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Evaluation Project

2007 – 2011

2008 Progress Report


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2008 Progress Report

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EXECUTIVE SUMMARY

Introduction

Alberta crop and livestock producers face challenges of increasing input costs, market competition, and continued pressure to improve environmental stewardship. The impact of agriculture on the environment has more recently focused on livestock production and, in particular, the intensive livestock industry and manure nutrient management. While several beneficial management practices (BMPs) have been developed to manage manure, and nutrient management in general, it is unlikely that one BMP will effectively utilize manure nutrients for crop growth and at the same time reduce all negative environmental impacts. It is more realistic that combinations of management practices are required.

The effectiveness of BMPs under Alberta conditions is not well known. However, producers are requesting site-specific, risk-based analytical tools to assist them in deciding which management practices would yield the greatest impact for their financial investment. Science-based proof is needed to validate that these practices reduce risks to producers, gain economic and environmental advantages, and provide viable options for producers to meet policy and regulatory requirements in Alberta.

At the farm and watershed scales, research becomes more difficult because fewer factors can be controlled, replication is less feasible, and large-scale studies are more expensive. In spite of the challenges involved with this type of research, several individual studies and large research projects have studied the effectiveness of BMPs, and in some cases carried out economic analysis. Under the leadership of Alberta Agriculture and Rural Development, and in partnership with the Alberta Crop Industry Development Fund, Alberta Environment, Municipality of Pincher Creek, and the County of Lacombe, a 5-yr research project was started to evaluate BMPs at field and watershed scales in Alberta. This report summaries the progress of the project after the first 2 yr.

Objectives

The overall objective of this project is to evaluate the environmental and economic effectiveness of BMPs at the field scale within selected Alberta agricultural watersheds, with a focus on nutrient management, manure and livestock management, and

riparian and rangeland management. Modeling techniques will be used to extrapolate results and the assessment of BMPs in other watersheds in Alberta. The specific objectives are:

- Evaluate the effectiveness of individual nutrient BMPs in reducing agricultural impacts on the environment at the farm scale.
- Assess the impacts of selected BMPs on the water quality in specific reaches of the stream in the watershed.
- Predict the cumulative impacts of selected BMPs on the overall quality of the watershed stream using models.
- Evaluate nutrient management BMPs for effective use of manure in crop production.
- Assess economic costs and benefits associated with individual BMPs implemented in this study.
- Investigate the ability to determine the source of nutrient loss to the environment, i.e., manure or fertilizer.

