

Regional Watershed Monitoring Program Progress Report 2008

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Watershed Monitoring and Reporting Section
Ecology Division



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Introduction

The Regional Watershed Monitoring Program (RWMP) is a science based, long-term monitoring initiative developed by the Toronto and Region Conservation Authority (TRCA). Its purpose is to collect aquatic and terrestrial ecosystem data at the watershed and sub-watershed scale, and across the region as a whole. The program provides the data and information that informs the key planning and reporting mechanisms of the TRCA.

In 2001, the RWMP was launched as a mechanism to bring most of the TRCA's ecological monitoring work under a single program. This in turn has enhanced planning and coordination, protocol standardization, filling of data gaps, effective data management, consistency and cost effectiveness. It also facilitates the communication of data availability and data sharing both internally and with external agencies. Some elements of the program were being collected prior to the RWMP, while others were initiated since 2001. By the end of 2008, most components of the monitoring program had completed at least five years of data collection.

The scope of the RWMP focuses on key components of the terrestrial and aquatic ecosystems, including:

- **Climate and Hydrology** – monitors changes in the water level of the regions watercourses along with contributing precipitation (rain and snow);
- **Water Quality in the Rivers** – assesses a variety of basic water chemistry, metals and microbiological parameters;
- **Aquatic Habitat and Species** – including benthic macroinvertebrates, fish populations, algae, fluvial geomorphology, stream temperature and larval West Nile Virus vector mosquitoes;
- **Terrestrial Natural Heritage** - monitors flora and fauna species and communities through biological inventories and fixed plots and through the use of trained volunteers; and
- **Groundwater Quantity and Quality** is assessed at a series of wells throughout the region.

The data collected are shared with partner municipalities and other agencies, and are used for planning, implementation and reporting activities. Project partnerships with academic institutions facilitate achievement of common research objectives as well as data sharing in support of academic study. All elements of the program are designed to provide data sets that allow for interpretation at the site, watershed and regional scales. Where restoration and recovery plans are implemented, future monitoring will track the progress of such enhancement initiatives.

As a means of ensuring continuous improvement, a review of the first seven years of the program was conducted in 2008. This review and subsequent report "*Regional Watershed Monitoring Program Review 2001-2008*," evaluated the RWMP with respect to its original goals and objectives. The report briefly touches on network operation as a whole as well as some of the work being done by other agencies participating in the network. In addition, a gap analysis (e.g. review of other reports such as Watershed Report Cards) was conducted, emerging issues were discussed, and recommendations were provided to help guide monitoring in the Toronto region.

All program elements are strongly focused on the collection of scientific data. When possible, community outreach and education are incorporated. This is accomplished through the involvement of trained volunteers (e.g. Terrestrial Volunteer Monitoring Program), through partnerships with community groups and other non-governmental organizations, and through special events that demonstrate to or involve the community.

In addition to regional monitoring, numerous special projects are undertaken annually by TRCA in order to address research questions related to restoration and mitigation techniques and to provide valuable baseline information on watershed condition. Where possible the monitoring for these special projects follows the same sampling methodology and protocols as the RWMP. This consistency in method increases efficiency and provides continuity in the data, allowing the data to be easily compared to RWMP monitoring sites.

This report provides an overview of each component of the monitoring program, highlights from the 2008 season, types of data available, and how the data is used. Due to differences in the timelines and types of analysis, data interpretation is at varied stages of availability. Since the program is multifaceted, a staff directory with contact information for the various staff involved is also provided to facilitate additional follow-up if necessary.

1. Terrestrial Habitat and Species

Staff Lead: Sue Hayes

Support Staff: Gavin Miller, Paul Prior, Kelly Purves, Paul Heydon, Natasha Gonsalves, Annette Lambert, Heather Kime, John Brett

Funding: City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan

1.1 Background

The Terrestrial Natural Heritage component of the Regional Monitoring Program was established in 2000 and builds on data collected over the preceding 15 years under the Environmentally Significant Areas (ESA) work. The core focus of the program to date has been systematic inventories of habitats and species throughout the region. This data informs watershed planning and reporting, land management planning, remedial action planning (RAP), and provides information to partner municipalities and other agencies. Terrestrial data has been key to the development and testing of terrestrial ecosystem modeling and the development of the Terrestrial Natural Heritage System Strategy (TRCA, 2007b). Annual data analysis provides for maintenance of the regional species and vegetation communities of conservation concern ranking to inform conservation, recovery and site restoration planning activities.

In 2008, the implementation of the long-term fixed plot monitoring began. This new component of the program will identify species and vegetation community trends that are occurring across the jurisdiction over time.

1.2 Methods

Figure 3 identifies the terrestrial areas surveyed in 2008. Three new Natural Channel Design (NCD) sites along with 21 biological inventory sites that covered approximately 1000 hectares were inventoried for vegetation community, flora and fauna species. In addition, parts of Glen Major were re-surveyed for flora and fauna species, fauna species were updated at Albion Hills Conservation Area and roadkill surveys were conducted in the Stouffville Rd. and Bayview Ave. area. Long-term fixed monitoring plots were set-up and initial data collected. Twenty-two forest, 15 wetland and 13 meadow fixed plots were distributed across the TRCA jurisdiction.

Terrestrial Inventories

A biological inventory of each site was conducted at the levels of vegetation community and species (flora and fauna) according to the TRCA data collection methodology (TRCA 2007a).

Vegetation community designations were based on the ELC and determined to the level of vegetation type (Lee *et al.* 1998). Community boundaries were outlined onto printouts of 2005 digital ortho-rectified photographs (ortho-photos) to a scale of 1:2000 and then digitized in ArcView. Flora and fauna species of concern were mapped as point data with approximate number of individuals seen. The methodology for identifying confirmed and possible breeding birds follows Cadman *et al.* (1987).

Sites for inventories are prioritized based on an identified need, such as imminent or recent local development or land management planning requests. Data are processed and stored in the main TRCA master ArcMap files.

Natural Channel Design (NCD)

The Natural Channel Design study is intended to measure the effectiveness of different stream construction techniques. The NCD terrestrial parameters are grouped into three parts: a) an inventory of all fauna and flora species found throughout the site, b) vegetation community mapping based on the ELC; and c) a quantitative quadrat and transect study. The transects have two purposes: firstly, they are a sampling method for measuring the occurrence of trees and shrubs; and secondly, they provide alignment for setting up quadrats to measure frequency and cover of all plant species. Three NCD sites were sampled in 2008. Please refer to the Natural Channel Design Terrestrial Monitoring Methodology for more information (TRCA 2007).

Fixed-plot Monitoring

Fixed-plots were set-up in forest, wetland and meadow habitats (22, 15 and 13 fixed plots respectively). Forest plots were set-up to document changes in tree health, ground vegetation, shrub and sapling regeneration, breeding birds and red-backed salamanders. The vegetation and red-backed salamander monitoring follows protocols outlined by the Ecological Monitoring and Assessment Network (EMAN) (Roberts-Pichette and Gillespie 1999; Zorn *et al.* 2004) and breeding birds follow the Forest Bird Monitoring Protocol (FBMP) (Cadman *et al.* 1998). Wetland plots and stations are designed to capture changes in aquatic vegetation, breeding birds, frogs and toads. Wetland bird, frog and toad monitoring protocols follow the Marsh Monitoring Program (MMP) (Bird Studies Canada 2008). Meadow plots were set-up to monitor meadow bird communities and vegetation.

1.3 Data

Data are processed and stored in TRCA ArcMap digital layers. Digitized ELC data are stored as polygons while the flora and fauna data are stored as points. Both data sets have associated attributes recorded. The data are available to internal and external clients as shape files or hardcopy maps. Full inventory data collection under the current protocol began in 2001 however, data exists in digital format from 1996 onwards.

At the regional scale, terrestrial data continues to inform initiatives such as species and vegetation community recovery planning and implementation of the Terrestrial Natural Heritage System Strategy. At the site scale, the data is often used for TRCA projects such as management plans and trail planning for TRCA property.

Externally, data is shared with other organizations to support initiatives such as wetland and ANSI evaluations, the update of the Ecological Land Classification system by the Ministry of Natural Resources, and input into land use planning. Collaboration on inventory and monitoring is occurring with neighbouring conservation authorities, especially Credit Valley Conservation (CVC).

1.4 2008 Highlights

The 2008 field season was split between setting up long-term fixed monitoring plots and conducting issue based site inventories. There were a total of twenty-two forest plots, fifteen wetland plots and thirteen meadow plots set-up along with the initial data collected. Incorporating this aspect of monitoring into the regional program will be extremely important as trends in vegetation communities and species will be documented.

Twenty-one sites were inventoried for vegetation community, flora and fauna species in 2008 that covered approximately 1000 hectares. Parts of the Glen Major area were also re-surveyed to update flora and fauna species information along with mapping of a number of selected invasive alien plant species. Updates to the breeding bird data were also collected at Albion Hills Conservation Area. Roadkill surveys were conducted in the Stouffville Rd and Bayview Ave. area during spring amphibian migration period.

Following are some of the highlights from the issue based site inventories:

- A small but thriving population of hooded warblers (*Wilsonia citrina*) were found on breeding territory in the north-eastern corner of the jurisdiction. Hooded warblers are listed under the *Federal Species at Risk Act* as threatened and only occasionally have individuals been found in the jurisdiction during the breeding season.
- Common raven (*Corvus corax*) has been added to the list of breeding birds found in the TRCA jurisdiction. Having nested (apparently successfully) on the communications tower in the north-eastern corner of the Glen Major Conservation Area, this species is now being seen more and more frequently in all corners of the jurisdiction. Several hypothesis have been put forth concerning the increased sightings, and they all seem to involve anthropogenic changes that this bird has been able to take advantage of (e.g. increased food sources from road kill, garbage and an increase in nesting sites from communication towers).



Figure 1: *Juniperus horizontalis*

- The first known documented record of creeping juniper (*Juniperus horizontalis*) was found in the jurisdiction during the field season (**Figure 1**). This plant requires sandy substrates and is generally restricted to sand dunes and sand barrens.
- Swamp dewberry (*Rubus hispidus*) was discovered for the first time in the jurisdiction in over 100 years. This plant generally grows in high quality peaty swamps and was actually found in a wetland that is part of the Heart Lake Provincially Significant Wetlands.
- A very rare hawthorn species (*Crataegus apiomorpha*) was found in Richmond Hill. This brings the total documented findings of this species to 7 for the province. A specimen was placed at the University of Toronto herbarium at the Royal Ontario Museum.
- The Secord property in the northeastern corner of the jurisdiction was found to have four different orchid species including showy lady's slipper (*Cypripedium reginae*) (**Figure 2**). This plant is one of the most spectacular native species that is found in the jurisdiction and is ranked as L2.
- Road kill surveys along Stouffville Rd. east of Bayview Ave. continue to document the need for amphibian tunnels to be installed in order to attempt to mitigate the impacts of Stouffville Rd. on local amphibian populations.

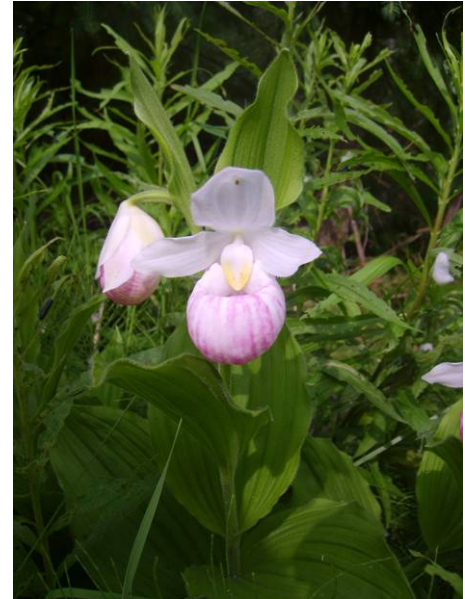


Figure 2: *Cypripedium reginae*

Figure 3: Terrestrial Natural Heritage Monitoring Sites

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2. Terrestrial Volunteer Monitoring Program

Staff Lead:	Theresa McKenzie
Support Staff:	Team of volunteers (133 participants during 2008)
Funding:	City of Toronto, Peel Region, Durham Region and York Region

2.1 Background

The Terrestrial Volunteer Monitoring Program (TVMP), in operation since 2002, uses trained volunteers to survey 10 hectare fixed sites distributed throughout the region (**Figure 5**). Volunteers collect data on the presence of a set of 56 amphibian, mammal, bird, vascular plant and lichen indicator species. Data are analyzed by TRCA to report on the condition of the terrestrial ecosystem of the region, document differences between watersheds and urbanization zones and to monitor change over time.

2.2 Methods

Volunteers, working in pairs, survey the assigned 10 hectare fixed site 10 times each year, with visits distributed throughout all four seasons (**Figure 4**). Each of the 10 visits is conducted within a specific date range and time of day, as established in the monitoring protocol. The surveys involve searching for specific indicator species in appropriate habitat on the site. Observations are recorded on a standardized data sheet, along with date, times and other environmental data. The recording of a species as present requires individual verification of two to three observation characteristics for each species. Characteristics to be observed may be visual, auditory or both depending on the species. Training is required for all participants, and a training manual, field guide, and visual/audio aids are provided. Volunteers are asked to commit to the program for a minimum of three years.



Figure 4: Volunteers sampling forest plots

2.3 Data

Data are recorded on paper data sheets in the field, then entered into an online MS Access database through a data entry website specific to the program. They are managed, quality assured, analyzed and reported on by TRCA staff. For each fixed site surveyed, the data captured includes the indicator species found by visit date, along with the presence/absence of categorized cultural impacts such as tree harvesting, trails, littering, and dog-walking. Data are analyzed in multiple ways in order to report on ecosystem condition in the region, and to support land and watershed management decision making by TRCA, municipalities and other land owners or land managers. As an example, TVMP data have recently been analysed to investigate relationships between landscape characteristics contained in other TRCA data sets and the observed indicator species richness, species richness of selected taxa and of selected habitat guild groups (TRCA, 2008).

