Regional Watershed Monitoring Program
Progress Report 2009

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Watershed Monitoring and Reporting Section
Ecology Division

TORONTO AND REGION Conservation
for The Living City

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1 Introduction

Healthy Rivers and Shorelines and *Regional Biodiversity* are key elements of the Toronto and Region Conservation Authority's strategic business plan. The ability to track and report on changes to these elements is paramount to the success of an organization that has a unique history of watershed planning, management and reporting in the greater Toronto region.

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. Further the program has enhanced the planning and coordination of monitoring activities, helped standardize protocols, and has filled several key data gaps that have been identified. It also facilitates the communication of data availability and data sharing both internally and with external agencies. By the end of 2009, 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 watershed and regional scales. In certain circumstances data can be assessed at the site scale and can be used as a "flag" to identify potential issues or direct additional assessment. Where restoration and recovery plans are implemented, future monitoring will track the progress of such enhancement initiatives.

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 is designed to provide an overview of each component of the monitoring program, identify the types of data available, document how the data is currently being used and to provide highlights from the 2009 season. This information will hopefully assist in promoting and facilitating additional opportunities for data sharing and collaboration based on this body of work, 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.

2 Terrestrial Habitat and Species

Staff Lead: Sue Hayes

Support Staff: Gavin Miller, Paul Prior, Kelly Purves, Paul Heydon, Natasha Gonsalves, Annette Lambert, Daniel Westerhof, Michael King

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

2.1 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 this component 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 modelling and the development of the Terrestrial Natural Heritage System Strategy (TRCA 2007a). 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, Toronto and Region Conservation Authority (TRCA) implemented terrestrial monitoring at a number of fixed plots throughout the Toronto region. This new component of the program will identify species and vegetation community trends that are occurring across the jurisdiction over time.

2.2 Methods

The terrestrial areas surveyed in 2009 are identified in Figure 3. Three Natural Channel Design (NCD) sites along with 18 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 breeding birds and roadkill surveys were conducted in the Stouffville Road and Bayview Avenue area. Long-term fixed monitoring plots were set-up and initial data was collected for project sites at Caledon East and Ontario Power Generation. As part of the regional fixed monitoring plots, data was collected at 22 forest, 15 wetland and 13 meadow plots distributed across the TRCA jurisdiction.

Terrestrial Inventories

A biological inventory of each of the 18 sites was conducted at the levels of vegetation community and species (flora and fauna) according to the TRCA data collection methodology (TRCA 2007b).

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 2009. Please refer to the Natural Channel Design Terrestrial Monitoring Methodology for more information (TRCA 2009a).

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, tree regeneration and shrubs, breeding birds and red-backed salamanders (Figure 1). 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.

Figure 1. TRCA biologists setting up fixed monitoring plots

2.3 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).

2.4 2009 Highlights

The 2009 field season was split between collecting plot data at the long-term fixed monitoring sites and conducting issue based site inventories. At the regional level, data was collected at 22 forest plots, 15 wetland plots and 13 meadow plots. In addition, wetland vegetation plots were set-up as part of a project in Caledon East. An additional fixed plot monitoring initiative was undertaken for Ontario Power Generation whereby forest, wetland and meadow plots were set-up and baseline data recorded at their Pickering property.

Eighteen sites were inventoried for vegetation community, flora and fauna species in 2009 that covered approximately 1000 hectares. Parts of the Glen Major area were also re-surveyed to update breeding bird species and roadkill surveys were conducted in the Stouffville Road and Bayview Avenue area during spring amphibian migration period.

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

- Common raven (*Corvus corax*) seems to be moving further south into the TRCA jurisdiction with a breeding pair found in Pickering around Hwy 7 this past season. This species is now being seen more and more frequently in all corners of the jurisdiction. Several hypotheses 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 provided by communication towers).

- Red-shouldered hawk (*Buteo lineatus*) was seen during the breeding season displaying around the Goodwood Tract in Uxbridge. This species requires large tracks of undisturbed mature deciduous forest for breeding. Since, this species has experienced large population declines in recent years due to habitat destruction; their populations are closely monitored throughout the province.

- Long-eared Owl fledglings (confirmed breeding evidence!) were found in south Caledon. Few records (seven known locations have been identified over the past decade) of this species have been recorded for this species by TRCA biologists during the breeding bird season.

- An active Northern Goshawk nest was discovered in the Glen Major forest tract. This is one of seven locations where this species has been found in the jurisdiction. They require large undisturbed

forests for breeding and therefore are generally restricted to the north-western and north-eastern corners of the jurisdiction where this habitat is still available.

- Rediscovery of Bicknell's cranebill (*Geranium bicknellii*), thought to be extirpated from the TRCA jurisdiction (Figure 2). This species is generally found in slightly disturbed or open areas.

- The first known documented records for grove stitchwort (*Moehringia lateriflora*), shoreline horsetail (*Equisetum* x *litorale*) and sweet gale (*Myrica gale*) were found in the TRCA jurisdiction.

- Road kill surveys along Stouffville Rd. east of Bayview Ave. continue to identify 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. Bicknell's cranebill *(Geranium bicknellii)*

Figure 3

2009 Terrestrial Natural Heritage Monitoring Sites

Toronto and Region Conservation for The Living City

Scale: 1:250,000

Legend

Fixed Plot Monitoring

Plot Types

- Forest
- Meadow
- Wetland

- Inventory 2009
- Inventory 2000-2008
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

Disclaimer:
The Data used to create this map was compiled from a variety sources & dates.The T.R.C.A. takes no responsibility for errors or omissions in the data and retains the right to make changes & corrections at anytime without notice. For further information about the data on this map, please contact the T.R.C.A. GIS Department. (416) 661-6600

Durham Region
York Region
Peel Region
Toronto
Duffins
Carruthers
Petticoat
Highland
Rouge
Humber
Don
Mimico
Etobicoke
9
7
400
404
407
401
427
409
410
403
0 1.5 3 6 9 12 Kilometers

3 Terrestrial Volunteer Monitoring Program

Staff Lead: Theresa McKenzie

Support Staff: Team of volunteers (138 participants during 2009)

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

3.1 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 6). Volunteers collect data on the presence of a set of 50 amphibian, mammal, bird, vascular plant and lichen indicator species. Beginning in 2009, they also conduct two surveys each year to establish the occurrence and extent of invasion of each site by eight selected invasive exotic plants. Data are analyzed by TRCA to report on the condition of the terrestrial ecosystem and major habitats of the region, document differences between urbanization zones and to monitor change over time.

3.2 Methods

Volunteers, working in pairs, survey their assigned 10 hectare fixed site 10 times each year, with visits distributed throughout all four seasons. Each of the visits is conducted within a specific date range and time of day, as established in the monitoring protocol. Visual and/or aural observations of indicator species are recorded on a standardized data sheet, along with date, times and other environmental data. Confirmation of species identification requires individual verification of two to three observation characteristics. Training is required for all participants, and a 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. Volunteer Conducting Survey

3.3 Data

Data are recorded on paper data sheets in the field, and then entered into an online MS Access database through a data entry website. They are managed, quality assured, analyzed and reported on by TRCA staff. For each fixed site, data records include the native indicator species found by visit date, the number of occurrences and size of the largest occurrence for the invasive plants, and the presence or absence of categorized cultural impacts such as tree harvesting, trails, litter, 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 used to investigate relationships between landscape characteristics from other TRCA data sets and the observed indicator species richness, species richness of selected taxa and of selected habitat guild groups (TRCA 2008).

3.4 2009 Highlights

- Fifty-three of the 56 TVMP fixed sites were monitored during 2009, with a total of 138 volunteers participating.
- Forty-four of the 56 TVMP fixed sites were monitored for invasive species; this reduced number of completed surveys was due to volunteer turnover during the summer months this year.
- The invasive plant species monitoring component was developed and implemented; relevant training and support materials were provided to volunteers.
- Invasive indicator species data were quality controlled, summarized and compiled into a presentation to provide information on the distribution and severity of invasion for these species across the region.
- Program highlights were presented at a client showcase hosted by Transport Canada, on whose lands two of the fixed sites are located.
- Following the release of the 2008 report on monitoring results, municipal partners have become more aware of the program and have recommended it to residents inquiring about volunteer opportunities in the field of ecology.
- A change in the composition of the volunteer group was noted during 2009, with the majority of new volunteers being third to fourth year undergraduates, post-graduates students or graduates of biology, environmental studies or ecology programs; fewer were employed in other fields or retired; the reason for this change has not been investigated, but may relate to poorer job prospects for biology graduates in the current economy.
- Five volunteers credited the training and experience obtained through the TVMP in assisting with their successful acceptance to graduate school or hiring in the environmental field during 2009.
- A winter wildlife tracking field trip was well attended and thoroughly enjoyed by volunteers.
- Seven of the eight invasive indicators were found within TVMP sites.
- European frog-bit (*Hydrocharis morsus-ranae*) was encountered at one location, adjacent to a fixed site located in the Duffins marsh (Figure 5).
- Invasive species varied in their distribution across the region and severity of invasion at TVMP sites, with Common buckthorn (*Rhamnus cathartica*) both most commonly found and recording the highest level of invasion (Table 1).
- Results indicate that 50% of TVMP sites were severely invaded by one or more of the indicators.
- The number of invasive indicators found per site ranged from 0 to 4.

Figure 5. European frog-bit at Duffins marsh

- Fifteen sites had an area of invasion estimated at greater than 1 ha, which represents over 10% of the total area of each site

Table 1. Summary of Invasive Plant Indicators found on 44 TVMP sites surveyed in 2009

Common Name	Scientific Name	Proportion of sites with indicator (%)	Proportion of sites severely invaded (%)
Garlic mustard	*Alliaria petiolata*	70	14
Dog-strangling vine	*Cynanchum rossicum, C. nigrum**	48	23
Common buckthorn	*Rhamnus cathartica*	73	25
Glossy buckthorn	*Rhamnus frangula*	9	2
Himalayan balsam	*Impatiens glandulifera*	14	2
Periwinkle	*Vinca minor*	9	2
Common reed	*Phragmites australis australis*	16	9
European frog-bit	*Hydrocharis-morsus ranae*	0 **	0

* The dog-strangling vine (also known as swallowwort) found to date in the TRCA jurisdiction is primarily *C. rossicum*, but one population of *C. nigrum* has been recorded by TRCA staff (TRCA 2007c). Since the two species are difficult to distinguish from each other when not in bloom, they were surveyed as a single indicator, and where possible, the species identification recorded.
** European frog-bit was observed immediately adjacent to a site in the Duffins marsh.

Figure 6

2009 Terrestrial Volunteer Monitoring Sites

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Scale: 1:250,000

Legend

- Monitoring Site
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

Disclaimer:
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0 2 4 8 12 16 Kilometers

4 Fish Community and Habitat Surveys

Staff Lead: Jeff Vandenberg

Support Staff: Nelson Amaral, Melanie Croft-White, Lindsay Code, Greg Dillane, Mike Brestansky, Ashley Favaro, Lauren Sharkey, Sarah Scharfenberg, Todd Copeland, Ian Fife, Lindsay Knezevich, Cindy Hignett, Megan Becker

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

4.1 Background

As part of the Regional Watershed Monitoring Program (RWMP), fish community and habitat are monitored at one-third of the long-term monitoring sites annually, on a three year rotation. Standardized sampling methods are used to allow for the comparison of the fish community with the physical conditions of streams, both spatially and temporally across the jurisdiction. Overall a total of 151 RWMP stream sites have been established for long-term monitoring.

In addition to the RWMP sites, a number of other project sites are also assessed annually on a special request basis. In 2009 requests came from other TRCA departments as well as various government organizations and academia. These projects included: Palgrave Fishway, Mill Pond Splash, Upper Mimico Creek Aquatic Restoration sites and Erosion Control sites.

4.2 Methods

Monitoring surveys follow the methods outlined in the Ontario Stream Assessment Protocol (OSAP) (Stanfield 2005). Fish community and habitat sampling includes data collection for: fish community composition, in-stream habitat (e.g. sediment type, vegetation), and bank stability. Fish communities are sampled by backpack electrofishing using a single pass approach. Electrofishing is a non-lethal sampling technique using electric currents and electric fields to immobilize fish, allowing capture. Captured fish are identified to species, weighed and measured and then released back into the water (Figure 7). 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 for verification by a qualified fish taxonomist.

Figure 7. Sorting and Identifying Fish

Habitat surveys involve both in-stream and bank assessments and are completed subsequent to the fish community surveys. The in-stream portion assesses the suitability of the habitat to support a diverse aquatic community whereas; the bank assessment quantifies the riparian condition and the stability of the land bordering the stream.

A total of 56 sites were sampled in 2009 (Figure 10), including 46 RWMP sites in the Rouge, Duffins and Carruthers watersheds, and 10 special project sites found in the Etobicoke, Mimico, Humber and Don watersheds. There are now three completed data sets available for the RWMP sites in the Rouge, Duffins and Carruthers watersheds (2003, 2006, 2009).

4.3 Data

Data are entered into a Microsoft Access database (HabProgs) and the original datasheets are maintained at the Boyd Field Centre as well as being 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 by the Southern Ontario Stream Monitoring and Research Team (SOSMART) for the development of tools and models to predict the effect of landscape level disturbance on aquatic habitats and communities.

4.4 2009 Highlights

- A number of fish species were captured in Carruthers Creek that had not previously been found during RWMP surveys in 2003 or 2006:
  - Northern Pike (*Esox lucius*) was captured at CC001WM (Figure 8)
  - Brook Stickleback (*Culaea inconstans*) were found at CC001WM
  - Rainbow Trout (*Oncorhynchus mykiss*) were found at CC003WM; the two individuals captured were young of the year (~5cm) which indicates Rainbow Trout are spawning in Carruthers Creek
- Round Gobies *(Neogobius melanostomus*) were found in the Duffins watershed at site DF001WM upstream of the Duffins marsh. This exotic invasive species was found for the first time in the Humber and Etobicoke Creek watersheds in 2007 and Mimico Creek in 2008.

Figure 8. Northern Pike *(Esox lucius)* from CC001WM

- Rainbow darters (*Etheostoma caeruleum*) were found for the first time during RWMP fish surveying in the Etobicoke watershed (ECMPEC1 and ECCDEC1). Rainbow darters prefer gravel bottomed clear water streams of moderate to large size (Scott and Crossman 1998). This species has been found in a number of watersheds in the TRCA jurisdiction.
- In 2009 the Redside Dace (*Clinostomatus elongatus*) was upgraded to "endangered" on the Provincial Species at Risk list. Through ongoing discussions with MNR Aurora District staff it was determined that a number of RWMP sites would be useful sampling locations for Redside Dace as part of a long-term index monitoring program being established as part of recovery plan for this species.
- In 2009 a total of eight sites were identified as Redside Dace index sites, six in the Rouge River and two in Duffins Creek. Of the eight index sites sampled, Redside Dace were captured at four. Redside Dace were also captured at four additional sites in the Rouge watershed.

The Index of Biotic Integrity (IBI) is a multi-metric index used to rate the overall health of a fish community (Steedman 1988). The scores are given a raking of very poor (0-8), poor (9-20), fair (21-27), good (28-37) or very good (28-45). An IBI score was determined for each site in the Rouge, Duffins and Carruthers watersheds. Table 2 summarizes the percentage of IBI scores according to ranking. Three habitat quality categories, good, fair and poor are present for the three watersheds.

