacity < inflow
Water balance in a Drainage Water Recycling system

Given: daily drain flow (plus surface runoff if desired).

The tool tracks
1. Soil-crop water use and irrigation needs
2. Storage water level and volume
Example: Davis Purdue Agriculture Center in Indiana

Field Data (2006-2016, daily)
- Drain flow
- On-site climate
- Water Quality
  - Nitrate-N

Data from Saadat, Bowling, Frankenberger
Various Sizes of Storage Reservoir

2% of field area
4% of field area
6% of field area
8% of field area
10% of field area

Avg. Depth: 3.05 m = 10 feet
Flow and Nitrate-N Recycled in System

Data from Reinhart et al., in preparation
Managing Water for Increased Resiliency of Drained Agricultural Landscapes

University of Missouri

Iowa State University

The Ohio State University

Purdue University

NDSU North Dakota State University

South Dakota State University

Managing Water for Tomorrow's Agriculture

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.
Field Research – Existing, New, Historical Sites
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$_2$O Flux – 2004 to 2005
- Grain nitrogen – 2006 to 2007

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Transforming Drainage Database now includes 186 site years of drainage storage practice data.

Each site has data with and without a drainage storage practice.

Synthesis across sites will allow us to develop regional recommendations.
Transforming Drainage Project Components

Strengthen and Broaden the Network
(Researchers, Industry, Contractors, Agencies)
Tools for Transforming Drainage

Drainage Water Recycling Evaluation Tool (DWRET) to assess the potential of drainage water recycling.
Calculates the benefits of various sizes of water storage ponds

User inputs a range of storage volumes. **Example:** 0 to 100 acre-feet
Input: Daily drain flow

If measured, that is great.
Input: Daily drain flow

To begin, click on a location to select a grid cell that will be used in calculations. Make sure to confirm the selection.

Select your location, to use estimated (modeled) drain flow.
Input: Storage, Soil, Irrigation characteristics

User inputs:
- irrigated area,
- depth applied at one time,
- soil available water
Output

**Annual captured flow across storage sizes**
(Average ± Std Dev)

Proportional to the nitrate and phosphorus loss reductions of the system

**Annual irrigation supply across storage sizes.**
(Average ± Std Dev)

6.5 inches
Tool 2: Controlled Drainage Suitability
Extension and Engagement to Transform Drainage

- Informative website: TransformingDrainage.org
- Regional Extension Publications:
  “Questions and Answers About Drainage Water Recycling for the Midwest”
- Field Days and other events throughout the region

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

Links to news and social media:
Private Sector Partners in the Network

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

- Iowa Soybean Association and other commodity groups.

Creating a project toolkit

An update on the Transforming Drainage project.

By Bob Clark

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

Water recycling feasibility

The latest on the Transforming Drainage project.

By Ben Rindfleisch

The Agricultural Drainage Management Coalition (ADMC), Agricultural Drainage Management Systems Task Force and Dr. Dan Jaynes with the National Laboratory for Agricultural & The Environment collaborated to demonstrate and evaluate saturated buffers at field scale to reduce nitrates and phosphorus from subsurface field drainage systems.
The Vision: Transforming Drainage

Long-term vision: Agricultural drainage will be transformed to include water storage and recycling.