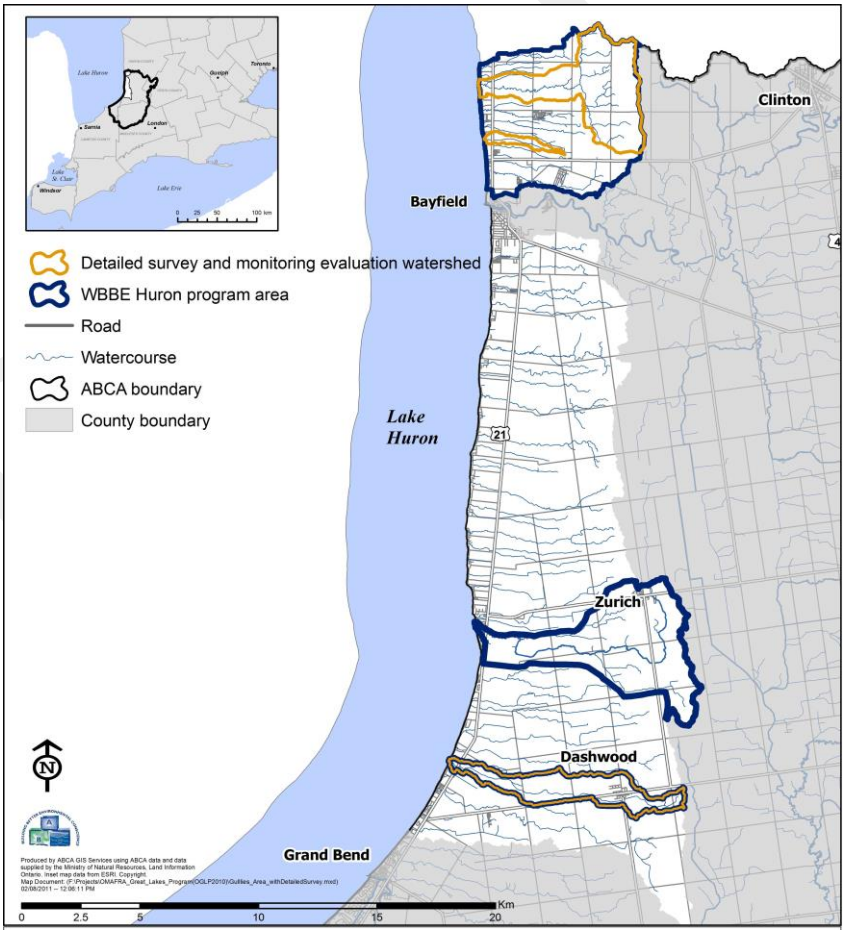
Crops & Creeks, Huron

A Watershed Based Best Management Practice Evaluation (WBBE) Pilot Project

Background and Issues

In 2010, the Ausable Bayfield Conservation Authority (ABCA) and the Huron County Federation of Agriculture (HCFA) received funding to study the economic and environmental effects of agricultural best management practices (BMPs). This project is one of two watershed based best management practice evaluation (WBBE) pilot projects funded by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) through the Canada Ontario Agreement on the Great Lakes.



Map 1: Watershed Based Best Management Project Evaluation (Crops and Creeks, Huron) within Ausable Bayfield Conservation Authority watershed jurisdiction.

The study area for WBBE Crops & Creeks, Huron is composed of several small watersheds that drain directly into Lake Huron including: The Bayfield North Watersheds, the Zurich Drain Watershed, and the Ridgeway (Kading) Drain Watershed. This study expands on previous water quality improvement efforts in each of the watersheds.

Since 2007, residents of a 40-km^2 area just north of Bayfield, Ontario have been active in developing a management plan for their watersheds. Tree planting, erosion control and small wetland projects took place in 2010. Crops & Creeks, Huron focuses on two of the sub-watersheds found in the Bayfield North area: Gully Creek (15 km^2) and Spring Creek (~ 1km^2). Gully Creek is one of the few cold water streams found in the ABCA jurisdiction. The majority of the land draining into Gully Creek is farmed. A Soil and Water Assessment Tool (SWAT) model is being developed for Gully Creek subwatershed to improve our understanding of what affects water quality. In contrast, the Spring Creek sub-watershed is comprised mainly of forested land.

