Evaluating Best Management Practices at the Field Scale for the Watershed Based Best Management Practices Evaluation, Huron

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The above photograph shows a device designed to collect samples in a concentrated flow path through which surface water runoff flows into a ponding area (visible in the distance) behind a Water and Sediment Control Basin.

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1.0 Introduction

A key objective of the Watershed Based Best Management Practices Evaluation (WBBE), Huron, was to evaluate the effects of best management practices (BMPs) at the field scale, particularly in relation to water quality. Many different BMPs have been implemented or identified for future implementation within the WBBE study area. (Please refer to the Appendix for a list of BMPs.) Four BMPs that are common in this area were chosen for evaluation at the field scale: conservation tillage, cover crop, nutrient management, and Water and Sediment Control Basins (WASCoBs). An opportunity to evaluate a fifth BMP – a grass filter strip – arose during the course of the project. These BMPs were assessed for their environmental effectiveness, and in some cases, their economic effectiveness for the producer.

2.0 Conservation Tillage

Conservation tillage is a generic term that refers to a wide range of tillage practices that intentionally leave higher amounts of crop residue on the field surface. Research has shown that maintaining a minimum of 30 per cent ground cover is critical to protecting soil from wind and water erosion (Stewart, 2012). A best practice goal is to keep the soil covered with at least 30 per cent plant cover (dead or alive) throughout the year. In 2011, conservation tillage (including no-till) was practised on 72 per cent of the agricultural land in the Gully Creek watershed (Gutteridge *et al.* 2013), but there are still some landowners who prefer to use conventional tillage methods (*e.g.*, fall mouldboard plough), which minimize the amount of residue cover left on the field, especially during the non-growing season of the year.

Water quality monitoring was set up at fields in the Gully Creek watershed with conservation tillage and conventional tillage practices to assess the impact of conservation tillage on sediment and nutrient concentrations during runoff events.

2.1 Methods

A site-specific comparison was planned for evaluating tillage practices on two neighbouring fields. Landowner G11 typically practises conservation tillage (no-till), while landowner G19 typically practises conventional tillage, and it was thought that both fields would be planted in corn in 2011 (Table 2.1, Figure 2.1). After water quality monitoring began at these locations, it became apparent that the crops were not consistent between the two tillage types: soybeans were planted on the G11 property (conservation tillage) and corn was planted on the G19 property (conventional tillage). Tillage practices could therefore not be compared between these two fields. In 2012, arrangements were made with landowner G16, who practises conservation tillage, to monitor runoff water quality on one of his fields, which was planted with the same crop as the G19 property (conventional tillage). However, landowner G19 ended up using conservation tillage, eliminating the opportunity to compare conservation and conventional tillage. Since plans for comparing these two tillage practices were foiled by crop rotation or landowner crop management decisions, no results are available for this BMP.

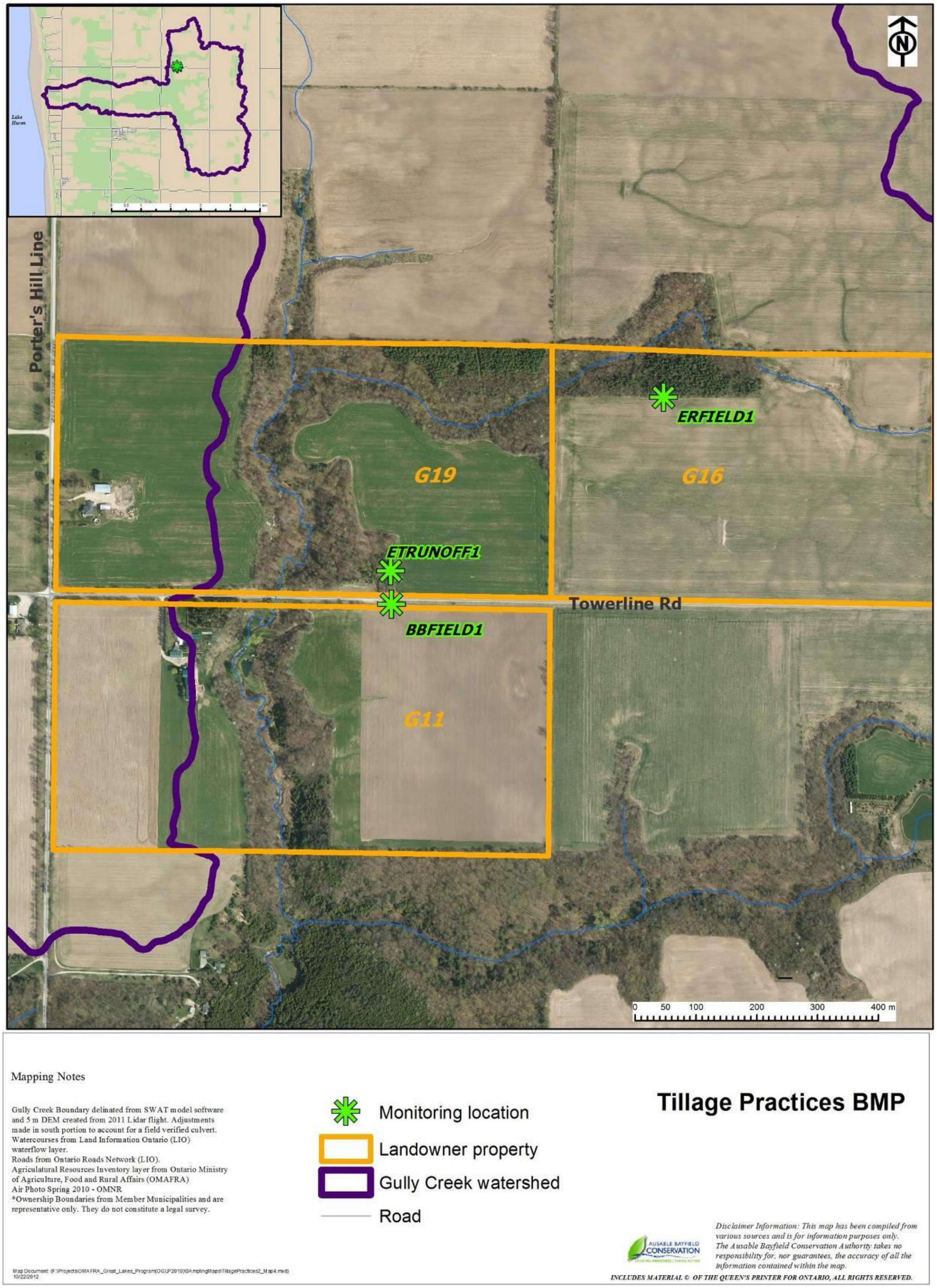

Figure 2.1: Monitoring stations for evaluating tillage practices at the G11, G19, and G16 properties in the Gully Creek watershed.

Table 2.1: Monitoring stations for evaluating tillage practices at the G11, G19, and G16 properties in the Gully Creek watershed.

Landowner	Site Code	UTM Coordinates		Location Description
		Easting	Northing	
G11	BBFIELD1	446963.88	4830327.45	North edge of field on south side of Tower Line Road
G19	ETRUNOFF1	446963.03	4830382.38	Runoff from west edge of field on north side of Tower Line Road
G16	ERFIELD1	447411.55	4830666.81	North edge of field on north side of Tower Line Road

2.2 Next Steps

An opportunity to monitor the environmental and economic effects of using conservation tillage instead of conventional tillage should continue to be sought out in the study area. In interpreting the results, it is important to consider the history of crop management on these fields. In the future, a long-term comparison of nutrient concentrations (both dissolved and particulate) in runoff from multiple fields using different cropping systems will help to develop BMPs that are effective in reducing nutrient release from fields.

3.0 Cover Crop

Cover crops have been encouraged in the study area, since they have many positive effects, including reducing surface erosion on bare fields, increasing soil organic matter levels, and improving overall soil health. Some cover crop types also have the potential to increase the soil nitrogen concentration. Producers often plant cover crops so that they grow together with the main crop, such as a red clover cover crop seeded into winter wheat. Red clover fixes nitrogen from the air and, as the clover plant decays, it supplies nitrogen to the soil for use by the subsequent corn crop. Cover crops might also be employed after harvest, between main crops, to either add or immobilize readily available nitrogen in the soil (depending on the type of cover crop) and to protect the soil.

Soil nitrate and yield monitoring was planned for two locations, within or near the Ridgeway Drain watershed, to compare plots with and without legume cover crops prior to a corn crop. Water quality monitoring was also set up at one location. Monitoring was intended to provide information on soil nitrate concentrations throughout the corn crop year, and on sediment and nutrient concentrations during runoff events.

3.1 Methods

3.1.1 Trial 1

On the R1A property (45 acres) in the Ridgeway Drain watershed, a legume cover crop (Austrian pea) was seeded in late September 2011, following an earlier winter wheat harvest. Across the road on the R7 property (18 acres), no cover crop was planted after a wheat harvest. Both properties were to be planted with corn in 2012. Most of the R1A field was turbo-tilled in the fall, but two plots (0.8 acres and 0.5 acres in size) were left untilled with an intact cover crop. Monitoring locations that differed in terms of cover crop presence, cover crop management (intact versus fall-tilled), and soil texture (clay versus sand dominant) (Table 3.1, Figure 3.1) were identified for comparison of soil nitrate concentrations and runoff water quality.

