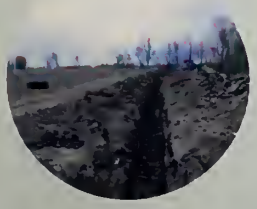
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Watershed Evaluation of Beneficial Management Practices (WEBs)



South Nation

Ontario

British Columbia
Alberta
Government of Saskatchewan
Manitoba
Ontario
Québec
Newfoundland Labrador
Nova Scotia / Nouvelle-Écosse
New Nouveau Brunswick
Prince Edward Island
Yukon Government
Northwest Territories
Nunavut
Canada
Ducks Unlimited Canada / Canards Illimités Canada

The Watershed Evaluation of Beneficial Management Practices (WEBs)

is a national project led by Agriculture and Agri-Food Canada (AAFC), with Ducks Unlimited Canada a key funding partner. Designed to measure the performance of selected agricultural beneficial management practices (BMPs) at a watershed scale, the project studies the impact of BMPs on water quality in seven micro-watersheds across Canada. Each site includes an on-farm economic assessment and a hydrologic modelling component, with integrated modelling occurring at two of the sites. WEBs was initiated in 2004 and will run to March 31, 2008.

The WEBs project has stimulated the formation of a network of living laboratories across Canada, bringing together hydrologists, economists, modellers and agri-environmental experts from government, academia and non-government organizations. The result is high quality applied research and exceptional opportunities for future collaboration in areas of common interest.

Beneficial management practices are science-based farming activities designed to help minimize potential environmental impacts such as sediment and nutrient runoff into water bodies. Prior to WEBs, the effectiveness of individual BMPs was evaluated largely on test plots or at a small field scale, with results extrapolated through modelling to the watershed scale. WEBs was created to address limitations to these evaluation methods by applying a suite of BMPs and studying their economic impact and effect on water quality at the micro-watershed level (i.e. approximately 300 hectares). The suites of BMPs have been specifically tailored to the unique conditions of each watershed.

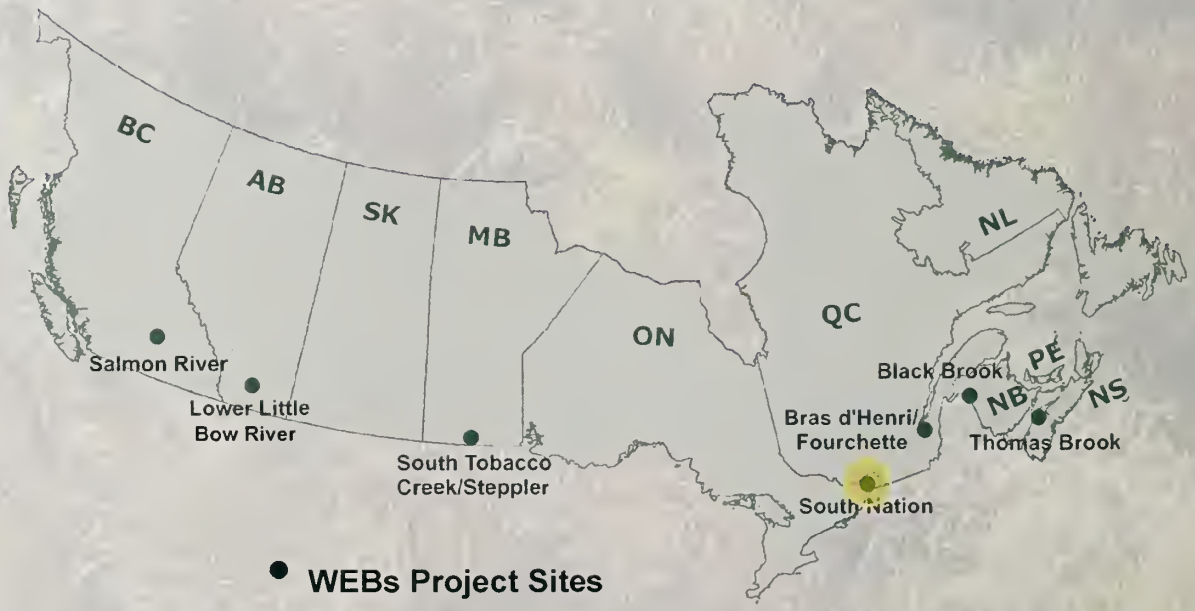
The long-term history of conditions and trends is generally well understood at each of the seven WEBs watersheds, due to past activities and data collection by local watershed associations and multi-agency teams. It is anticipated that these sites will continue as long-term benchmarks for watershed health.

