WATERSHED SCIENCE CENTRE

Surface Water Quality Threat Assessment Method

Using Landscape-Based Indexing

Increased frequency of low flow conditions and steadily increasing demand for water in Ontario have highlighted the need to better understand the impact of decreasing streamflow on surface water quality. Baseflow conditions are particularly important because of the decreased potential for dilution of contaminants at lower flows. This study examines methods and tools that can be integrated into a water quality susceptibility index for the screening of potential threats to surface water conditions across watersheds.

In December 2001, the Ministry of the Environment, Ministry of Natural Resources and Conservation Ontario formed a partnership to develop a series of watershed-based pilot projects. Phase I, completed in 2003, included six pilot projects that focused on new and innovative approaches to watershed stewardship. Phase II, with the objective to develop, implement and demonstrate place-based environmental management approaches, will provide some of the building blocks for the anticipated watershed-based drinking water source protection that will be undertaken in Ontario.

This is one of four pilot projects completed during Phase II which seeking on the ground results, focusing on implementation, and the technical issues faced by practitioners when implementing drinking water source protection.

The full reports and fact sheets are available on Conservation Ontario's website.

www.trentu.ca/wsc
www.conservation-ontario.on.ca

The Project
at a Glance...

This research project was conducted by the Watershed Science Centre at Trent University, in partnership with the Ministry of Natural Resources (MNR). The focus of the study was the development of methods, data layers, models, and tools to predict baseflow characteristics and potential nutrient loading at ungauged sites that could be integrated into a water quality susceptibility index used for screening potential threats to surface water conditions across watersheds. Research objectives were:

1. To develop a predictive model for estimating baseflow parameters at ungauged sites using landscape attributes.

2. To evaluate the degree to which landscape features at watershed scales influence nutrient loading in streams, and to develop a predictive model for identifying surface waters at greatest risk of high levels of nutrient loading across regional scales.

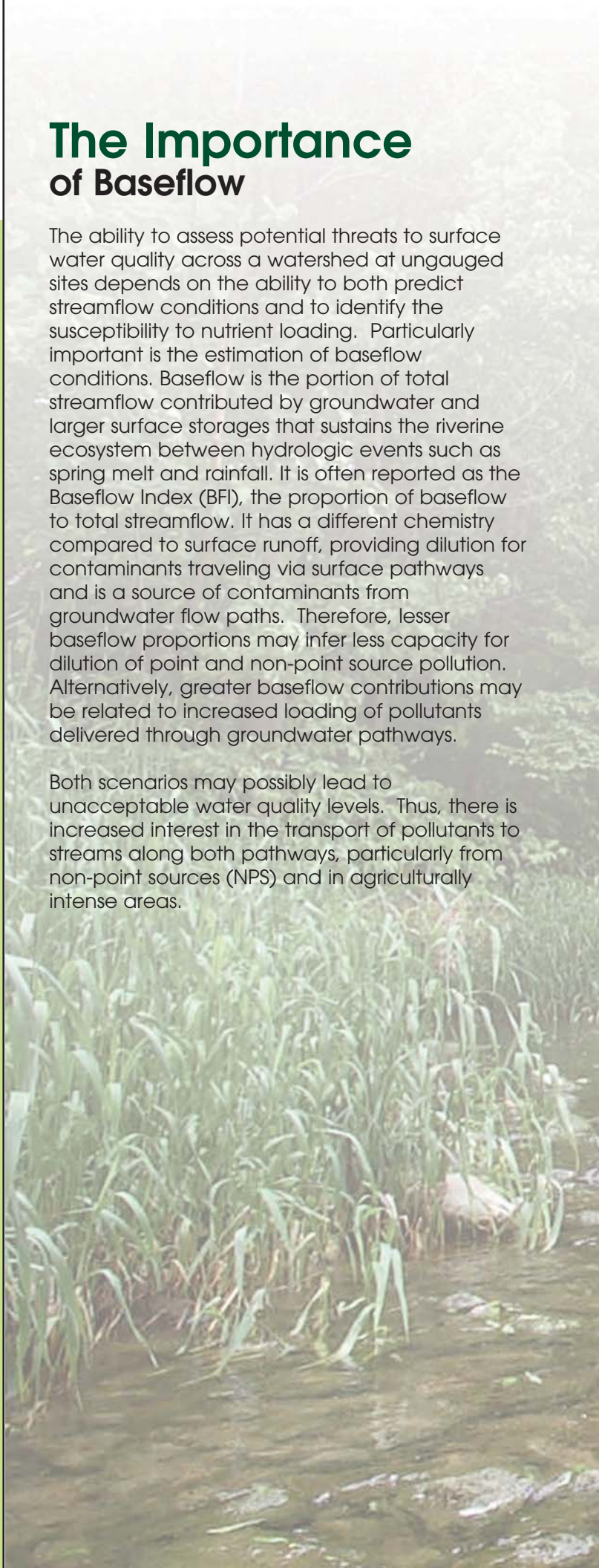
3. To use combined results of the baseflow and nutrient loading models to develop a susceptibility index for surface water quality that can be used to identify potential threats across regional scales.