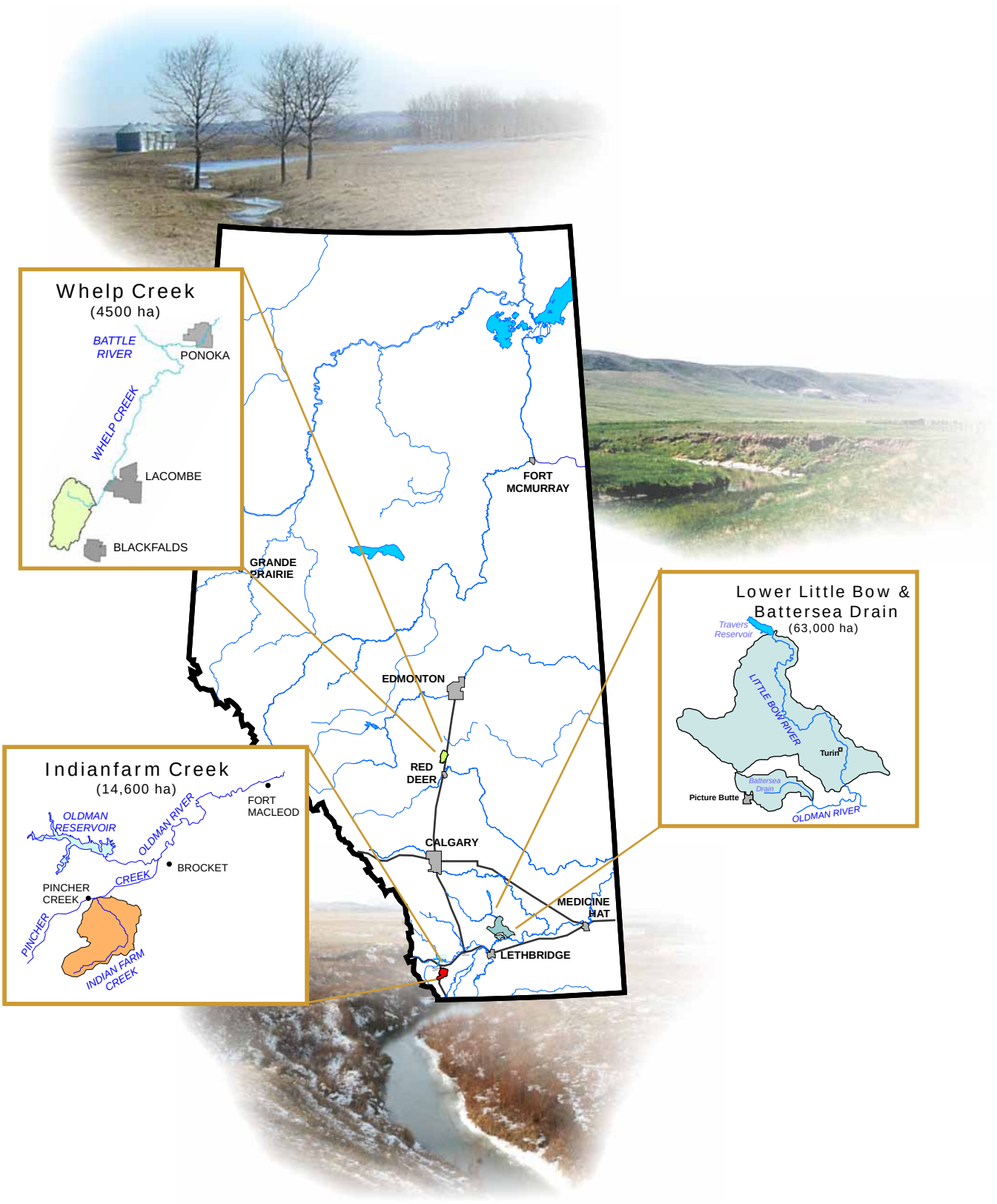
Project Design and Methods

Watershed sites. Indianfarm Creek Watershed (about 14,624 ha) near Pincher Creek, and Whelp Creek Sub-watershed (about 4685 ha) near Lacombe were selected for the study. In addition, two field sites were selected: one (65ha) in the Battersea Drain Watershed and the other (130 ha) in the Lower Little Bow River Watershed. Through previous studies, these two field sites were known to have very high nutrient content (i.e., 300 to 700 Mg kg^{-1} soil-test phosphorus) caused by manure application, and they are both under irrigation management, which is not represented in the Indianfarm Creek (IFC) and Whelp Creek (WHC) watersheds. All sites are under intensive crop and livestock production.

The northern part of Indianfarm Creek Watershed.

Beneficial management practice sites. Seven BMP sites were established in the IFC Watershed and six BMP sites were established in the WHC Sub-watershed. Including the Battersea Drain Field (BDF) and Lower Little Bow Field (LLB) sites, there are a total 15 BMP sites.

The seven BMP sites in the IFC Watershed included three manured fields: North Manure Field (NMF), South Manure Field (SMF), and the Dairy Manure Field (DMF). A pasture management site (PST) and a corral site (COR) are managed as a single BMP. As well, there is a livestock wintering site (WIN) and a water impoundment (IMP), which is a body of water created by an earth dam across one of the tributaries of IFC. A cereal field, without manure application, was also selected to serve as a reference site (REF).



Location of study watersheds in Alberta.