Table 2. IBI ratings for sites in the Rouge, Duffins and Carruthers watersheds (2006, 2009), shown as percentages.

	2006			2009			Change
	Good	Fair	Poor	Good	Fair	Poor	
Carruthers	33%	66%		33%	66%		No Change
Duffins	29%	66%	5%	33%	57%	10%	No Change
Rouge	17%	72%	11%	33%	47%	20%	No Change

4.4.1 Project Specific Aquatic Surveys

Restoration Services Erosion Control Sites

The TRCA's Restoration Services Division undertakes a number of construction projects designed to stabilize eroding stream banks in order to protect property and create habitat for local wildlife. In order to determine the success of these efforts, pre and post construction fish community sampling is undertaken. Staff from the RWMP group assisted the Restoration Services Division by conducting baseline aquatic surveys at 7 Erosion Control sites (Figure 10**)**.

In 2009, two sites (DNBPEC1 and HUBTEC2) were assessed as baseline for upcoming erosion control work. In addition several other sites were sampled at which the erosion control works had been previously

completed. These sites included: MCWCEC1, MCEC1, ECCDEC1, ECMPEC1 and HUBTEC1. 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).

Restoration Services Upper Mimico Creek Sites

As part of an ongoing effort to revitalize and restore Mimico Creek, the TRCA selected an aquatic habitat restoration site within a highly urbanized area of the watershed in the City of Brampton. This site is known as the Upper Mimico Creek Aquatic Restoration site. This area of Mimico Creek was previously straightened and hardened with stone to stabilize the land adjacent to the rail yard. The restoration project involved redirecting the channel to a more natural meander including pool-riffle sequences. The improvement of habitat conditions for fish and invertebrates was also undertaken.

The implementation of the project was completed in the spring of 2009 and post construction monitoring was undertaken by the RWMP group using OSAP protocols. Three sites were selected, CTSC4, UMP2 and UMP3, with one located in each of the three phases of construction.

Mill Pond Splash

Mill Pond Splash is a yearly eco-festival held at Mill Pond Park near downtown Richmond Hill. This festival promotes public awareness of conservation issues affecting our natural environment. Electrofishing and fish community sampling was demonstrated by RWMP staff at Mill Pond on May 31st, 2009. The general public benefits from this demonstration by learning how a monitoring project is conducted and seeing some native fish species up close (Figure 9). The species information collected during the Mill Pond Splash contributes valuable data on the state of the pond and provides a baseline for future studies.

Figure 9. Mill Pond Splash

Figure 10

2009 Fish Community and Habitat Monitoring Sites

TORONTO AND REGION Conservation for The Living City

Scale: 1:250,000

Legend

- Aquatic Habitat & Species Site
- Erosion Control Site
- Special Project Site
  - 1. Mill Pond Splash
  - 2. Palgrave Fishway
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

Disclaimer:
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Durham Region
York Region
Peel Region
Toronto
Duffins
Carruthers
Rouge
Petticoat
Highland
Don
Humber
Etobicoke
Mimico
1
2
400
401
403
404
407
409
410
427
7
9
0 2 4 8 12 16 Kilometers

5 Algae Biomonitoring

Staff Lead: Cheryl Goncalves

Support Staff: Angela Wallace

Funding: Ministry of the Environment

5.1 Background

In 2008, TRCA and the Ministry of the Environment partnered to introduce and promote an Algae Bioassessment Protocol (ABP) (Zugic-Drakulic 2006) under the Regional Watershed Monitoring Program. Until recently, the importance of plants (and particularly algae and diatoms) has been undervalued in watershed monitoring. Algae, including diatoms (Figure 11, Figure 14), are among the first group of organisms to be impacted by shifts in chemical conditions in a waterbody, as they are very sensitive to changes in basic water chemistry. 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. Because plants (including algae and diatoms) are more sensitive to changes in water quality, any changes in the community structure would be seen earlier and at lower concentrations than with other communities currently monitored, such as benthic invertebrates. The ability to monitor the algae community provides the advantage of having an early warning system of change in a watershed.

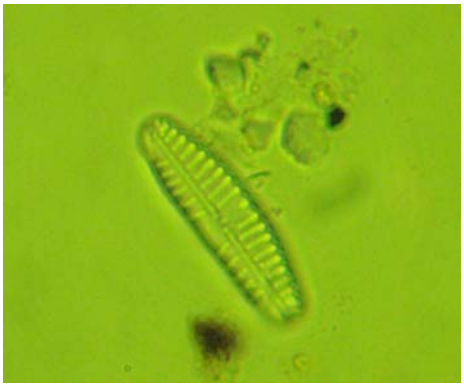


Figure 11. ***Reimeria uniseriata***

In its first year the repeatability of the Algae Bioassessment Protocol was assessed through the collection of samples from 20 RWMP monitoring sites. In its second year the partnership was extended until March 2011, with the goal of recruiting participants to test application of the protocol from other Conservation Authorities across the province.

5.2 Methods

For the 2009 field season 20 sampling sites across Southern Ontario were sampled following the ABP. At each of the sites in-situ water quality data was collected using a water quality probe. Field crews observed four points along each of five transects set up in a riffle area, describing the different growth forms of algae, the colour,

Figure 12. Algae on rock

texture, thickness, odour (if detected) and percentage of subsurface covered by each algal growth form (Figure 12). One algae sample was collected from each transect and pooled together for a composite (Figure 13). At 14 of these sites the TRCA Algae Biologist also collected a second sample of algae so that comparisons could be made between experienced staff and crews that were newly trained in the protocol.

To identify the diatoms to species level the samples were processed and permanent slides were prepared. A minimum of 400 diatoms are identified and counted for each sample. By September of 2009 all of the samples collected in 2008 had been identified. Pictures and slides were sent to Isabelle Lavoie (Algae and diatom specialist Trent University, Université du Québec) for Quality Control/Quality Assurance. Permanent slides have been prepared for all of the 2009 samples and the identification and enumeration process has begun.

Figure 13. Collecting algae sample from rocks

5.3 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 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 2008 and 2009.

Figure 14. *Cymatopleura solea*

5.4 2009 Highlights

- On April 27, 2009 an Algae Biomonitoring Protocol Workshop was held with the intention of introducing practitioners to the use of benthic algae (particularly diatoms) as indicators of water quality in streams. Guest presentations helped to show practical uses of diatoms for water quality assessments that are currently being employed in Ontario and Quebec. The presenters included Natasa Drakulic, Katie Thomas (MSc. candidate at University of Waterloo) and Isabelle Lavoie. Attendees included 35 participants from 16 different Conservation Authorities, the Severn Sound RAP and MOE staff. The goal of the workshop was to introduce the opportunity for a Partnership Study using the ABP to be conducted in the fall of 2009. As a result of this workshop six Conservation Authorities volunteered to participate in the Partnership study.

- In September and October TRCA's Algal Biologist travelled to six Conservation Authorities (Nottawasaga, Credit Valley, Upper Thames, Saugeen, Ausable Bayfield and Cataraqui Creek) to conduct algal sampling for the 2009 Partnership study. As partners each Conservation Authority provided staff members for one day to collect algal samples. All participants were trained in the application of the ABP. A total of 20 sites were sampled; at 14 of these sites a second sample was collected by TRCA's Algae Biologist for comparison purposes, for a total of 34 samples.

- In November participants of the Partnership study were forwarded a survey and asked to evaluate the ABP and the training provided. Recommendations to improve the protocol were considered and improvements are being written into a revised protocol.

- TRCA acquired a microscope camera able to capture details at the 1000X magnification. This tool will be extremely helpful for both identification and documentation purposes of permanent algae slides in the Boyd Office lab

Figure 15

Toronto and Region Conservation for The Living City

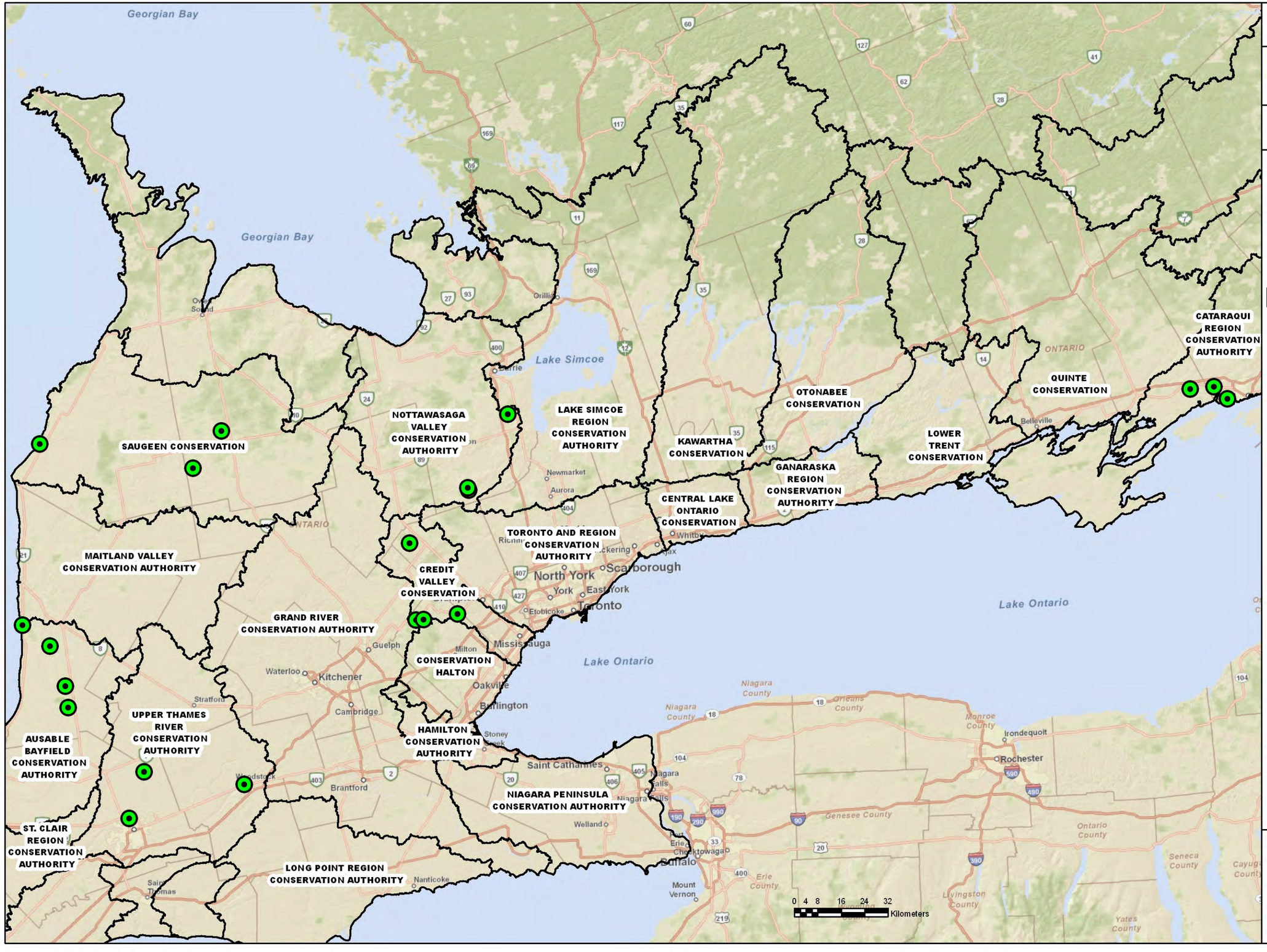
Scale: 1:1,250,000

Legend

- Algae Biomonitoring
- Conservation Authority Boundaries

Basemap: ESRI, ArcGIS Online World Street Map

2009 Algae Biomonitoring Sites



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6 Surface Water Quality

Staff Lead: Angela Wallace

Support Staff: Nelson Amaral, Ming Guo, Roger Hua, Derek Smith (Wet Weather Flow)

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

6.1 Background

Since 2002, TRCA has partnered with the Ontario Ministry of the Environment (MOE) to monitor surface water quality throughout the TRCA's jurisdiction. Surface water quality samples were collected monthly at 38 sites in 2009 (Table 3, Figure 21) across the jurisdiction. This included two new sites: one in the Petticoat Creek watershed and one site in Pine Creek, a small tributary of Frenchman's Bay. TRCA staff also took over water quality sampling at the mouth of the Humber River and the mouth of the Don River (previously sampled by Ontario Ministry of the Environment (MOE) staff). In addition to the routine monitoring, these two sites are also analyzed for mercury and pesticides.

Figure 16. Taking in-situ water quality readings

Table 3. Number of Surface Water Quality Sampling Sites by Watershed

Etobicoke Creek	Mimico Creek	Humber River	Don River	Highland Creek	Rouge River	Duffins Creek	Carruthers Creek	Petticoat Creek	Frenchman's Bay	Total
3	2	11	5	1	7	6	1	1	1	38

6.2 Methods

Water sampling followed the MOE Provincial Water Quality Monitoring Network (PWQMN) protocols (OMOE 2003) and included field water chemistry measurements (e.g. water temperature, conductivity, and dissolved oxygen). Sampling occurred year round and was independent of precipitation. TRCA staff collected water samples at 13 sites as part of the MOE's Provincial Water Quality Monitoring Network (PWQMN) and at 25 additional sites.

Samples were submitted either to the MOE Rexdale Laboratory, York-Durham Environmental Laboratory, or Guelph University for analysis of the parameters listed in Table 4. Pesticide samples for the mouth of the Don and Humber Rivers were submitted to the University of Guelph for analysis. PWQMN samples were sent to the MOE laboratory from April to November. The TRCA augments the PWQMN sampling by collecting water quality during the winter months and submitted the samples to the York-Durham laboratory for analysis. Non-PWQMN sites were sent to the York-Durham laboratory year-round. Previously, non-PWQMN samples were analyzed at the City of Toronto laboratory. The City of Toronto laboratory is undergoing renovations, therefore, samples were sent to the York-Durham laboratory in the interim. The RWMP also collected microbiology samples at every water quality site in the network, including the PWQMN sites, which were analyzed at the York-Durham laboratory. Microbiology samples were previously sent to Maxxam Analytics Inc. (a private laboratory) but were sent to the York-Durham laboratory in 2009 to streamline the sample delivery process.

Table 4. Select water quality parameters analyzed as part of the RWMP

General Chemistry	Water Temperature	Total Suspended Solids*	Total Dissolved Solids	Dissolved Oxygen	Turbidity
	Conductivity	Hardness	Magnesium	pH	Potassium
	Alkalinity	Sodium	Calcium	Chloride	
Nutrients	Nitrogen, Total Kjeldahl	Total Phosphorus*	Phosphate	Ammonia	Nitrate/Nitrite*
Microbiological	Escherichia coli				
Metals	Aluminum	Barium	Beryllium	Cadmium	Chromium
	Cobalt	Copper*	Iron	Lead8	Manganese
	Molybdenum	Nickel	Strontium	Vanadium	Zinc

Note: Additional parameters may be analyzed depending on laboratory (e.g. DOC, Sulphates)
*PWQMN indicator parameters

6.3 Data

Water quality data is stored in the *Water* database which is part of the *Envirobase* database, the TRCA's corporate database which houses monitoring data. In 2009, the *Water* database was converted from a Microsoft Access database to a structured query language (SQL) database. This database includes

laboratory results and metadata (e.g. laboratory analysis methods, sampling equipment). In November 2009, the SQL database was made available to all TRCA staff to access internally via the intranet. Improvements to the database are on-going.