The successful development of predictive models to infer both baseflow characteristics and phosphorus/nitrate loading in ungauged/unmonitored basins is important for assessing the regional variability of potential threats to surface water quality. The results are encouraging, showing that predictive models for both parameters, based on strong observed relationships, can be developed with minimum data while still being physically sound. In doing so, the approach provides screening tools that are easily accessible to a variety of jurisdictions largely independent of available resources.

The Importance
of Baseflow

The ability to assess potential threats to surface water quality across a watershed at ungauged sites depends on the ability to both predict streamflow conditions and to identify the susceptibility to nutrient loading. Particularly important is the estimation of baseflow conditions. Baseflow is the portion of total streamflow contributed by groundwater and larger surface storages that sustains the riverine ecosystem between hydrologic events such as spring melt and rainfall. It is often reported as the Baseflow Index (BFI), the proportion of baseflow to total streamflow. It has a different chemistry compared to surface runoff, providing dilution for contaminants traveling via surface pathways and is a source of contaminants from groundwater flow paths. Therefore, lesser baseflow proportions may infer less capacity for dilution of point and non-point source pollution. Alternatively, greater baseflow contributions may be related to increased loading of pollutants delivered through groundwater pathways.

Both scenarios may possibly lead to unacceptable water quality levels. Thus, there is increased interest in the transport of pollutants to streams along both pathways, particularly from non-point sources (NPS) and in agriculturally intense areas.



How the Model Basins
Were Selected

Basins with an historical streamflow record and a geographically-referenced digital drainage divide, providing the location and spatial extent of the basin, were considered for the analysis. Daily streamflow time series were obtained from Environment Canada's HYDAT database, an historical archive of over 1,000 gauging stations in Ontario. Digital drainage divides have been delineated for 532 of these gauging stations by the Water Resources Information Project (WRIP), led by the Ministry of Natural Resources (MNR). These boundaries are considered to be the most accurate currently available and thus were used in the analysis. Secondary criteria for basin selection included: i) a natural flow regime; ii) 20 years or greater period of records, iii) non-nested data (i.e. within the drainage area of another model basin), to meet the independence requirement for regression analysis; and iv) continuous flow measurement throughout the year (i.e. not seasonal). Ninety gauging stations in Ontario met these criteria with drainage areas ranging between 30 km^2 and 8,510 km^2.

Below: Ninety HYDAT gauging stations used in the baseflow analysis.

Implications for
Watershed Management

Both baseflow and non-point source contaminant loading from agriculture are a function of landscape-scale processes. Strong linkages have been observed between landscape attributes (such as soil, geology, land use, land cover, and topography of a watershed) and stream chemistry, allowing the development of predictive models of surface water quality. Working at the landscape-scale allows the development of methodologies applicable over wider areas, facilitating meaningful comparisons and the demonstration of broader environmental patterns. It is important to recognize that not only are physical processes scale-dependent but so too are management decisions. Thus, combined information on baseflow and land cover/land use patterns across regional scales can be used to identify potential areas susceptible to surface water quality threats. This can be strengthened by adding information on known point sources for a subsequent classification. The combined information is a valuable screening tool for identifying areas where greater attention should be focused, for both understanding process and evaluating susceptibility to water contamination.

Conclusions

Assessing potential threats to surface water quality requires information on streamflow, particularly baseflow, and contaminant loading at sites that are neither gauged nor monitored. This requires a novel approach based on observed relationships and known processes that can be applied with limited data. This research has resulted in data layers, models, and methods to elucidate both of these parameters in the development of a water quality susceptibility index that can be used in comparative analyses to assess potential threats to surface water conditions across watersheds.

The transferability of the methods over larger regional scales provides a common approach for threats assessment. Although not appropriate for guiding site-specific management actions within a watershed, the methods developed here show promise as screening tools for assessing potential threats to surface water quality using landscape parameters. They also provide a systematic screening strategy accessible to all resource managers to prioritize areas for more intensive research, monitoring, and management.

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