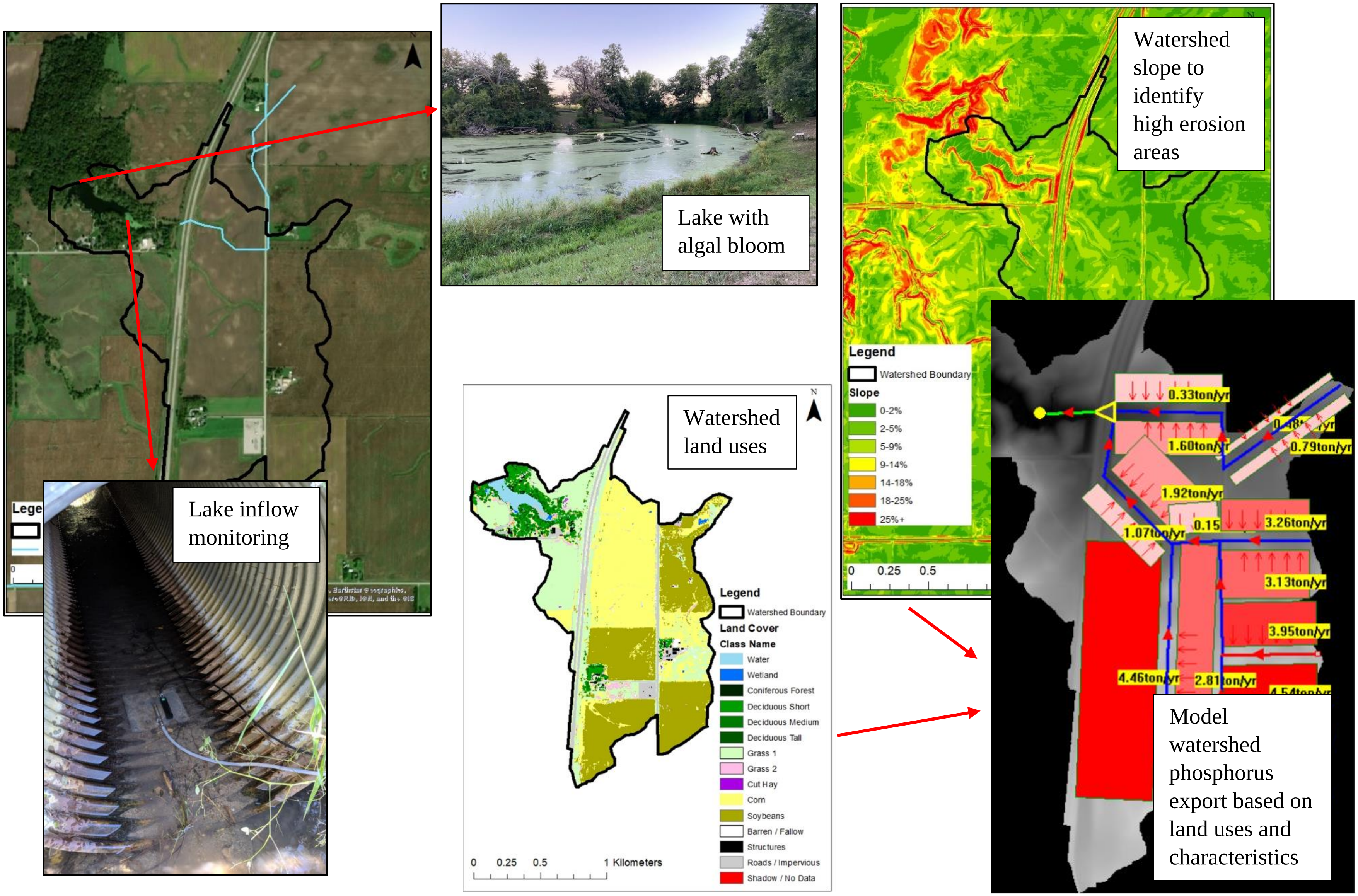
Table of Contents

Project #1: Recreational Lake watershed monitoring and improvement plan

Spatial analysis and hydrology modeling (ArcGIS, WEPP)



Watershed management plan (waste allocation calculations; water quality implementation and evaluation plan)

Watershed Management Plan

Prepared by:
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[redacted]

Prepared for: [redacted]

Published: March 31, 2021
Plan Timeframe: Twenty years (
Reevaluation Dates: Every five y

Table 5: Sediment load and lake volume loss estimates using ISU morphometry study (1999), and WEPP model (100-yr average).

Estimation method	Period	Annual sediment delivery (ton/yr)	Annual sediment delivery (ton/ac)
ISU inlet monitoring	2019	43.6	0.152
ISU morphometry study	1999	128.1	NA
WEPP model	100-yr average	62.6	0.221

Table 6: Estimated volumes for McFarland Lake in the past, annual lake volume loss rates.

Year	Scenario	Est. lake volume (ac-ft)	Total lake volume loss (%)	Annual lake volume loss (ac-ft)	Ann lake volu loss	
1947		NA				
1969	Actual	55.5	NA	NA	NA	
1999	Actual	42.8	22.9%	0.41	0.74	
2020	Estimated	33.8	39.1%	0.41	0.74	
2050	Projection A	42.8	22.9%	0.41	0.74	
	Projection B	49.3	11.2%	0.20	0.36%	Lake volume restored, 0.36% annual lake volume loss
	Projection C	21.1	62.0%	0.41	0.74%	No lake restoration, 0.74% annual lake volume loss
	Projection D	27.6	50.3%	0.20	0.36%	No lake restoration, 0.36% annual lake volume loss
2120	Projection A	14.1	74.6%	0.41	0.74%	Lake volume restored, 0.74% annual lake volume loss
	Projection B	35.3	36.4%	0.20	0.36%	Lake volume restored, 0.36% annual lake volume loss
	Target	41.6	25.0%	0.14	0.25%	Lake volume restored, 0.25% annual lake volume loss

Table 10: Implementation schedule of practices and expected outcomes in McFarland Lake and its watershed.