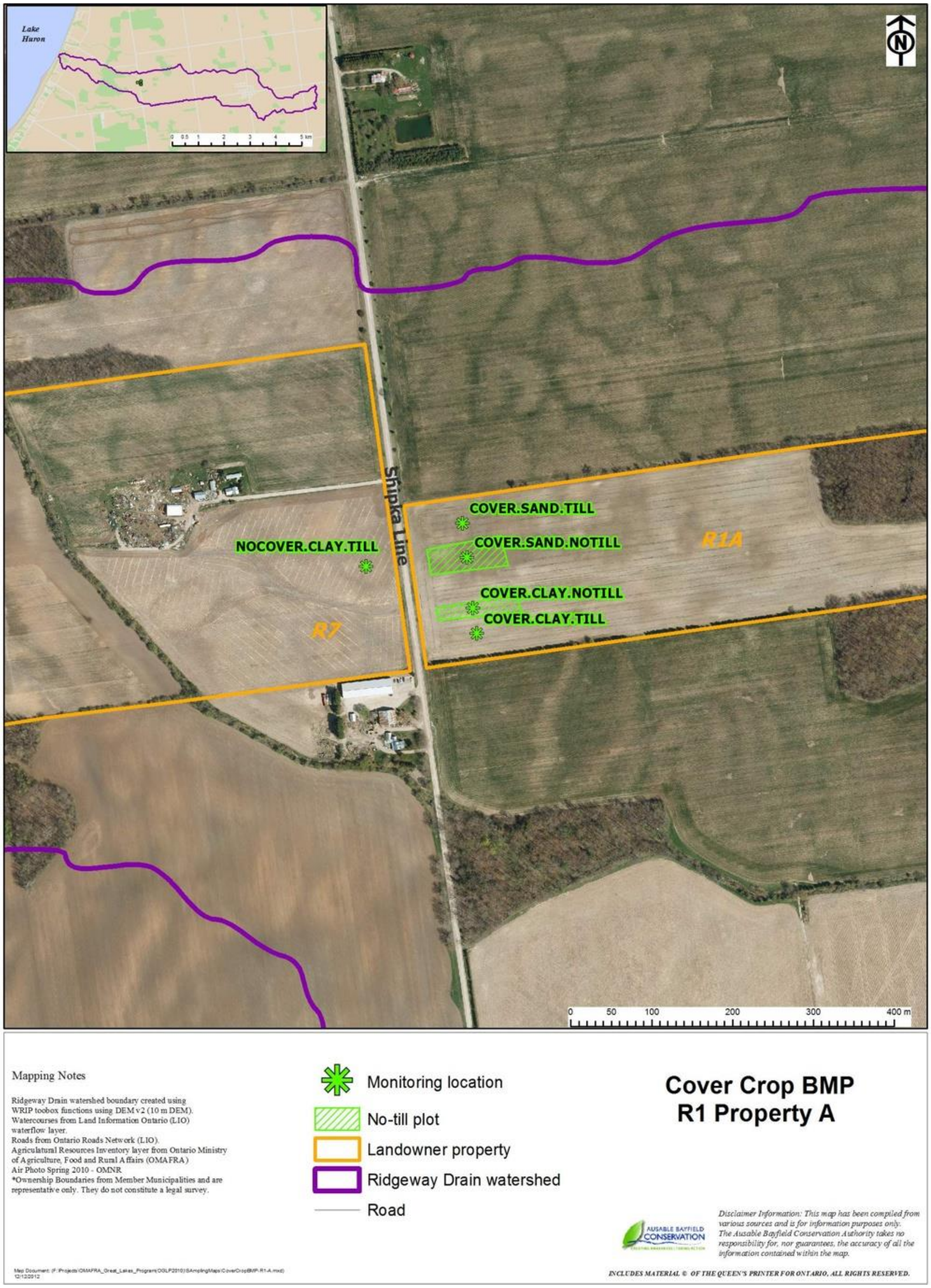

Figure 3.1: Plots for evaluating a legume cover crop at the R1A and R7 properties in the Ridgeway Drain watershed.

Table 3.1: Plots for evaluating a legume cover crop at the R1A and R7 properties in the Ridgeway Drain watershed.

Landowner	Plot	Dominant Soil Texture	Tillage
R1A	COVER.CLAY.NOTILL	Clay	None
	COVER.CLAY.TILL	Clay	Fall-tilled (turbo)
	COVER.SAND.NOTILL	Sand	None
	COVER.SAND.TILL	Sand	Fall-tilled (turbo)
R7	NOCOVER.CLAY.TILL	Clay	Fall-tilled (mouldboard)

A composite soil sample was collected with a hand probe from each of the monitoring locations. The sampling protocol followed the sampling guidelines for the Pre-Sidedress Nitrogen Test (PSNT), but deviated in terms of the timing. Soil sampling took place in early spring (March 2012) to determine soil nitrogen concentrations before corn was planted on the plots and was planned again for early summer (June 2012), when the corn would be 15 to 30 centimetres in height (as per standard PSNT methods).

Low rainfall levels in 2012 and the low slope of the landscape in this area of the watershed made it impossible to capture surface runoff during natural rainfall events. A rainfall simulation experiment was therefore designed to produce surface runoff from each plot. A sprayer unit was mounted on a garden tractor, with a pump providing pressure and a tank providing a water reservoir (Plate 3.1). The unit was calibrated to spray 2.5 litres of water per minute on a one-square-metre quadrat so that a five-centimetre rainfall event could be simulated over a twenty-minute period. The experiment was run in March 2012 to simulate a heavy spring rainfall event and capture samples of surface water runoff from the various plots. The water samples were to be analyzed for nutrient and suspended sediment concentrations, which would provide information on nutrient and soil losses through surface runoff.

Plate 3.1: Rainfall simulation set-up on a plot with no cover crop (left) and a plot with an intact cover crop (right) in the Ridgeway Drain watershed.

3.1.2 Trial 2

The R1B property, north of the Ridgeway Drain watershed, was also seeded with a legume cover crop (Austrian pea) in late September 2011, following an earlier winter wheat harvest. The cover crop was turbo-tilled in late November 2011, in preparation for a corn crop to be planted the following spring. A 0.7-acre plot within this 84-acre field was left without a cover crop in order to compare its soil nitrate concentration and yield with a 0.7-acre plot that had the cover crop (Figure 3.2).

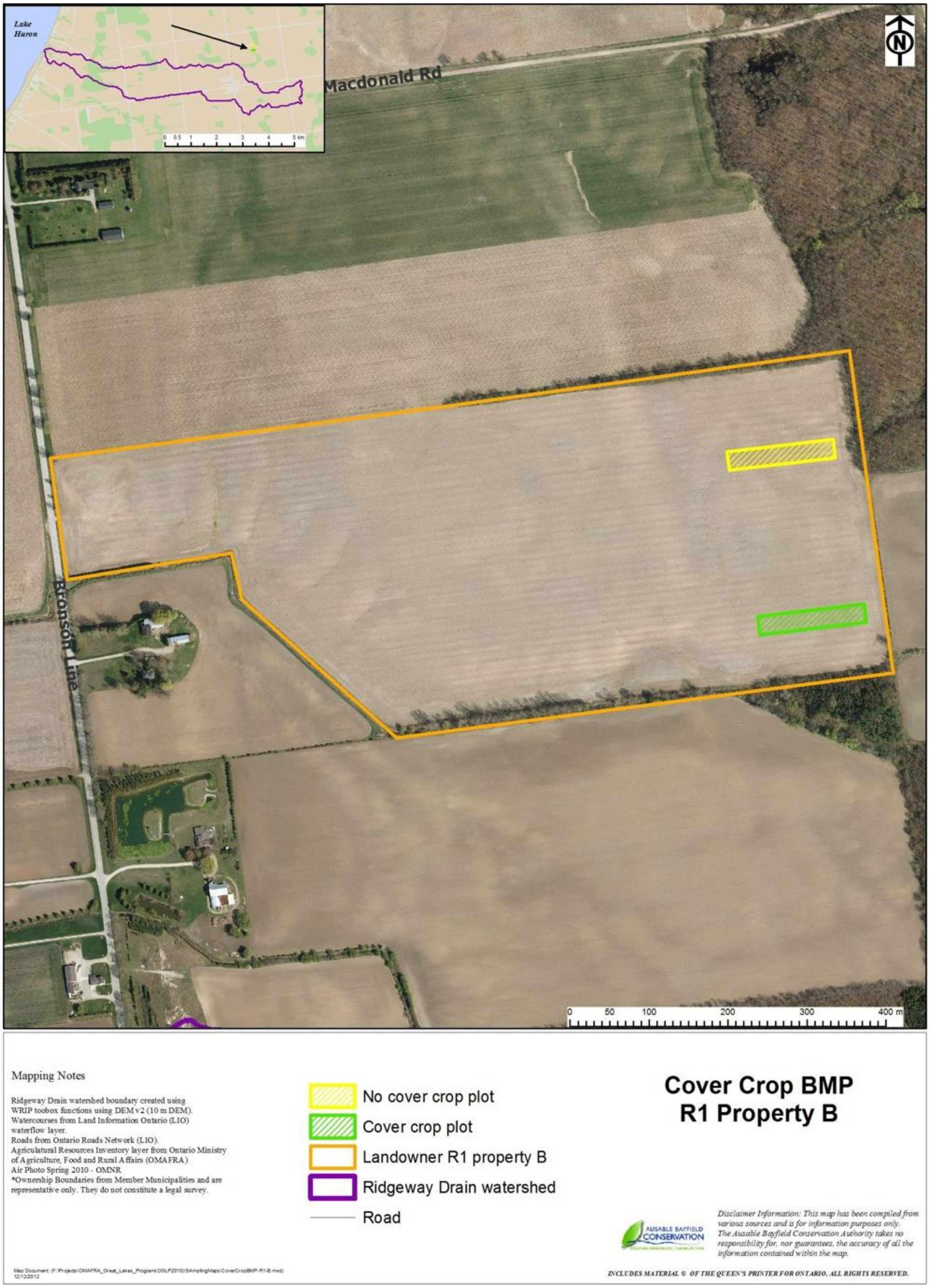

Figure 3.2: Plots for evaluating a legume cover crop at the R1B property north of the Ridgeway Drain watershed.

Composite soil samples were collected with a hand probe from both plots. The sampling protocol followed the sampling guidelines for the Pre-Sidedress Nitrogen Test (PSNT), but deviated in terms of the timing. Soil nitrate sampling took place in April 2012 (before the corn crop was planted), June 2012 (when the corn crop was 15 to 30 centimetres in height), and November 2012 (after the corn crop was harvested). Since the plots were uniform in terms of slope and soil texture, the sample from each plot (cover crop and no cover crop) was a composite of ten soil cores collected from random locations throughout the plot. The cores were collected with a hand probe from the top 30 centimetres of soil, following the sampling guidelines for the PSNT.

Crop yield from the plot with a cover crop was measured by using a Pioneer weigh wagon to determine the bushels of corn harvested from a known area of the field. Yield from the plot without a cover crop was determined from the combine's yield monitor data, which is likely less accurate than the weigh wagon.

3.2 Results

3.2.1 Trial 1

Soil samples collected from the R1A and R7 properties in March 2012 indicated that nitrate was consistently low and did not differ much in relation to cover crop presence, cover crop management, or soil texture (Table 3.2). Corn, which could benefit from the nitrogen-fixing ability of the pea cover crop, was to be planted on both properties. Circumstances changed for landowner R1, however, and soybeans were planted instead of corn on the R1A field. A nitrogen-fixing cover crop does not offer a benefit to soybeans, which also fix nitrogen, so this change in crop rendered further soil sampling unhelpful.

Table 3.2: Soil nitrate concentrations in March 2012 from plots for evaluating a legume cover crop at the R1A and R7 properties in the Ridgeway Drain watershed.

Landowner	Plot	Nitrate (parts per million)
R1A	COVER.CLAY.NOTILL	9
	COVER.CLAY.TILL	8
	COVER.SAND.NOTILL	6
	COVER.SAND.TILL	6
R7	NOCOVER.CLAY.TILL	9

Dry antecedent soil conditions and the low slope of the landscape on these fields thwarted attempts at collecting water samples during simulated rainfall events.

