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DISCOVERY FARMS WISCONSIN

Lessons Learned from Bragger Family Dairy

How farm management influences water quality in a challenging, diverse landscape

By Callie Herron, Dennis Frame, Amber Radatz, Tim Radatz

How do farm fields impact nearby streams? How do soil and nutrient losses from cropland compare to losses from pasture or woodland? Is there such a thing as zero loss? Can numbers from working farms be useful to policymakers? What practices are effective in reducing soil and nutrient loss? The UW Discovery Farms® Program was founded in 2000 to answer these questions, and its first project, located on Bragger Family Dairy, did just that. The project was the perfect blend of ideal sites and exceptional partnerships and provided reliable, actionable water quality data for landowners and policymakers that is still being used today.

PROJECT BACKGROUND

Joe Bragger walks his family farm in the hilly landscape of Buffalo County, Wisconsin.

Bragger Family Dairy became the first Discovery Farms Core Farm through monitoring efforts on two streams from October 2002 through 2008. The dairy is located in Buffalo County, Wisconsin, an area with a challenging landscape that allows for only small fields and demands attention to soil conservation due to its 10-30% slopes. To account for the sensitivity of this landscape, the dairy used conservation practices (Table 1) and management strategies throughout the study to minimize runoff and soil loss into the two streams connected to its property. While the streams are mostly spring-fed, they are also influenced by surface water runoff and watershed land use.

On-farm research presents a unique set of challenges, especially relative to control and replicability. The study at Bragger Family Dairy was unique in that it allowed for an experimental site and a control site – one comprised of cropland and one comprised primarily of pasture/woodlands – within separate watersheds. Having two sites on the same farm made it possible to compare soil, phosphorus, and nitrogen losses while holding weather, soil type, and other geographical features equal.

Seven years of data collection in the two watersheds connected to the Bragger farm show that there is no such thing as zero loss, no matter the land use. The data suggest that during several months out of the year losses from the two watersheds were similar, but there were times during the growing season when the agricultural watershed was more vulnerable to loss.

This dataset sheds light on how nutrient and soil loss from land used for agriculture compares to land that is predominantly pasture/woodland as well as the factors for loss that farmers can and cannot control. The goal of this research was and continues to be to provide clear recommendations for ways to minimize soil and nutrient losses during the times of the year when management matters most.

Policymakers and farmers alike can use this information when making difficult decisions. Prior to this on-farm research, decisions were informed by models and research plots. Field-level research conducted by Discovery Farms advances the understanding of soil and nutrient loss. This study and the others that have come after it have created a base of knowledge that supports efforts to continuously improve water quality while maintaining on-farm profitability.

Table 1. Conservation practices used at Bragger Family Dairy

PRACTICE	INDICATION
Dams (Grade Stabilization Structures)	Constructed where concentrated flow begins. Works to slow water and capture sediment-bound nutrients.
Waterways	Efficiently conveys surface runoff away from farmed areas while protecting soil in concentrated flow areas.
No-till Planting	Minimizes soil disturbance, decreases rock damage to equipment.
Cover Crops	Protects soil surface from raindrop impact and nutrients during fallow periods.

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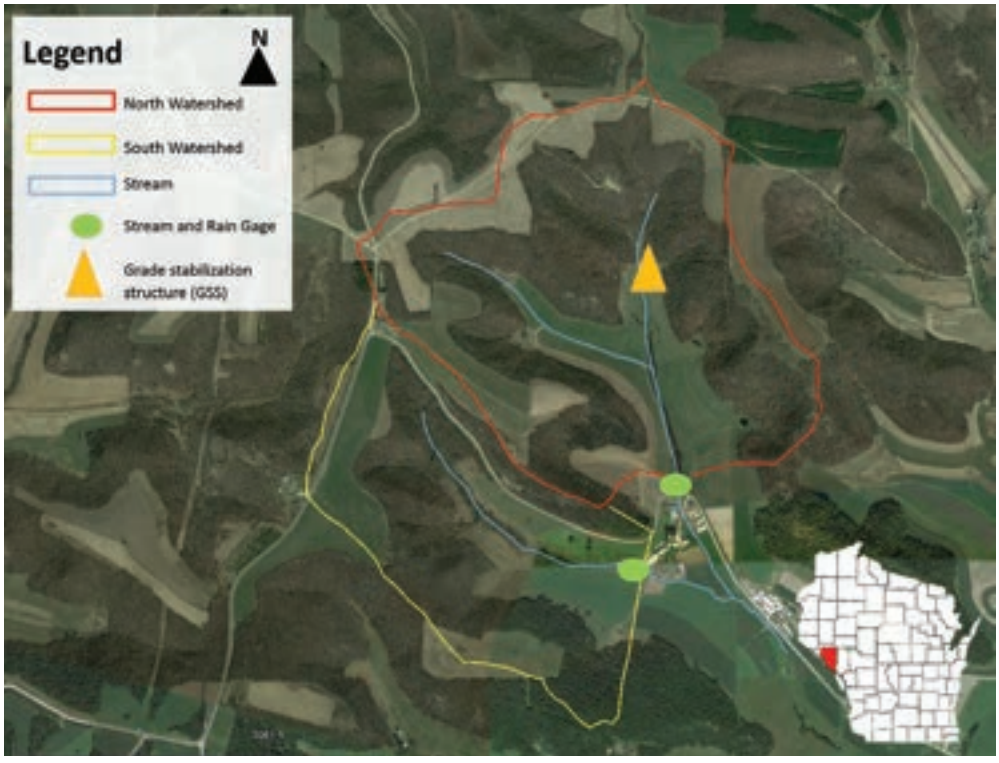
STUDY DESIGN