Objectives	Components	Phase 1 milestone (Y1-Y4)	Phase 2 milestone (Y5-Y8)	Phase 3 milestone (Y9-Y20)	Overall outcomes
Goal 1: Increase public awareness of water quality challenges, causes, and solutions in McFarland Lake					
Goal 2: Improve and maintain the water quality of McFarland Lake through the implementation of restoration and best management practices					
Reduce external and internal loading of phosphorus and sediment					
Reduce sediment and phosphorus delivery from the shorelines	Shoreline stabilization	Stabilized 1,500 ft of shoreline	Maintained	Maintained	Up to 100% TP and sediment reduction from shoreline erosion
Reduce sediment and phosphorus delivery from McFarland Park	Septic systems inspection/upgrade	Inspected and upgraded McFarland Park septic systems	Maintained	Maintained	100% TP reduction from septic tanks
	Forest stand improvement	Improved forest stand in McFarland Park	Maintained	Maintained	Reduced TP and sediment loading from McFarland Park
Reduce sediment and phosphorus delivery from the watershed	No-till management	Implemented no-till management in 85.2 ac of targeted agricultural areas	Maintained	Maintained	Up to 90% and 73% reductions in TP and sediment loads from targeted agricultural areas
	Cover crops		Implemented cover crops in 194.4 ac of agricultural areas	Maintained	Up to 29% TP reduction from all agricultural areas; reduced sediment loading
	Phosphorus management	Implemented phosphorus	Maintained	Maintained	Up to 17% TP reduction from all agricultural areas
				information	
	Public outreach	Developed outreach materials and conducted educational events	Updated outreach materials and conducted educational events	Updated outreach materials and conducted educational events	Increased and maintained public awareness through outreach materials (posters, handouts) and educational events
Provide easy access to technical and financial information related to BMPs.	Document development and maintenance	Developed one-stop summary document containing information related to technical and financial assistance	Updated the summary document with latest changes	Updated the summary document with latest changes	Simplified the process to obtain technical and financial assistance for landowners/managers who are interested in implementing BMPs

Evaluation process

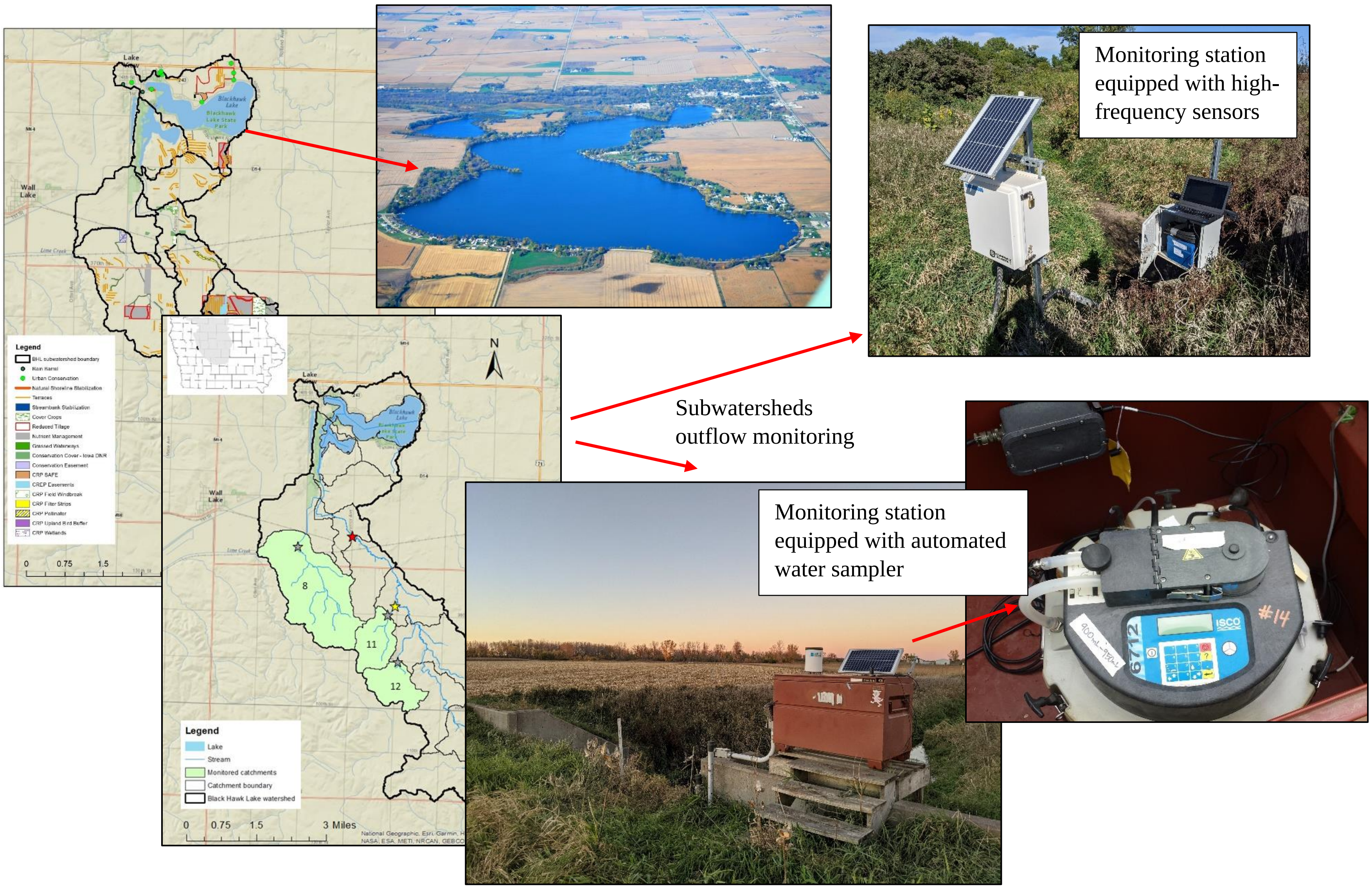
Table 12: Evaluation process described with a logic table consisting of inputs, outputs, and expected outcomes of the watershed improvement project.

