ONFARM

Edge-of-Field Technical Report

March 31, 2024

Acknowledgements

The On-Farm Applied Research and Monitoring (ONFARM) program is a nine-year, applied research initiative delivered by the Ontario Soil and Crop Improvement Association (OSCIA) on behalf of the Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA) to support soil health and water quality research across farms in Ontario. This program is currently funded by the Sustainable Canadian Agricultural Partnership, a five-year federal-provincial-territorial initiative. OSCIA would like to acknowledge the support of several organizations and members of the agricultural community for their contributions to the program:

- Soil health data is collected, compiled, and analyzed by The Soil Resource Group (SRG) located in Guelph, Ontario. SRG plays an instrumental role working directly with ONFARM cooperators to organize and execute the soil health trials, and collect soil health data for the edge-of-field sites.
- Three partnering Conservation Authorities (CAs) implement the edge-of-field monitoring component of ONFARM. They collect key water quality, water quantity, and land-use data to achieve the program objectives. CAs also provide technical advice and work directly with cooperators to carry out ONFARM outreach activities. Partnering CAs include: Ausable Bayfield Conservation Authority (ABCA), Lower Thames Valley Conservation Authority (LTVCA), and Upper Thames River Conservation Authority (UTRCA).
- Representatives from Agriculture and Agri-Food Canada (AAFC), Environment and Climate Change Canada (ECCC), and OMAFRA who sit on the ONFARM Technical Working Group and provide valuable input on several technical aspects of the program, such as data management and collection.
- OSCIA would like to highlight the critical role of the participating ONFARM Cooperators in accommodating the research program’s objectives on their respective farms. ONFARM is an applied research program that is being implemented on working farms across the province. ONFARM would not be possible without the dedication of cooperating farmers and the agricultural community.

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1.0 Introduction

The On-Farm Applied Research and Monitoring (ONFARM) program is a nine-year applied research initiative that supports soil health and water quality research on farms across Ontario.

The program is currently funded by the Sustainable Canadian Agricultural Partnership, a five-year federal-provincial-territorial initiative. Developed by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and delivered by the Ontario Soil and Crop Improvement Association (OSCIA), ONFARM builds on work accomplished under the Great Lakes Agricultural Stewardship Initiative's (GLASI) Priority Sub-watershed Project with an expanded emphasis on soil health. The program encompasses a range of activities, including rigorous monitoring of soil health and water quality on working farms across the province and examining the effectiveness of different agricultural best management practices (BMPs) through paired trials and how they impact soil health, water quality and productivity.

ONFARM has three primary objectives:

1. Evaluate soil health indicators and test BMPs through continued paired plot trials at sites across Ontario.
2. Study impacts of BMPs on in-field soil-water dynamics and water quality.
3. Engage with farmers and stakeholders to transfer knowledge on BMP implementation and impact.

With the success of ONFARM's initial phase from 2019-2023, the program has recently been renewed for continuation through 2028.

The program's renewal will allow for the continued collection of critical data supporting BMP outcomes from the long-term soil health trial and edge-of-field water quality monitoring sites. This will enable a deeper understanding of the impacts of BMPs, such as cover cropping and organic amendment application, and the novel soil health indicators being tested.

Additionally, the program's extension aims to uncover insights into how these BMPs support good soil-water dynamics for crop resilience and learn more about how profitability and site-specific agronomy can support farmers' management decisions.

1.1 Organization Structure and Research Sites

ONFARM can be divided into three components based on the three pillars: Soil Health, Water Quality, and Outreach and Engagement. OSCIA administers all components and the Soil Health and Water Quality activities are guided by the ONFARM Technical Working Group. Established in 2019, the Technical Working Group acts as a scientific advisory committee. The Technical Working Group supported the selection of sites and BMPs for the soil health trials and provides guidance to ensure best practices for data collection, analysis, and reporting across the program. The Technical Working Group includes members from the following organizations:

- Ontario Soil and Crop Improvement Association (OSCIA)
- Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
- The Soil Resource Group (SRG)
- Ausable Bayfield Conservation Authority (ABCA)
- Lower Thames Valley Conservation Authority (LTVCA)
- Upper Thames River Conservation Authority (UTRCA)
- Agriculture and Agri-Food Canada (AAFC)

In addition to their roles in the Technical Work Group, SRG and the CAs play an instrumental role in collecting ONFARM soil and water data. SRG is responsible for carrying out activities in the soil health component and partnering CAs are responsible for carrying out the edge-of-field water quality component.

The ONFARM program is being implemented on working farms across the province in collaboration with partner organizations and cooperating farmers. In the next phase of ONFARM there will be 32 research sites (Figure 1). Each research site is owned and operated by an agricultural producer who has agreed to work with researchers to manage the field plots where trials are conducted. There will be 25 Soil Health sites. 22 sites of these are being continued and three new sites will be added, including two new sites in northern Ontario. The other seven sites are Edge of Field (EOF) water quality monitoring stations.

