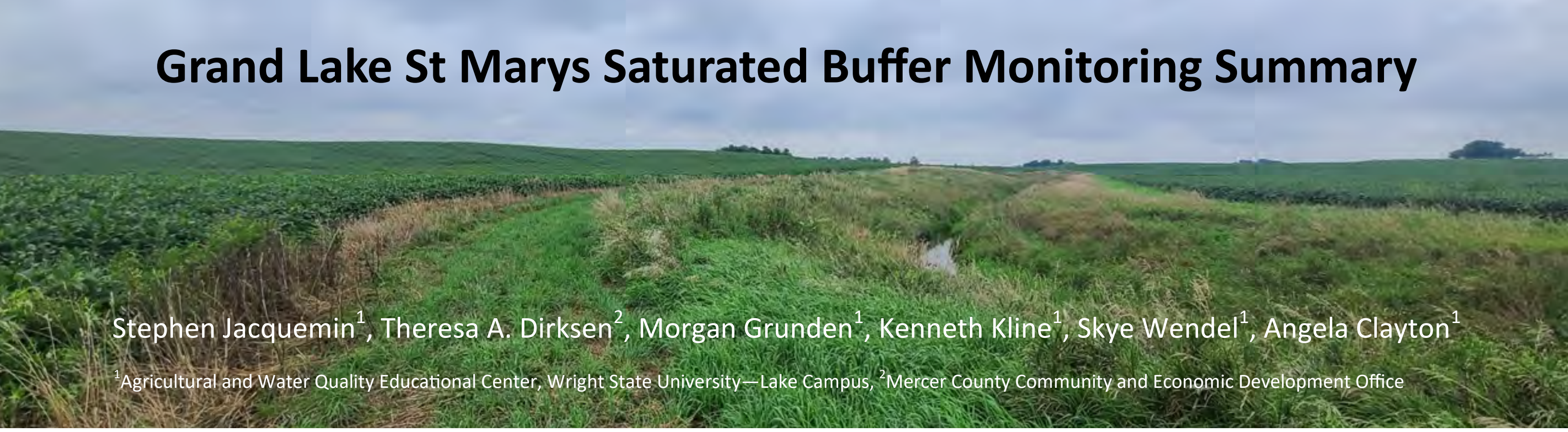
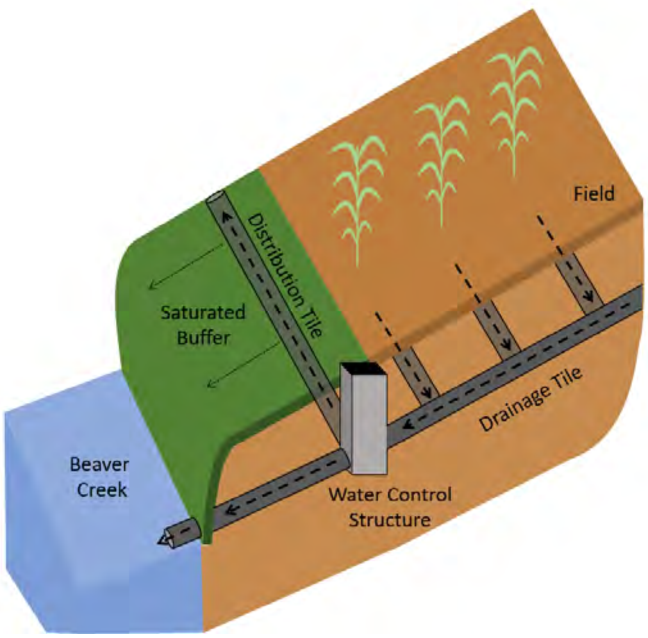
Grand Lake St Marys Saturated Buffer Monitoring Summary



Stephen Jacquemin[1], Theresa A. Dirksen[2], Morgan Grunden[1], Kenneth Kline[1], Skye Wendel[1], Angela Clayton[1]

[1]Agricultural and Water Quality Educational Center, Wright State University—Lake Campus, [2]Mercer County Community and Economic Development Office