Inputs	Outputs		Outcomes – Impact		
Inputs ▪ McFarland Lake ▪ McFarland Park ▪ Agricultural lands ▪ Non-agricultural lands ▪ Technical staff ▪ Outreach staff ▪ Contractors ▪ Financial resources	**Activities** ▪ Set up watershed improvement management team ▪ Meetings with landowners and managers ▪ Implementation and maintenance of conservation practices ▪ Water quality monitoring ▪ Development of outreach materials ▪ Outreach events	**Participation** ▪ Agricultural landowners and managers ▪ Rural residents ▪ Iowa Natural Heritage Foundation ▪ Story County Conservation Center ▪ Iowa State University ▪ Natural Resources Conservation Service ▪ Iowa Department of Agriculture and Land Stewardship ▪ Iowa Department of Natural Resources ▪ Prairie Rivers of Iowa ▪ McFarland Park visitors/users ▪ Contractors ▪ Media outlets	**Knowledge Gain (short-term outcomes)** ▪ Landowners, managers, and public will increase awareness on current water quality issues and causes in McFarland Lake ▪ Landowners, managers, and public will increase knowledge on the benefits of conservation practices	**Behavior Changes (medium-term outcomes)** ▪ Increase number of agricultural producers who adopt conservation practices ▪ Increase number of park visitors for recreational activities ▪ Increase number of park visitor for educational events	**Conditions changes (long-term outcomes)** ▪ Reduced long-term phosphorus and sediment loading into McFarland Lake ▪ Reduced or eliminated summer algal blooms in McFarland Lake ▪ Improved water clarity caused by low suspended sediment and algal density ▪ Improved aquatic ecosystem in McFarland Lake ▪ Successful case demonstration for other agricultural watersheds
			Milestones not reached	Milestones not reached	Milestones not reached

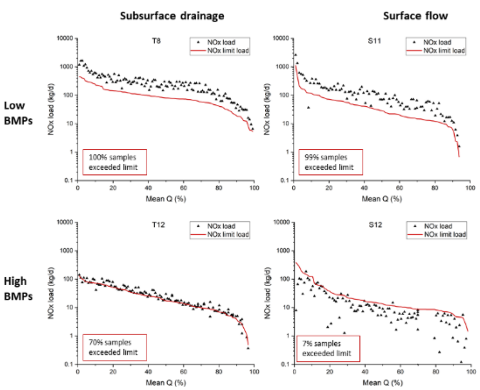
Revision

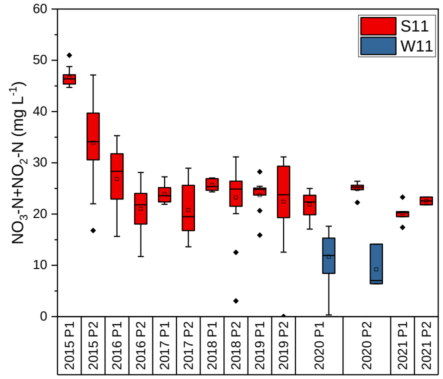
Project #2: Paired subwatersheds water quality monitoring to inform watershed-scale improvement plan

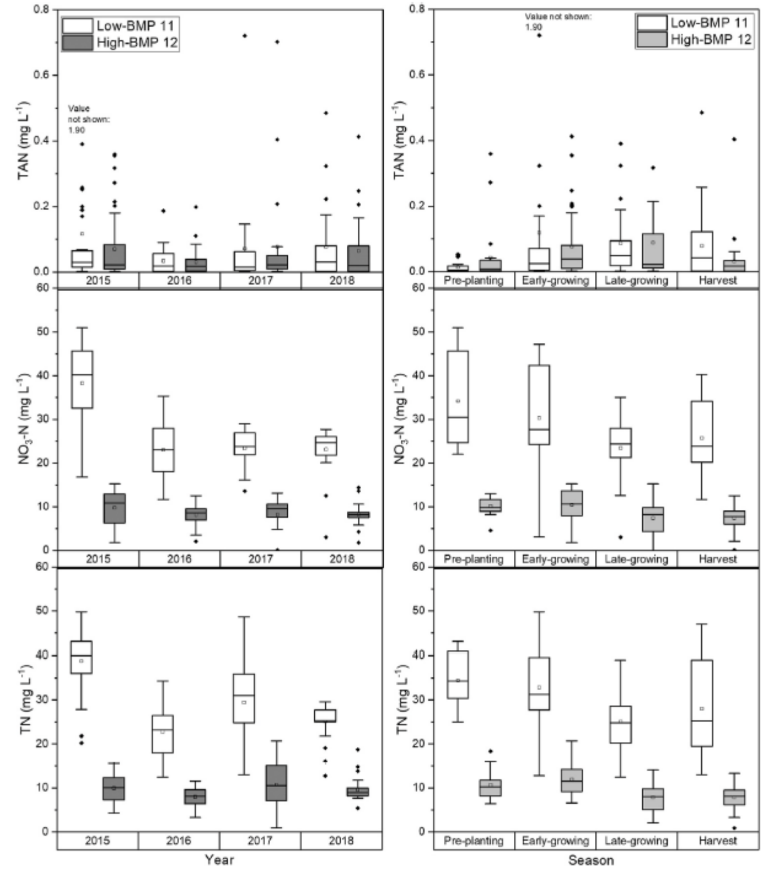
Paired subwatersheds monitoring

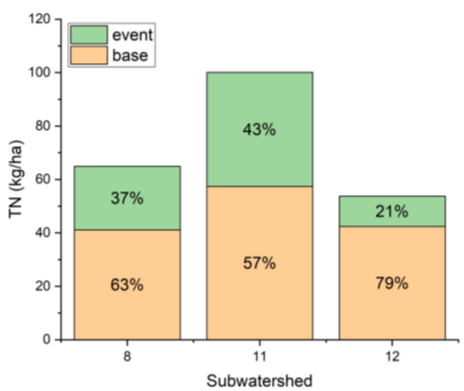


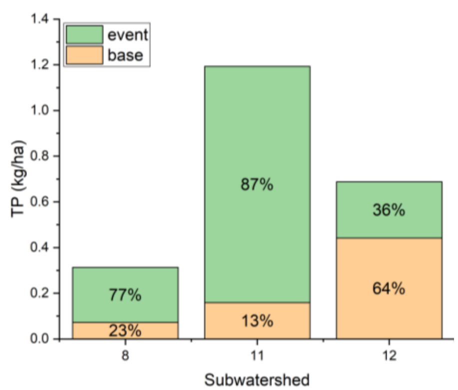
Example results and data analysis (load duration curves, nutrient concentration annual/seasonal trends, nutrient load comparisons)