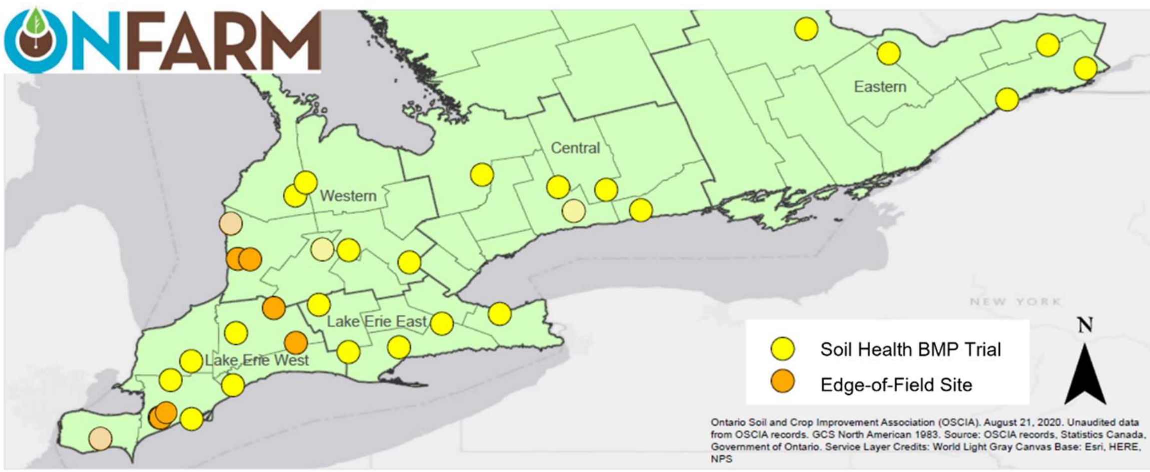

Figure 1. Locations of ONFARM Soil Heath BMP Trial (yellow) and Edge-of-Field Sites (orange).

1.2 Edge-of-Field Technical Report Overview

The objective of the Edge-of-Field (EOF) Technical Report is to describe the edge-of-field research sites, summarize lessons learned and layout next steps for the program. Technical reports for ONFARM are released annually. All previous technical reports can be found on the ONFARM Web Page.

2.0 Water Quality Monitoring and Best Management Practices (BMP) Assessments

In this next phase of ONFARM the water quality monitoring component will focus on evaluating BMP effectiveness at EOF sites. EOF monitoring will be conducted at 7 sites. Six of the sites are being continued from the first phase of ONFARM and one site is being added to the ONFARM program. Each site captures tile and/or surface runoff as runoff exits the field. Together the sites are being used to evaluate several BMPs, including, cover crops, reduced tillage, nutrient application and drainage BMPs.

2.1 Edge-of-Field Site Overview

Collection of data at the EOF scale began at different times, some monitoring locations were established through other programs and have collected up to a decade of water quality data, whereas other EOF sites were established in either 2016 through Great Lakes Agricultural Stewardship Initiative's (GLASI) or in 2019 directly through ONFARM. Each EOF site and monitoring location collects a large variety of monitoring parameters which are detailed in Table 1.

Monitoring includes surface runoff flow and water quality, and where possible, subsurface (tile drainage) flow and water quality at most sites. This monitoring is visualized in the conceptual diagram shown in Figure 2. Overland flow patterns were assessed at site establishment to ensure all flow leaving a sub-watershed within the field area was directed through flumes or water control basins. Monitoring the rate of flow and the depth of water allowed for the calculation of discharge at any given time. Similarly, sensors in the tile drain captured subsurface flow rates. ISCO water samplers were used to collect samples for water quality analysis at regular intervals when triggered by the flow sensorsFigure 4. Visual assessment of variations in water quality following a sampling event, demonstrating baseline [Left], rising flow [Middle Left], peak flow [Middle], and descending limb of flow [Right].Figure 4. Figure 3 shows the inside of one of the water quality monitoring stations with this equipment in place. Figure 4 shows the visual variation in water quality following a sampling event at Merlin B.

Table 1. Examples of data collected at each EOF location.

Data Collected	Examples
Weather	Rainfall, snowfall, snowpack, temperature
Hydrologic layers	Stream/water body layer, municipal drainage layer (open and closed), tile surface inlet locations, subsurface tile drainage layer
Land use layers	Non-agricultural land use boundaries, land-based BMP layer (Water and Sediment Control Basins, buffer, etc.), field boundaries, agricultural land use by field
Field/soil characteristics	Soil phosphorus (P) and potassium (K) test, potentially mineralizable nitrogen (N), soil organic matter, soil aggregate stability, bulk density, infiltration
Field activities information	Fertilizer application, manure application, tillage, surface residue cover, planting, point discharges
Water quantity	Stream flow
Stream water quality	Total suspended solids, total P, dissolved reactive P, total organic P, total N, nitrate-N, ammonia-N, organic-N

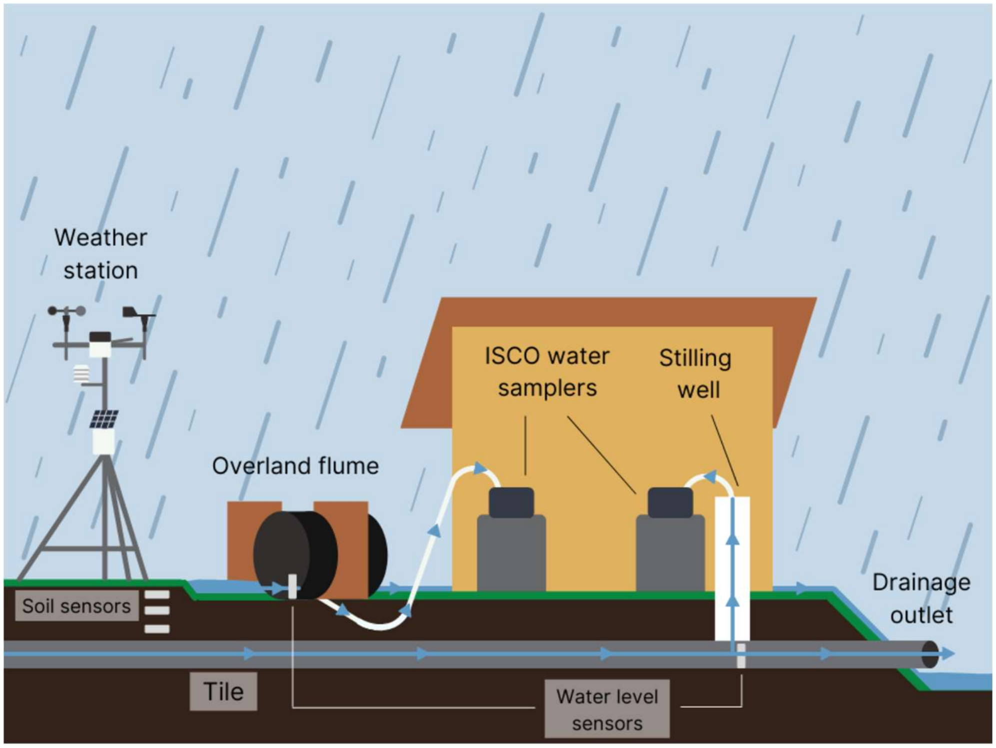

Figure 2. Conceptual diagram of an Edge of Field (EOF) monitoring station.Sensors capture weather, soil, and water level data, and water movement triggers automatic collection of water samples from overland flow or tile drains.

