



Regional Watershed Monitoring Program

Progress Report 2010

April 2011

**Watershed Monitoring and Reporting Section
Ecology Division**



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Table of Contents

	Page
1 Introduction.....	1
2 Terrestrial Habitat and Species	3
2.1 Background	3
2.2 Methods	3
2.3 Data.....	4
2.4 2010 Highlights.....	5
3 Terrestrial Volunteer Monitoring Program	9
3.1 Background	9
3.2 Methods	9
3.3 Data.....	9
3.4 2010 Highlights.....	10
4 Fish Community and Habitat Surveys.....	13
4.1 Background	13
4.2 Methods	13
4.3 Data.....	14
4.4 2010 Highlights.....	14
5 Algae Biomonitoring.....	21
5.1 Background	21
5.2 Methods	22
5.3 Data.....	22
5.4 2010 Highlights.....	22
6 Surface Water Quality	25
6.1 Background	25
6.2 Methods	26
6.3 Data.....	26
6.4 2010 Highlights.....	26
7 Water Temperature Monitoring.....	31
7.1 Background	31
7.2 Methods	31
7.3 Data.....	32
7.4 2010 Highlights.....	32
8 Benthic Invertebrates	37
8.1 Background	37
8.2 Methods	37
8.3 Data.....	38

8.4	2010 Highlights.....	38
9	Fluvial Geomorphology	43
9.1	Background	43
9.2	Methods	44
9.3	Data.....	44
9.4	2010 Highlights.....	45
10	West Nile Virus Vector Monitoring.....	49
10.1	Background	49
10.2	Methods	50
10.3	Data.....	50
10.4	2010 Highlights.....	51
11	Groundwater Quality and Quantity	55
11.1	Background	55
11.2	Methods	56
11.3	Data.....	56
11.4	2010 Highlights.....	56
12	Water Quantity-Stream Flow, Precipitation and Snow Course.....	61
12.1	Background	61
12.2	Methods	62
12.3	Data.....	64
12.4	2010 Highlights.....	65
13	Water Quantity-Baseflow.....	71
13.1	Background	71
13.2	Methods	71
13.3	Data.....	72
13.4	2010 Highlights.....	73
14	Meteorological (Climate Monitoring)	77
14.1	Background	77
14.2	Methods	79
14.3	Data.....	81
14.4	2010 Highlights.....	81
15	Staff Contributions	85
15.1	Staff.....	85
15.2	Training and Workshops	86
15.3	Professional Activities.....	87
15.4	Committees.....	89
16	References	91

List of Figures

Figure 1. Nodding ladies' tresses (<i>Spiranthes cernua</i>).....	5
Figure 2. Red-backed salamander (<i>Plethodon cinereus</i>)	6
Figure 3. Terrestrial natural heritage monitoring sites	7
Figure 4. Terrestrial volunteer monitoring program fixed sites.....	11
Figure 5. Native species richness report card scores calculated using observed vs expected ratio.	15
Figure 6. IBI Scores related to road density (2007-2009)	16
Figure 7. Fish community and habitat monitoring sites	19
Figure 8. Algae biomonitoring sites	23
Figure 9. Water quality index scored by watershed from <i>The Living City Report Card</i>	27
Figure 10. Surface water quality monitoring sites	29
Figure 11. Example of temperature data collected for a site in Etobicoke Creek (EC006WM)	31
Figure 12. Example of a box and whisker plot displaying water temperature data (EC006WM).....	32
Figure 13. Percentage of warm, cool and cold water fish species in the Humber and Etobicoke watersheds	33
Figure 14. Water temperature monitoring sites	35
Figure 15. Benthic macroinvertebrate metrics calculated for 2002-2008.....	39
Figure 16. Benthic macroinvertebrate monitoring sites.....	41
Figure 17. Cross-sectional profile of GHU-1 (a) and GHU-2 (b).....	45
Figure 18. Fluvial geomorphology monitoring sites	47
Figure 19. West Nile Virus monitoring sites	53
Figure 20. Groundwater monitoring sites	59
Figure 21. Various RT stream gauge stations (from left) Taylor Massey Creek, McFall Dam, and the real-time gauging home page.....	62
Figure 22. Various precipitation gauges including both “stand alone” and RT systems. From left to right: three season “stand-alone” rain gauge, a four season RT weight gauge with windscreen, and a four season heated rain gauge.	63
Figure 23. Snow course monitoring, Albion Hills, Conservation Area.....	64
Figure 24. Water quantity monitoring sites (stream flow gauges)	67
Figure 25. Water quantity monitoring sites (snow & precipitation).....	69
Figure 26. Cross section of a stream – baseflow transect.....	72
Figure 27. Total estimated baseflow outflow by watershed from in Litres per second (L/s)	73
Figure 28. Baseflow monitoring sites.....	75
Figure 29. Finch Avenue culvert failure August 19 th , 2005 Toronto, Ontario, >125mm in 1 hour.	78
Figure 30. Various TRCA MET stations, pictured from left to right: Claremont (Transport Canada), Vaughan (Kortright Conservation Area), and Richmond Hill (16 th Ave Fire Hall).	79

Figure 31. Automated evaporation pans located at Glenn Haffey Conservation Area (left) and Kortright Conservation Area (right). Glenn Haffey station depicting operational setup and Kortright station prior to spring deployment.	80
Figure 32. Automated Bowen Ratio Energy Balance system used to determine “actual” evapotranspiration values, located at Kortright Conservation Area (left) and Downsview Park (right).....	80
Figure 33. Meteorological monitoring sites	83

List of Tables

Table 1. IBI ratings for sites in the Etobicoke and Humber watersheds (2007, 2010), shown as percentages.	14
Table 2. Grading criteria for native species richness report card score.....	15
Table 3. Number of surface water quality sampling sites by watershed	25
Table 4. Select water quality parameters analyzed as part of the RWMP	26
Table 5. Thermal stability classifications for Etobicoke Creek and Humber River in 2010	33
Table 6. Comparison of Hilsenhoff ratings calculated for sites sampled in 2009 and 2010 (n = 140)	39
Table 7. Percent change in measured 2010 low flow watershed outflows.....	74

Appendices

- A. 2010 RWMP monitoring activities by watershed
- B. 2010 RWMP monitoring activities by region
- C. 2010 RWMP site location maps by region

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 vital to the success of an organization that is responsible for 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. Since its inception in 2001, 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.

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

- **Stream Water Quality** - assesses a variety of basic and enhanced water chemistry;
- **Stream Water Quantity** - stream gauges and in-stream measurements monitor changes in the water levels of the region's watercourses;
- **Aquatic Habitat and Species** - including aquatic insects, fish populations, algae, stream temperature and the physical shape of the stream;
- **Terrestrial Habitat and Species** - staff and trained volunteers monitor flora and fauna species and communities through biological inventories and fixed plots;
- **Meteorology** - assesses the contribution of rain and snow to the hydrology of the region; and,
- **Groundwater Quantity and Quality** - 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 purposes. 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 methodology 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, and to provide highlights from both the 2010 season and the analysis completed to date. This information will hopefully assist in promoting and facilitating additional opportunities for data sharing and collaboration based on this body of work. 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, Natasha Gonsalves, Michael King, Annette Lambert, Allison Scovil, Daniel Morodvanschi, and Catherine Polcz

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 RWMP 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 2010 are identified in **Figure 3**. Two Natural Channel Design (NCD) sites along with 15 biological inventory sites that covered approximately 1560 hectares were inventoried for vegetation community, flora and fauna species. In addition, approximately nine erosion control sites were inventoried for flora species of concern and road kill surveys were conducted in the Stouffville Road and Bayview Avenue area. As part of the regional fixed monitoring plots, data was collected at 24 forest, 18 wetland and 13 meadow plots distributed across the TRCA jurisdiction. Long-term fixed monitoring plots for project sites such as Caledon East, Ontario Power Generation and Duffins Heights were monitored.

Terrestrial Inventories

A biological inventory of each of the 15 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 Ecological Land Classification (ELC) and determined to the level of vegetation type (Lee *et al.* 1998). Community boundaries were outlined onto printouts of 2007 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 sites are inventoried for all fauna (breeding birds and amphibians) and flora species found throughout the site along with vegetation community mapping based on the ELC. In addition, invasive non-native flora species are mapped. Two NCD sites were sampled in 2010. Please refer to the Natural Channel Design Terrestrial Monitoring Methodology for more information (TRCA 2009).

Fixed-plot Monitoring

Fixed-plots were set-up in forest, wetland and meadow habitats (24, 18 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. 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.

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 along with the associated attributes. 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 Area of Natural & Scientific Interest (ANSI) evaluations, the update of the ELC 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 2010 Highlights

The 2010 field season was split between collecting plot data at the long-term fixed monitoring sites and conducting issue based site inventories.

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

- The Brock North property was found to have a good number of highly sensitive ground-nesting birds such as veery (*Catharus fuscescens*), ovenbird (*Seiurus aurocapillus*), black and white warbler (*Mniotilta varia*) and Nashville warbler (*Vermivora ruficapilla*). Ground-nesting birds are usually one of the first groups of bird species to disappear from a natural area when there is disturbance such as free roaming pets and increased user activity.

- A new native flora species for the TRCA jurisdiction was identified in Rouge Park during the terrestrial natural heritage inventories – *Senecio pauperculus*. This species belongs to the Aster family and is generally found in alvar communities.



Figure 1. Nodding ladies' tresses (*Spiranthes cernua*)

- Over 20 hectares of seepage fen vegetation communities were identified on the Brock North property. Fens are an unusual vegetation community in the TRCA jurisdiction and often support sensitive flora species of concern. Species such as *Spiranthes cernua* (nodding ladies' tresses), *Eriophorum viridi-carinatum*, (thin-leaved cotton-grass), *Carex flava* (yellow sedge), *Carex viridula* (greenish sedge), and *Panicum acuminatum* var. *lindheimeri* (Lindheimer's panic grass) which are all species of regional conservation concern were identified on this property.
- The Humber Marshes area was found to have oak savannah and woodland habitat which are provincially-significant ecosystems. Only a tiny proportion of this habitat type is left in Ontario. The examples near Humber Marshes are part of the historic Humber Plains prairie and savannah complex, which includes High Park and Lambton Prairie. Flora species of concern found there

included *Quercus velutina* (black oak), *Sassafras albidum* (sassafras), *Salix humilis* (prairie willow), *Penstemon hirsutus* (hairy beard-tongue), *Comandra umbellata* (bastard toadflax), *Andropogon gerardii* (big bluestem) and *Carex siccata* (hay sedge).

- Forest stands containing coniferous tree species such as *Tsuga canadensis* (eastern hemlock), *Pinus strobus* (white pine), *Thuja occidentalis* (white cedar) are not regenerating in the Black Creek ravine system inventoried. This issue is not restricted to the Black Creek system however as it appears that this is a problem in most urban forest systems. These species are not able to compete with species such as *Acer negundo* (Manitoba maple) and *Juglans nigra* (black walnut) which are common in the urban ravine systems. It is anticipated that eastern hemlock will disappear altogether from the urban forest as they have shallow root systems and are not able to tolerate compacted soils or drought.
- The Downsview Dells long-term monitoring plot, situated along the Humber River and within the City of Toronto, was found to have the highest number of red-backed salamanders (*Plethodon cinereus*) compared to any other plot throughout the TRCA region. It was anticipated that monitoring plots located in the more rural parts of the jurisdiction would have a higher abundance of this species than plots located in the urban core. It is not clear why the numbers are so high at this urban location but perhaps additional monitoring will help to determine the reason.
- One of the key components of this monitoring is the development and maintenance of a scoring and ranking system for the Region's flora and fauna species. This ranking system is based on a set of criteria that focus mainly on a species' sensitivity to development impacts, and is designed to identify the conservation needs and priorities of the Region's flora and fauna before they disappear. This listing of "Species of Conservation Concern" has been an important tool that has been used extensively in various planning, development application, and land management decisions and has been used to support various modeling exercises such as the TRCA's Terrestrial Natural Heritage Systems Strategy.