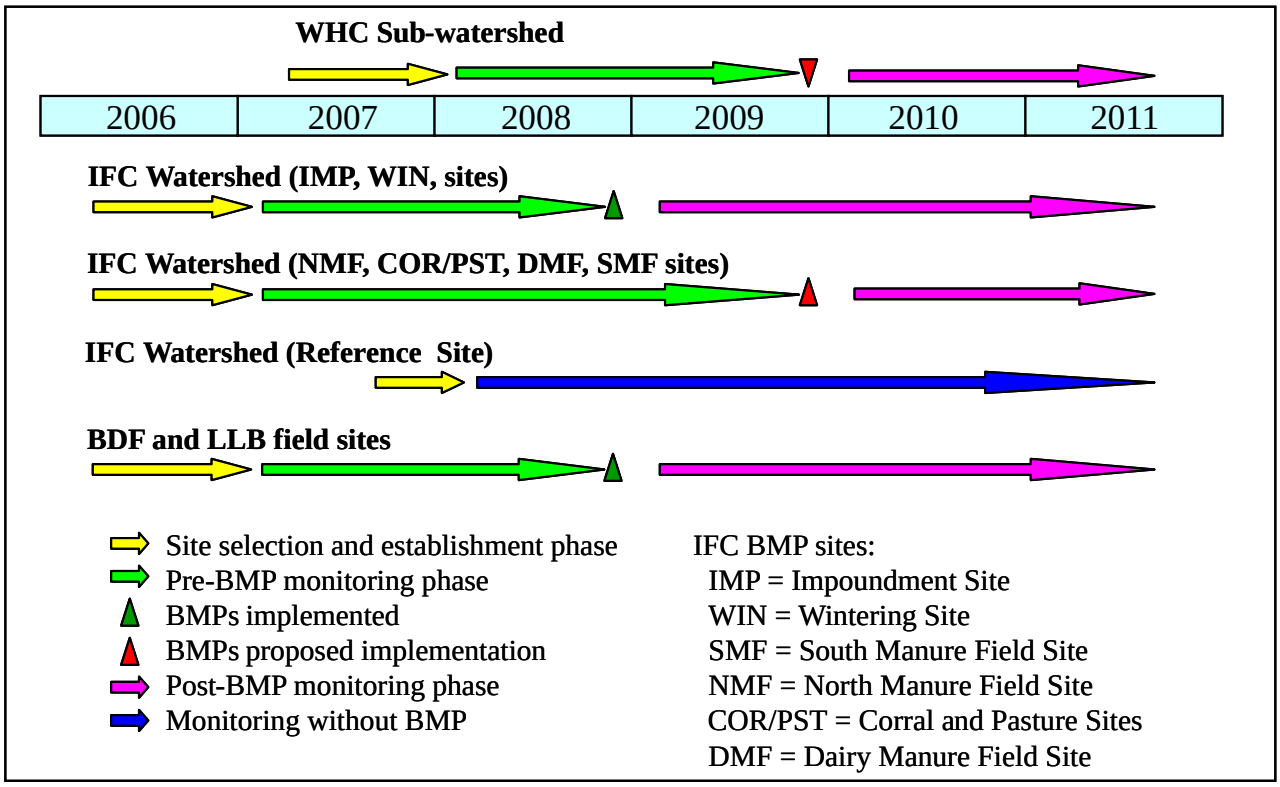
The WHC Sub-watershed BMP sites included four crop fields with manure management: North Field (NFD), West Field (WFD), East Field (EFD), and South Field (SFD). There are also two pasture sites and two reference sites: North Pasture (NPS), South Pasture (SPS), Reference 1 (REF1) and Reference 2 (REF2).

Whelp Creek Sub-watershed.

Experimental design. The main focus will be on water quality, but other indicators, such as rangeland and riparian health will be assessed as well. The study will examine the effectiveness of individual BMPs within watersheds. In addition, watershed-wide assessments of water quality, land use, economics, and the information obtained from individual BMP sites will be used in a modeling exercise to predict BMP influence on agricultural watersheds in Alberta.

The experimental design was to monitor the BMP sites under existing practices for 2 yr, beginning in 2007 for IFC, BDF, and LLB and in 2008 for WHC. Then, BMPs would be implemented followed by post-BMP monitoring for 2 yr in the WHC and 3 yr in the IFC, BDF, and LLB. Water monitoring techniques at the individual BMP sites includes upstream-and-downstream sampling, edge-of-field sampling, or a combination of both. In addition, where applicable, monitoring the health and changes in riparian and rangeland will be included. The experimental design was slightly altered in 2008. Due mainly to limited water quality data, some of the sites in the IFC Watershed will be extended for a third year of pre-BMP monitoring.

Land cover, land use, and economics. Watershed-wide land cover data were collected in the IFC and WHC watersheds by using air photos and visual observations. Detailed field management and economic information of the BMP sites were obtained from the cooperating producers.



Project experimental design and timeline.