Figure 3. The inside of a water monitoring station established by UTRCA

Figure 4. Visual assessment of variations in water quality following a sampling event, demonstrating baseline [Left], rising flow [Middle Left], peak flow [Middle], and descending limb of flow [Right].

Conservation Authority (CA) staff collected data and entered the results into the Water Information System by Kisters (WISKI) database for long-term storage and analysis. The WISKI database is well suited for time-series data, such as the water discharge, and using WISKI has enhanced the management and reporting of ONFARM data.

Monitoring is being conducted at seven sites; some of the sites have multiple treatments or plots being monitored. Table 3provides an overview of the sites, including treatments, flow paths being monitored, and if water quality and quantity are being captured.

There are seven fields where all flow pathways are captured, either separately or in a combined outlet, and can be used to estimate total field discharge, sediment and nutrient losses. There are four fields where both tile and surface pathways are captured independently. These fields can be used to understand the role of different transport pathways. At these sites, field totals, of runoff, sediment and nutrients, are calculated by adding surface and tile totals together. There are three fields where an outlet that combines tile and surface runoff is monitored. Capturing both flow paths is not possible in all fields for various reasons. There are six fields where tile is the only flow path measured, and two where only surface is measured. In addition, surface runoff from an untitled field and a wooded (untiled) area are also captured. In total, tile runoff is being monitored at ten fields, and surface runoff at seven fields (not including the woodlot). The long-term dataset from these sites will allow for in depth analysis of paired BMP trials, but also across sites.

Table 2. Summary of edge-of-field sites, treatments, and flow paths.

CA	Site	Treatment	Tile Monitoring	Surface Monitoring	Combined Tile and Surface	Site Total	Water Quality and Quantity?
LTVCA	Merlin A	Conventional	X	X		Addition	Yes
	Merlin B	No-till and cover crop	X	X		Addition	Yes
	Fairview	Manure application	X			Tile Only	Yes
UTRCA	Upper Medway - CD1	Control drainage	X			Tile Only	Yes
	Upper Medway - CD2	Control drainage	X			Tile Only	Yes
	Upper Medway - FD	Free drainage	X			Tile Only	Yes
	North Kettle - EOFN	Cover crop			x	Combined Outlet	Yes
	North Kettle - EOFS	No cover crop			x	Combined Outlet	Yes
ABCA	Gully-DFTEL3	Cover crop		X		Surface Only	Yes
	Gully-DFTEL5	No cover crop		X		Surface Only	Yes
	Gully-DFTILE	Field outlet			x	Combined Outlet	*Quantity Only, Historical Quality Data*
	Huronview Field A	Contour drainage	X	x		Addition	Yes
	Huronview Field B	Pattern drainage	X	x		Addition	Yes
	Huronview Tile 15’	Tile spacing 15’	X			*Tile Only*	*Quantity Only*
	Huronview Tile 30’	Tile spacing 30’	X			*Tile Only*	*Quantity Only*
	Huronview Field D	Untiled field		X		*Surface*	*Quantity Only*
	Huronview Woods	Natural area		X		Surface	Yes

2.2 Edge-of-Field BMP Trials

Table 3 lists the BMP trials that have been planned, the associated sites and flow pathways that are being monitored.

Table 3. Summary of BMP Trials, associated sites and flow paths being monitored.

BMP Trials	Site	Pathways
Tillage (Conventional vs No-Till)	Merlin A and B	Tile and Surface
Manure Application	Fairview	Tile
Cover Crops vs None	North Kettle	Combined
Cover Crops vs None	Gully	Surface
Controlled vs Free	Upper Medway	Tile
Contour Controlled vs Free	Huronview	Tile and Surface
Tile Spacing 15' vs 30'	Huronview	*Tile*
vs Wooded	Huronview	Surface
vs Untiled	Huronview	*Surface*

2.3 Edge-of-Field Site Descriptions

2.3.1 Merlin A and B

The two Merlin sites (Merlin A and Merlin B) neighbour each other and are both on clay soils with predominantly flat landscapes. The fields have opposing management characteristics which can provide great insight to varying management practices and their effect on water quality (Table 4).

Table 4. Field and management characteristics at the Merlin A and Merlin B sites.

Site	Field Size	Tillage	BMPs	2023 Crop
Merlin A	50 Acres	Conventional Tillage	No Cover Crop	Soybeans
Merlin B	90 Acres	No-Till	Cover Crop	Corn

Consistant monitoring set ups are used for each site. Each site contains two tile sampling locations, one flume for surface runoff, and one well depth monitoring site. There is some variation in the equipment used to measure depth, velocity, and flow (Table 5).

Table 5. Plots and equipment present at Merlin A and Merlin B.

