Constructed Wetlands to Reduce Nutrients From Cropland Runoff:

IMPLICATIONS FOR URBAN STORMWATER – Design and Construction Considerations


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THE WETLANDS INITIATIVE

CBB

The Nature Conservancy

Illinois Central College

Green Infrastructure / Constructed Wetland

- "Green infrastructure" means any storm water management technique or practice employed with the primary goal of preserving, restoring, or mimicking natural hydrology.
- Many types of GI...
  - bioswales, rain gardens, permeable pavement, tree boxes, etc.
- **Constructed wetlands** are engineered ecosystems specifically sited, designed, built, and operated to treat water.
- On farmland, these wetlands are sited and designed specifically to remove nitrate and phosphorous from subsurface drainage (drain tiles).

Conservation Reserve Program

THE WETLANDS INITIATIVE

- The Wetlands Initiative (TWI) has successfully facilitated the design and construction of a treatment wetland on **several** private farms in north central Illinois over the past ten years.
- Goal of reestablishing valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat.
- Conservation Reserve Program is a land conservation program under the U.S. Department of Agriculture's (USDA) in exchange for a yearly rental payment.
  - Farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production, already low yielding areas, and plant other species that will improve environmental health and quality.
- Contracts lasts 10 to 15 years.
- Since 1985, CRP is one of the largest private-lands conservation programs in the United States.

ILLINOIS
NUTRIENT LOSS
REDUCTION STRATEGY

Improving our water resources with collaboration and innovation

Nutrient pollution is a major threat to water quality in Illinois. Over the decades, state and local efforts to control nutrients have yielded positive results, but new strategies are needed to improve the effectiveness of existing water quality programs and secure the long-term health of water bodies in Illinois and throughout the Mississippi River Basin.

What is nutrient pollution?

Plants and animals need nitrogen and phosphorus to survive. But when too much of either is carried in runoff from city streets and farm fields or flows out of wastewater treatment plants, it can fuel algal blooms that decrease oxygen needed by aquatic plants and animals. In the Gulf of Mexico, nutrients washed down by the Mississippi River have created a 'dead zone' that covers thousands of square miles. Algal blooms also lower property values, hinder recreation, and threaten public health. In addition, nutrient pollution can degrade drinking water quality and require utilities to install costly treatment equipment.

What is Illinois doing to address the problem?

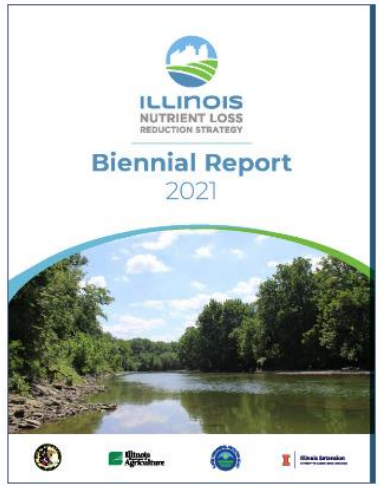
To help protect local streams and the Gulf, Illinois and 11 other states in the Mississippi River Basin have pledged to develop strategies to reduce the nutrient loads leaving their borders. These strategies are part of a national plan developed by the Mississippi River, Gulf of Mexico Watershed Nutrient Task Force to reduce the size of the Gulf of Mexico hypoxic zone.

The Illinois Nutrient Loss Reduction Strategy builds on existing efforts by state and local governments, as well as non-profits and industry, to protect and restore Illinois waterways.

Key Strategy Components

1. Extends ongoing regulatory and voluntary efforts
2. Identifies priority watersheds for nutrient loss reduction efforts
3. Establishes the Nutrient Monitoring Council to coordinate water quality monitoring efforts by government agencies, universities, non-profits, and industry
4. Creates the Nutrient Science Advisory Committee to develop numeric nutrient criteria for Illinois waters
5. Forms the Agricultural Water Quality Partnership Forum to oversee outreach and education efforts
6. Establishes the Urban Stormwater Working Group to coordinate and improve stormwater programs and education
7. Lays out strategies for improving collaboration among government, non-profits, and industry
8. Defines a process for regular review and revision

Why ?



- Nutrient runoff is primarily responsible for the annual "dead zone" in the Gulf of Mexico and large algal blooms in parts of the Great Lakes.
- Row-crop agriculture is the biggest source of nutrients.
- Gulf of Mexico Hypoxia Action Plan
  - Requires all watershed states to develop a plan to reduce their nutrients.
- Illinois **Nutrient** Loss **Reduction** Strategy
  - Address point-source, urban runoff, and agricultural runoff

Drain Tiles

We need fertilizer and drainage for productive farming.

The drain tile has been a critical aspect to farming since the mid-19th century responsible for making planting and harvesting more consistent and reliable from year to year.

The drain tile acts as a transport vehicle, allowing field drainage of excess water to carry nutrients with it, including nitrates.

Illinois Nutrient Loss Reduction Strategy

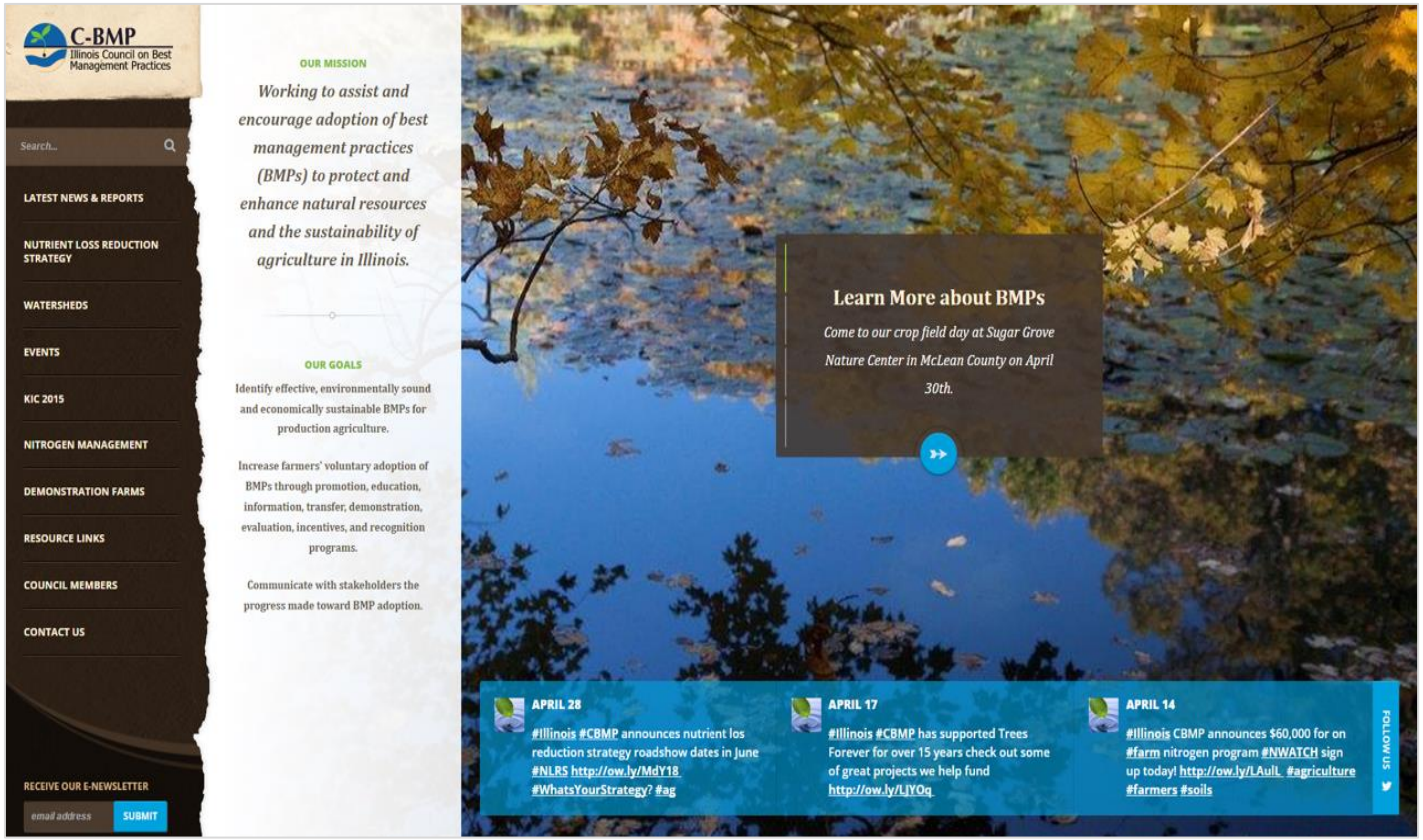
- Identifies BMP Strategies for farmers
- Illinois sought input from major agricultural commodity organizations to support the strategies identified.
  - Illinois Farm Bureau,
  - Fertilizer and Chemical Association,
  - Corn Growers Association

- **Focused on keeping nutrients in the field for crops and not in waterways.**

WHAT'S YOUR STRATEGY?