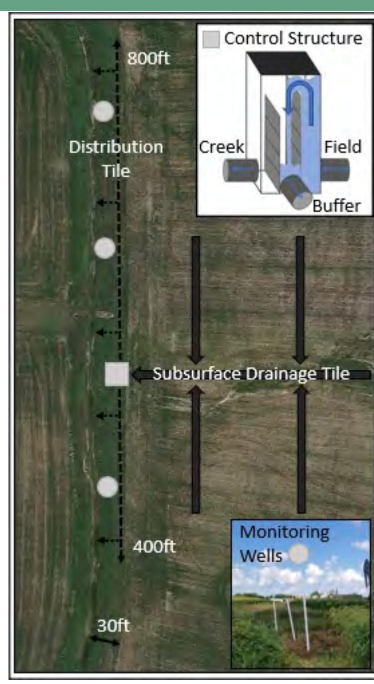
- Saturated buffers are a conservation practice which diverts subsurface tile drainage water through restored riparian areas.
- Rerouted water is distributed laterally from a perforated distribution tile via a control structure where gravity can then gradually move water through the riparian soils as it makes its way to an adjacent stream.
- Changing the flow of water from a typical tile flowing directly into the stream to one that moves through the riparian subsurface reduces flashiness of field discharge, allows the ground to saturate and hold more water, and provides an opportunity for nutrient reduction through adsorption with sediment, uptake from riparian vegetation, as well as denitrification.
- Ideal sites should have a riparian buffer planted with grasses/trees/shrubs, be at least 30' wide, be lower in elevation than the field, have soils that contain at least 1.2% organic matter, contain loam like soils to facilitate gradual water movement, and have a stable stream bank (NRCS CPS Code 604).
- As saturated buffers are a relatively new practice, they are currently underutilized with much potential to expand across the state of Ohio.
- Grand Lake St Marys Watershed has struggled with excess nutrient loading for decades— however, with recent conservation efforts showing promise, this tool could be a positive addition to further improve water quality.



** Conceptual schematic of a saturated buffer*

St Charles Center Saturated Buffer Design

- Study area was a 27 acre subwatershed field adjacent to Beaver Creek that has historically been no-till corn/soybean with rye cover crop.
- Riparian area was approximately 30' wide planted with mixture of tolerant grasses (e.g. orchard, timothy, alfalfa, clover, milkweed, susan).
- Predominant soils were Blount silt loams (60%) and Glynwood silt/clay loams (33%) in field with Eel silt loams along the riparian (5%).
- Survey elevations of field ranged from 918'-938', riparian from 914'-917', and stream from 903'-905' (overall field slope of 2.6%).
- Saturated buffer was installed using 1200' of 8'' distribution tile set at 910' (elevation) connected to a 12'' wide 3-chambered water control structure.
- A network of buffer groundwater wells were installed at 5', 10', and 20' intervals to assess water quality changes as water moved away from the distribution tile.
- Adjacent to the study watershed, a paired watershed draining 37 acres was used to record free flowing drainage (no control box) as a reference.
- Hydrology of the site was consistently monitored while water sampling for nutrient analyses took place immediately following ½''+ rain events.
- Before and after soil sampling from established strata horizons (O, A, E, B, C) was also conducted to assess nutrient changes in the riparian and field areas.