Water quality and flow monitoring. A combination of circular flumes, in-stream flow monitoring, grab sampling, and automatic samplers (Iscos) were used for in-stream and/or edge-of-field sites. Water flow was determined using a variety of methods. Water samples were analyzed for nitrogen, phosphorus, and bacteria.

Soil, manure, crop sampling. Soil samples (0 to 15 cm) were collected from all the annual cropped BMP fields in both watersheds in the spring and fall 2008. In addition, the BDF and LLB sites were soil sampled (0 to 60 cm) in the fall 2008 to develop nutrient management plans as part of the BMP implementation. All samples were analyzed for soil-test phosphorus, extractable nitrate nitrogen, and extractable ammonium nitrogen. Manure samples were taken during application at three BMP sites in the WHC Sub-watershed (NFD, SFD, and REF1 sites) and at the DMF site in the IFC Watershed in 2008. All samples were dairy manure. Crop samples were not taken from any of the BMP sites in 2008. It was decided to rely on information from the cooperating producers to obtain yield estimates.

Rangeland and riparian assessments. The rangeland health assessment was continued at the PST site in the IFC Watershed in 2008 and percentages of individual plant canopy cover were determined. Production cages were also placed in the PST site. Riparian health assessments were carried out at the PST, WIN, and IMP sites and the number of individual species, except grasses, was counted and percentage cover was visually estimated.

Water monitoring station in the Whelp Creek Sub-watershed showing a circular flume and equipment shed.

Summary of Progress

Indianfarm Creek Watershed. In 2008, the second season of the pre-BMP monitoring phase was completed in the IFC Watershed. In addition to work repeated in 2007, a basin-wide synoptic survey was carried out. The purpose of the survey was to track water quality from the headwaters to the outlet. As well, BMP implementations were initiated at two sites (IMP and WIN).

Monthly mean average daily temperature in 2008 was similar to the 30-yr avenge for most months. Total precipitation in 2008 was 643.5 mm, and was more than double the amount of total precipitation in 2007.

Much like 2007, the IFC Watershed was split into two major land use categories: annual cropping at 44% of the land base, and perennial forage at about 55% cover. Mapping products revealed where the transition from perennial to annual plant cover occurs within the watershed. Livestock production is mainly cattle with cow-calf operations, a few small feedlots, and one large feedlot.

The watershed-wide monitoring and the synoptic surveys showed, regardless of time of year, water quality deteriorated downstream from the headwaters to the outlet. The degradation of water quality was most prevalent during periods of rainfall. Most nutrient parameters exceeded water quality guidelines at one time or another. Parameters that exceeded water quality guidelines most frequently were total nitrogen. The Nutrient Water Quality Sub-Index showed that most monitoring stations had poor water quality.

A comprehensive riparian inventory was completed in 2008 at the PST/COR and WIN sites. All sites were heavily influenced by livestock activity and high water events, which was evident by the amount of exposed soil, cattle trails, bank slumping, and invasive plant species. In almost every

instance, the growth of riparian specific vegetation had been impeded leading to invasive species dominance and riparian system degradation.

Additional range assessment transects were added in 2008 at the PST/COR site. The grass and forb production was concurrent with what be normally expected. The presence of undesirable grass species did not necessarily inhibit production but it will alter the desired plant community as well as limit the available forage for healthy grazing in the latter part of the year. The most notable information gathered from the production data was the limited amount of plant litter or old growth left from prior grazing.

In 2008, the six BMP and reference sites were monitored for the second year of the pre-BMP phase. After 2 yr of collecting pre-BMP data, only two sites proceeded with BMP implementation: the Impoundment (IMP) and Wintering (WIN) sites.

The IMP site water quality met livestock drinking guidelines, but the nitrogen and phosphorus concentrations exceeded the guidelines for the protection of aquatic life. Nutrient concentrations were driven by surface runoff from snowmelt and precipitation, as well as livestock and wildlife. Bacteria concentrations generally met established parameters except during rainfall runoff events. The BMP involved the construction of a barbed wire fence around the IMP water body. A portable livestock watering system will be installed in the spring 2009 and bioengineering will be implemented. The BMP costs to date are $13, 250 and 8 hr of labour.