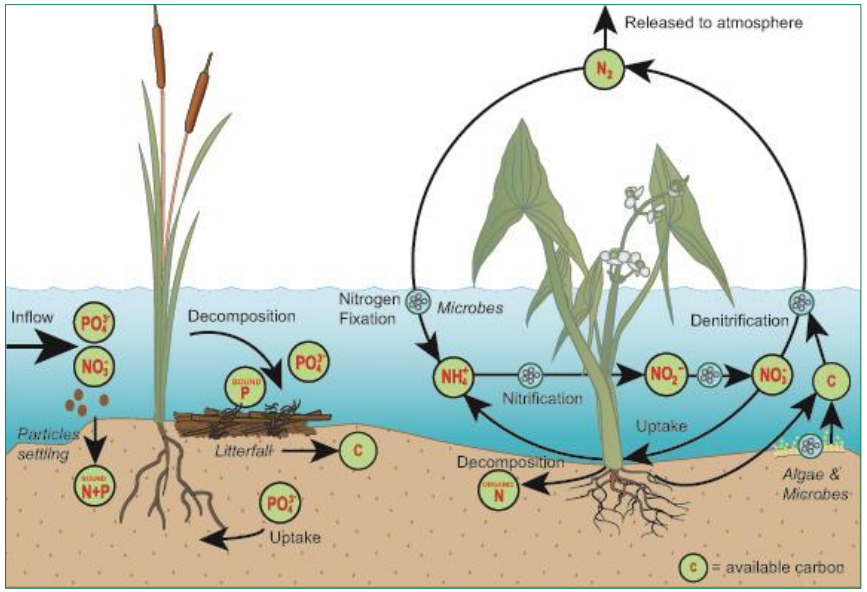
IL COUNCIL ON BMPs

www.illinoiscbmp.org



Green Infrastructure Practices

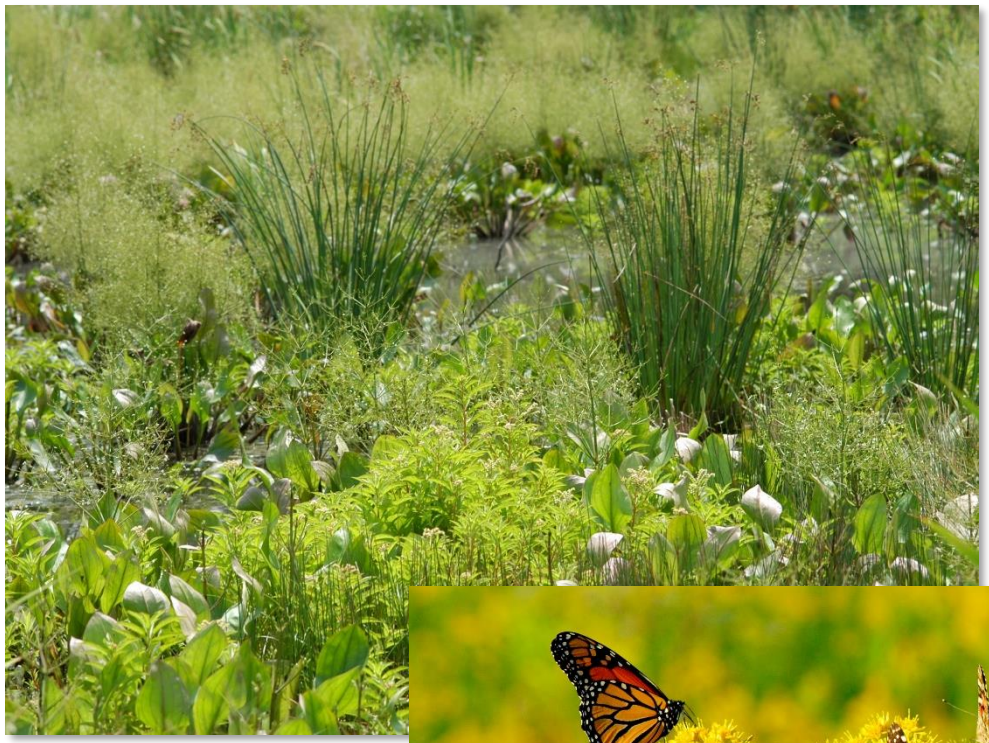
- Achieve significant nitrate reduction by treating nutrients leaving the field through drain tiles
  - Vegetated Buffers
  - Bioreactors
  - Constructed Wetlands



- Constructed Wetlands
  - Specifically located and designed for a particular drainage area for the purpose of intercepting drain tile drainage to reduce nutrients before reaching a receiving waterway.
  - Optimize the natural process to remove nutrients.

- **The same concept seen in a rain garden or bioswale used in an urban application for nutrients in urban stormwater runoff.**

Constructed Wetland



- Densely vegetative marsh versus open water
- Vegetation is critical to slow water down while providing substrate for working microbes
- 50-year functionality with very low maintenance
- **Can be used to intercept field tile drainage.**
  - Pollinator habitat
  - Wildlife habitat
  - Carbon sequestration

Buy-In and Cost Share

- The Wetlands Initiative works with farmers (1 on 1) to promote interest.
  - TWI is a non-profit organization dedicated to restoring the wetland resources of the Midwest.
  - Land owner confidence that the practice will work.
    - Local buy-in, trusted farm leaders.
    - Implemented in often low producing areas of the farm.

- Not simply building a few wetlands and assume other farmers will copy and take action.
  - TWI is spreading the practice within the real-life economics of the working Farm Belt.
  - TWI wants to prove this type of on-the-ground conservation is not some little boutique thing but a **normal part of the working farm-belt landscape** just like nutrient management, grassed waterways or drainage ditches.

- Federal cost share programs → Farm Service Agency
  - Offset the cost for this practice while reducing investment in less-profitable land.
    - EQIP – Environmental Quality Incentives Program
    - CRP – Conservation Reserve Program
      - Is the project eligible
  - NRCS – must approve the design.

THE WETLANDS INITIATIVE

1 POSITION

- Intercept tile drainage before outlet ditch or stream
- Capture high nutrient loads
- Locate in watershed headwater areas
- Marginal or unprofitable land

2 SIZE

- Key to nutrient removal
- Allow adequate residence time
- Treatment area is 0.5-5.0% of the drainage area
- Treatment area is 12" above to 24" below permanent pool

3 DEPTH

- Marsh wetland (aka shallow "pond")
- At least 50% of the permanent (normal) pool is 12" or less
- Anything greater than 24" in depth doesn't count towards the ratio or treatment area

Design

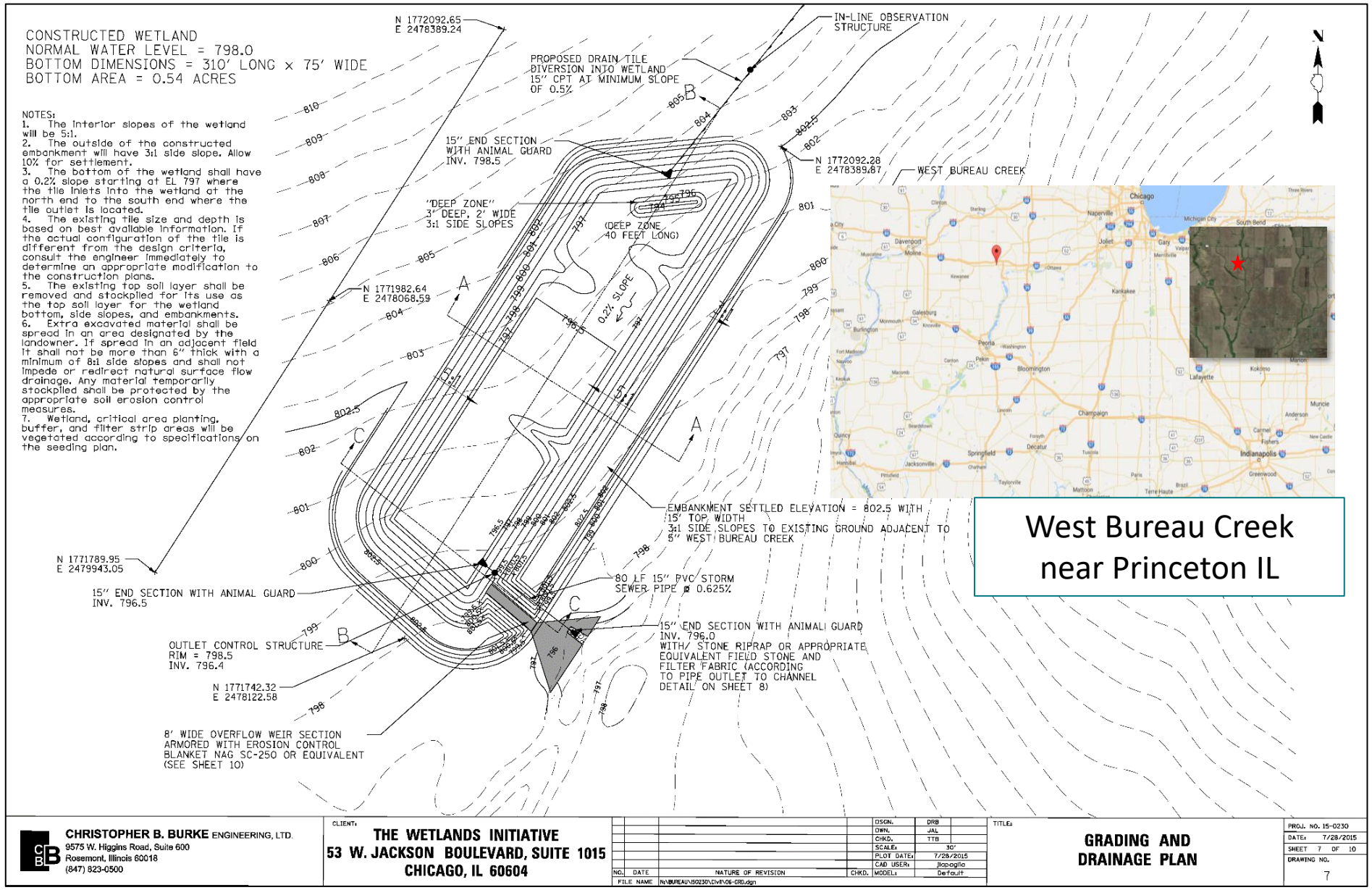
NRCS Criteria

HMS Hydrologic Modeling

- SCS Methodology
- 25-yr, 24-hr
- Max velocity = 1.5 ft/sec
- 72-hr draw down; 10yr, 24-hr storm

Constructed Wetland Design (Agricultural Use)

- Intercept existing drain tile
- Located adjacent to creek
- Inlet and outlet structures
- 40 acres of tributary area
- Treatment area is 0.5 acres
- Small berms to increase flow path



West Bureau Creek near Princeton IL

Construction

Conservation Expo
2015

ILLINOIS CHAPTER
Land Improvement Contractors of America
LICA
DEDICATED TO PROFESSIONAL CONSERVATION OF SOIL & WATER

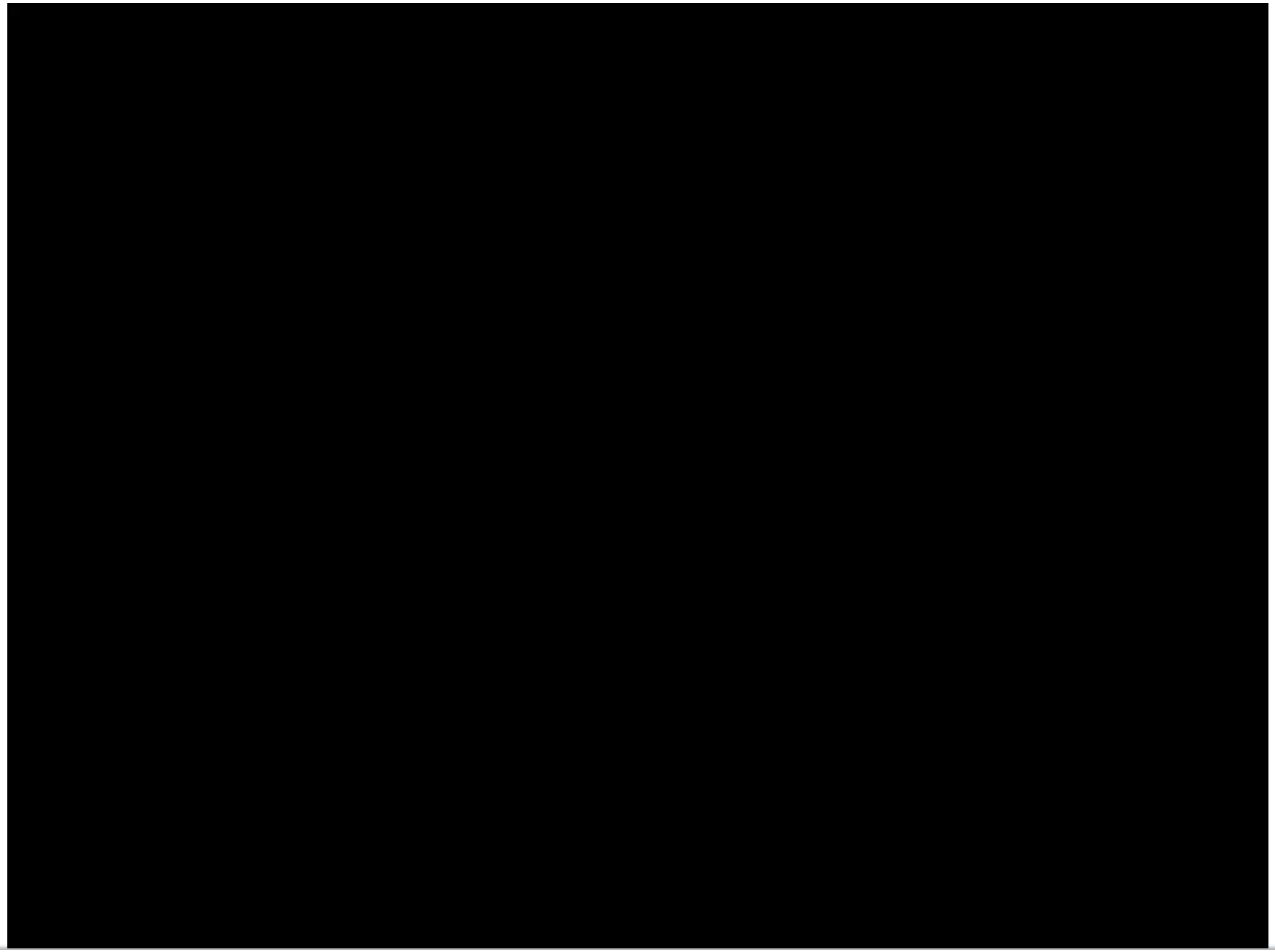
THE WETLANDS INITIATIVE

In an effort to increase public awareness and education, TWI partnered with the IL chapter of the Land Improvement Contractors of America.