The study locations at Bragger Family Dairy consisted of the north site (corn and alfalfa rotation next to the stream) and the south site (pasture and woodland with cropped acres further from stream) to compare cropped acres to perennial grassland and woodland. The study area at the north site (also referred to as the agricultural watershed) was 430 acres, of which 172 acres were cropland and the balance was woodland and grassland. The study area at the south site was 214 acres, of which 38 acres were cropland and the balance was woodland and grassland. For the purposes of this study, the south site served as a control or basis for comparison.

Perennial stream flowing through the north monitoring site.

Crops in the watersheds included corn (mostly silage), alfalfa, and soybeans or other small grains. Manure was applied to crop fields year-round, though special attention was given to emptying the manure pit in the late fall so that only small amounts of solid manure were spread during the winter months or when runoff was imminent.

Because the streams adjacent to the sites are perennial, baseflow and stormflow data were available for both throughout the study. **Baseflow** is daily normal flow and is influenced by groundwater. **Stormflow** is influenced by surface runoff and precipitation events. A grade stabilization structure (GSS) dam was installed in the agricultural watershed near the headwaters of the stream to slow water from upland, non-farmed areas. This offered an opportunity to compare losses between sites pre and post installation of the GSS.



North and south sites (watersheds) at Bragger Family Dairy.

Three forms of nitrogen (nitrate, ammonium, and organic), total phosphorus, dissolved phosphorus, and suspended sediment (a measure of soil loss) were measured along with flow, precipitation, soil moisture, soil temperature, humidity, and air temperature. Field management information was also recorded.

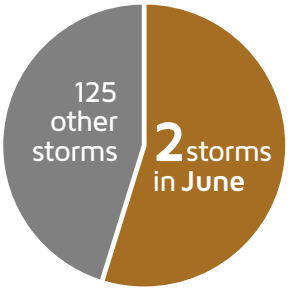
FINDINGS

Both watersheds lost soil, phosphorus, and nitrogen. Average monthly losses while the ground was frozen and after crop canopy was established were similar between the two sites.

- **When the soil was frozen,** soil and nutrient losses at the two sites were comparable. Runoff at this time of year was driven by snowmelt. This relationship shows that the farming system, including manure management, did not have a significant impact on the stream while the soil was frozen or when snow was melting. Bragger Family Dairy minimized phosphorus and nitrogen loss during the frozen ground period by carefully timing manure applications to avoid time periods with high risk for runoff.
- **Annual soil loss** was relatively low in the agricultural watershed at less than 300 pounds per acre, but farming practices did influence soil loss in the spring. From April to June, the north site had higher losses than the south site by a factor of four to five; however, after crop canopy was established, losses were very similar between the two watersheds. Spring planted crops did not develop a full canopy until July, and most of the runoff (when the ground was not frozen) occurred in April, May, and June.
- **Increased soil protection and carefully monitored weather conditions** prior to manure or fertilizer application likely reduced the risk of soil, phosphorus, and nitrogen loss. Additionally, implementing a network of practices – waterways in concentrated flow areas, grade stabilization structures, no-till planting, and cover crops – kept overall soil and nutrient losses low in the period between frozen ground and established crop canopy and helped infiltrate precipitation water and slow surface water runoff.