3.2.2 Trial 2

Soil samples collected from the R1B property in April and June 2012 showed that the plot with a legume cover crop had a higher soil nitrate concentration than the plot without a cover crop, both before corn had been planted and when the corn was 15 to 30 centimetres high (Table 3.3). After the corn had been harvested, soil samples collected in November 2012 were considerably lower than earlier in the season, with little difference between the two plots.

Table 3.3: Soil nitrate concentrations in April, June, and November 2012, and corn crop yield, from plots for evaluating a legume cover crop at the R1B property north of the Ridgeway Drain watershed.

Plot	Nitrate (parts per million)			Yield
	Apr	Jun	Nov	(bushels per acre)
Cover Crop	23	68	4	211.9
No Cover Crop	17	52	6	188.1

The corn crop yield from the plot with the legume cover crop was 13 per cent higher than the yield from the plot without the cover crop (Table 3.3). A few factors other than the cover crop may have contributed to this discrepancy in yield between the two plots. The plots differed in terms of the corn hybrid planted and the method for determining yield. The soil type may also have differed slightly between the plots, since they were not side-by-side.

3.3 Next Steps

Some recommendations for designing a future cover crop trial arose from the first two trials:

1) Determine the purpose of the cover crop and choose the plant accordingly. For example, if the purpose of the cover crop is to control erosion, the plant should have robust residue over the winter.
2) Eliminate issues of slope and soil texture by ensuring that these landscape features are uniform throughout the test plots.

4.0 Nutrient Management

Nutrient management plans were created with the software program NMAN3 (OMAFRA, 2012) for fields in the study area. Initial analysis suggested that reducing the amount of nutrients applied to the land would not compromise yield goals. Two landowners in the study area, one in the Gully Creek watershed and one from the Ridgeway Drain watershed, agreed to conduct fertilizer rate reduction trials on their farms.

Monitoring for a change in water quality from small test plots is a difficult undertaking, but it was assumed that applying less nitrogen on the land would result in less nitrogen lost through surface water runoff. Instead of monitoring water quality, soil was monitored for nitrate concentrations. Soil monitoring can also be considered a BMP, as it helps landowners determine the quantity of a nutrient they need to apply, taking into account the pre-existing amount of the nutrient in the soil. Further information on the soil testing that took place as part of this project can be found in Gutteridge *et al.* (2013).

In addition to monitoring soil nitrate to evaluate a nutrient management BMP, a comparison of crop yields and net crop income was made between the plot with the full rate of fertilizer application and the plot with a reduced rate of fertilizer application.

4.1 Methods

4.1.1 Trial 1

On the northern boundary of the Gully Creek watershed, landowner G1 applied chicken manure in the fall of 2010 to a field on which he planned to plant a corn crop in 2011. A side-by-side trial was set up to determine the impact of reducing his nitrogen fertilizer application rate to the rate recommended by Ontario’s nutrient management software program (NMAN3) on a 4-acre test plot within an 80-acre field. On the control plot, he applied nitrogen fertilizer (in the form of urea) at a rate of 100 pounds per acre (his normal fertilization rate), while on the treatment plot, he applied only 50 pounds per acre (according to his nutrient management plan, the additional amount needed after considering the nitrogen available from the chicken manure applied the previous fall). Even with this reduction, the NMAN3 software indicated that the landowner's target yield of 160 bushels per acre could be reached.

Soil nitrate sampling was conducted on the G1 test plot in June 2011 and May 2012 to compare the nitrate levels on the control and treatment plots as a further check on the validity of the NMAN3 fertilizer recommendation (Table 4.1, Figure 4.1). The control and treatment plots were each sampled at the low, middle, and high positions on a slope, with two replicate composite samples per slope position. Each composite sample was a combination of samples from three locations and each of those samples consisted of four cores collected from the top 30 centimetres of soil with an auger, two of which were collected near a crop row and two of which were collected in between crop rows.

Table 4.1: Soil nitrate monitoring samples for evaluating nitrogen reduction at the G1 property in the Gully Creek watershed.

Composite Sample Code	Location Description
CL123	Control plot; low slope; samples 1, 2, and 3
CL456	Control plot; low slope; samples 4, 5, and 6
CM123	Control plot; mid slope; samples 1, 2, and 3
CM456	Control plot; mid slope; samples 4, 5, and 6
CH123	Control plot; high slope; samples 1, 2, and 3
CH456	Control plot; high slope; samples 4, 5, and 6
TL123	Treatment plot; low slope; samples 1, 2, and 3
TL456	Treatment plot; low slope; samples 4, 5, and 6
TM123	Treatment plot; mid slope; samples 1, 2, and 3
TM456	Treatment plot; mid slope; samples 4, 5, and 6
TH123	Treatment plot; high slope; samples 1, 2, and 3
TH456	Treatment plot; high slope; samples 4, 5, and 6

Yield information was obtained from the G1 test plot after the corn crop had been harvested in 2011 to determine the impact of the reduced nitrogen application rate on crop yield and confirm that the yield goal could be met with the reduced application rate. The net income from the crop yield was calculated by subtracting the fertilizer cost from the crop revenue, assuming that corn was sold at a rate of $6.34 per bushel (the November 2011 float price for corn claims that was used locally by Agricorp). Net income was compared between the control and treatment plots to assess whether this nutrient reduction BMP trial resulted in a financial gain or loss for the producer.

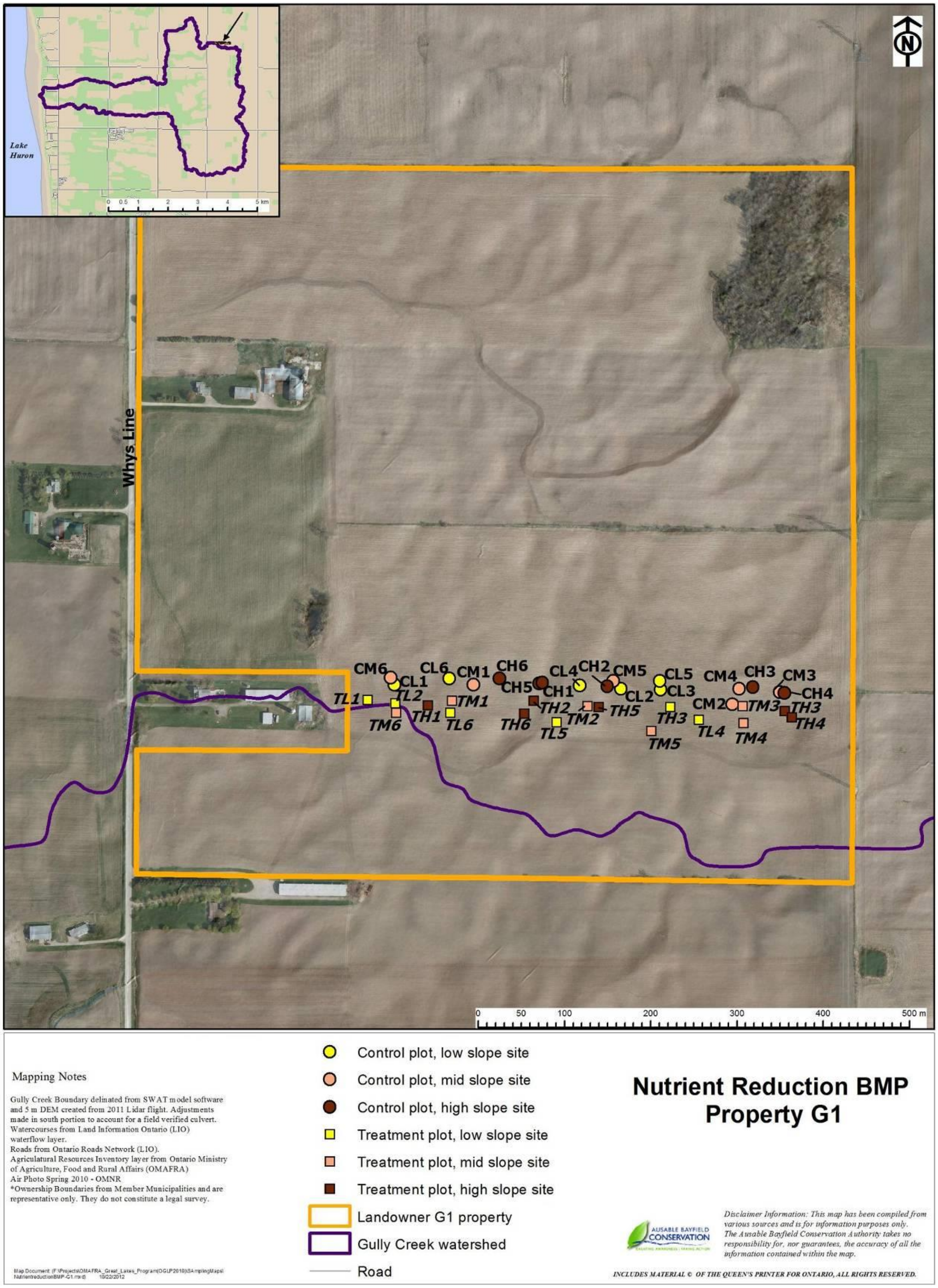

Figure 4.1: Soil nitrate monitoring sites for evaluating nitrogen reduction at the G1 property on the northern boundary of the Gully Creek watershed.

4.1.2 Trial 2

On a field north of the Ridgeway Drain watershed, landowner R1 applied a nitrogen-phosphorus-potassium (N-P-K) mixed starter fertilizer to his corn crop in 2011. The full fertilizer rate (control) included 185 pounds of N (50% urea, 50% Environmentally Smart Nitrogen or ESN), 80 pounds of P (phosphorus pentoxide), and 150 pounds of K (potassium oxide) per acre. This full rate was applied to a 2-acre control plot within a 72-acre field on property R1C (Figure 4.2). A nutrient reduction trial was conducted by reducing the N-P-K fertilizer application rate to the rate recommended by the NMAN3 software on a 2-acre treatment plot within the same field. The control plot received 185 pounds of N per acre, while the treatment plot received 123 pounds of N per acre. The NMAN3 software indicated that the landowner's target yield of 160 bushels per acre could be reached with the lower fertilization rate.

Yield information was obtained from the R1C test plot after the corn crop was harvested in 2011 to determine the effect of N-P-K fertilizer reduction on crop yield and compare the actual yield with the yield goal. The net income from the crop yield was calculated by subtracting the fertilizer cost from the crop revenue, assuming that corn was sold at a rate of $6.34 per bushel (the November 2011 float price for corn claims that was used locally by Agricorp). Net income was compared between the control and treatment plots to assess whether this nutrient reduction BMP trial resulted in a financial gain or loss for the producer.

4.1.3 Trial 3

In 2012, landowner R1 repeated his nutrient reduction trial on a different field, also north of the Ridgeway Drain watershed. The landowner's normal fertilization rate (control) was the same as in 2011 (185 pounds of N per acre in a N-P-K mixed starter fertilizer) and was applied to a 0.7-acre control plot within an 84-acre field on property R1B (Figure 4.3). A 0.7-acre treatment plot was fertilized with the rate recommended by the NMAN3 software (123 pounds of N per acre). The NMAN3 software indicated that the landowner's yield goal of 200 bushels per acre could be reached with this fertilization rate.

