ANNUAL BI-WEEKLY GRAB SAMPLING:

A cost-effective approach for conducting tile line monitoring on your farm

Extension
UNIVERSITY OF WISCONSIN–MADISON
AGRICULTURE WATER QUALITY

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INTRODUCTION

Agricultural tile drainage can increase crop yields on poorly drained soils, improve timeliness of field access, and reduce yield variability; however, they can also serve as conduits for nutrient loss, most notably nitrogen in the nitrate form. Because nitrate is negatively charged, it does not bind with negatively charged soil and readily moves with water. Elevated nitrate-nitrogen concentrations in waters from the Mississippi River Basin have contributed to persistent hypoxic conditions in the Gulf of Mexico. This area is often referred to as the Gulf of Mexico Dead Zone because these low oxygen conditions cannot sustain aquatic life. Elevated nutrients can also contribute to harmful algal blooms observed in surface waters. **Sampling tile water on a bi-weekly basis can be a useful tool to assess nitrate-nitrogen leaving the field and evaluate how results are related to in-field nitrogen management practices.** This article will explain best practices for collecting tile line samples and interpreting these data based on Discovery Farms research.

RECOMMENDED STRATEGY

1 Defining the tile watershed

The first step to planning a tile line monitoring strategy is defining the tile watershed, or mapping out the tile on your landscape. To make interpretations about nutrient concentrations in tile flow; for example, comparing how a certain farming practice or landscape attribute impacts nutrient concentrations in tile flow, you must determine where that water is coming from. If you do not have a map of your tile system, use this resource to help you create one. This can be a difficult task, but it is an important step to ensure you are accurately assessing the fields, areas, or practices of interest.

2 Sample distribution (year-round, tile flows even during winter in Wisconsin)

The second step is to determine sample distribution. Discovery Farms compared 53 tile sites across 38 farms and found that tile flows all year in Wisconsin, notably during winter. Notice peaks during snowmelt in March and April, and again in January (Figure 1). It is best practice to sample year-round, including winter, so you do not miss key tile flow events.

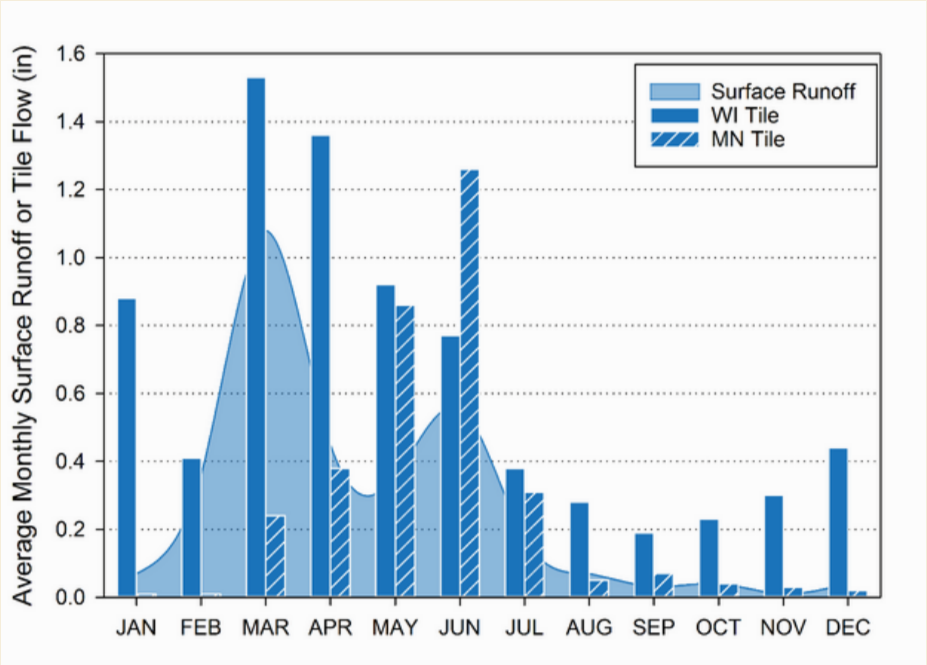

Figure 1. Average surface runoff and tile flow from 53 Discovery Farms sites across Wisconsin and Minnesota 2018 - 2020.

Notice substantially less tile flow occurs in Minnesota, especially during winter, compared to Wisconsin (Figure 1). Climate and surface runoff are very similar between these two regions, so it is unknown exactly what causes this difference. It could be due to groundwater interception or a perched water table at the Wisconsin sites sampled. Wisconsin sites in this study also used dairy manure and most Minnesota sites only used commercial fertilizer. It's possible your tile sites may look more similar to Minnesota flow patterns regardless of physical location, but you cannot confirm this without monitoring during the winter months.