2.4 2008 Highlights

- Results from the Terrestrial Volunteer Monitoring program from 2002 – 2007 were compiled into a report that was published in June 2008.
- Municipal partners and other groups including Rouge Park and Seneca College have made follow-up inquiries with respect to the data for their areas of interest and are using the report to inform their work.
- Training materials are being used as a teaching resource for Environmental Studies Program at Seneca College.
- The volunteer manual and field guide was updated this year.
- A new invasive plant species monitoring component will be instituted in 2009. Currently the preliminary planning is being carried for its implementation.

Figure 5: Terrestrial Natural Heritage Volunteer Sites

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3. Fish Community and Habitat Surveys

Staff Lead:	Melanie Croft-White, Jeff Vandenberg
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Funding:	City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan

3.1 Background

Fish community and habitat are monitored every three years as part of the RWMP. Standardized sampling methods are used to compare the fish community along with the physical conditions of streams, both spatially and temporally across the jurisdiction. A total of 149 stream sites have been established for long-term monitoring.

In addition to the RWMP sites, a number of other project sites are also assessed. Project specific aquatic surveys were undertaken on a special request basis. These requests came from other TRCA departments as well as various government organizations and academia. In 2008 special projects included: Taylor Pond, Palgrave Fishway, Natural Channel Design Study, various Erosion Control Sites and Duffins Heights.

3.2 Methods

Monitoring surveys follow the methods outlined in the Ontario Stream Assessment Protocol (OSAP) (Stanfield, 2005). Fish community and habitat sampling is conducted on a 3-year rotation and includes data collection for: fish community composition, in-stream habitat (e.g. sediment type, vegetation), and bank stability (**Figure 6**). Fish communities are sampled by backpack electro-fishing using a single pass approach. Electrofishing is a non-lethal sampling technique using electric currents and electric fields to immobilize fish, allowing capture. Fish are identified to species, weighed and



Figure 6: Weighing and measuring fish

measured and then released back into the water. Quality Control/Quality Assurance of identified samples is carried out by certified TRCA staff and where the identification of a specimen is uncertain it is sent out to Scott Gibson (formerly MNR) and/or Erling Holm (Royal Ontario Museum).

Habitat surveys follow the OSAP protocol (Stanfield 2005) and are conducted subsequent to the fish community surveys, and involve both in-stream and bank assessments. The in-stream portion measures the suitability of the habitat to support a diverse aquatic community. The bank assessment quantifies the riparian condition and the stability of the land bordering the stream.

A total of 78 sites were sampled in 2008 (**Figure 9**), including 42 RWMP sites in the Mimico Creek, Humber River, Don River, Highland Creek, Petticoat Creek and Frenchmans's Bay watersheds, and 36 special project sites throughout the TRCA's jurisdiction. There are now three completed data sets available for these watersheds (2002, 2005, 2008).

3.3 Data

Data are entered into a Microsoft Access database (HabProgs) and the original datasheets are maintained at the Boyd Field Centre and stored in laserfishce.

Aquatic habitat and fish community data are used to report on watershed health in documents such as Watershed Report Cards and Watershed/Sub-Watershed Plans. The data has been used for the Fisheries Management planning process, and have been used by the Southern Ontario Stream Monitoring and Research Team (SOSMRT), formerly the Lake Ontario Modeling Team, for the development of tools and models to predict the effect of landscape level disturbance on aquatic habitats and communities.

3.4 2008 Highlights

- Round gobies (*Neogobius melanostomus*), an invasive species, were found in Mimico Creek for the first time in the RWMP surveys. They had been found in the Humber and Etobicoke Creek watersheds for the first time in 2007.
- In 2008 the mottled sculpin (*Cottus bairdi*) was identified in the Etobicoke creek watershed (ECCREC1) for the first time since RWMP sampling began. This site is close to the mouth of the Etobicoke Creek so it is possible that it originated at the lake. Mottled sculpins have been found at the mouth of the river previously (1990). The mottled sculpin has been found annually in other watersheds.
- Three Atlantic salmon (*Salmo salar*) fingerlings were found at one of our special project sites in Duffins Creek (DH02) in 2008. There has been an effort to restore an Atlantic salmon population to Duffins Creek watershed. Atlantic salmon have been released into the creeks of the Duffins watershed and were also found during our surveys in 2006 and 2007.

- The emerald shiner (*Notropis atherinoides*) was identified for the first time during RWMP sampling in the Mimico Creek watershed in 2008 (MM001WM). It has been identified in the Humber, Highland and Etobicoke creek watershed during the RWMP sampling. This species is usually associated with large rivers or lakes, so it is not unusual that it would be found at the mouth of Mimico Creek.
- The northern redbelly dace (*Phoxinus eos*) was found for the first time in the Highland Creek watershed (NCD5-C), since RWMP monitoring began. The species was also found at a new location in the Don River this year (DN022WM). This species is found in other TRCA watersheds.
- Two young-of-the-year rainbow trout (*Oncorhynchus mykiss*) were found for the first time in Petticoat Creek watershed (PT001WM) since RWMP sampling began. This species is found in several other watersheds in the jurisdiction.

The Index of Biotic Integrity (IBI) is a multi-metric index used to rate the overall health of a fish community. An IBI score was determined for each site in the Mimico Creek, Don River, Highland Creek, Petticoat Creek and Frenchman's Bay watersheds which were sampled as part of the RWMP. **Table 1** summarizes the IBI scores into three habitat quality categories: good, fair and poor.

Table 1: IBI ratings for sites in the Mimico Creek, Don River, Highland Creek, Petticoat Creek and Frenchman's Bay watersheds (2005, 2008), shown as percentages

	2005			2008			Change
	Good	Fair	Poor	Good	Fair	Poor	
Mimico		20%	80%		20%	80%	No Change
Don		26%	74%		45%	55%	Improved
Highland		27%	73%	10%	20%	70%	Improved
Petticoat*		67%	33%		50%	50%	Decline
Frenchman's*	25%	50%	25%		67%	33%	Decline

*Sampled in 2006

3.4.1 Project Specific Aquatic Surveys

Taylor Pond

Taylor Pond was located on the Humber River in the Albion Hills Conservation Area. The pond was originally created for irrigation and recreation. In 2005, the pond was taken offline by TRCA to restore the river to a more naturalized state (**Figure 7**). TRCA has been monitoring both upstream and downstream of the pond since 2004. In 2006 after the pond was taken offline, two additional sites were created within the new channel of the watercourse. The final monitoring of this project was conducted in 2008.



Figure 7: New channel created in former Taylor Pond

Since the removal of the dam at Taylor Pond changes in the fish community have been noted, such as the transition from pond to stream species. The pond only had three species and was dominated by smallmouth bass (*Micropterus dolomieu*) and white sucker (*Catostomus commersonii*), whereas the newly constructed stream has 7 species including central mudminnow (*Umbra limi*), northern redbelly dace (*Phoxinus eos*) and brook stickleback (*Culaea inconstans*). There was also a 2°C decrease in the median summer water temperature downstream of the former pond location between 2004 and 2008. A detailed report on the monitoring of this site will be completed in 2009.

Palgrave Dam

The Palgrave Dam on the Humber River was built in the 1850's to support a saw mill operation and later a flour mill operation. In 2001, a fishway was constructed to mitigate the barrier to fish migration created by the dam (**Figure 8**). A partnership with Trout Unlimited Canada was formed in 2005 in order to monitor the effectiveness of the fishway. Fish were collected for a telemetry study. A telemetry study was developed that involved tagging fish with Passive Integrated Transponder (PIT) tags and monitoring their movement with antennas installed along the fishway. Data produced over the course of this project will further the understanding of the migrational capabilities of the fish community and the success of the fishway design.



Figure 8: Electrofishing at Palgrave fishway

The Palgrave Fishway project continues to experience success by accumulating data on the movement of fish through the Palgrave Dam area. A number of fish have been recaptured in subsequent surveys. This project is scheduled to continue until 2009, with analysis being conducted by Trout Unlimited.

STEP Natural Channel Design Study

The Sustainable Technologies Evaluation Program (STEP) Natural Channel Design study is intended to measure the effectiveness of different stream construction techniques. The results of this study will be used to develop policy on Natural Channel Design practices and how they are monitored post construction. In 2008, five test sites and five control sites were sampled for macroinvertebrates and two of these sites along with their associated control sites were sampled for fish and in-stream habitat.

As monitoring for this project continues, the data collected will help guide planners and engineers as to the best natural channel design techniques. The Natural Channel Design study is scheduled for completion in 2010.

Restoration Services Erosion Control Sites

Staff from the Watershed Monitoring and Reporting Section assisted TRCA's Restoration Services Section by conducting baseline aquatic surveys at a number of proposed Erosion Control Sites (**Figure 9**). Nineteen sites were established across six watersheds with the intent of collecting pre construction data.

Site conditions assessed included benthos, fish and in-stream habitat. The information will be used as baseline data to assess various erosion control measures used on these sites. Assessment reports will be completed post implementation (schedule varies by project).

Duffins Heights

The Duffins Creek watershed has the least amount of urban development and the highest quality of natural cover in TRCA's jurisdiction. There are several developments proposed in the North Pickering area which could have negative impacts on the watershed as a whole. Duffins Heights will be the first of several significant development areas that will be developed within the next 10 to 20 years including the Seaton Community, the former A9 Planning Area in Ajax and the potential development within the Federal Lands north of Hwy 7 within the Duffins Watershed.

A monitoring program was established in consultation with the City of Pickering, TRCA and the proponent landowner group. One of the goals of the development is to minimize and/or mitigate the impacts that may occur to the natural environment and, in specific to the sensitive natural heritage features and watercourses within or adjacent to the development. Preliminary baseline data was collected in 2008, but further data collection is required before recommendations can be made.

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Figure 9: Fish Community and Habitat Monitoring Sites

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4. Algae Biomonitoring

Staff Lead: Cheryl Goncalves

Support Staff: Lindsay Code, Robynne Hubert, Melanie Croft-White, Thilaka Krishnaraj, Angela Wallace

Funding: Ministry of the Environment

4.1 Background

Algae are simple, rootless plants which create their own food through photosynthesis (**Figure 10**). As primary producers benthic algae are an important foundation of food webs in rivers and littoral zones of lakes, and are essential food sources for both fish and benthic invertebrates. Algae, including diatoms, are among the first group of organisms to be impacted by shifts in physical and chemical conditions in a waterbody, as they are very sensitive to changes in basic water chemistry, including the introduction of pollutants, at relatively low concentrations. Due to their sensitivity and short lifecycles, impacts to the food web could be detected earlier when the changes in algal communities are studied. Hence, benthic algae and diatoms are an important component of an early warning system of change in a watershed.

TRCA staff began collecting algal samples from the 150 RWMP monitoring sites on a yearly basis in 2002. Under a partnership with the University of Toronto these samples were identified to species, and a diatom species database was created. From this partnership two water quality assessment indices using diatom species data from the Toronto area were developed, as well as an algal assessment protocol, which was field tested by TRCA's Regional Watershed Monitoring staff in the fall of 2005 (Zugic-Drakulic 2006).



Figure 10: Algae on rock

In spring 2008, TRCA and the Ministry of the Environment entered into a partnership to introduce and promote this algal assessment protocol under the Regional Watershed Monitoring Program. Under this partnership, an Algae Biomonitoring Biologist was hired to assess the repeatability of the field sampling protocol, and to introduce the protocol to TRCA, other Conservation Authorities and interested parties.

4.2 Methods

In September 2008 a study was conducted to compare the precision of algal data collected by different field crews using the Algal Assessment Protocol (MOE 2005). Twenty RWMP sites were sampled by two separate field crews (**Figure 14**), with each site being independently sampled by both crews on the same

day. Site conditions, sampling locations and water quality parameters including temperature, pH, conductivity and dissolved oxygen concentration, were also recorded.

At each site five transects were established within riffle areas. Observations were taken according to the Algal Assessment Protocol (MOE 2005) at five equally spaced locations along each transect. The different growth forms of algae were identified and descriptions of colour, texture, thickness or length, odour (if detected) and percentage of subsurface covered were recorded for each algal growth form observed.

For each transect one point was selected where an algal sample was collected from the substrate (**Figure 11**). The five samples were combined and later identified in the lab. Measurements of water depth and hydraulic head were recorded at each sample location, for a total of five measurements of each.

Identification and enumeration of the “soft” algae, consisting of mostly green algae (**Figure 12**) and cyanobacteria (blue-green algae) began in November 2008, with identification to the genus level by TRCA staff. In late November and December, twenty algal samples were processed and permanent slides were prepared for diatom identification. In early 2009 the remaining twenty samples will also be processed and identified. Reference slides and photos will be sent to Isabelle Lavoie (Algae and diatom specialist Trent University, Université du Québec) for Quality Control/Quality Assurance. Once diatom identification is complete, results will be compared to evaluate whether the protocol is repeatable by different sampling crews.

4.3 Data

Currently algae and diatom data is stored in a Microsoft Excel database. This database includes the information collected on the field sheets, as well as the record of soft algae and diatoms identified at each site. It is expected that this data will be rolled into a new database that is currently in the design phase. Algae and diatom data is available, from TRCA for the 2008 field year only.

4.4 2008 Highlights

- A new partnership between TRCA and the Ministry of the Environment was formed, to introduce the Algal Bioassessment Protocol to TRCA, other Conservation Authorities and interested parties.



Figure 11: Collecting algae sample from rocks



Figure 12: Green algae genus *Xanthidium*

- RWMP staff have learned many new skills including: algal identification techniques, digital photography techniques to obtain photos of diatom and algae slides, and preparation of permanent slides for diatoms (**Figure 13**).
- TRCA developed and extensive library of reference material and keys for the identification of algae and diatoms
- TRCA acquired equipment and materials for the preparation of permanent algae slides at the Boyd office.