6.4 2009 Highlights

- Two additional water quality sites were established as part of the RWMP. One site was established in the Petticoat Creek (July 2009) watershed and one site in Pine Creek, a small tributary of Frenchman's Bay (June 2009).

- The report Source *Water Protection: Surface Water Quality Update* (TRCA 2009b) analyzed the current water quality (2003-2007) across the TRCA's jurisdiction. The general conclusion was that water quality issues are correlated to the amount of urbanization within a watershed. The Duffins Creek watershed along with the upper Humber River and Rouge River continue to exhibit the best water quality within the TRCA's jurisdiction. Lower levels of urbanization, larger riparian buffers, and groundwater contributions may play a role in the water quality in these areas. In addition, temporal trends in water quality were analyzed where there was sufficient data. Total suspended solids and total phosphorus were found to decrease over time while chloride showed an increasing trend.

- RWMP staff continued to collect surface water quality samples at Bathurst Glen Golf Course as part of the Audubon Cooperative Sanctuary Program (ACSP) certification. The ACSP is a certification program that helps golf courses protect and preserve the natural environment. Additional sampling, including benthic macroinvertebrate and fish collection, was also conducted in 2009. A summary report on the water quality (2007-2009) and biological results will be completed in early 2010.

- For the past four years, TRCA staff in cooperation with the Regional Municipalities of Durham and York, the Town of Ajax, University of Waterloo and the MOE, have been undertaking water quality surveys of the western portion of the Lake Ontario waterfront in Durham Region. RWMP staff took over the stream water quality sampling in 2009. The objective of this monitoring project is to determine which factors are affecting lake water quality along the waterfront. Water entering Lake Ontario from the Duffins Creek, Carruthers Creek, and the Rouge River, as well as direct discharges from storm sewer outfalls near and on the waterfront will be considered. Ultimately, the goal is to identify practices or sources of pollutants which are impacting water quality of the lake, causing beach closures along the waterfront, and affecting the growth of *Cladophora* (algae). Findings from this study will be presented at 2010 International Association of Great Lakes Research (IAGLR) conference in Toronto and drinking Source Water Protection reports being prepared for by Province of Ontario.

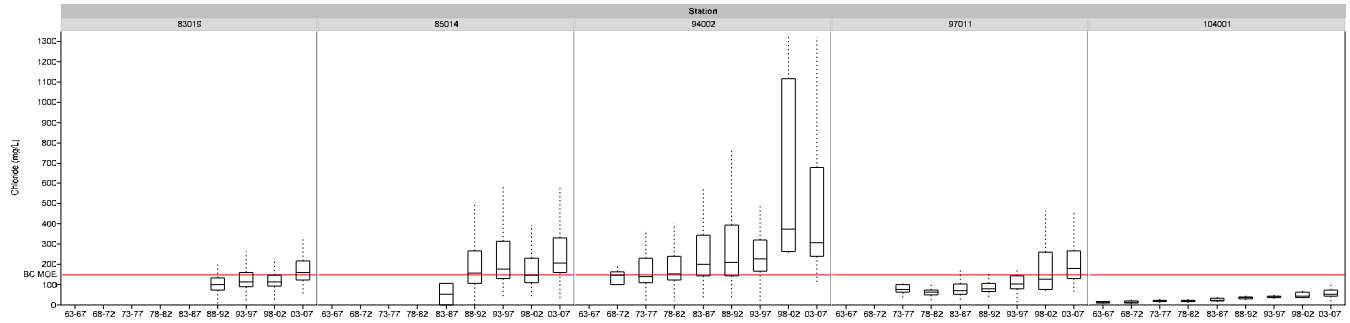


Figure 17. Chloride concentrations for the mouth of the Humber River, Don River, Highland Creek, Rouge River and Duffins Creek over time

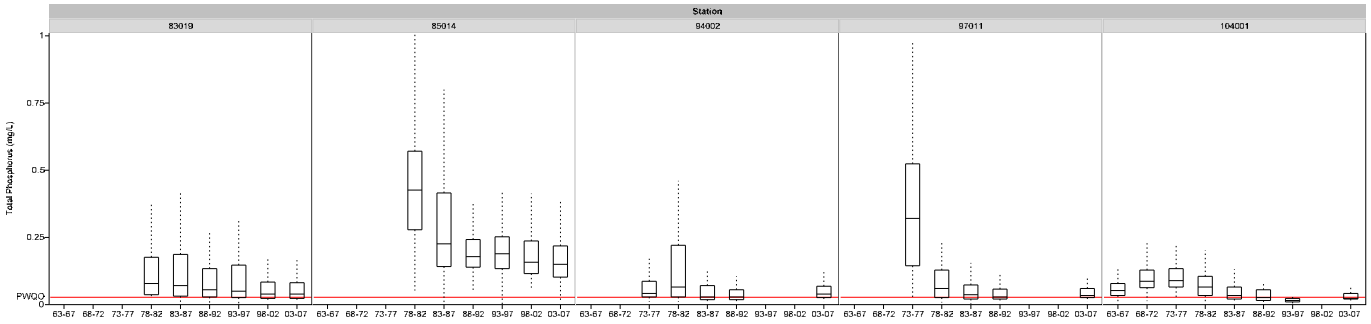


Figure 18. Total phosphorus concentrations for the mouth of the Humber River (83019), Don River (85014), Highland Creek (94002), Rouge River (97011) and Duffins Creek (104001) over time

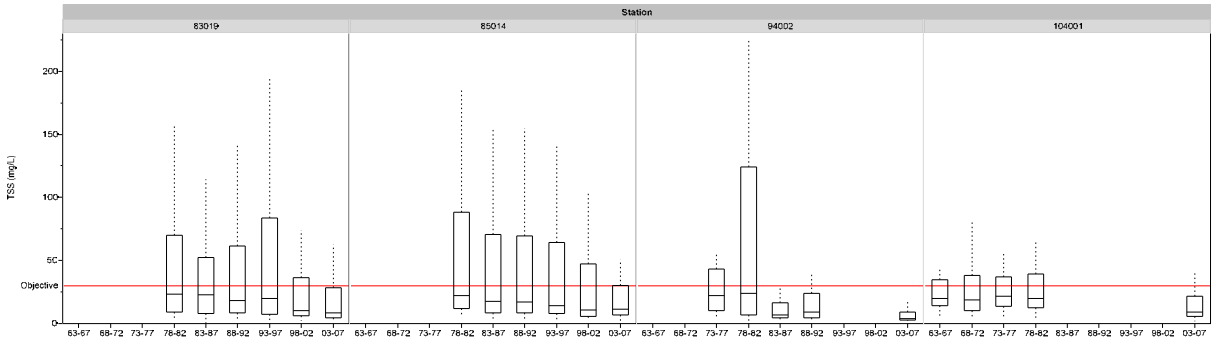


Figure 19. Total suspended solids (TSS) concentrations for the mouths of the Humber River (83019), Don River (85014), Highland Creek (94002), and Duffins Creek (104001) over time

- TRCA staff continued to collect wet weather surface water quality and stream flow samples on behalf of the City of Toronto (the City). In 2003, the City completed its Wet Weather Flow Management Master Plan (WWFMMP), which utilizes various control strategies to manage combined sewer overflows and stormwater (runoff) discharges into rivers and creeks. Toronto Water is now undertaking a 25 year initiative to monitor all major watercourses in the City's jurisdiction for the purpose of assessing water quality/quantity before and after the implementation of the City's WWFMMP guidelines. An advanced monitoring network was developed to collect information during storm events in all watercourses simultaneously to document the rise, peak, and recession of river waters. As the TRCA has extensive expertise and an on-going role in the monitoring of its watercourses, the City entered into an agreement in November 2008 with the TRCA to lead the implementation and operation of 14 automated water quality/quantity monitoring stations strategically positioned throughout Toronto (Figure 21). The TRCA designed and constructed the City's wet weather flow (WWF) monitoring network and is responsible for all field services and statistical analysis of the collected data. Each station was designed to operate remotely in order to minimize unnecessary travel and coordinate operations using wireless technology (Figure 20). Water samples are collected over a 42 hour period for both wet and dry weather and are triggered to sample via water level. Water samples are ultimately submitted to City laboratories for analysis of over 40 water quality attributes. Highlights from the 2009 WWF sampling program include:
    - To date, all 14 stations have been working flawlessly and the City is currently proposing to extend the agreement with TRCA for several more years.
    - TRCA staff successfully collected 15 wet weather and 5 dry weather samples for all stations.
    - Seven new stand alone, self cleaning conductivity sensors were installed in November 2009. One new stand alone, self cleaning chlorophyll/turbidity sensor was installed in the Don River in August 2009. The sensor has been working well and continues to be maintained by TRCA staff.
    - Data summaries and preliminary analysis of all data was submitted to the City one month prior to deadline.
    - Five point stage/discharge curve were developed for all stations. Currently work has started to add an additional 5 points to each curve in 2010. All measurements were collected according to Water Survey Canada standards.
    - The networks advanced telemetry system successfully eliminated over 15,000 km of unnecessary travel by allowing TRCA staff to program and operate the stations remotely via wireless technology.

Figure 20. Several examples of Wet Weather Flow (WWF) monitoring stations

Figure 21

2009 Surface Water Quality Monitoring Sites

Toronto and Region Conservation for The Living City

Scale: 1:250,000

Legend

Water Quality Monitoring Site

- PWQMN (MOE/TRCA)
- TRCA
- Toronto Wet Weather Sampling Site
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

Durham Region
York Region
Peel Region
Duffins
Rouge
Carruthers
Petticoat
Humber
Don
Highland
Etobicoke
Mimico
Toronto
404
400
407
401
427
409
410
403
0 1.5 3 6 9 12 Kilometers

7 Water Temperature Monitoring

Staff Lead: Greg Dillane

Support Staff: Ashley Favaro, Mike Brestansky

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

7.1 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 up-wellings 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.

7.2 Methods

Water temperature data is collected on a three year rotation with approximately one third of the 151 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.

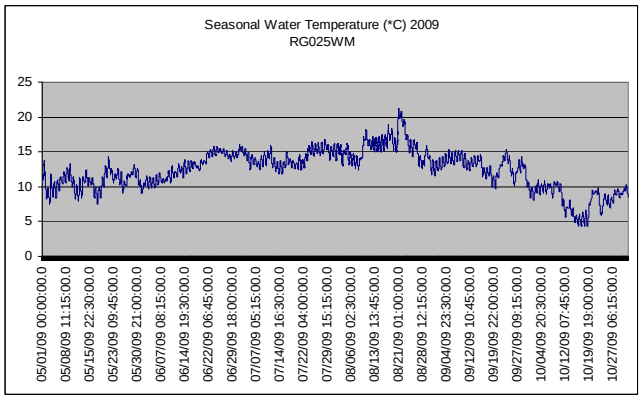


Figure 22. Example of temperature data collected for a site in the Rouge River (RG025WM)

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 22 illustrates

patterns of the typical heating and cooling cycles of a stream from spring through to the fall season. Figure 23 is a sample box and whisker plot that shows both the temperature ranges as well as the predominant seasonal temperatures for a site.

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.

7.3 Data

Logged temperature data is stored electronically in a Microsoft Excel spreadsheet. Thermal stability ratings are developed using the HabProgs MS Access database.

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.

7.4 2009 Highlights

- In 2009, loggers were deployed at 51 RWMP aquatic sites in the Rouge River, Duffins Creek, and Carruthers Creek watersheds as well as two project specific sites in the Don and Highland watersheds (Figure 24).

- There are now three sets of data available for most sites in the Rouge River, Duffins Creek and Carruthers Creek watersheds (2003, 2006, 2009).

- In a normal sampling year a small number of temperature loggers are lost due to storm events and erosion. In 2009 no loggers were lost, but two were not functioning at the midseason download and needed to be replaced.

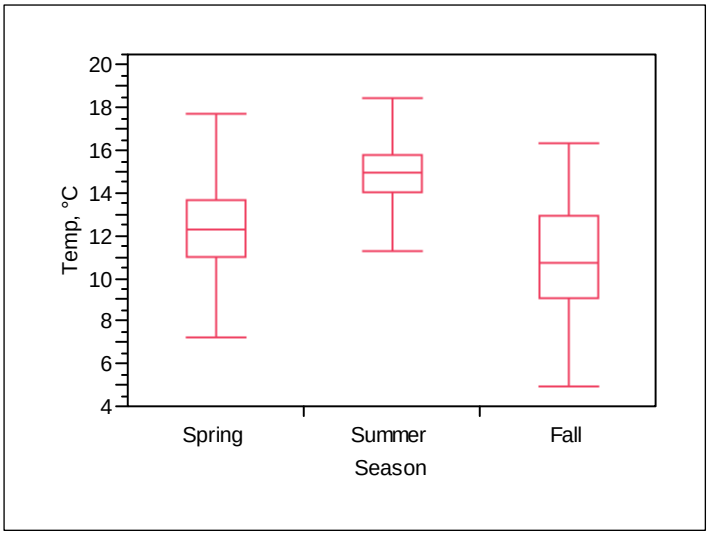


Figure 23. Example of a box and whisker plot displaying water temperature data (DF008WM)

- Table 5 shows the percentage of sites that fall in the three stability categories (stable, moderately stable, and unstable) for the three years monitored. The temperature stability in the Duffins and

Carruthers Creek watersheds has declined since 2003. The Rouge River has shown increased stability since 2003.

- The highest temperature was observed at a site on the Highland Creek in Scarborough (HL007WM) with a maximum temperature of 33.2° C. This site was sampled as a project site to confirm the data gathered in 2008.