Environmental evaluations are being conducted through a range of validation techniques to determine the impact of individual and suites of BMPs on water quality at each watershed. Methods employed include historic benchmarking, paired watersheds, upstream and down-stream monitoring, and edge-of-field testing. All studies have been designed with in-field assessments, intended to yield scientifically valid and publishable results at the end of the project.

On-farm economic assessments are being conducted at all WEBs watersheds, using approaches that are best suited to the unique circumstances of each site. Through the development of economic models and impact assessment tools, economists will be able to determine the costs and benefits of BMP implementation scenarios. The socio-economic factors that might affect producers' decisions to adopt BMPs are also being examined.

Hydrologic modelling is being conducted at each WEBs site in order to characterize watershed processes under baseline conditions and to examine the water quality benefits of BMP implementation. In most cases, models based on the Soil and Water Assessment Tool (SWAT) are being used to evaluate the impact of different BMP scenarios. These models are being modified to suit Canadian climatic conditions and to accommodate specific BMPs. The South Tobacco Creek, Bras d'Henri and Black Brook watershed sites are particularly well advanced in the process.

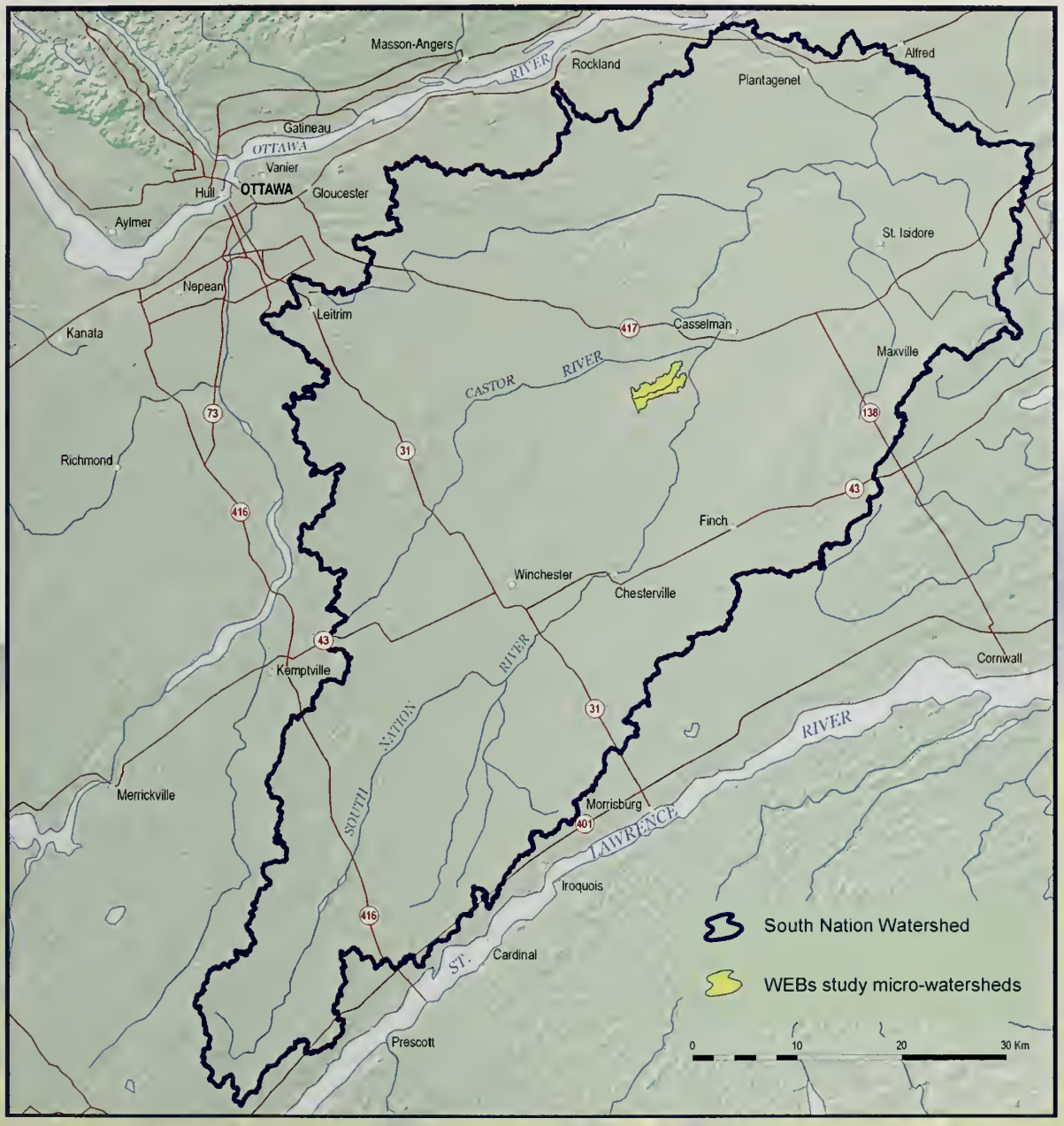
Integrated modelling is underway at the South Tobacco Creek and Bras d'Henri sites. This component incorporates hydrologic, environmental, economic and producer behavioural aspects into a multi-faceted decision tool at the micro-watershed and larger watershed scale. Models are being validated using actual watershed data, as opposed to data extrapolated from other studies.