**Figure 2. Red-backed salamander
(*Plethodon cinereus*)**

Figure 3

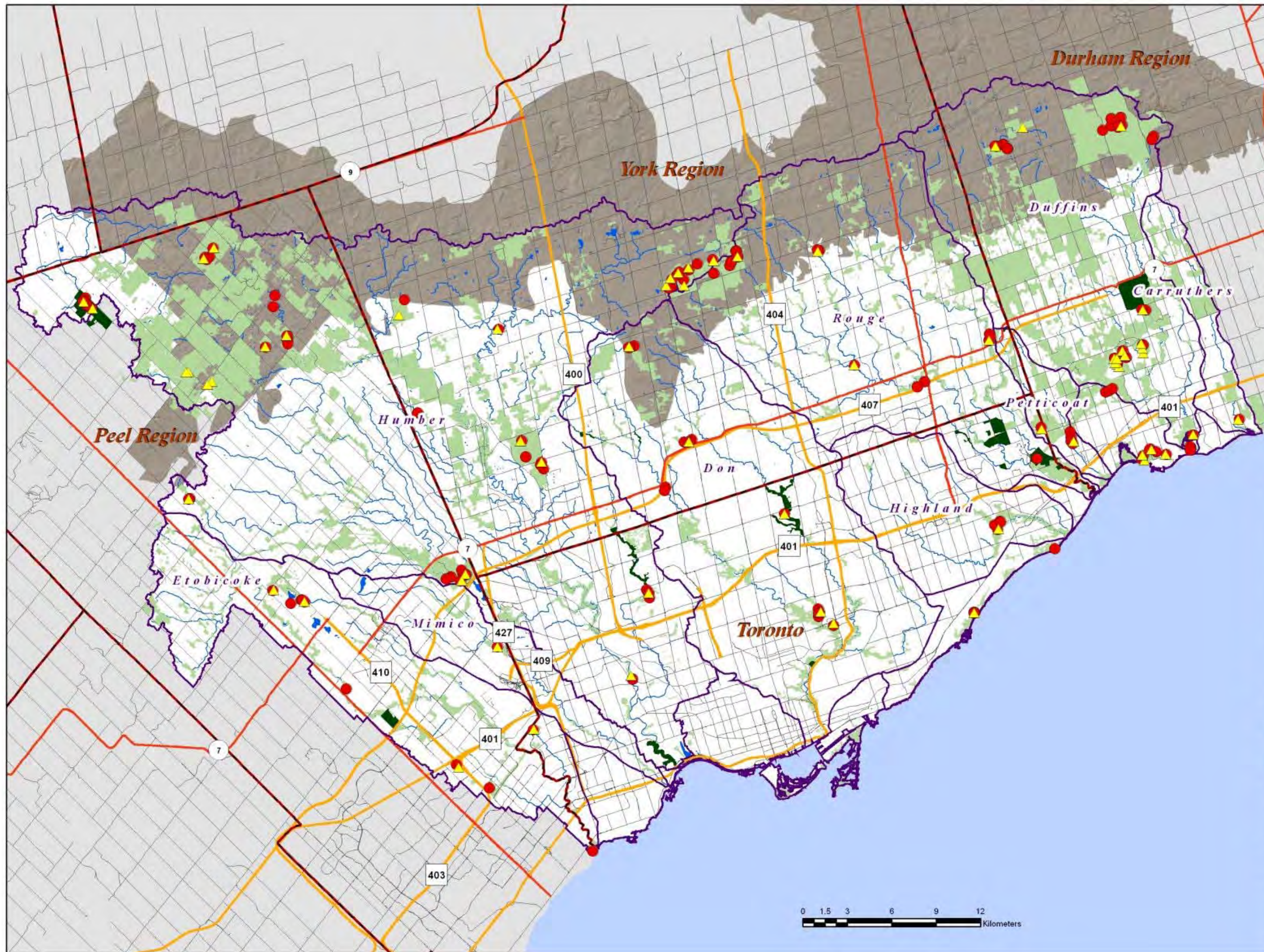
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Scale: 1:250,000

Legend

- Fauna Fixed Plot Monitoring
- ▲ Flora Fixed Plot Monitoring
- Inventory 2000-2009
- Inventory 2010
- 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 of 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



0 1.5 3 6 9 12 Kilometers

3 Terrestrial Volunteer Monitoring Program

Staff Lead: Theresa McKenzie

Support Staff: Team of volunteers (152 participants during 2010)

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 4**). 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.



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 2010 Highlights

- Site coverage was very good for the year with 474 visits completed across 55 sites. Monitoring effort has increased each year since the program's inception.
- Program highlights and invasive species monitoring results were presented at the GTA Conservation Authorities Watershed Monitoring Forum.
- Two of the TVMP volunteers progressed to employment with TRCA this year, while multiple others reported that the experience gained in the program had been helpful in securing employment with other organizations.
- Analysis of the species richness data (number of species) indicate that species richness scores were lower in urban sites compared to rural sites.

Figure 4

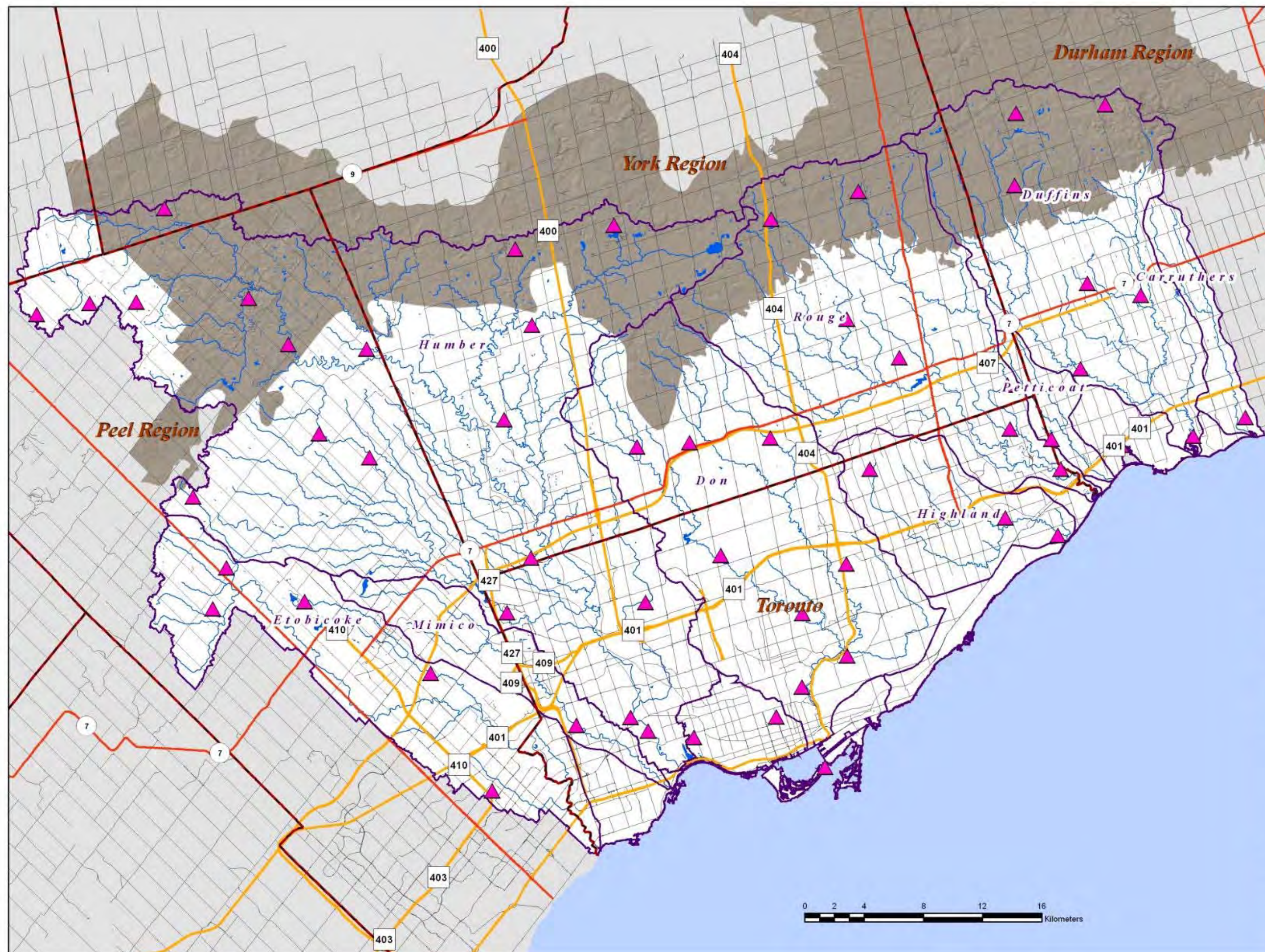
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Scale: 1:250,000

Legend

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

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4 Fish Community and Habitat Surveys

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Support Staff:

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Funding:

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

4.1 Background

The aquatic habitat and species component of the RWMP includes fish community and habitat sampling at approximately 150 sites throughout the region. About one-third of these sites are monitored 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

In addition to the RWMP sites, a number of other project sites are also assessed annually on a special request basis. In 2010 these projects included: the Palgrave Fishway, Mill Pond Splash, Duffins Heights and Natural Channel design.

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. Quality Assurance/Quality Control (QA/QC) 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.



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 64 sites were sampled in 2010 (**Figure 7**), including 47 RWMP sites in the Humber and Etobicoke watersheds, and 17 special project sites found in the Don, Highland, Rouge and Duffins watersheds. There are now four completed data sets available for the RWMP sites in the Etobicoke and Humber watersheds (2001, 2004, 2007 and 2010).

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 2010 Highlights

- The Index of Biotic Integrity (IBI) is a biotic index used to rate the overall health of a fish community (Steedman 1988). An IBI score was determined for each site in the Etobicoke and Humber watersheds. **Table 1** summarizes the percentage of IBI scores according to ranking. Three habitat quality categories, good, fair and poor are present for the three watersheds. A total of 44 sites were sampled in both 2007 and 2010 in the Etobicoke and Humber watersheds. In the Etobicoke watershed there was an improvement in IBI scores in 46% of the sites and no change in 54% of the sites. In the Humber watershed there was an improvement in IBI scores in 19% of the sites, no change in 45% and a decline in 36% of the sites.

Table 1. IBI ratings for sites in the Etobicoke and Humber watersheds (2007, 2010), shown as percentages.

	2007			2010			Change
	Good	Fair	Poor	Good	Fair	Poor	
Etobicoke	7%	43%	50%	38%	38%	24%	Improve
Humber*	46%	37%	11%	34%	43%	20%	Decline

*Some sites were fished but no fish were caught, therefore total does not equal 100%

- Analysis of nine years of fish data for over 150 RWMP monitoring sites began in 2010. Some of the findings were reported in the Living City Report Card (TRCA 2011) and this will be followed by a

more in depth report later in 2011. The number of native fish species collected at each monitoring station was determined and a grade score was assigned (**Figure 5** and **Table 2**). Scores varied widely between watersheds, ranging from an “A” for the Rouge River to “F”s for the Don River, Highland Creek and Mimico Creek watersheds. In general, sites within the lower, urbanized portions of watersheds had lower numbers of native fish species than expected when compared to headwater sites.

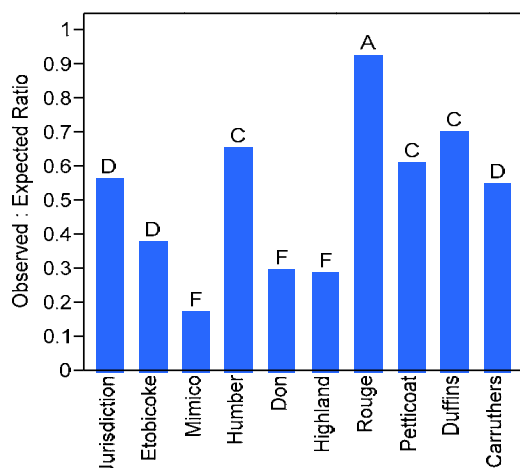


Figure 5. Native species richness report card scores calculated using observed vs expected ratio.

Table 2. Grading criteria for native species richness report card score

Grading Criteria for Species Richness	
Grade	% of Expected Native Species
A	Greater than or equal to 80%
B	70% to 79%
C	60% to 69%
D	50% to 59%
F	Less than 50%

- Further analysis identified a strong relationship between road density and IBI as well as road density and native species richness. As road density increases there is a decrease in the IBI Score (**Figure 6**) and native species richness. Road density acts as a surrogate for urbanization and incorporates many factors associated with the urban landscape.

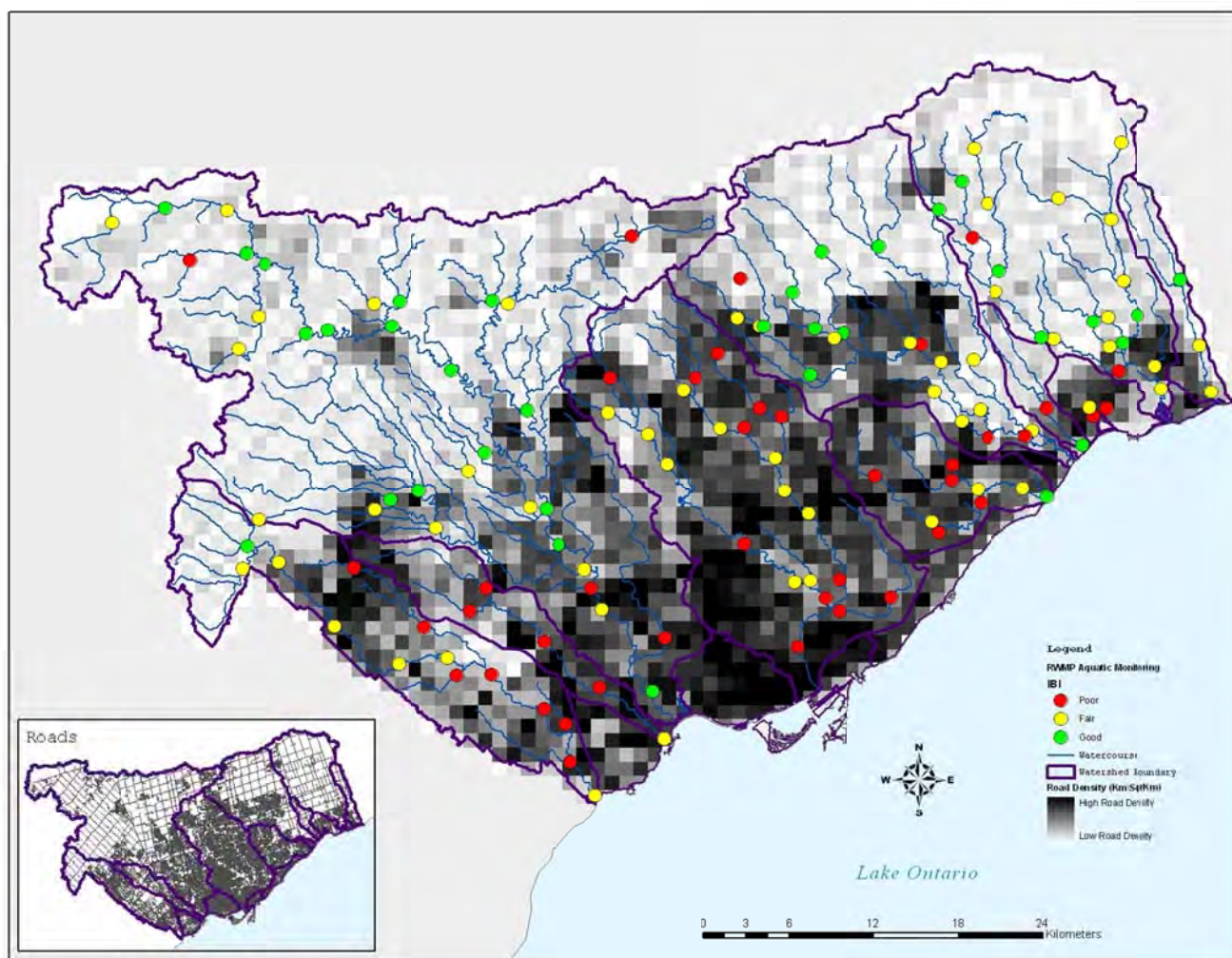


Figure 6. IBI Scores related to road density (2007-2009)

Additional Highlights

- A new site was set up in the Humber River (HU039WM) to replace HU017WM which has not been accessible for several years due to landowner issues.
- A Common Shiner / Creek Chub hybrid (*Luxilus cornutus x Semotilus atromaculatus*) was found for the first time in the jurisdiction in the Humber River (HU012WM) (Identified by Erling Holm, Royal Ontario Museum). Hybridization of the Common Shiner occurs because of their tendency for breeding over the nests of other cyprinids (Menzel 1978).
- The Round Goby (*Neogobius melanostomus*) is an invasive exotic species that was introduced into the Great Lakes basin in 1990 via ship ballast water (Corkum et al. 2004). This species was first identified in 2007 at our RWMP monitoring sites in Etobicoke Creek (EC001WM) and the Humber River (HU003WM). Round Goby were also found at the mouth of Duffins Creek (2008) and Mimico Creek (2009) and at a special project site in Etobicoke Creek in 2008. The 2010 survey found Round Goby in the same sites in Etobicoke Creek and Humber River as the 2007 survey. From RWMP

data, it appears that there has been no further movement of the species upstream in the three years because it was not found at the next upstream monitoring station.