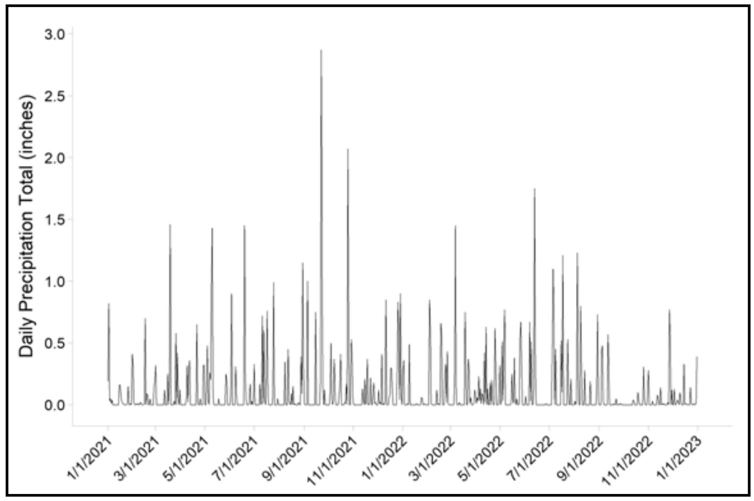


** Study site outline and setup*

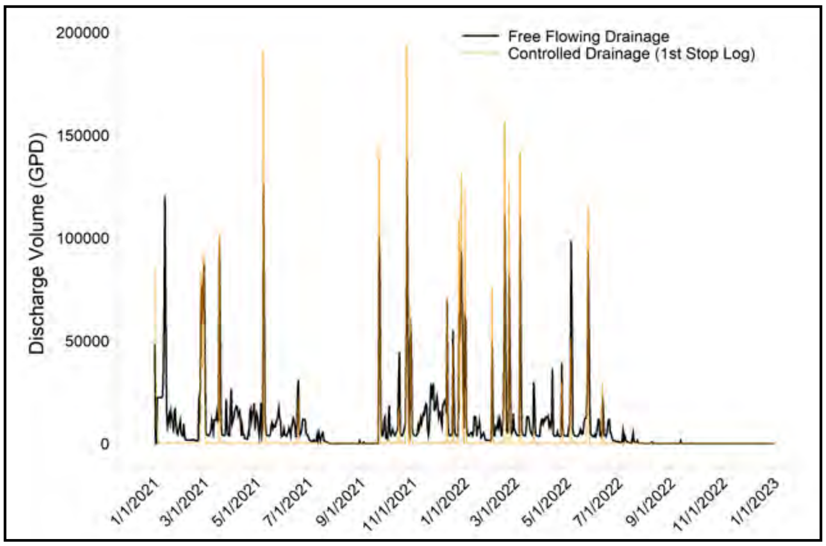
** This site is the second saturated buffer in Mercer County and the first of its kind in the Grand Lake St Marys Watershed*

Precipitation and Field Drainage Discharge

- A total of 42.2’’ of rain fell in 2021 compared with 34.9’’ in 2022 — totaling ~56.6 MG of precipitation over the subwatershed.
- The adjacent subwatershed tile discharge was watershed weighted to match drainage sizes to provide an estimate of what tile flows *would have been* at the buffer study site had no control box been present.
- Adjusted total subsurface tile volumes from the free flowing comparison site indicated ~6.75 MG drained into the stream.
- The super majority of discharge from the study site occurred over 10 days or less in both 2021 (60% of all volume) and 2022 (85% volume).
- Field tiles under controlled drainage ran 45 and 25 days in 2021 and 2022, respectively, compared to 300 and 189 days under free drainage.
- Precipitation that did not make its way to the tiles likely either ran off as surface runoff or seepage, was taken up by growing crops, evaporated, or remained in the soil.



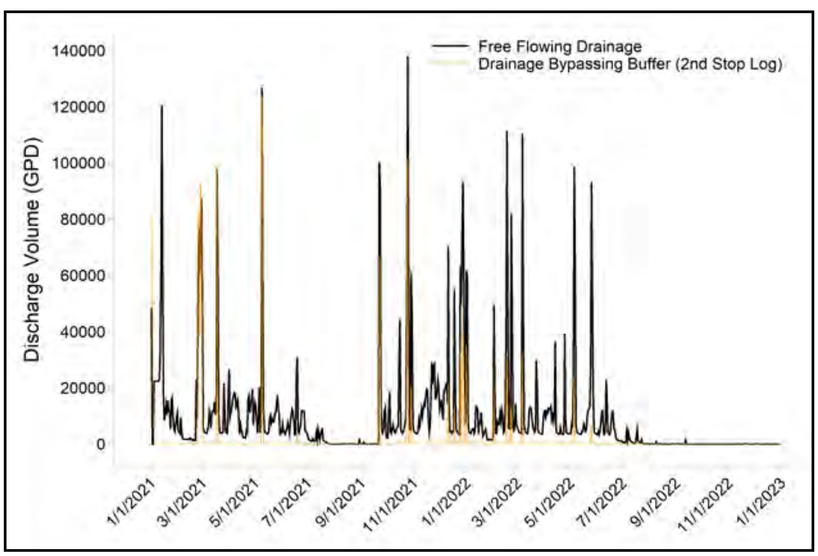
** Daily rainfall totals over the two year study period*



** Comparison of controlled drainage discharge vs free flowing drainage discharge volumes*

** View of the free flowing drainage comparison site*

- A total of 3.3 MG drained from the study field (first stop log) —representing ~48% of the total flow that *would have drained* with no control box.
- A total of 1.4 MG drained over the second stop log, bypassing the buffer section of the control box — representing ~21% of the total flow.