Soil and phosphorus were mostly delivered to the stream in May and June during storms.

- **Soil and phosphorus** were mostly transported by stormflow, even when the land use was not row crops. Although stormflow accounted for less than 25% of the total water flow from the north and south sites in the seven years of the study, more than 80% of the soil and total phosphorus losses from the south site were from stormflow. Storms have the biggest impact on water quality when the soil is not covered by a fully developed crop canopy. Much of the phosphorus and nitrogen loading from May through June can be tied to storm events and corresponding soil loss.
- **May and June** were the only months of the year when average monthly phosphorus and nitrogen losses were elevated at the north site compared to the south site. Two particular storm events in June 2002 and June 2004 delivered significant proportions of the soil (55%) and total phosphorus (44%) lost during the entire study period (2002-2008). The rain events were 3.2 and 3.4 inches respectively. These events were short and intense: 1-2.5 inches of rain per hour.
- **The large storm events** were more impactful in the agricultural watershed during the early June time period due to limited crop canopy, and as a result, soils were more vulnerable to runoff and erosion.

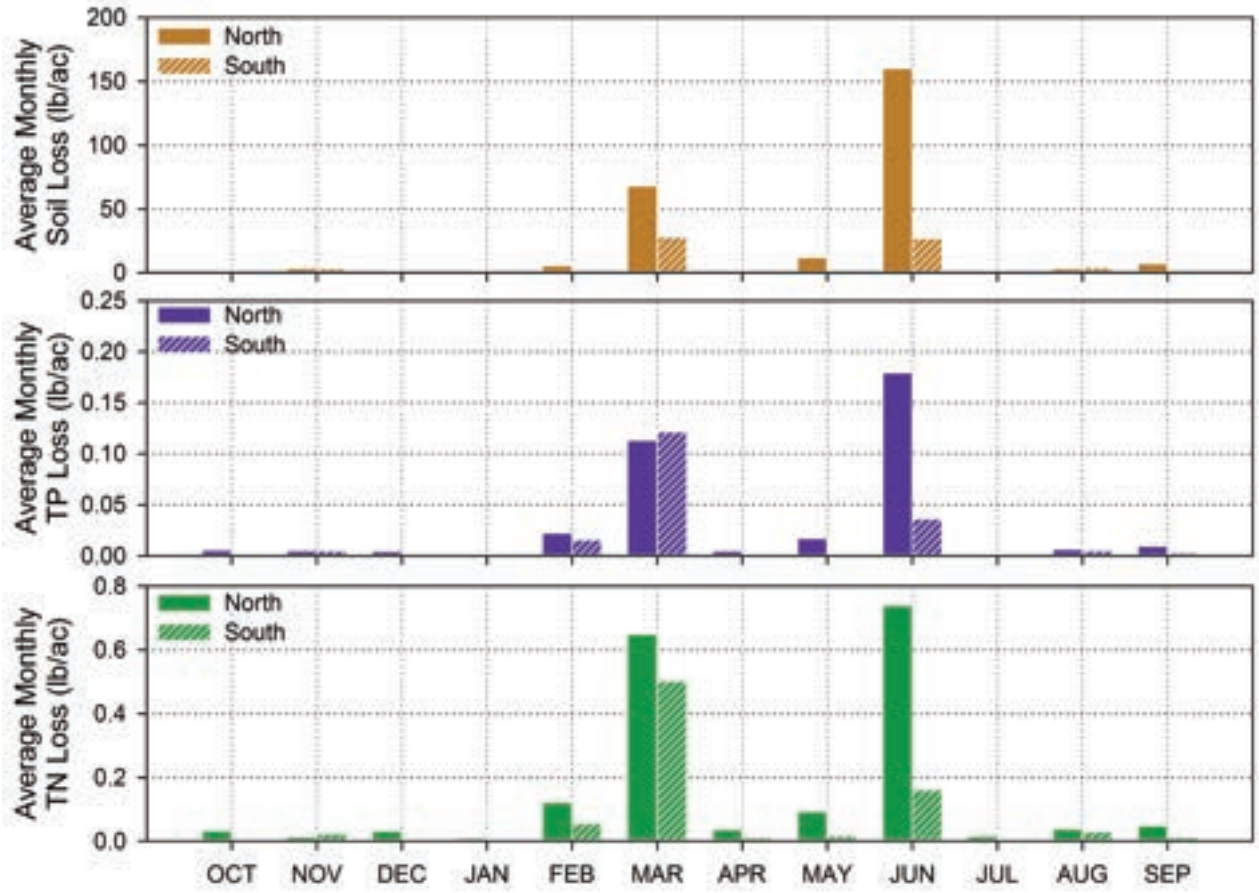


During the six-year study period, more than half of the total soil loss occurred during two June storms.