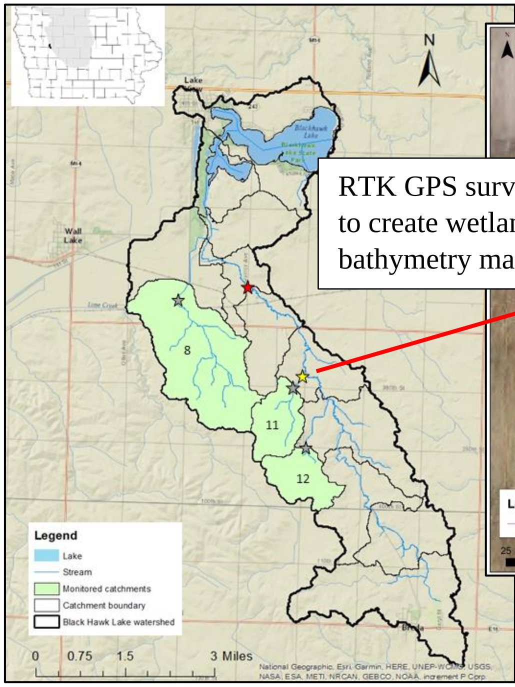




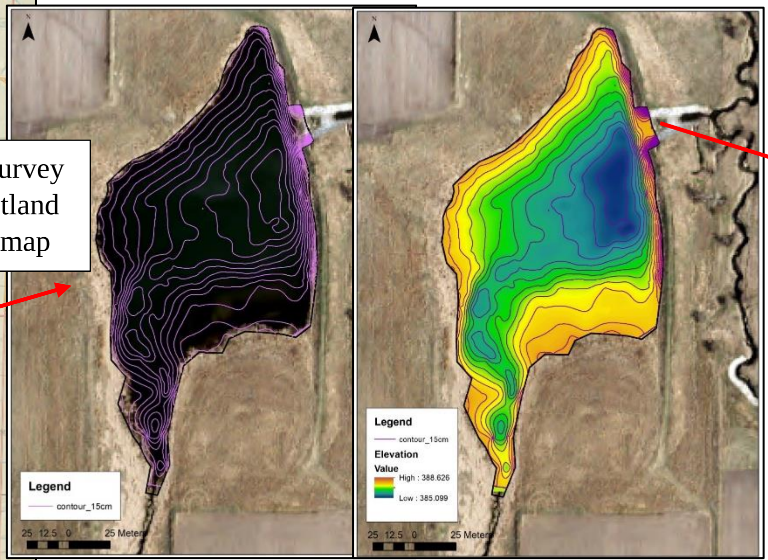




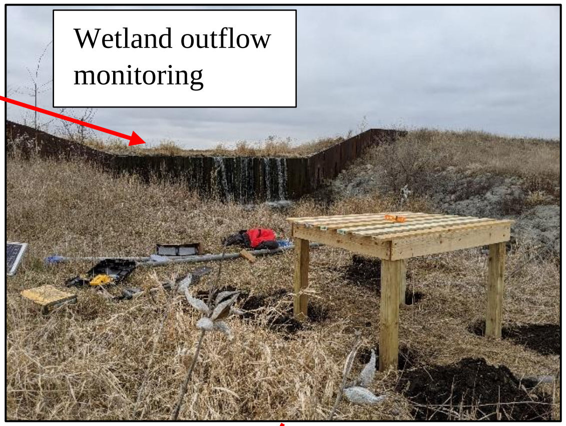
Wetland delineation (ArcGIS, AutoCAD), hydrology modeling, and water quality monitoring



RTK GPS survey to create wetland bathymetry map



Wetland outflow monitoring



Use wetland depth-volume relationship to calculate seepage rate

$$S = Q_{in} - Q_{out} - ET - \Delta Volume$$

Table 5: Depth-to-volume relationship of wetland downstream of subwatershed 11 developed using the elevation data collected on RTK GPS.

Pool depth		Elev		Incremental area		Cumulative volume	Cumulative volume
m	ft	m	ft	m^2	ac	m^3	ac-ft
0.0	0.0	385.1	1263.5	2	0.00	0	0.0
0.2	0.7	385.3	1264.1	1279	0.32	121	0.1
0.4	1.3	385.5	1264.8	2831	0.70	517	0.4
0.6	2.0	385.7	1265.5	5563	1.37	1352	1.1
0.8	2.6	385.9	1266.1	8121	2.01	2710	2.2
1.0	3.3	386.1	1266.8	10586	2.62	4585	3.7
1.2	3.9	386.3	1267.4	23941	5.92	7950	6.4
1.4	4.6	386.5	1268.1	27610	6.82	13082	10.6
1.6	5.2	386.7	1268.7	30928	7.64	18946	15.4
1.68	5.5	386.79	1269.0	32371	8.00	21790	17.7
1.8	5.9	386.9	1269.4	34276	8.47	25456	20.6
2.0	6.6	387.1	1270.0	37150	9.18	32581	26.4
2.2	7.2	387.3	1270.7	41236	10.19	40472	32.8
2.4	7.9	387.5	1271.4	42353	10.47	48844	39.6
2.6	8.5	387.7	1272.0	43068	10.64	57400	46.5
2.8	9.2	387.9	1272.7	43480	10.74	66059	53.6
3.0	9.8	388.1	1273.3	43839	10.83	74794	60.6
3.2	10.5	388.3	1274.0	44115	10.90	83593	67.8
3.4	11.2	388.5	1274.6	44298	10.95	92438	74.9
3.6	11.8	388.7	1275.3	44423	10.98	101313	82.1
1.86	12.0	388.77	1275.5	44454	10.98	104425	84.7

Project #3: Drainage wastewater treatment system (denitrification bioreactors) design and monitoring