The wetland was built as part of ILICA's conservation expo that was held Aug 4-6th. The construction was between the 3nd- 8th.

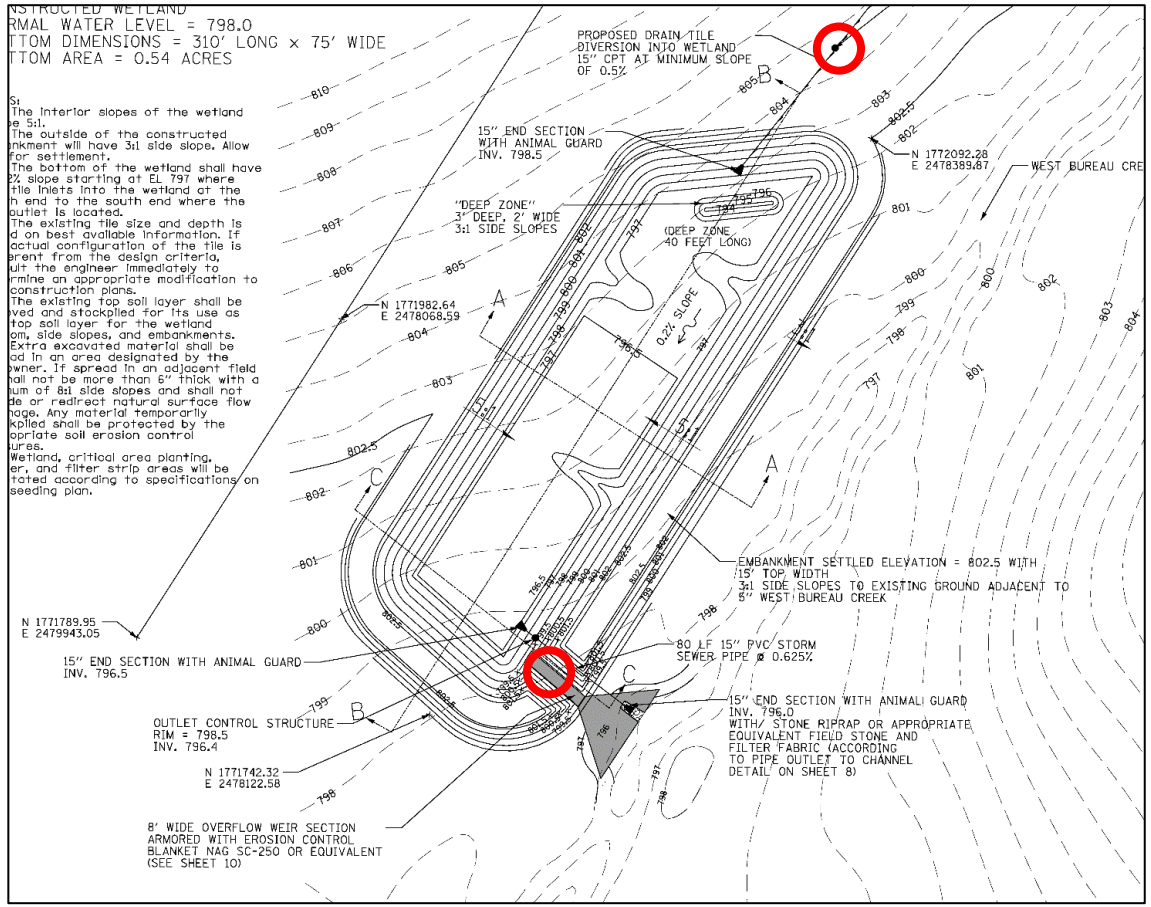
7000 Cubic Yards

Compacted Clay Liner

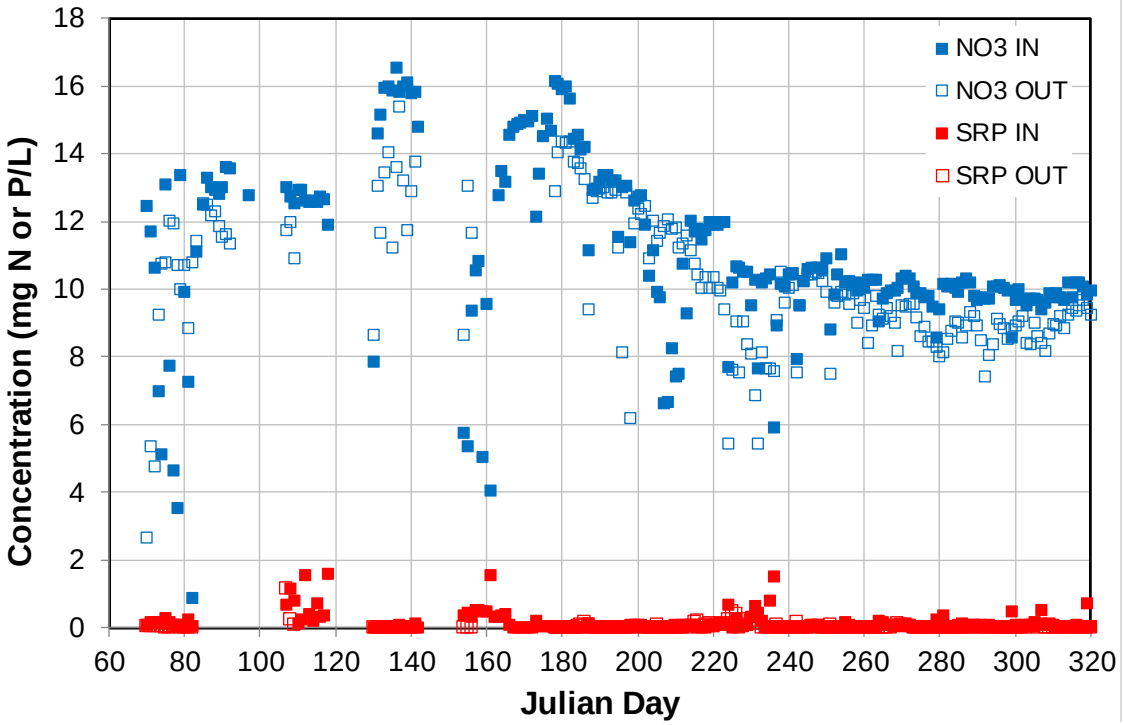


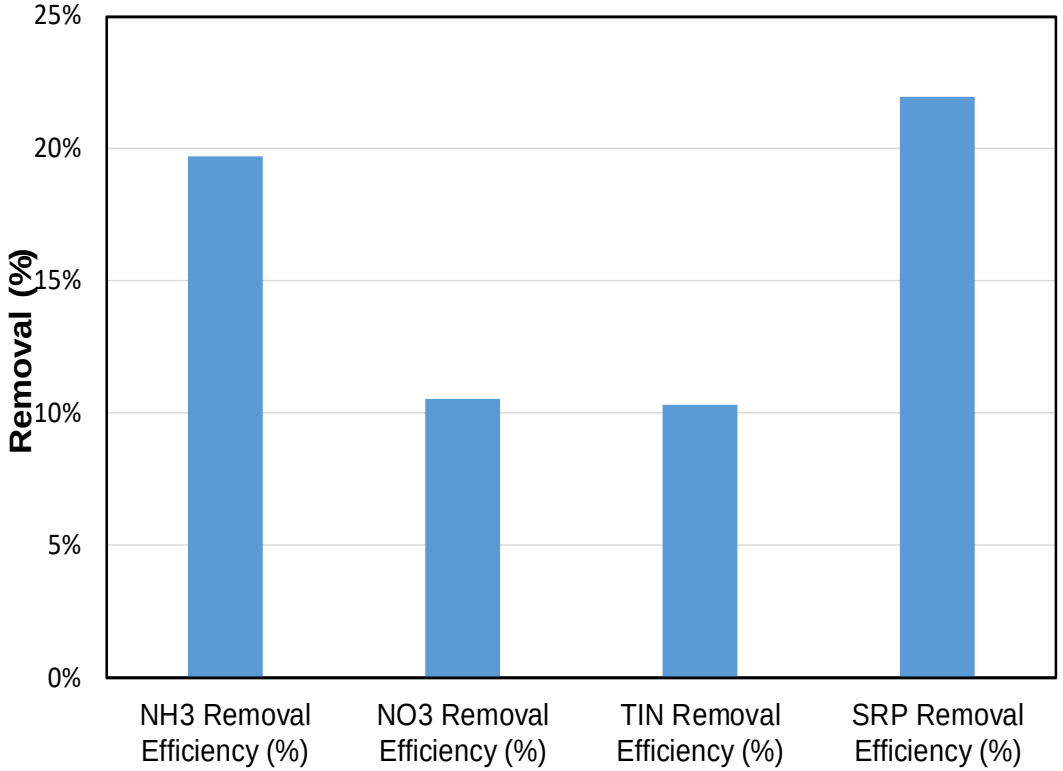
Performance Monitoring by UIC Dept. of Civil and Materials Engineering