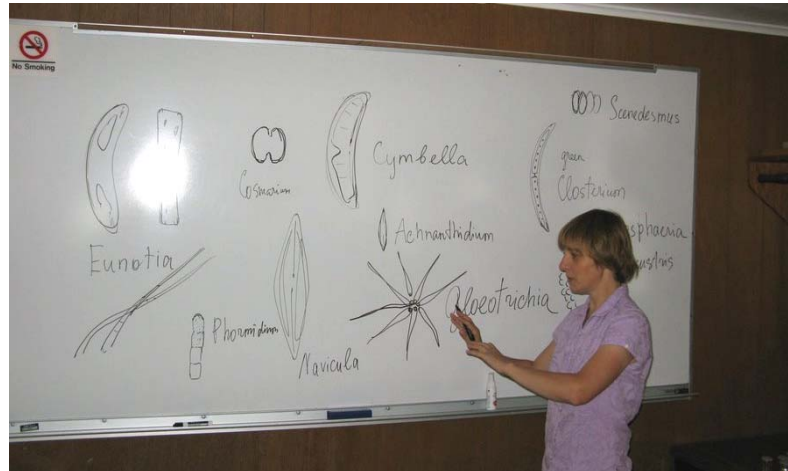


Figure 13: Diatom identification at training course in New York

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Figure 14: Algae Biomonitoring Sites

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5. Surface Water Quality

Staff Lead: Angela Wallace

Support Staff: Nelson Amaral, Ming Guo, Roger Hua

Funding: City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan

5.1 Background

Since 2002, TRCA has partnered with the Ministry of the Environment (MOE) and the City of Toronto (City) to monitor surface water quality throughout the TRCA's jurisdiction. In 2008, surface water quality was monitored at 36 sites (**Figure 17**) on a monthly basis. A recent review of the RWMP (TRCA 2008) recommended that two additional sites be added to the sampling program: one site near the mouth of Petticoat Creek and one site in the Frenchman's Bay watershed (actual location of sites to be determined). Planning for these two new sites is currently underway.



Figure 15: Recording in-situ water quality measurements

5.2 Methods

TRCA staff collected water samples at 11 sites as part of the MOE's Provincial Water Quality Monitoring Network (PWQMN) and at 23 other sites in a partnership with the City who provide in-kind laboratory analysis (**Figure 15**). Samples are collected at two additional PWQMN sites (one near the mouth of the Humber River, and one near the mouth of the Don River) by MOE staff. Water sampling follows the MOE Provincial Water Quality Monitoring Network (PWQMN) protocols (MOE 2003) and include in-situ water chemistry measurements (e.g. water temperature, conductivity, dissolved oxygen). Sampling occurs year round and is independent of precipitation, however the majority of samples are taken during dry weather events.

Samples are submitted either to the MOE, the City, or private laboratories for analysis of the parameters listed in **Table 2**. PWQMN samples are sent to the MOE laboratory from approximately April to November. The RWMP augments this sampling by collecting water quality during the four winter months and submits these samples to the City of Toronto for analysis. Samples from non-PWQMN sites are

sent to the City laboratory year-round. The RWMP also collects microbial samples at every water quality site in the network, including the PWQMN sites, which are analyzed at a private lab (Maxxam Analytics Inc).

Table 2: Water quality parameters analyzed as part of the RWMP

General Chemistry	Water Temperature	Biochemical Oxygen Demand	*Total Suspended Solids	Total Dissolved Solids	Dissolved Oxygen
	Conductivity	Hardness	Magnesium	pH	Potassium
	Alkalinity	Sodium	Calcium	*Chloride	Turbidity
Nutrients	Nitrogen, Total Kjeldahn	*Total Phosphorus	Phosphate	Ammonia	*Nitrate/Nitrite
Microbiological	<i>Escherichia coli</i>	Background Colonies			
Metals	Aluminium	Barium	Beryllium	Cadmium	Chromium
	Cobalt	*Copper	Iron	*Lead	Manganese
	Molybdenum	Nickel	Strontium	Vanadium	*Zinc

Note: Base parameters analyzed, additional parameters may be analyzed depending on laboratory (e.g. DOC, sulphates)

**PWQMN recommended indicator parameters*

In the fall of 2008, the RWMP undertook a split sample QA/QC program in conjunction with the City. Because several laboratories analyze the RWMP data, there have been some issues meshing the various datasets together due to differing laboratory techniques and detection limits. A split sample quality assurance/quality control (QA/QC) program was implemented to evaluate inter-laboratory performance from on identical parameters. The results from this program will allow the RWMP to determine the comparability of the four laboratories that are currently analyzing water quality samples. The samples have been collected and submitted to the various laboratories and results are expected in late 2008/early 2009.

In 2003, the City of Toronto adopted their *Weather Flow Master Plan* (WWFMP) along with a 25-Year implementation plan. The goal of the WWFMP is to reduce and ultimately eliminate the adverse impacts of wet weather flow, which is runoff generated when it rains or snows, to protect the environment and improve the health of Toronto's watersheds. In 2008 14 sites were instrumented with automated samplers in order to monitor stream water quality during and after storm events. The automated samplers are set-up along the northern border of the City as well as near Lake Ontario. There are 5 year-round stations and 9 three-season stations (no winter collections) which are automated to collect samples when stream flow increases due to precipitation. Each station is telemetered allowing for remote access to data and each sampler has a refrigeration unit to cool the samples until they are taken to the lab. In addition, grab samples will be collected during baseflow periods for comparison with the wet weather flow data. TRCA is responsible for many aspects of this monitoring including; instrument installation, maintenance of the equipment, sample collection and delivery. City staff will perform the laboratory analysis for the water quality samples as well as the data analysis and reporting.

5.3 Data

Surface water quality data is stored in *Water*, a relational Microsoft Access database that is part of, the TRCA's suite of corporate databases housing monitoring data. This database includes laboratory results and metadata (e.g. laboratory analysis methods, sampling equipment). During the summer of 2008, the database underwent a substantial QA/QC program. The QA/QC process revealed several sets of duplicated data, parameter naming inconsistencies and missing metadata. It was determined that removing the duplicated data would be very time consuming, therefore, the water quality data was re-imported into the database including historical MOE water quality data starting from 1964. As part of the re-import of the data, the metadata was updated and parameter names were made consistent. Site location information was also updated. The database user interface was updated to allow groups of water quality parameters (e.g. metals, nutrients) to be queried efficiently. Future upgrades include the ability to export data by watershed and subwatershed. Changes to the corporate database structure (e.g. upgrading to structured query language (SQL) which is a standard language for querying and modifying data and managing databases) will enable more effective sharing and use of the relational database by TRCA staff.

5.4 2008 Highlights

- In 2008, staff continued to collect water samples as part of a pilot study being conducted by Environment Canada and the MOE to evaluate the enzyme-linked immunosorbent assay (ELISA) method, as a cost-effective way to determine the concentration of certain pesticides in water. Samples were analyzed using ELISA test kits and compared against liquid chromatography tandem mass spectrometry which is a conventional method for analyzing pesticides. ELISA is significantly cheaper than its counterpart - for example, laboratory tests for a single pesticide (e.g. glyphosate) can cost \$300+ using typical laboratory techniques while the ELISA method costs approximately \$10. The results of the study indicated that the ELISA method worked well for atrazine and glyphosate when compared with traditional methods (Byer *et al.* 2008). Following the successful 2007 pilot study, a smaller scale confirmatory study was conducted in 2008 to evaluate the capability of a private lab to use the ELISA method to determine if this analysis method could be contracted out to an outside laboratory.
- RWMP staff also collected surface water quality samples from two sites at Bathurst Glen Golf Course as part of the Audubon Cooperative Sanctuary Program (ACSP) certification (**Figure 16**). The ACSP is a certification program that helps golf courses protect and preserve the natural environment. A summary report on the water quality



Figure 16: Collecting water quality samples at Bathurst Glen Golf Course

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results for these sites will be completed early in 2009 and will be used as part of the submission package for certification.

- Through a partnership with the City of Toronto, TRCA installed 14 wet weather flow/water quality monitoring stations in 2008. Monitoring of flow and water quality is scheduled to begin in 2009.
- Following the results of the split sample QA/QC program, water quality data for (2002-2007) will be analyzed and reported on in 2009. The focus will be on temporal and spatial changes in surface water quality with special attention placed on key parameters such as chloride and phosphorus.

Figure 17: Surface Water Quality Monitoring Sites

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6. Water Temperature Monitoring

Staff Lead: Lindsay Code

Support Staff: Greg Dillane, Michael Brestansky

Funding: City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan

6.1 Background

Water temperature data is collected as part of the aquatic monitoring component of the Regional Watershed Monitoring program (RWMP). Since aquatic organisms are highly dependent on the temperature of the water they inhabit, much of the diversity within a reach can be associated with temperature. Tracking water temperature can also help indicate the influence of groundwater on the watercourse. Coldwater streams are of particular importance since certain fish species such as brook trout (*Salvelinus fontinalis*) rely on groundwater upwellings for spawning. In addition, the data collected by the RWMP may be able to show long-term changes in water temperature over time caused by anthropogenic factors or climate change.

6.2 Methods

Water temperature data is collected on a three year rotation with approximately one third of the 149 RWMP aquatic survey sites sampled each year. Temperature data is collected at the same sites where fish collections occur. Additional sites are monitored on a project specific basis.

Data is collected using digital temperature loggers installed in the stream in the spring and removed in the fall. All loggers are programmed to sample at 15 minute intervals. The data are assessed using the nomogram developed by Stoneman and Jones (1996) in order to classify stream sites along the continuum from highly stable to unstable in relation to ambient air temperature. Thermally unstable streams are generally unsuitable for coldwater fish species, since their water temperature reaches excessive levels (>25°C) on hot summer days. **Figure 18** illustrates patterns of the typical heating and cooling cycles of stream from

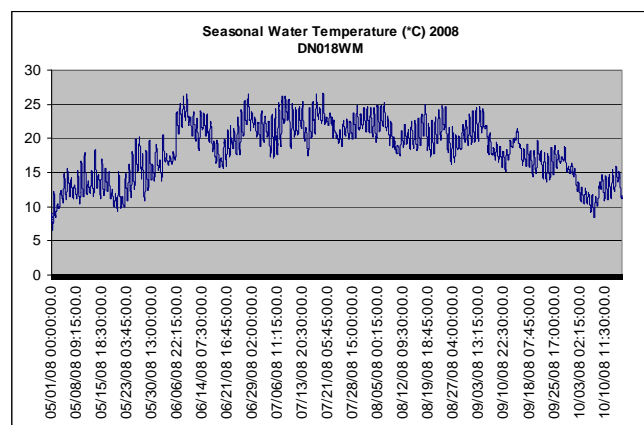


Figure 18: Example of temperature data collected for a site in the Don River (DN018WM)

spring through the fall season. **Figure 19** is a sample box and whisker plot that shows both the temperature ranges as well as the predominant seasonal temperatures for a site. Logged temperature data is stored electronically in a Microsoft Excel spreadsheet. Thermal stability ratings are developed using the Habprogs MS Access database.

The temperature data is downloaded mid-summer and at the end of the fall and this compensates for data losses by ensuring that data is collected from at least half the season. In the event that the temperature data is not sufficient for thermal stability calculation, another attempt to capture stability information will be made in the following season.

6.3 Data

Thermal stability information is primarily used for the development of fish management plans, watershed plans and for restoration purposes. Data is also used to characterize daily and seasonal temperature variation resulting from the influences of air temperature, warm water run-off, and cold thermal contributions from groundwater sources.

6.4 2008 Highlights

- In 2008, loggers were deployed at 47 RWMP aquatic sites in the Don River, Highland Creek, Mimico Creek, Petticoat Creek and Frenchmen's Bay watersheds and six project specific sites (**Figure 20**).
- There are now three sets of data available for most sites in the Don River, Highland Creek, Mimico Creek, Petticoat Creek and Frenchmen's Bay watersheds (2002, 2005, 2008).

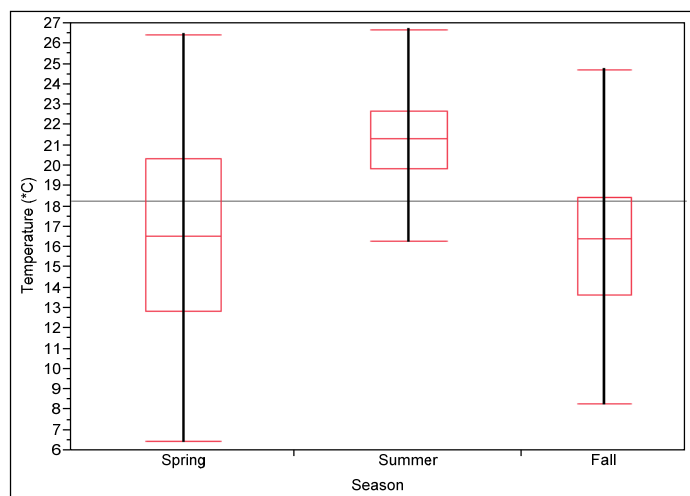


Figure 19: Example of a box and whisker plot displaying water temperature data (DN018WM), horizontal line indicates the mean of all sites

- In a normal sampling year a small number of temperature loggers are lost due to storm events and erosion. A higher than usual number of temperature loggers were lost in the 2008 due to increased frequency of storm events.
- **Table 3** shows the percentage of sites that fall in the three stability categories (stable, moderately stable, and unstable) for the three years monitored.
- The highest temperature was observed at a site on the Humber River in East Brampton (HU014WM) with a maximum temperature of 28.9° C.

- Proportionately, the stability ratings in 2008 were similar to those in 2002 with a trend towards an increased number of sites ranked as unstable and a decreased number of sites ranked as stable or moderately stable.