3 Sample type & frequency (bi-weekly nitrate-nitrogen concentrations, no flow calculations)

The third step is to determine what and how often to sample. Water quality challenges related to agriculture in Wisconsin are phosphorus, nitrogen, and sediment loading. Typically, high phosphorus and sediment losses are associated with surface waters, while nitrate losses are more prevalent in subsurface water like tile drainage. However, phosphorus and sediment losses can still occur in tile drainage, especially during high flow periods or in older, more degraded tile lines. This article will focus on nitrate-nitrogen sampling.

Consider the following definitions as you work through your tile monitoring strategy:

Nitrate-Nitrogen Concentration: The mass of nitrate-nitrogen in a defined amount of water. Typically reported as parts per million (PPM) or mg/L.

Flow or Discharge: Volume of water that moves over a designated point during a fixed time. Tile flow is affected by many factors such as climate, precipitation, weather, soil moisture, and soil type. It often varies considerably during the year.

Nitrogen Loading: Cumulative amount of nitrogen leaving the field. Typically reported in pounds. Several accurate flow measurements & nitrogen concentrations are needed to calculate this. You can sometimes calculate an estimation of nitrogen loading using statistical calculations & models if you have enough accurate flow and concentration samples. Grab sampling alone does not accurately predict nitrogen loading.

Flow-Weighted Mean Concentrations: Total load lost per year divided by the total volume of flow. Integrates concentration measurements and flow measurements using automated samplers that collect data 24/7 to account for all flow events. Golden standard of calculating nitrogen loading.

Nitrate-nitrogen concentrations are easy to measure with a grab sample and are informative for a single snapshot in time. However, nitrate-nitrogen concentrations can vary over the course of a day, and even more over the course of a week, month, or even year. Without several samples, you cannot draw conclusions beyond a single snapshot in time.

Flow-weighted mean concentrations are the most accurate measure we have to assess nitrogen leaving a particular field in tile drainage because it takes into account both flow and concentration. This is important because flow and concentration interact to impact water quality. For example, a field with a low concentration of nitrate-nitrogen and high tile flow may have a larger negative impact on a nearby waterbody than a field with a high concentration of nitrate-nitrogen and low flow.

Although flow-weighted mean concentrations are the most accurate measure we have, taking this measurement requires highly specialized, expensive equipment that is equipped to take samples 24/7. This is typically not economically or logistically feasible for individuals looking to monitor tile drainage on their farm.

To help address this limitation, from 2018-2020 Discovery Farms compared the cost-effective approach, annual bi-weekly grab sampling for nitrate-nitrogen concentrations, to the more involved 24/7 automated flow samplers collecting flow-weighted mean concentrations to see how these two approaches compared in terms of accuracy.

Findings:

- Bi-weekly nitrate-nitrogen concentrations were consistent with flow weighted mean concentrations and produced a high quality measurement of average annual nitrate-nitrogen concentration. Notice how the trend lines overlap in the nitrate graph (Figure 2).

- Bi-weekly flow measurements are inaccurate because there is too much variability in flow rates to only measure once every two weeks.

- Bi-weekly sediment & phosphorus concentrations underestimate actual concentrations because this sampling strategy is too infrequent to capture all high flow times. Notice how the sediment and phosphorus trend lines diverge (Figure 2).

Recommended sampling type and frequency based on research:

Annual bi-weekly grab sampling for nitrate-nitrogen concentrations with no flow calculations.