Table 2. Average annual soil/nutrient losses at Bragger Family Dairy

CONSTITUENT	NORTH BASIN			SOUTH BASIN		
	Average Annual	Baseflow (% of loss)	Stormflow (% of loss)	Average Annual	Baseflow (% of loss)	Stormflow (% of loss)
Runoff	5.32 (in)	84%	16%	2.52 (in)	75%	25%
Soil Loss	283 (lb/ac)	6%	**94%**	72 (lb/ac)	4%	**96%**
Total Phosphorus	0.42 (lb/ac)	10%	**90%**	0.23 (lb/ac)	17%	**83%**
Total Nitrogen	4.19 (lb/ac)	56%	44%	1.60 (lb/ac)	48%	52%

Figure 1. Average monthly stormflow losses at the Bragger farm



- **A storm in August 2007** had similar intensity to the June storms but was not in the top twenty storms for soil loss. Fully grown crops intercepted rainfall and protected the soil surface, thus preventing runoff. When storms happen at a time of year when the landscape is more resistant to losses, the resulting erosion and nutrient loss will be less. It is impossible to control when large storm events will occur, but when practices like waterways and grade stabilization structures are in place, impacts are minimized.

A grassed waterway on Bragger Family Dairy cropland.

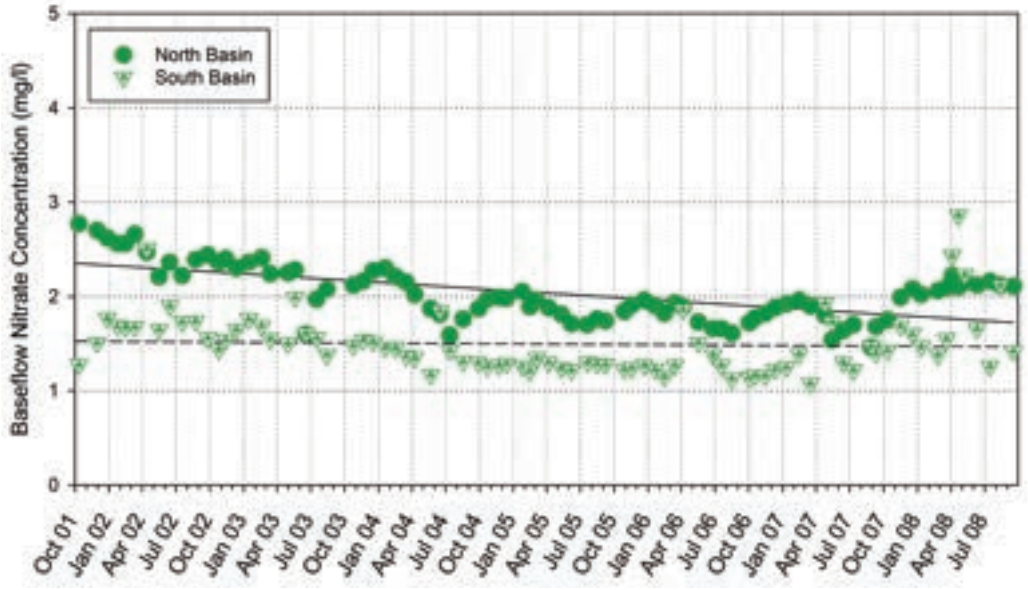
A grade stabilization structure dam reduced the amount of soil delivered to the nearby stream.

- **In 2005, a grade stabilization structure** was installed at the headwaters of the stream in the agricultural watershed to slow water from the wooded areas upstream of the cropland. The structure reduced the average sediment concentrations deposited in nearby waterways by 73%. For more information on the impacts of grade stabilization structures, please read the Extension publication titled *Conservation Benefits of a Grade Stabilization Structure,* available through the UW-Extension Learning Store, (learningstore.uwex.edu).

By the end of the study, baseflow nitrate concentrations at the north site were similar to the south site, showing that targeted nutrient stewardship makes a difference.