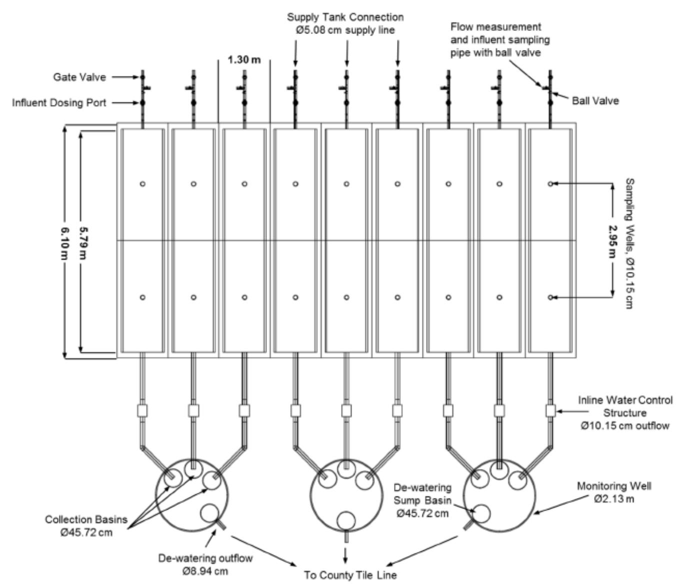


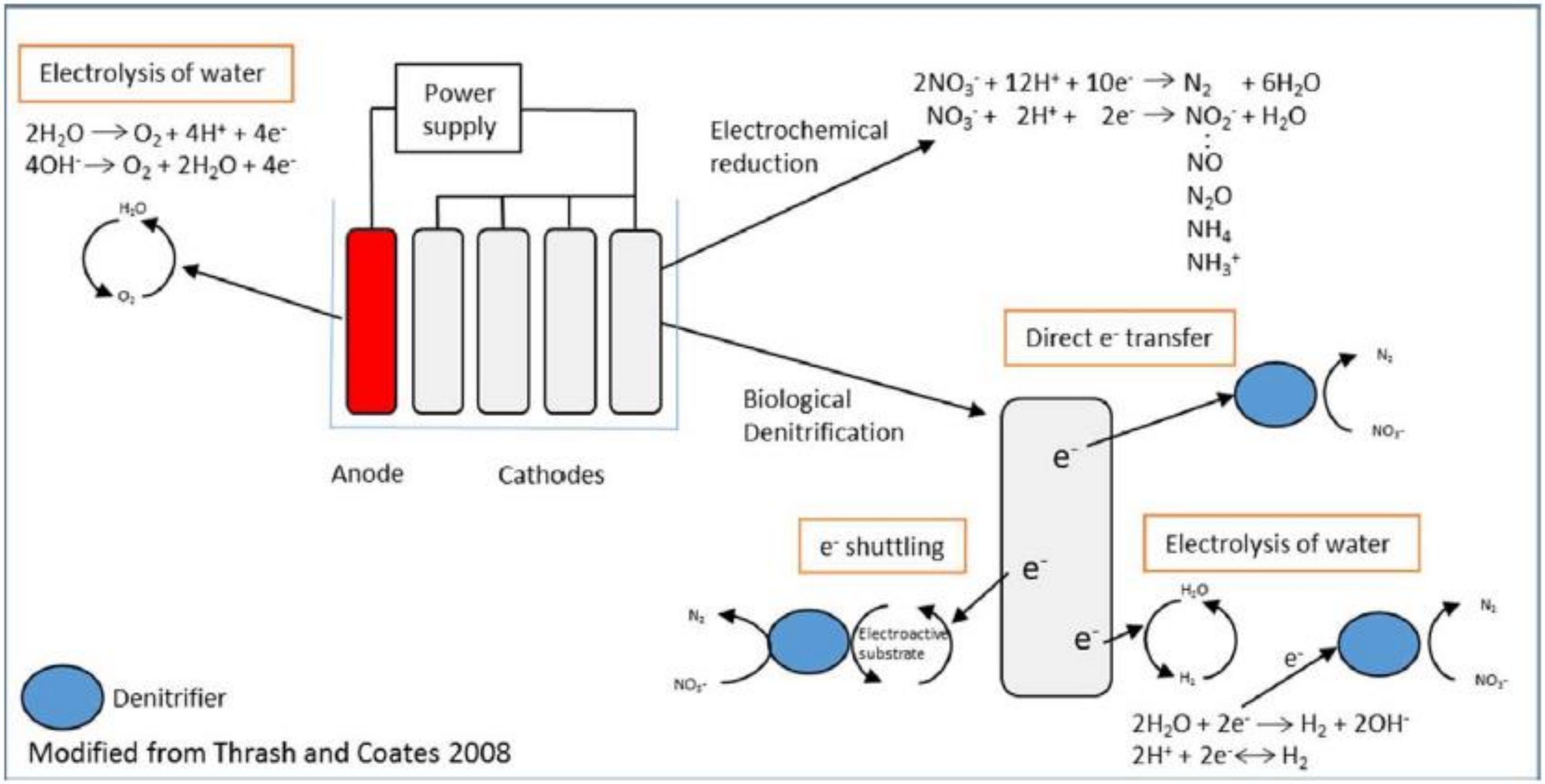
Figure 1. Schematic of nine pilot-scale denitrification bioreactors.

Hydraulic retention time model

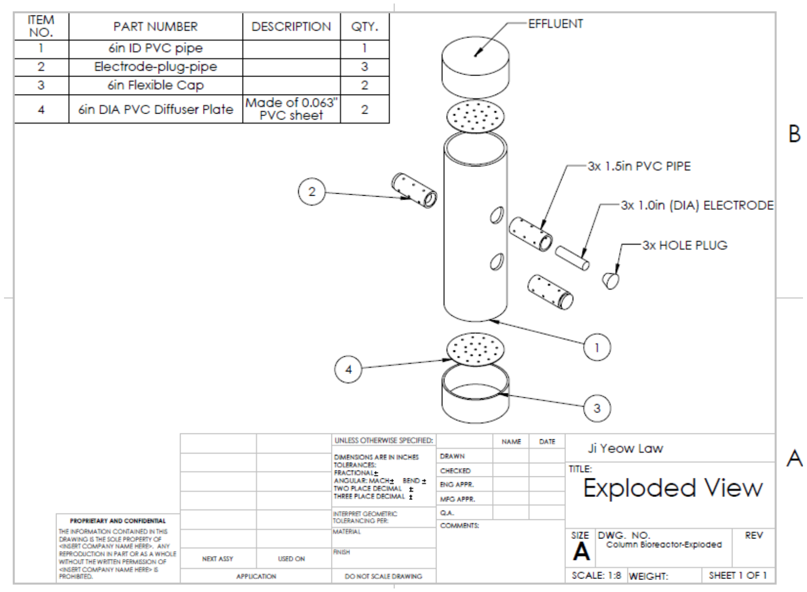
	English	Metric	
Field Information:			**Explanatory Notes:**
Tile Size (in)	[redacted]		not needed here
Tile Grade (%)			
Dual Wall			0
Velocity in Pipe (ft/s)			
Peak Flow from Tile Size (cfs)	1.00		assumed
Media Information:			
Conductivity of Wood Media (ft/s) (K)	0.31168		Converted from 9.5 cm/s to ft/s; value determined in Porous Media Lab, ABE-ISU
Porosity of Wood (ρ)	0.7		Taken from van Driel et al., 2006
Bioreactor Inputs and Calculations:			
Volume (ft3)	3531.5	100	In solver, set to 100 m3
Length:width ratio	5.0	5	In solver, set this to 1, 2, 3, 4, 5 (L:W ratio)
Flow Length (ft) (L)	73.36	22.36068	
Trench Width (ft) (W)	14.67	4.472136	
Inlet height (ft)	1.64	0.5	1 m bioreactor H, but assumed only half of the height is available due to low field water table
Outlet height (ft)	1.31	0.4	Iteratively choose
Head Drop (ft) (ΔH)	0.328084		Calculated based on diffference between inlet and outlet
Flow Depth (ft) (d)	1.476378		Calculated to be in bioreactor middle (average of inlet and outlet height)
Hydraulic Gradient (i)	0.004472		Head Drop / Flow Length
Results:			
Bioreactor Flow Rate (cfs) (Q)	0.03		Darcy's Law for Porous Media Flow = $Hyd.Conductivity \times Hyd.Gradient \times Flow\ Area = KiA = Ki(W \times d)$
Hydraulic Retention Time (hours) (HRT)	10.23		$\tau = \frac{Volume \times porosity}{Flow\ rate} = \frac{V\rho}{Q} = \frac{l \times w \times d \times \rho}{Q}$ (conversions included)
% of peak flow that can be passed through bioreactor	3.02		Bioreactor Flow Rate / Peak Flow from Tile