Water quality monitoring has been on-going in the Zurich Drain Watershed since 2006. Approximately 20 BMPs were implemented in this watershed through the Adopt-a-Watershed Program in 2007, and Eco-Action funding from Environment Canada in 2008-2009. Zurich Drain is monitored and studied as part of the WBBE Project.

The Ridgeway Drain (also known as the Kading Drain), is a small ravine that empties into Lake Huron just north of Grand Bend, Ontario. It is one of the ravines that have been monitored for several summer seasons as a result of funding provided by the Bluewater Shoreline Resident's Association (BSRA), in cooperation with the Municipality of Bluewater. Additionally, the ravine was monitored where it crosses the Bluewater Highway (Highway 21) for two years in the 1980s, as part of the Clean Up Rural Beaches (CURB) Program.

The WBBE study has biophysical, economic and modelling components for evaluation of the following BMPs:

- Nutrient reduction
- Erosion control structures (i.e., berms)
- Cover crops
- Conservation tillage

Biophysical Component

The biophysical component focuses on evaluating the ecological effect of the several agricultural BMPs on water quality.

Nutrient reduction

Nutrient Management plans were completed, using the software program NMAN, for some of the fields in the study watersheds. Initial analysis suggested that there was some room for reducing the amount of nutrients applied to the land, without compromising yield goals. Two landowners in the study area agreed to do a nutrient reduction trial on their farms.

Farmer A, in Gully Creek subwatershed, applies both chicken manure and fertilizer nitrogen (in the form of urea) to his corn crop. The trial consisted of reducing the fertilizer nitrogen application from 100 lbs/acre to 50 lbs/acre on a four acre test plot. Even with this reduction, NMAN showed that Farmer A should still be able to reach his 160 bushel/acre target.

Farmer B, in Ridgeway Drain, applies a N-P-K mixed starter fertilizer to his corn crop. In this trial, the N-P-K fertilizer was reduced by one third. Again, NMAN showed that Farmer B should also be able to reach his 160 bushel/acre target with this reduction. This was attempted on a two acre test plot.

Monitoring for a change in water quality from small test plots is a difficult undertaking. However, it was assumed that less nutrients being put on the land should result in less nutrients available for surface water runoff. Soil was monitored for nutrient concentrations. Results will be forthcoming. Another way of monitoring this type of trial is to examine the crop yield. Although both landowners did reach, or were very close to reaching the 160 bu/acre target on the test plot, yield on the control area (where regular amounts of nitrogen was applied) was higher in both cases. Determining nutrient application amount and the influence on water quality can change each year. Nutrients are taken up by crops, absorbed to soil, transformed by microbes and released to the air and water in different amounts each season.

Erosion control structures

Several erosion control structures, in the form of berms (or Water and Sediment Control Basins – WASCoB's), have been implemented within the study area. These structures help to hold back surface water runoff in the headland areas of the gullies. These structures keep more sediment and nutrients on the land, rather than running off into the streams and gullies.

Water quality and quantity data has been collected on one site for the "pre-berm construction" stage. The site where this data has been collected has been confounded by a municipal drain process that is looking to incorporate the berms into the drain and therefore berm construction will be delayed. On two other completed berm sites water quality samples are collected where water runs across the field toward the berm, as well as at the hickenbottom where water

settles before draining. This data will be used to increase the understanding of nutrient levels and water flows so that berms may be constructed appropriately.