- **Most of the nitrogen** measured in the stream at Bragger Family Dairy was delivered during baseflow and was in the nitrate form due to the carbonate bedrock that underlays the Buffalo County landscape and the springs that feed the perennially flowing streams. The Braggers have targeted and continue to target nutrient stewardship practices to improve nitrogen use efficiency and prevent groundwater leaching.
- **The Braggers' commitment** to the right rate, time, placement, and source of nitrogen was illustrated by the downward trend in baseflow concentrations at the north site during the study period. By the end of the project, concentrations at the north site were nearly identical to those at the south site. Overall, nitrate-nitrogen concentrations at the south site stayed constant at less than 2 mg/L, which is the preferred concentration in groundwater. The nitrate-nitrogen concentration at the north site ranged from 1.5 to 2.5 mg/L.

Figure 2. Baseflow nitrate concentrations at Bragger Family Dairy



Manure impacted phosphorus and nitrogen loss on two out of 2,557 days monitored, illustrating that timing of manure application matters.

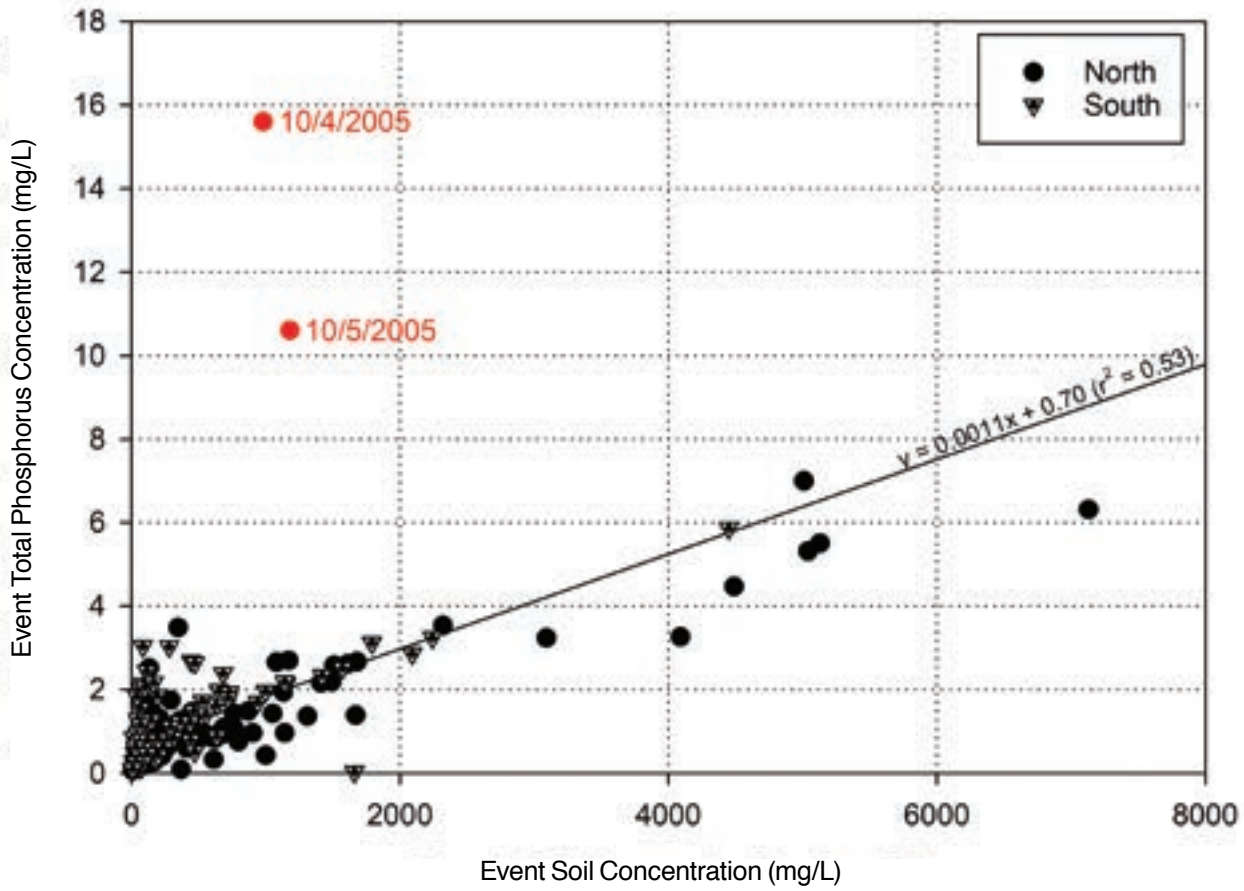
- **Water quality monitoring** results show that the Braggers paid careful attention to conditions before applying manure. Manure applications in November and December were made in six of the seven years, and March applications were made in two years when snow had already melted. None of these instances increased nitrogen or phosphorus loss relative to the south site.
- **Manure and fertilizer** were applied in the monitored areas dozens of times, but only two of the 2,557 monitored days indicated an impact from an application. When manure was applied immediately before a runoff event in October 2005, phosphorus and nitrogen loss increased, but soil loss did not (Figure 3). While the event increased phosphorus and nitrogen concentration, it did not impact annual loss significantly, and there were no effects on the trout population present in the stream. **In short, carefully timed manure applications, based on an understanding of field conditions and the weather forecast, can have positive impacts on crops and water quality.**