	Merlin A		Merlin B	
Type of Sites	Site ID Name	Equipment	Site ID Name	Equipment
Tile Sites	Plot 2	1 ISCO 6712 sampler 1 Hach AV9000 Area Velocity Analyzer Module and submerged AV sensor 1 HOBO U20 water level logger in tile, 1 HOBO Barometric logger	Plot 1	1 ISCO 6712 sampler 1 Blue Siren AV sensor (eco siren model) 1 HOBO U20 water level logger in tile
	Plot 3	1 ISCO 6712 sampler, 1 Hach FL902 logger with HACH Flo-Tote 3 AV sensor (Issues with sensor - Not reliable AV data), 1 U20 level logger in tile	Plot 2	1 ISCO 6712 sampler 1 ISCO 750 Area Velocity Flow Module and AV sensor 1 HOBO U20 water level logger
Surface Flume Sites		1 ISCO 6712 sampler 1 HOBO U20 water level logger in flume	Plot 4	1 ISCO 6712 sampler - at flume for surface water samples 1 HOBO U20 water level logger in flume
Well Monitoring Sites		1 HOBO U20 water level logger in groundwater well		1 HOBO U20 water level logger in groundwater well

Recent improvements have been made to the site including installing a permanent structure to house an ISCO 6712 (Figure 5), as well as improved telemetry which will allow us to remotely monitor flow and to select sample bottles before getting to the field.

Figure 5. Merlin A's flume newly installed permanent enclosure with a solar panel.

2.3.2 Fairview

The Fairview site is located approximately 30 kilometers east of the Merlin A and B sites or 15 kilometers east of Chatham. The field is 100 acres, has high soil phosphorus levels, poorly drained soils, and drains into the Thames River. The Fairview site was previously used to test phosphorus absorbent materials and contains two tanks, and an inflow and outflow ISCOs (Figure 6).

Figure 6. Fairview site containing an inflow permanent ISCO enclosure with solar panel [Right], first tank [Right Middle], second tank [Left Middle], and outflow permanent ISCO enclosure with solar panel [Left].

Currently, only the inflow ISCO is being used to concentrate the study on the quality and quantity of tile runoff from a swine manure applicated field. This site allows for the assessment of how organic amendments can affect soil health, and biological, chemical and structural indicators. The equipment at this site is similar to the equipment at the Merlin A & B sites for tile monitoring. There is no well or flume monitoring at this site.

Table 6. Equipment located at the Fairview site.

Type of Site	Fairview
Inflow Tile Site	1 ISCO 6712 sampler 1 ISCO 750 Area Velocity Flow Module and AV sensor 1 ZL6 with a hydrosensor (Installed December 2023)

Recent improvements to the site include the installation of a ZL6 data logger and hydrosensor. The hydrosensor autocorrects for barometric pressure, which is more efficient than downloading two loggers and adjusting the data periodically. The ZL6 logger provides telemetry so that water levels can be monitored remotely.

2.3.3 Gully

Gully EOF (DFTILE EOF) was established in 2012 by ABCA. The overall catchment is 18 ha and outlet is monitored at the tile outlet. This larger catchment is further divided and monitored at three upstream WASCOB sites (DFTEL2, DFTEL3 and DFTEL5) with drainage areas between three and five ha (Figure 7). ABCA has used the data from these established sites to understand the relationship between vegetative cover and hydrologic conditions (flow/no flow). Since 2017, vertical till and no-till practices have replaced more conventional tillage practices. In ONFARM, the site is used to monitor the impact of cover crops, by establishing cover/no cover plots utilizing the WASCoBs as monitoring points.

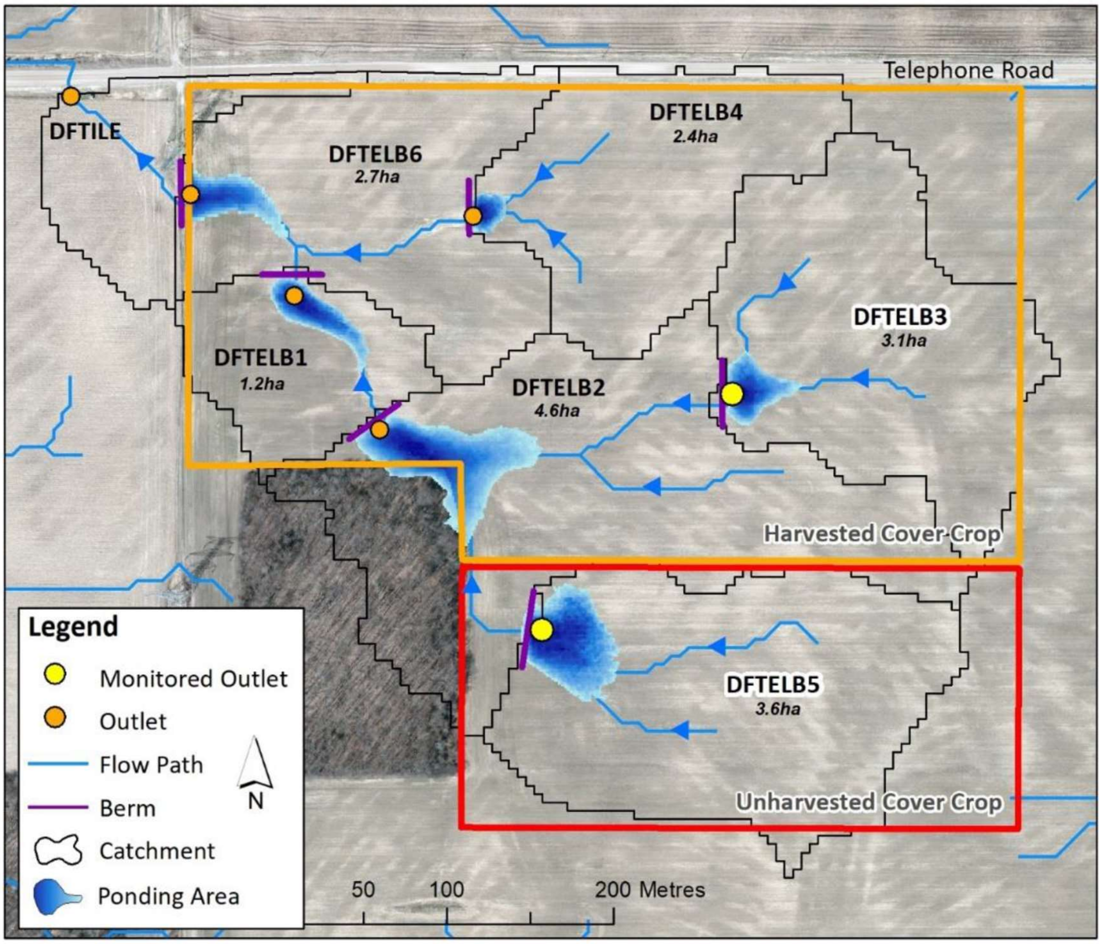

Figure 6. Map of Gully EOF (DFTILE EOF) site in the Gully Creek watershed. WASCoBs 2, 3, 5, were monitored for water quality from sub-basins within the field, and the tile outlet (top left) was monitored for water leaving the entire field.