- Proportionately, the stability ratings in 2009 were similar to those in 2003 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 5. Thermal stability classifications for Rouge, Duffins and Carruthers Creek sites in 2003, 2006 and 2009

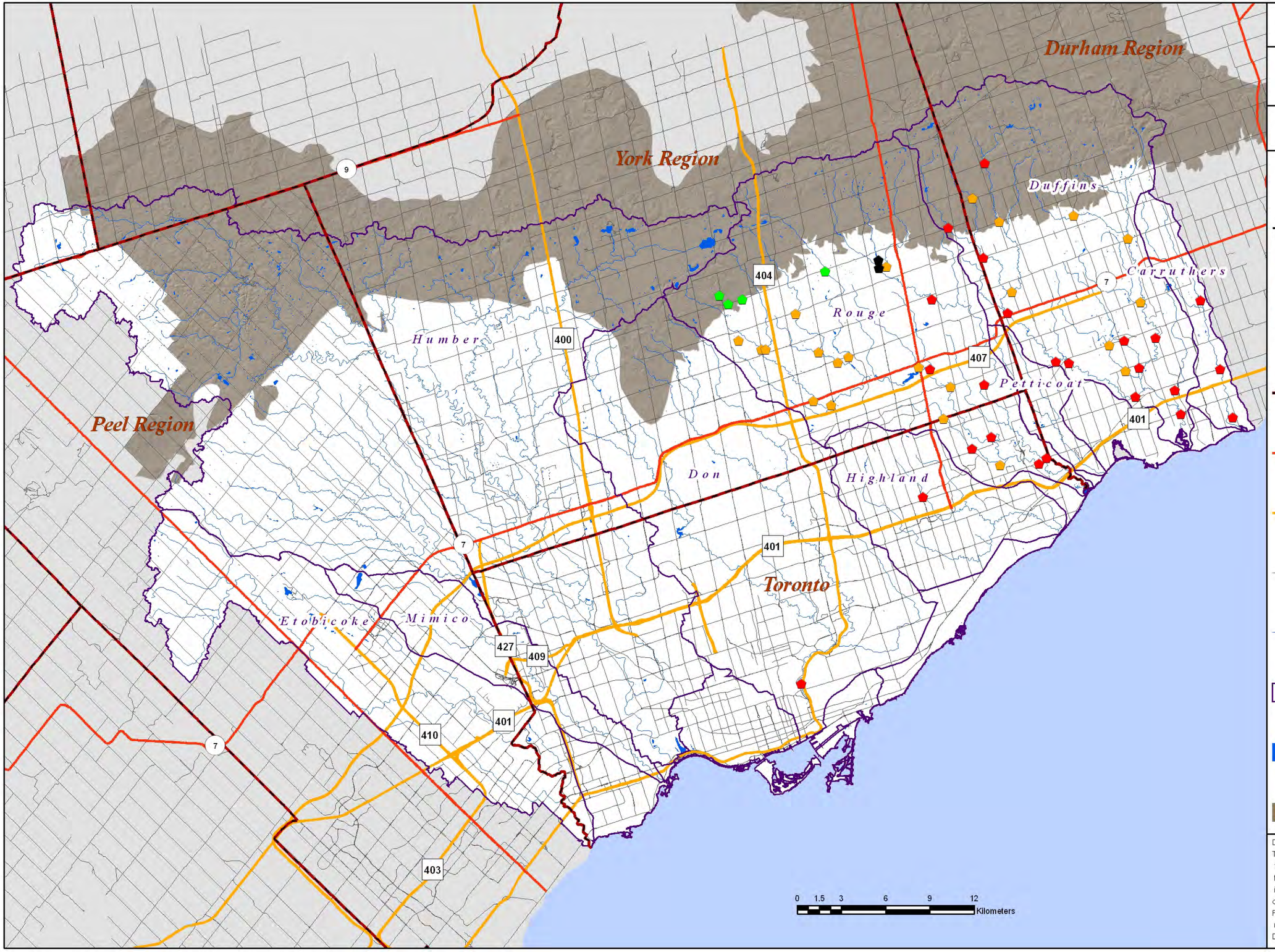
	2003			2006			2009			
	Stable	Mod. Stable	Unstable	Stable	Mod. Stable	Unstable	Stable	Mod. Stable	Unstable	Change
Carruthers		67%	33%		67%	33%			100%	Decline
Duffins		57.9%	42.1%	10.5%	63.2%	26.3%	5%	40%	55%	Decline
Rouge	10%	50%	40%	8%	48%	44%	16%	56%	28%	Improved

Figure 24

TORONTO AND REGION Conservation for The Living City

Scale: 1:250,000

2009 Water Temperature Monitoring Sites



Legend

Thermal Stability

- Stable
- Moderately Stable
- Unstable
- Incomplete Data

- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

8 Benthic Invertebrates

Staff Lead: Thilaka Krishnaraj

Support Staff: Angela Wallace, Ashley Favaro, Cindy Hignett, Lauren Sharkey, Lindsay Knezevich, Ian Fife, Sarah Scharfenberg and Todd Copeland

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

8.1 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 (Figure 25) to pollution make them ideal candidates for biomonitoring purposes. 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 151 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 25. An adult predaceous diving beetle (*Dytiscus sp*.)

8.2 Methods

The set-up of the sampling stations and the field sample collection techniques follow the Ontario Stream Assessment Protocol (OSAP) (Stanfield 2005). Benthic invertebrates are collected using the "traveling kick-and-sweep" method (Figure 26) whereby stream sediments are disturbed by kicking the stream bottom. Invertebrates are dislodged and swept downstream by the current into a net. During the summer months, sampling at each station is carried out along a number of transects (dependant on stream width) established

Figure 26. Traveling kick & sweep

across the stream. 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).

8.3 Data

Benthos data for RWMP sites are available from 2001 to 2009. 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).

8.4 2009 Highlights

- A total of 146 RWMP stations and 14 special project stations were sampled in 2009 (Figure 27). Five sites could not be sampled this year, of which three were due to landowner issues (HU017WM, RG013WM and RG014WM), one site due to beaver dam at RG025WM and one due to extreme changes in the stream geomorphology (EC002WM).

- The special projects included the continuation of an Erosion Control project from 2008; Audubon Certification process for Bathurst Glen Golf Course, and a Shorebird Benthic invertebrate survey at Claireville Conservation Area, Brampton.

- There were several data requests from external agencies (e.g. consulting agencies, academic institution) as well as by the Province, Municipalities and other TRCA departments.

- The preliminary water quality assessment using the Hilsenhoff Biotic Index for 2008 and 2009 (Table 6) showed that there is an overall change in the Hilsenhoff scores for all the watersheds. Noticeably, sites have shifted from "Good" and “Fair” ratings to “Poor” and “Very Poor” ratings at Petticoat creek. Similarly, sites in the Frenchman’s Bay tributaries and Carruthers Creek have dropped one rating level lower compared to 2008 ratings.

- Overall more sites have changed from “Fair” category to “Fairly Poor” category in other watersheds such as Humber, Don, and Rouge. However confirmation is needed through detailed taxonomic identification on benthos collected in 2009. Other factors such as water chemistry results from these sites should also be looked at to determine if similar changes have been noticed.

Table 6. Hilsenhoff water quality rating calculated for sites sampled in 2008/2009, number of sites under each rating by watershed.

Watersheds	Water Quality Ratings* based on Hilsenhoff scores									
	2008					2009				
	Good	*Fair*	*Fairly Poor*	*Poor*	*Very Poor*	*Good*	*Fair*	*Fairly Poor*	*Poor*	*Very Poor*
Etobicoke Creek		1	2	9	1			2	10	1
Mimico Creek			2	1	2				1	4
Humber River	2	8	16	11		3	4	24	5	2
Don River		2	8	10	3		3	5	11	4
Rouge River	2	11	10	3		1	5	9	9	
Highland Creek				7	4			4	7	
Petticoat Creek	1	1	2					3	1	
Duffins Creek	2	8	5			2	11	7	1	
Frenchman's Bay Tributaries				2	2					4
Carruthers Creek			3						3	

**Water quality ratings were calculated using coarse level taxonomic identifications of benthic macroinvertebrates collected during 2008 - 2009.*

Figure 27

2009 Benthic Macroinvertebrate Monitoring Sites

Toronto and Region Conservation for The Living City

Scale: 1:250,000

Legend

Benthic Macroinvertebrate Monitoring Sites

- RVMP Monitoring Site
- Erosion Control Site
- Special Projects
  1. Mimico Creek Restoration
  2. Claireville Reservoir Shorebird Study
  3. Bathurst Glen Golf Course

- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

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0 1.5 3 6 9 12 Kilometers

9 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

9.1 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 watercourses to changes in the environment 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 processes, both natural and anthropogenic, 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 30) were placed throughout the nine watersheds in the TRCA jurisdiction between 2001 and 2003 as part of the 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.

9.2 Methods

TRCA staff conduct follow-up monitoring at 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 28), 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 28. 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.

9.3 Data

RWMP fluvial geomorphological data is available from 2001 to 2009. Data from 2001-2003 is stored in an Access database and data from 2004-2009 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.

9.4 2009 Highlights

- A total of 51 RWMP sites and 1 project site were surveyed in 5 watersheds (Etobicoke Creek, Rouge River, Petticoat Creek, Duffins Creek and Carruthers Creek) in 2009. Figure 30 displays all 150 RWMP fluvial geomorphology sites, the 51 RWMP sites surveyed in 2009 and one project site.

- In December 2009, staff surveyed a special project fluvial geomorphology site as part of the Sustainable Neighbourhood Retrofit Action Plan (SNAP) Study in Brampton. The purpose of this site was to collect baseline data prior to the deployment of equipment aimed at improving the water quality and quantity of stormwater runoff with the study area. Cross sectional profiles and substrate data was collected at five benchmarked cross-sections. Figure 29 shows the longitudinal profile of GSNAPCC1.

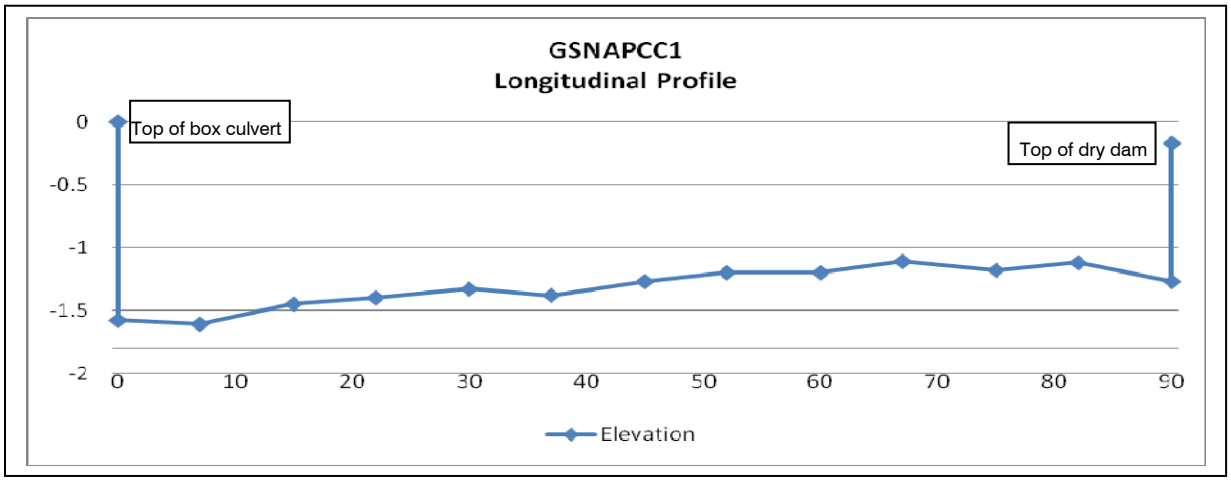
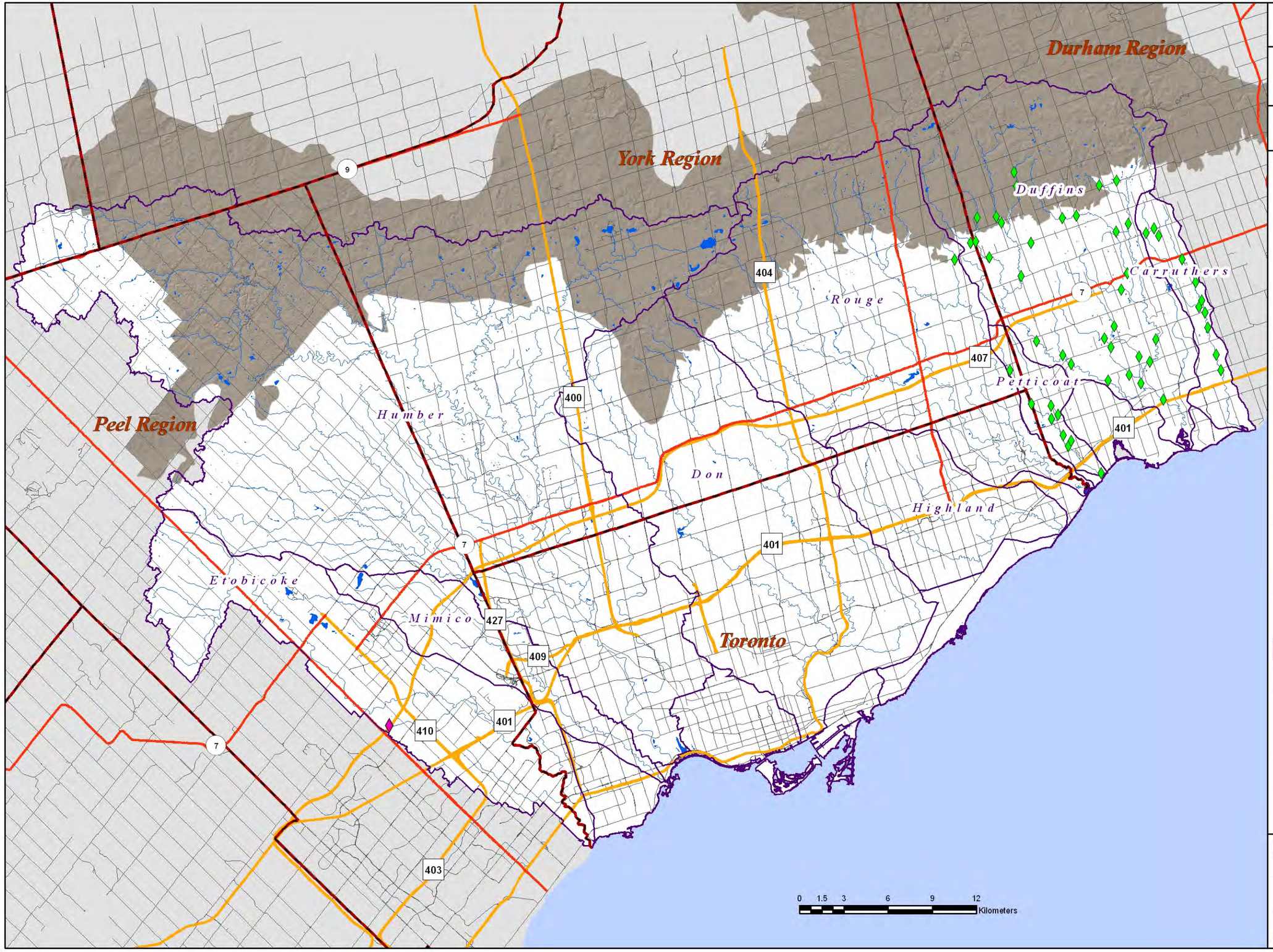


Figure 29. SNAP fluvial geomorphology project site GSNAPCC1 longitudinal profile

Figure 30

2009 Fluvial Geomorphology Monitoring Sites



TORONTO AND REGION Conservation for The Living City

Scale: 1:250,000

Legend

- 2009 RWMP Site
- Special Project Site
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

10 West Nile Virus Vector Monitoring

Staff Lead: Thilaka Krishnaraj

Support Staff: Cameron Sangster, Ashley Favaro, Megan Becker and Lauren Sharkey

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

10.1 Background

The TRCA West Nile Virus (WNV) Monitoring and Surveillance Program was established in 2003 with an objective to conduct vector larval monitoring for the presence of two key vector mosquito species namely, *Culex pipiens* and *Culex restuans* on TRCA properties (Figure 31). 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 31. Larvae of *Culex sp.*

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 31), characterize the abundance of larvae (vector and non-vector species) and identify vector "hot spots".

10.2 Methods

For 2009, monitoring started on May 27th and continued at three week intervals until the first week of September. A total of 36 wetlands and nine SWMPs were monitored during this period in the City of Toronto, Peel, Durham and York Regions (Figure 33).