● **WEBs Project Sites**

South Nation Watershed

Ontario's South Nation River drains 3,810 square kilometres from its headwaters just north of the St. Lawrence River near the city of Brockville, northward to its confluence with the Ottawa River near the community of Plantagenet. Approximately 60 per cent of the watershed is farmed, with a mix of livestock and cash crop production—mostly on flat, tile-drained fields.



Two micro-watersheds within the South Nation Watershed, each about 300-400 hectares, have been chosen to evaluate the effectiveness of two BMPs designed to alleviate pollutant loads to water courses. One of these watersheds—the Blanchard Municipal Drain—drains into the Little Castor River, and the other—the Bisaillon Municipal Drain—drains directly into the South Nation River. These two micro-watersheds feature agricultural-based activities typically found throughout Ontario.

Water quality in the South Nation Watershed is reduced in many areas, while agricultural and urban pressures continue to increase.

Problems include direct cattle access to streams and rivers, and manure runoff from fields which can lead to fecal contamination of water resources. Research in this watershed has shown that tile drainage allows high levels of nutrients (nitrogen in particular) to rapidly move into streams and municipal drains.

South Nation Conservation is a community-based environmental organization dedicated to conserving, restoring, developing, and managing natural resources in the South Nation Watershed. They are involved in all aspects of the WEBs project, including landowner liaison.

Beneficial Management Practices a

Two BMPs are being assessed within the South Nation Watershed within two paired mi

Controlled tile drainage

The effects of controlled versus uncontrolled drainage outlets are being evaluated to determine whether controlled drainage effectively reduces pollutant inputs to streams—while at the same time improving crop performance. Tile drainage is controlled by installing water level control structures at header drain outlets to seasonally restrict the water in these drains from discharging into water courses, thereby retaining soil water and nutrients in the field for crop growth.

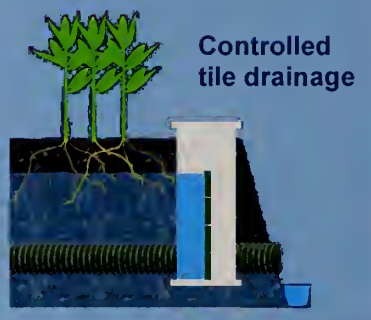
How does controlled tile drainage work?