Sampling at Inflow and Outflow



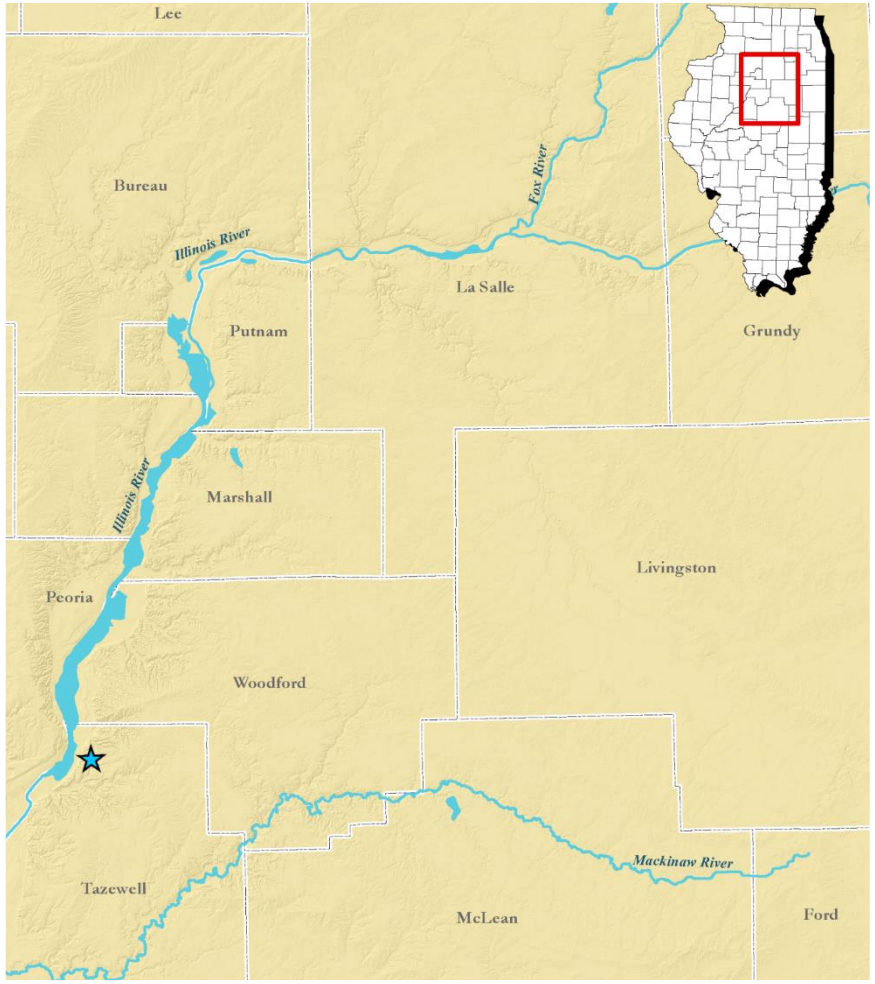
P removal > N removal (on a % basis)





Overall, removal averaged 22% for SRP, 10.6% for nitrate

Illinois Central College – East Peoria Campus



- Agricultural Production (Certificate Program)
- Agricultural Science and Technology (Associate, Career Program)
- Agriculture (Associate, Transfer Program)

Illinois Central College – East Peoria Demonstration Farm

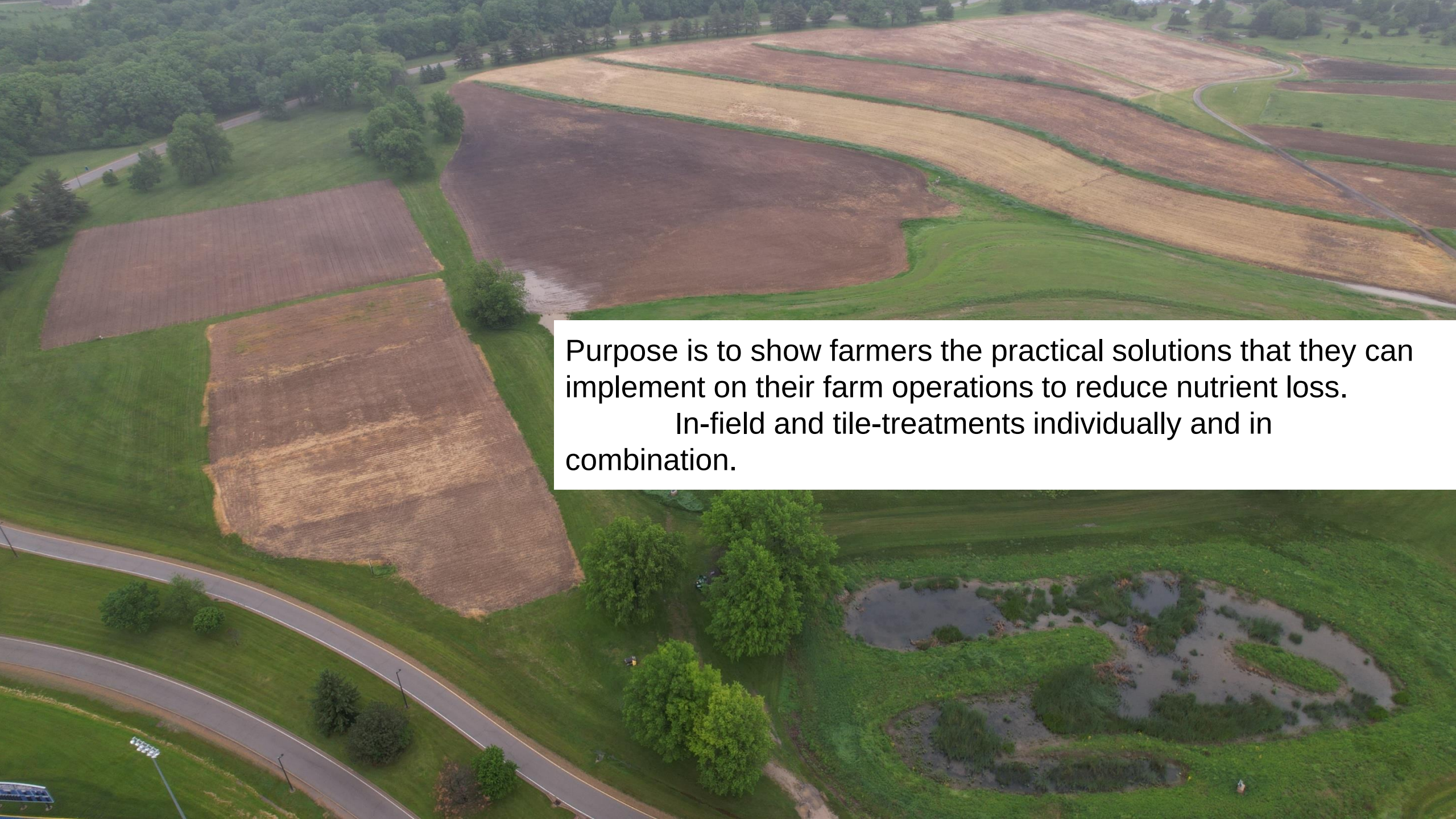
History

- 50-acre of demonstration fields in 2001
- 20 additional acres added in 2019

Applied Research

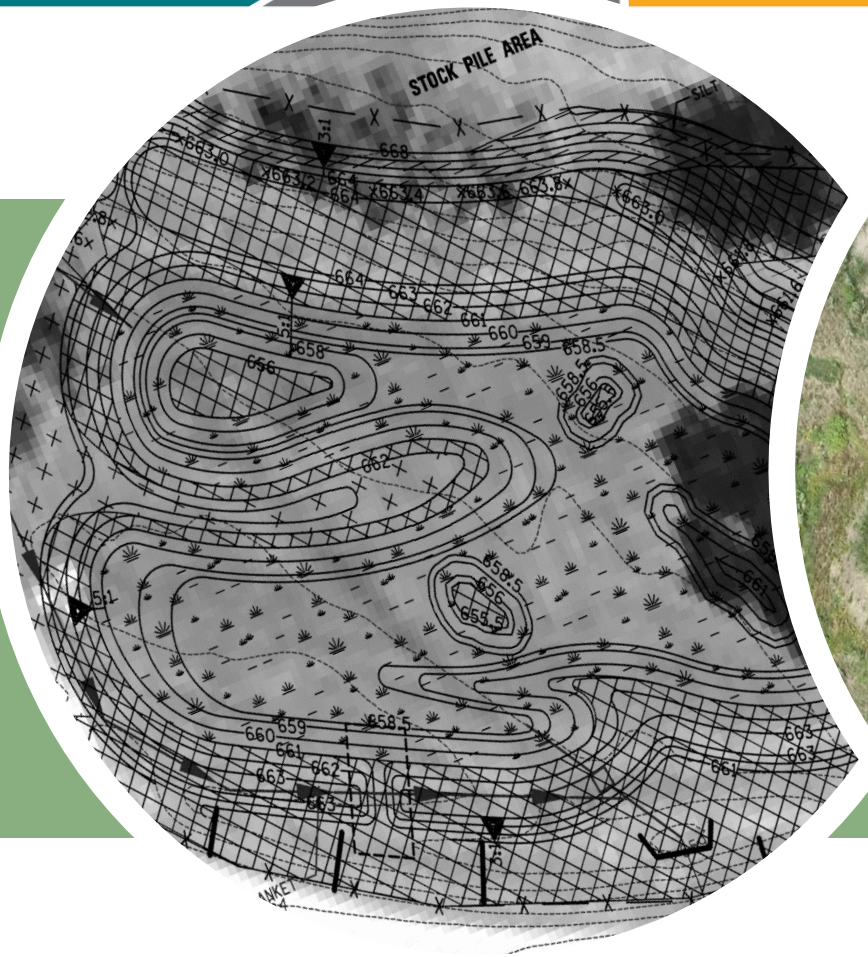
- Herbicide trials focused on residual
- **Paired trial of conventional tillage vs. no-till with cover crops**

ICC's AG programs are advancing research for the AG community for water quality. Field days for farmers, landowners and advisors.

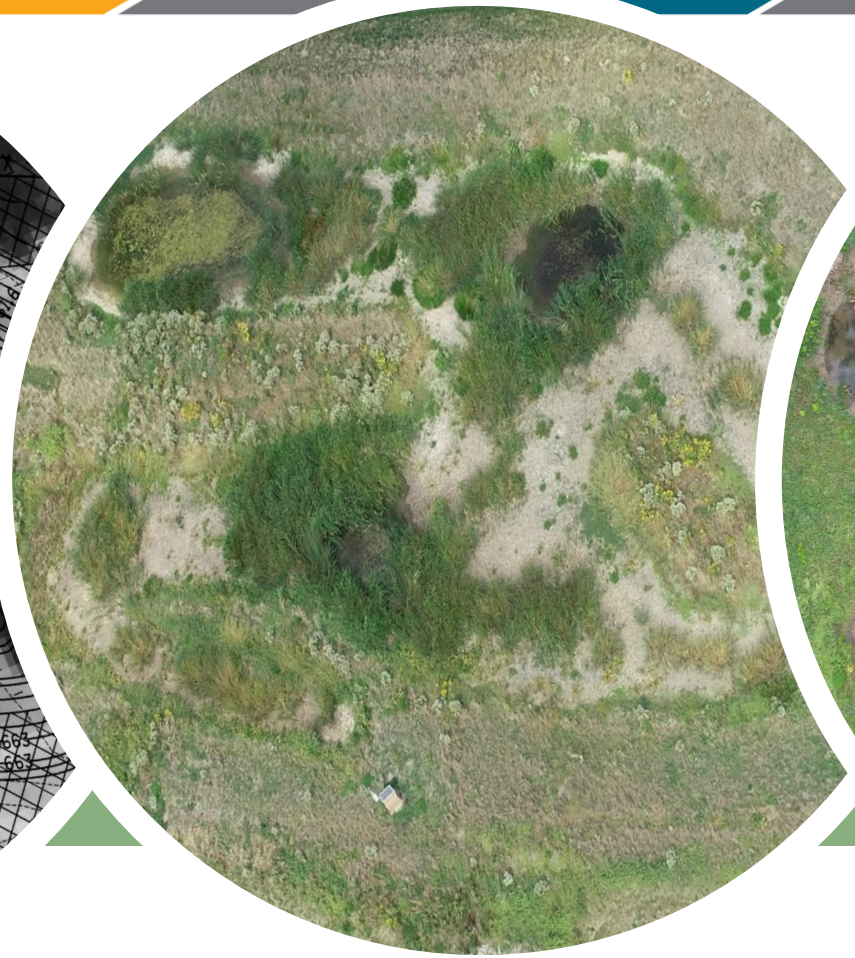


Purpose is to show farmers the practical solutions that they can implement on their farm operations to reduce nutrient loss.