Soil nitrate sampling was conducted on the R1B field in April, June, and November 2012 to compare the nitrate levels on the control and treatment plots. Since the plots were uniform in terms of slope and soil texture, the sample from each plot (control and treatment) was a composite of ten soil cores collected from random locations throughout the plot. The cores were collected with a hand probe from the top 30 centimetres of soil, following the sampling guidelines for the PSNT.

Yield information was also obtained from the R1B corn crop in 2012 to compare the control and treatment plots and to determine if they met the yield goal. The net income from the crop yield was calculated by subtracting the fertilizer cost from the crop revenue, assuming that corn was sold at a rate of $7.01 per bushel (the November 2012 float price for corn claims that was used locally by Agricorp). Net income was compared between the control and treatment plots to assess whether this nutrient reduction BMP trial resulted in a financial gain or loss for the producer.

Figure 4.2: Nutrient reduction test plots on the R1C property north of the Ridgeway Drain watershed in 2011.

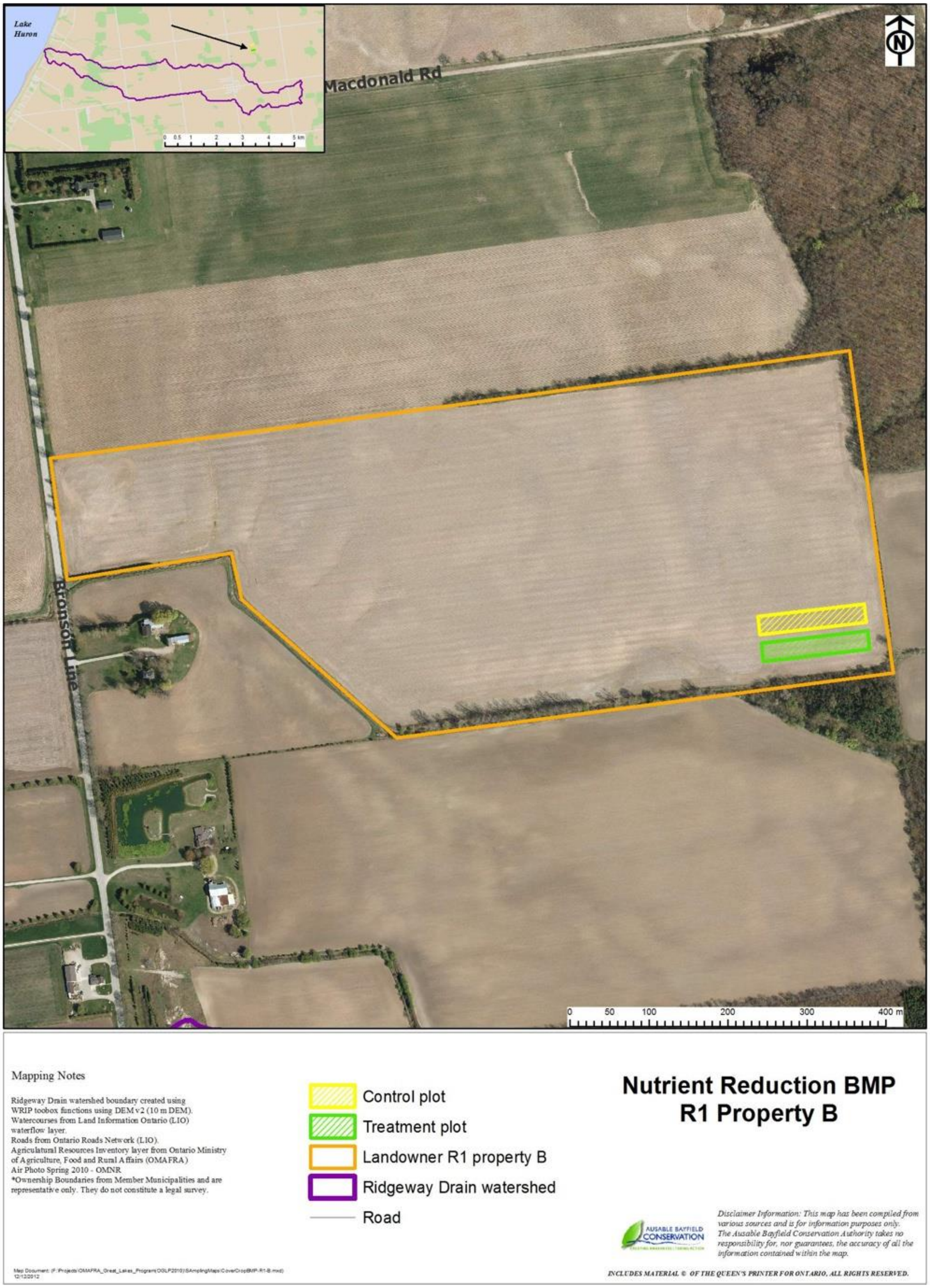

Figure 4.3: Nutrient reduction test plots on the R1B property north of the Ridgeway Drain watershed in 2012.

4.2 Results

4.2.1 Trial 1

The nitrate concentrations in soil cores collected in June 2011 from the G1 property of the Gully Creek watershed were consistently higher at the control sites, which received the full rate of nitrogen fertilizer application, than at the treatment sites, which received the reduced rate recommended by the NMAN3 software (Table 4.2). This suggests that reducing the fertilizer application rate results in less nitrogen being available for loss from the soil during rainfall events in the late spring or early summer. By the following spring, in May 2012, soil nitrate concentrations were consistently low, and similar between the control and treatment sites, suggesting that the extra nitrogen that was present the previous June either contributed to an increased crop yield (if weather conditions were favourable) or were lost to the environment.

Table 4.2: Soil nitrate concentrations (in parts per million) from control and treatment sites in a nitrogen fertilizer reduction trial at the G1 property in the Gully Creek watershed.

Slope (Soil Core Numbers)	June 2011		May 2012	
	Control	Treatment	Control	Treatment
Low (1,2,3)	39	32	6	8
Low (4,5,6)	42	23	7	7
Mid (1,2,3)	43	26	5	4
Mid (4,5,6)	32	27	5	8
High (1,2,3)	35	22	7	6
High (4,5,6)	31	25	4	5

The yield from landowner G1's 2011 corn crop exceeded the goal of 160 bushels per acre in both the control and treatment plots (Table 4.3), indicating that there was sufficient nitrogen in the soil to meet the yield goal at the NMAN3-recommended fertilization rate. However, decreasing the nitrogen fertilizer application rate to the NMAN3-recommended rate reduced the corn yield by 18 bushels per acre in comparison with the landowner's normal application rate. In 2011, the savings on fertilizer on the treatment plot were not sufficient to offset the loss in income from the reduced crop yield: landowner G1 lost 87 dollars per acre by reducing his fertilizer application to the rate recommended by NMAN3.

Table 4.3: Differences in crop yield, income, fertilizer cost, and net income (per acre) for the control and treatment plots in a nitrogen fertilizer reduction trial in the G1 property of the Gully Creek watershed in 2011.

	Control (C)	Treatment (T)	Difference (T-C)
Crop Yield (Yield Goal = 160 bushels)	186.4 bu	168.4 bu	-18.0 bu
Income from Crop Yield*	$1181.78	$1067.66	-$114.12
Fertilizer Cost	$54.95	$27.48	-$27.48
Net Income (Income – Fertilizer Cost)	$1126.83	$1040.18	-$86.65

*Assuming corn was sold at a rate of $6.34 per bushel, which was the November 2011 float price for corn claims used locally by Agricorp.

Anecdotal observations from the custom operator suggest that landowner G1's nitrogen fertilizer trial in 2011 had no residual effect on the subsequent soybean crop in 2012.

4.2.2 Trial 2

The yield from the 2011 corn crop on the R1C property exceeded the goal of 160 bushels per acre in the control plot and met the goal in the treatment plot, suggesting that 2011 was an excellent growing year by providing the heat and moisture needed to exceed yield goals (Table 4.4). Although reducing the N-P-K fertilizer application rate to the rate recommended by NMAN3 provided enough nitrogen to meet the yield goal of 160 bushels per acre, the corn yield was reduced by 13 bushels per acre in comparison with the full fertilization rate, which was able to take advantage of the excellent growing conditions of 2011. During this year, the savings on fertilizer on the R1C property's treatment plot were not sufficient to offset the loss in income from the reduced crop yield and the landowner lost 23 dollars per acre by reducing his fertilizer application to the NMAN3-recommended rate.

Table 4.4: Differences in crop yield, income, fertilizer cost, and net income (per acre) for the control and treatment plots in a nitrogen fertilizer reduction trial at the R1C property north of the Ridgeway Drain watershed in 2011.

	Control (C)	Treatment (T)	Difference (T-C)
Crop Yield (Yield Goal = 160 bushels)	171.8 bu	159.1 bu	-12.7 bu
Income from Crop Yield*	$1089.21	$1008.69	-$80.52
Fertilizer Cost	$173.71	$115.81	-$57.90
Net Income (Income – Fertilizer Cost)	$915.50	$892.88	-$22.62

*Assuming corn was sold at a rate of $6.34 per bushel, which was the November 2011 float price for corn claims used locally by Agricorp.

4.2.3 Trial 3

Soil nitrate concentrations on the control and treatment plots of the R1B property north of the Ridgeway Drain watershed were similar in April 2012 (Table 4.5). After fertilizer was applied, the treatment plot had nearly a third less soil nitrate than the control plot. Therefore, reducing the nitrogen fertilizer application rate to the NMAN3-recommended rate likely reduced the soil nitrogen available for loss during late spring or early summer rainfall events. By November 2012, soil nitrate concentrations were low in both the control and treatment plots.

Table 4.5: Soil nitrate concentrations (in parts per million) from control and treatment sites in a nitrogen fertilizer reduction trial at the R1B property north of the Ridgeway Drain watershed in 2012.

Plot	April 2012	June 2012	November 2012
Control	39	32	6
Treatment	42	23	7

The yield from the 2012 corn crop on the R1B property was about the same on the control and treatment plots, with both plots exceeding the goal of 200 bushels per acre (Table 4.6). Thus, reducing the N-P-K fertilizer application rate to match the NMAN3 recommendation for the planned yield goal still supplied sufficient nitrogen to the soil to exceed the crop yield goal. In 2012, the savings on fertilizer on the R1B property's treatment plot offset the loss in income due to a slightly reduced crop yield in comparison with the control plot. The landowner gained 62 dollars per acre by reducing his fertilizer application rate to match the NMAN3 recommendation.