- The Central Stoneroller (*Campostoma anomalum*) is native to south western Ontario but is a non-native species in the TRCA's jurisdiction. Range expansion has been occurring through bait bucket transfer and natural dispersal. The species was found at four sites in 2001 and at eight sites in 2010 in the Humber River, and at one site in 2004 and six sites in 2010 in Etobicoke Creek. The abundance of Central Stonerollers at these sites has also increased. The Central Stoneroller is tolerant of low dissolved oxygen and fluctuating turbidity. The range expansion may be due to their ability to fill a new niche after a disturbance.

Figure 7

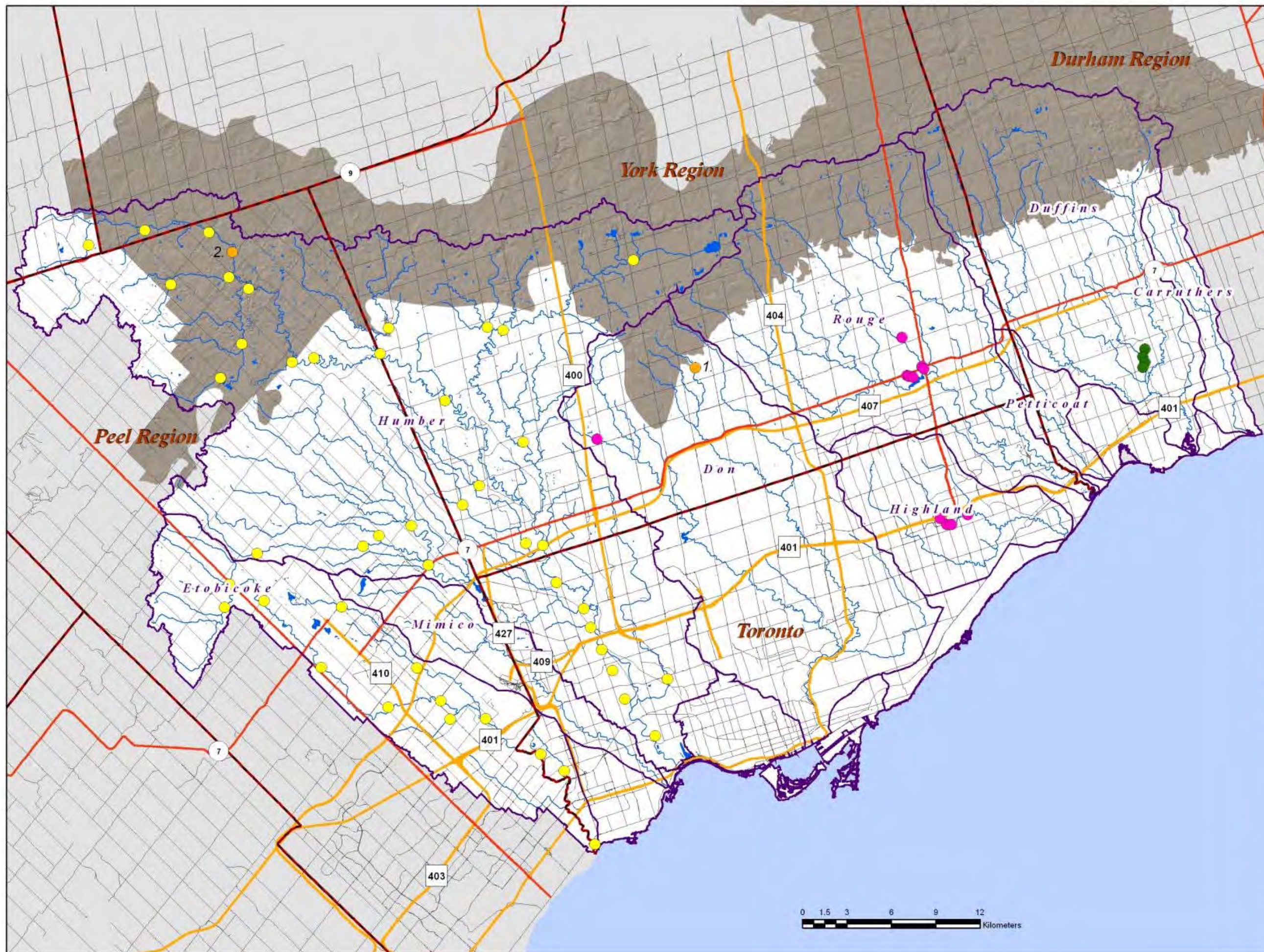
TORONTO AND REGION
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Scale: 1:250,000

Legend

- Aquatic Habitat and Species Site
- Duffins Heights
- Natural Channel Design
- 1. Mill Pond Splash
- 2. Palgrave Fishway
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

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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 RWMP. Until recently, the importance of plants (and particularly algae and diatoms) has been undervalued in watershed monitoring. Algae, including diatoms, are among the first group of organisms to be impacted by shifts in chemical conditions in a water body, 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.



The repeatability of the Algae Bioassessment Protocol (ABP) was assessed during its first two years through the collection of samples from 20 RWMP monitoring sites in 2008 and 20 sites outside of the TRCA jurisdiction in 2009. In its second year algae sampling was conducted with the help of six other

Conservation Authorities: Ausable Bayfield, Cataraqui River, Credit Valley, Nottawasaga Valley, Saugeen Valley, and Upper Thames.

5.2 Methods

For the 2010 field season 39 sites were sampled in TRCA's watersheds. At each of the sites in-situ water quality data was collected using a water quality probe. Five replicated diatom samples were collected at each site from riffle areas, and pooled together for a composite sample.

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. Identification of the 2009 samples was completed in February 2010.



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. Algae and diatom data is available from TRCA for 2008 and 2009. Once identification is completed on the 2010 sampling season this data will also be made available.

5.4 2010 Highlights









- In the spring of 2010 TRCA's Algal Biologist gave a presentation at the GTA Conservation Authorities Watershed Monitoring Forum entitled "Algae Biomonitoring: when inverts are not enough".
- A study was conducted in 2010 to look at the diatom community related to the water quality within TRCA's jurisdiction. Sixty sites were selected for this study by ranking them based on the percentage of agriculture, natural cover and road density in the upstream drainage area. Diatom identification and data analysis will be carried out in 2011.
- In October a final draft of the ABP was released and distributed to the Conservation Authorities who participated in Algal sampling in 2009. Reports for each of the six participating Conservation Authorities were also sent at this time. Feedback from the reports and draft protocol were very positive and there was support for the continued use of this protocol.

Figure 8

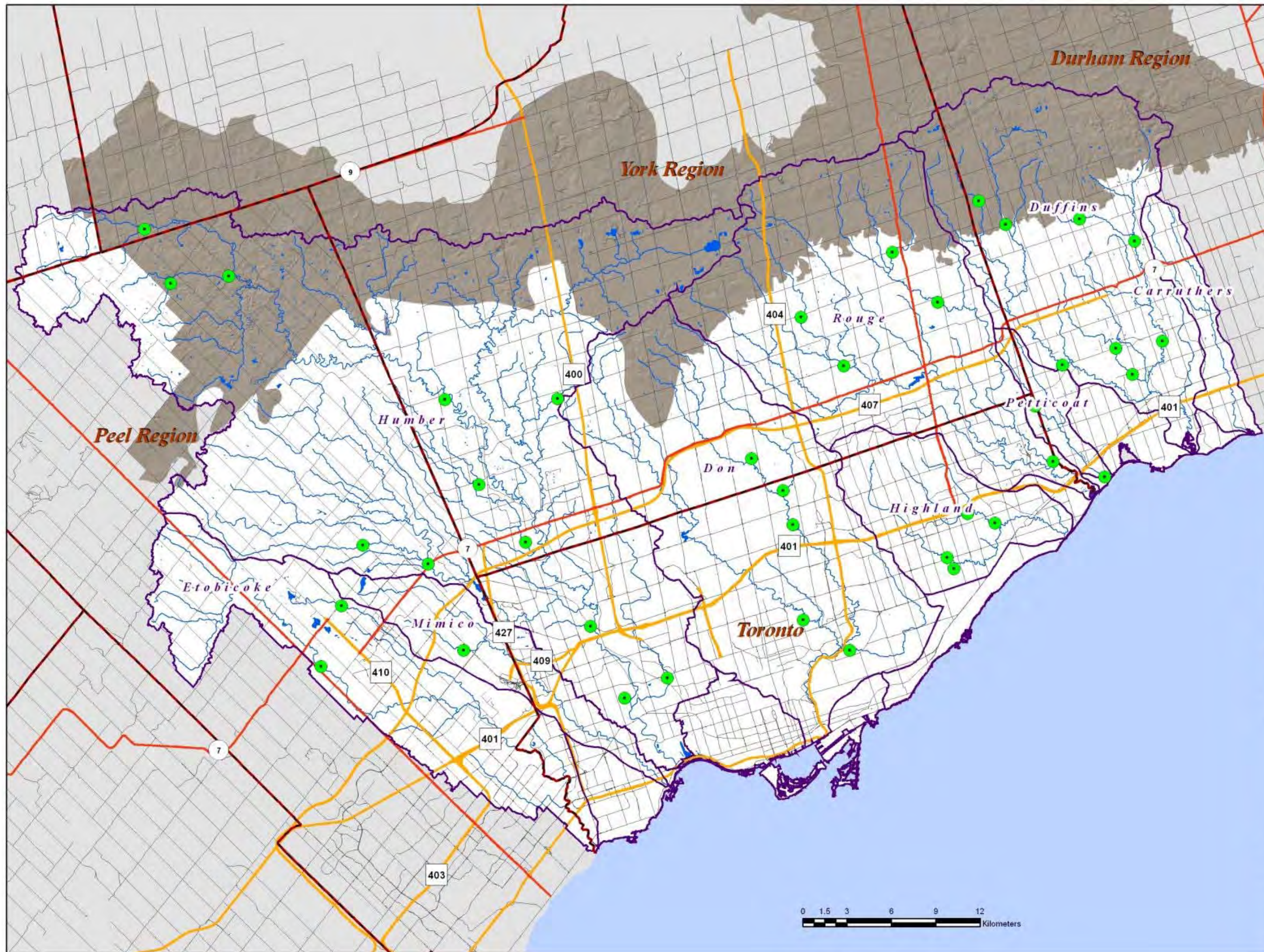
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Scale: 1:250,000

Legend

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

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6 Surface Water Quality

Staff Lead: Angela Wallace, Clare Holeton

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 2010 (Table 3) across the jurisdiction.



Table 3. Number of surface water quality sampling sites by watershed

Watershed	# Sites
Etobicoke Creek	3
Mimico Creek	2
Humber River	11
Don River	5
Highland Creek	1
Rouge River	7
Duffins Creek	6
Carruthers Creek	1
Petticoat Creek	1
Frenchman's Bay (Pine Creek)	1
Total	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 or York-Durham Environmental Laboratory, for analysis of the parameters listed in Table 4.

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	<i>Escherichia coli</i>				
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. This database includes laboratory results and metadata (e.g. laboratory analysis methods, sampling equipment).

6.4 2010 Highlights

- The Living City Report Card (TRCA 2011) analyzed the current water quality (2005-2009) across the TRCA's jurisdiction (**Figure 9**). The report used the Water Quality Index (WQI; CCME 2001) which incorporates three elements: *scope* - the number of variables not meeting water quality objectives; *frequency* - the number of times these objectives are not met; and *amplitude* - the amount by which the objectives are not met. The overall water quality grade for the TRCA was "C" with the Duffins Creek watershed receiving the highest rating (A) and the Don River and Highland Creek watersheds receiving the lowest grade (D).

- Water quality results for the TRCA's jurisdiction were presented at the International Association on Great Lakes Research (IAGLR) conference in Toronto in May 2010 through a poster entitled "Long-term Water Quality Monitoring: Trends in the Toronto and Region AOC".
- Water quality samples were collected to conduct the bi-annual inter-laboratory QA/QC program.
- Three additional historic MOE stations were included in monthly sampling starting in October 2010, as part of the Duffins Heights/Seaton Lands Development Project.
- Baseline water quality samples for the York Region's Nobleton Phosphorous Offsetting project were collected on a monthly basis.
- 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.