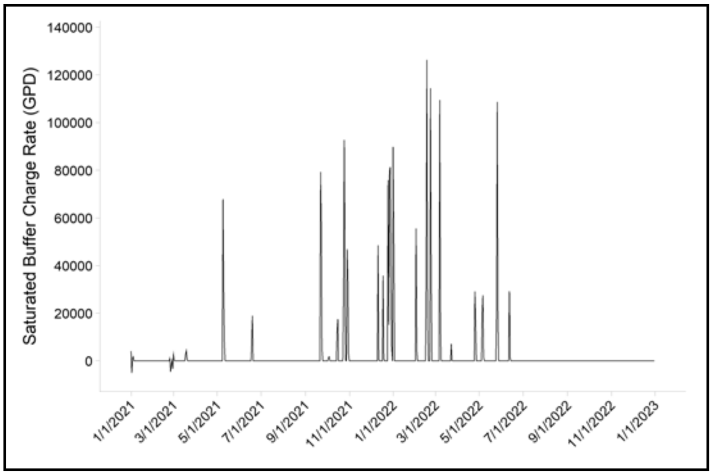
** Comparison of discharge bypassing the saturated buffer vs free flowing volumes*

Flow Data (Volumes in Total Gallons)

Year	Variable	Winter	Spring	Summer	Fall
2021	Free Flowing Site Discharge	1,733,999	1,144,372	200,813	1,483,628
	Field Discharge	998,306	362,555	30,069	770,716
	Discharge Bypassing Buffer	668,239	250,092	3,537	313,017
2022	Free Flowing Site Discharge	1,026,961	1,052,088	101,155	409
	Field Discharge	798,311	305,074	0	0
	Discharge Bypassing Buffer	147,118	30,872	0	0

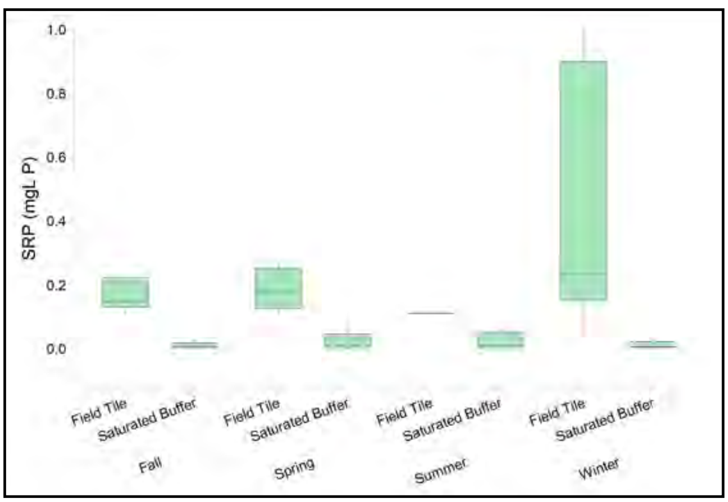
** Saturated buffers can provide valuable wildlife habitat—for example, during this study, dozens of species of birds were noted using the newly restored habitat*

Nutrient Reductions



** Calculated from flow volume leaving the field minus volume leaving the buffer*

Saturated Buffer Charge Total Volume (Gallons)		
Season	**2021**	**2022**
Winter	330,067	651,193
Spring	112,463	274,202
Summer	26,532	0
Fall	457,699	0



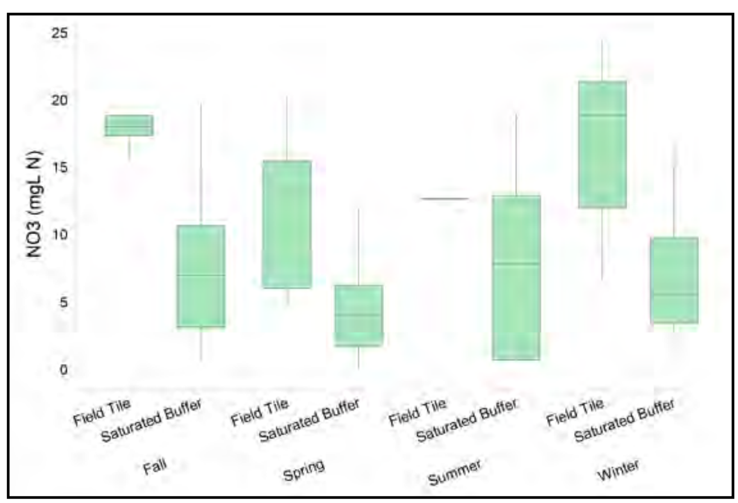
** Soluble reactive phosphorus mean concentrations by season*

** Undergraduate lab student analyzing samples for nutrients*

- Over the two years a total of 1.85 MG passed through the buffer—with the majority of water saturating the riparian during the Fall (2021) and Winter (2022) months.
- Lack of rain during the second half of 2022 resulted in no water detected to have entered the buffer.
- No appreciable backflow events were detected.
- The buffer charged on 27 occasions (water leaving field) - including 17 events in 2021 and 10 in 2022.
- Of the water leaving the field, the buffer captured ~57% over the two years (43% in 2021 and 84% in 2022).