Table 4.6: Differences in crop yield, income, fertilizer cost, and net income (per acre) for the control and treatment plots in a nitrogen fertilizer reduction trial at the R1B property north of the Ridgeway Drain watershed in 2012.

	Control (C)	Treatment (T)	Difference (T-C)
Crop Yield (Yield Goal = 200 bushels)	211.9 bu	211.2 bu	-0.7 bu
Income from Crop Yield*	$1485.42	$1480.51	-$4.91
Fertilizer Cost	$200.00	$133.33	-$66.67
Net Income (Income – Fertilizer Cost)	$1285.42	$1347.18	$61.76

*Assuming corn was sold at a rate of $7.01 per bushel, which was the November 2012 float price for corn claims used locally by Agricorp.

4.3 Next Steps

The availability of soil nutrients and the ability of crops to take up those nutrients can change with location (*e.g.*, due to differences in soil) and over time (*e.g.*, due to annual variation in precipitation amounts and timing) (Table 4.7). It is therefore important to continue conducting nutrient reduction trials on several fields during several years in order to determine an average effect of reducing fertilizer application rates on soil nitrate concentration, crop yield, and net crop income.

Table 4.7: Summary of three nutrient reduction trials and their results.

Property	G1	R1C	R1B
Location	Gully Creek watershed	north of Ridgeway Drain watershed	north of Ridgeway Drain watershed
Year	2011	2011	2012
Previous Crop	soybeans	winter wheat	winter wheat
Fertilizer Type	commercial nitrogen; chicken manure (fall)	commercial N-P-K*	commercial N-P-K*
Difference Between NMAN-Recommended Nitrogen Fertilization Rate and Normal Rate Used	reduction of 50 lbs/acre	reduction of 62 lbs/acre	reduction of 62 lbs/acre
Soil Nitrate Concentration (June)	decreased	not measured	decreased
Net Crop Income	lost $87/acre	lost $23/acre	gained $62/acre

*N-P-K is a nitrogen-phosphorus-potassium mixed starter fertilizer.

5.0 Water and Sediment Control Basins

Several erosion control structures, commonly referred to as Water and Sediment Control Basins (WASCoBs), have been implemented within the study area. These structures hold back surface water runoff in headwater areas. This has been demonstrated to reduce sediment and nutrient loading into watercourses (Harmel *et al.*, 2008, Makarewicz *et al.*, 2009, Stuart *et al.*, 2010).

Water quality and quantity was monitored at selected WASCoB locations in the Gully Creek watershed to determine their influence on sediment and nutrient concentrations and the timing and magnitude of peak flows during runoff events within the study area.

5.1 Methods

Initially, monitoring of the impacts of WASCoBs on water quality and quantity was planned for two sites in the Gully Creek watershed, following a Before, After, Control, Impact (BACI) study design. Multiple WASCoBs were to be installed by landowner G5 upstream of site GULGUL3 (Table 5.1, Figure 5.1), where monitoring began in July 2009. At site GULGUL4, no WASCoBs were planned and monitoring started in March 2011. The construction of WASCoBs was to begin in 2012, but has been delayed until 2013 due to a municipal drain process. As a result, the pre-WASCoB state has been monitored extensively for future comparison with the WASCoB construction and post-WASCoB installation states.

Table 5.1: Monitoring stations for evaluating Water and Sediment Control Basins (WASCoBs) at the G5 and G4 properties in the Gully Creek watershed.

Landowner	Site Code	UTM Coordinates		Location Description
		Easting	Northing	
G5	GULGUL3	448094.80	4829666.40	Gully Creek South Branch Tributary b upstream of Whys Line
	GULGUL4	448120.66	4830208.11	Gully Creek North Branch Tributary c upstream of Whys Line
G4	KVBAY-IN	448403.81	4826382.06	WASCoB inflow on north side of Bayfield Road, between Whys Line and Tipperary Line
	KVBAY-HB	448312.56	4826362.05	WASCoB ponding area on north side of Bayfield Road, between Whys Line and Tipperary Line

Since construction delays prevented an evaluation of WASCoBs at these sites during the timeframe of this project, water quality and quantity monitoring was initiated during rainfall events at an existing WASCoB on the G4 property, just south of the Gully Creek watershed, in June 2012. Samplers were installed both at the inflow to the WASCoB (site KVBAY-IN) and adjacent to the hickenbottom, the outflow point of the WASCoB ponding area (site KVBAY-HB; Table 5.1, Figure 5.2). At the inflow, bottles were installed at different heights above the ground surface (0”, 3.5”, 7”, 11”, and 14”) to attempt to capture water entering the WASCoB at different times during the event (Plate 5.1). Near the hickenbottom outlet, Global Water automatic samplers were installed to capture water approximately 15 centimetres above the bottom of the ponding area at different times during the event. Each Global sampler was set to collect an initial sample when it was first triggered and a composite sample over a period of time. One Global sampler was triggered when the water depth in the ponding area reached 40 centimetres and its composite sample was made up of 400-mL samples taken every 30 minutes over a period of five hours. The other Global sampler was triggered at a water depth of 80 centimetres, with its composite sample composed of 200-mL samples every 30 minutes over a ten-hour period. Water samples were analyzed for nutrients and sediment concentrations.

A Diver®-type level logger was installed in the ponding area to record water depth (stage) at 15-minute intervals (Plate 5.2). The water depth and associated time data from this logger were used to estimate the time when the Global samplers would have triggered and when the inflow bottles would have filled.

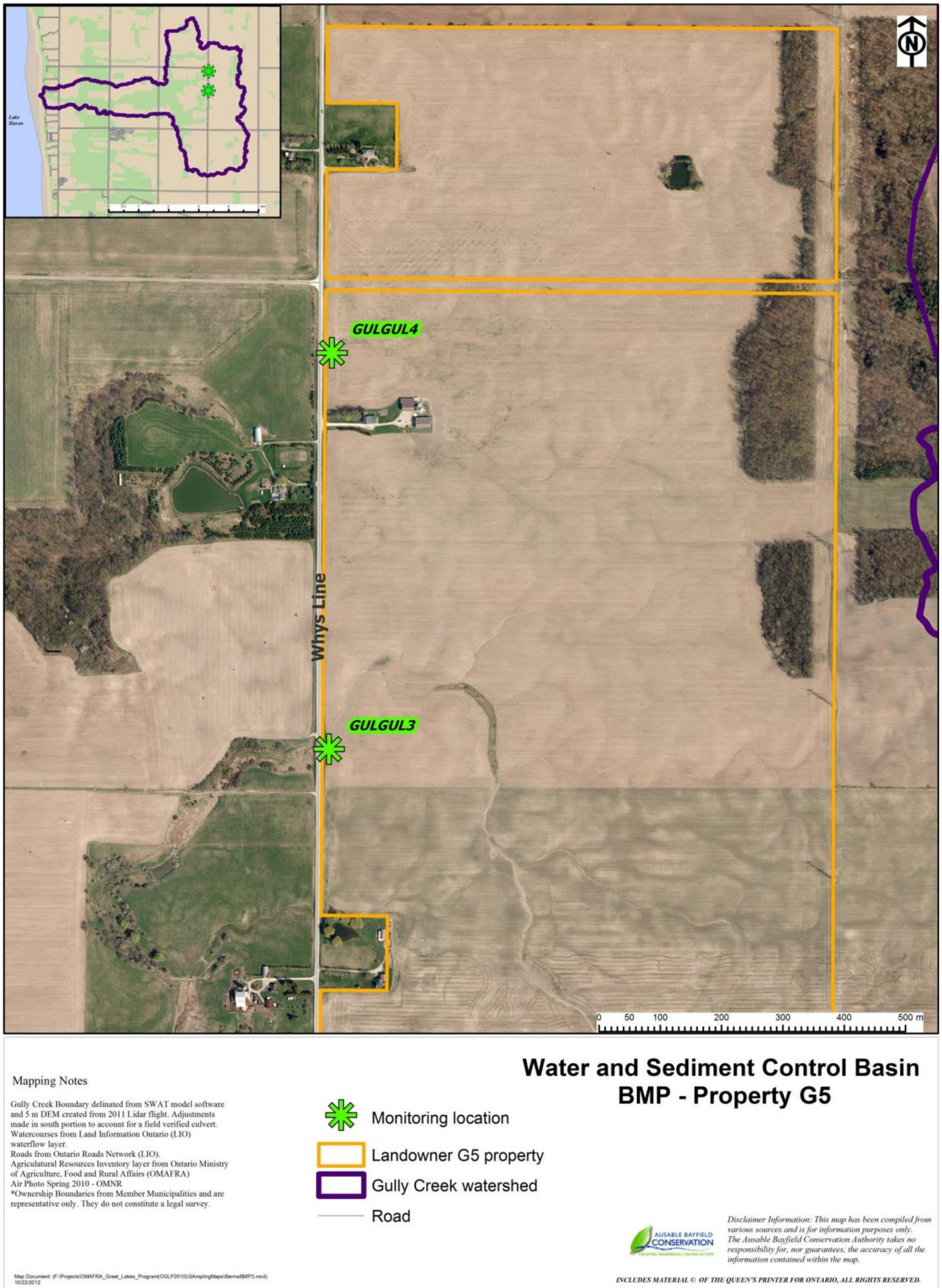

Figure 5.1: Monitoring stations for evaluating Water and Sediment Control Basins at the G5 property in the Gully Creek watershed.