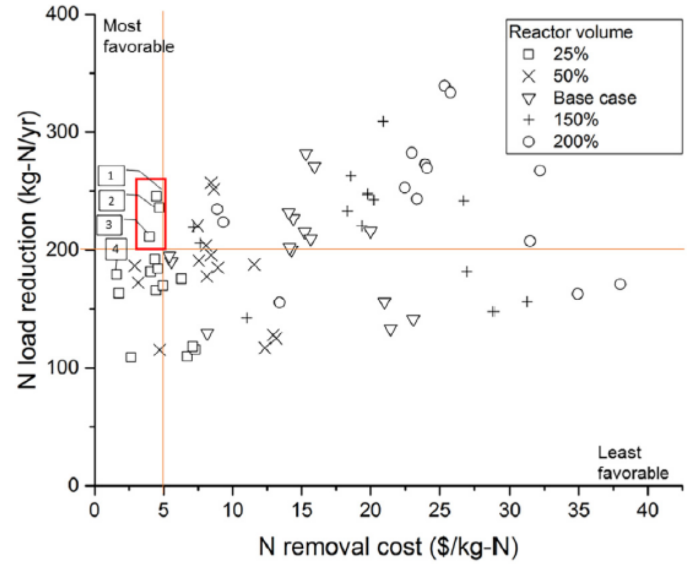
Project #4: Modification of denitrification bioreactors (research study – proof of concept)

Theory



Bioreactor design (SolidWorks), experimental results, and engineering cost analysis





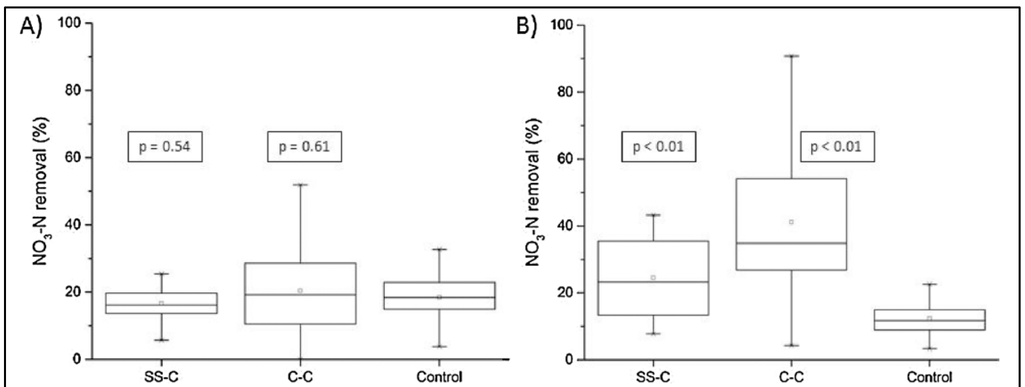
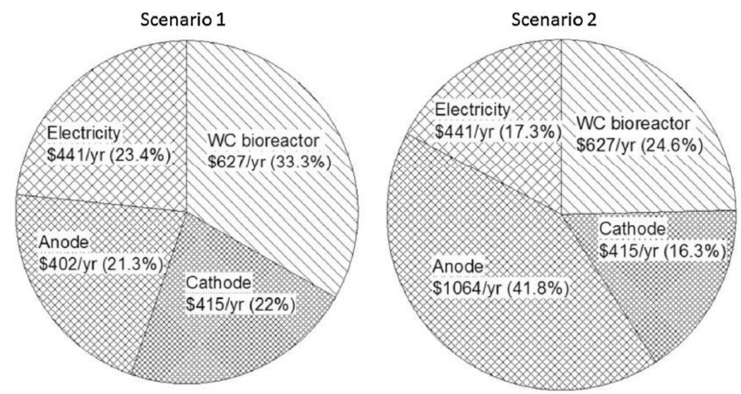


Fig. 3. Nitrate removal efficiency of each treatment at 100 mA (A) and 500 mA (B). SS-C: stainless steel anode-carbon cathode; C-C: carbon anode-carbon cathode.



Project #5: Spatial/temporal distribution of fecal indicator bacteria in recreational lakes and beaches across Iowa