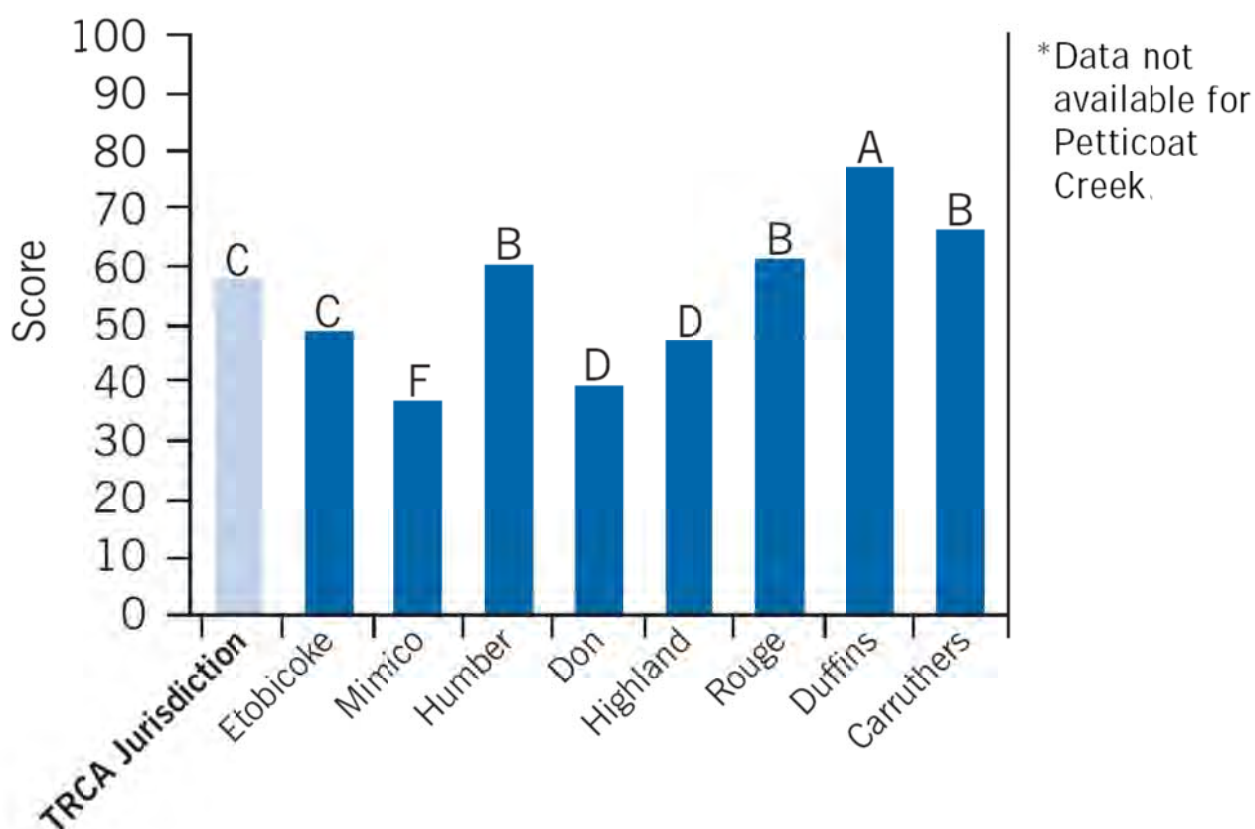


Figure 9. Water quality index scored by watershed from *The Living City Report Card*

Figure 10



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Scale: 1:250,000


Legend


Water Quality Monitoring Site


Program


-  PWQMN / RWMP
-  RWMP


 Toronto Wet Weather Sampling Station


 Regional Boundary

 Expressway/Highway


 Freeway

 Major Road

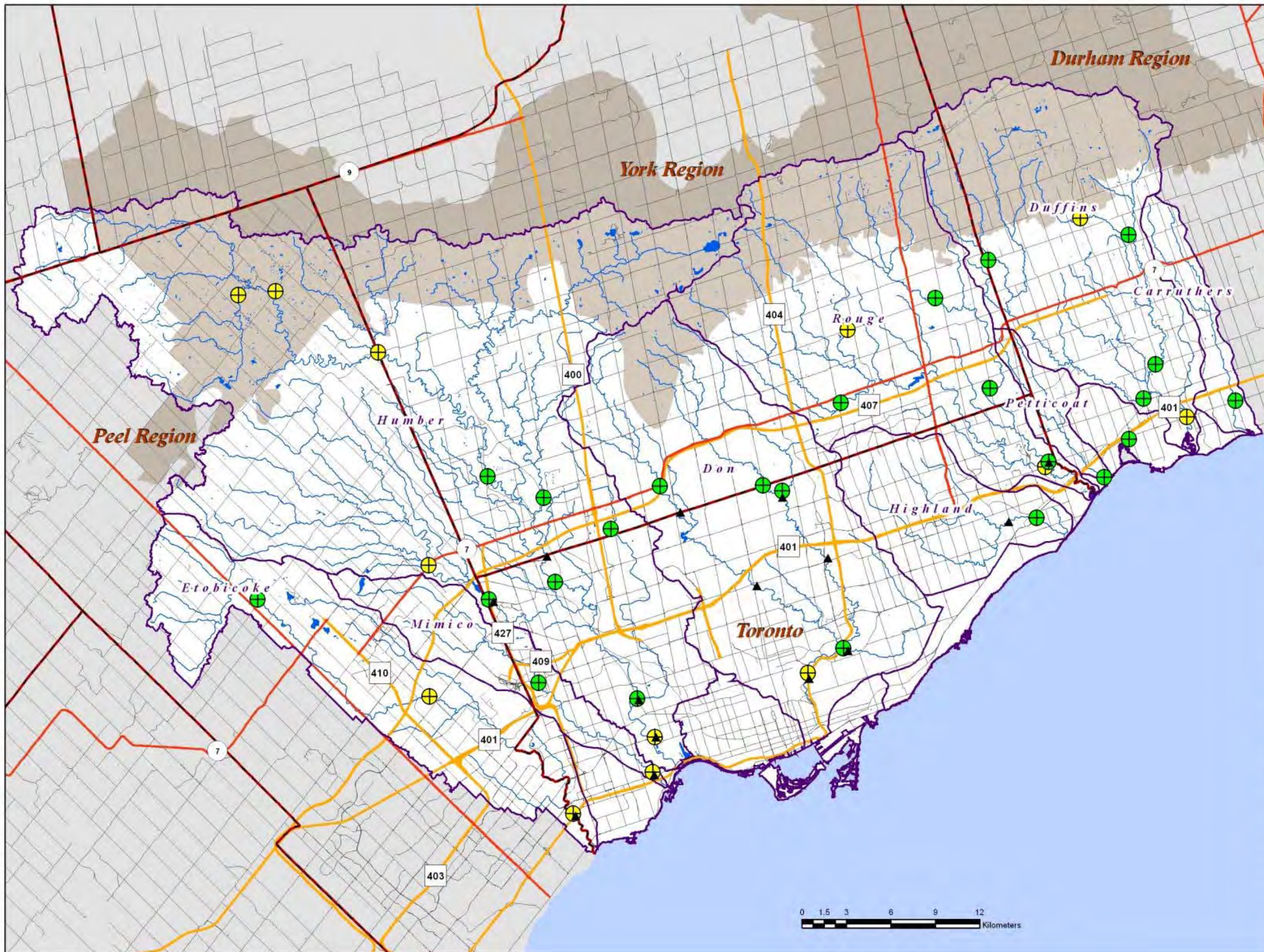
 Watercourses/Rivers

 TRCA Watersheds

 Waterbodies

 Oak Ridges Moraine

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7 Water Temperature Monitoring

Staff Lead: Melanie Croft-White

Support Staff: 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 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.

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

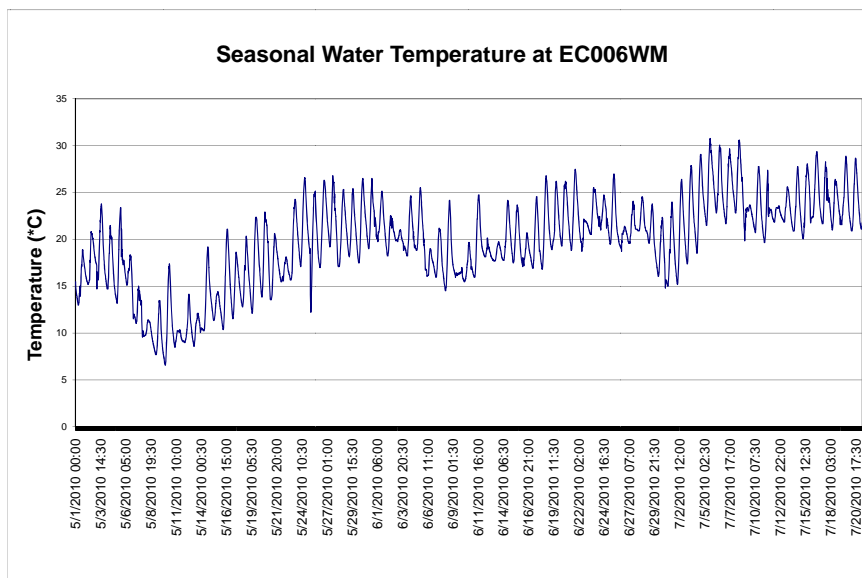


Figure 11. Example of temperature data collected for a site in Etobicoke Creek (EC006WM)

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 ($>25^{\circ}\text{C}$) on hot summer days. **Figure 11** illustrates patterns of the typical heating and cooling cycles of a stream from the spring and early summer. **Figure 12** 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, warmwater run-off, and cold thermal contributions from groundwater sources.

7.4 2010 Highlights

- In 2010, loggers were deployed at 52 RWMP aquatic sites in the Etobicoke Creek and Humber River watersheds as well as 8 project specific sites in the Duffins Creek watershed (**Figure 14**).
- There are now four sets of data available for most sites in the Etobicoke Creek and Humber River watersheds (2001, 2004, 2007 and 2010).
- In a normal sampling year a small number of temperature loggers are lost due to storm events and erosion. In 2010 no loggers were lost, but loggers will need to be redeployed in two sites because of water level issues (beaver dam (HU028WM), low water (HU031WM)). One site in the Humber River was not sampled due to landowner access issues (HU017WM) but a new site was created in the same reach (HU039WM).

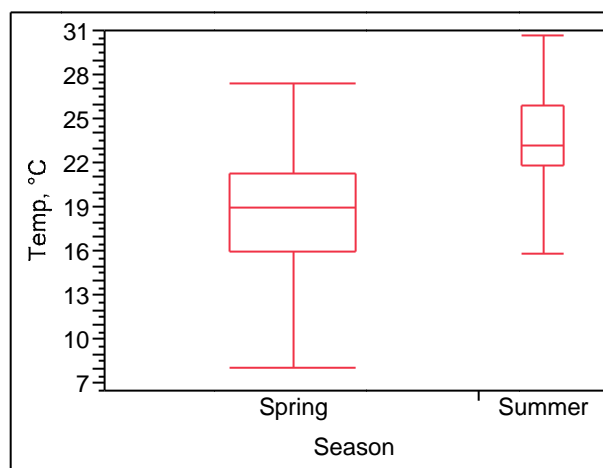


Figure 12. Example of a box and whisker plot displaying water temperature data (EC006WM).

- **Table 5** shows the percentage of sites that fall in the three stability categories (stable, moderately stable, and unstable) for 2010. The temperature stability in the Etobicoke Creek watershed has improved since 2001. Thermal stability is a reflection of how stream temperature changes with ambient air temperature. Stable streams often have significant groundwater inputs and are well shaded, whereas unstable streams have minimal groundwater inputs and experience more extreme temperature fluctuations throughout the day. Changes in run-off, soil permeability and amount of natural cover as a result of urbanization can negatively impact thermal stability.

Table 5. Thermal stability classifications for Etobicoke Creek and Humber River in 2010

Year	Thermal Stability	Watershed	
		Etobicoke	Humber
2010	Stable	14%	8%
	Moderately Stable	36%	49%
	Unstable	50%	43%

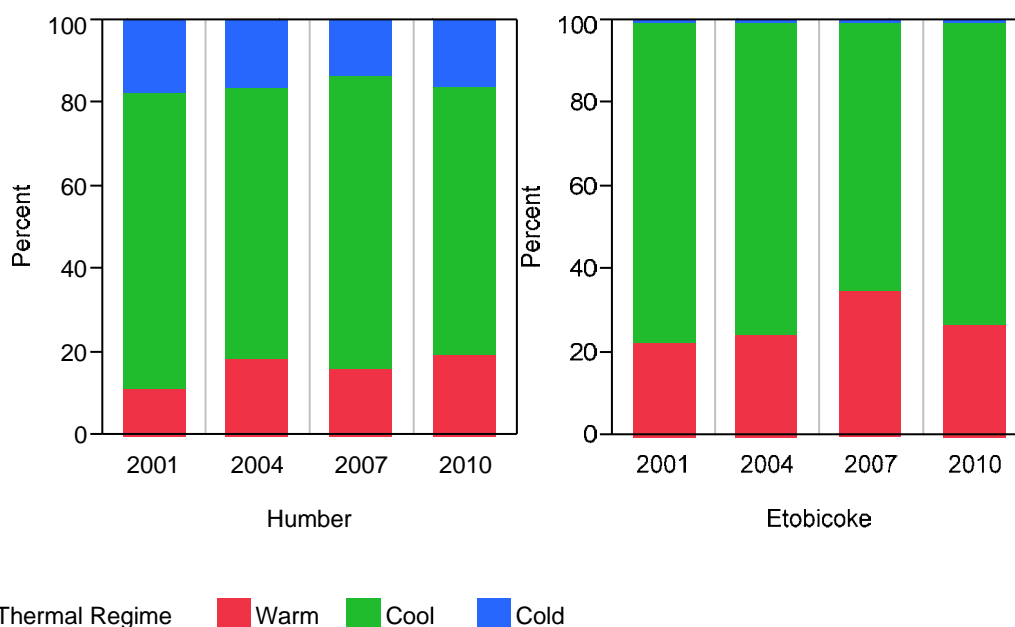


Figure 13. Percentage of warm, cool and cold water fish species in the Humber and Etobicoke watersheds

- According to the fish communities present the Humber River and Etobicoke Creek are predominantly coolwater systems but the Humber river has some coldwater fish (**Figure 13**). Percentages fluctuate slightly from year to year as a result of natural factors such as climate, fish migration and the timing of the sampling. **Table 5** shows that 50% of the streams in the Humber and 43% of the streams in the Etobicoke watershed are unstable. The majority of these unstable streams have a higher proportion of warmwater fish species, but there are some sites in the Humber River that are unstable but have some coldwater species. Unstable streams with coolwater and coldwater species are at risk of losing these sensitive species because of the potential for high

water temperature during heat waves. Further analysis may identify sites that could benefit from restoration.