Table 3: Thermal stability classifications for 2002, 2005 and 2008

	2002			2005			2008			Change
	Stable	Mod Stable	Unstable	Stable	Mod Stable	Unstable	Stable	Mod Stable	Unstable	
Mimico		33%	67%			100%			100%	Decline
Don		96%	4%	5%	74%	21%	4.5%	91%	4.5%	Improved
Highland		50%	50%		46%	54%	10%	40%	50%	Improved
Petticoat*		100%			60%	40%		100%		No Change
Frenchman's*					75%	25%		100%		Improved

**Sampled in 2006 not 2005*

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Figure 20: Water Temperature Monitoring Sites

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7. Benthic Invertebrates

Staff Lead: Thilaka Krishnaraj

Support Staff: Robyn Hubert, Julie Hennigar, Lauren Sharky, Adam Wood, Monique Smart, Jonah Kelly, Jessica Wright, Ashley Favaro, Meaghan Becker, Angela Wallace

Funding: City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan

7.1 Background

Established as a core program activity for the Regional Watershed Monitoring Program (RWMP) in 2001, the benthic biomonitoring program has been used to track changes in the aquatic biota and water quality of the nine watersheds across the TRCA's jurisdiction. The different ecological requirements as well as the sensitivity of various benthic organisms to pollution make them ideal candidates for biomonitoring purposes (**Figure 21**). Hence analyzing the composition of benthic macroinvertebrate communities in streams is useful as a practical method to evaluate stream water quality and habitat characteristics. As an on-going watershed monitoring activity each year, the TRCA benthic biomonitoring program provides information on the biological health of the watersheds. Data on this indicator is used in watershed reporting, Remedial Action Plan (RAP) tracking and for other watershed reporting requirements of TRCA and its partner municipalities. Benthic monitoring is conducted at 149 fixed stations across the TRCA watersheds as well as at a number of additional stations for special projects (e.g monitoring for land use changes or restoration works).



Figure 21: Trichoptera larva on the stream bottom

7.2 Methods

The set of the sampling stations (**Figure 23**) and the field collection protocol have followed to the Ontario Stream Assessment Protocol (OSAP; Stanfield *et. al.* 2005). Benthic invertebrates are collected using the “traveling kick-and- sweep” method (**Figure 22**) whereby stream sediments are dislodged by kicking the stream bottom and invertebrates are swept downstream into a net. During the summer months, sampling at each station is carried out along a number of transects (number of transects dependant on stream width) established across the stream width (modified OSAP protocol



Figure 22: Traveling kick & sweep

Stanfield *et. al.* 2005). Each transect sample is collected using a 500 µm mesh D-net, with all transect samples combined into a single composite sample per station. Samples are preserved and brought back to the laboratory for sub-sampling and identification. A minimum of 100 macroinvertebrate individuals are counted and identified. The samples are initially identified to the coarse 27-group OSAP standard and then further identified to the lowest practical level (usually genus/species).

7.3 Data

Benthos data for RWMP sites are available from 2001 to 2008. In addition, there are electronic versions of benthos surveys for selected watersheds that pre-date the RWMP (e.g. Etobicoke-Mimico 1997, Humber 2000). Coarse identification data are entered into the Ministry of Natural Resources Habprogs database. Lower level taxonomic data are currently stored in standardized Excel spreadsheets. The benthos data stored in Excel spreadsheets are currently being transferred to the corporate “Envirobase” database. The use of the database will allow for easier data extraction and manipulation. Future upgrades to the database include the automation of metric calculations (e.g. Hilsenhoff Biotic Index).

7.4 2008 Highlights

- A total of 147 RWMP stations and 31 special project stations (**Figure 23**) were sampled in 2008. Two RWMP sites could not be sampled due to landowner issues (HU034WM) and changes in the stream geomorphology resulting in the site being moved (EC002WM). A number of sites in the Duffins Creek and Rouge River watershed were not surveyed in 2008 because of access issues related to Transport Canada properties. The special projects include the continuation of
- TRCA's Natural Channel Design monitoring program, Taylor Pond decommissioning at Albion Hills, and monitoring of Erosion Control sites. In addition benthic sampling was initiated at the Duffins Heights to provide baseline conditions for a land development project.
- There were several data requests from external agencies (e.g. consulting agencies, academic institution) as well as multiple requests by the Province, municipalities and other TRCA departments. Benthos data for the Humber River was submitted to Environment Canada for inclusion in a national report “*Mixed-wood Plains Ecozone Status and Trends Report: Benthic Invertebrates*”.
- The preliminary water quality assessment using the Hilsonhoff Biotic Index for 2008 (**Table 4**) showed that there is an overall improvement in the Hilsonhoff scores for all the watersheds except Mimico, Carruther's creek and Frenchman's Bay. While the scores for Mimico and Carruther's Creek remained the same as those found in 2007, the scores for Frenchman's Bay changed in two sites from “Poor” to “Very Poor”. Noticeably, a number of sites (in the Don River) have improved from “Poor and Very Poor” conditions into “Fairly Poor” conditions. This could be due to changes in the benthos composition as a result of the amount of precipitation received in 2008, which was significantly higher than 2007. However confirmation is needed through detailed taxonomic identification on benthos collected in 2008.

Table 4: Hilsenhoff water quality rating calculated for sites sampled in 2007/2008, number of sites for each rating by watershed

Watersheds	Water Quality Ratings* based on Hilsenhoff scores									
	2007					2008				
	<i>Good</i>	<i>Fair</i>	<i>Fairly Poor</i>	<i>Poor</i>	<i>Very Poor</i>	<i>Good</i>	<i>Fair</i>	<i>Fairly Poor</i>	<i>Poor</i>	<i>Very Poor</i>
Etobicoke Creek			4	9	1		1	2	9	1
Mimico Creek				2	3				2	3
Humber River	1	7	15	14		2	9	16	10	
Don River		3	1	12	7		2	8	10	3
Rouge River		5	11	9	1	2	11	10	3	
Highland Creek			4	5	2				7	4
Petticoat Creek				1	1	1	1	2		
Duffins Creek		6	10	5		2	8	5		
Frenchman's Bay				4					2	2
Carruther's Creek			3					3		

**Water quality ratings were calculated using coarse level taxonomic identifications of benthic macroinvertebrates collected during 2008.*

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Figure 23: Benthic Macroinvertebrates Monitoring Sites

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8. Fluvial Geomorphology

Staff Lead: Nelson Amaral

Support Staff: Greg Dillane, Mike Brestansky

Funding: City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan

8.1 Background

Fluvial geomorphology measures the physical characteristics of the stream channels and strives to understand how the natural setting and human land use in a watershed determine the shape of watercourses. It also attempts to predict the physical changes that will occur to a stream channel in response to alterations in watershed conditions, and in turn, how these changes will impact human infrastructure and fish habitat. The adjustment of the watercourse to watershed perturbations may take thousands of years (e.g. response to deglaciation) or channel modifications may occur in less than a decade, as is frequently the case with direct human activity in a watershed. Understanding how these perturbations, operating at different time scales, alter the width, depth, and planform of a channel is critical for identifying potential problem areas in a river system.

As the population of the Toronto Region continues to increase, more pressure is being placed on rural, and natural areas through urban sprawl and changes in land use. Watercourse alteration, sedimentation, construction activities, changes in hydrology, and increases in the frequency of extreme weather events, are increasing the geomorphic stresses on watercourses. Ongoing monitoring identifies the amounts, trends and rates of change at the site, sub-watershed, and watershed scale caused by channel form adjustment in response to these changes in hydrology and the physical landscape.

A total of 150 fluvial geomorphology sites (**Figure 26**) were placed throughout the nine watersheds in the TRCA jurisdiction between 2001 and 2003 as part of the Regional Watershed Monitoring Program (RWMP). Detailed geomorphic data was collected at each site in order to quantify and characterize the channel dimensions along with various bed and bank properties. Data collected includes: longitudinal profile, cross-sectional profile, bankfull width and depth, particle size distribution, substrate characteristics and bank stability. Erosion pins and bed chains were installed in order to monitor changes in bank and stream bed erosion. In addition, historical assessments were conducted using aerial photography to calculate channel widths and migration rates.

Several project sites have also been monitored annually to record baseline geomorphic data as well as document changes in constructed and natural stream channels at a site specific scale.

8.2 Methods

As part of the RWMP, TRCA staff monitors approximately 50 sites each year on a 3-year cycle. Monitoring efforts include: re-evaluating channel stability through stability indexes, re-measuring channel dimensions along an established “control” cross-section (**Figure 24**), reassessing particle size distribution, and re-measuring bed chains and erosion pins in streambeds and banks.

“Control” cross-sections, usually located in a representative riffle, and erosion pins were installed at the beginning of the program to serve as the starting point for future monitoring efforts.



Figure 24: Conducting a cross-sectional profile survey

Geomorphic stability indices such as the Rapid Geomorphic Index (RGA) are also calculated at each site. The RGA is a visual inspection at the site level of four main categories of geomorphic adjustment: evidence of aggradation, evidence of degradation, evidence of widening, and evidence of planimetric form adjustment. The average of the combined score of each of these categories determines the stability index classification of each site.

8.3 Data

RWMP fluvial geomorphological data is available from 2001 to 2007. Data from 2001-2003 is stored in an Access database and data from 2004-2007 is stored in excel files. Database updates are currently underway and all data should be consolidated in a single database in the near future. This data will be used to compare geomorphic changes temporally at the site, subwatershed, and watershed scale that may be attributed to changes in hydrology or watershed land-use. Regional, municipal and academic partners use the data to assess stream channel adjustment and assist with design and construction of erosion controls and other capital infrastructure projects.

Sites are compared to the control/reference data. This type of data is used to calculate geomorphologic measures such as cross-sectional area, width/depth ratio, and the amount of erosion or deposition. Particle size distribution and bed chains are assessed at the monitoring cross-sections to identify any changes in streambed composition and movement. Longitudinal profile graphs can be created to depict changes in elevation in the streambed and bankfull levels.

As previously noted, a change in land-use or a watercourse may take several decades for a measurable change to be noted in fluvial geomorphology. Baseline measurements for the TRCA jurisdiction were completed from 2001-2003, therefore, this component of the RWMP has not been running long enough to show any large-scale changes in the stream channels on the watershed scale. Fluvial geomorphology data will be analyzed in detail in 2009/2010 as part of the 10-year RWMP report.

8.4 2008 Highlights

- A total of 53 RWMP and 2 project sites in 4 watersheds (Humber River, Don River, Highland Creek and Rouge River) were resurveyed in 2008. Included in the 53 RWMP sites were 3 sites not surveyed in 2007 due to local construction activities, weather restrictions and staff constraints. **Figure 26** displays the 55 monitoring sites that were surveyed in 2008.
- On July 23rd, 2008, staff resurveyed two Evaluation of the Effectiveness of Erosion and Sediment Control Practices (EEESCP) project sites on Marigold Creek in response to an overflow from a stormwater retention pond, that was suspected to have introduced excessive sediment and water into Marigold Creek. A comparison between the downstream site (GHUDS2) and the upstream site (GHUDS1) showed that the downstream site did not have any significant increases or additional types of channel form adjustment compared to upstream. **Figure 25** shows the monitoring cross-section profile of GHUDS2 in 2007 and 2008. However, these findings were not conclusive. To draw definitive conclusions with regards to the morphological impacts of the overflow, an in depth survey of each site was recommended.

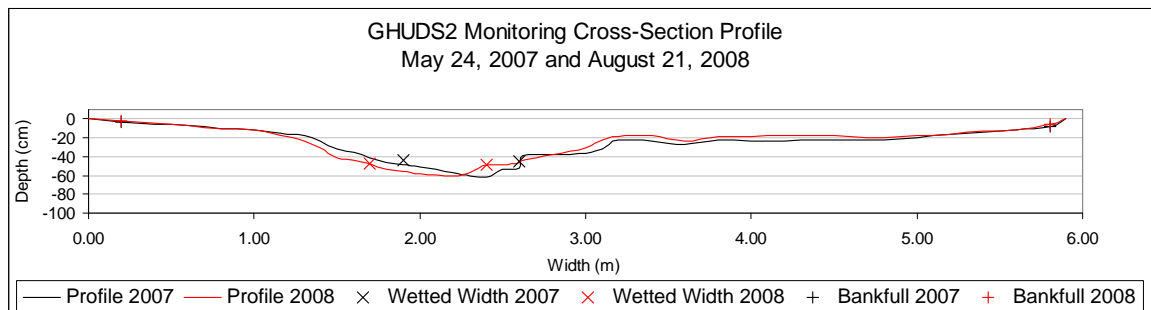


Figure 25: Marigold Creek fluvial geomorphology EEESCP project site GHUDS2 located downstream of stormwater pond

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Figure 26: Fluvial Geomorphology Monitoring Sites

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9. West Nile Virus Vector Monitoring

Staff Lead: Thilaka Krishnaraj

Support Staff: Dan Bechard, Ashley Favaro

Funding: City of Toronto, Peel Region, Durham Region, York Region and Ministry of the Environment

9.1 Background

The TRCA West Nile Virus (WNV) Monitoring Program was established in 2003 with an objective to conduct vector larval surveillance and monitoring for the presence of two key vector mosquito species namely, *Culex pipiens* (**Figure 27**) and *Culex restuans* on TRCA properties. The monitoring activities complement the WNV vector source reduction activities carried out by TRCA's Regional Health partners in Durham, Peel, York and the City of Toronto. In addition, the program objectives also include WNV public education and outreach, and collaboration with Regional Health Units.



Figure 27: Larva of *Culex pipiens*

The public outreach and education involves addressing any public or staff concerns about WNV through TRCA's Standing Water Complaint Procedure, while the collaboration with the Regional Health Units consists of participation on WNV advisory committees, information sharing and notification about vector hot spots. WNV vector larval surveillance and monitoring is an ongoing seasonal assessment of selected TRCA natural wetlands and Storm Water Management Ponds (SWMPs) to determine the presence of WNV vector larvae (**Figure 27**), characterize the abundance of larvae (vector and non-vector species) and identify vector "hot spots". For 2008, monitoring started on May 27th and continued at three week intervals until August 25th. A total of 36 wetlands and nine SWMPs were monitored during this period in the City of Toronto, Peel, Durham and York Regions (**Figure 29**).