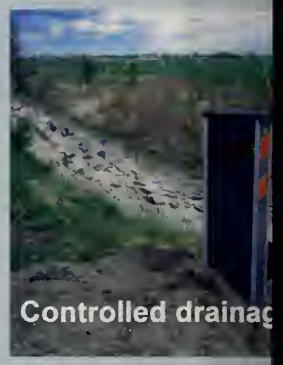
With uncontrolled tile drainage (see figure at top right), drainage occurs from the tile drain directly into the water body. Contaminants from agricultural usage reach the water more quickly than in non-tile drained fields. Runoff from uncontrolled tile drained fields typically contains very high concentrations of nitrogen.

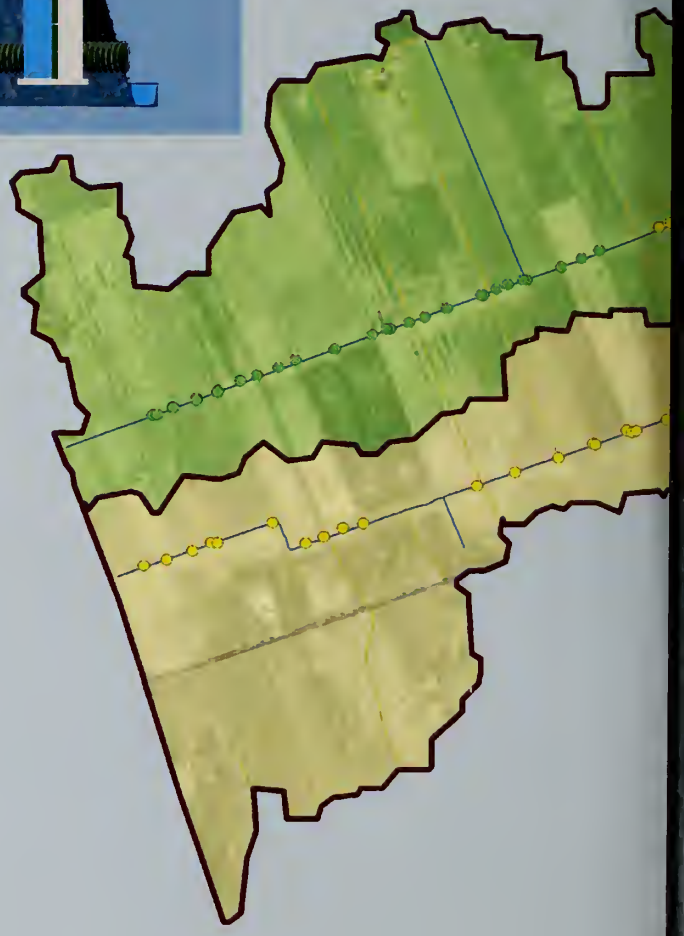
With controlled drainage (see figure at bottom right), the control structures on the tile headers remain open in spring to permit free drainage and allow for improved soil aeration until after field operations or, in some cases, until after crops are adequately established. The structures are then closed to restrict drainage. This practice stores nutrient-rich water for crops to access later in the growing season.

This BMP reduces nitrogen runoff through two processes. Firstly, the volume of drainage water leaving the field is reduced—controlled drainage may completely eliminate outflow in dry years. Secondly, the high water table facilitates a denitrification process within the soil.

The effects of controlled drainage are studied through assessment of nitrogen balances (in solute and gas form), crop performance, and soil/groundwater hydrology.







Field evaluation of the controlled drainage BMP is conducted through the establishment of land-use pairs in the WEBs study fields (as marked on the map and legend). A transect monitoring-based approach is used to conduct detailed water quality analysis at permanent monitoring locations in these study fields.

Tile flow is the primary source of stream flow within the Blanchard and Bisaillon micro-watersheds. To date, 75 drainage control structures have been installed throughout these micro-watersheds.