** Overhead view of 3-chamber box actively charging—note water flowing over first stop log (right) from the field and no water flowing over the second stop log (left) indicating an active charge event*

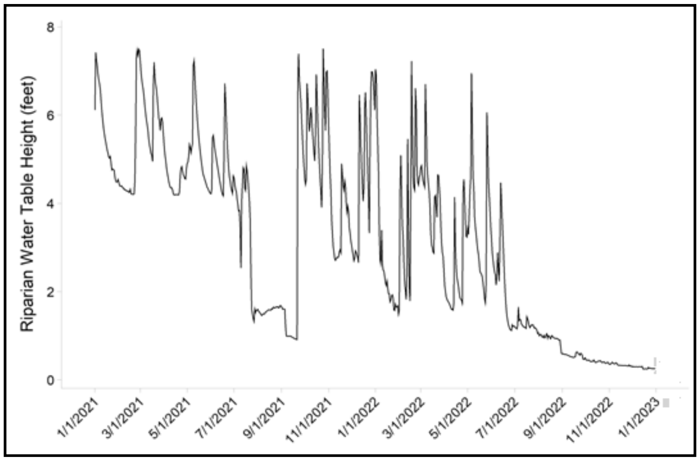
- Water sampling captured data from 24 of 27 runoff events.
- Overall nutrient reductions, comparing Field Tile to average Buffer Monitoring wells indicated an ~59% decrease in NOx and 84% decrease in SRP concentrations.
- Critical spring decreases were 58% N and 40%P.
- In addition to SRP and NOx, TP and TSS values from the tile were also reduced as particulates are not transported through the distribution tile.



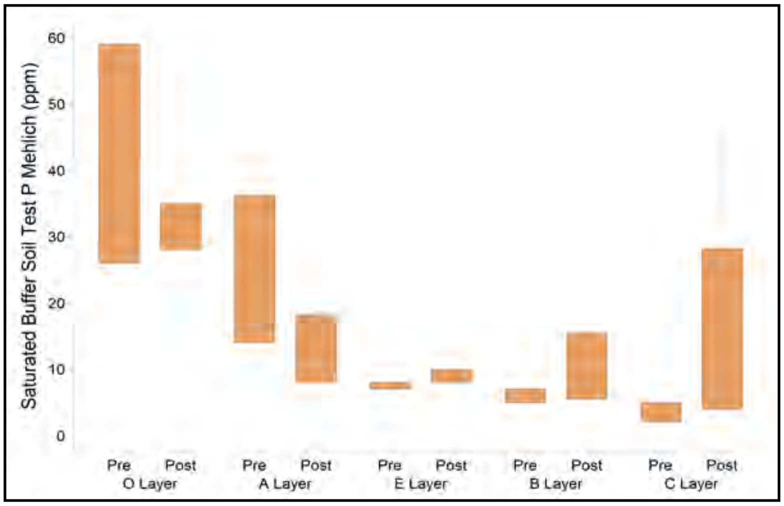
** Nitrate—Nitrogen mean concentrations by season*

Sediment Characteristics and Groundwater Saturation

- Soil test P levels in the buffer exhibited a decline over the monitoring period near the surface and an increase in deeper layers—likely indicating uptake from surface plants and deposition (adsorption) of P into the subsurface.
- Factoring in Aluminum and Iron, soil P storage capacity statistics (SPSC) were all positive indicating likelihood of additional P capacity in the buffer.
- Unfortunately, STP levels in the field adjacent the riparian went up in the surface horizons (O & A)—and while positive SPSC values indicate that this is technically still a P sink—it does signal potential problems in the future.



** Water table in the saturated buffer over time adjacent distribution line*



** Soil test phosphorus levels arranged by increasing depth of soil strata before and after study*

** Soil sampling for phosphorus levels*

Surface Runoff Potential

- Given that saturated buffers are an extension of drainage water management strategies, it is reasonable to question their impact on surface runoff.
- This study did not directly assess surface water runoff volumes or concentrations.
- Past studies on DWM have suggested that surface runoff could increase by as much as 50% compared with free flowing sites given the raised water table.
- However, recent meta analyses have pointed out that while surface runoff may increase post DWM, that these upticks likely pale by an order of magnitude or more, in comparison to the amount of water reduced from managed tile flow.
- While not part of this study, surface water concentrations and observations were made on a single large surface flow event following a nearly 2'' spring rain on a dormant crop—essentially emblematic of a 'worst' case runoff scenario.