2.3.4 Huronview

The Huronview Demonstration Farm is actively farmed by the Huron County Soil and Crop Improvement Association to demonstrate agricultural BMPs (particularly to inform management of tile drainage and its impact on water quality). The site has two permanent subsurface water quality monitoring stations located in Field A and Field B (Figure 7). There are four treatments of water management being measured:

i) no drainage; ii) wetland treatment of tile water; iii) systematic drainage (with a side comparison of 15’ and 30’ spacing); and, iv) contour drainage with control structures in the lateral lines.

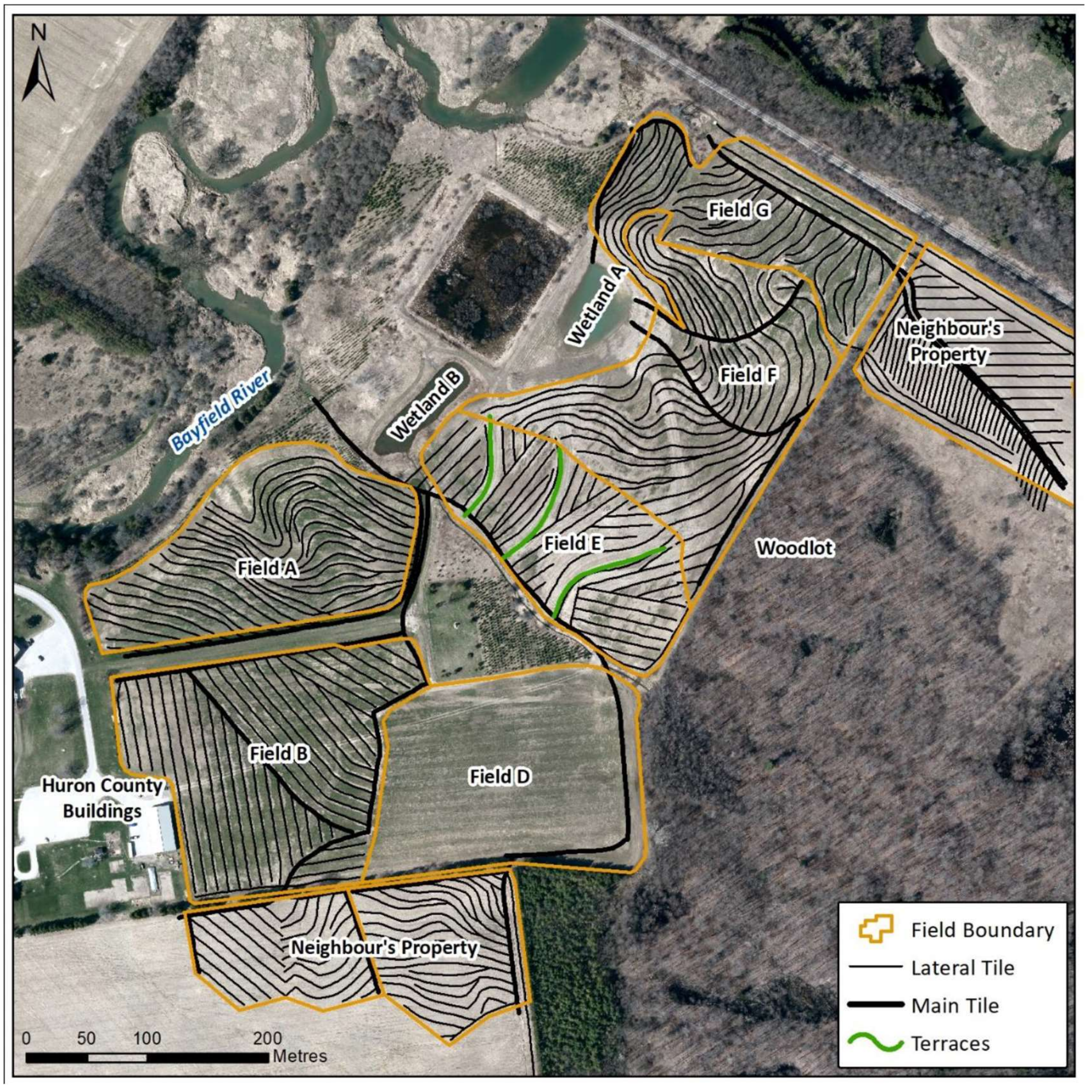

Figure 7. The Huronview Demonstration Farm, shown by field and drainage sub-basins with the various tile drain setups.

2.3.5 Upper Medway

Within the Upper Medway Creek subwatershed, data will be captured from a unique EOF site that has been monitored since 2015 by Agriculture Agri-Food Canada (AAFC). At the Controlled Drainage Site, tile runoff is sampled from two controlled drainage plots and one free drainage plot (Figure 8). This site is currently being monitored to show the impact of controlled drainage on water quality. There is an opportunity to demonstrate and compare the effects of stacking of BMPs in the future, such as the impact of cover crops and controlled drainage. This site is highly valuable to the Upper Medway project, given the long history of background data that has been collected here.

Figure 8. Upper Medway EOF Site.