The WIN site water quality showed that concentrations of nitrogen, phosphorus, and *E. coli* increased upstream to downstream. Livestock had direct access to the stream year round and this was evident by visual observation and the amount of livestock related indicators. In the fall of 2008, a barbed wire fence was constructed to control cattle access to the creek, and a new wintering site was constructed further from the creek. A new watering system was also installed for the wintering site. The BMP costs to date are $13, 900 and 40 hr of labour. Another watering system and bioengineering will be completed in 2009.

Construction of a new wintering site.

Whelp Creek Sub-watershed. In 2008, the first season of the pre-BMP monitoring phase was completed in the WHC Sub-watershed. Data collected included water flow and quality, soil, weather, manure, land cover, and land management information.

Monthly average daily temperatures were generally above the 30-yr average during the winter and fall months of 2008 and were similar to the 30-yr average during the spring and summer months. Total precipitation was below the 30-yr average through most of the growing season.

In 2008, 61% in the sub-watershed was annually cropped and 20% was perennial forage and pasture. Livestock production in 2008 remained similar to 2007, with 10 dairy operations, three hog operations, seven feedlots, and cow-calf grazing and production operations.

Watershed-wide water quality monitoring was carried out in 2008. Nutrient concentrations were highest during snowmelt compared with rainfall runoff. Total coliforms and *E. coli* levels were highest during rainfall runoff.

In 2008, six BMP sites and the two reference sites were monitored for the first year of the pre-BMP phase. A second pasture site was established in 2008. Generally, water quality data suggested that the BMP sites contributed to water quality degradation. The relatively shallow slopes at the sites made hydrology interpretation difficult. It became apparent that areas within the sub-watershed are influenced by groundwater hydrology.

Battersea Drain Field Site. The second year of pre-BMP monitoring was carried out at the BDF site in 2008. Potatoes were grown in 2007 followed by corn silage in 2008.

Precipitation in 2008 was 11% below the 30-yr average, but higher than the precipitation in 2007. In 2008, the total flow volume was 92% of the volume in 2007. Edge-of-field flow was nearly five-fold greater in 2008 compared to 2007. Most edge-of-field runoff occurred during irrigation or rainfall events, and the edge-of-field volume was small (<0.2%) compared to the flow volume in the drain.

Total nitrogen concentration increased from upstream to downstream. This increase mainly occurred during low flow when the irrigation delivery was shut down. The large increase in total nitrogen from upstream to downstream suggests nitrogen may leach from the site soil profile and into the shallow groundwater. Total phosphorus concentration did not change from upstream to downstream in 2007. In 2008, total phosphorus decreased from upstream to downstream. Concentration of *E. coli* was similar between 2007 and 2008 and showed little difference from upstream to downstream.

Concentrations of nitrogen, phosphorus, and *E. coli* were higher in edge-of-field runoff compared to the concentrations in the Battersea Drain. The difference between instream and edge-of-field was much greater for total phosphorus compared to total nitrogen. The difference in concentrations may be attributed to mobility as nitrogen is more readily leached into groundwater and phosphorus has greater surface runoff potential. In 2007, total suspended solids concentration was 5.6 to 9.9 times higher in the edge-of-field runoff compared to instream. In 2008, the reverse of this was true. Total suspended solids was 1.6- to 2.3-fold higher instream compared to edge-of-field runoff. This discrepancy may be the result of the different crops.

The nutrient loads were higher in 2008 than in 2007 at the downstream station. Most of the flow occurred during the irrigation season. However, nutrient loading did not coincide with flow volume. The edge-of-field loads ranged from 0.01 to 6% of the loads at the downstream station.

Mean soil test phosphorus concentrations ranged from 328 to 475 mg kg^{-1}, which are well above the agronomic threshold of 60 mg kg^{-1}.

The BMPs identified for this site included nutrient and irrigation management. Part of the nutrient management plan is to stop applying manure, or any form of phosphorus. Soil samples will be collected in the fall 2009 and 2010 to determine nitrogen fertilizer requirements for 2010 and 2011. If required, the Manure Management Planner software will be used to develop application rates. The irrigation system will be modified with a programmable control panel to stop

the corner arm application of irrigation as the pivot approaches and passes over the Battersea Drain. In addition, the Alberta Irrigation Management Model program will be used to schedule irrigation events. The BMP costs to date are about $9, 500 and 3 hr of labour.

Metering water flow in the Indianfarm Watershed.