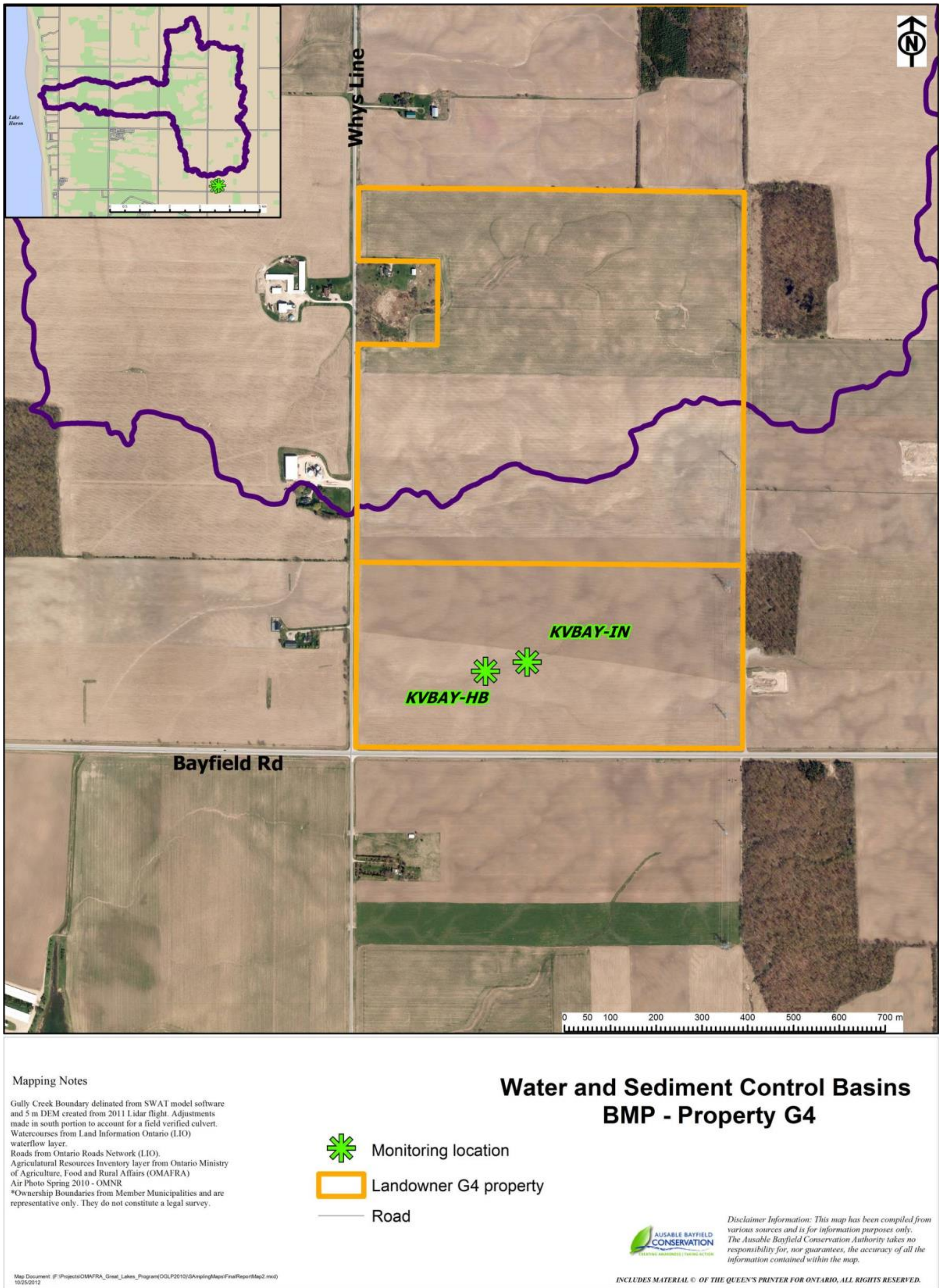

Figure 5.2: Monitoring stations for evaluating a Water and Sediment Control Basin at the G4 property just south of the Gully Creek watershed.

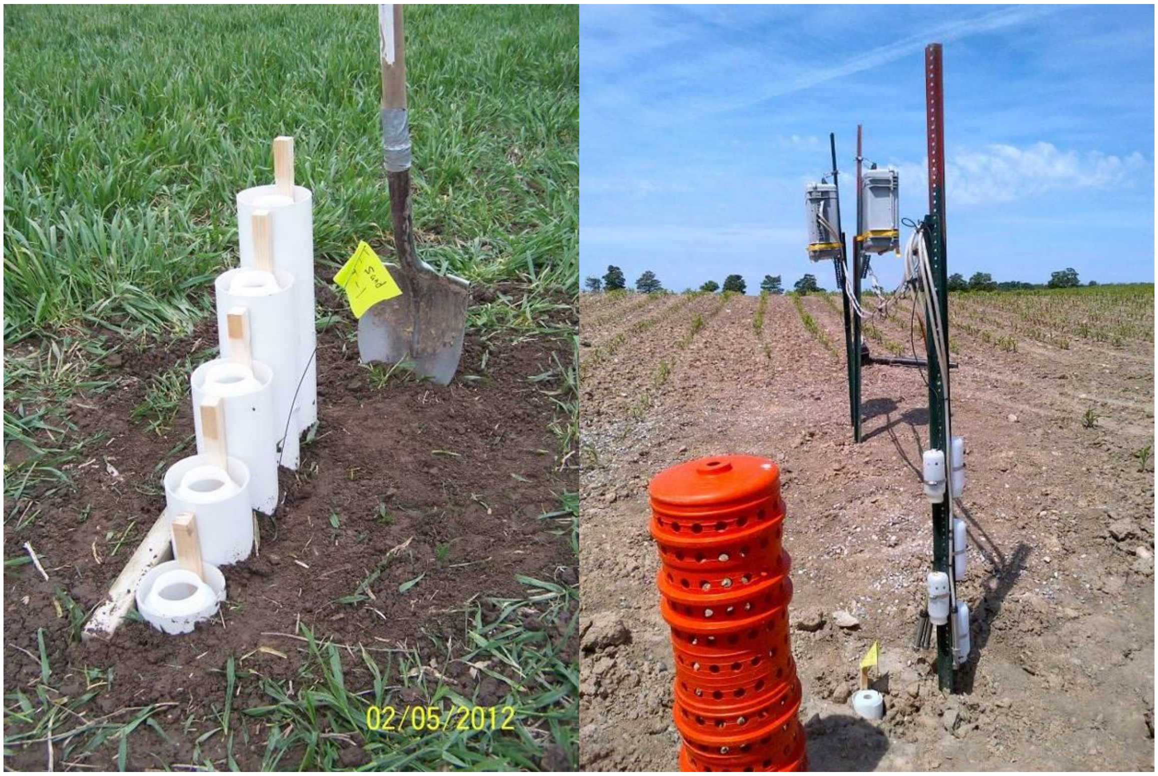

Plate 5.1: Water samplers installed at the G4 property in the Gully Creek watershed to monitor the Water and Sediment Control Basin inflow (left) and hickenbottom (right).

Plate 5.2: Diver® level logger installed at the G4 property in the Gully Creek watershed to monitor the water level in the Water and Sediment Control Basin ponding area.

Delays in and attenuation of peak flow were determined by looking at the difference between the timing and magnitude of peak flows at the inflow and outflow of the WASCoB. The inflow of water into the ponding area (cubic metres per second) was determined by subtracting the outflow (cubic metres per second) from the change in ponding area storage over a 15-minute period (cubic metres per 900 seconds). The outflow of water from the ponding area was calculated from a stage-outflow relationship based on the diameter of the outflow pipe. The volume of water stored in the ponding area at each 15-minute interval during a runoff event was calculated from a stage-storage relationship based on the shape and dimensions of the ponding area.

5.2 Results

Preliminary water quantity and quality information were collected from the WASCoB on the G4 property during a storm event on July 4, 2012. This is the only storm event that resulted in samples at the WASCoB between the installation of the samplers and the completion of this project.

The water level in the WASCoB's ponding area reached a maximum height of 1.129 metres. Since the height of the WASCoB was 1.386 metres, higher than the maximum water level, the WASCoB captured all of the upstream surface runoff and reduced surface erosion along the overland flow path downstream.

The peak water inflow to the WASCoB was nearly 1,000 litres per second, while the peak discharge at the WASCoB outflow was only about 150 litres per second (Figure 5.3). Most of the water runoff flowed into the WASCoB over a 1.5-hour period, but the WASCoB captured this water and released it slowly over a 9-hour period. Hence, the WASCoB reduced the magnitude of the peak flow by about 85 percent and delayed the transmission of flow by several hours.

The inflow into the WASCoB filled the inflow bottle sampler set at the ground surface (0") with sediment and buried it under an inch of sediment, so this sample was not submitted for analysis. The bottles positioned 3.5 and 7 inches above the ground surface contained samples suitable for analysis. The water level at the inflow did not reach the bottles at 11 and 14 inches. Near the hickenbottom outlet in the WASCoB ponding area, both Global automatic samplers triggered, collecting initial and composite samples from 15 centimetres above the bottom of the ponding area.

The water sample results for this single event showed a clear decrease in total suspended solids concentrations between the inflow and ponding area samples (Figure 5.4), suggesting that the WASCoB was successfully retaining sediment that would otherwise flow into watercourses downstream. Total ammonia also showed a clear decrease between the inflow and ponding area for this event (Figure 5.5). The other nutrient water quality indicators showed too much variability (in terms of standard error values) to determine whether they changed between the inflow and ponding area.

5.3 Next Steps

The strategy for monitoring the effects of WASCoBs on water quality has evolved throughout this project and improvements are still being made. Moving forward, adjustments could be made to monitor water inside the hickenbottom outlet rather than in the ponding area, as the hickenbottom water more accurately represents the quality of water leaving the WASCoB.

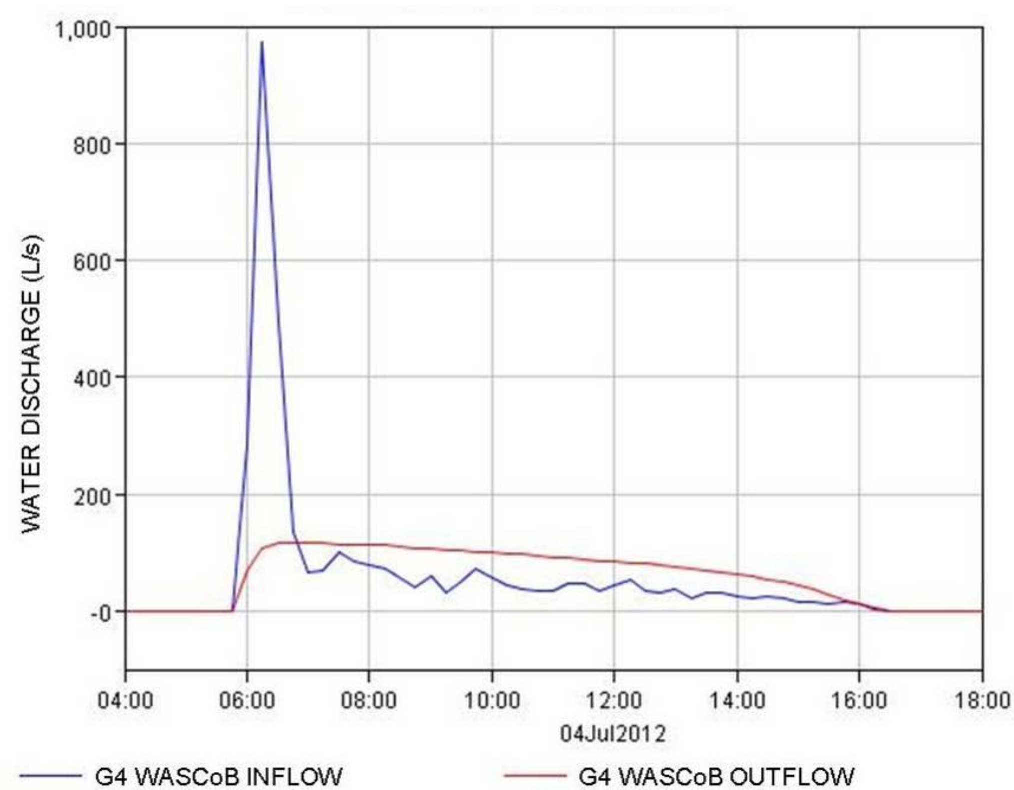

Figure 5.3: Water discharge, in litres per second, flowing into and out of the ponding area behind the Water and Sediment Control Basin (WASCoB) on the G4 property in the Gully Creek watershed.