9.2 Methods

Each site was visited four times from May through August of 2008, and a total of four replicate samples were collected from each site per visit. Each replicate sample consisted of 10 dips using a standard dipper (**Figure 28**). The mosquito larvae from each dip were counted and recorded. The larvae from 10 dips were then pooled, placed in plastic sample vials and transported to the Boyd Office for species identification. Upon arrival at the Boyd field centre, the mature larvae from each sample were killed and

preserved in 70% ethanol for identification. Species identification was carried out using the taxonomic keys.

Smaller larvae from each replicate were reared until they reached fourth instar and the identification procedure was repeated.

Risk ranking is applied to each site for a given vector species based on the average number of vector larvae found (40 dips/4 replications). A site is ranked as:

nil/no risk site if no vector larvae are present

low risk site if the average number of vector larvae collected is between 1-2 per 10 dips

moderate risk site if the average number of vector larvae collected is between 2-30 per 10 dips

high risk site if the average number of vector larvae 10 dips is greater than 31 per 10 dips

Risk ranking is undertaken for each individual vector species found at a site and not on the cumulative number of vector larvae found. This is due to variation in their biology, host preference and the efficiency of each vector species to transmit the virus.

Data on water quality such as pH, temperature, electrical conductivity, total dissolved solids and dissolved oxygen were collected using a YSI meter (650 MDS) to quantify the relationships between mosquito species and the water quality parameters. Qualitative Information about water clarity, the type of predators present at the time of site visit, marginal and total vegetation was also recorded.



Figure 28: Larval sampling in wetlands

9.3 Data

Data on site information, the number of vector and non-vector species found in wetlands and SWMPs, and the water quality parameters are available from 2003-2008. Data are stored in a MS Access Data Base.

For 2008, data collected were used to determine WNV vector and non-vector species composition and abundance, as well as WNV risk ranking for different wetland and SWMP sites. Statistical analyses such as Correspondence Analysis (CA) and Canonical Correspondence Analysis (CCA) were carried out to determine the influence of different water quality parameters on vector presence and abundance. The results from the 2008 data analysis were used to generate the Annual Report: *West Nile Virus Vector Mosquito Larval Monitoring and Surveillance – 2008*.

9.4 2008 Highlights

- A total of 17 standing water complaints were addressed in 2008, of which four complaints involved TRCA properties that are under direct management. Two out of four TRCA sites had vector larvae in high numbers in several tire ruts and potholes which were subsequently filled

with clean fill to prevent further breeding of vector larvae. The other two sites had no vector larvae present.

- The larval sampling yielded a total of 4183 larvae. Of this total, 3928 larvae were sampled from the wetlands. *Culex territans*, a non-vector mosquito species continues to be the most predominant mosquito as in previous years. Out of the 36 wetland sites monitored, Cold Creek pond was the only “hot spot” (risk ranked as high) for *Cx. pipiens* and *Cx. restuans* (vector species) during the 3rd sampling period with an average of 45.25 and 25 larvae per 10 dips respectively. About 255 larvae were collected from SWMPs, and *Culex pipiens* was the predominant vector species representing 27% of the total number of larvae while *Cx. restuans* comprised only 1% of the identified larvae from SWMPs.
- Investigation of water quality parameters (pH, conductivity, water temperature, total dissolved solids and dissolved oxygen) showed no influence on the presence or absence of any given mosquito species by any of the above parameters. Analysis of water quality parameters using Canonocal Correspondence Analysis (CCA) showed that only about 30% of the variance in the abundance of mosquito larvae could be explained by the water quality variables. CCA showed that *Culex salinarius* and *Cx. restuans* were positively related to water temperature, *Culex pipiens* to pH and *Anopheles punctipennis* and *A. quadrimaculatus* to dissolved oxygen levels. Some of these results were similar while others were quite different from those found in 2005 and 2006 data sets.
- Results from the 2008 monitoring are consistent with previous findings that indicate that healthy functioning wetlands typically do not support high number of WNV vector mosquito larvae. These sites pose a low risk overall to public health in terms of WNV.

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Figure 29: West Nile Virus Monitoring Sites

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10. Groundwater Quality and Quantity

Staff Lead: Jeff Vandenberg

Support Staff: Don Ford, Jehan Zeb, Andrew Taylor

Funding: Ministry of the Environment (partial)

10.1 Background

Approximately three million residents in Ontario rely on groundwater from municipal and private wells as their primary source of drinking water. The increasing demand for groundwater in Ontario is elevating the stress placed on this vital resource through overdraw and contamination. Many communities are dependent on groundwater supplies to maintain existing domestic, commercial, industrial, agricultural and institutional operations.

Historically, there was no comprehensive data available that could provide a reliable description of the state of groundwater in the province. A need was identified for a network of ongoing monitoring sites to be created to assess current groundwater conditions. This network would also provide an early warning system for changes in water levels and water quality.

The Provincial Groundwater Monitoring Network (PGMN) was established to meet these needs. A partnership was formed between the Ministry of the Environment (MOE) and Conservation Authorities to efficiently utilize staff and resources. The fact that Conservation Authorities are watershed oriented has made them ideal partners that conduct all field operations and data analysis/reporting on a local level. The MOE's role in the network is to set policy direction, strategic objectives and maintain the Provincial Groundwater Monitoring Information System (PGMIS) database for the program.



Figure 30: PGMN well with telemetry equipment and dedicated pump installed

10.2 Methods

The mandate of the TRCA as a program partner is to maintain the telemetry systems, collect water level data, and collect and arrange for chemical analysis of water quality samples at dedicated wells on an ongoing basis. There are currently 21 groundwater monitoring wells in the Toronto and Region Conservation Authority (TRCA) jurisdiction (**Figure 32**). Telemetry equipment has been installed at 18 of these sites, which allows for remote downloading of data. The remaining three sites were deemed unsuitable for telemetry installation and these wells are downloaded manually. One site has been equipped with a barologger in order to 'normalize' the data from wells across the TRCA jurisdiction by taking barometric pressure into account. In addition, five wells have been outfitted with dedicated (Redi-Flo 2) pumps allowing for water quality sampling (**Figure 30**).

10.3 Data

The data collected from the loggers at these sites are downloaded by the MOE and uploaded to the PGMIS website. The data collected is subjected to quality control checks performed by TRCA staff. The data is used internally for monitoring regional groundwater levels and for Source Water Protection Planning. The data collected is also supplied to the York-Peel-Durham-Toronto (YPDT) coalition and the Conservation Authorities Moraine Coalition (CAMC). The goal of the YPDT-CAMC is to characterize and improve the understanding the hydrogeology of the Oak Ridges Moraine. The YPDT-CAMC is a multi-agency, collaborative approach to collecting, analyzing and disseminating water resource data as a basis for effective stewardship of water resources.

10.4 2008 Highlights

- Solar panels were purchased by the MOE in late 2007 for installation at sites utilizing telemetry. Installation of these panels was completed early in 2008. These installations have kept the batteries on-site fully charged and as a result has decreased the number of site visits required.
- Amendments to Regulation 903 were approved in 2007 which now enables Authority staff to troubleshoot all well problems on-site, take manual water measurements and collect water quality samples at wells. These changes have greatly increased the efficiency of the program by cutting down on the number of site visits required, and eliminating the need to hire outside contractors to help with minor issues.
- The MOE approved the purchase of a portable Waterra pump for collecting water samples at sites without dedicated



Figure 31: Portable Waterra pump

pumps. As a result, 10 sites were sampled for water quality in 2008 including five wells equipped with dedicated pumps and five more using the portable Waterra pump (**Figure 31**). The groundwater samples from the 10 wells met the Ontario Drinking Water Quality Standards (Ontario Regulation 169/03). A full report on Groundwater Quality will be produced later in 2009.

- The PGMN telemetry system currently uses an analog cellular phone system. The phone companies have switched over to a digital network and no longer service the old analog system (as the old infrastructure breaks down it is no longer repaired). To date the switch over to the digital system has occurred piecemeal as certain areas lose their analog capability. In 2008 two sites in the jurisdiction were switched over to digital modems because of the failure of the analog system. As of December 16th 2008 we have been advised that the analog system has been discontinued. The MOE is currently exploring options to switch the entire network to a digital system. This is expected to be implemented early in 2009.

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Figure 32: Groundwater Monitoring Sites

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11. Water Quantity - Stream Flow

Staff Lead: Derek Smith

Support Staff: Craig Mitchell, Bill Kerr, Lisa Moore, Jamie Duncan, Christy Sommerville, Rita Lucero, Matt Derro, and Seasonal Staff

Funding: City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan

11.1 Background

One of the indicators monitored under the Region Watershed Monitoring Program (RWMP) is water quantity which includes stream flow, rainfall, and snowfall. Stream flow data has been collected in TRCA's jurisdiction for over 50 years. Compiling and archiving flow data was originally implemented by the federal government to meet its international obligations related to the Great Lakes. Today the TRCA has installed a multitude of stream gauges as part of the RWMP and flood warning programs. Typically, data is used for stormwater management and water budget development, operation of flood control structures and flood warning, infrastructure modeling and to track changes to watercourses caused by land use change.

Similarly, rain gauges are widely used as a water quantity indicator to document event flows, annual discharges, and for weather or flood forecasting. When maintained properly, their data is regularly used to calculate design details for municipal road and sewer infrastructure, stormwater management technologies, and bridge/culvert construction. In the Toronto Region and surrounding area there are just over 100 rain gauges which are owned and operated by all levels of government, the TRCA, educational institutions, other Conservation Authorities, and in some instances by the private sector. Of that total, the TRCA owns and operates 32 gauges as part of the RWMP.

The TRCA currently monitors snow at ten sites under the RWMP. The sites were originally selected to give a representative assessment of the snow characteristics across the Toronto Region. Data collected at these sites includes snow depth, water equivalent, snow density, snow crust, and underlying soil condition. The data is submitted to the Ministry of Natural Resources (MNR) where it is archived and published bi-weekly during the winter months to monitor the snow melt flood threat in our watersheds. The data is also used by TRCA flood warning staff to monitor the watershed's conditions prior to the spring snow melt.

Historically, water quantity data has made it possible for decision makers to design infrastructure, assess public risk and forecast severe weather events, develop much needed watershed plans and water budgets, and is commonly used to assess aquatic habitat. With the onset of climate change and

increased extreme weather events, the data has now become instrumental to the on-going and future operations of the municipalities in TRCA's jurisdiction.

11.2 Methods

11.2.1 Stream Flow

In 2008, flow and water level data was collected at 31 RWMP stream gauges and 24 Water Survey Canada (WSC) gauges (**Figure 36**). Water level data is averaged and recorded every 15 minutes. Monthly, each station is downloaded, corrected (if applicable) and converted to flow. Stage-discharge checks are carried out annually at each stream gauge location and rating curves were either verified or generated depending on the hydraulic conditions.

Each stream gauge station is maintained annually by flushing wells, sensor calibration, and logger battery replacement (where applicable). Of the 31 RWMP stream gauges, 17 stations are part of the TRCA Real Time (RT) Gauging Network (**Figure 33**). This network is a web accessible RT data system that offers precipitation, water levels, alarms, and stream discharge data in one convenient location in order to monitor the current flood status of the watersheds. Additional RWMP stream gauges will eventually be incorporated into the RT network as maintenance and upgrades to the existing gauge network continue.

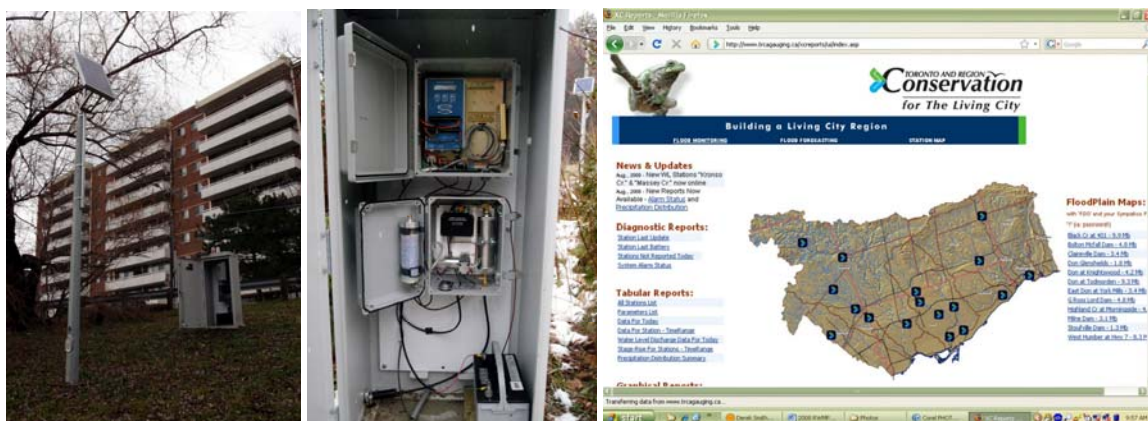


Figure 33: Various RT stream gauge stations (from left) Taylor Massey Creek, McFall Dam, and the RT gauging home page

11.2.2 Precipitation (rainfall and snowfall)

In 2008, precipitation data was collected from 32 stations (**Figure 37**). The precipitation network consists of 26 three-season tipping bucket gauges and seven, four season gauges (three weigh gauges and four heated tipping buckets). Of these 32 stations, 13 are telemetered gauges, of which seven are part of the TRCA RT gauging network (**Figure 34**).

All three-season tipping bucket rain gauges are installed every spring and removed for the winter season while the four-season gauges are monitored year round. All gauges are maintained every four weeks

which includes data downloads (if not RT); station cleaning, and battery/AC power checks. In contrast, the weigh gauges require less maintenance because it uses a 12 litre collection bucket (600mm of precipitation) and needs to be emptied about every three months, however, because the weigh gauges are located on or near TRCA property, they are checked much more frequently.