A paired watershed approach is applied using a control watershed and a research watershed that are alternated throughout the course of the study. This practice provides the necessary baseline data with which to assess the water quality improvements resulting from BMP implementation.

he South Nation Watershed

-watersheds—the Blanchard and the Bisaillon Municipal Drains.

Meteorological Station
Edge-of-field monitoring sites
In-stream monitoring sites
Restricted cattle access
Unrestricted cattle access
Micro-watershed boundary
Drainage control study field
Free tile drainage study field
Control structure
Uncontrolled outlet
Bisaillon drainage contributing area (free-drained area)
Blanchard drainage contributing area (control-drained area)

Restricted cattle access

A 500-metre upstream portion of a pasturing system in the Blanchard micro-watershed has been fenced to prevent cattle access. Cattle density is 2.6 head/hectare. A three-metre riparian buffer has been established in accordance with Ontario Ministry of Agriculture and Rural Affairs (OMAFRA) guidelines.

A small cattle bridge (left) has been added to allow a single cattle access point to pasture on the north and south sides of the stream. Off-stream watering has been provided.

Immediately downstream from the cattle exclusion area, cattle are allowed unrestricted access to the stream. Comparisons of nutrient and fecal pollutants at the end-flow point of each system are being compared.

The National Water Quality Surveillance Research Program—also referred to as the Microbial Source Tracking (MST) study—is being conducted by Health Canada and AAFC, in partnership with Environment Canada. Fecal source identification is being conducted in the South Nation Watershed through this initiative in an attempt to determine the most effective BMPs to reduce microbial contamination.

In addition, collaboration with OMAFRA has resulted in the development of nutrient management plans for participating producers in the area.

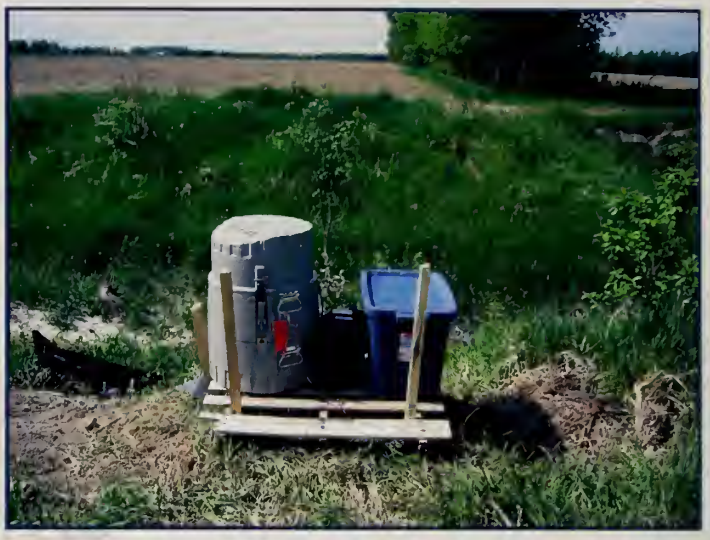
Monitoring Techniques

Water quality and quantity within the South Nation Watershed are monitored at 7 in-stream sites as well as at 8 edge-of-field sites and 32 in-field sites. The in-stream and edge-of-field sites are marked on the BMP map on the preceding pages.

Four of the **in-stream monitoring** sites feature YSI multi-probes which measure dissolved oxygen, pH and water temperature; area velocity sensors which calculate discharge rates; auto-samplers which collect samples intermittently throughout hydrograph events; and tipping buckets which measure precipitation.

The in-stream monitoring sites within the cattle access area are equipped with auto-samplers only. Water samples are taken manually (grab samples) twice a week at all sites from April to December, and analyzed for nutrient, sediment and bacterial content.

Water samples from the cattle access areas are used to determine the source of the fecal matter in the stream, as part of the MST study.