- The highest temperature was observed at a site on Etobicoke Creek (EC007WM) (Dixie Rd and Derry Rd) with a maximum temperature of 33.4° C. This site has little natural cover, is relatively shallow and is surrounded by industrial land.
- Two real time temperature loggers were installed as part of a pilot program and other temperature loggers may be added to existing real time stream gauge stations in the future.

Figure 14

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Legend

Thermal Stability

- Stable
- Moderately Stable
- Unstable
- Incomplete Data

— Regional Boundary

— Expressway/Highway

— Freeway

— Major Road

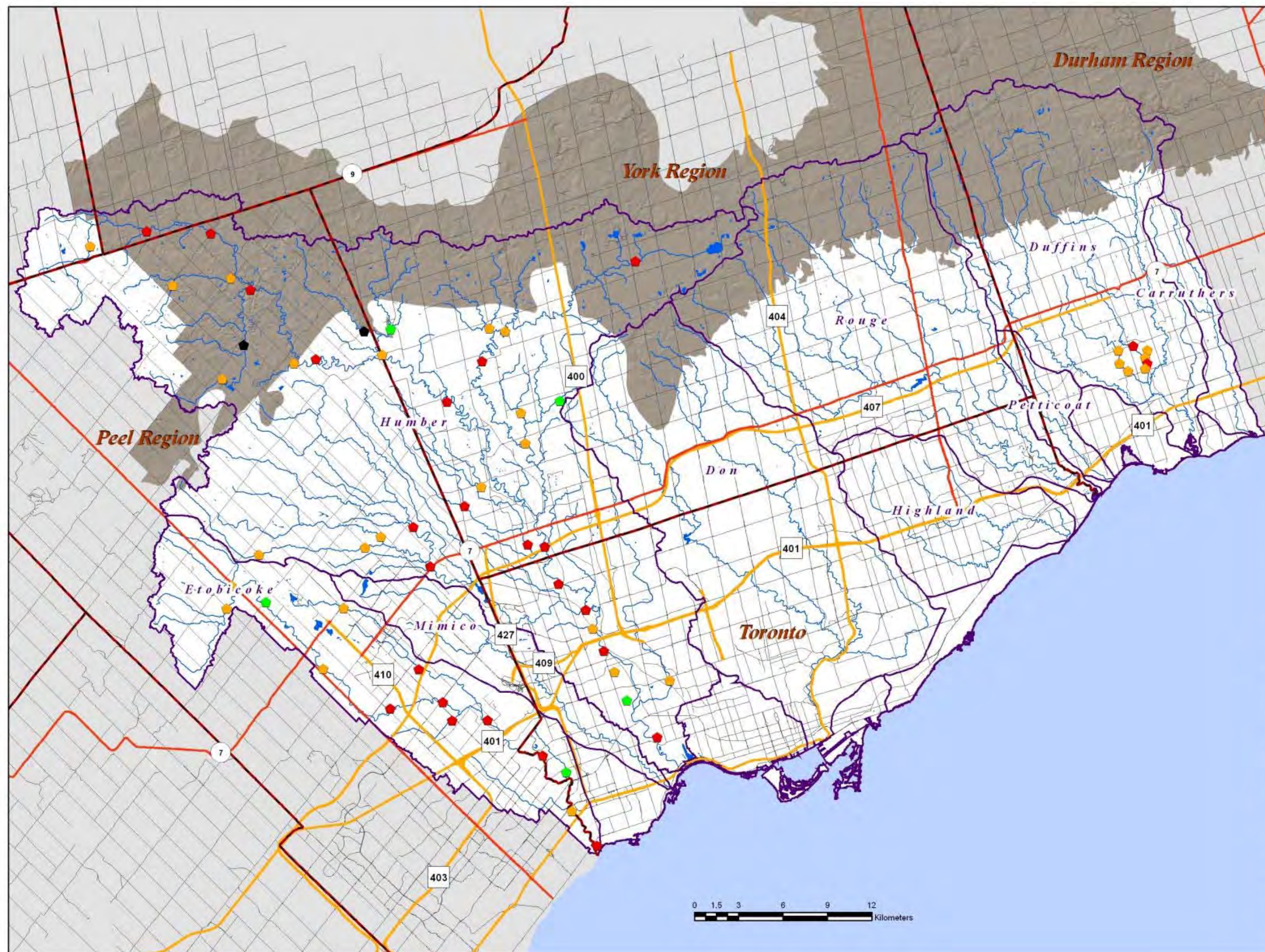
— Watercourses/Rivers

 TRCA Watersheds

 Waterbodies

 Oak Ridges Moraine

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8 Benthic Invertebrates

Staff Lead:

Thilaka Krishnaraj, Angela Wallace

Support Staff:

Chris Cummings, Ellen Fanning, Lori Knight, Sarah Scharfenberg, Deborah Silver and Mark Szonda

Funding:

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

8.1 Background

Benthic invertebrates are organisms which inhabit the bottom of watercourses for at least portion of their lives. These organisms are sensitive to disturbances in their environment, and are useful indicators of change. Established as a core program activity for the RWMP in 2001, the benthic biomonitoring program has been used to track changes in aquatic biota and water quality across TRCA's jurisdiction. The different ecological requirements as well as the sensitivity of various benthic organisms to pollution make them ideal candidates for biomonitoring purposes. 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 yearly at approximately 150 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).



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 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 across the stream. Each transect sample is collected using a 500 μ m 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) depending on availability of resources.

From the data various indices of water of watershed condition are calculated to summarize the data and compare sites both temporally and spatially.

8.3 Data

Benthic invertebrate data (OSAP Coarse level 27 groups) for RWMP sites are available from 2001 to 2010. In addition, there are electronic versions of benthic invertebrate 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 and data are available up to year 2008. The benthos data stored in Excel spreadsheets will be 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 2010 Highlights

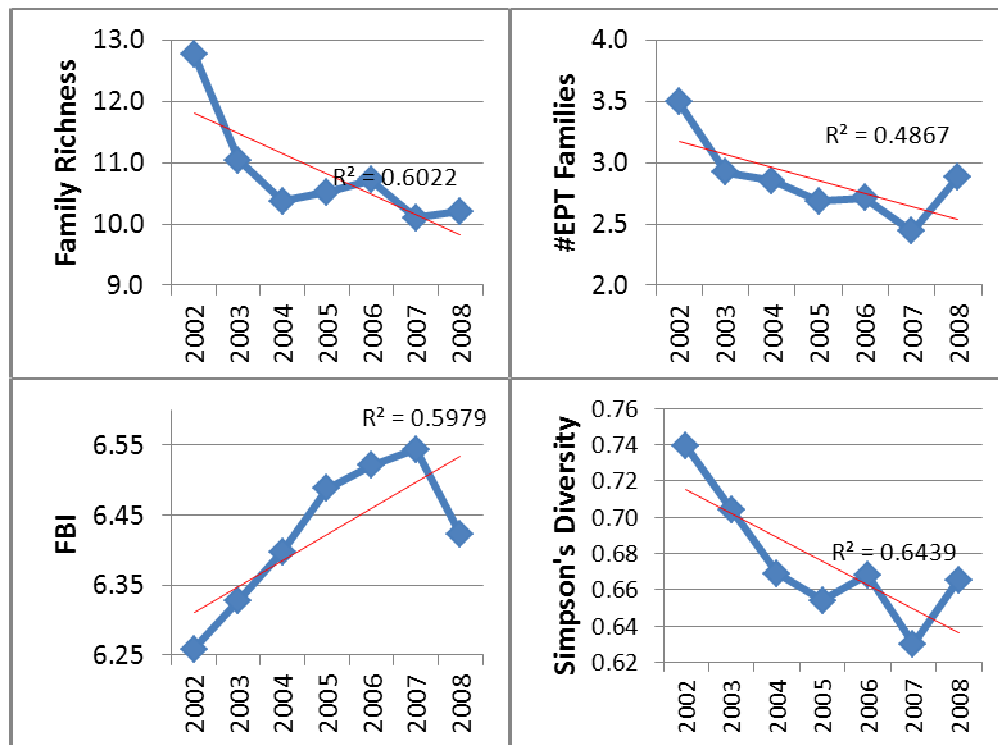
- A total of 140 RWMP stations and 16 special project stations were sampled in 2010 (Figure 16). Eleven sites could not be sampled this year due to site access issues (five sites), beaver dams (five sites) and extreme changes in the stream geomorphology (one site).
- Sampling for the Natural Channel design and Duffins Heights special projects continued in 2010 (last sampled in 2008).
- As in previous years, there were several data requests from external agencies (e.g. consulting agencies) as well as by the Province, Municipalities and other TRCA departments.
- The preliminary water quality assessment using the Hilsenhoff Biotic Index for 2009 and 2010 (**Table 6**) showed that there is an improvement in the Hilsenhoff scores for Etobicoke Creek, Mimico Creek, Humber, Don, Rouge, Carruthers and Frenchman's Bay watersheds. Conversely, sites in Highland Creek, Petticoat Creek and Duffins Creek, have dropped one to two rating levels compared to 2009 ratings.
- Analysis of eight years (2001-2008) of invertebrate data for over 150 RWMP monitoring sites began in 2010. **Figure 15** shows Family Richness (number of families), number Ephemeroptera Plecoptera Trichoptera (EPT) Families, Hilsenhoff's Family Biotic Index (FBI) (Hilsenhoff 1988) and Simpson's Diversity. A decrease in Family richness, number of EPT families, and Simpson diversity as well as an increase in FBI indicate a decline in the benthic community that is likely attributed to increased

urbanization and changes in water quality, particularly increases in chloride concentrations. Similar to the water quality and fish species data, there is a strong linkage to road density indicating that urbanization is a key driver of aquatic health.

Table 6. Comparison of Hilsenhoff ratings calculated for sites sampled in 2009 and 2010 (n = 140)

Watershed	Decline	No Change	Improve
Etobicoke Creek	2	8	3
Mimico Creek	1	1	3
Humber	5	20	12
Don	2	9	12
Highland	7	2	2
Rouge	4	8	8
Petticoat	2	2	
Frenchman's Bay*		2	2
Duffins	12	5	3
Carruthers		2	1

*Amberlea Creek, Dunbarton Creek, Pine Creek and Krosno Creek



-2008

Figure 16

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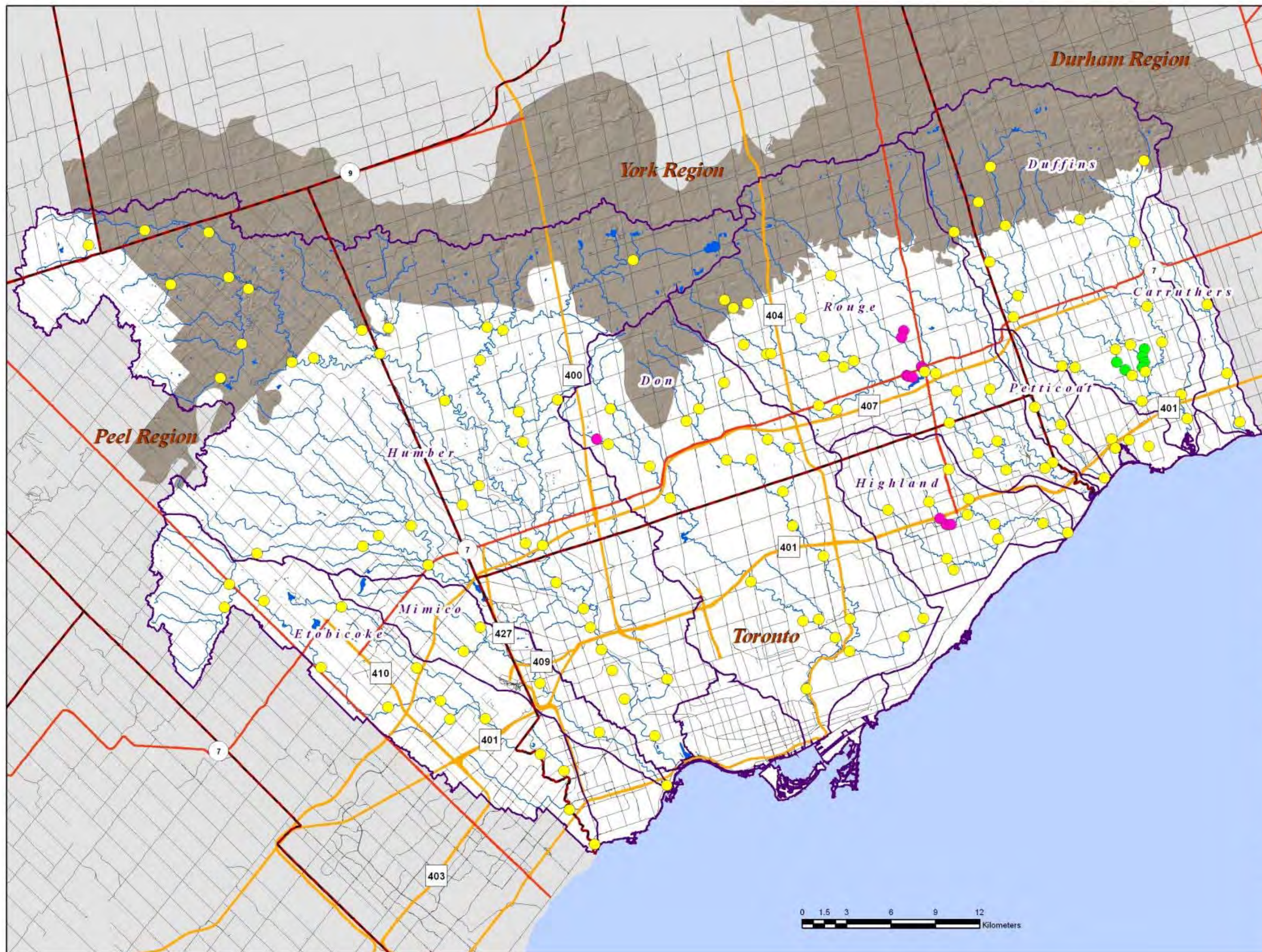
Legend

Benthic Macroinvertebrate Monitoring Sites

- RWMP Monitoring Site
- Duffins Heights
- Natural Channel Design

- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
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9 Fluvial Geomorphology

Staff Lead:

Nelson Amaral

Support Staff:

Mike Brestansky, Mark Szonda, Ashely Favaro, Ellen Fanning, Andrea Hibert

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 18**) were established 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 conducts follow-up monitoring at approximately 50 sites each year on a 3-year rotation. Monitoring efforts include: re-evaluating channel stability through stability indexes, re-measuring channel dimensions along an established “control” cross-section, 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.