Precipitation data is entered into a spreadsheet where each station has its own spreadsheet. Tipping bucket data is recorded as *counts* per five or 15 minutes. The number of tips (counts) measured during the allotted recording interval is then multiplied by the gauges bucket value (0.2 mm or 0.1 mm, depending on gauge design). Each spreadsheet includes station details, the maintenance schedule, counts and converted values (in mm) and monthly summaries.



Figure 34: Various precipitation gauges including both remote and RT systems

In contrast, while four-season precipitation gauges are capable of measuring snowfall, the TRCA continues to conduct snow course measurements at ten stations across our jurisdiction (**Figure 35**). They include:

- | | |
|-----------------------------------|-----------------------------------|
| 1) Clairville Dam | 6) Claremont Conservation Area |
| 2) G. Ross Lord Dam | 7) Greenwood Conservation Area |
| 3) Heart Lake Conservation Area | 8) Bruce's Mill Conservation Area |
| 4) Boyd Conservation Area | 9) Milne Conservation Area |
| 5) Albion Hills Conservation Area | 10) Glen Major Conservation Area |

Each snow course is visited twice a month during the winter season (approx. the 1st and 15th day of each month). At each snow course, ten samples spaced 30m apart are taken along a 270m transect, however in cases where the full linear distance is not feasible, the transects are arranged in a "T", "Z", "L", or "+" pattern in order to compensate for the distance (**Figure 35**)



Figure 35: Snow course monitoring, Albion Hills, Conservation Area

At each sampling location, a snow core is taken and the depth of snow is measured in centimetres. The snow core is then weighed and converted into millimetres to determine its water equivalent. Underlying soil condition and the presence of a snow crust is also recorded. The snow depth and water equivalent values are then averaged over the ten samples to estimate the amount of water contained in the snow pack for each location.

11.3 Data

11.3.1 Stream Flow

Since its inception, and due to the large number of gauges, the TRCA has been working with Ontario Hydrometric Services (OHS) to develop rating curves, QA/QC data, and generate tabular annual and monthly reports. Monthly reports are used to identify any known interferences with data collection. The data files provided by OHS are stored on the TRCA network Water Resources database and ultimately placed in the Envirobase. The majority of data records for the stream gauge network date back to 1997 however, additional stream flow data is available prior to 1997 for some gauges.

The primary use for this data is for flood structure operations (e.g. dams) and flood warning, however its value is much more than that. The data has made it possible for decision makers to design infrastructure, assess public risk and forecast severe weather events, develop much needed watershed plans and water budgets, and is commonly used to assess risks to habitat. While discussed later in section 14, with the onset of climate change and increased extreme weather events, the data has now become vital to the on-going and future operations of the municipalities in TRCA's jurisdiction.

11.3.2 Precipitation (rainfall and snowfall)

The majority of data from the TRCA precipitation network dates back to 2002. Prior to this date, the TRCA typically relied on local governments for the information. On a monthly basis the data is exported electronically to a spreadsheet stored on the TRCA network; ultimately it's uploaded to Envirobase.

In contrast, snow survey data at several of the network locations has been collected since 1957. The data is submitted to the Ministry of Natural Resources and also archived on the TRCA local network. During the winter and spring months, the snow depth and water equivalent data is crucial to determining the antecedent conditions of each watershed in context with snowmelt and the snow "ripeness" (potential for liquid precipitation storage in the snowpack before generating runoff).

Similar to the stream gauge network, the primary use of both the precipitation and snow courses data is for flood control structure operation and flood warning, as well as for decision makers to design infrastructure, assess public risk and forecast severe weather events, watershed planning, and determine risks to habitat. Again, with the onset of climate change and increased extreme weather events, the data has now become vital to the on-going and future operations of the municipalities in TRCA's jurisdiction.

11.4 2008 Highlights

- RT stream gauges installed on Taylor Massey Creek and Krosno Creek. Laidlaw Bus Depot, G. Ross Lord dam, and Albion Hills Conservation Area upgraded to RT precipitation gauges.
- Public access to TRCA's RT flood warning website made available in winter 2008. Since its activation, over 3600 people have visited the website from over 29 countries.
- Initial phase of OHS job shadowing begins fall of 2008. TRCA expected to take over rating curve development for stream gauging network in spring 2010.
- Installation of remotely operated Purpleville Creek stream gauge to be used for flood vulnerable area monitoring.
- Approvals finalized for the construction of four new RT stream gauges located on Miller Creek, German Mills Creek, Humber River at Highway 7, and Font Hill Creek (Unionville). Construction expected to begin in spring 2009. Gauging data to be used for both flood warning and flood vulnerable area monitoring.
- All rating curve development or corrections contracted by OHS completed for 2009.
- Approvals finalized to install a RT video camera and precipitation gauge on the property of Evergreen "Brick Works". Construction to begin in summer 2009.

- RT level gauge to be installed at Secord Dam to improve wet weather operations and dam safety.
- The most snowfall recorded in 2008 was observed at Glen Major Forest with a total accumulation of 150.1 cm. The average snow depth across the TRCA jurisdiction was 15.9 cm. It was observed that snowfall within the GTA increased by 42% when compared with 2007 observations.
- Water quantity data collected by the TRCA's stream and precipitation gauging stations continues to be a valued asset in constant demand by our clients and is instrumental to the planning process and watershed management.

Figure 36: Water Quantity Monitoring Sites (Stream Flow Gauges)

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Figure 37: Water Quantity Monitoring Sites (Snow & Precipitation)

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12. Water Quantity - Baseflow

Staff Lead:	Jamie Duncan
Support Staff:	Rita Lucero, Jacek Tchórzewski, Leslie Croskery
Funding:	City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan

12.1 Background

Baseflow conditions represent the lowest stream flows that typically occur in a watercourse, and are usually supplied primarily by groundwater discharge occurring along the stream corridor and the gradual release of water from wetlands. The term low flow refers to the amount of stream flow that is sustained in a watercourse during extended periods of dry weather. In the case of the TRCA Low Flow Monitoring Program, low flow conditions occur in the drier summer season between June and September. The TRCA Low Flow Monitoring Program was established in 2000 and conducts ongoing jurisdictional monitoring of low flows during the drier summer season and important contribution to the Regional Watershed Monitoring Program (RWMP). The program consists of more than 1100 individual monitoring stations, with ongoing summer monthly monitoring occurring at an average of 70 stations per year. These 70 stations are called Indicator Stations and are usually located at the outflow of each major subwatershed. The other stations are more intensely distributed within each watershed and are measured systematically during a specific summer in order to obtain baseline data for upcoming watershed plans. Baseflow data has been measured annually since 2000; however data availability varies, depending on the site of interest. Currently, baseline data exists for all TRCA watersheds, with additional monthly data available from the indicator stations. All collected data is archived annually into an MS Access Database for future storage and analysis. Data is typically used for:

- Permit to Take Water (PTTW) review
- Development review
- Groundwater Model Calibration / Validation
- Ontario Low Water Response
- Fisheries Management Plans
- Source Water Protection Planning

The main purpose of the Low Flow Program is to develop data that allows for a better understanding of the interconnections between the groundwater and surface water systems. The program also helps to establish contacts and relationships with water users as a basis for promoting awareness and stewardship activities. The long term goal of the TRCA Low Flow Program is to guide the management and protection of baseflow levels to protect aquatic life and sustainable human use of surface water.

12.2 Methods

The low flow monitoring data are all collected according to Geological Survey of Canada protocols and methodologies (Hinton, 2005). The methodology requires that all overland runoff has ceased after a storm event and river flows are comprised solely of baseflow before any sampling can be done. Given the hydrologic response of the TRCA watersheds, a 72-hour period was established as the minimum time to wait following a rainfall event prior to any baseflow measurement. Upon arrival at the sampling location, a suitable transect must be found. For accuracy of measurements the stream segment should have a uniform bed, and be free of debris such as logs and rocks. The transect should be well away from any bends or meanders, and the riverbanks should not be undercut. Transects must be at a 90° angle to the streamflow.

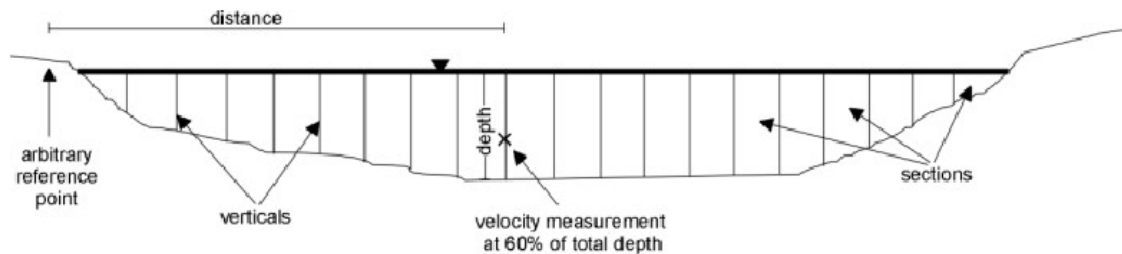


Figure 38: Cross section of a stream – baseflow transect

Once a suitable transect has been located, the channel is broken into 20 panels (or 5% of river per panel). These panels are measured for depth, width and water velocity. This is the velocity-area method of stream gauging (**Figure 38**). Depth and velocity are measured using a Marsh McBirney portable flow meter and depth rod. Velocity measurements are taken at 60% of the depth from the water surface. The width is acquired from a graduated tape spanning the transect. The collected measurements are recorded into an Excel spreadsheet where the panels are calculated and the total discharge of that stream segment is given. Field crews are also required to record any comments regarding that segment of the river. Permitted and non-permitted water takers are noted, as well as any land use that may be surface water dependant.

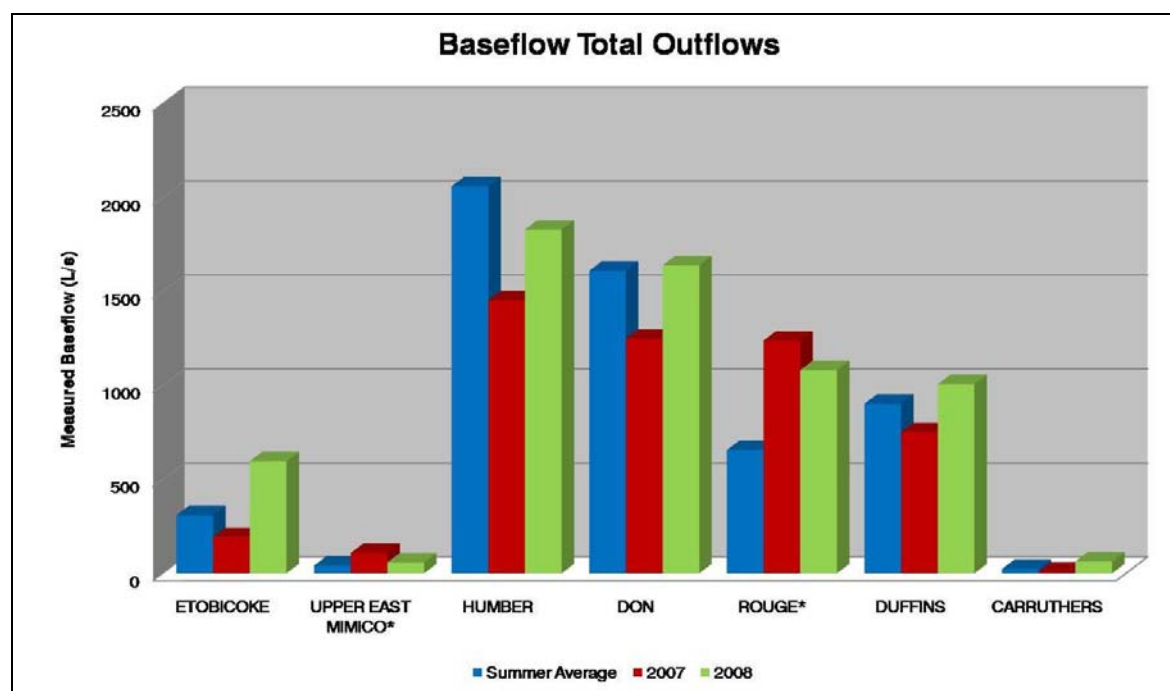
12.3 Data

Fieldwork for the 2008 summer included monthly measurements at 70 indicator stations throughout the TRCA jurisdiction. Extensive watershed wide sampling was not scheduled for 2008 because funding was not available. However, the headlining story for the 2008 field season was the record precipitation amounts during the summer, not to mention the record snowfall amounts in the preceding winter months. According to Environment Canada's climate station at Toronto Lester B. Pearson, almost 370mm of rain fell in the months of July to September, which is a 57% increase from normal amounts for that time of year. The frequent and excessive summer rainfall made low flow sampling very difficult, as often more

than 72-hours had to elapse for water levels to return to baseflow conditions. Nonetheless, 53 indicator stations were monitored with a total of 57 measurements, conducted at the beginning of July, the end of August and mid-September (**Figure 41**). All of the TRCA watersheds were sampled once, except for Highland Creek due to time, weather and staff constraints.

12.4 2008 Highlights

- For the most part, 2008 low flows were consistently higher than in 2007 when precipitation was significantly below normal amounts. Several comparisons were made between the 2007 and 2008 indicator site measurements. When 2008 watershed outflows were compared, most were much higher than in 2007 as displayed in **Figure 39**. In addition, 2007 and 2008 baseflow were compared with summer average outflows calculated from 2000 to 2006 data where it was available.