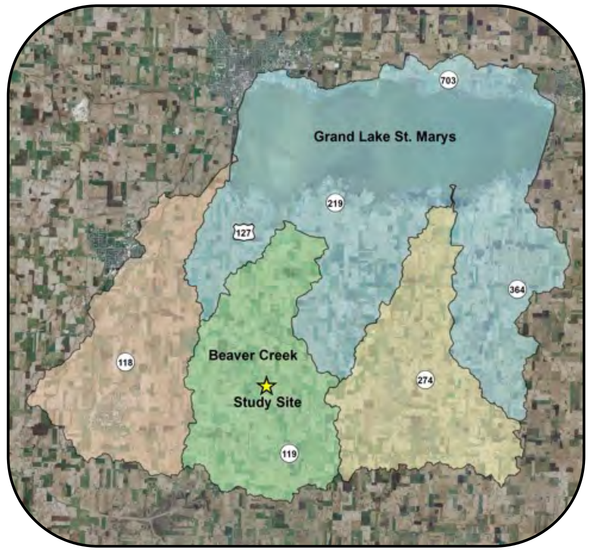
Surface Runoff Event Case Study (*Post* 1.9'' 24 HR Precipitation)			
Water Quality Variable (mgL)	**Field Surface**	**Buffer Surface**	**Percent Change**
SRP	1.24	0.94	- 24%
TP	2.12	1.55	-27%
NOx	5.65	8.29	+ 47%
TSS	591	340	- 42%

- Given the elevation of the control box coupled with the depth loggers and field observations, it was possible to estimate how many surface runoff events occurred over the study. In 2021, surface runoff occurred 7 times with 3 being 'large' events lasting 12 hours or more. In 2022, surface runoff occurred 5 times with 1 being a 'large' event lasting more than 12 hours.
- Despite these surface events, we are encouraged by the overall reduction in surface P loading as a result of the restored buffer.

** Surface runoff event—note concentrated flow area leaving study field and flowing through restored buffer area prior to discharging into the adjacent Beaver Creek*

Moving Forward and Learning More

- Additional sites for saturated buffers are needed across the state of Ohio—particularly in northwest Ohio.
- Future monitoring needs to include surface runoff directly as other controlled drainage study results have been mixed.
- Saturated buffers represent a high impact edge of field practice that do not take many acres out of production, are affordable to install (between $5,000 and $10,000), are supported by certain cost share programs, and can be easily managed and maintained.
- Contact your local Soil and Water Conservation District or Natural Resources Conservation Service office today about this practice (NRCS CPS Code 604).



** Site location situated within GLSM watershed in NW Ohio—many opportunities for future sites here and elsewhere around the state*

** Saturated buffer establishment*

- For more overview information, read through ‘Questions and Answers about Saturated Buffers for the Midwest’ by Jaynes et al. (2018) and published through Purdue Extension (ABE-160).
- For more technical information, read through ‘On the potential for saturated buffers in northwest Ohio to remediate nutrients from agricultural runoff’ by Jacquemin et al. (2020) and published through PeerJ.
- For more commentary, read through ‘Saturate that buffer for crop’s sake’ by McGlinch and Jacquemin (2023) and published through Ohio’s Country Journal.

PeerJ

On the potential for saturated buffers in northwest Ohio to remediate nutrients from agricultural runoff

Stephen J. Jacquemin[1], Greg McGlinch[2], Theresa Dirksen[3] and Angela Clayton[1]

[1] Agriculture and Water Quality Education Center, Wright State University - Lake Campus, Celina, OH, USA
[2] Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH, USA
[3] Mercer County Community and Economic Development Office, Celina, OH, USA

Blanchard River DEMONSTRATION FARMS NETWORK

Acknowledgements

We wish to thank the Blanchard River Farms Demonstration Network and their partners at Ohio Farm Bureau, USDA Natural Resources Conservation Service, as well as the Great Lakes Restoration Initiative for supporting this project. Ohio’s 319 Program provided funding for installation of the buffer through the Mercer Soil and Water Conservation District. In addition, we thank the strong local support for the project, including the St Charles Center as well as VTF Excavation, and Cy Schwieterman Inc. Lastly, much appreciation to the many Lake Campus undergraduate students involved in the project over the years: K Kline, B Strang, C Ewing, B Axe, M Gels, S Wendel, and A Selby, whose many long hours in the field made the data collection and results possible.