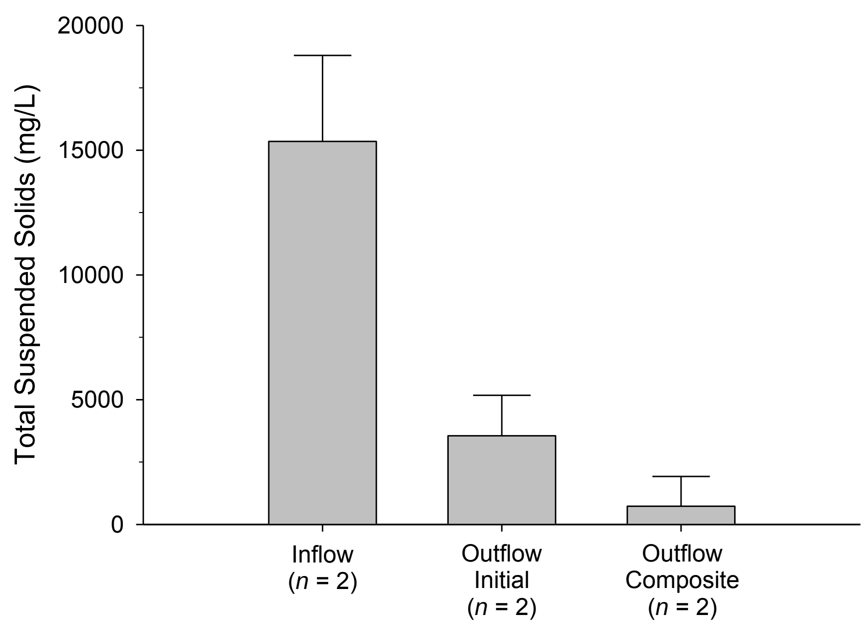

Figure 5.4: Total suspended solids concentrations at landowner G4's Water and Sediment Control Basin inflow and ponding area during a runoff event in July 2012. Columns are averages and bars are standard errors with sample sizes (*n*) of two.

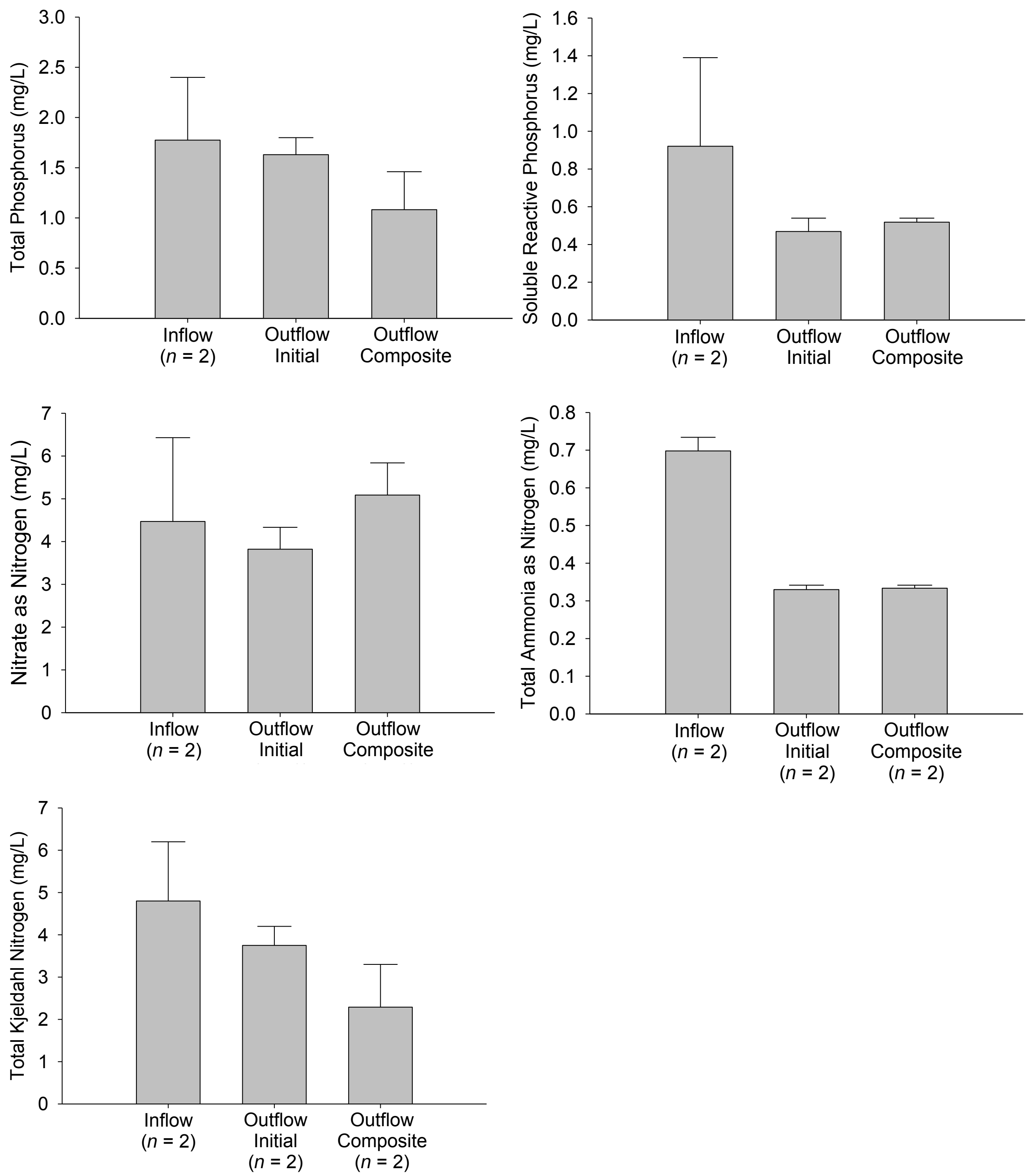

Figure 5.5: Total phosphorus, soluble reactive phosphorus, nitrate, total ammonia, and total Kjeldahl nitrogen concentrations at landowner G4's Water and Sediment Control Basin inflow and ponding area during a runoff event in July 2012. Columns are averages and bars are standard errors with sample sizes (*n*) of two.

6.0 Grass Filter Strip

As monitoring of tillage practices began in the Gully Creek watershed, an opportunity to monitor a grass filter strip at the edge of a field (essentially, a roadside ditch) became apparent. Grass filter strips can filter out sediment and nutrients from surface runoff.

Water quality of surface runoff was monitored before and after it had travelled through the grass filter strip formed by the roadside ditch.

6.1 Methods

Along the edge of landowner G11's field, which was originally identified for a trial to evaluate conservation tillage, a grassy area appeared to entrain some sediment when water ran off the field surface during rain events. This 25-square-metre grass strip filters runoff from a 3-hectare area of the 12-hectare field (Figure 6.1). Two sites were set up for monitoring water quality, one at the edge of the field and one at the outlet of a culvert that drains the grass filter strip (Table 6.1).

Table 6.1: Monitoring stations for evaluating a grass filter strip at the G11 property in the Gully Creek watershed.

Site Code	UTM Coordinates		Location Description
	Easting	Northing	
BBFIELD1	446963.88	4830327.45	North edge of field on south side of Tower Line Road
BBCULV1	446956.95	4830346.06	Culvert outlet from north edge of field on north side of Tower Line Road

To collect water samples when rainfall or snowmelt events resulted in water flow, bottles were embedded into the ground (Plate 6.1). Water samples were transferred to laboratory sample bottles and analyzed for nutrients and suspended sediment. A flow sensor, which records when water runoff occurs, was installed at the culvert outlet to help determine the time that samples collected in the embedded bottles (Plate 6.2).

Plate 6.1: Two types of embedded water quality samplers at the G11 property in the Gully Creek watershed.

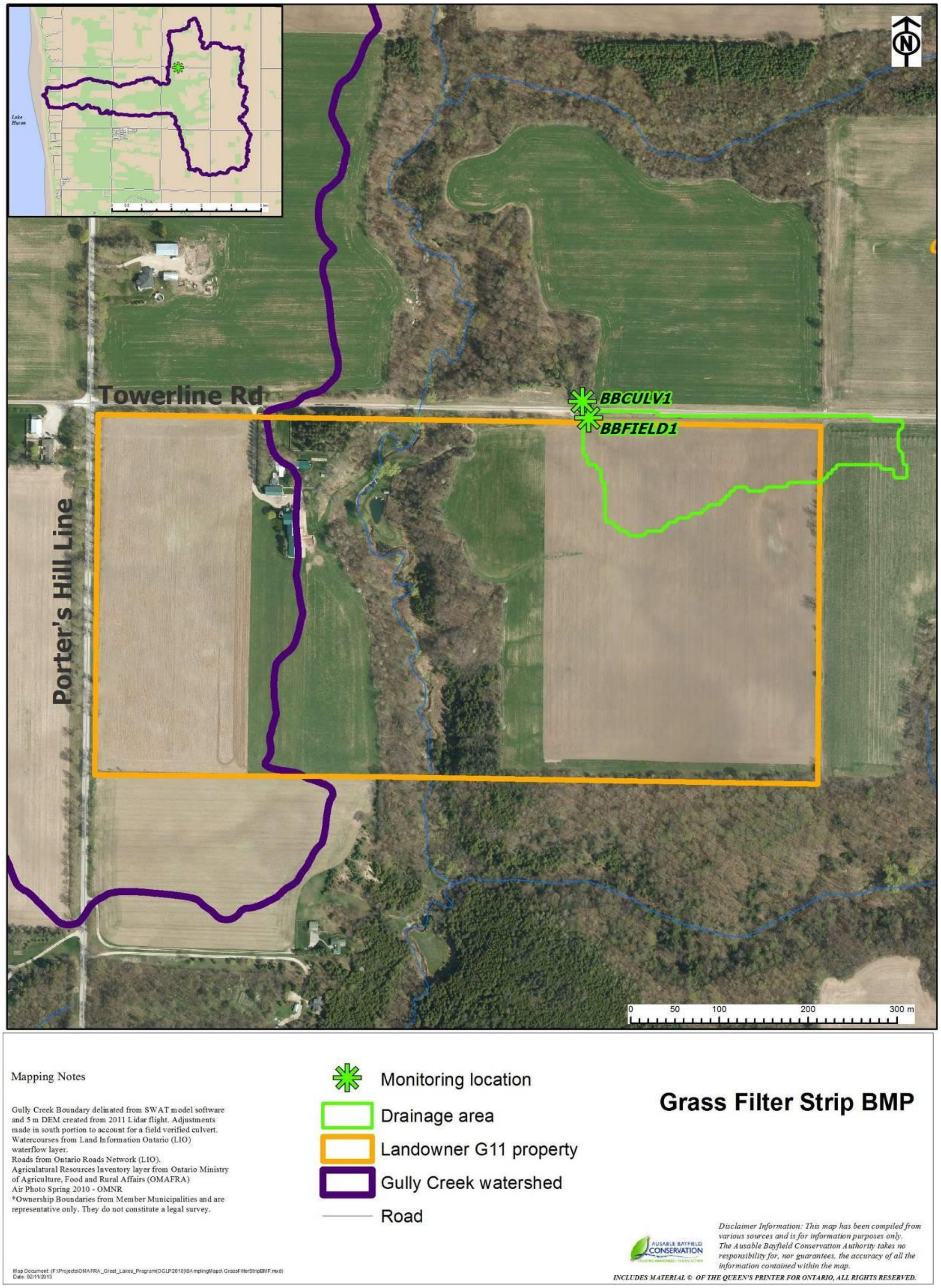

Figure 6.1: Monitoring stations for evaluating a grass filter strip at the G11 property in the Gully Creek watershed.