* **Note:** 2007 data from some locations in the watershed have been deemed skewed

Figure 39: Total baseflow outflow by watershed from west to east in L/s

- In most cases, the watershed outflows peaked in 2008 with the largest increases (greater than 100% from 2007) measured in the Carruthers and Etobicoke Creeks. Other increases from 2007 baseflow greater than 25% were measured at the outflows of the Duffins Creek, the Don and Humber Rivers. The Upper East Mimico Creek and Rouge River were the exceptions in which data showed measured flow in 2007 was highest. However, with further investigation, it was found that some of the data may have been influenced by other factors. In the Upper East Mimico Creek, measured baseflow at the outflow of the subwatershed was unusually high with

very elevated water levels for baseflow conditions. The high water levels may have been caused by various anthropogenic activities as the Mimico Creek watershed is 100% urbanized. However, this could not be confirmed, as these activities are difficult to quantify. In the Rouge watershed, there were several measurements that seemed like outliers, at individual stations and at the main Rouge River outflow station. Upon communications with several TRCA staff, it was discovered that Milne Dam, located in the Main Rouge River in Markham was operating its fishway in July of 2007, when baseflow was measured. This involved the discharging of water downstream into the creek system for several days. Also, active dewatering from shallow aquifers was occurring at the time of sampling in the Rouge River as part of the post 16th Avenue sewer trunk construction, to supplement flow to Robinson's Creek. Therefore, the 2007 data from these particular locations have been deemed skewed due to non-ideal sampling conditions.

- To further exemplify that 2008 was one of the wettest years on record, measured baseflow was also consistently higher than some average watershed outflows (calculated from 2000 to 2006 low flow data). **Table 5** shows the percent change in 2008 low flow from 2007 and from average low flow measurements. Again, Carruthers and Etobicoke Creeks have the largest increases in 2008 along with Petticoat Creek, all with close to, or greater than, 100% increases. Others with increases from average low flows included Rouge River, the Upper East Mimico and Duffins Creek. Two watersheds, the Don River and Frenchman's Bay (Amberlea Creek, Dunbarton Creek, Pine Creek and Krosno Creek) were stable with minimal changes. However the Humber River watershed shows a decrease in baseflow from the average. Although the decrease percentage is low (11%), it should be noted that the Humber River (and the Don River) contains a large flood control dam along the watercourse. If the dam(s) were operated prior to sampling, spot measurements taken downstream would be influenced by the gradual release of water from the dam reservoir, which would also affect trends found in the low flow data set.

Table 5: Percent change in measured 2008 low flow from 2007 and average outflow data

Watershed	2008 Measured Outflow (L/s)	% Increase from 2007 Low Flow	% Increase from Average Low Flow
Etobicoke	596	210%	93%
Upper East Mimico*	58	-46%	42%
Humber	1829	26%	-11%
Don	1638	31%	2%
Highland	n/a	n/a	n/a
Rouge *	1081	-13%	65%
Petticoat	98	n/a	476%
Frenchman's Bay	71	n/a	-2%
Duffins	1007	34%	12%
Carruthers	63	546%	171%

* Note: 2007 data from some locations in this watershed have been deemed skewed due to non-ideal sampling conditions

- The low flows occurring in 2007 and in 2008 are best demonstrated in site photos taken in the Little Rouge Creek with an optimal reference point (refer to **Figure 40**). These two photos are

very telling for the change in water levels that occurred in a summer that experienced below average rainfall (a) to that of a summer with above average rainfall (b).

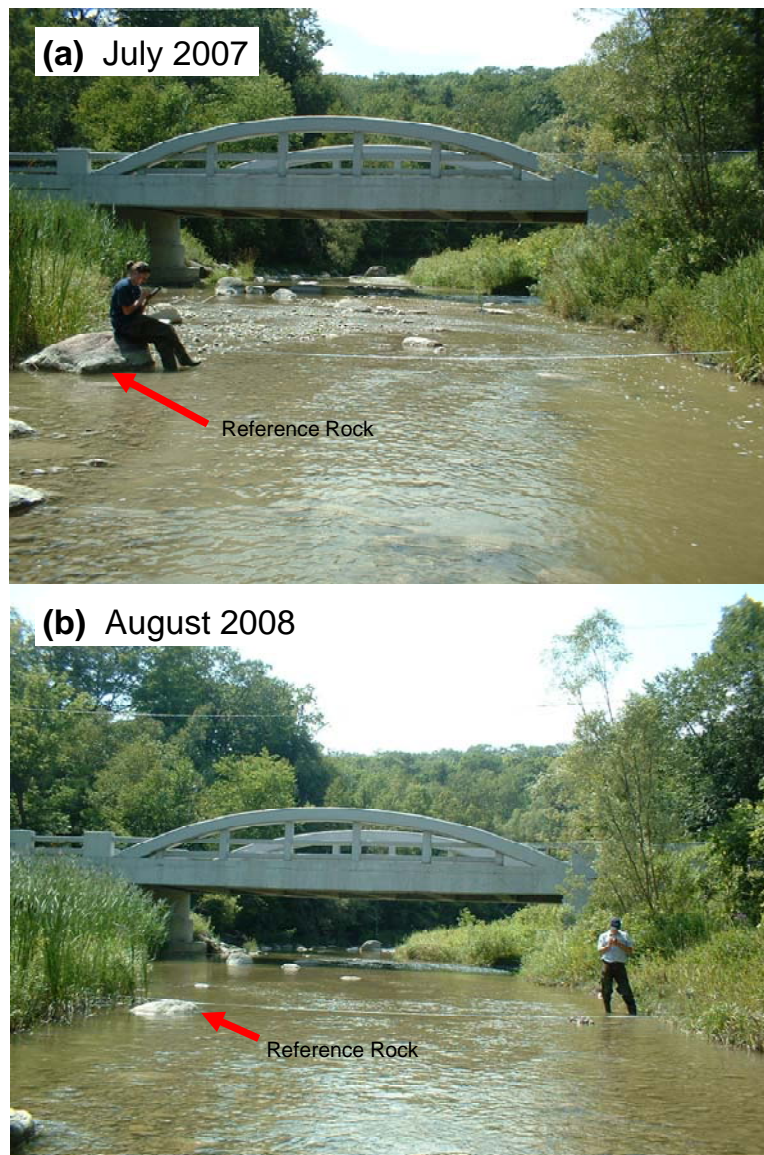


Figure 40: Baseflow transects taken at the Little Rouge Creek at Twyn Rivers Drive (facing upstream) in July 2007(a) and August 2008(b) under baseflow conditions

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Figure 41: Baseflow Monitoring Sites

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13. Climate Monitoring (Meteorological Network)

Staff Lead: Derek Smith

Support Staff: Craig Mitchell, Bill Kerr, Christy Somerville, Rita Lucero, Matt Derro, Seasonal Staff

Funding: City of Toronto, Peel Region, Durham Region and York Region

13.1 Background

No longer just a buzz word, *climate change* has become not only a national issue for governments but a commonly discussed concern among the public. Today, there is strong scientific evidence that climate change is a reality which is having environmental, social, and economic impacts. Socially and economically we're witnessing the evolution of alternative energy technology, shifts towards sustainable development and even the auto industry is making cars lighter, smaller, and more fuel efficient in order to combat climate change. Environmentally, we are seeing global temperature increases, weather pattern shifts, and range shifts of both flora and fauna.

The Intergovernmental Panel on Climate Change (IPCC) expects that warming in the 21st century will be greatest over land, and even greater in the higher northern latitudes. They further suggest that it is very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent (IPCC, 2007).

Canada has already begun feeling the affects of climate change, primarily in the arctic, but the consensus in the scientific community is that Ontario is slowly becoming impacted by climate change. For instance rising air temperatures, less snowfall, winter rainfall, increased summer evaporation, extreme weather events, suspect flora and fauna range shifts and lower lake levels have already been observed or predicted to occur in Ontario (CCIARN, 2005).

The TRCA identified Climate Change as an important issue related to its Watershed Management Mandate in the mid 1990's. While it's well know that urbanization has an impact on natural systems, the additional stress of climate change will serve to further influence change within our natural systems and create new or increased challenges to the TRCA's management objectives (Haley, 2006). For example, early attempts to deal with increased volumes of water in waterways were centered on stormwater management by reducing peak flow to match pre-development conditions. While this practice is now commonplace, urban infrastructure falls short of dealing with extreme weather such as rainfall greater than a 100 year storm (Haley, 2006) (**Figure 42**).



Figure 42: Finch Avenue culvert failure August 19th, 2005 Toronto, Ontario, >125mm in 1 hour

Conservation Authorities are in a unique position to be able to deal with climate change from both an adaptive and mitigation perspective since we are strategically placed to provide our clients with effective direction and input around managing local ecosystems under the challenges that climate change can create (Haley, 2006).

That being said, municipal, provincial and federal governments are recognizing the changes in microclimates and are now anticipated program and policy action items. Our clients continue to rely on the TRCA's data collection services and monitoring expertise to provide them with as much information regarding their watersheds as possible. This, in context with the TRCA's flood warning, infrastructure and water budget modelling, and natural heritage needs lead to the development of the TRCA's meteorological (MET) network (**Figure 45**).

Currently, the MET network consists of a variety of sensory devices including generic climate stations, evaporation pans, and speciality instrumentation (designed by York University) to monitor evapotranspiration. The MET network is still under construction and is anticipated to be complete in 2009.

13.2 Methods

Similar to our water quantity monitoring, the network is designed for remote operations and long-term deployment (>15 years). Construction of the TRCA MET network began in the spring of 2006 with the acquisition of two MET stations from Natural Resources Canada (NRC) and one from Guelph University. Since that time, partnerships with both Guelph University and York University have surfaced where they are investigating wind eddy covariance and evapotranspiration respectively. Currently, the TRCA has five MET stations deployed with three more stations expected to be installed in the spring/summer of 2009 (**Figure 43**).

Each station is fully automated and requires little human intervention. Various meteorological and land attributes are recorded every five minutes (some at 15 minute intervals) and vary depending on the stations capabilities and siting criteria. Sensor selection was determined to suit the needs of both modelling and generic MET observations. Monitored parameters include: rainfall, wind direction and speed, air and soil temperature, relative humidity, solar radiation, snow depth, barometric pressure, soil moisture, evaporation, evapotranspiration (ET) and leaf wetness. Each station is maintained monthly which includes sensor cleaning (if applicable) and data downloads.



Figure 43: Various TRCA MET stations (left: Transport Canada, Claremont; right: Kortright Conservation Area)

It should be noted that not all of the parameters listed above are monitored at each MET station. For instance, evaporation is monitored at only two of the five existing stations, a third evaporation system is anticipated to be installed in the spring of 2009. Evaporation is measured using a class A evaporation pan and stilling well. The stilling well is wired to a logger which records the water level in the pan every five minutes. Because the pans are located in remote areas, the pans are filled automatically via a 945L water tank and float/timer switch. As part of the monthly maintenance protocols, technicians simply

screen floatable and sunken debris (e.g. insects, air borne deposits) from the pan, test the float switch, and note tank water levels.

Similarly, ET is currently being monitored at only one station (Kortright Conservation Area) using an automated Bowen Ratio Energy Balance (BREB) system (**Figure 44**). Because of the complexity of ET monitoring, York University will be maintaining the BREB system and using TRCA MET data to calculate ET values for differing landuses. A second BREB system is currently under construction and will be deployed in the spring of 2009. The stations were designed to be portable and can be relocated to differing parts of the TRCA jurisdiction. Ultimately, all MET stations are expected to be telemetered which will drastically reduce site visits for data acquisition.



Figure 44: Automated Bowen Ratio Energy Balance system used to determine “actual” evapotranspiration values, located at Kortright Conservation Area

It should be noted that since 2005, eight air temperature stations were deployed by request of TRCA fisheries biologist with the intent to correlate air temperature fluctuations with tributary water temperatures. The sensors have been recording data every five minutes and record 365 days a year. It is expected that the data will be incorporated into the MET station database.

13.3 Data

Data at two of the MET stations has been collected since 2000 (stations acquired from NRC). The data are entered electronically into spreadsheet format and are stored on the TRCA network. Ultimately the data will be uploaded to the Envirobase database. All MET data are available to outside agencies and the general public upon request.

The initial purpose of this data was for flood warning and infrastructure modeling purposes. However, the general consensus of TRCA clients and personnel has confirmed that the data are necessary to document long term climate changes, and for both natural heritage and biological works.

Using the TRCA flood warning website as a portal, TRCA staff are currently working to make the MET station data available to both staff and the public. While not all stations will be posted, a request by flood warning staff to have strategically chosen stations posted will significantly advance flood warning bulletins.

13.4 2008 Highlights

- Town of Richmond Hill council members approved the installation of TRCA/Guelph University MET station on town property. It will be installed in a small green space behind a town fire hall near Sixteenth Avenue and Leslie Avenue. Because of the difficulty of meteorological monitoring in urban centres (e.g. vandalism, land acquisition), the station will be one of only a few located across North America. Faculty from Guelph University will be observing the effects that two storey developments (suburbia) have on wind dynamics. The data will also be used by York University for their ET research.
- ET monitoring within the Toronto Region has begun with help from York University where a BREB station was installed at Kortright Conservation Area. Also considered one of a kind research, ET monitoring of differing land uses will be conducted over the next several years to develop “actual” (not potential) ET values for typical land uses found in the Toronto Region and across Canada. The values will be used by modellers and decision makers to improve the accuracy of water budget and infrastructure models as well as document microclimate changes due to climate change.
- Two automated evaporation pan systems were installed in the spring of 2008 at Glenn Haffey and Kortright Conservation Areas. A third station is proposed to be installed in the spring of 2009, where land acquisition is already in progress. Data collected by each station will not only satisfy crucially needed evaporation data for the Toronto Region and southern Ontario modellers, but will also be used in the research being conducted by both York University and Guelph University.
- Three MET stations were installed in the spring of 2008 at Downsview Park, Seneca College King Campus, and Kortright Conservation Area.
- Land acquisitions underway for three new MET stations to be located in the southwest, central, and eastern regions of TRCA’s jurisdiction. A third automated evaporation pan system will also be installed at one of the three locations. Installation is anticipated to begin in the spring/summer of 2009.
- Correspondence with the Ministry of Environment and Environment Canada has unveiled data sharing and partnership interest.
- Continued air temperature monitoring for TRCA aquatic biology program in 2008.