In-field and tile-treatments individually and in combination.



2019

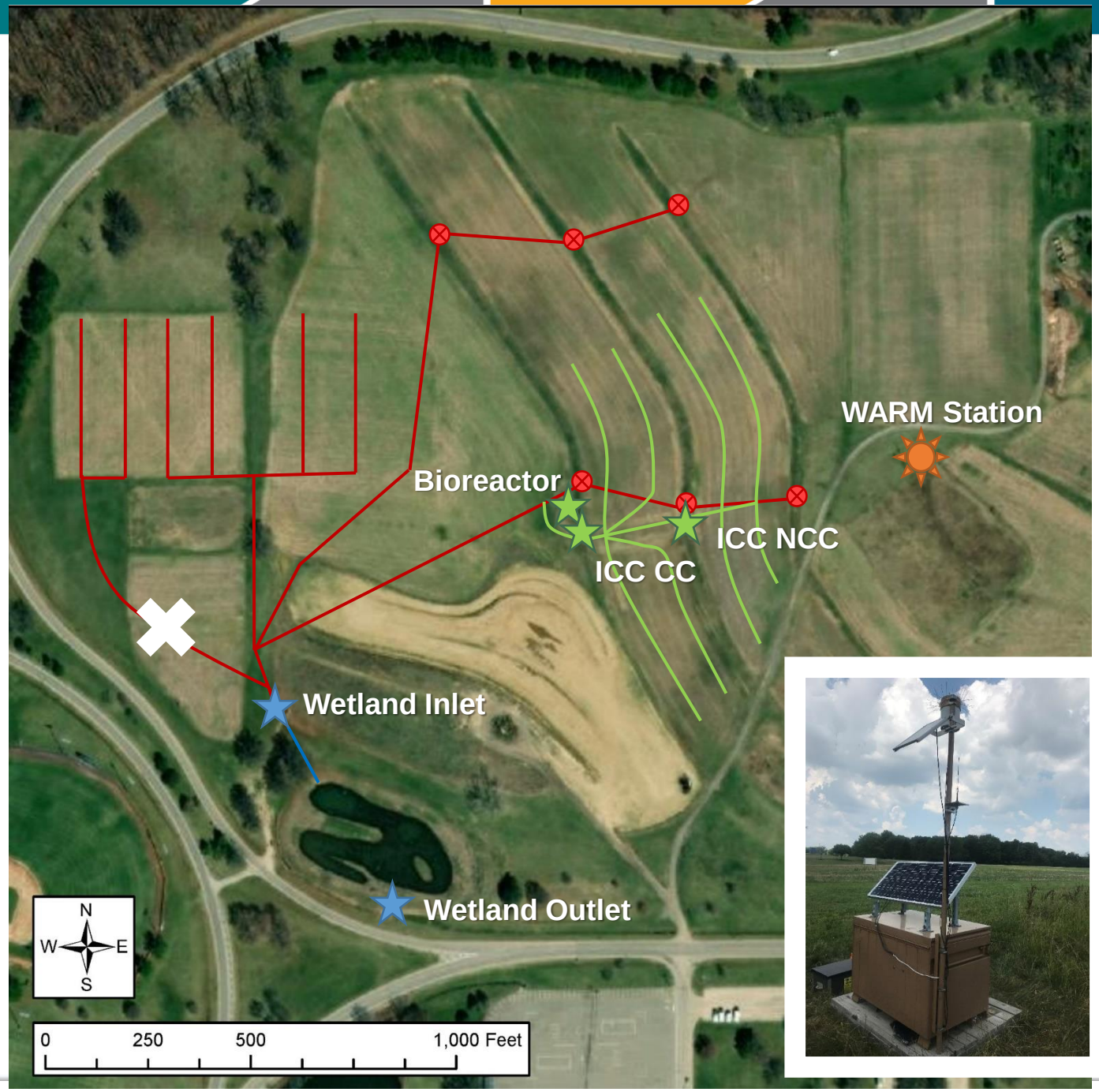


9/2021

5/2022

- 35-acre drainage area includes surface intakes (terraces) and subsurface (tile) drainage
- Sediment control basin at inlet for any surface soil particles entering wetland
- Wetland treatment area = 0.9 acre (2.5% of drainage area)
- Native wetland vegetation tolerant to nutrient concentrations and changing water levels

Water Quality Monitoring



- USDA SARE grant & IL Corn Growers provided funding for continuous tile water quality monitoring.
- ICC staff/students collect the samples that are currently analyzed at Illinois State University.

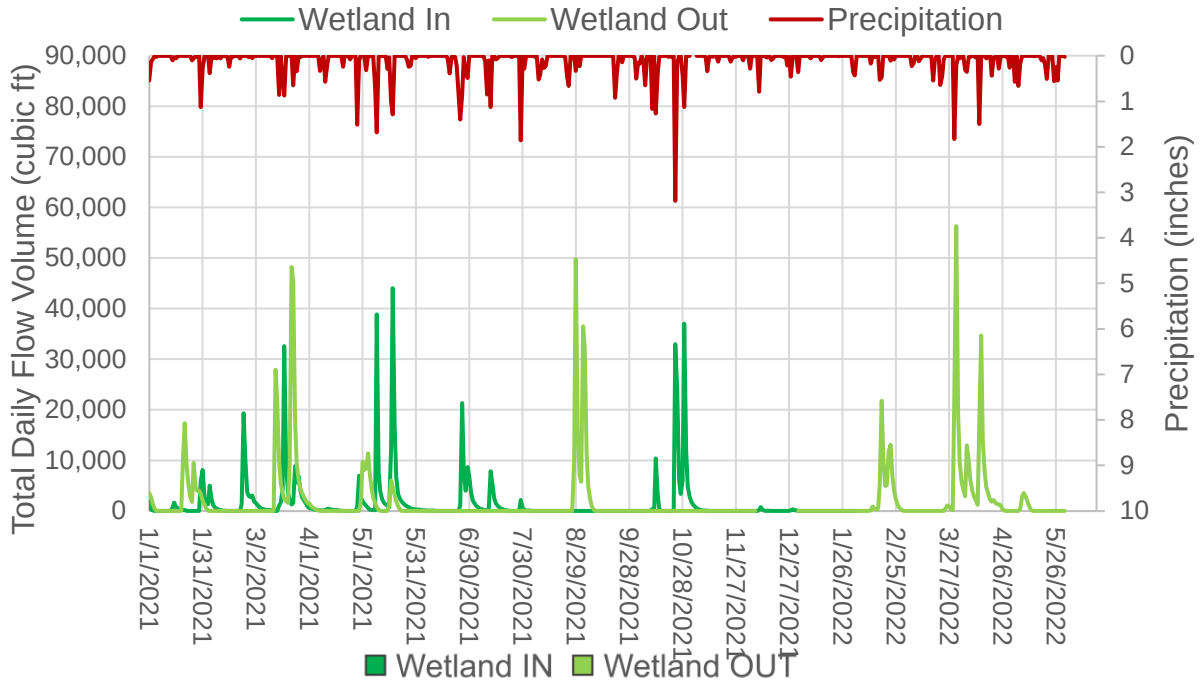
SARE
Sustainable Agriculture Research & Education

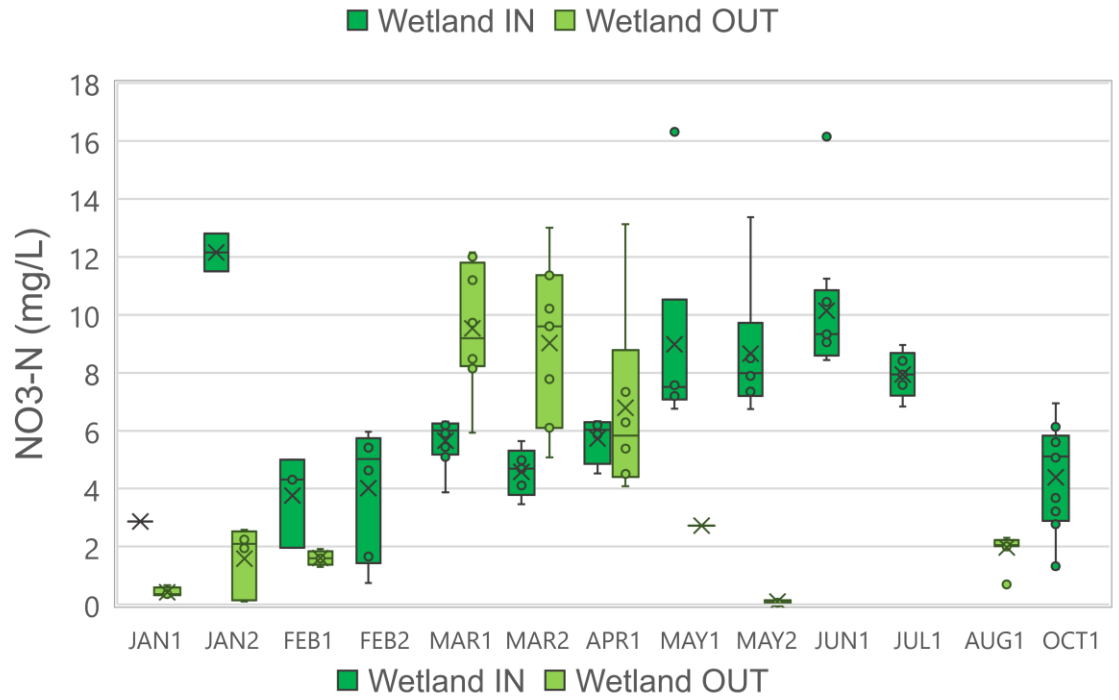
Illinois Corn Growers Association

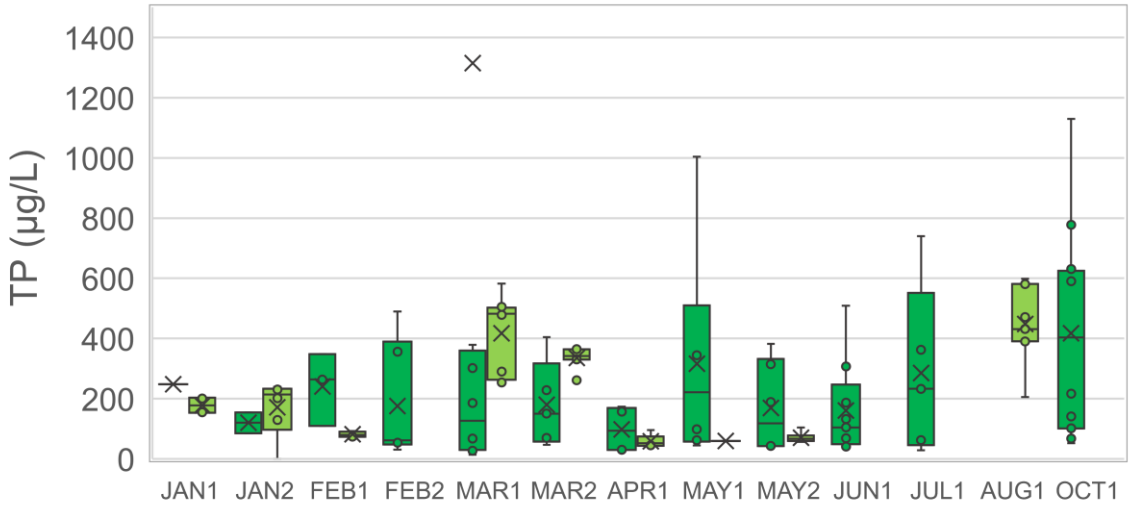
Water quality monitoring is supported by the IL Corn Growers Association and C2A3 SARE grant to ICC.