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 2010. Data from 2001-2003 is stored in an Access database and data from 2004-2010 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 2010 Highlights

- A total of 50 RWMP sites were surveyed in 3 watersheds (Etobicoke Creek, Mimico Creek and the Humber River) in 2010. **Figure 18** displays the 50 RWMP sites surveyed in 2010. The geomorphic data collected in 2010 will be used to identify changes occurring over time.
- Figure 17 displays the geomorphic data collected at Station GHU-1 (a) and GHU-2 (b) located south of Bloor Street in the lower portion of the Humber River watershed. The cross-sectional profile of GHU-1 identifies typical changes associated with natural geomorphic processes. Since 2004 there has been an increase in deposition along the streambed but the banks have remained relatively stable. The cross-sectional profile of GHU-2 identifies substantial deposition between 2004 and 2007 likely related to erosional processes occurring upstream. Watercourses are dynamic systems and this trend may be reversed quite quickly in the future. The data collected in 2010 will be compared to 2007 and 2004 to identify the active processes acting on each station. Cross-sectional area, width/depth ratio and erosion/deposition will also be calculated and compared over time to help characterize each station, subwatershed, watershed and various land-use areas.

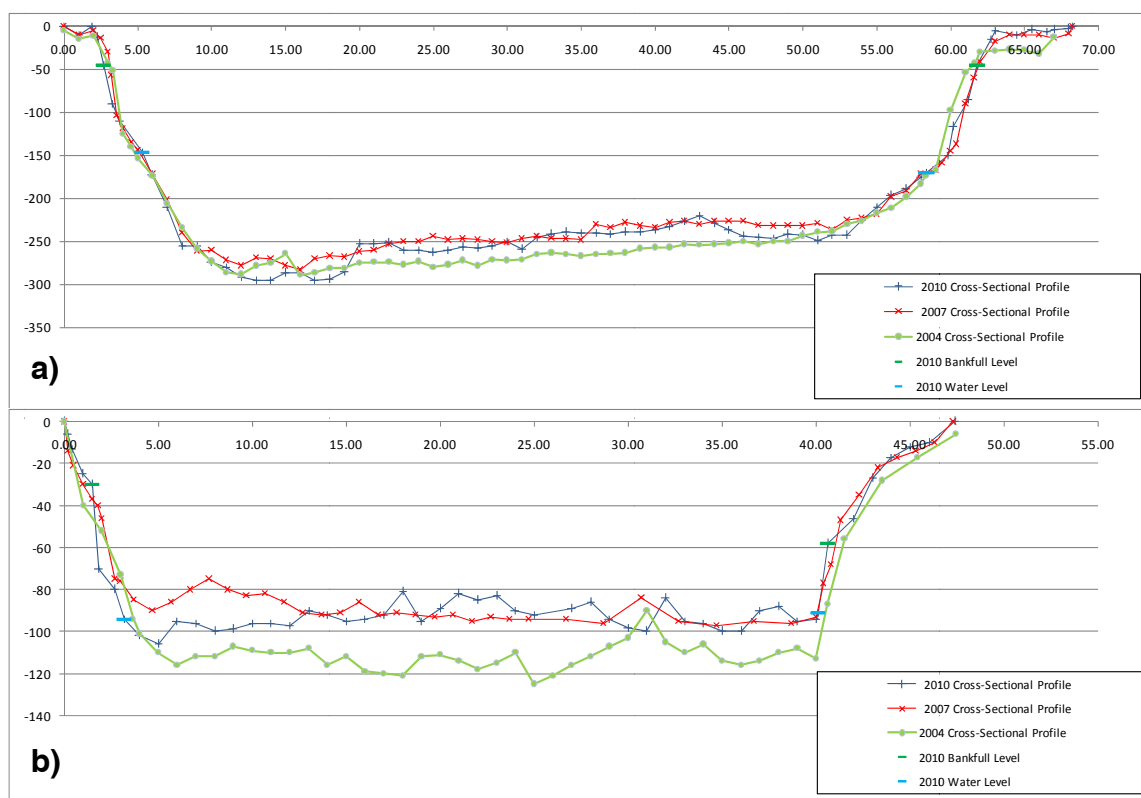


Figure 17. Cross-sectional profile of GHU-1 (a) and GHU-2 (b)

Figure 18

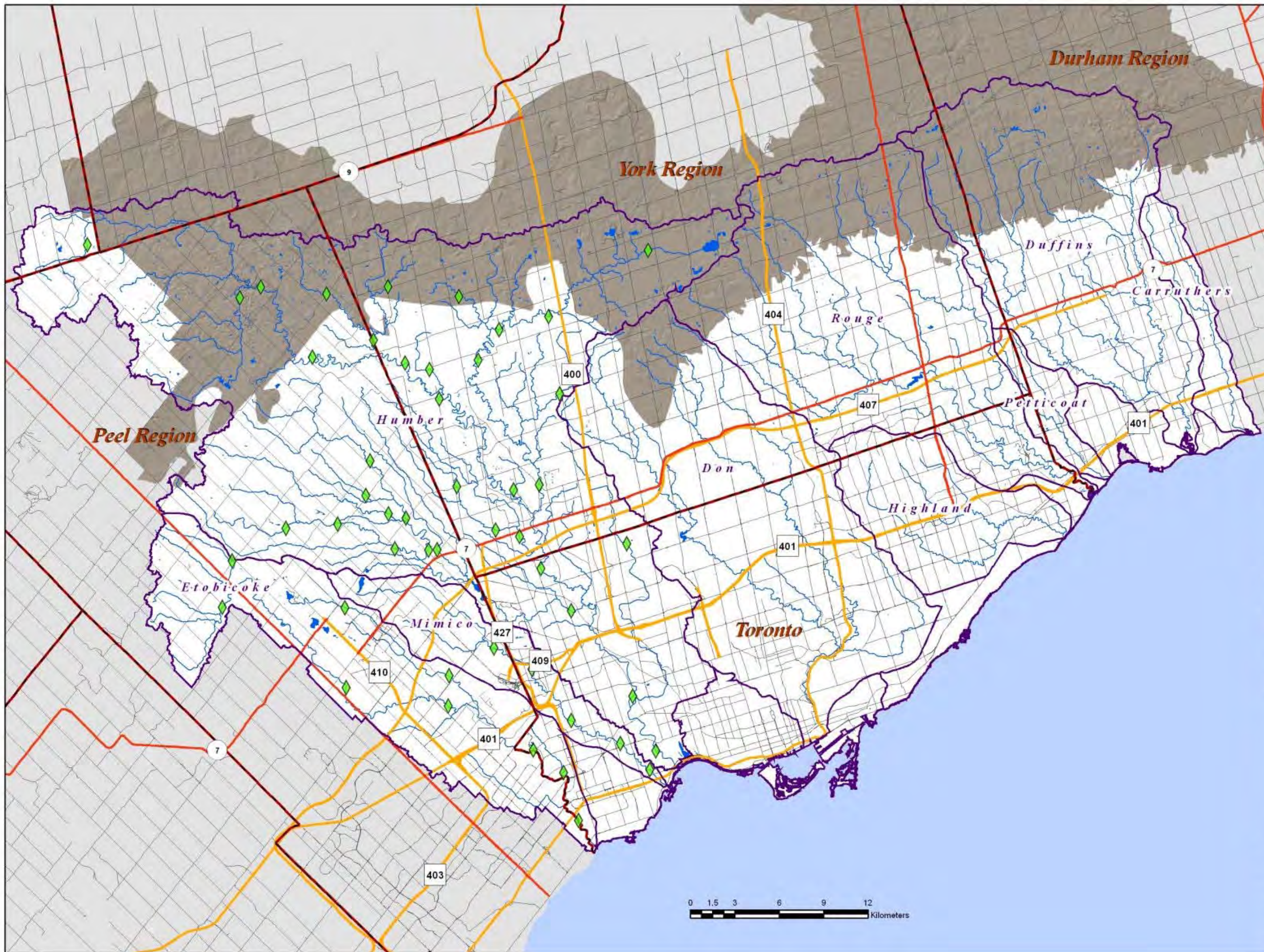
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Legend

-  2010 RWMP Site
-  Regional Boundary
-  Expressway/Highway
-  Freeway
-  Major Road
-  Watercourses/Rivers
-  TRCA Watersheds
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10 West Nile Virus Vector Monitoring

Staff Lead: Thilaka Krishnaraj

Support Staff: Damian Khan

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

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. The monitoring activities carried out in the wetlands and selected stormwater ponds 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.



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 in 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, characterize the abundance of larvae (vector and non-vector species) and identify vector "hot spots". A vector "hot spot" is characterized as having at least 31 vector larvae per 10 sampling dips.

10.2 Methods

For 2010, monitoring started on May 31st and continued at three week intervals until the third week of August. WNV vector larval surveillance and monitoring was undertaken in 38 wetlands and 9 SWMPs across the Toronto Region (**Figure 19**). Each site was visited four times from May through August.

The mosquito larvae from each dip were counted and recorded. The larvae from 10 dips were then pooled and preserved in alcohol for identification using taxonomic keys.

Risk ranking was applied to each site for a given vector species based on the average number of vector larvae found per 10 dips (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 pertaining to site information, the number of vector and non-vector species found in wetlands and SWMPs, and the water quality parameters are available from 2003-2010. Data are stored in a MS Access Data Base (WNV Database Ver 2.7).

For 2010, 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. The results from the 2010 sampling were used to generate the Annual Report: *West Nile Virus Vector Mosquito Larval Monitoring and Surveillance – 2010*. In addition data from 2005 – 2009 were used to compile a five year report on the influence of different water quality parameters and aquatic vegetation on vector presence and abundance.

10.4 2010 Highlights

- In 2010 TRCA received eight standing water complaints, of which four were concerned with TRCA properties. None of the complaint site investigations resulted in larvicide application.
- The larval sampling yielded a record high of 9398 larvae. Record rainfall and dry periods were the factors contributing to the increased numbers of mosquito larvae sampled during the 2010 season.
- Within the wetlands 64.4% of the larvae found were vectors while the remaining 35.6% were non-vectors. Unlike the previous sampling years, the percentages of vectors species collected were higher in 2010. The reason for this increase was due to the increased number of *Aedes vexans* collected from the wetlands. *Culex territans* (non-vector) and *Aedes vexans* were the most commonly collected (34% each) mosquito species from the wetlands. *Culex pipiens* and *Culex restuans* the two key WNV vector species represented 19.7% and 3.8% of the larvae identified respectively.
- WNV risk ranking was undertaken for the five out of eight vector species (*Ae. vexans*, *An. punctipennis*, *Cx. pipiens*, *Cx. restuans* and *Oc. trivittatus*) found in the wetlands to determine vector “Hotspots” in 2010. In total four sites were ranked as “Hot spots” for *Aedes vexans* and two sites for *Culex pipiens*. Larvicide was only applied at one of the “Hot spots” (Claireville CA).
- Within SWMPs vector species comprised 77.8% while the non-vectors made up the remaining 13.2%. *Culex pipiens* was the predominant vector species found in SWMPs. L’Amaroux Park North Pond was a “Hotspot” for *Cx. pipiens*. This site is under management agreement with the City of Toronto and larvicide was applied by the City upon notification.
- In addition to the annual summaries, a five year data roll up and summary was carried out using the data collected from 2005-2009. The data was summarized to look at the effect of water quality and aquatic vegetation on WNV vector larval abundance in Toronto and Region wetlands and stormwater management ponds. The following conclusions were made from the outcome of the five year data analysis:
 - Wetlands support higher numbers of mosquito larvae and a higher species diversity than stormwater management ponds, however overall the percentage of WNV vector species in wetlands was lower compared to stormwater ponds;
 - Mosquito and WNV vector management in the SWMPs should include proper maintenance and vegetation control in order to prevent mosquito breeding since denser vegetation seems to lead to higher numbers of mosquito larvae in general, and;
 - Conductivity and total dissolved solids need to be monitored on a regular basis especially in the SWMPs since vector species prefer these conditions compared to conditions found in the wetlands.