Each site was visited four times from May through September of

Figure 32. Mosquito larval sampling in wetlands

2009, 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 32). 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 Field Centre 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 (1st to 3rd instars) from each replicate were reared until they reached 4th instar and the identification procedure was repeated.

Risk ranking was 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 below 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.

In-situ water quality data such as pH, temperature, electrical conductivity, total dissolved solids and dissolved oxygen were collected using an 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.

10.3 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 2003-2009. Data are stored in a MS Access Data Base.

For 2009, data 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 analysis to determine the influence of different water quality parameters on vector presence and abundance is pending. The results from the 2009 sampling will be used to generate the Annual Report: *West Nile Virus Vector Mosquito Larval Monitoring and Surveillance – 2009*.

10.4 2009 Highlights

- On February 27, 2009 the Authority approved the revised Standing Water Compliant Procedure to address the public and staff concerns about WNV issues on TRCA properties in a timely and consistent manner. In addition, this revised procedure outlines the protocol to be followed when larviciding is needed on TRCA properties which are vector hot spots.

- A total of 10 standing water complaints were addressed in 2009, of which 9 complaints involved TRCA properties. One TRCA property had vector larvae in high numbers and larvicide was applied. Of the remaining complaints, 6 sites either did not have vector larvae in the samples collected or were found to be dry during the site visits. One site was under Management Agreement with King City, York Region and hence the complaint was referred to their attention. The remaining one complaint was a private property.

- The larval sampling yielded a total of 7904 larvae. The number of larvae collected was twice the number of larvae collected in previous years. One of the reasons for the high number of larvae collected was that the 2009 season was a wet year with high amounts of rainfall and alternating dry periods which is very conducive for mosquito breeding.

- Approximately 6826 larvae were sampled from the wetlands. As in previous years, *Culex territans,* a non-vector mosquito species continued to be the predominant mosquito. Out of the 36 wetland sites monitored, only one site near Kleinburg was found to be a "hot spot" (risk ranked as high risk site) for *Cx. pipiens* and *Cx. restuans* (vector species). This site had an average of 37.75 Cx. restuans per 10 dips and 52.5 Cx. pipiens larvae per 10 dips during the 2nd and 3rd sampling periods respectively. Hence larviciding was deemed necessary to reduce human health risk. This larviciding operation was an example for the effectiveness of TRCA's revised Standing Water Complaint Procedure. It helped to streamline the communications between the municipal and provincial authorities and allowed larvicide permitting and application to be carried out in a timely manner.

- The number of larvae collected from the SWMPs was also high in 2009. *Aedes vexans, Anopheles punctipennins, Cx. pipiens, Cx. restuans* and *Cx. territans* represented the 1078 larvae collected during the sampling season. *Culex pipiens* was the predominant vector species representing 51% of the total number of larvae while *Cx. restuans* comprised only 3% of the identified larvae from SWMPs. L'Amaroux Park North Pond was a "hot spot" for *Cx. pipiens* during the third sampling event. This site is under management agreement with the City of Toronto and larviciding was undertaken by the City upon notification.

- Water quality (pH, conductivity, water temperature, total dissolved solids and dissolved oxygen) and vegetation data is being used for a five year roll up of the data and will be reported upon separately at a later date.

- Results from the 2009 monitoring are consistent with previous findings indicating that healthy functioning wetlands typically do not support high numbers of WNV vector mosquito larvae. These sites pose a low risk overall to public health in terms of WNV.

10.4.1 Special Project

In 2008 – 2009 TRCA obtained funding from the Ontario Ministry of Environment to conduct a special study on factors influencing the breeding of vector mosquitoes in stormwater management ponds. A number of factors such as SWMP design characteristics including: slope, depth and size, presence of predators (invertebrates and fish), chemical parameters (pH, conductivity, dissolved oxygen, turbidity, total organic content and temperature) were measured to determine the relationships between these factors and the mosquito abundance and diversity. Data analysis for this project is currently underway and a detailed report will be submitted to the Ministry of Environment in March 2010. The results from this study will help identify the ponds that have the potential for breeding vector mosquitoes and help target the control measures for the problem sites in the future.

Figure 33

TORONTO AND REGION Conservation for The Living City

Scale: 1:250,000

Legend

Habitat Type Monitored

- Storm Water Pond
- Wetland
- Vector Hotspot
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

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2009 West Nile Virus Monitoring Sites

Durham Region
York Region
Peel Region
Toronto
Duffins
Carruthers
Rouge
Petticoat
Highland
Don
Humber
Mimico
Etobicoke

0 1.5 3 6 9 12 Kilometers

11 Groundwater Quality and Quantity

Staff Lead: Jeff Vandenberg

Support Staff: Don Ford, Jehan Zeb, Andrew Taylor

Funding: Ministry of the Environment (partial)

11.1 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 overdrawing and contamination. Many communities are dependent on groundwater supplies to maintain existing domestic, commercial, industrial, agricultural and institutional operations.

Figure 34. PGMN well with telemetry equipment and dedicated pump installed

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.

11.2 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 (Figure 35). There are currently 21 groundwater monitoring wells in the Toronto and Region Conservation Authority (TRCA) jurisdiction (Figure 37). Currently 3 sites are equipped with telemetry equipment, which allows for remote downloading of data. The remaining sites were either deemed unsuitable for telemetry installation or have not yet been upgraded to the new digital system and have to be 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 34).

Figure 35. Groundwater well monitoring

11.3 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.

11.4 2009 Highlights

- In 2008 the MOE approved the purchase of a portable Waterra pump (Figure 36) for collecting water samples at sites without dedicated pumps. Using this pump (10), a portable Redi-Flo pump (5) and the dedicated pumps (5) previously installed, a total of 20 sites were sampled for water quality in 2009. To date no groundwater sample results have been made available from the MOE. A full report on Groundwater Quality will be produced later in 2010.

- The PGMN telemetry system was originally configured as an analog system. The phone company which had been moving away from analog to digital discontinued the analog system entirely as of December 2008. Because of this change more site visits were necessary in 2009 to download data manually. To date the switch over to the digital system has occurred piecemeal as MOE funding becomes available. An additional 2 sites were converted to the digital system in November 2009. This brings the number of telemetred sites back to four. More sites are expected to be upgraded back to fully telemetred as funding becomes available.

Figure 36. Portable Waterra pump

- The MOE hired a consultant to assist with their data correction project. The consultant verified the locations of all of the wells, and the depth that each of the loggers was installed, as well as attaching new identification tags on all of the wells and taking static water levels. This work was carried out in TRCA's jurisdiction in November 2009 a report is expected early in 2010 detailing the findings.

- In conjunction with the MOE and the University of Waterloo, an isotopic study has been undertaken to gather useful information on groundwater recharge, discharge, and relative age. An extra isotopic sample was collected at all wells in 2009 to contribute to this effort.

- Due to access and vandalism issues the North York well (W75) has been discontinued from the PGMN program. An alternate well was previously identified and monitoring was initiated but subsequently dropped as the well is being monitored by the City of Toronto and well data is being forwarded on to our hydrogeology section. Going forward this will bring our number of monitored wells down to 20.

Figure 37

2009 Groundwater Monitoring Sites

Toronto and Region Conservation for The Living City

Scale: 1:250,000

Legend

- Groundwater Well
- Groundwater Well Water Quality Monitoring
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

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Durham Region
York Region
Peel Region
Toronto
Humber
Don
Rouge
Duffins
Carruthers
Petticoat
Highland
Etobicoke
Mimico
400
401
404
407
427
409
410
403
9
7
0 1.5 3 6 9 12 Kilometers

12 Water Quantity - Stream Flow, Precipitation (Rain and Snow)

Staff Lead: Derek Smith and Craig Mitchell

Support Staff: Bill Kerr, Lisa Moore, Jamie Duncan, Christy Somerville, Rita Lucero, Matt Derro, Paul Greck, and Claudia Scali.

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

12.1 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 and was originally implemented by the federal government to meet its international obligations related to the Great Lakes. Today, the TRCA has installed numerous stream gauges as part of the RWMP and flood warning programs. Typically, data is used for stormwater management, water budget development, flood control structure operation and flood warning, infrastructure modeling, and land use influences to watercourses.

Similarly, precipitation gauges are widely used to document storm flows, annual discharges, and for flood forecasting. The data is regularly found in road and sewer design details, water quality/quantity reports, and flood models and bulletins. In Toronto and the surrounding area there are over 100 rain gauges which are owned and operated by all levels of government, educational institutions, and the private sector. Of that total, the TRCA owns and operates 33 gauges. Stations in this network were strategically located approximately ten kilometers apart from one another in order to provide good coverage of TRCA's jurisdiction and all of its watersheds. Originally conceptualized for flood warning uses to track storm movement, it has evolved into a regional database utilized by government and non-government organizations, educational institutes, and the TRCA on a regular basis.

Unlike the TRCA's stream and precipitation networks, which are fully automated, the TRCA manually monitors snow accumulation at ten sites in order to determine the antecedent condition of the watershed prior to the spring thaw. The stations were selected to provide a jurisdictional assessment of snow characteristics including: snow depth, water equivalent, snow density, snow crust, and underlying soil attributes (e.g. frozen). The data is submitted to the Ministry of Natural Resources (MNR) and TRCA flood duty officers (FDO) bi-weekly in order to assess the snow melt flood threat in our watersheds.

12.2 Methods

12.2.1 Stream Flow

In 2009, flow and water level data was collected at 30 RWMP stream gauges and 24 Water Survey Canada (WSC) gauges (Figure 41). 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 30 stream gauges, 13 stations are part of the TRCA Real Time (RT) Gauging Network (Figure 38). This network is a web accessible system that posts precipitation, water level, alarm, and stream discharge data in real time and depicting current watershed flood conditions. Additional RWMP stream gauges will eventually be incorporated into the RT network as upgrades to the existing gauge network continue.

Figure 38. Various RT stream gauge stations (from left) Taylor Massey Creek, McFall Dam, and the new RT gauging home page

12.2.2 Precipitation (rainfall and snowfall)

In 2009, precipitation data was collected from 33 stations (Figure 42). The precipitation network consists of 27 three-season tipping bucket gauges and 6, four-season gauges (3 weigh gauges and 3 heated tipping buckets) (Figure 39). Of the 33 stations, 13 are telemetered gauges, of which 8 are part of the TRCA RT gauging network

All three-season tipping bucket rain gauges are activated every spring and shut down for the winter season while the four-season gauges monitor year round. All gauges are maintained every four weeks which includes data downloads (RT not applicable), 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.

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). Database records also include station details, the maintenance schedule, and monthly summaries.

Figure 39. 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 42). They include:

1) Claireville Dam
2) G. Ross Lord Dam
3) Heart Lake Conservation Area
4) Boyd Conservation Area
5) Albion Hills Conservation Area
6) Claremont Conservation Area
7) Greenwood Conservation Area
8) Bruce's Mill Conservation Area
9) Milne 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 accommodate the distance (Figure 40).

Figure 40. Snow course monitoring, Albion Hills, Conservation Area

At each sampling location, a snow core is taken and the depth of snow is measured in centimeters. The snow core is then weighed and converted into millimeters 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.

12.3 Data

12.3.1 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. The 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 TRCA 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, forecast severe weather events, develop 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.

12.3.2 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 by the MNR and the measurements were taken over by TRCA staff in 2000. 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).

Precipitation and snow course data is used much the same way as the stream gauge data described above (12.3.1). However, in many cases the data is also used in meteorological, thermal, and agricultural studies.

12.4 2009 Highlights

- A *Streamflow Monitoring Techniques* course was offered by TRCA Hydrometrics staff in June of 2009 at Albion Hills Conservation Area. Attendees included staff from other CAs, NGO's, environmental consultants and municipalities. The one day course presented information on: streamflow measurement theory and methodologies, types of monitoring equipment, site selection and considerations, how to establish a monitoring network, as well as a field component applying the aforementioned tools.

- In the winter of 2009, snow accumulation and cold temperatures produced large ice sheets in the lower parts of the watersheds. Fortunately, little damage to steam gauging equipment occurred.

- Beaver activity has increased in TRCA's watersheds, especially in the Duffins Creek which is affecting flows for some stream gauges.

- Updates/modifications to the stream and precipitation gauge networks in 2009 included the following;
    - The Ganetsekiagon Creek stream gauge located in the Duffins Watershed was replaced and relocated about 5 km downstream, in June of 2009 as it had been washed out in 2008.
    - The Highland Creek at Morningside (temporary) stream gauge was closed and removed from the network, including the TRCA real time network.
    - All 2009 rating curve development or corrections contracted by OHS will be completed in spring 2010
    - A temporary RT stream gauge was installed in Black Creek near Sheppard Avenue to serve as an early warning system for downstream construction works.
    - A new precipitation gauge was installed on the property of Evergreen "Brick Works" in August of 2009 and is part of the TRCA RT network. A RT video camera is also expected to be installed in order to monitor the lower Don River water level.
    - The Dufferin Reservoir precipitation gauge was upgraded into the TRCA RT network.
    - Laidlaw Bus Depot precipitation gauge was down-graded to a three-season gauge
    - Test trials of a new weigh gauge designed to eliminate wind interference was installed at Stouffville Dam. Positive results will likely lead to upgrades to the remaining two weigh gauges.

- Water quantity data collected by the TRCA's stream and precipitation gauging stations are being used by the City of Toronto's Wet Weather Flow Monitoring Network.

- The TRCA Flood Monitoring and RT Gauging website was upgraded with a new layout and format. It is now linked to TRCA's corporate site (trca.on.ca), has quicker and easier access to data, improved public access, and enhanced reporting (Smart phone compatible viewing, interactive mapping, RT graphs and tables). A revised data disclaimer was also added, as well as TRCA's Flood Forecasting and Warning (FFW) and RSS feed.

- A RT stream gauge was installed at Cooksville Creek, in Mississauga, as part of a 12-month Pilot Study with the Credit Valley Conservation (CVC).

- The most snowfall recorded in 2009 was observed at Glen Major Forest with a total accumulation of 202.1 cm. The average snow depth across the TRCA jurisdiction was 10.1 cm. It was observed that snowfall within the GTA decreased slightly by 4% when compared with 2008 observations.

- Due to the vast amount of data collected by the three networks, a yearly report summarizing observations is proposed to be drafted by the Hydrometrics and Flood Infrastructure program. The publication of this document is expected to coincide with the release of the 2010 RWMP report. The first draft is expected in 2010 and will primarily focus on report feasibility and structure and data analysis.

Figure 41

Toronto and Region Conservation for The Living City

Scale: 1:250,000

Legend

Stream Flow Gauges

Operator:

- TRCA
- Water Survey Canada
- Real Time Gauge
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

Disclaimer:
The Data used to create this map was compiled from a variety sources & dates.The T.R.C.A. takes no responsibility for errors or omissions in the data and retains the right to make changes & corrections at anytime without notice. For further information about the data on this map, please contact the T.R.C.A. GIS Department. (416) 661-6600

2009 Water Quantity Monitoring Sites (Stream Flow Gauges)

Durham Region
York Region
Peel Region
Toronto
Duffins
Carruthers
Rouge
Petticoat
Highland
Don
Humber
Mimico
Etobicoke
9
7
400
404
407
401
427
409
410
403
0 1.5 3 6 9 12 Kilometers

Figure 42

TORONTO AND REGION Conservation for The Living City

Scale: 1:250,000

Legend

Precipitation Gauges

- 3 Season Gauge
- 4 Season Gauge
- Snow Course Site
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

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0 1.5 3 6 9 12 Kilometers

2009 Water Quantity Monitoring Sites (Snow & Precipitation)

13 Water Quantity-Baseflow

Staff Lead: Jamie Duncan and Rita Lucero

Support Staff: Mallory MacDonald and Kerry Ann Brooks

Funding: Regional Watershed Monitoring Program (City of Toronto, Peel Region, Durham Region, York Region and Toronto Remedial Action Plan)

13.1 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 is an 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 68 stations per year. These 68 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.