2.3.6 North Kettle

In the North Kettle Creek subwatershed, an EOF station was constructed at a T-shaped berm that separates two distinct catchments in the field (Figure 10). Each side of the berm also has a separate surface inlet and tile outlet, allowing for different treatments to occur on either side. The North catchment serves as the experimental side, with a cover crop planted each fall, while the South catchment provides the control where no cover crop is planted (Figure 11).

Figure 9. Photo of T-shaped berm separating the two monitored catchments at the North Kettle EOF.

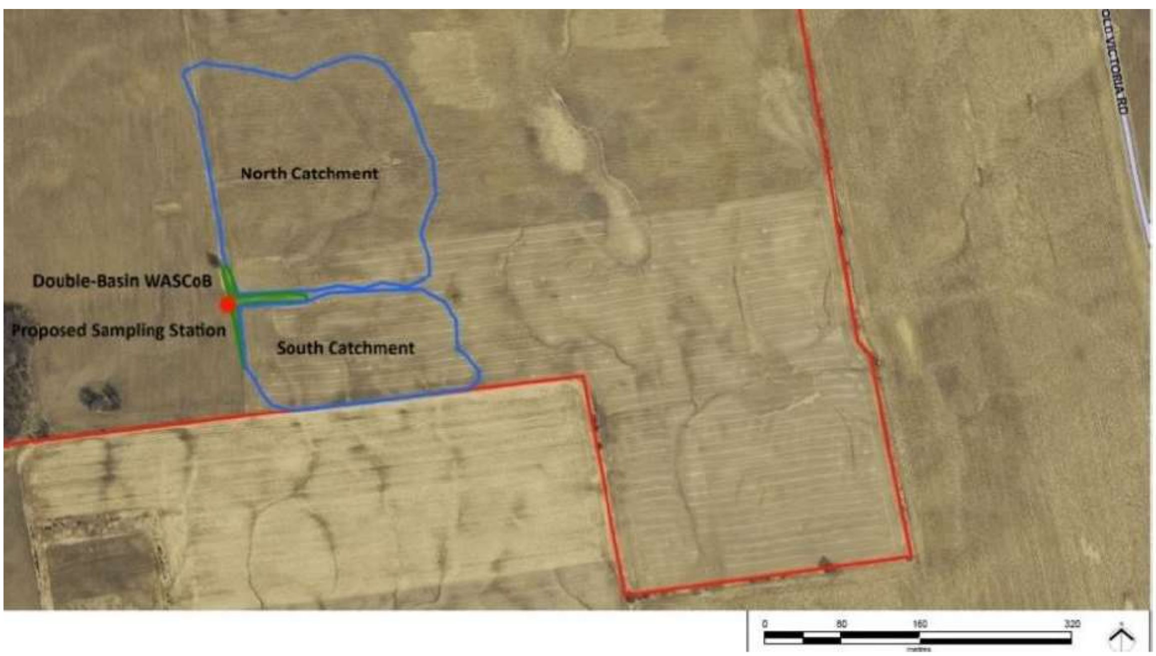

Figure 10. Site map showing the layout at the North Kettle EOF.

3.0 Lessons Learned

The section summarizes some of the key lessons learned from the monitoring program to date, and the questions that remain.

3.1 Overwinter Cover

Overwinter cover trials have been established at North Kettle and Gully edge-of-field sites. Both sites are able to capture cover vs no cover treatments. Additionally, overwinter conditions are monitored across all sites to capture differences between years.

The results from EOF monitoring have shown that increasing over winter cover, both living or dead, can reduce the occurrence of runoff and nutrient concentrations, leading to lower losses overall. Figures 12-14 show that at Huronview concentrations of suspended sediment, phosphorus and nitrate were lower when there were higher levels of overwinter cover. However, there has been variability in water quality benefits and crop performance at the sites, which warrants further investigation. The amount of surface residue matters in-terms of the water quality impact, as well as for crop performance. In years with less residue cover due to poor cover crop establishment, the benefits were not significant from a water quality perspective, as was observed at the North Kettle EOF site (Figure 14 and Figure 15). From the agronomic perspective, there have also been circumstances where the management of cover crop residue led to notable differences in crop performance. At Huronview, high cover crop residue led to lower nutrient concentrations in runoff through the winter. However, the high residue led to a poor crop of no-till soybeans the following growing season relative to where the same residue had been sprayed and strip-tilled. This highlights that there is more to learn to optimize overwinter cover to achieve environmental and production benefits. The plan for this next phase of ONFARM is to continue to evaluate the effectiveness of overwinter cover. An emphasis will be put on documenting conditions that may lead to increased water quality benefits and crop performance.

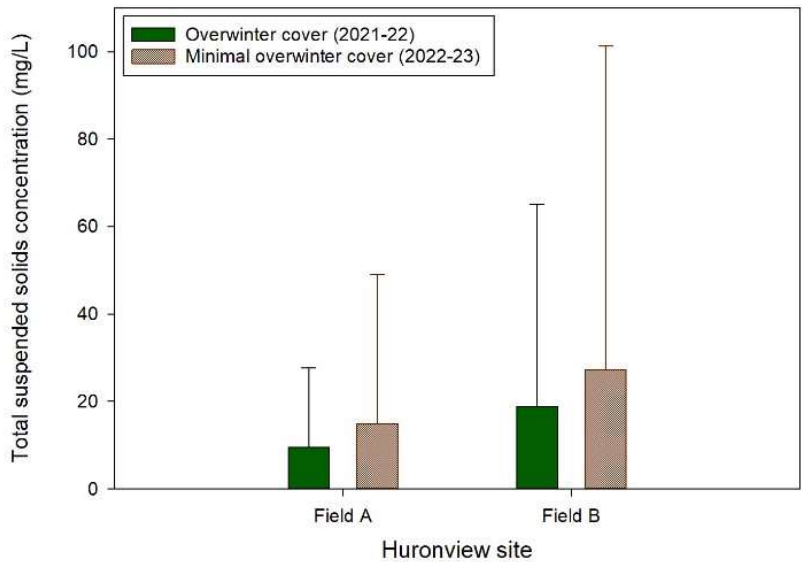

Figure 11. Total suspended solid concentrations at Huronview Fields A and B.