Lower Little Bow River Field Site. The second year of pre-BMP monitoring was carried out at the LLB site. In 2008, the two quarter sections were seeded to canola. Due to hail damage, the northwest quarter section was re-seeded to barley in June.

The export of nutrient, sediment, and bacteria from the LLB site was primarily driven by irrigation runoff. Very little, if any, runoff occurred due to snowmelt or rainfall. Generally, nutrient concentrations tended to be higher during the rainfall than irrigation events. Average total nitrogen and total phosphorus concentrations were more than two-fold higher in 2008 than 2007, and this may be attributed to the manure that was applied. Bacteria tended to peak in July or August. The total suspended solids concentrations were variable, peaking during either rainfall or irrigation runoff.

The BMPs identified for this site included nutrient and irrigation management. The former includes developing a nutrient management plan and to stop applying manure to the site. To control the amount of surface runoff, the irrigation system will be modified and irrigation scheduling will be carried out using the Alberta Irrigation Management Model program. Total BMP costs to date are about $57, 000 and 10 hr of labour. The majority of the cost (about $42, 000) was for manure handling and hauling.

Application of the CEEOT Model

The application of the Comprehensive Economic and Environmental Optimization Tool (CEEOT) to evaluate BMPs in this study was initiated in 2008. The CEEOT model includes environmental and economic components, and it was chosen because of its capabilities in evaluating a wide range of BMPs at the watershed and smaller scales. The primary focus of the CEEOT activities in 2008 was data collection and baseline establishment.

A protocol report for BMP assessment in Alberta was prepared. The protocol document covered only the computer simulation and analysis. A subsequent report will provide a more detailed discussion of transferability of the assessments to other watersheds in Alberta. Preparation of input files were started including digital elevation models, land management, soil distribution and characteristics, hydrographic data, location of water monitoring stations, climate data, water quality and quantity, and economics. In addition, the model calibration and verification process for the WHC and IFC watersheds were initiated.

Work in 2009 will be a continuation of tasks initiated in 2008 such as calibration and baseline establishment, as well as carrying out initial simulations.

Communication Activities

The communication team continued regular contact with participating producers and partners to maintain relationships and expand partnerships for the project. A variety of communication strategies and activities were implemented in 2008 including individual contact with producers, collaboration with partners, media requests, conferences, information meetings, and the development of extension resources and presentations. A Project Steering Committee was established with industry representatives, research institutions, and funding partners to assist with reviewing and communicating the project results.

The communication team also led the formation of watershed groups in the IFC and WHC watersheds to identify and address local issues. The IFC Watershed group identified stream bank erosion as an issue; whereas, groundwater and surface water interaction and water well protection are areas of interest for the Whelp Creek Sub-watershed group.

Future Work

The third year of water quality and quantity monitoring will occur in the IFC Watershed and at the BDF and LLB sites in 2009. The second year of pre-BMP site monitoring will occur in the WHC Sub-watershed. A synoptic water survey will be carried out on the main stem in the WHC Sub-watershed in the spring 2009. Also, in the WHC Sub-watershed groundwater work will be initiated in collaboration with the University of Alberta to better understand the influence of agriculture on this resource.

The management of the four sites with implemented BMPs (IMP and WIN sites in the IFC Watershed; BDF; LLB) will continue in 2009. Monitoring in 2009 will be the first of the post-BMP phase for these four sites. The remaining BMP sites in the IFC Watershed (NMF, SMF, DMF) will continue to be monitored and the feasibility of BMP implementation will be assessed. The 2009 monitoring season will be the second pre-BMP year in the WHC Sub-watershed and the feasibility of implementing BMPs at the BMP sites will also be assessed.

Soil and manure samples will be collected as required. Soil samples will include surface (0 to 15 cm) samples to relate to runoff water quality, agronomic samples (0 to 60 cm) for nutrient management plans, and site characterization samples. Additional riparian and rangeland assessments will be carried out in the IFC Watershed.

Input files for the CEEOT model will be completed and verified. Research staff will continue to receive training on the CEEOT model at the TiAER facility.

Communication strategies and activities carried out in 2007 and 2008 will continue, and information will continue to be provided to commodity groups and other stakeholders to help meet project objectives and to obtain feedback on the progress and outcomes of the project.

Synoptic survey water sampling at Indianfarm Creek.

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