Picture above: auto-sampler with edge-of-field equipment

Picture left: in-stream multi-probe

The WEBs study fields (indicated on the BMP map on the preceding pages) consist of four paired fields instrumented for in-field and tile-drainage monitoring. Under a common management practice, each pair consists of one tile-drain managed and one unmanaged field. An **edge-of field monitoring** site located at the tile outlet of each study field allows for direct comparison of treatments.

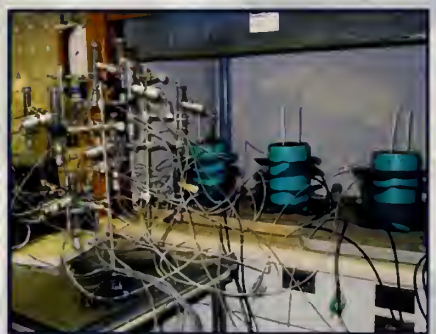
These edge-of-field sites are equipped with weirs and automatic water samplers. Water quality samples are collected manually twice a week from April to December, as well as automatically during hydrograph (discharge) events. Samples are tested for nutrient, sediment and bacterial content, in addition to turbidity, conductivity and pH.

In total, there are 32 **in-field monitoring** sites situated within the study fields. Groundwater levels and nutrient content are sampled using clustered piezometers; nutrient samples are then sent to a laboratory for immediate analysis. Suction lysimeters collect soil water samples, and Time Domain Reflectometry (TDR) probes record soil water content.

A **meteorological station** records climate data, including air temperature and precipitation.

Soil samples are taken from the study fields in spring, summer and fall, and analyzed for changes in nutrient (particularly nitrogen) content. Nitrogen budgets for crops grown in the study fields are then evaluated.

Pictures from left to right: Grab sampling as part of the MST project, suction lysimeters and greenhouse gas chambers in corn field, laboratory analyses of bacteria persistence and transport, meteorological station



Greenhouse gas chambers measure **greenhouse gas fluxes** (nitrous oxide, methane, carbon dioxide) from the surface. By comparing emissions from controlled and uncontrolled study fields, it may be possible to calculate denitrification rates for this BMP.

In addition, the amount of nitrogen being absorbed by the crop (plant nitrogen uptake), crop yields and crop growth/health are monitored using multi-spectral-based remote sensing platforms, and validated by handheld instrumentation that measures soil water or normalized difference vegetative index (NDVI).

A detailed **land-use assessment** has also been conducted. Land-use history has been gathered for the watershed (see map below) and will be used as part of an economic assessment that examines the on-farm costs and benefits incurred by South Nation producers as a result of BMP implementation. A producer survey is being carried out to collect data that is unavailable by other means. Data analysis is being used to compare on-farm revenues with BMP implementation costs to determine the feasibility of BMP adoption. Through the development of economic models and impact assessment, the costs and benefits of various BMP implementation scenarios can be examined.

Site manager Mark Sunohara operating portable TDR equipment.

Land use in the South Nation Watershed Fall 2005

Hydrologic modelling is being conducted using MACRO; a 1-D dual porosity soil water flow model to characterize tile-flow processes and tile-drainage management impact on those processes. Fundamental model input data include weather, land management and soil physical properties. Modelling is being calibrated using field-level data, and will be scaled up to the micro-watershed level.

WEBs studies will lead to a greater understanding of the ecology of the South Nation Watershed, thus bringing us a step closer to achieving improved water quality and a clearer picture of the value of BMPs for agriculture and the environment.

Methods and findings from this study may one day be applicable to larger watersheds and contribute to a better quality of life for more Canadians.

Project Partners

WEBs is a multidisciplinary project led by Agriculture and Agri-Food Canada, with Ducks Unlimited Canada a key funding partner. Various other provincial and federal government departments, universities, and conservation groups are also providing valuable cash and in-kind contributions. The support of local producers and watershed associations has greatly contributed to the project's success. The project's overall national budget totals more than $16 million.

Other participating partners in the South Nation WEBs project include: South Nation Conservation; Environment Canada; Health Canada; the Ontario Ministry of Agriculture, Food and Rural Affairs; and the University of Ottawa. Landowners within the two micro-watersheds are key cooperators.

Further Information

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