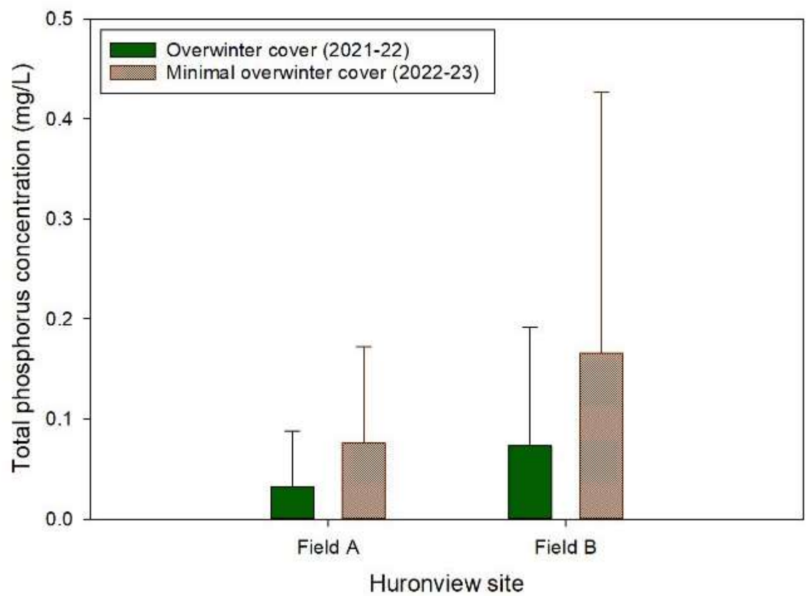

Figure 12.Total phosphorus concentrations at Huronview Fields A and B.

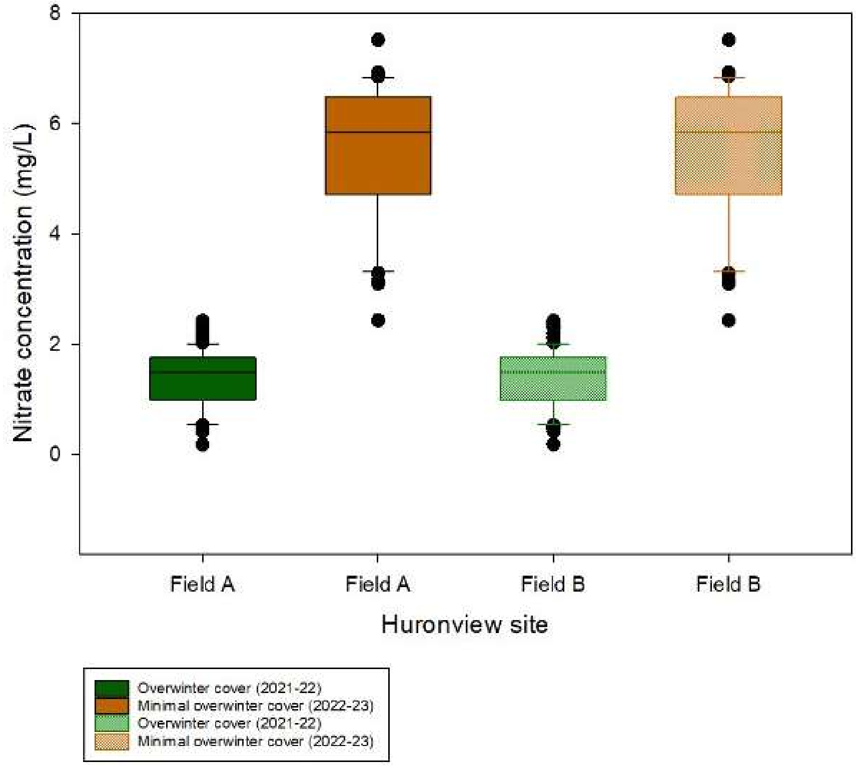

Figure 13.Nitrate concentrations at Huronview Fields A and B.

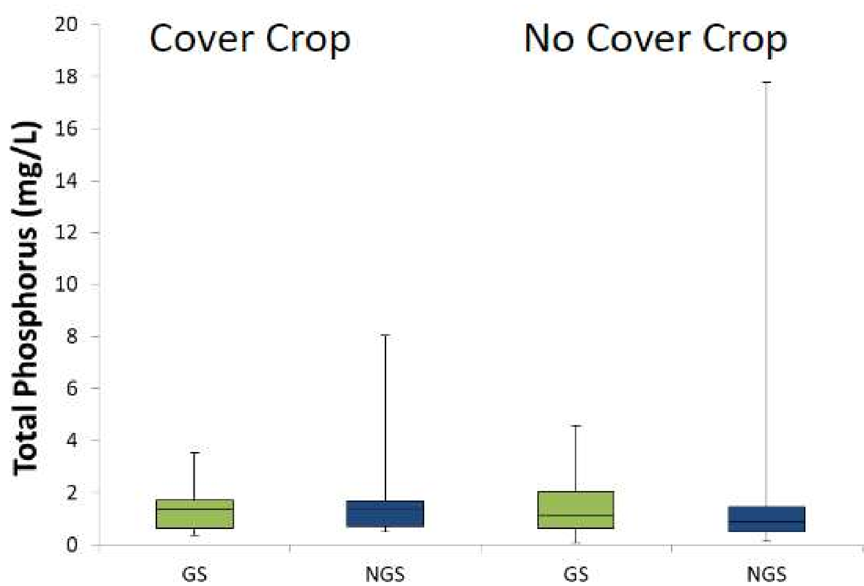

Figure 14. Total phosphorus concentrations at the North Kettle EoF Site

Figure 15. Visual of cover crop establishment relative to no cover crop plot at North Kettle EoF.