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.

13.2 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. 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 43). 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.

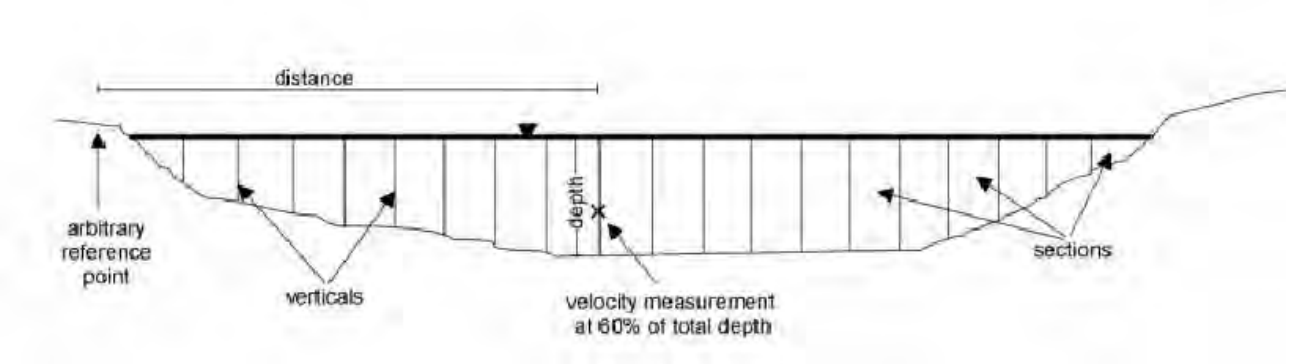


Figure 43. Cross section of a stream – baseflow transect

13.3 Data

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

Fieldwork for the 2009 summer was limited to measurements at the indicator stations only, which are located throughout the TRCA jurisdiction. Extensive watershed wide sampling was not scheduled for 2009 because funding was not available. A total of 64 transect measurements were conducted in 2009, which included 57 of the 68 indicator stations (Figure 45). Eleven indicator stations in the Humber River Watershed were not measured due to time limitations and weather constraints. Some sites were measured more than

once due to special circumstances. The measurements were conducted during the months of July to mid-September with the help of summer student interns from the University of Toronto.

13.4 2009 Highlights

- A Streamflow Monitoring Techniques Course was offered by TRCA Hyrdrometrics staff in June of 2009 for the first time at Albion Hills Conservation Area. The course was attended by staff from other CA's, NGO's, environmental consultants and municipalities. This one day course included information on streamflow measurement theory, methodologies and equipment, site considerations, establishing monitoring networks and a field component for manual discharge measurements.

- The Baseflow and Water Use section of the Etobicoke and Mimico Creeks Watersheds Technical Update was reviewed and finalized in 2009 as part of the Watershed Planning process.

- In the 2009 field season, summer precipitation was not as high as in 2008, but was still 31% above normal precipitation amounts for the months of June, July and August. However, it was the timing of summer rainfall events that limited the number of days in which low flow measurements could be conducted.

- The most interesting trend identified from the 2009 low flow measurements, was that total discharges at most of the indicators sites were higher than 2008 measurements. About 78% of sites measured in both 2008 and 2009 were recorded as having higher discharge flows in 2009.

- Total watershed outflows were also measured to be higher in 2009 than in 2008. Figure 44 displays the estimated watershed outflows (where data was available) for 2007, 2008, 2009 as well as a summer average value from 2000-2006 data. As shown, for most watersheds there is an annual increase in total estimated discharges from 2007 to 2009. In some cases, 2008 flows were higher than the summer average, but in 2009, all watershed outflows were measured as higher than the summer low flow average.

- To further exemplify the scale in which low flow measurements have increased in 2009, Table 7 lists the estimated watershed outflow discharges measured in 2009 and than lists the percent change in total discharge from previous years. All watersheds in 2009 show an increasing percent change from 2008, 2007 and summer average discharges. The highest percent increase in 2009 from 2008 was measured in the Humber River Watershed where total outflow discharge increased by 72%.

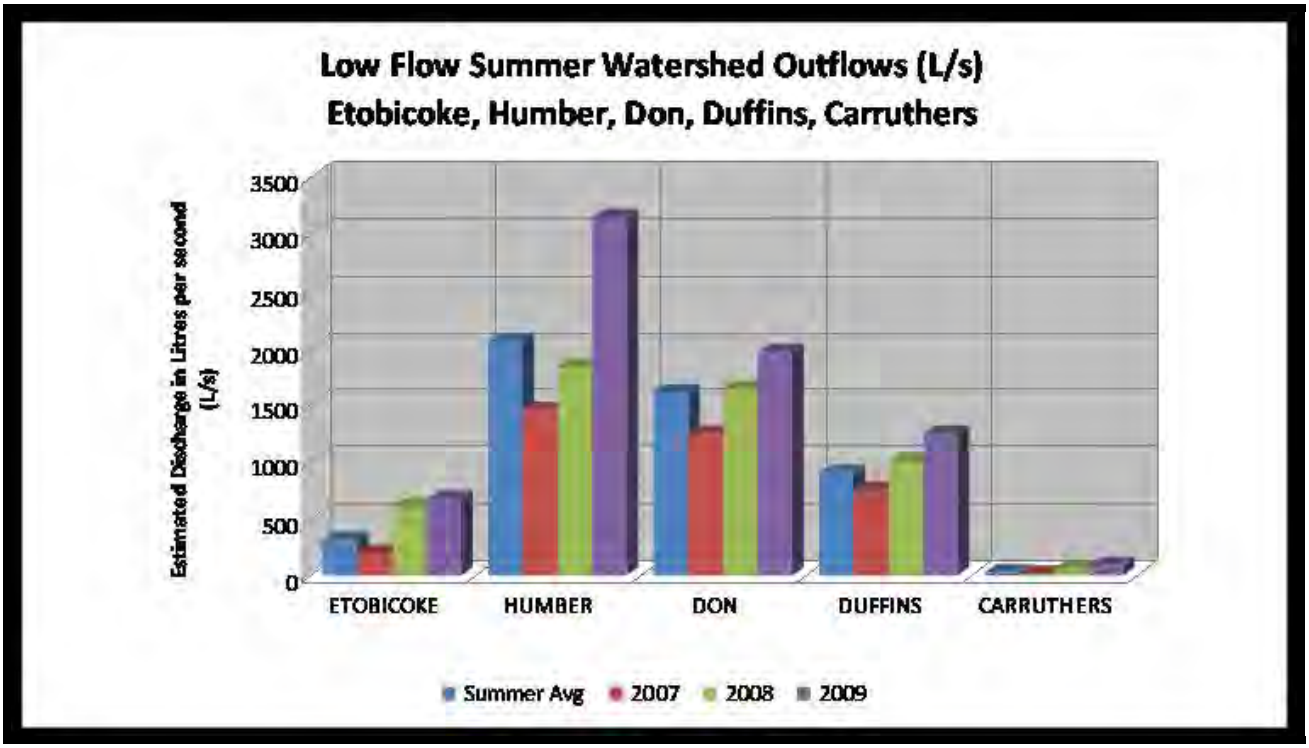


Figure 44. Total estimated baseflow outflow by watershed from in Litres per second (L/s)

Table 7. Percent change in measured 2009 low flow watershed outflows

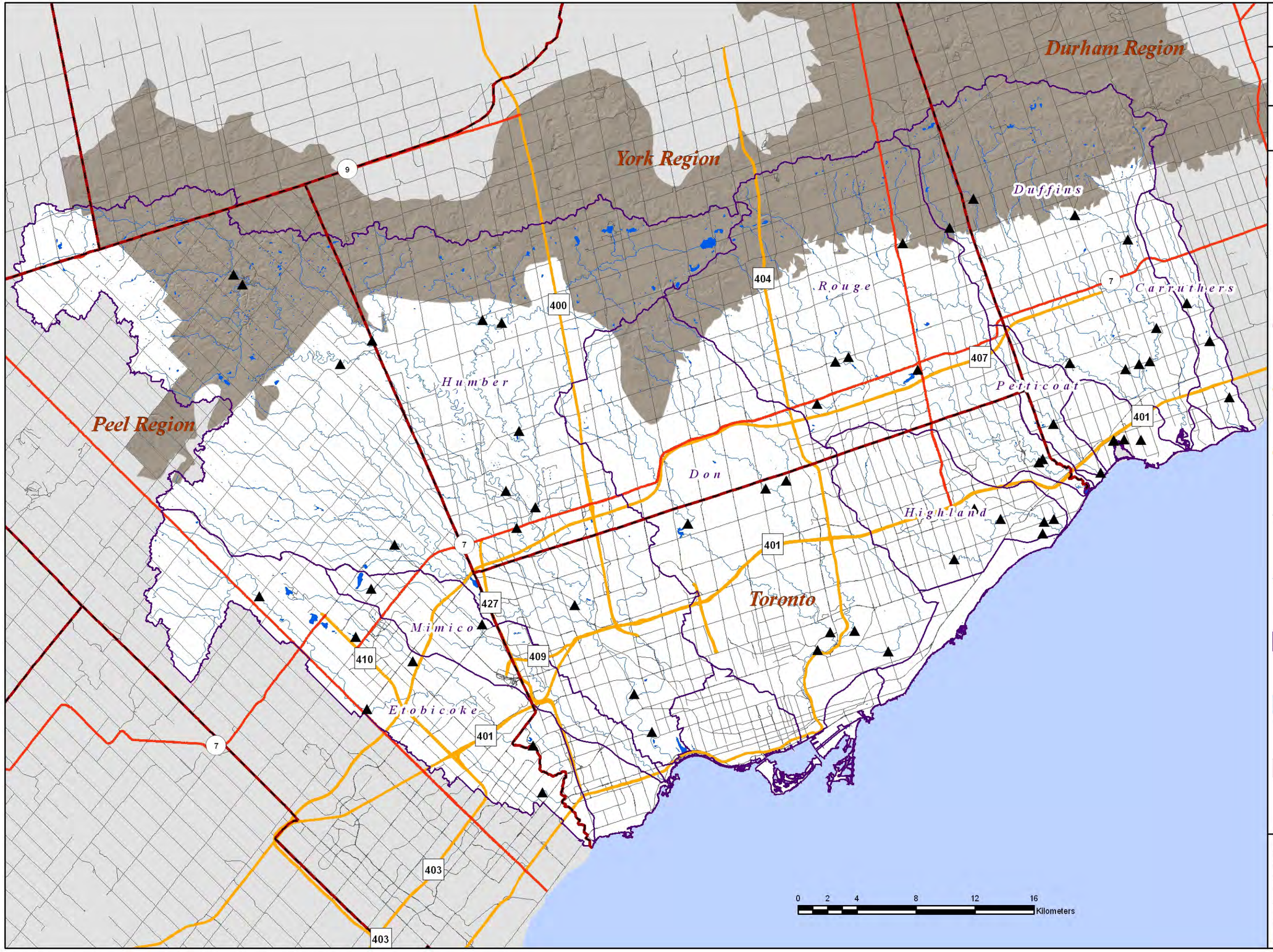
WATERSHED	2009 Watershed Outflows (L/s)	% Increase from 2008 Low Flow	% Increase from 2007 Low Flow	% Increase from Average Summer Low Flow (2000-2006)
Etobicoke	**672**	**13%**	**>100%**	**>100%**
Humber	**3,147**	**72%**	**>100%**	**53%**
Don	**1,966**	**20%**	**57%**	**22%**
Duffins	**1,248**	**24%**	**66%**	**38%**
Carruthers	**87**	**38%**	**>100%**	**>100%**

Figure 45

Toronto and Region Conservation for The Living City

Scale: 1:250,000

2009 Baseflow Monitoring Sites



Legend

- 2009 Baseflow Site
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

14 Climate Monitoring (Meteorological Network)

Staff Lead: Derek Smith

Support Staff: Craig Mitchell, Bill Kerr, Christy Somerville, Rita Lucero, Matt Derro, Paul Greck and Claudia Scali

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

14.1 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. 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 changes will be most noticeable over land masses 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). In Ontario 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 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 modify 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 46).

Figure 46. 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). TRCA partners continue to rely on our 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/water budget modelling, and natural heritage needs lead to the development of the TRCA's meteorological (MET) network (Figure 49).

Currently, the MET network consists of a variety of sensory devices including generic climate stations, evaporation pans, and speciality instrumentation (designed by York University). The MET network is still under construction and is anticipated to be complete in 2010.

14.2 Methods

Similar to our water quantity monitoring, the MET 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 seven MET stations deployed with two more stations expected to be installed by the end of 2010 (Figure 47).

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 47. Various TRCA MET stations, pictured from left to right: Claremont (Transport Canada), Vaughan (Kortright Conservation Area), and Richmond Hill (16th Ave Fire Hall).

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 seven existing stations, while a third evaporation system is anticipated to be installed in the spring of 2010. Evaporation is measured using a class A evaporation pan and stilling well. The stilling well is connected 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, airborne deposits) from the pan, test the float switch, and note tank water levels.

Similarly, ET is currently being monitored at two stations (Kortright Conservation Area and Downsview Park) using an automated Bowen Ratio Energy Balance (BREB) system (Figure 48). Because of the complexity of ET monitoring, York University maintain the BREB system and use TRCA MET data to calculate ET values for differing land uses. The stations were designed to be portable and can be relocated to differing parts of

the TRCA jurisdiction. Ultimately, all MET stations will be telemetered which will drastically reduce site visits for data acquisition.


Figure 48. Automated Bowen Ratio Energy Balance system used to determine "actual" evapotranspiration values, located at Kortright Conservation Area (left) and Downsview Park (right).

Since 2005, eight air temperature stations were also 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. The data is ultimately incorporated into the MET station database.

14.3 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 is 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 personnel and clients has confirmed that the data is necessary to document long term climate changes, and for both natural heritage and biological works.

Using the TRCA RT flood warning website as a portal, TRCA staff is working to post the MET station data for public use once telemetry is established. 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.

14.4 2009 Highlights

- The Guelph University Eddy Covariance MET station was installed in Richmond Hill in August 2009. It is located 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 is one of only a few located across North America. Faculty from Guelph University will be observing the effects that two storey developments (suburbs) have on wind dynamics. The data will also be used by York University for their ET research.

- ET monitoring continues in the Toronto Region with help from York University where a second BREB station was installed at Downsview Park. 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.

- A new MET station was installed in the Town of Ajax in the spring of 2009.

- A third evaporation pan system was proposed to be installed in the spring of 2009, but land acquisition issues delayed the progress. Progress is being made on the location of the station and is hoped to be installed in the Ajax area in spring/summer 2010. 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 conduct by both York University and Guelph University.