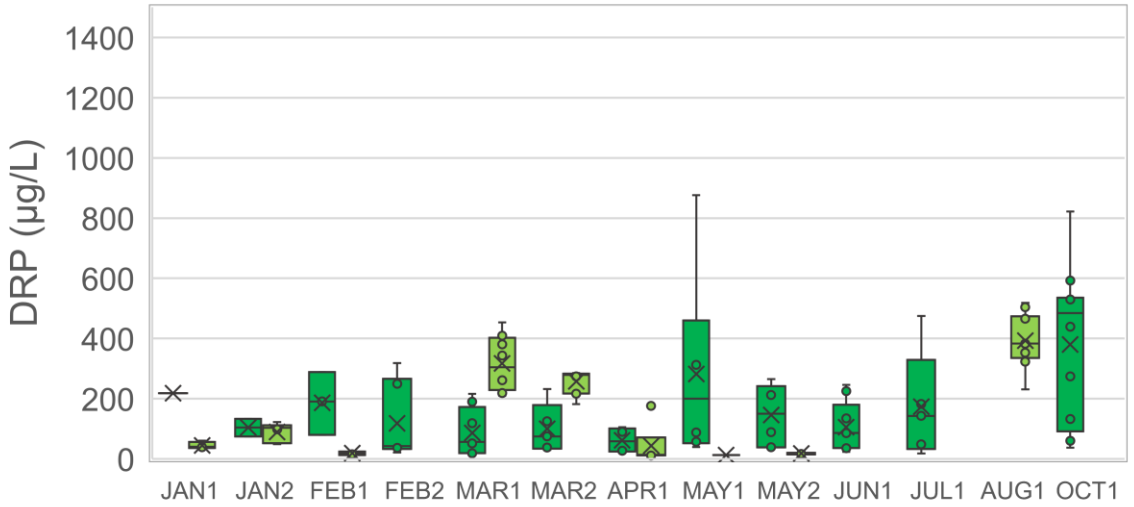
SMART WETLANDS
A Program of the Wetlands Initiative

Clif Bar Family Foundation
Grand Victoria Foundation
Illinois Nutrient Research & Education Foundation
The McKnight Foundation
National Fish & Wildlife Foundation, Conservation Partners Program
Patagonia
U.S. Fish and Wildlife Service, Fishers & Farmers Partnership
The Walton Family Foundation
Zea Mays Foundation

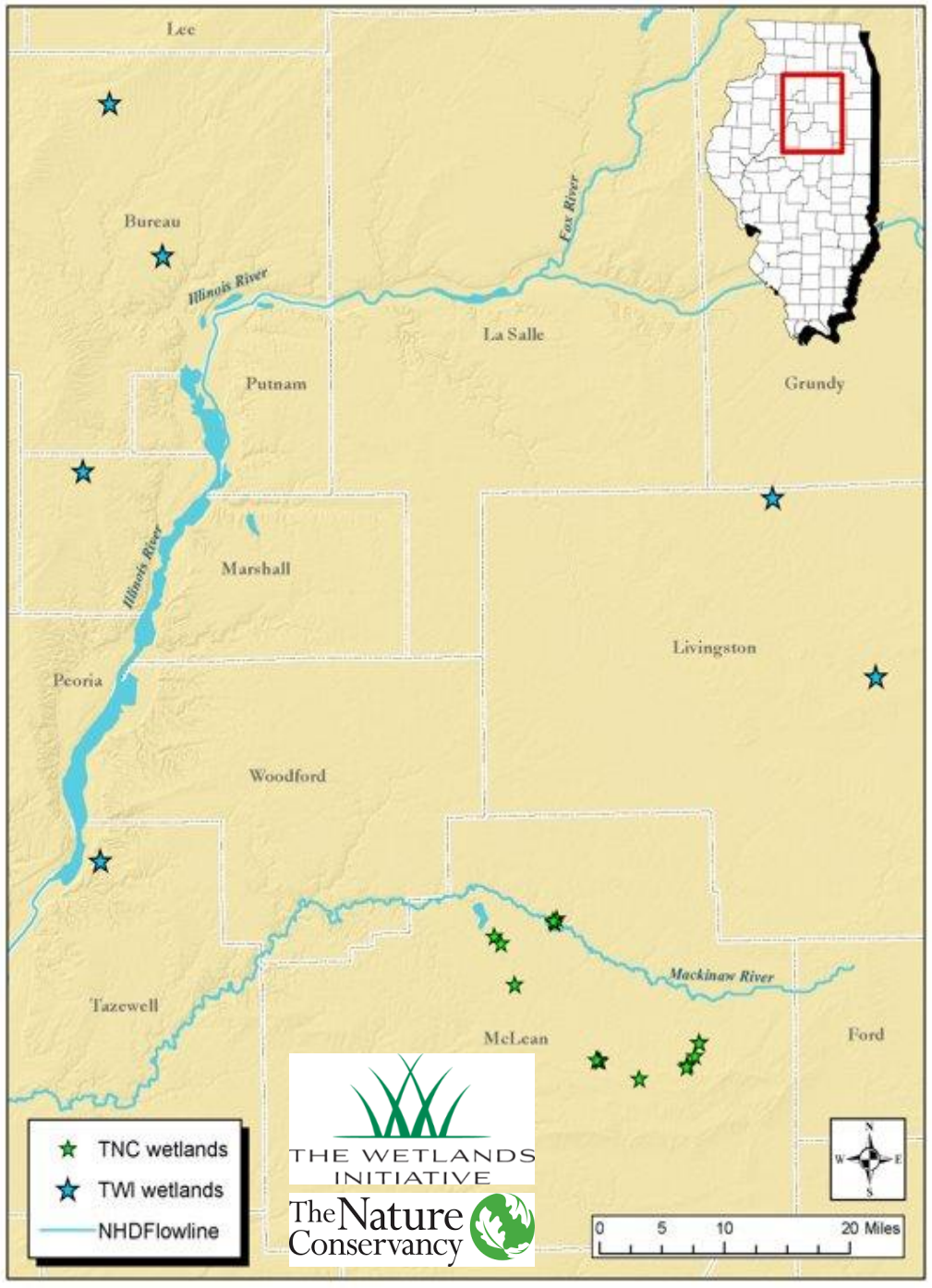

Wetland In
Wetland Out
Precipitation
Total Daily Flow Volume (cubic ft)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Precipitation (inches)
0
1
2
3
4
5
6
7
8
9
10
1/1/2021
1/31/2021
3/2/2021
4/1/2021
5/1/2021
5/31/2021
6/30/2021
7/30/2021
8/29/2021
9/28/2021
10/28/2021
11/27/2021
12/27/2021
1/26/2022
2/25/2022
3/27/2022
4/26/2022
5/26/2022
Wetland IN
Wetland OUT


Wetland IN
Wetland OUT
NO3-N (mg/L)
18
16
14
12
10
8
6
4
2
0
JAN1
JAN2
FEB1
FEB2
MAR1
MAR2
APR1
MAY1
MAY2
JUN1
JUL1
AUG1
OCT1
Wetland IN
Wetland OUT