Plate 6.2: Flow sensor at the G11 property in the Gully Creek watershed.

6.2 Results

Surface runoff samples showed declines in total phosphorus (TP), soluble reactive phosphorus (SRP), and total suspended solids (TSS) after the runoff had passed through the grass filter strip (Figure 6.2). On average, TP declined by 47 per cent, SRP by 63 per cent, and TSS by 48 per cent during runoff events between June 2011 and March 2012. Nitrate, on the other hand, did not show consistent declines as runoff passed through the filter strip. In fact, in several cases, nitrate concentrations were higher downstream of the filter strip than upstream.

These results suggest that a 25-square-metre treatment area (grass filter strip) can effectively reduce phosphorus and sediment in surface runoff from a 3-hectare area of cropland. This translates to an 8-square-metre treatment area per hectare of cropland area, or 0.1 per cent of the cropland area.

6.3 Next Steps

Continued monitoring of this location is recommended, as the results presented here are based on a single crop year with a limited number of samples (nine for nutrients and six for sediment). Investigation of other locations within the watershed at which surface runoff passes through a grass filter strip would help in determining the variability in the size of the filter strip required to treat a hectare of cropland area. A study could also be undertaken to determine the feasibility of establishing strategically-placed filter strips within fields, perhaps with the aid of precision planting and spraying tools.

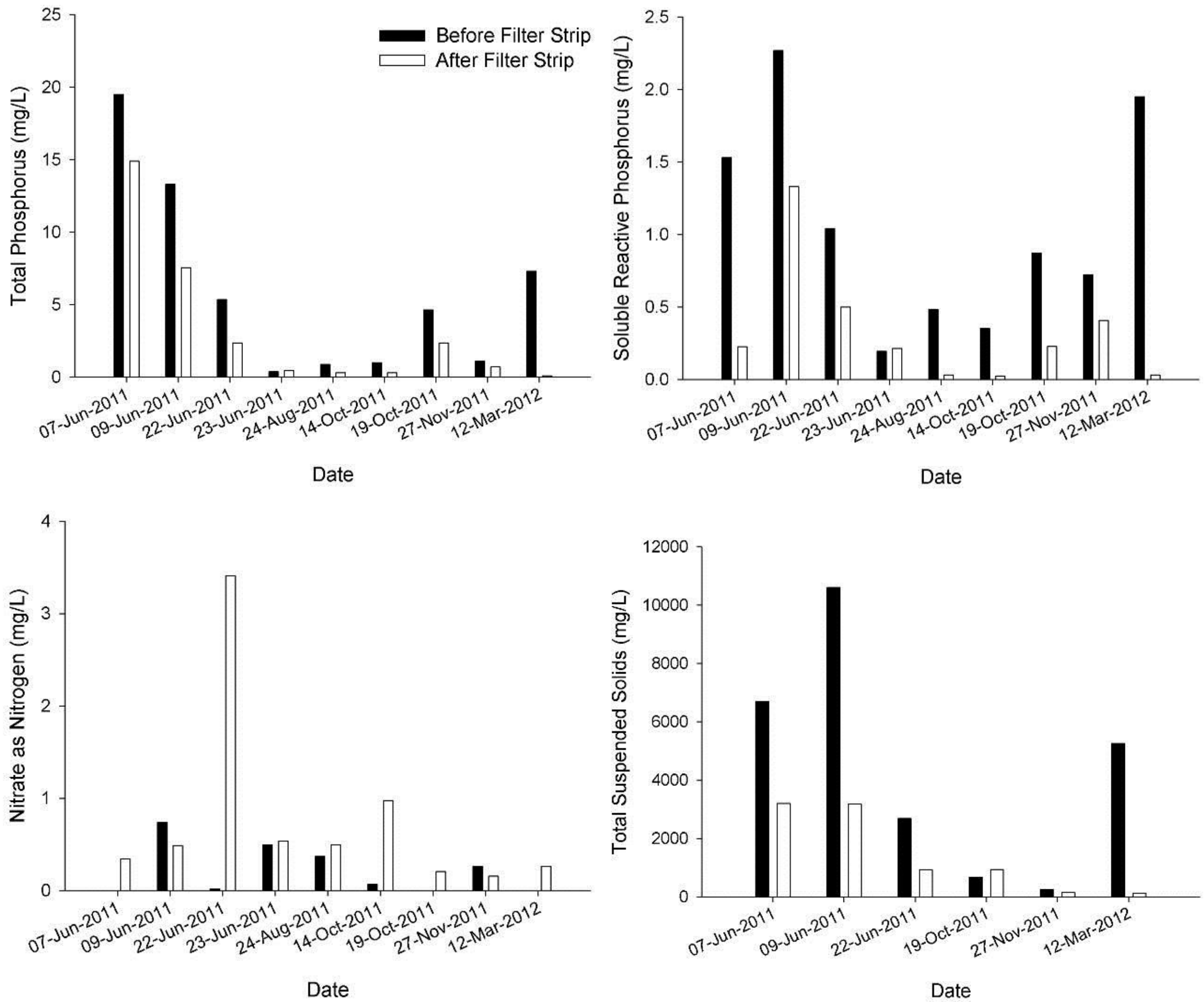

Figure 6.2: Concentrations of total phosphorus, soluble reactive phosphorus, nitrate, and total suspended solids before and after surface runoff travelled through a grass filter strip on the G11 property in the Gully Creek watershed.

7.0 Summary

Monitoring of BMPs at the field scale proved to be challenging. Strategies for monitoring were developed based on landowner plans, but economics and weather often intervened and changed landowner decisions. Water quality information was difficult to obtain at the field scale. Concentrated flow paths, particularly in those fields where agronomic BMPs were being evaluated, were not always available for collecting samples and monitoring techniques had to be modified several times to capture samples at the desired locations and times. Much of 2011 was spent tweaking monitoring techniques so that better data could be collected in 2012. However, low rainfall amounts in 2012 resulted in considerably fewer samples being collected that year.

Despite these challenges, valuable information was collected on the environmental and economic effectiveness of BMPs:

1) A Water and Sediment Control Basin reduced the magnitude of peak flow and retained a portion of the sediment and ammonia that ran off cropland during a rainfall event.

2) A legume cover crop increased soil nitrate concentrations in April and June 2012 (before a corn crop was planted and when the corn was between 15 and 30 centimetres in height), with no effect on soil nitrate concentrations in November 2012 (after the corn was harvested).

3) Nutrient reduction trials in 2011 resulted in lower net incomes for the producers despite their yield goals being met, while a nutrient reduction trial in 2012 decreased the soil nitrate available for loss during late spring and early summer rainfall events.

4) A grass filter strip decreased phosphorus and sediment concentrations in surface runoff.

Future evaluation of BMPs at the field scale could be improved by assessing BMP effectiveness under representative combinations of land use, soil, and slope over the long-term and during seasonal high-flow events. Information about climate, land use, management practices, topography, and soil composition are crucial for evaluating BMPs at the field scale.

8.0 References

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Appendix: Best Management Practices Implemented and Identified Within Study Area

Table A.1: Best management practices (BMPs), by watershed, that were implemented during the Watershed Based BMP Evaluation, Huron.

Watershed	BMP Description*	Landowner Code	BMP Type				
			Nutrient	Sediment	Agronomic	Structural	Fragile Land Retirement
Bayfield North Watersheds	Nutrient reduction trial on corn crop 2011	G1	✓		✓		
	Soil testing 2011	G1	✓		✓		
	Manure testing 2011	G1	✓		✓		
	Conservation tillage with wavy coulter 2011	G1		✓	✓		
	Conservation tillage with wavy coulter 2012	G1		✓	✓		
	Soil testing for residual effect of nutrient reduction trial 2012	G1			✓		
	Manure storage upgrade 2010	G2	✓			✓	
	Fragile land retirement 2012	G7					✓
	Installation of several WASCoBs 2012	G8		✓		✓	
	Upgrade of a WASCoB 2011	WK		✓		✓	
	Installation of a broad-based WASCoB 2011	KV		✓		✓	
	Installation of a WASCoB 2011	S3		✓		✓	
	Nutrient reduction trial on corn crop 2011	R1	✓		✓		
Ridgeway Drain	Nutrient reduction trial on corn crop 2012	R1	✓		✓		
	Cover crop trial 2011	R1	✓		✓		
	Cover crop trial 2012	R1	✓		✓		
	Upgrade of a WASCoB 2011	R4		✓		✓	
	Cover crop trial 2011	R1	✓		✓		
Zurich Drain	Cover crop trial 2012	R1	✓		✓		
	Barn water diversion (eavestroughs) 2010	GE				✓	

* A WASCoB is a Water and Sediment Control Basin.

Table A.2: Best management practices (BMPs), by watershed, that were identified during the Watershed Based BMP Evaluation, Huron.

Watershed	BMP Description*	Landowner Code	BMP Type				
			Nutrient	Sediment	Agronomic	Structural	Fragile Land Retirement
Bayfield North Watersheds	Installation of a WASCoB	G5		✓		✓	
	Installation of up to twelve WASCoBs	G5		✓		✓	
	Implementation of contour cropping	G8		✓	✓		
	Installation of a grassed waterway	G4		✓		✓	
	Implementation of a cover crop	G4	✓	✓	✓		
	Implementation of wetland	EP					✓
	Installation of a WASCoB	SF		✓		✓	
	Installation of a WASCoB	GB		✓		✓	
	Installation of wetland	SF					✓
	Fragile land retirement – pond	SF					✓
Ridgeway Drain	Manure storage upgrade	R5	✓			✓	
Zurich Drain	Installation of two WASCoBs	PS		✓		✓	
	Installation of a drop inlet	PS		✓		✓	
	Manure storage upgrade	GE	✓			✓	

* A WASCoB is a Water and Sediment Control Basin.