- Land acquisition is still underway for two new MET stations proposed to be located in the southwest and south central regions of TRCA's jurisdiction.

- Correspondence with Environment Canada has unveiled data sharing and partnership interest to conduct local climate studies for the 2015 Pan Am Games.

- Continued air temperature monitoring for TRCA aquatic biology program in 2009.

Figure 49

Toronto and Region Conservation for The Living City

Scale: 1:250,000

Legend

Meteorological Monitoring Sites

Status

- Existing
- Proposed

- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

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0 1.5 3 6 9 12 Kilometers

Durham Region
York Region
Peel Region
Toronto
Duffins
Carruthers
Rouge
Petticoat
Highland
Humber
Don
Etobicoke
Mimico

400 401 403 404 407 409 410 427 7 9

2009 Meteorological Monitoring Sites

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Paul Greck, Monitoring Technician
Roger Hua, Database Administrator
Bill Kerr, Flood Infrastructure Technologist
Gavin Miller, Flora Biologist
Craig Mitchell, Flood Infrastructure Coordinator
Lisa Moore, Flood Infrastructure and Hydrometrics Analyst
Paul Prior, Fauna Biologist
Kelly Purves[1], Flora Biologist
Christy Somerville, Sustainable Technologies Analyst
Jason Tam, GIS specialist

[1] Parental leave until May 2009.

15.1.3 Seasonal Staff

Megan Becker
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Cindy Hignett
Michael King
Lindsay Knezevich
Annette Lambert
Mallory MacDonald
Cameron Sangster
Claudia Scali
Sarah Scharfenberg
Lauren Sharkey
Daniel Westerhof

15.2 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.

15.2.1 Conducted by TRCA Staff

- Class 2 Backpack Crew Leader Electrofishing Course conducted for 20 people (6 internal, 14 external), on June 2 2009 at Boyd Office(Jeff Vandenberg, Nelson Amaral, Scott Jarvie, Lindsay Code)
- OSAP training course conducted for 6 internal staff and 1 external staff from City of Toronto on June 1-5 2009 at Boyd Office (Jeff Vandenberg)
- Excel training workshop conducted for 10 TRCA staff, December 11,2009 at Restoration Services Centre (Natasha Gonsalves)
- SAS JMP training workshops conducted for 15 TRCA staff, three half days, at Boyd Field Center (Melanie Croft-White)
- Give Snakes a Break: Snakes and the TRCA Head Office, 6 participants, October 22, 2009 at Head Office (Paul Prior)
- The Algae Biomonitoring Protocol Workshop conducted for 35 agency participants, April 27, 2009 at OMOE 125 Resources Road (Cheryl Goncalves)
- Benthic invertebrate field sampling procedures, processing and sorting of preserved benthic samples in the laboratory, June, 2009, Boyd Field Center (Thilaka Krishnaraj)
- WNV vector larval mosquito identification training for Durham Public Health Staff, May, 2009 (Thilaka Krishnaraj)
- Streamflow Monitoring Techniques course for 20 agency and municipality participants, June 3rd, 2009 at Albion Hills Conservation Area (Jamie Duncan, Rita Lucero and Derek Smith)

15.2.2 Attended by TRCA Staff

- Raising Awareness for Pollinators Symposium, Toronto Zoo, February 12, 2009 (Paul Prior and Theresa McKenzie)
- A.D. Latornell Conservation Symposium, Conservation Ontario, November 18-20, 2009 (Angela Wallace, Melanie Croft-White, Cheryl Goncalves, Nelson Amaral, Thilaka Krishnaraj, Scott Jarvie)
- New Directions in Stormwater Management, Ontario Ministry of the Environment, November 30-December 2, 2009 (Nelson Amaral, Melanie Croft-White, Angela Wallace)
- Thermal Impacts of Urban Development and Design Considerations, Credit Valley Conservation/Ontario Ministry of the Environment, December 4, 2009 (Angela Wallace)

- Study Design Workshop, Southern Ontario Stream Monitoring and Research, March 25-26, 2009 (Angela Wallace)
- Bird Conservation Planning Workshop, Bird Studies Canada, March 5, 2009 (Paul Prior)
- EMAN Training Course at Turkey Point, June 14 – 16 2009 (Paul Prior and Natasha Gonsalves)
- Proposal Writing Workshop on Species at Risk Stewardship Funding at Black Creek Pioneer Village September 24, 2009 (Natasha Gonsalves)
- Ontario Invasive Plant Council AGM, Cobourg ON, October 28, 2009, (Gavin Miller)
- Symposium on Bird Conservation at the City of Toronto, November 19, 2009 (Paul Prior)
- 44th Central Canadian Symposium on Water Quality Research at the Centre for Inland Waters in Burlington, Ontario, February 23-24, 2009 (Cheryl Goncalves)
- WNv Mini forum – Dept of Parks and Culture, City of Toronto, Scarborough, February, 2009 (Thilaka Krishnaraj)
- Ontario Vector Control Association meeting held at Mississauga Grand, March, 2009 (Thilaka Krishnaraj)
- Durham Regional Health WNV Committee meeting, Whitby, March , 2009 (Thilaka Krishnaraj)
- York Regional Health WNV Committee meeting, Aurora, March 2009 (Thilaka Krishnaraj)
- Active Tick Surveillance training, Provincial Ministry of Health and Long Term Care, Claireville Conservation Area, Brampton, August, 2009 (Thilaka Krishnaraj)
- TRCA Diversity Committee: Train the Trainer, BCPV, October, 2009 (Thilaka Krishnaraj)
- Provincial Flood Forecasting and Warning Workshop, Black Creek Pioneer Village, September 22-23, 2009 (Craig Mitchell, Jamie Duncan, Lisa Moore)
- Sontek & Hoskin River Surveyor Training Demonstration, Don River (Todmorden Mills) Toronto, July 22nd , 2009 (Craig Mitchell and Derek Smith)
- Ministry of Natural Resources Network Assessment and Design – User Workshop at Black Creek Pioneer Village, March 9-10th, 2009 (Derek Smith)
- Technical Writing Workshop, Conservation Ontario, December 2009 (Nelson Amaral)
- Ontario Low Water Response Training at the Ministry of the Environment Toronto offices on June 18-19, 2009 (Jamie Duncan and Rita Lucero)

15.3 Professional Activities

Watershed Monitoring and Reporting Section staff annually participates in a variety of professional activities such as presenting at conferences and contributing to numerous committees. In addition numerous reports or journal articles are completed based on the data collected under RWMP or through special projects.

15.3.1 Presentations

- Southern Ontario Conservation Authorities Terrestrial Monitoring Network. TRCA Terrestrial Volunteer Monitoring Results: 2002-2007 (April 2009) (Theresa McKenzie)
- Ministry of Natural Resources Network Assessment and Design – User Workshop. *The TRCA Hydrometrics Program & Gauging Networks: Development and Operations.* March 9, 2009. (Derek Smith)

- Lake Ontario Tributary Event Sampling (Load Estimation) and SWAT Modelling Workshop. *Durham Surface Water Quality Monitoring: Carruthers Creek and Duffins Creek.* March 11, 2009 (Derek Smith)
- A.D. Latornell Conservation Symposium – The Value of Long-term Monitoring Data. November 19, 2009 (Scott Jarvie)

15.3.2 Reports and Publications

- Taylor Pond Decommissioning: Project Summary and Monitoring Results. TRCA. October 2009.
- *Source Water Protection: Surface Water Quality Update*. TRCA. December 2009.
- *Etobicoke-Mimico Technical Update: Surface Water Quality*. TRCA. December 2009.
- Terrestrial biological inventory reports for Albion Hills, Maple Nature Reserve and Milliken Park,
- Terrestrial breeding bird reports for Don Valley Brickworks, Chester Springs Marsh and the Sun Valley and Snow Dump site.
- *Evaporation from a Fallow Field and Urbanized Surface within the Humber River Watershed.*
- *Etobicoke and Mimico Creeks Watersheds Technical Update Report: Baseflow and Water Use (Section 4.0(draft)).*
- 2008 Surface Water Quality Summary Report
- 2009 Bathurst Glen Golf Course Surface Water Quality Monitoring Report

15.4 Committees

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

- Southern Ontario Conservation Authorities Terrestrial Monitoring Network – Toronto & Region Conservation, Conservation Halton, Credit Valley Conservation, Central Lake Ontario Conservation, April 8, 2009 (Theresa McKenzie)
- Database Working Group – Toronto and Region Conservation (Scott Jarvie, Angela Wallace, Jamie Duncan)
- Southern Ontario Stream Monitoring and Research Team (SOSMART) (Scott Jarvie, Angela Wallace)
- Natural Areas Inventory Management and Technical Team – Credit Valley Conservation (Sue Hayes)
- Jefferson Salamander Recovery Team – Ontario Ministry of Natural Resources (Sue Hayes)
- Southern Ontario Terrestrial Monitoring Network – Southern Ontario Conservation Authorities (Sue Hayes and Theresa McKenzie)
- Oak Ridges Moraine Corridor Park Management Plan Staff Steering Committee – Toronto and Region Conservation Authority (Sue Hayes)
- Ecological Land Classification Technical Sub-Committee – Ontario Ministry of Natural Resources (Gavin Miller)
- York Region Low Water Response Team – York Region (Jamie Duncan and Rita Lucero)
- Etobicoke and Mimico Creeks Watersheds Technical Team – Toronto and Region Conservation (Jamie Duncan and Rita Lucero)

16 References

Bird Studies Canada. 2008. *Marsh Monitoring Program Participant's Handbook for Surveying Marsh Birds.* 2008 Edition. 17 pages. Bird Studies Canada, Environment Canada and U.S. Environmental Protection Agency. February 2008.

Cadman, M.D., H.J. Dewar and D.A. Welsh. 1998. *The Ontario Forest Bird Monitoring Program (1987 – 1997): Goals, methods and species trends observed.* Technical Report Series No 325, Canadian Wildlife Service. http://ontario.on.ec.gc.ca/wildlife/newsletters/fbmp05-e.html

Cadman, M.D., P.F.J. Eagles, and F.M. Helleiner. 1987. *Atlas of Breeding Birds of Ontario.* Waterloo, Ontario: University of Waterloo Press.

Canadian Climate Impacts and Adaptation Research Network (CCIARN), 2005. *Integrations of Climate Change Impacts and Adaptation into Municipal Policy and Programs—A Focus on Water Management.* Black Creek Pioneer Village, Downsview, Ontario: Nov 3, 2005.

Haley, Don and Auld. Heather, 2000. *Integration of Climate Change into Watershed Management.* White Paper: Ontario Water Conference, Challenge and Solutions. Richmond Hill, Ontario: Apr 26-27, 2000.

Haley, Don. 2006. *The Role of Conservation Authorities in a Changing Climate.* Presentation: A.D. Latornell Symposium, Session W1G, Nov 15, 2006.

Hilsenhoff. W.L. 1988. *Rapid Field assessment of organic pollution with a family level biotic index*. J.N. AM. Bentholoc. 7(1): 65-68.

Hinton, M.J., 2005. *Methodology for measuring the spatial distribution of low streamflow within watersheds.* Geological Survey of Canada, 62 pp.

International Panel on Climate Change (IPCC), 2007. *Climate Change 2007: The Physical Basis, Summary of Policy Makers.* Internet: International Panel on Climate Change. http://ipcc-wg1.ucar.edu/wg1/

Lee, H., W.D. Bakowsky, J.Riley, J. Bowles, M. Puddister, P. Uhlig, and S. McMurray. 1998. *Ecological Land Classification for Southern Ontario: first approximation and its application.* Peterborough, Ontario: Ministry of Natural Resources, South-central Science Section, Science Development and Transfer Branch.

OMOE. 2003. *Water Sampling and Data Analysis Manual for Partners in the Ontario Provincial Water Quality Monitoring Network*.

OMOE. 2008. Water quality in the Greater Toronto Area 2003-2007. Ontario Ministry of the Environment, Toronto, Ontario, Canada. Available on-line at: http://www.omoe.ca/waterquality/WQGTA03-07.pdf [Accessed: 17 January 2009].

Roberts-Pichette, P. and L. Gillespie. 1999. *Terrestrial Vegetation Biodiversity Monitoring Protocols.* EMAN Occasional Paper Series Report No. 9. EMAN Coordinating Office. Canada Centre for Inland Waters. Burlington, ON.

Scott, W.B. and Crossman, E.J. 1998. Freshwater Fishes of Canada. Galt House Pub. Oakville Canada.

Stanfield, L (Editor). 2005. Ontario Stream Assessment Protocol, Version 7. Fish and Wildlife Branch. Ontario Ministry of Natural Resources. Peterborough, ON. 256 Pages.

Steedman, Robert, J. 1988. *Modification and assessment of an Index of Biotic Integrity to quantify stream quality in Southern Ontario.* Canadian Journal of Fisheries and Aquatic Sciences. Vol 45. 492-501.

Stoneman, C. and M. L. Jones. 1996. *A simple method to classify stream thermal status with single observations of daily maximum water and air temperature.* North American Journal of Fisheries Management 16:728- 737.

Toronto and Region Conservation Authority (TRCA). 2007a. *The Terrestrial Natural Heritage System Strategy.* Toronto, ON.

Toronto and Region Conservation Authority (TRCA). 2007b. *Terrestrial Natural Heritage Program Data Collection Methodology.* Toronto, ON.

Toronto and Region Conservation Authority (TRCA). 2007c. *Dog-strangling vine - Cynanchum rossicum (Kleopow)Borhidi. A review of distribution, ecology and control of this invasive exotic plant.* Toronto, ON.
Available on-line at: http://www.rougepark.com/unique/reports/RP_DSV_Report_Dec07.pdf [Accessed: 09 Dec. 2009].

Toronto and Region Conservation Authority (TRCA). 2008. *Terrestrial Volunteer Monitoring Program: Monitoring Results 2002 – 2007.* Toronto, ON.
Available on-line at: http://www.www.trca.on.ca/TerrestrialNaturalHeritage [Accessed: 10 Dec. 2009].

Toronto and Region Conservation Authority (TRCA). 2009a. *Evaluating the Effectiveness of 'Natural' Channel Design Projects: A Protocol for Monitoring New Sites.* Toronto, ON.

Toronto and Region Conservation Authority (TRCA). 2009b. *Source Water Protection: Surface Water Quality Update.* Toronto, ON.

Zorn, P., V. Blazeski and B. Craig. 2004. *Joint EMAN / Parks Canada National Monitoring Protocol for Plethodontid Salamanders*. Parks Canada. Ottawa, ON.

Zugic-Drakulic, N. 2006. *Use of Diatom algae as biological indicators for assessing and monitoring water quality of the rivers in the Greater Toronto Area, Canada*. PhD Thesis. Department of Geology, University of Toronto.