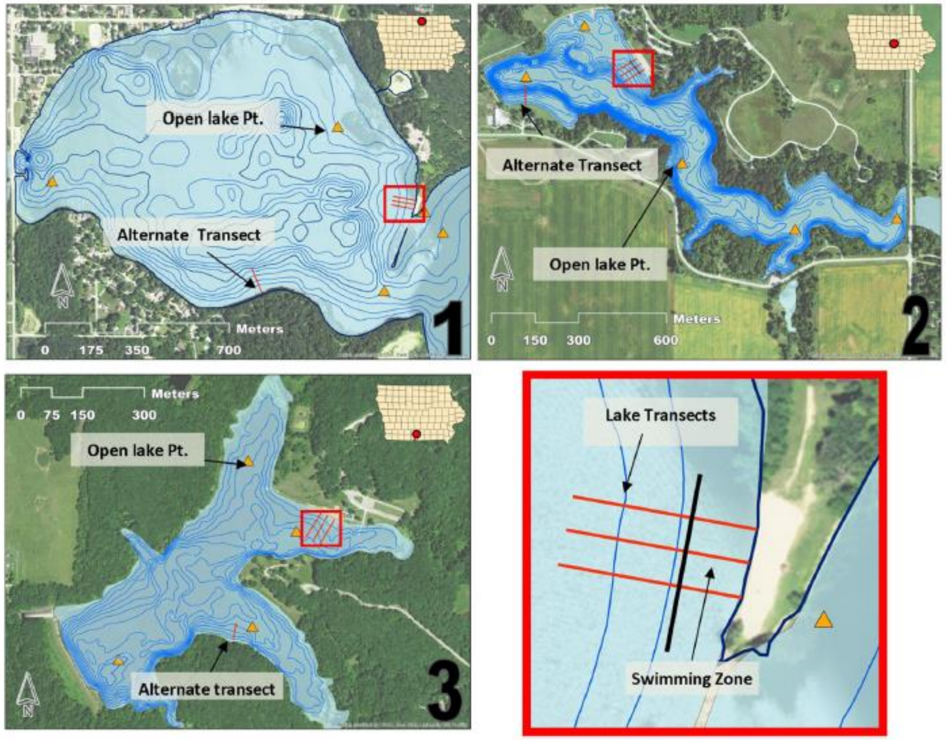


Fig. 1. Figure 1 Lake Locations and sampling layout for all three systems: (1) McIntosh Woods Beach, (2) Hickory Grove Lake, and (3) Nine eagles Lake. The insert shows the transect locations where water and sand sediments were collected (red outline on each lake).

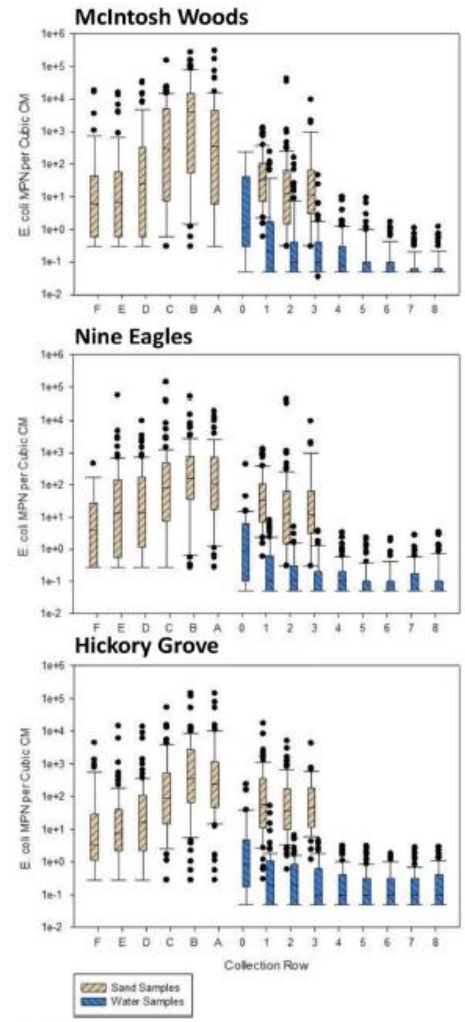
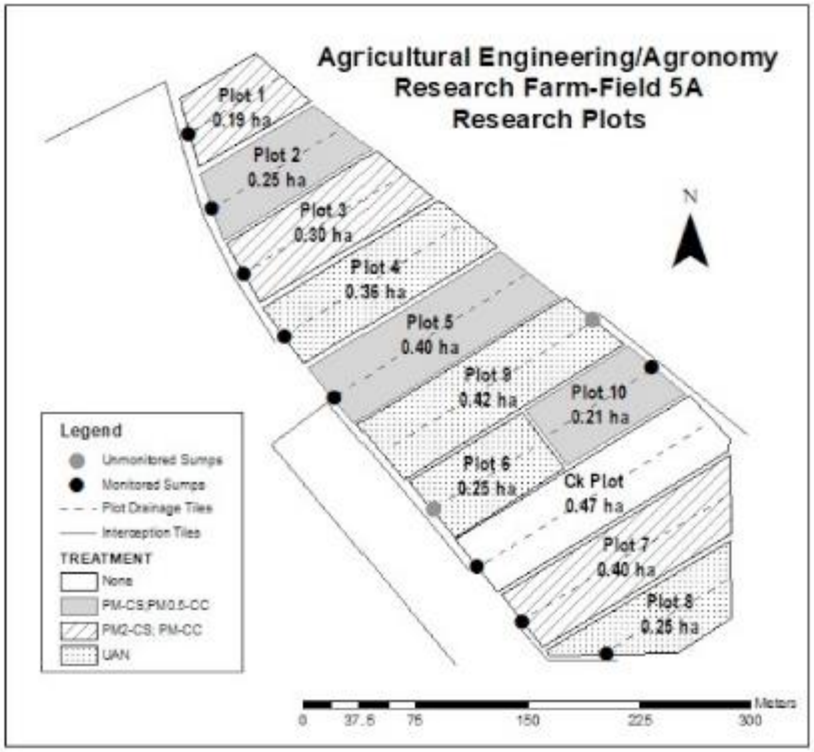


Fig. 2. Figure 2 Box plot of sand and water sampling from transects along McIntosh Woods, Hickory Grove, and Nine Eagles beaches reported in MPN/per cubic cm. Sampling points in figure correspond to following locations in relation to shoreline: A=shoreline, B (+2.5 m), C (+5m), D (+10M), E (+15M), F (20M), 0 (Ankle deep), 1 (Knee deep), 2 (waist deep), 3 (chest deep), 4 (swimming rope), 5 to 8 (10 m spacing beyond swimming rope)

Project #6: Engineering cost analysis for row crop production systems receiving conventional and manure fertilizers