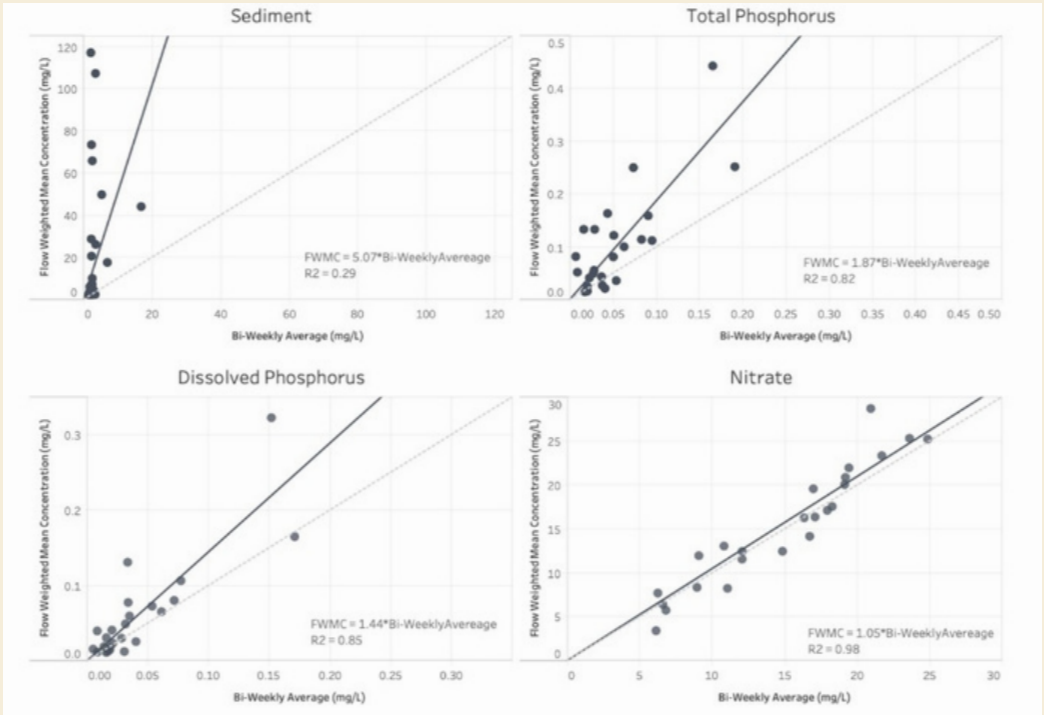

Figure 2. Bi-weekly grab sampling concentration averages compared to flow weighted mean concentrations for sediment, total phosphorus, dissolved phosphorus and nitrate.

4 Interpreting data

An important part of interpreting water quality data is recognizing that all sampling approaches have limitations. A grab sampling approach cannot be used to calculate nitrogen loading; however, calculating annual nitrate-nitrogen concentrations is still highly valuable because this is the factor you have the ability to change. For any nutrient loss to occur, you must have a source and a transport mechanism. You cannot control the transport mechanism (tile flow) because you cannot control the weather, but you can help control the source (nitrate-nitrogen concentration) with nitrogen best management practices.

Be sure to assess concentrations as an annual average to account for concentration variability over time. With a yearly average, you can have more confidence that the average concentration takes into account this variability and is more representative of what is actually happening on a field during the course of a year. The more years of data you collect, the more meaningful this data can be. With multi-year data sets you can potentially start to see trends, comparisons between fields, differences in management practices or landscape conditions, or how anomaly years, like drought or excessive snowfall, may impact concentrations in tile-flow.

If possible, collect local weather data including precipitation timing, volume, and intensity and make notes of management decisions on the farm such as timing of manure spreading or nutrient applications, fertility rates, tillage type, and crop rotations. Also consider recording landscape conditions such as soil moisture, soil properties (texture, restrictive layers, sand lenses, textural changes from glacial deposits), field slope, and proximity to surface water. More complete records allows for more meaningful data interpretation.

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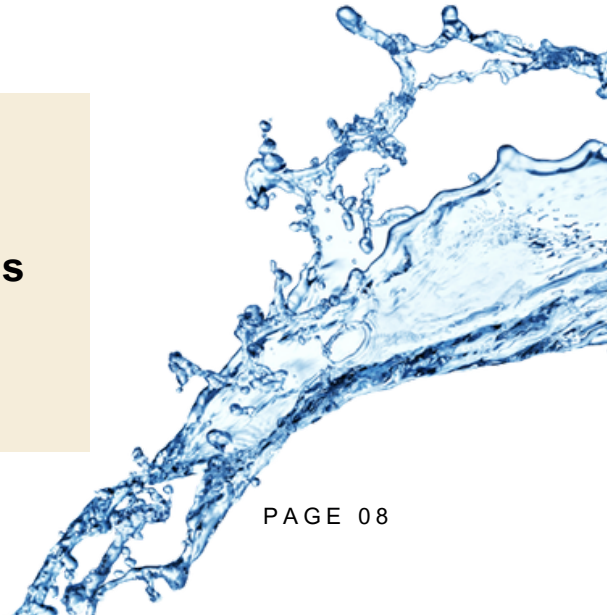

5 Reach out to your local Agricultural Water Quality Outreach Specialist

Tile line monitoring is a complex process. This document is not an exhaustive list of all variables or interpretation considerations that may arise, but rather serves as a guide to get you started. The UW-Madison Extension Agriculture Water Quality Outreach Specialists are here to help you during any step of the process from planning to implementation to interpretation. Reach out to your regional specialist for any help along the way:

Amber Radatz, Program Manager, amber.radatz@wisc.edu
Chelsea Zegler, Southern Wisconsin, zegler@wisc.edu
Guolong Liang, Central Wisconsin, gliang6@wisc.edu
. **Laura Paletta**, Northeast Wisconsin, paletta@wisc.edu
Kelsey Hyland, Northwest Wisconsin, kelsey.hyland@wisc.edu

Check out our Topic Hub website for other related resources: agwater.extension.wisc.edu

Did you know tile can flow 365 days a year?

FREQUENTLY ASKED QUESTIONS

What should I do if the tile line is submerged or frozen when I try to sample?

Unfortunately, collecting tile samples comes with its challenges, especially during winter. Tile lines can freeze, become submerged under water, or become inaccessible with snow. In these circumstances, this would count as a missing data point if you cannot sample. Luckily, if you implement a year-round sampling strategy, you will likely have enough data from the rest of the year to have meaningful results, despite the potential for missing data points.

What should I do if no water is running?

Try coming back within the same week and sampling again. If water is still not running, make a note of this. While you won't collect any concentration data during this time, this may still help you see trends of high vs. low flow over time. This is very useful information because high flow periods are when nutrients have the greatest potential to be leached from the crop root zone.

Where do I send my sample?

Most commercial testing labs are equipped to conduct a nitrate-nitrogen concentration analysis.

How do I store a sample?

Refrigerate and send in your sample as soon as possible after collection. We recommend sending it or dropping it off within a week if possible to prevent extensive sample degradation or transformation.

Tile blowout

Sediment in tile flow

What other observations should I look for while tile sampling?

It's important to know and understand your tile system. Note the material and condition of your tile. As older tile continues to age, especially those made of clay and concrete, tile blowouts can occur. Blowouts can introduce soil and nutrients into the drainage system and increase the potential for nutrient loss. If you consistently see large amounts of sediment in tile water, this may be a sign of a tile blowout. Check out this resource for more information on repairing tile blowouts

Some tile systems will also have a surface inlet that will drain an area on the surface of a field that typically ponds (such as prairie potholes or along terraces), in which case, you may see sediment or manure that is surface applied in the tile drainage after a storm event. Check out this resource for more information on surface inlets.

Surface inlet

CASE STUDY #1: HOW CAN I USE ANNUAL NITRATE-NITROGEN CONCENTRATION?

Pagel's Ponderosa Dairy:
Tile monitoring occurred from 2005 - 2008. This study used year-round automated flow sampling, which allowed them to collect nitrogen loading.

- 56% of flow occurred during frozen ground conditions.
- Total average nitrogen loss during the monitoring period was 62 lbs N/acre/year.
- Tile flow from a single storm contributed to almost 30% of total nitrogen lost for a total year.
- Manure applications made in the fall of 2005, soon after the removal of corn silage, showed elevated loss of nitrogen to tile.

Changes in agricultural management as a result of on-farm monitoring:

- Application of manure to fields in subsequent years occurred at a later date when soils were cooler and the conversion to nitrate was minimized.
- Participants did not spread manure on snow-covered or ice-crusted fields.

CASE STUDY #2: HOW CAN I USE ANNUAL NITRATE-NITROGEN CONCENTRATION?

Koepke Farms:
Tile monitoring occurred from 2005 - 2009.

- Spikes in total nitrogen concentrations could often be correlated to recent manure applications.
- Manure applications made in December 2005, December 2007, and March 2008 resulted in elevated nitrogen concentrations in subsequent months.
- Most nitrogen loss (84%) occurred during non-frozen ground periods.
- A rapid response time was observed in tile flow from rain events, especially when soil moisture rates were already high.
- Total nitrogen loss in tile under alfalfa was lower than corn and soybean.
- Monitoring showed that a single storm contributed to over 70% of total nitrogen loss for the entire field year.

Changes in agricultural management as a result of on-farm monitoring:

- Manure storage was constructed in 2008, so that they could minimize manure applications on frozen ground and when soil moisture was high.
- The farm was able to evaluate strengths and weaknesses in their nitrogen management program and make adjustments accordingly by utilizing end of the year stalk nitrate tests.
- Experimentation with different cover crops across the farm began to help reduce the potential for nitrate loss.

note both studies also conducted surface monitoring, so changes in management decisions were likely a result of both surface and tile monitoring