Cover Crops

Cover crops are encouraged in the watershed since they have many positive effects. They can reduce surface erosion on bare fields, add organic matter to improve soil health and manage nitrogen content of soils. Farmers have used cover crops that grow together with the main crop such as red clover seeded into winter wheat. The red clover takes nitrogen from the air to supply this nutrient to a following corn crop. Cover crops might also be employed after harvest between main crops to either add or remove nitrogen from the soil (depending on the type of cover crop) and to protect the soil. A pea cover crop was used on a field in the Ridgeway Drain. The landowner has fall tilled the cover crop in late November, leaving two plots un-tilled so that effect of tillage timing on soil erosion, soil nitrogen content and ease of planting in the spring can be studied..

Several different monitoring methods can be used. The soil can be tested in these plots to determine if there is any difference in nitrogen left in the soil on the areas that were left for cover crop compared to the areas that were tilled. The soil temperature and moisture can be measured in the spring to determine any differences in potential planning dates that could affect crop yields. Additionally, surface water runoff can be analyzed for total suspended sediment and nutrients. This will show the effect a cover crop has on soil erosion and nutrient runoff.

As there has been very little runoff on the trial field over the winter, a rainfall simulator will be employed to collect water runoff samples. Additionally, soil samples will be collected to test for nutrients. Results will be forthcoming.

Conservation Tillage

No-till and conservation tillage is used by many farmers within the study area; however, there are still some landowners who prefer to use conventional tillage methods. Conservation tillage refers to tillage that leaves higher amounts of crop residue on the field (at least 30 percent). The residue keeps the soil in place, preventing wind and water erosion.

A site-specific comparison is being conducted between two neighbouring fields; one typically uses no till or conservation tillage and the other typically uses conventional tillage. Runoff from these fields was analyzed for nutrient levels. During several high rainfall and runoff events, water samples from the field with conservation tillage showed concentrations of total phosphorus and nitrate that were generally lower than those taken from the conventionally tilled field. In contrast, concentrations of soluble reactive phosphorus were generally higher in the field with conservation tillage.

These findings are based on limited data, as the fields were only sampled for one year, during heavy rainfall events. Also, the crop rotation for the comparison fields is not the same since crops are offset (e.g., corn vs. soybeans). A history of the management of both fields is necessary to interpret the water quality tests. Comparing nutrient types, forms and concentrations in runoff over the long term from multiple fields using these different cropping systems will help develop BMPs that are effective in reducing nutrient release from fields. More data is needed to gain a better understanding of the effects of conservation tillage on surface water runoff. Additional sites with the same crops are being identified to gather better data.

Additional Studies

Monitoring BMPs at the site scale is a necessary component of this study. Additional water quality monitoring and data collection has also been undertaken at the watershed scale. These additional components are beneficial not only for a greater understanding of the watershed processes, but also to assist in the modelling component of the study.

Water Quality Monitoring

Eight water quality stations have been established throughout the study area: two in Gully Creek, two in Spring Creek, one in Zurich Drain, and three in Ridgeway Drain.

Water quality is monitored for nutrients, bacteria and sediment, as well as a number of physicochemical parameters, such as pH and dissolved oxygen. Sampling at these sites is undertaken monthly, as well as more frequently during high rainfall, snowmelt or flooding events. Additionally, water levels and flow have also been measured throughout the study. Understanding how water and nutrients move throughout the watershed can lead to better placement and selection of BMPs.

Landowner Land Management Surveys

To date, 29 landowner land management surveys have been completed during the study. The surveys have been completed for 69, 92, and 67 per cent of the agricultural land in Gully, Spring, and Ridgeway Drain Watersheds. These surveys collect information on cropping and tillage practices, nutrient inputs into the land, and any BMPs that landowners may have undertaken in the past decade. Additionally, information on the cost of the BMPs and the effectiveness of implementing them was also collected. In general, many landowners implement the BMPs because they believe that they are effective, even if they do not see immediate results.

The information gained from these surveys, specifically those conducted in Gully Creek, assists the modellers in determining the environmental and economic effectiveness of different production system choices and BMPs. The surveys also provide an opportunity to discuss implementing new BMPs as part of the WBBE Program.