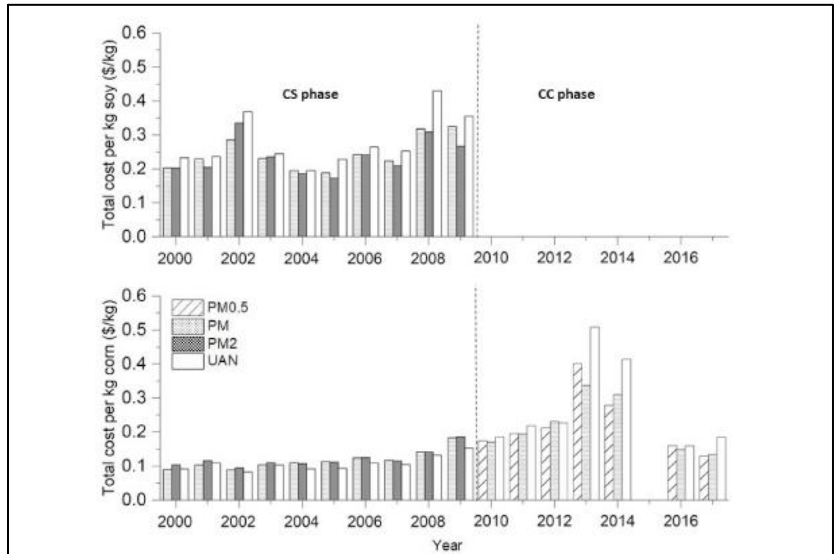


Fig. 3. The left side of the figure shows the annual corn and soybean production cost during corn-soybean rotation years (2000–2009), while the right side shows the corn production cost during continuous-corn years (2010–2017). Each phase consisted of three different fertilizer treatments: PM (manure applied at crop agronomic recommended N rate); PM0.5 or PM2 (manure applied at half (CC phase) or double (CS phase) recommended N rate); and UAN (28% Urea-ammonium nitrate applied at recommended N rate).

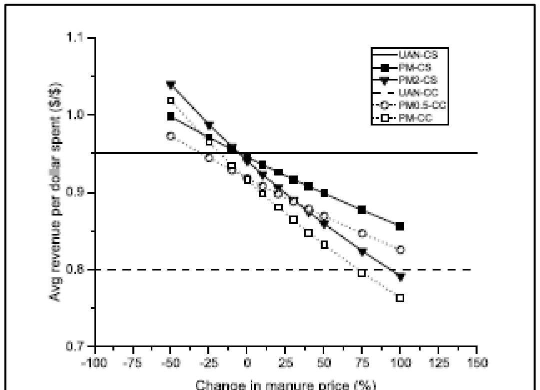


Fig. 5. This figure presents the impact of manure price (10-year average during CS phase, 7-year average during CC phase) on revenue per dollar spent of manure treatments (PM0.5, PM, PM2) relative to UAN treatments (horizontal dotted (CC phase) and solid lines (CS phase)).

Project #7: Estimating surface and subsurface flows and nitrogen loads from tile-drained landscapes (Hydrus-1D. DRAINMOD)

Input files into DRAINMOD

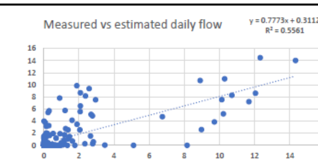
- **General inputs, entered manually**
  - Parameters are summarized in "Flow estimation xx field – inputs.xlsx"
  - Parameters such as drainage coefficient, surface storage, soil temperature freeze-thaw coefficients were manipulated so that estimated drainage fits the measured drainage.
- **Weather inputs**
  - Rainfall: converted from .txt files into .RAI
  - Temperature: converted from .txt files into .TEM files
  - .RAI and .TEM files imported into DRAINMOD
- **Soil inputs**
  - Soil-water characteristic curve generated from HYDRUS 1-D (Rosetta lite) based on sand-silt-clay distribution, bulk density, water contents @1/3 bar and 15 bar
  - Formatted in "Soil properties input for DRAINMOD.xlsx", converted into .txt file
  - Converted from .txt into .SOI, then into .SIN, .MIS
  - .SIN and .MIS files imported into DRAINMOD

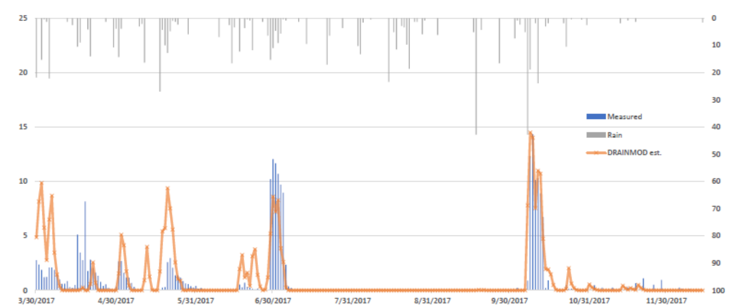
Output from DRAINMOD (all outputs are presented in cm)

- Water table
- Surface storage
- Rainfall
- Infiltration
- Evaporation
- Drainage
- Surface runoff

AN Field 2017 estimation (ref: "comparison output file 10.xlsx)

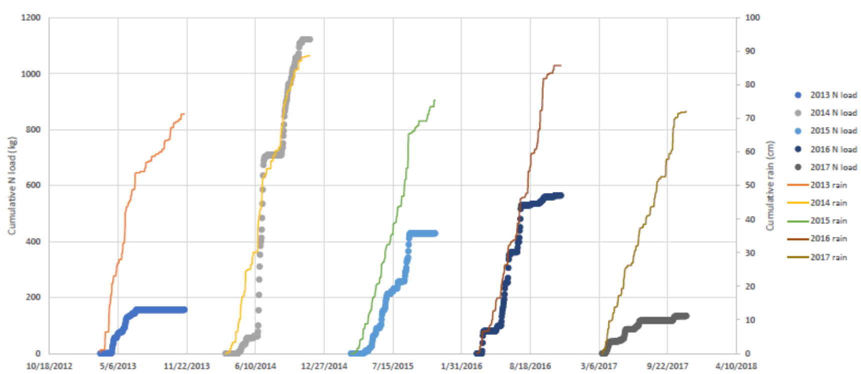
Side note:
This calibration is only available for AN field 2013, 2017.
SB and AV estimated drainage were validated based on precipitation trend





AN Field (2013-2017), 15.9 ha (ref: "AN field estimation.xlsx")

Summary	NO3-N avg (mg/L)	Cum. N load (kg)	Cum. N load per area (kg/ha)	Cum. Rain (cm)	Cum. drainage (m^3)	Cum. drainage (mm)
2013	3.49	156.2	9.82	71.43	42899.03	269.81
2014	13.31	1123.8	70.68	88.72	78088.74	491.12
2015	8.69	429.5	27.02	75.47	45830.14	288.24
2016	10.66	565.1	35.54	85.84	62723.26	394.49
2017	2.55	134.2	8.44	72.12	42803.86	269.21



Data management (sample project) – workflow, data processing (VBA, Python), data scrapping (Python), statistical analysis (Python)