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Figure 45: Meteorological Monitoring Sites

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14. Staff Contributions

14.1 Watershed Monitoring and Reporting Section Staff

14.1.1 Full-time Staff

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¹ Parental leave until May 2009.

14.1.2 Seasonal Staff

Dan Bechard, West Nile Virus Monitoring Technician
Meaghan Becker, Watershed Monitoring Technician
Mike Brestanksy, Watershed Monitoring Technician
John Brett, Fauna Field Biologist
Leslie Croskery, Field Monitoring Technician Intern
Greg Dillane, Watershed Monitoring Technician
Ashley Favaro, Watershed Monitoring Technician
Natasha Gonsalves, Flora Field Assistant
Paul Greck, Monitoring Technician (STEP)
Julie Henningar, Watershed Monitoring Technician
Robynne Hubert, Watershed Monitoring Technician
Jonah Kelly, Watershed Monitoring Technician
Heather Kime, Flora Field Assistant
Annette Lambert, Fauna Field Assistant
Lauren Sharkey, Watershed Monitoring Technician
Thomas Sciscione, Monitoring Technician (STEP)
Monique Smart, Watershed Monitoring Technician
Jacek Tchórzewski, Field Monitoring Technician Intern
Adam Wood, Watershed Monitoring Technician
Jessica Wright, Watershed Monitoring Technician

14.1.3 Other Staff Contributors (Ecology Division)

Jamie Duncan, Water Resources Data Management Analyst
Don Ford, Manager Geoenvironmental Section
Ming Guo, Database Administrator
Bill Kerr, Flood Infrastructure Coordinator
Rita Lucero, Monitoring Technician
Craig Mitchell, Flood Infrastructure Coordinator
Patricia Moleirinho, GIS Technologist
Lisa Moore, Hydrometric Analyst
Derek Smith, Hydrometrics Coordinator
Christy Somerville, Sustainable Technologies Analyst
Jason Tam, GIS Specialist
Jehan Zeb, Assistant Hydrogeologist

14.2 Training and Workshops

The TRCA's Ecology Division is committed to the belief that both the transfer of knowledge and continuous education are critical elements to effective management of our environmental resources. In addition to attending various training sessions, Watershed Monitoring and Reporting Section conducted several workshops for both internal and external participants.

14.2.1 Conducted by TRCA Staff

- WNV vector Mosquito larval ID training conducted for 13 staff from the Ministry of Transportation and Halton Region Health, May 6th, June 23rd 2008 at Boyd Office (Thilaka Krishnaraj)
- Terrestrial Volunteer Monitoring Program seasonal training for 117 volunteers, 12 sessions during 2008 (Theresa McKenzie)
- Ontario Stream Assessment Protocol (OSAP) training for 8 TRCA staff and 40 external participants
- Class II Backpack Electrofishing training to roughly 20 people (internal and external)

14.2.2 Attended by TRCA Staff

- Ontario Road Ecology Stewardship Symposium at the Toronto Zoo, April 23-24, 2008 (Paul Prior and Sue Hayes)
- Turtle Stewardship and Management workshop at the Toronto Zoo (Paul Prior)
- Butternut Health Assessment Workshop put on by the Forest Gene Conservation Centre (Gavin Miller)
- Ontario Urban Forest Council Symposium called "The Urban Forest – A Place to Evolve" (Gavin Miller and Paul Heydon)
- Biology and Biological Control of Invasive Plants in Canada symposium in Ottawa (Gavin Miller).
- Cootes Paradise State of the Forest Ecosystem workshop at the Royal Botanical Gardens (Sue Hayes)
- Provincial Water Quality Monitoring Network Workshop (Nelson Amaral)
- YSI water testing equipment training (Nelson Amaral)
- MICA writing course (Nelson Amaral, Lindsay Code, Thilaka Krishnaraj, Jeff Vandenberg)
- Ontario Freshwater Mussel Identification Workshop in Burlington, June 17-18, 2008 (Angela Wallace)
- Latonnell Conference in November 2008 (Angela Wallace, Jeff Vandenberg, Thilaka Krishnaraj and Nelson Amaral)
- Ontario Low Water Response Debriefing workshop conducted by the Ministry of Natural Resources in Toronto, Ontario, in May of 2008 (Jamie Duncan and Rita Lucero)
- Provincial Low Flow Database Development workshop conducted by the Ministry of Natural Resources in Port Hope, Ontario, in June of 2008 (Jamie Duncan)
- Unilock North America Annual Meeting, Feb 2008. Sustainable Technologies Evaluation Program, Niagara on the Lake, Ontario (Derek Smith)
- Unilock North America 8th Annual Permeable Paver Symposium, April 2008. Sustainable Technologies Evaluation Program, U.S. Cellular Field, Chicago, Illinois, USA (Derek Smith)

- Credit Valley Conservation Authority Seminar, Feb 2008. Automated Water Quality and Quantity Monitoring (Derek Smith)
- Clean Air Partnership ARC, Climate Change and the Great Lakes Webinar, Oct 2008 (Derek Smith)
- Water Environment Association of Ontario, Technical Symposium, March 2008 (Derek Smith)
- Freshwater Algae including Diatoms Identification Workshop in Warrensburg, New York, August 25 - 29, 2008 (Cheryl Goncalves)
- American Fisheries Society Conference in Ottawa (Aug 17-21, 2008)(Scott Jarvie)
- Monitoring The Moraine Symposium, Black Creek Pioneer Village (March 31, 2008) (Scott Jarvie)

14.3 Professional Activities

Watershed Monitoring and Reporting Section staff participated in several professional activities such as presenting RWMP at conferences and contributing to numerous committees. Several reports, including a peer reviewed journal article, were completed using data collected under RWMP.

14.3.1 Presentations

- Etobicoke–Mimico Watersheds Coalition. *Baseflow conditions and trends based on 2007 low flow monitoring data*. November 2008 (Jamie Duncan)
- Unilock North America Annual Meeting, Niagara on the Lake. *Performance Evaluation of Permeable Pavement and a Bioretention Swale*. February 2008. (Derek Smith)
- Unilock North America 8th Annual Permeable Paver Symposium, Chicago Ill. *Performance Evaluation of Permeable Pavement and a Bioretention Swale*. April 2008. (Derek Smith)
- Credit Valley Conservation Authority Seminar, Mississauga. *Automated Water Quality and Quantity Monitoring*. Feb 2008. (Derek Smith)
- Clean Air Partnership ARC, Climate Change and the Great Lakes Webinar. *TRCA's Water Management Guideline and STEP program*. Oct 2008. (Derek Smith, Sameer Dhalla)
- Water Environment Association of Ontario, Technical Symposium, Milton. *TRCA's Water Management Guideline and STEP program*. March 2008. (Derek Smith, Sameer Dhalla).
- Seneca College, King Campus, Classroom Seminar. *Automated Water Quality and Quantity Monitoring*. Oct 2008. (Derek Smith)
- South Mimico Community Action Group. *Water Quality information*. January 2008. (Scott Jarvie)
- Toronto and Region Conservation. *Durham Storms 2008 - A Preliminary Analysis of TRCA Precipitation and Stream Gauge Data*. August 2008. (Laurian Farrell)

14.3.2 Reports and Publications

- Terrestrial biological inventory reports for Bolton Resource Management Tract, Glen Major, Dagmar, Indian Line Campground and West Gormley
- Terrestrial Volunteer Monitoring Program: Monitoring Results 2002 - 2007
- Regional Watershed Monitoring Program Review 2001-2008, November 2008
- Annual Report on West Nile virus Vector Status in Toronto and Region Conservation Wetlands & Storm Water Management Ponds – 2008
- Technical brief for the Etobicoke-Mimico Watershed Plan Update
- Performance Evaluation of a Rainwater Harvesting System – Toronto, Ontario. Interim Report #2
- Performance Evaluation of Permeable Pavement and a Bioretention Swale - King City, Ontario
- Erosion and Sediment Control Practices Evaluation - Interim Report #1
- Fish Collection Report 2007 for Ministry of Natural Resources
- Bathurst Glen Golf Course Surface Water Quality Monitoring Report
- Fluvial Geomorphology Component of the EEESCP Project Report
- RWMP Field Safety Guide and daily safety checklist
- Humber River Watershed Plan - Pathways to a Healthy Humber
- Humber River State of the Watershed Reports: Aquatic System; Fluvial Geomorphology; Geology and Groundwater Resources; Surface Water Quality; Surface Water Quantity; Terrestrial System
- Farrell, L., D'Andrea, M., Haley, D., Snodgrass, William. *Storm of August 19, 2005: a Catalyst for Change from Reactive to Adaptive Urban Flood Management in Toronto, Ontario, Canada*. In Conference Proceedings ICLR May 7, 2008. Toronto.

14.3.3 Peer Reviewed Publications

- Kricsfalussy, V.V., Miller, G.C. 2008. Invasion and Distribution of *Cynanchum rossicum* (Asclepiadaceae), in the Toronto Region, Canada, with remarks on taxonomy. *Thaiszia – J. Bot.* 18: 21-36

14.4 Committees

Watershed Monitoring and Reporting Section staff participated on the following committees:

- Don Watershed Technical Team – Toronto and Region Conservation (Gavin Miller, Rita Lucero, Jamie Duncan)
- Humber Watershed Technical Team - Toronto and Region Conservation (Jamie Duncan)
- Jefferson Salamander Recovery Team – Ministry of Natural Resources (Sue Hayes)
- Natural Areas Inventory Technical and Management Teams – Credit Valley Conservation (Sue Hayes)
- Oak Ridges Corridor Park East Management Plan Staff Steering Committee – Toronto and Region Conservation (Sue Hayes)
- Bolton Resource Management Tract Technical Team – Toronto and Region Conservation (Sue Hayes)
- Southern Ontario Conservation Authorities Terrestrial Monitoring Network (Sue Hayes)

- Provincial Low Flow Database Development (LFLOW) – Ministry of Natural Resources (Jamie Duncan)
- Tap Runs Dry – Drought Adaptations in Southern Ontario – Environment Canada (Jamie Duncan)
- Ontario Low Water Response – Ministry of Natural Resources (Jamie Duncan, Rita Lucero)
- Toronto and Region Remedial Action Plan Technical Team (Scott Jarvie)
- Monitoring the Moraine - Technical Advisory Committee (Scott Jarvie)
- Database Working Group – Toronto and Region Conservation (Scott Jarvie, Angela Wallace, Jamie Duncan)
- Conservation Authorities Terrestrial Monitoring Network (Theresa McKenzie)
- Peel West Nile Virus Task Force Committee (Thilaka Krishnaraj)
- City of Toronto West Nile Virus Task Force Committee (Thilaka Krishnaraj)
- Durham West Nile Virus Response Committee (Thilaka Krishnaraj)
- York Regional West Nile Virus Response Committee (Thilaka Krishnaraj)
- SWMP and WNV Working Group –Ministry of Environment (Thilaka Krishnaraj)
- Etobicoke-Mimico Technical Team – Toronto and Region Conservation (Jamie Duncan, Rita Lucero, Paul Prior)
- OSAP training Steering Committee (Scott Jarvie)
- Southern Ontario Stream Monitoring and Research Team (SOSMRT) formerly Lake Ontario Modeling Team (Scott Jarvie, Angela Wallace)
- WNV Central East Committee (Thilaka Krishnaraj)

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Appendix A

Appendix A. 2008 RWMP Monitoring Activities by Watershed

		Etobicoke	Mimico	Humber	Don	Highland	Rouge	Petticoat	Duffins	Carruthers	Other ¹	Total
Regional Watershed Monitoring Program	Fish Species & Aquatic Habitat	6	7	10	24	12	6	2	8	0	3	78
	Algae Biomonitoring	2	2	4	3	1	6	0	2	0	0	20
	Benthic Invertebrates	19	10	46	24	11	35	4	21	3	4	178
	Fluvial Geomorphology	0	0	5	17	7	26	0	0	0	0	55
	West Nile Virus Monitoring	3	0	15	4	2	3	1	7	2	7	44
	Surface Water Quality	3	2	11	5	1	7	0	6	1	0	36
	Baseflow	9	2	14	7	0	7	2	8	3	5	57
	Stream Flow	2	1	5	8	1	3	1	7	1	2	31
	Precipitation	4	0	11	5	2	4	1	4	1	0	32
	Snow	1	0	4	1	0	2	0	2	0	0	10
	Groundwater Quality & Quantity	2	0	9	1	0	3	0	6	0	0	21
	Terrestrial Natural Heritage ²	16	0	1026	49	0	240	0	898	0	120	2349
	Terrestrial Volunteer Mon	5	1	19	6	3	7	1	7	1	4	54
	Climate Change	0	0	3	1	0	1	0	1	0	0	6
	Water Temperature	3	5	2	23	11	0	4	0	0	4	52

¹ Other minor watersheds including Frenchman's Bay

² Italicized numbers are the number of hectares monitored

Appendix B

Appendix B. 2008 RWMP Monitoring Activities by Region

		Durham	Peel	Toronto	York	Other ¹	Total
Regional Watershed Monitoring Program	Fish Species & Aquatic Habitat	13	13	38	15	0	78
	Algae	2	3	9	6	0	20
	Benthic Invertebrates	31	39	55	50	2	178
	Fluvial Geomorphology	0	1	25	29	0	55
	West Nile Virus Monitoring	10	11	10	13	0	44
	Surface Water Quality	7	5	13	11	1	36
	Baseflow	17	15	13	12	0	57
	Stream Flow	11	5	11	4	0	31
	Precipitation	5	9	9	9	0	32
	Snow	2	3	1	4	0	10
	Groundwater	6	7	2	6	0	21
	Terrestrial Natural Heritage²	<i>1008</i>	<i>542</i>	<i>10</i>	<i>790</i>	0	<i>2349</i>
	Terrestrial Volunteer Monitoring	10	14	17	12	1	54
	Climate Change	1	1	1	3	0	6
	Water Temperature	7	5	28	12	0	52

¹ Dufferin/Simcoe

² *Italicized numbers are the number of hectares monitored*