Windshield Crop Surveys

To supplement the cropping information gained through the landowner land management surveys, a windshield survey of the study area was completed in summer 2011, with a follow up in fall 2011. The Ontario Ministry of Agriculture, Food and Rural Affairs has also conducted windshield surveys in the study area since 2007. The information gained on cropping practices from the landowner surveys is based on intentions for the forthcoming season. Thus, the possibility exists that crops planted may have changed from initial plans. The windshield surveys show what is in the ground at the time, and can provide a good understanding of the cropping rotations in the area with several years of data. They also are used to validate what was proposed in the landowner surveys, and correct crop rotations that may have changed.

In addition to noting the crop type, the windshield surveys also provided information on tillage practices (conventional vs. conservation), percentage of crop residue left on fields, tillage direction and row width. All of this is helpful information when studying the influence of cropping practices in the WBBE Program area.

Economics Component

Understanding the environmental effectiveness of BMPs is an important part of the WBBE program. At the same time it is also critical to the successful uptake of BMPs that agricultural landowners know the economic effect of such actions and that they are not unduly burdensome. Both environmental and economic components are what make a BMP useful for water quality improvement by agricultural landowner. Economic evaluation of BMPs will utilize three sources of information: the land management surveys, crop production economic survey, and provincial crop budgets.

While conducting the landowner land management surveys, data on the cost of BMPs was collected. However, some BMP costs were estimates, as the landowners did not always have that information in detail.

The land management data that was collected provides valuable information on crop production inputs and outputs. Expense and income price information can be used with this data to estimate production costs and net returns. If land

management data is available for both before and after BMP implementation, private costs of BMPs may also be evaluated.

Provincial crop budgets have itemized production inputs and cost information for main crops (*i.e.,* corn, soybeans, wheat), and the changes related to BMPs for some crops (*e.g.*, corn production under various tillage systems). Provincial templates can be adapted to the WBBE study area.

Perhaps a better understanding of economic efficacy of BMPs can be explained by using on the ground trials and experiments with BMPs. An example of this is the previously mentioned nutrient reduction trials that were held in the study area. The economic effect of this BMP was examined (Table 1).

Table 1: Summary economic results of nitrate reduction field trials in the Watershed Based Best Management Practices Evaluation Crops and Creeks, Huron Project

	Control Yield (bu/acre)	N Reduction (%)	N Reduction Yield (bu/acre)	Control Income ($/acre)	N Reduction Income ($/acre)	N Savings ($/acre)	Difference ($/acre)
Farm A	186.4	50	168.4	1181.78	1067.66	27.47	**- 86.65**
Farm B	179	33	159	1090.48	1008.06	57.80	**- 24.62**

Note: Farmer A also used chicken manure. Corn price used was $6.34 (based on November 2011 float price for corn claims used locally by Agricorp)

Although, both farmers reached or came close to reaching the target yield of 160 bu/acre, the yield on the plot with the reduced nutrients was less than that of the control site with the regular amount of nutrients applied. Even when savings on fertilizer cost are taken into account, both Farmer A and B lost money on the trial plots due to such a large gap in yield. This would have been a costly endeavour if the farmers had used the nutrient reduction on the entire field.

This is only one example of the economic outcome of one BMP for one year. If weather conditions or crop prices were different, the outcome may have been different. Therefore, further studies and trials need to be examined to understand the economic effect of BMPs. BMP effectiveness will vary from year to year and therefore the goal is to find practices that have acceptable environmental and economic risks and benefits.

Modeling Component

The Soil and Water Assessment Tool (SWAT) was originally designed to simulate hydrologic and water quality processes in large watersheds – it has been adapted for use in small watersheds, as in the case of the WBBE Program.

The University of Guelph's WEG (Watershed Evaluation Group) is adapting the SWAT to simulate hydrologic processes and to assess BMP performances for the Gully Creek Watershed.

The preliminary setup of the SWAT model has been completed, and the preliminary model has been run. The initial run of the model showed room for improvement, as some nutrient and sediment levels were either over or under estimated. This performance will be improved by incorporating further BMP, updated climate and hydrological data.