- Recently, York University and the TRCA have partnered to use the data collected on WNV surveillance and monitoring to predict the impact of Climate change on vector population dynamics. In this regard, a presentation was made at York University's LAMPS (Laboratory for Mathematical Parallel Systems) weekly seminars about "Wetlands and West Nile virus: facts and fiction". This presentation was also featured at the Climate Consortium for Research Action and Integration (CC-RAI) and can be found at <http://www.climateconsortium.ca>.

Figure 19

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Scale: 1:250,000

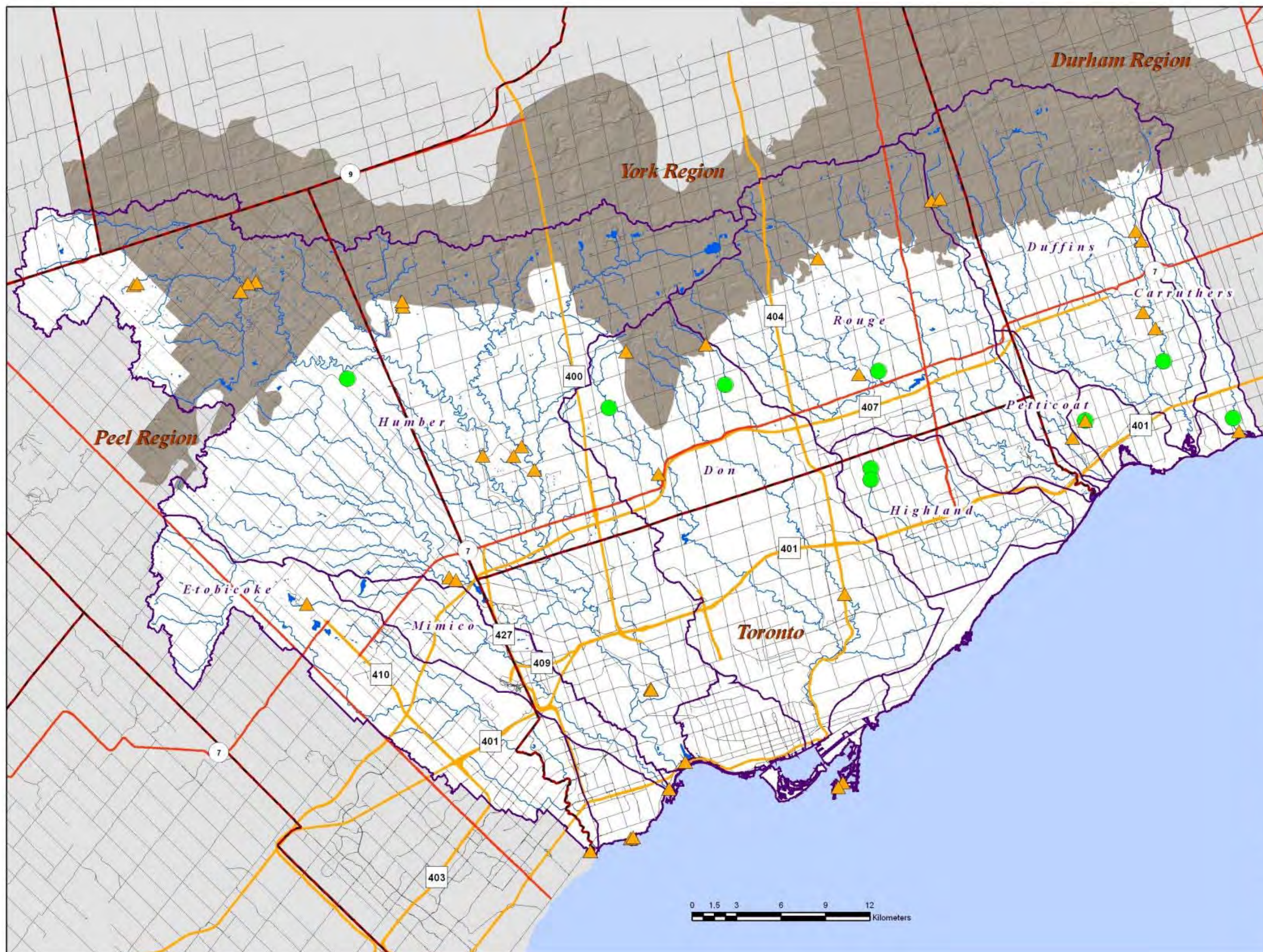
Legend

Habitat Type Monitored

- Stormwater Management Pond
- ▲ Wetland

- 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

11 Groundwater Quality and Quantity

Staff Lead: Jeff Vandenberg

Support Staff: Don Ford, Jehan Zeb, Andrew Taylor

Funding: Ministry of the Environment and TRCA

11.1 Background

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

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. As a program partner, the mandate of the TRCA 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 20**).

11.2 Methods

Each groundwater well in the program is equipped with a levellogger which is installed at least five metres below average standing water level. These loggers measure water depth and temperature every hour on the hour. There are currently 21 groundwater monitoring wells in the Toronto and Region Conservation Authority (TRCA) jurisdiction (**Figure 20**). Currently, 14 sites are equipped with telemetry equipment, which allows for remote downloading of data from the levelloggers. 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.



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) who use the data to characterize and improve the understanding of the hydrogeology of the Oak Ridges Moraine.

11.4 2010 Highlights

- The PGMN telemetry system was originally configured as an analog system, with 18 sites in TRCA's jurisdiction having telemetry installed. The telephone service provider, which had been moving away from analog signals to digital, discontinued the analog system entirely as of December 2008. Because of this change, additional site visits were necessary in 2010 to download data manually. To date the MOE has been purchasing new digital telemetry equipment as funding becomes available. This year an additional 10 sites were converted to the digital system. This brings the number of sites with telemetry back to 14. Additional sites are expected to be upgraded to the digital system as funding becomes available.
- In 2010 the MOE wanted to address the problem of logger slippage as part of the recommendations for the PGMN program. When loggers were being removed from the well during downloading or maintenance it was noted that minute changes in depth were occurring which was affecting depth readings over time. To prevent logger slippage, TRCA started installing downrigger cables of

specific length to each logger in 2010 and the installation is expected to be finished early 2011 during the first maintenance run.

- 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. A water sample was collected for isotopic analysis by the contractor at the five wells sampled in conjunction with the YPDT-CAMC program and submitted on TRCA's behalf to contribute to this effort.
- The water level data collected indicates that groundwater level fluctuations have been typically less than 1 m since 2003. These fluctuations are not considered significant and indicate stable groundwater conditions. The only exceptions are rising water levels in two PGMN wells in the Heart Lake Conservation Area in Brampton. Groundwater levels in these two wells have risen 2 to 4 metres since 2005. TRCA staff are assessing this situation with staff from the City of Brampton and the Region of Peel to determine if the rising groundwater poses a risk to local infrastructure.
- Baseline groundwater quality was assessed for a broad list of parameters included general chemistry as well as a full suite of organic parameters and nutrients. In following years, selected wells were assessed for a reduced set of parameters including general chemistry and metals. In 2010, 15 of the 21 wells were assessed. Concentrations of all measured parameters have been well below the Ontario Drinking Water Standards (ODWS) since the program began. The only potential water quality concern is the detection of nitrate at 7 mg/L in a shallow PGMN well at Milne Park, in Markham. Although this concentration is below the ODWS of 10 mg/L, the well is directly down gradient of a subdivision and is likely affected by local application of lawn fertilizers. Another well in Caledon East is likely impacted due to the same reason, but at a lower concentration of 3 mg/L.

Figure 20

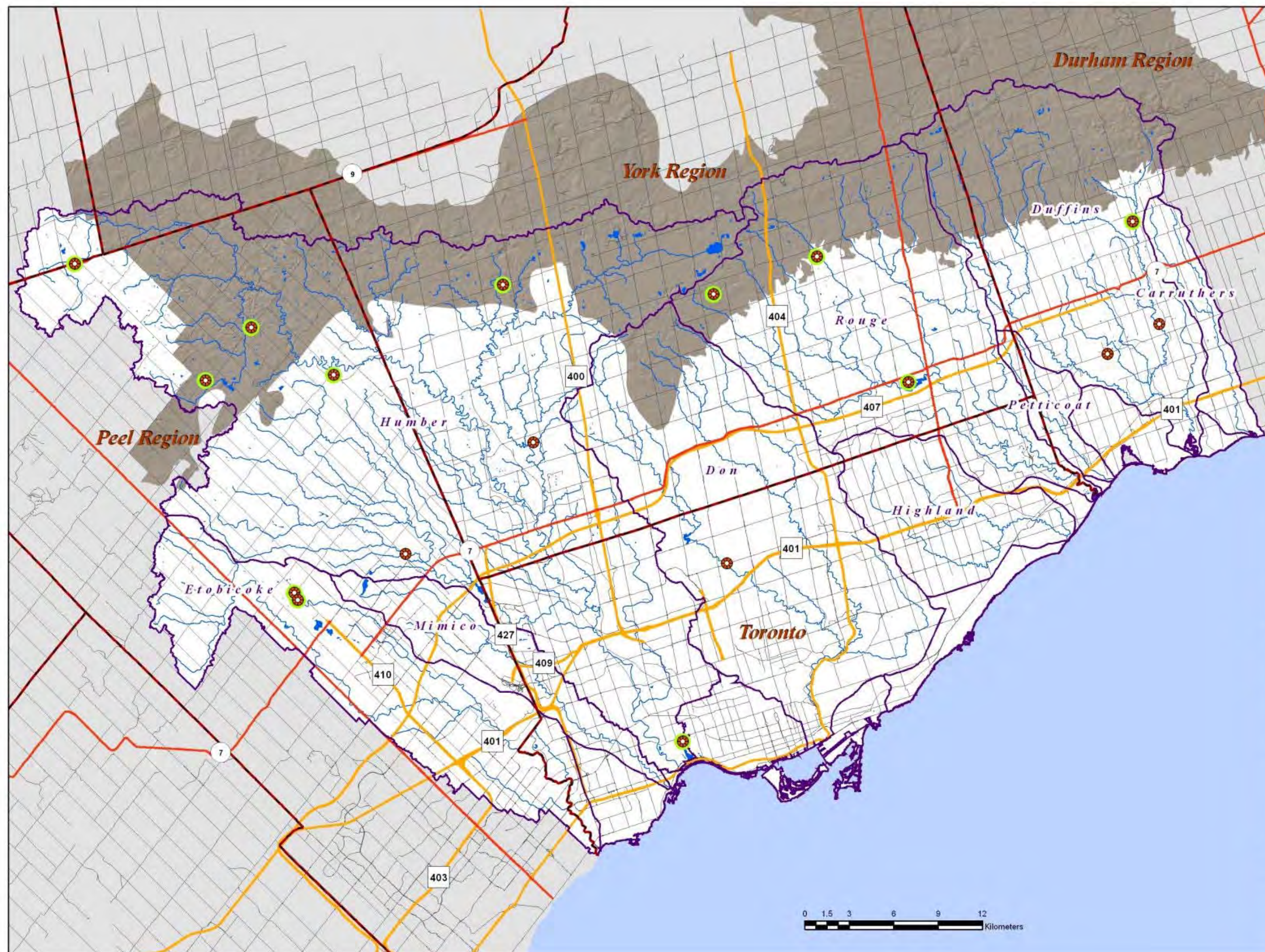
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Scale: 1:250,000

Legend

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

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12 Water Quantity - Stream Flow, Precipitation and Snow Course

Staff Lead: Derek Smith

Support Staff: Bill Kerr, Craig Mitchell, Lisa Moore, Jamie Duncan, Rita Lucero, Matt Derro, Paul Greck, Greg Dillane.

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 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 31 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 purposes and 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 2010, flow and water level data was collected at 34 TRCA stream gauges and 21 Water Survey Canada (WSC) gauges (**Figure 24**). 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 34 TRCA stream gauges, 14 stations are part of the TRCA Real Time (RT) Flood Warning Network, of which five are used to observe dam reservoir levels and storage (**Figure 21**). This network is a web accessible system that posts precipitation, water level, alarms, video, and stream discharge data in real time in order to depict current watershed flood conditions. Additional RWMP stream gauges will eventually be incorporated into the RT network as upgrades to the network infrastructure continues.



Figure 21. Various RT stream gauge stations (from left) Taylor Massey Creek, McFall Dam, and the real-time gauging home page

12.2.2 Precipitation (Rainfall and Snowfall)

In 2010, precipitation data was collected from 31 stations (**Figure 25**). The precipitation network consists of 25 three-season tipping bucket gauges and 6, four-season gauges (3 weigh gauges and 3 heated tipping buckets) (**Figure 22**). Of the 31 stations, 13 are telemetered; 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 tipping bucket 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 (600 mm of precipitation) and needs to be emptied about every three months. Each station is calibrated twice a year in the spring and fall.

Tipping bucket data is recorded as counts per 5 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 22. Various precipitation gauges including both “stand alone” and RT systems. From left to right: three season “stand-alone” rain gauge, a four season RT weight gauge with windscreen, and a four season heated rain gauge.

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 25**). They include:

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

Each snow course is visited twice a month during the winter season (approx. the 1st and 15th day of each month). At each snow course, ten samples spaced 30 m apart are taken along a 270 m 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 23**).