3.2 Nutrient Management

There are no paired trials within ONFARM that are set up to evaluate water quality impacts of nutrient applications. Still, there have been notable high loss events that were directly related to nutrient applications at the sites. In previous years there have been significant nutrient losses when fertilizer or manure applications were followed by heavy rains or melts. Elevated total phosphorus concentrations and losses were observed at the Garvey-Glenn EOF site following manure application in late October (Figure 16). Three years later manure was applied to the field again, but during the drier period in August when no runoff was generated. Adjusting the timing of the application at this site measurably reduced losses. A similar occurrence was observed at the Huronview Site when a fall application of phosphorus (P) fertilizer was followed by heavy rains and resulted in significantly higher TP losses. These high runoff events can happen any time of the year but have been more common during the non-growing season during the ONFARM trials. The Fairview site has been added because it offers an opportunity to evaluate manure application practices.

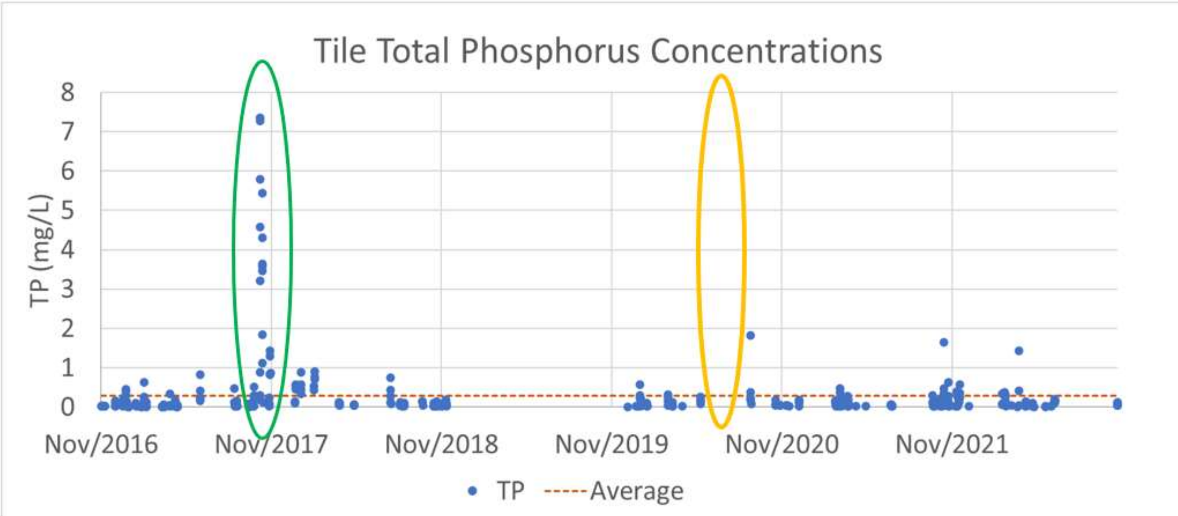

Figure 16. Total phosphorus concentrations in tile runoff at the Garvey-Glenn EoF. The green oval indicates a fall manure application, and the yellow oval indicates a summer application.

3.3 Tillage

Merlin A and B provide the opportunity to compare different tillage systems. These sites have shown that aggressive tillage can lead to higher Particulate Phosphorous (PP) and Total Phosphorous (TP) losses. The comparison of systems has also highlighted the risks associated with surface broadcast applications of fertilizers. In the no-till system, (Merlin B), phosphorus is applied on the surface and not incorporated. It was observed that when these surface applications are followed by heavy rains, it can lead to elevated losses. There were no periods of elevated losses following phosphorus application in the more aggressive tillage system, where phosphorus fertilizer is always incorporated with tillage. In future years we will evaluate if adjustments to timing, or placement of fertilizer applications in the no-till system can reduce incidence of these fertilizer related losses.

3.4 Controlled Drainage

Controlled tile drainage systems are being evaluated at Upper Medway and Huronview. These systems allow an operator to back up water in the tiles by inserting gates into a control box. The gates can be added or removed to adjust the water level in the field, or removed completely to allow for free drainage. At Upper Medway, using the controlled drainage system reduced the runoff volume measured at the outlet, and the reduction in runoff volume led to reduced nutrient losses. At Huronview, the trial is evaluating contour-controlled drainage. More time is required to understand tile flow during high runoff events at the Huronview site. New sensors are being installed to measure both depth and velocity in tiles to better understand flow rate during periods where tiles are full but may not be flowing. Several high runoff events will need to be captured before tile flow will be finalized.

4. Next Steps

4.1 QA/QC Protocols

In 2024 the CA's will develop new guidelines for data collection and analysis. These protocols will be incorporated into the data management plan as part of the annual review. The guidelines will ensure that all data goes through similar quality control procedures at each CA. Guidelines will also ensure that event and field conditions are consistently documented, which will allow for further comparisons across sites. Field conditions, such as presence/absence of snow cover during events, or residue cover, can influence runoff and nutrient losses measured at the sites. It is important that this data be documented using consistent protocols, as it helps to explain differences observed between the sites.

5.0 Conclusion

The continued monitoring at the EOF sites will contribute to a valuable long-term dataset, that will provide insight into the water quality impacts of soil health BMPs on real working farms in Ontario. The sites have already provided valuable lessons, but continuing the monitoring provides the opportunity to dig deeper into remaining questions, providing more confidence in BMP recommendations and the impact of stacked approaches. The focus at the EOF sites during the next phase of ONFARM is to better understand the trade-offs that arise when adopting BMPs, to help optimize these systems on real working farms.

To stay up-to-date on ONFARM activities, and to view past reports, please visit the ONFARM Web Page.