There are several next steps in the modeling process. These include:

- Incorporating the LiDAR based Digital Elevation Models (DEM)
- Parameterize WASCOBs using the 'Pond' function in SWAT
- Calibrating and validating flow, sediment and water quality data
- Running a pre and post BMP scenario and comparing results

The LiDAR DEM will increase the spatial resolution of the input data that is used in the modeling process. This will give further confidence in the results. This new DEM has the potential to change the delineation of the subwatershed and HRU boundaries. While the changes are unlikely to be large, they could impact the land management data that was entered. Further calibration would be needed.

To model the WaSCoBs for this study, the "Pond" function in SWAT will be used. This function has the necessary variables to capture WaSCoB features, but also has some limitations. The LiDAR DEM should help alleviate some of these limitations, but further study will be needed.

Further calibration of water flow data is needed for the model. Currently, the model is based on monthly flow data. Additionally, further calibration and validation of nutrient data can be completed using water quality data from the ABCA.

Once the model setup is complete, the modelers will be able run the model on pre and post BMP senarios to further examine the effects of the four types of BMPs on water quality at both field and watershed scales. This model can also be used to examine different BMP scenarios such as the effects on water quality with no BMP, an existing BMP, or planned BMPs.

Results Summary Table

Table 2: A summary of the biophysical, economic and modelling results for Watershed Based Best Management Practices Evaluation Crops and Creeks, Huron Project

BMP	ENVIRONMENTAL EFFECTIVENESS	ECONOMIC EFFECTIVENESS	HYDROLOGIC MODELING
Nutrient reduction in crop fertilizer	• Soil test numbers to come • Unable to measure nutrients in water due to lack of surface water runoff	• Initial findings suggest yields may be lower with reduced N – results in net loss • Based only on one year of data – more data collection needed • Financial incentive needed to adopt	• Preliminary SWAT setup has been initiated • Results to be determined
Erosion control structures (berms)	• To be determined	• Can be costly to install • Some loss of land associated with narrow based berms	
Cover crops	• To be determined	• Cover crop seed can be costly	
Conservation tillage	• Initial findings suggest reduction in nitrates, and show differences in phosphorus forms. Further study and characterization of sites is needed. No observed difference in surface water runoff amounts	• Initial investment in equipment can be costly (references needed) • Returns may be limited and dependant on crop type	

Conclusions

The Crops & Creeks, Huron WBBE Program has used different approaches to evaluate the environmental and economic effectiveness of agricultural BMPs at both the watershed scale, and site-specific scale. At this early stage, specific findings regarding the impact of BMPs are unclear. However, this project has provided good information about watershed processes, including water quality and quantity information, as well as specific land use systems.

Initial findings regarding the economic impacts of BMPs show that some farmers prefer some type of financial incentive to implement BMPs. However, there are numerous landowners that consider the use of BMPs as "good farming practices," and employ them without additional financial incentive. Further study and analysis is needed to determine the specific economic benefits and costs in implementing BMPs.

The preliminary SWAT setup has been successfully initiated for this project. Improvements to the model continue to be made, and further data collection is needed to continue the process.

Overall, continued data collection is needed to further evaluate the effectiveness of BMPs and to gain confidence in the initial findings. Next steps to further this study include:

- Determine more specific BMP sites for environmental and economic study (including cover crop, conservation tillage and nutrient reduction)
- Continue to collect pre and post berm water quality data
- Continue to collect water quality and water flow data at both the watershed and field scales
- Continue to collect land management data through landowner surveys where possible to supplement the modeling process
- Continue to collect windshield crop survey data to supplement the modeling process

Please note that the format of this summary was based on:

Stuart, V., D.B. Harker, T. Scott, and R.L Clearwater (eds). 2010. Watershed Evaluation of Beneficial Management Practices (*WEBs*): Towards Enhanced Agricultural Landscape Planning – Four-Year Review (2004/5 – 2007/8). Agriculture and Agri-Food Canada, Ottawa, Ont.