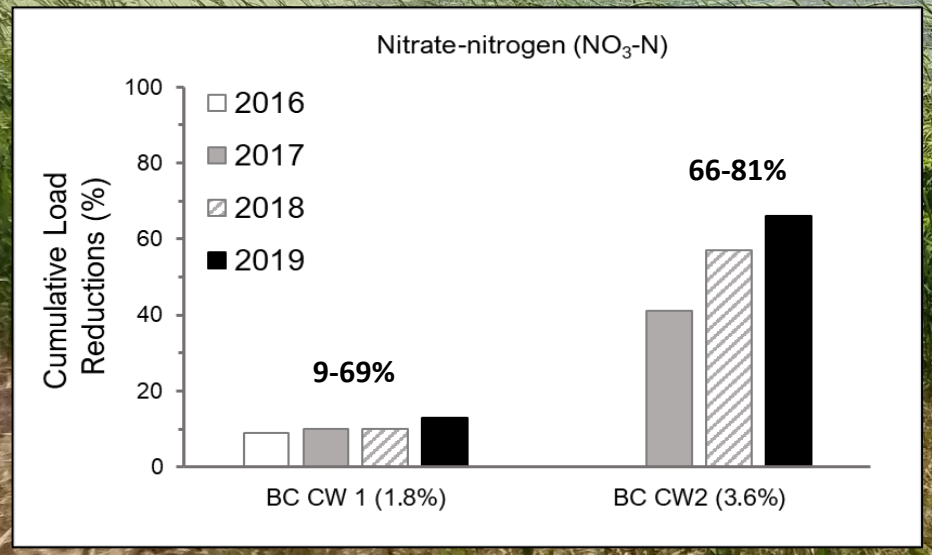

TP (µg/L)
1400
1200
1000
800
600
400
200
0
JAN1
JAN2
FEB1
FEB2
MAR1
MAR2
APR1
MAY1
MAY2
JUN1
JUL1
AUG1
OCT1

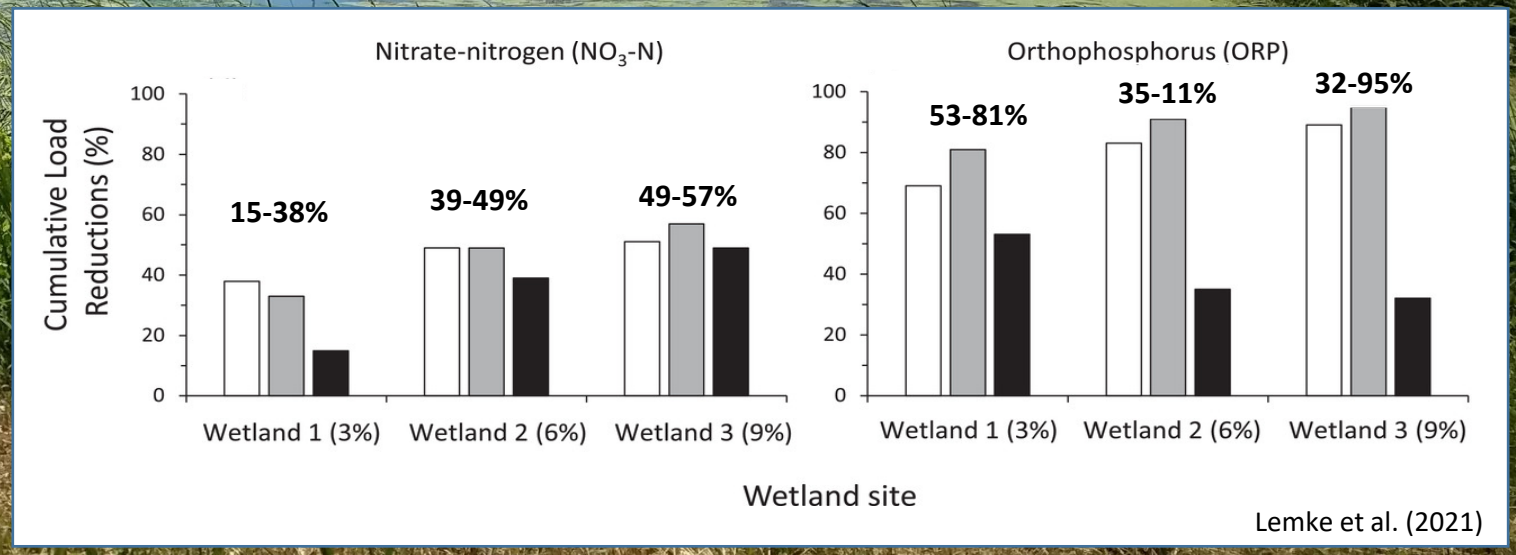

DRP (µg/L)
1400
1200
1000
800
600
400
200
0
JAN1
JAN2
FEB1
FEB2
MAR1
MAR2
APR1
MAY1
MAY2
JUN1
JUL1
AUG1
OCT1

TWI and TNC Constructed Wetlands



- Constructed wetlands are a highly effective, long-life practice to remove nitrate-nitrogen (NO_3-N) and phosphorus (P). Kovacic et al. (2000), Kovacic et al. (2006), Lemke et al. (2021)
- Require little maintenance after 1-2 years





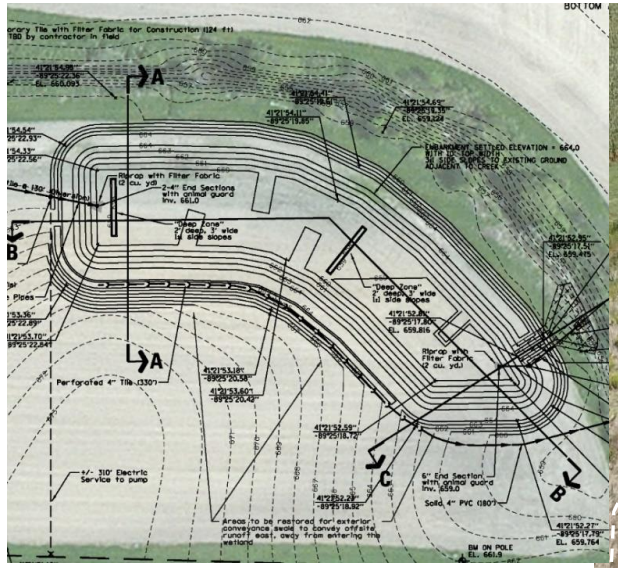
Lemke et al. (2021)

- Siting → area with grade change are ideal to minimize excavation

- CLAY can be both good and required if trying to create a wetland.
  - If clay is not the underlayer, undercutting with 6” lifts may be required.
  - Soil media on clay serves to hold water as well as the planting media

Sizing

- Sizing is around 1-5% of the total tributary area.
  - (2.5-5% is shown for >50% removal; Nature Conservancy research)
  - Use berms for longer residence
  - Microtopography helps contact time
- Not a detention basin per se.
  - 10-year volume with 25-year overflow.
- Sediment pools are required if surface runoff will be captured
  - **Case of urban application.**



Establishing Vegetation

- Natural Regeneration
  - Works with existing hydric soils
  - Just add water to promote dormant seed bank
- Seeding
  - Frost seeding (sometimes due to construction timing)
  - Native, tolerant of water depths
- Plugs
  - Useful with nonhydric soils complimented with seeding
  - Fill open water areas
  - Costly (1 acre comp)
    - Seeding = ~$1000
    - Plugs = $4,500 @ 4'x4'

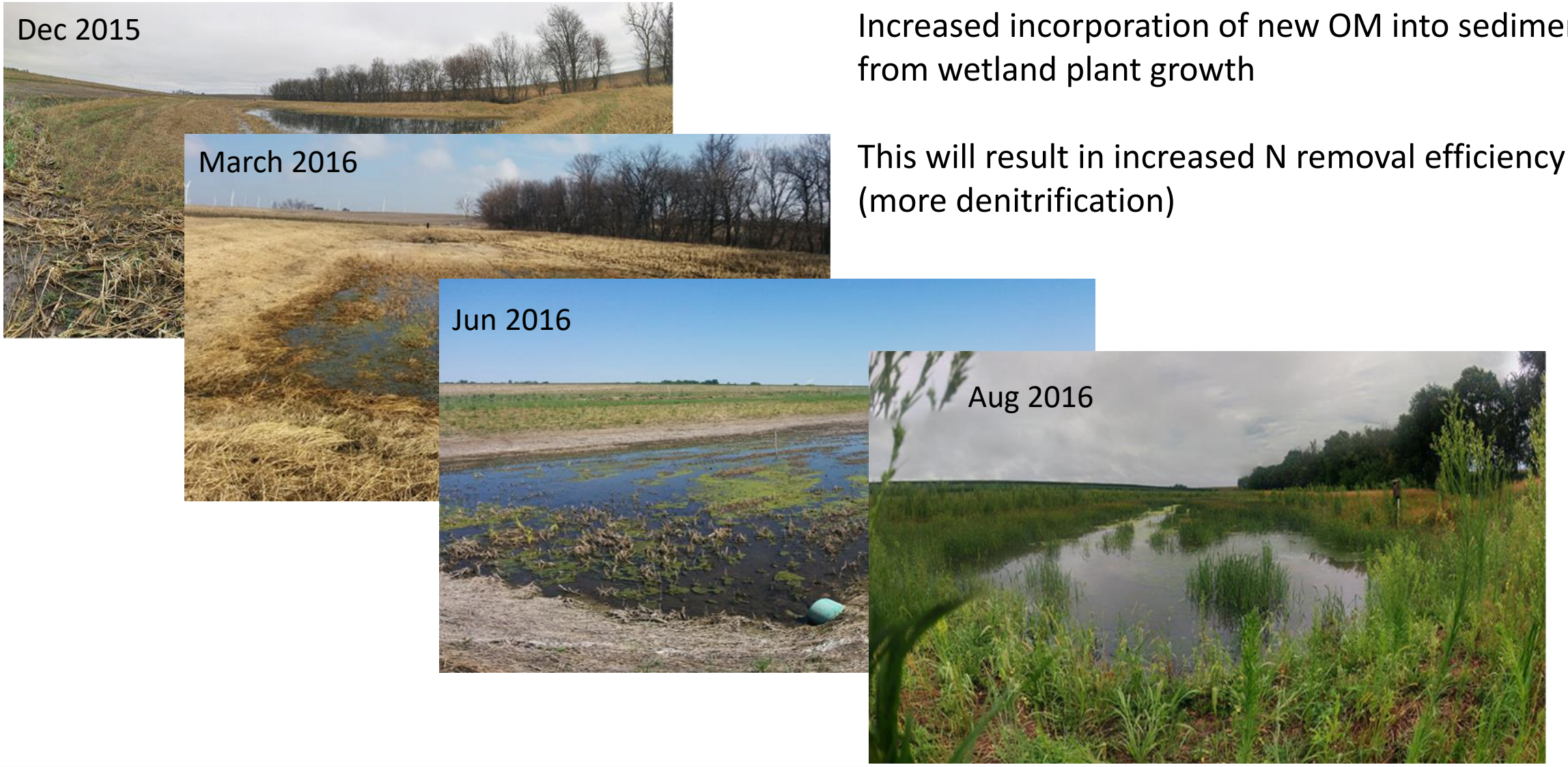
- The wetland plants rapidly grow in the first summer
  - Created a **high-value wetland habitat** for wildlife
  - Wetlands created in areas with hydric soils result in high initial organic matter allowing for growth and nitrate removal

Seeding Establishment

- For denitrification the microbial community and available carbon content may take 1-2 years to fully develop.

- Need dormant/dead cycle to occur to produce organic matter for the denitrification process to begin and use nitrate.
  - **Microbes need food too. Carbon….**

Wetland development: From planting to operation



Increased incorporation of new OM into sediments from wetland plant growth

This will result in increased N removal efficiency (more denitrification)

Always rains right after seeding.

Lack of initial vegetation leads to sediment deposition and erosion requiring regrading and fabric ditch checks.

Water Levels

- Initial establishment of the wetland plants will require manipulation of water depths.
- Water levels are raised after one year
- Leaving 4-6 inches of vegetation above water
- Stoplog structures

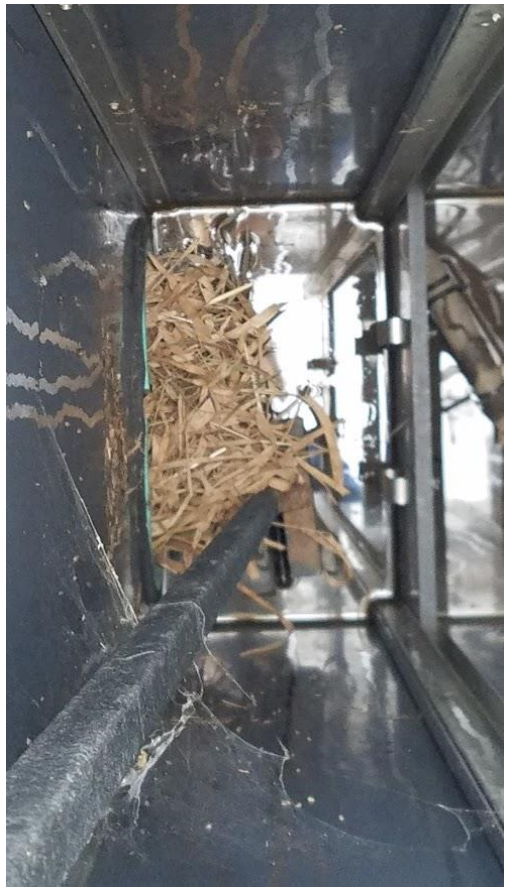
- Water depths = 12-18-24”
  - Emergent wetland vegetation
  - Better nitrate transfer between soil and water
  - Anoxic system
  - Warmer temps improve denitrification process
  - Prevent wetland from drying out

Outfall Maintenance

CORN STALK/ALGAE CLOG

Outfall Operation

Mice can enter stoplog structures via inlet pipes during dry conditions, building nests and blockages (typically late summer or fall)



Wetland “plug” may require jetting.