Avoid spreading manure when runoff risk is high. Check the risk on the Wisconsin Manure Management Advisory System:

www.manureadvisorysystem.wi.gov

Pack manure applied to a growing cover in early December when runoff risk was low.

Figure 3. Event total phosphorus vs. event soil concentration on the Bragger farm



TAKEAWAYS

Water quality can be maintained with appropriate use of conservation practices and careful timing of nutrient applications.

- **The agricultural practices** on the north site contributed to phosphorus, nitrogen, and soil losses; however, the losses at the site were still low throughout the study.
- **Both streams** were always below the numeric phosphorus criteria for Wisconsin – an indicator that both were of good quality – and neither was impaired, regardless of land use.

Cover crop in early December at Bragger Family Dairy.

- **Higher soil loss** resulted in higher overall phosphorus and nitrogen loss from the agricultural watershed. However, losses were at levels that allowed the stream to be below water quality criteria.
- **Agricultural management and water quality** complemented (and still complement) each other at Bragger Family Dairy as a result of the thoughtful use of conservation practices and nutrient management.

From Joe Bragger:

After joining Buffalo County Farm Bureau, I had an opportunity to be on the committee that developed the land-use plan for the county. While on the committee, I quickly became aware of the disconnect between farmers and their non-farm neighbors. Shortly after, I met Dennis Frame (co-founder of UW Discovery Farms) at the Wisconsin Farm Bureau Annual Meeting. A special friendship was formed and I promised myself to always work to show the positives of farming and the benefits we provide society. While not only preserving our natural beauty and environment, we improve on the past. Discovery Farms offered an opportunity to fulfill that promise.

Through Discovery Farms I learned too many things to go over all of them, but here are a few:

1. **When you open up your farm to others you learn more from discussions than you could ever imagine.** I was able to start to understand the concerns that others had. Right or wrong, it is a starting point to developing solutions or explaining how practices you have in place are working.

2. **When not sure, ask a farmer. Never assume.**
3. **Residue management is huge in helping our heavy clay ridge tops hold water.** I believe at the end we were capturing 98% of annual precipitation.
4. **On our farm, no-till is a success in keeping both soil and nutrients on the field.**
5. **Non-farm areas can also have substantial soil and nutrient losses.**
6. **Snowmelt and runoff are a unique science.** One really has to know what the soil conditions are under the snow and be careful during critical times (which as I have learned are usually February and March).
7. **I feel that the final numbers show that our farming practices were effective in limiting nutrient and soil loss.**
8. **Partnerships are everything.** Partners during the process included Discovery Farms, USGS, DATCP, UW-Extension, WDNR, farmers, farm groups, and environmental organizations. We had the opportunity to be part of an amazing partnership that has developed powerful data. Thanks to all I have had the opportunity to meet and learn from. I hope to use what I have learned and to never disappoint all those who have shared so much with us.

- Joe Bragger, Bragger Family Dairy

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This publication is available in pdf format at uwdiscoveryfarms.org and available from the UW Discovery Farms office, PO Box 429, Pigeon Falls, WI 54760, 715-983-5668

The UW Discovery Farms Program would like to thank the Bragger family for their willingness to participate in the project and for their continued engagement and friendship. Thank you to the many reviewers who contributed to this publication.

For over a decade, UW Discovery Farms has worked with Wisconsin farmers to identify the water quality impacts of different farming systems around the state. The program, which is part of UW–Extension, is under the direction of a farmer-led steering committee and takes a real-world approach to finding the most economical solutions to agriculture's environmental challenges. If you are interested in learning more about UW Discovery Farms, visit www.uwdiscoveryfarms.org, email callie.herron@ces.uwex.edu, or call 715.983.5668.

USGS science for a changing world

The data presented in this article were provided by the U.S. Geological Survey as part of a cooperative agreement with the UW Discovery Farms Program.

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