Appendix A

Appendix A. 2009 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**	2	5	2	1	0	22	0	21	3	0	56
	Algae Biomonitoring[2]											
	Benthic Invertebrates	15	10	44	24	11	24	4	21	3	4	160
	Fluvial Geomorphology	1	0	0	0	0	0	9	31	10	0	51
	West Nile Virus Monitoring	3	1	16	4	2	3	1	7	2	6	45
	Surface Water Quality	3	2	11	5	1	7	1	6	1	1	38
	Baseflow	7	2	14	7	6	9	2	9	4	4	64
	Stream Flow	2	1	5	8	0	3	1	7	1	2	30
	Precipitation	4	0	11	6	2	4	1	4	1	0	33
	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[3]	*40*	*5*	*30*	*105*	*16*	*115*	*63*	*573*	*100*	*0*	*1047*
	Terrestrial Volunteer Mon.	5	2	19	6	3	7	1	8	1	4	56
	Climate Change	0	0	3	1	0	1	0	2	0	0	7
	Water Temperature	0	0	0	1	1	25	0	21	3	0	51

[1] Other minor watersheds including tributaries of Frenchman's Bay

[2] Algae was sampled outside TRCA's jurisdiction in 2009

[3] Italicized numbers are the number of hectares monitored

Appendix B

Appendix B. 2009 RWMP Monitoring Activities by Region

		Durham	Peel	Toronto	York	Other[1]	Total
Regional Watershed Monitoring Program	**Fish Species & Aquatic Habitat**	23	7	6	20	0	56
	Algae[2]						
	Benthic Invertebrates	30	34	45	49	2	160
	Fluvial Geomorphology	48	1	0	2	0	51
	West Nile Virus Monitoring	10	10	11	14	0	45
	Surface Water Quality	9	5	13	11	0	38
	Baseflow	18	12	21	13	0	64
	Stream Flow	11	5	10	4	0	30
	Precipitation	5	9	10	9	0	33
	Snow	2	3	1	4	0	10
	Groundwater	6	7	2	6	0	21
	Terrestrial Natural Heritage[3]	*736*	*69*	*66*	*176*	0	*1047*
	Terrestrial Volunteer Monitoring	11	15	17	12	1	56
	Climate Change	2	1	1	3	0	7
	Water Temperature	23	0	8	20	0	51

[1] Dufferin/Simcoe
[2] Algae was sampled outside TRCA's jurisdiction in 2009
[3] Italicized numbers are the number of hectares monitored

Appendix C

Appendix A. 2009 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**	2	5	2	1	0	22	0	21	3	0	56
	Algae Biomonitoring[2]											
	Benthic Invertebrates	15	10	44	24	11	24	4	21	3	4	160
	Fluvial Geomorphology	1	0	0	0	0	0	9	31	10	0	51
	West Nile Virus Monitoring	3	1	16	4	2	3	1	7	2	6	45
	Surface Water Quality	3	2	11	5	1	7	1	6	1	1	38
	Baseflow	7	2	14	7	6	9	2	9	4	4	64
	Stream Flow	2	1	5	8	0	3	1	7	1	2	30
	Precipitation	4	0	11	6	2	4	1	4	1	0	33
	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[3]	*40*	*5*	*30*	*105*	*16*	*115*	*63*	*573*	*100*	*0*	*1047*
	Terrestrial Volunteer Mon.	5	2	19	6	3	7	1	8	1	4	56
	Climate Change	0	0	3	1	0	1	0	2	0	0	7
	Water Temperature	0	0	0	1	1	25	0	21	3	0	51

[1] Other minor watersheds including tributaries of Frenchman's Bay
[2] Algae was sampled outside TRCA's jurisdiction in 2009
[3] Italicized numbers are the number of hectares monitored

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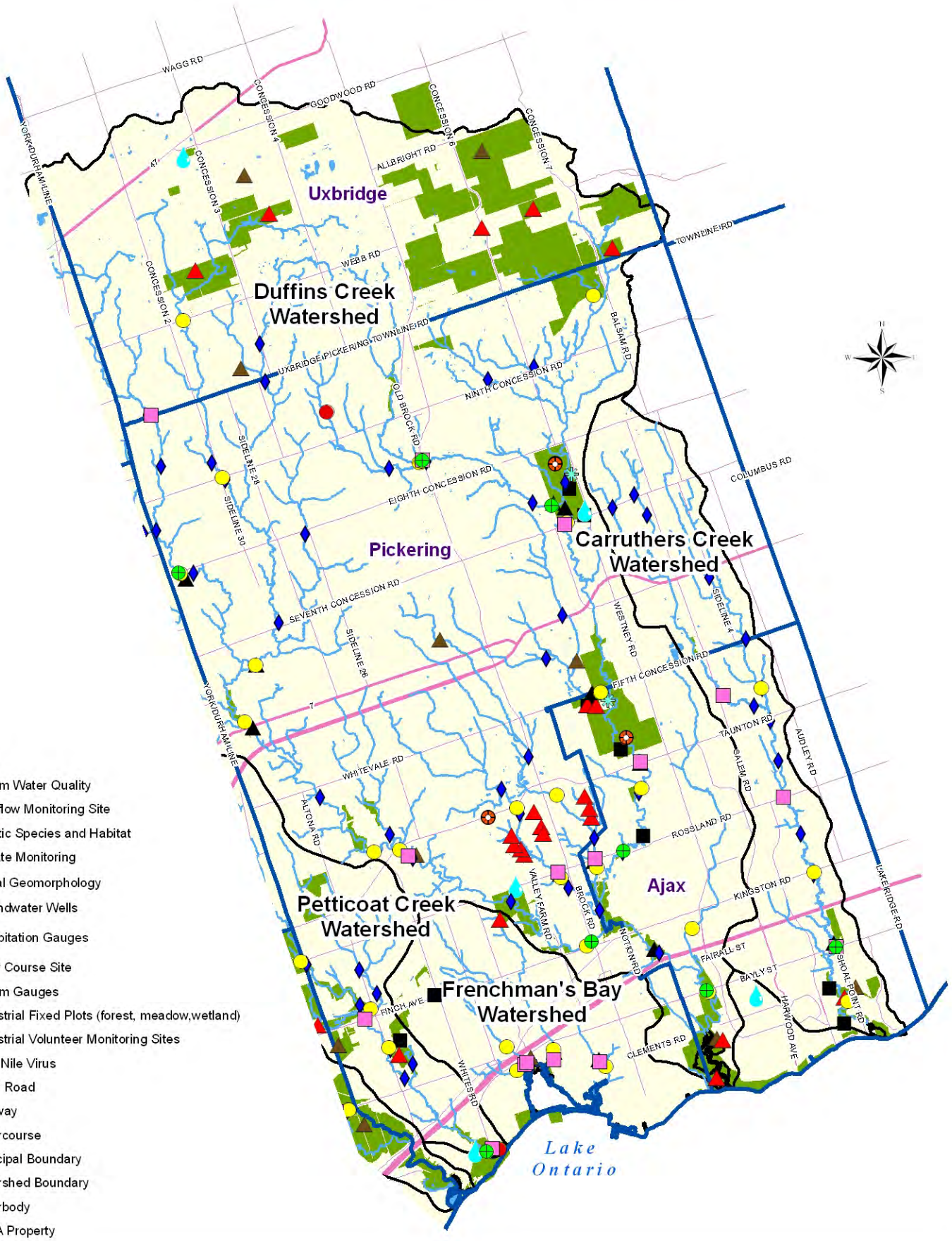
Durham Region Monitoring Locations



Legend

- Stream Water Quality
- Baseflow Monitoring Site
- Aquatic Species and Habitat
- Climate Monitoring
- Fluvial Geomorphology
- Groundwater Wells
- Precipitation Gauges
- Snow Course Site
- Stream Gauges
- Terrestrial Fixed Plots (forest, meadow,wetland)
- Terrestrial Volunteer Monitoring Sites
- West Nile Virus
- Major Road
- Highway
- Watercourse
- Municipal Boundary
- Watershed Boundary
- Waterbody
- TRCA Property

TORONTO AND REGION Conservation
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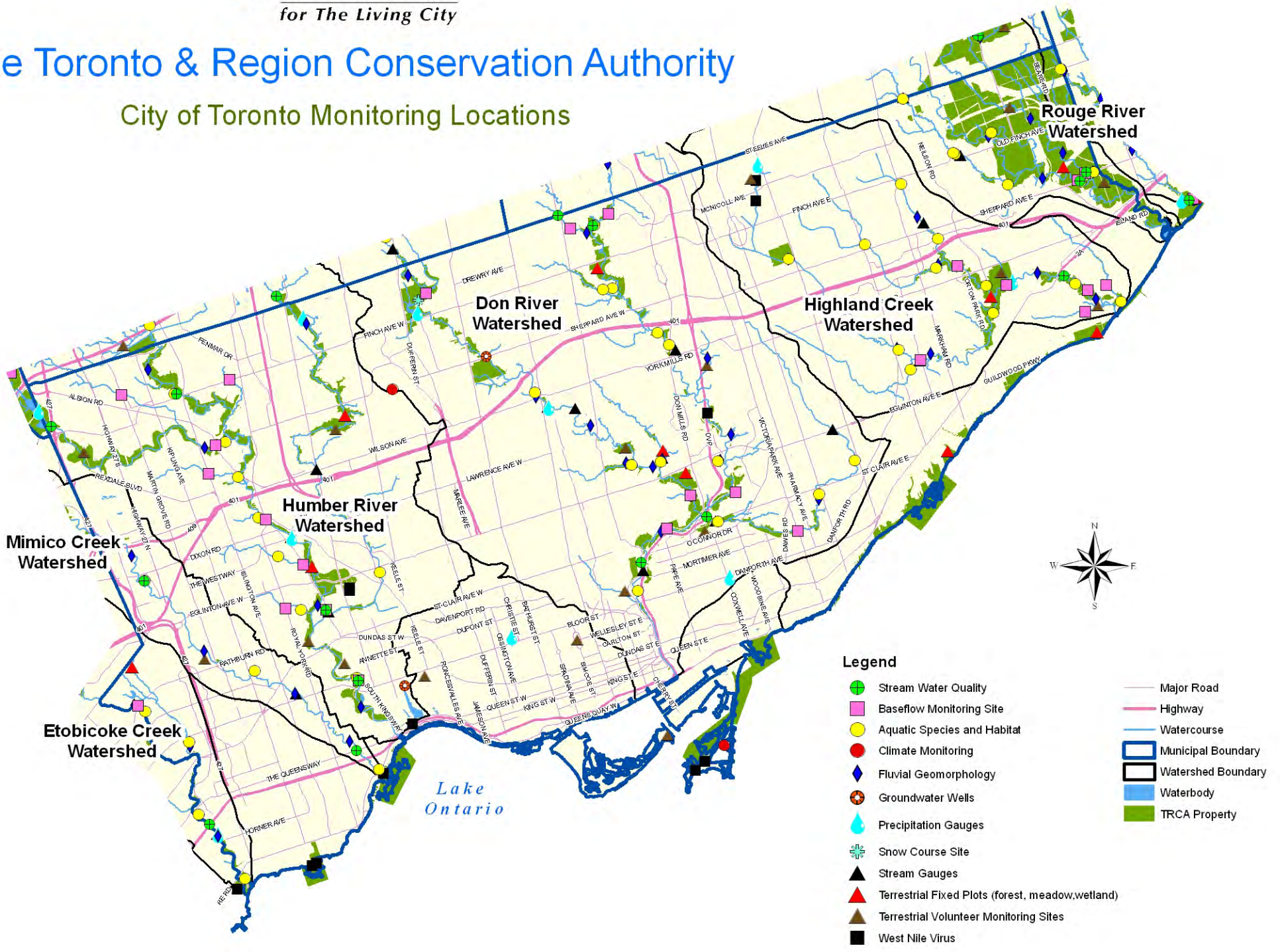
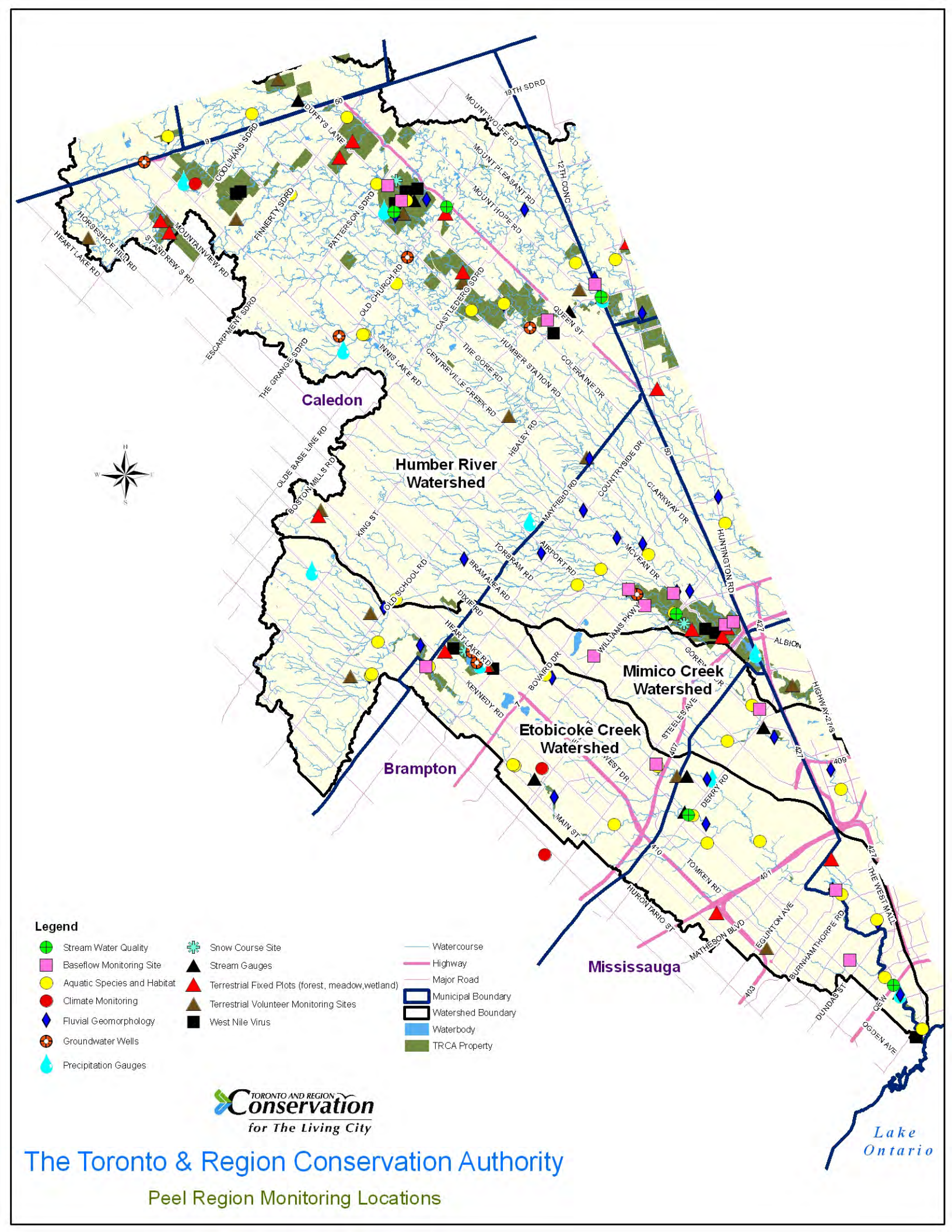
City of Toronto Monitoring Locations





The Toronto & Region Conservation Authority

Peel Region Monitoring Locations

The Toronto & Region Conservation Authority

York Region Monitoring Locations