Observed sustained high water levels




Green Infrastructure as a Constructed Wetland

- **Monitoring data suggests constructed wetlands lowered Phosphorous and Nitrate levels when compared to the concentrations coming in.**

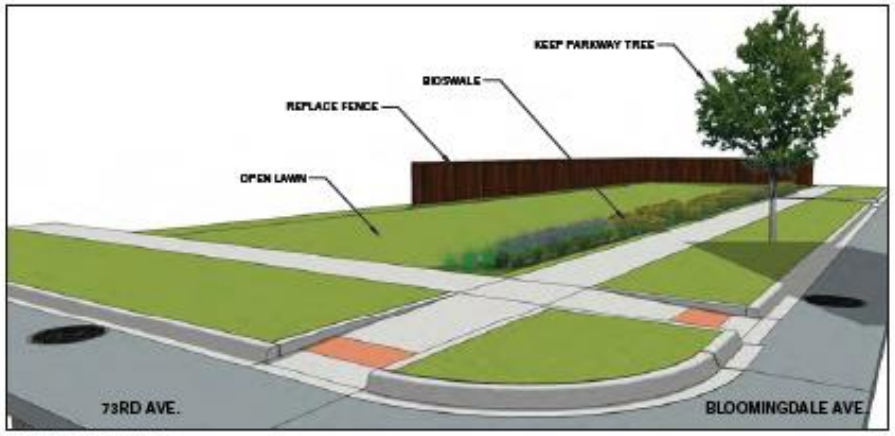
- If it works, are we targeting runoff reduction by promoting infiltration?
- What about water quality?
- What are the implication in an urban setting since we know it works?
- What if we don't have infiltrative soils?
- **Construction……and site constraints.**

Urban Application

- Village of Elmwood Park
- Stormwater Treatment Train
  - Residential lot and roadway ROW
  - Area is impacted by local flooding.
  - Property purchase and grant funded.

System Components Gray and Green

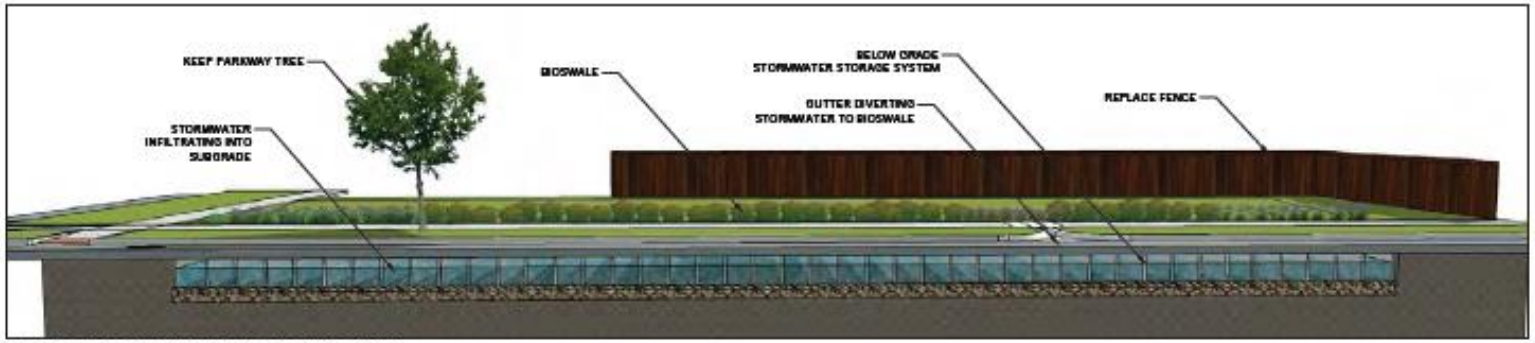
- Twin open bottom cells
  - Infiltration into subgrade
- Three-sided culvert under roadway
  - Infiltration into subgrade
- Curb cuts with direction through bio swale
- Rain garden
- $600K
- 0.14 acre size lot



VIEW FROM CORNER

Village of Elmwood Park
GREEN INFRASTRUCTURE PROJECT

PLAN VIEW of 1746 73RD AVENUE



VIEW FROM BLOOMINGDALE AVE. LOOKING SOUTH

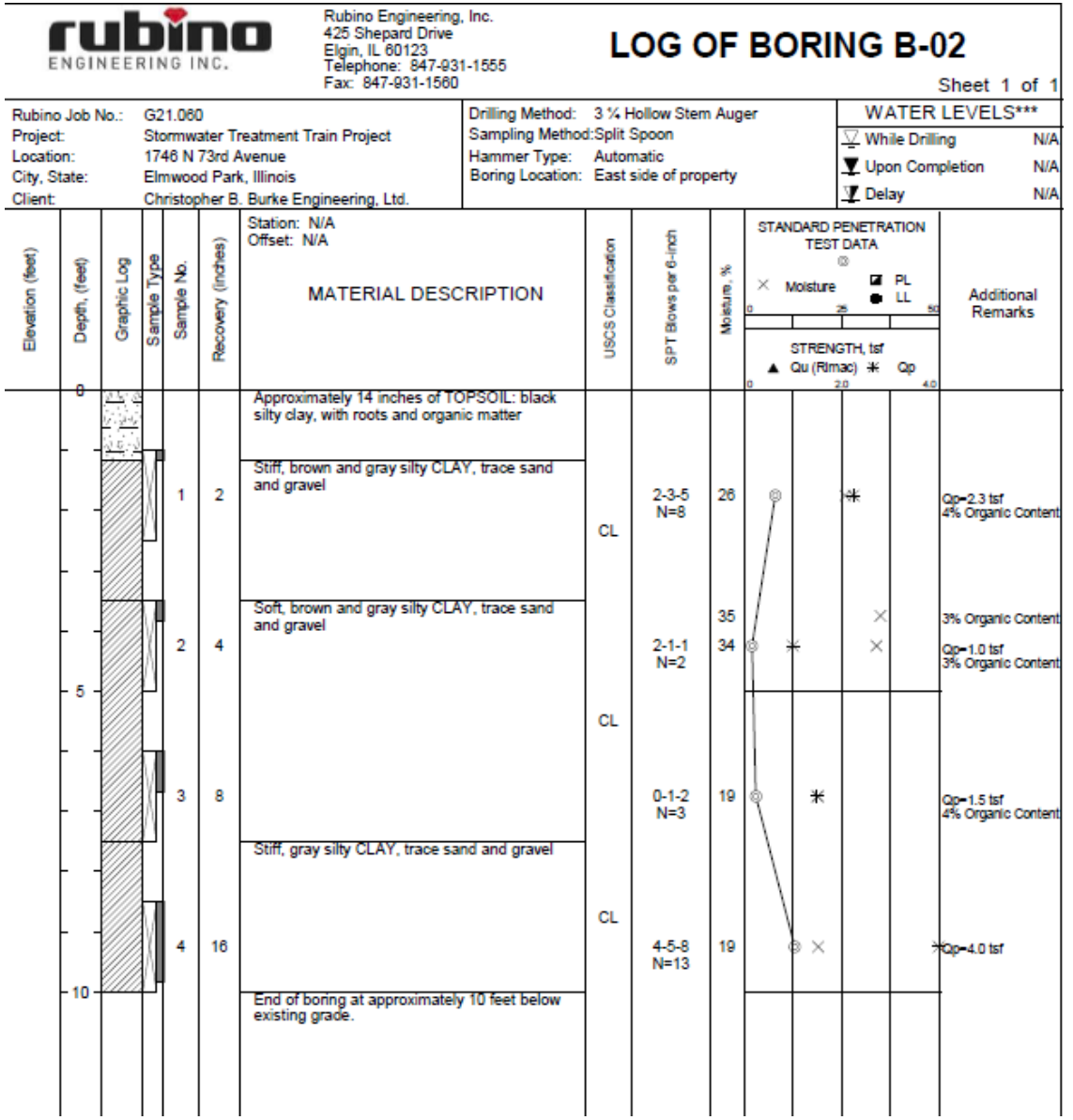
Twin open bottom cells – clay soil / trace sand

Three-sided culvert under roadway

Curb cuts with direction through bio swale

Lessons with Urban Application

- Design
  - Always collect soil borings, porosity and water table elevation to determine excavation depth and if underdrain system is required.
- Construction
  - NEVER compact subgrade
  - Undercut soft spots to avoid settlement
    - Geogrid is recommended
  - Pothole anu utility
- Considerations if using pavers
  - Concrete under wheel paths to avoid rutting. Pitched toward center, storage in void space of entire section.
  - Determine best pattern to avoid cutting pavers. Don't forget about joint widths.
  - Be aware of hardscape tie-ins → alleys have driveways, garage floor aprons. Be sure positive drainage is maintained.



rubino ENGINEERING INC.

Rubino Engineering, Inc.
425 Shepard Drive
Elgin, IL 60123
Telephone: 847-931-1555
Fax: 847-931-1560

LOG OF BORING B-02

Sheet 1 of 1

Rubino Job No.:	G21.060	Drilling Method:	3 ¼ Hollow Stem Auger
Project:	Stormwater Treatment Train Project	Sampling Method:	Split Spoon
Location:	1746 N 73rd Avenue	Hammer Type:	Automatic
City, State:	Elmwood Park, Illinois	Boring Location:	East side of property
Client:	Christopher B. Burke Engineering, Ltd.		

WATER LEVELS***
While Drilling N/A
Upon Completion N/A
Delay N/A

Station: N/A
Offset: N/A

Elevation (feet)	Depth, (feet)	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch	Moisture, %	Additional Remarks
	0				Approximately 14 inches of TOPSOIL: black silty clay, with roots and organic matter				
			1	2	Stiff, brown and gray silty CLAY, trace sand and gravel	CL	2-3-5 N=8	26	Qp=2.3 tsf 4% Organic Content
			2	4	Soft, brown and gray silty CLAY, trace sand and gravel		2-1-1 N=2	35 34	3% Organic Content Qp=1.0 tsf 3% Organic Content
	5		3	8		CL	0-1-2 N=3	19	Qp=1.5 tsf 4% Organic Content
			4	16	Stiff, gray silty CLAY, trace sand and gravel	CL	4-5-8 N=13	19	Qp=4.0 tsf
	10				End of boring at approximately 10 feet below existing grade.				

STANDARD PENETRATION TEST DATA
Moisture PL LL
STRENGTH, tsf
Qu (Rimac) Qp

Construction photos and thanks to all involved:

ILLINOIS SUSTAINABLE AG PARTNERSHIP

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VILLAGE OF ELMWOOD PARK

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THE WETLANDS INITIATIVE

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Illinois Corn Growers Association

- Bureau County SWCD
- Livingston County SWCD
- Marshall-Putnam SWCD
- USDA – NRCS
- USDA – FSA

CBB

The Nature Conservancy

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