Figure 23. 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 information 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 ongoing 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 and it is ultimately 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 2010 Highlights

- The 2nd Annual Streamflow Monitoring Techniques Course was offered by TRCA Hydrometrics staff on June 3rd, 2010 at Albion Hills Conservation Area. Attendees included staff from other Conservation Authorities, Non-governmental Organizations, environmental consultants, students, and municipalities. The one day course presented information on: streamflow measurement theory and methodologies, types of monitoring equipment, site selection and considerations, linking stream flow to water quality loadings, and a field component applying the aforementioned tools.
- Updates/modifications to the stream and precipitation gauge networks in 2010 included the following:
 - A new stream gauge was installed on Wilket Creek (#STRM092), in Edwards Gardens, Toronto.
 - The Yonge at York Mills (#PRECIP110 Hoggs Hollow) and Lawrence at Weston Road (#PRECIP117) precipitation gauges were permanently closed and removed due to tree line interference.
 - King Road and Albion/Vaughan Sideroad (#PRECIP092 Cold Creek) precipitation gauge was upgraded to four season capability via a heated tipping bucket.
 - Ajax works yard precipitation gauge (#PRECIP84) was permanently closed and removed at the end of 2010 monitoring season. It was relocated approximately one kilometer away alongside the Bayly MET station (#MET007). The gauge was moved to increase field productivity.
 - All ground level precipitation gauge pedestals/mounts upgraded to aluminum in order to increase sensor stability during high winds.
 - Clairville Dam (#STRM012) bubbler system (level) was upgraded to ultrasonic “out of water” technology to monitor dam reservoir level and the presence of ice.
 - All 2010 rating curve development contracted by OHS completed in winter 2011.
 - A RT video camera was installed at Todmorden stream gauge, on the Don River, Toronto. Camera is regularly used for flood warning initiatives.
 - The Dufferin Reservoir and Albion Hills Conservation Area precipitation gauges were upgraded to a four season precipitation weight gauge.

- The Boyd Field Centre rain gauge (#PRECIP044) was permanently closed and removed. In its place, a new three season precipitation gauge was installed at TRCA's Restoration Services office less than 300 m away.
- Water quantity data collected by the TRCA's stream and precipitation gauging stations are being used for the City of Toronto's Wet Weather Flow Monitoring study. Moreover, in 2010 numerous requests for stream flow, precipitation, and snowcourse data collected by the TRCA have been made by all levels of government, other Conservation Authorities, educational institutions, private industry (e.g. consultants), and various students. Recently, TRCA winter precipitation data was used in an Environment Canada case study to calibrate the King City radar system.
- The City of Toronto has asked the TRCA to install a RT stream gauge on the Don River near the Keating Channel to improve flood warning initiatives for the flood prone lower Don Valley Parkway. The sensor will use radar technology which permits the positioning of the sensor out of water and detect the presence of ice and water level. TRCA staff working to install the gauge in the spring of 2011.
- The TRCA Flood Monitoring and RT Gauging website continues to raise considerable interest by advancing environmental monitoring techniques and streamlining field activities. In 2010, fisheries staff identified the need for RT water temperature data to assist them with directing field activities and collect data without regular downloading of instrumentation. A pilot demonstration was installed at both the Todmorden (#STRM002) and McFall Dam (#STRM120) stream gauges and has been working well. Future installations at other RT stations have been proposed.
- Two new RT stream gauges were installed on Fletchers Creek in Mississauga, as part of a partnership with the Credit Valley Conservation Authority (CVCA).
- Due to the vast amount and complexity of the data collected by the hydrometrics networks (meteorological, stream, precipitation, snow course), a bi-annual report summarizing jurisdictional observations collected by the Hydrometrics program is expected to coincide with the RWMP report. The first draft is almost complete and is expected to be published in the summer of 2011.
- TRCA Hydrometrics staff field tested the new Sontek River Surveyor system to assess its potential to streamline stage-discharge curve development at TRCA stream gauges as well as increase staff safety when working near water during high flows.

Figure 24

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Legend

Stream Flow Gauge

Operator

- TRCA
- Water Survey Canada
- Real Time Gauge

Reservoir Level

- Dam Reservoir Level

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

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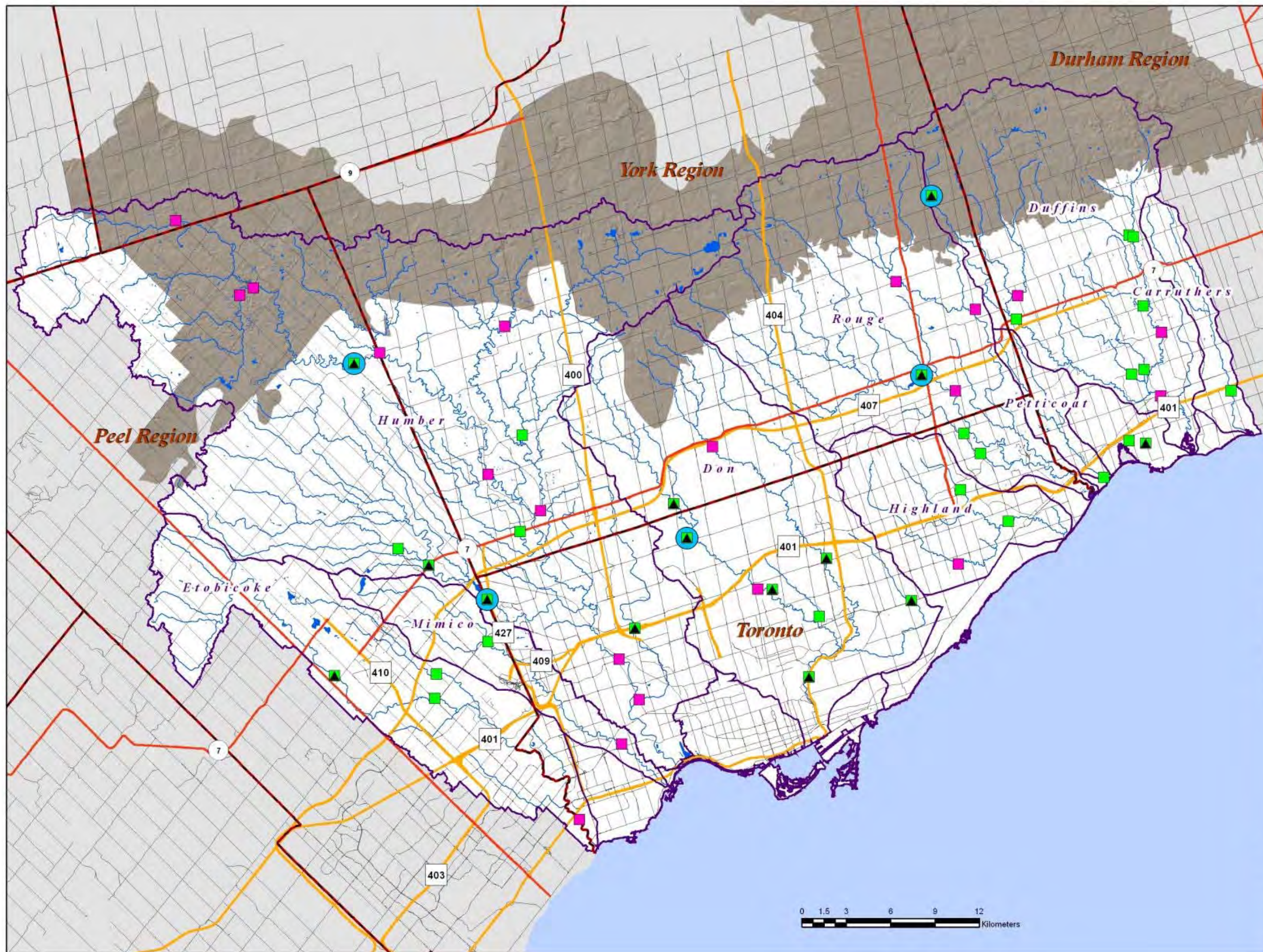


Figure 25

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Scale: 1:250,000

Legend

Precipitation Gauges

- 3-season
- 4-season
- snow course

● Real Time Gauge

X Call In Gauge

Regional Boundary

Expressway/Highway

Freeway

Major Road

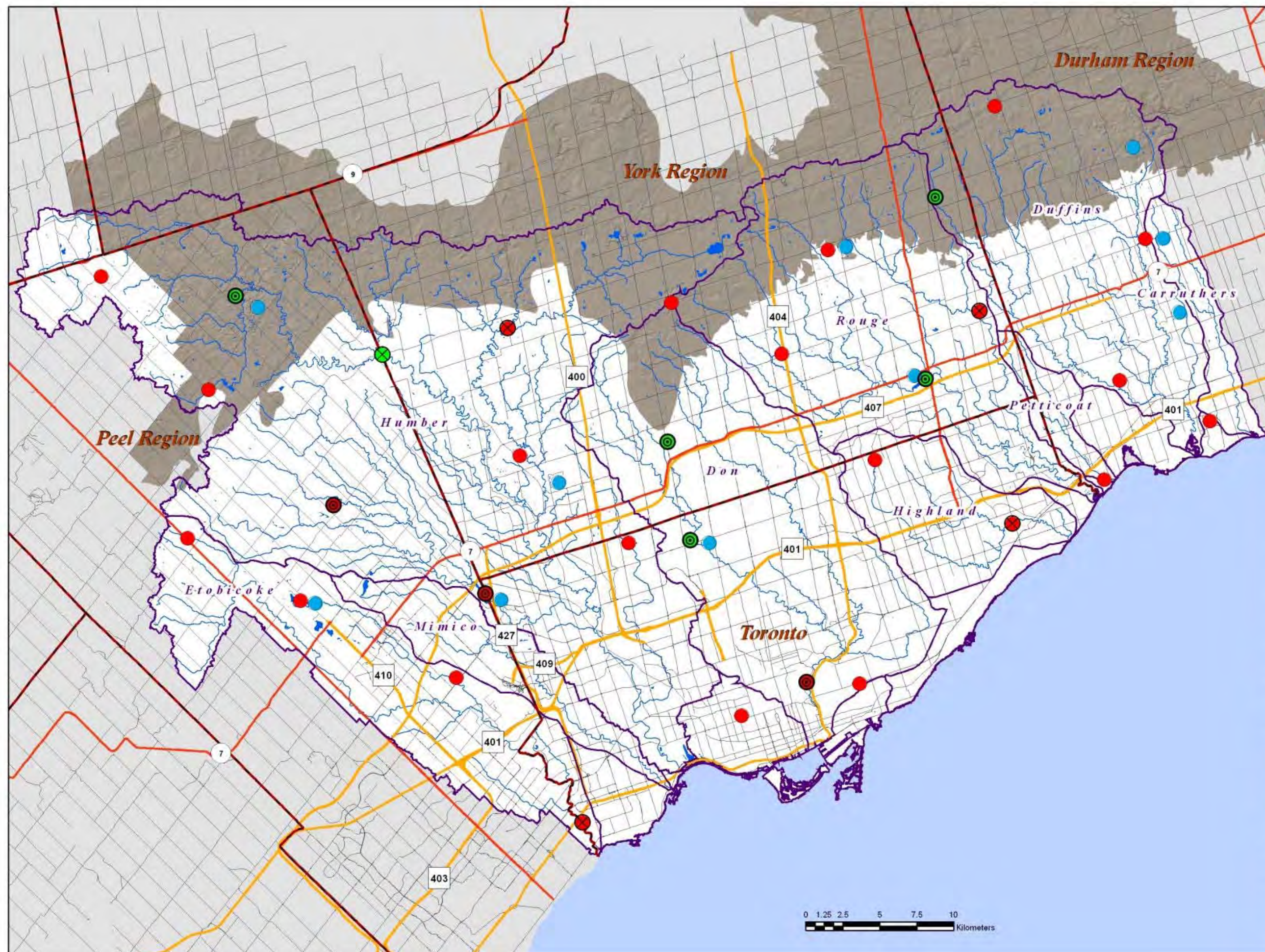
Watercourses/Rivers

TRCA Watersheds

Waterbodies

Oak Ridges Moraine

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13 Water Quantity - Baseflow

Staff Lead: Jamie Duncan and Rita Lucero

Support Staff: Gerrit Atkinson, Johanna Perz and Terri Bocz

Funding: 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 every five to seven years in order to obtain provide a higher resolution of ground and surface water interactions.

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 protocol 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 26**). 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.

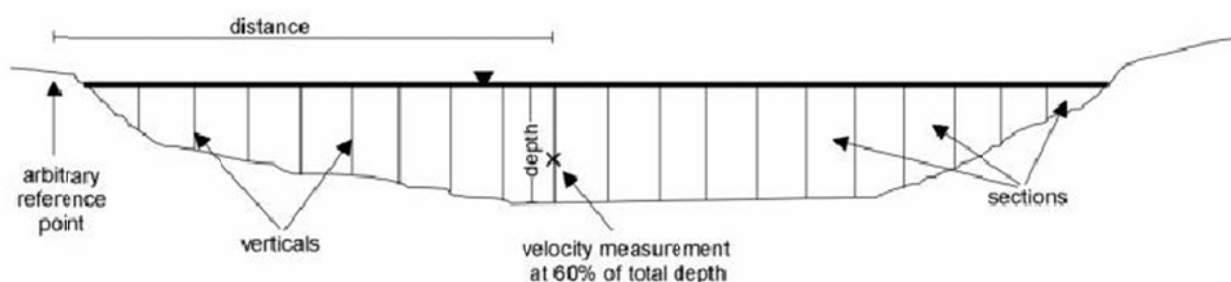


Figure 26. Cross section of a stream – baseflow transect

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 2010 summer was focused on extensive watershed wide sampling in the Rouge and Petticoat watersheds. A total of 185 transect measurements were conducted in 2010, which included 59 of the 68 indicator stations (**Figure 28**). Some sites were measured more than once due to special circumstances. The measurements were conducted from the end of May to September with the help of a crew leader and two summer student interns from the University of Toronto.

13.4 2010 Highlights

- A Streamflow Monitoring Techniques Course was offered by TRCA Hydrometrics staff in June of 2010 for the second consecutive year time at Albion Hills Conservation Area. The course was attended by staff from other Conservation Authorities, Non-governmental Organizations, 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.
- In spite of being one of the wettest summers in recent record, 2010 low flows measured at the outlets of TRCA's watersheds decreased from 4% (Rouge) to 46% (Etobicoke Creek) from 2009 (Figure 27 and Table 7). This reduction is being attributed to a 42% reduction in precipitation during the winter and spring seasons. This combined with the distribution and intensity of rainfall during the summer months meant that more water was flowing quickly through the system and not being "recharged". This has direct implication to the climate change predictions of frequent and intense precipitation events, and the resulting impact on the regions groundwater and baseflow resources.

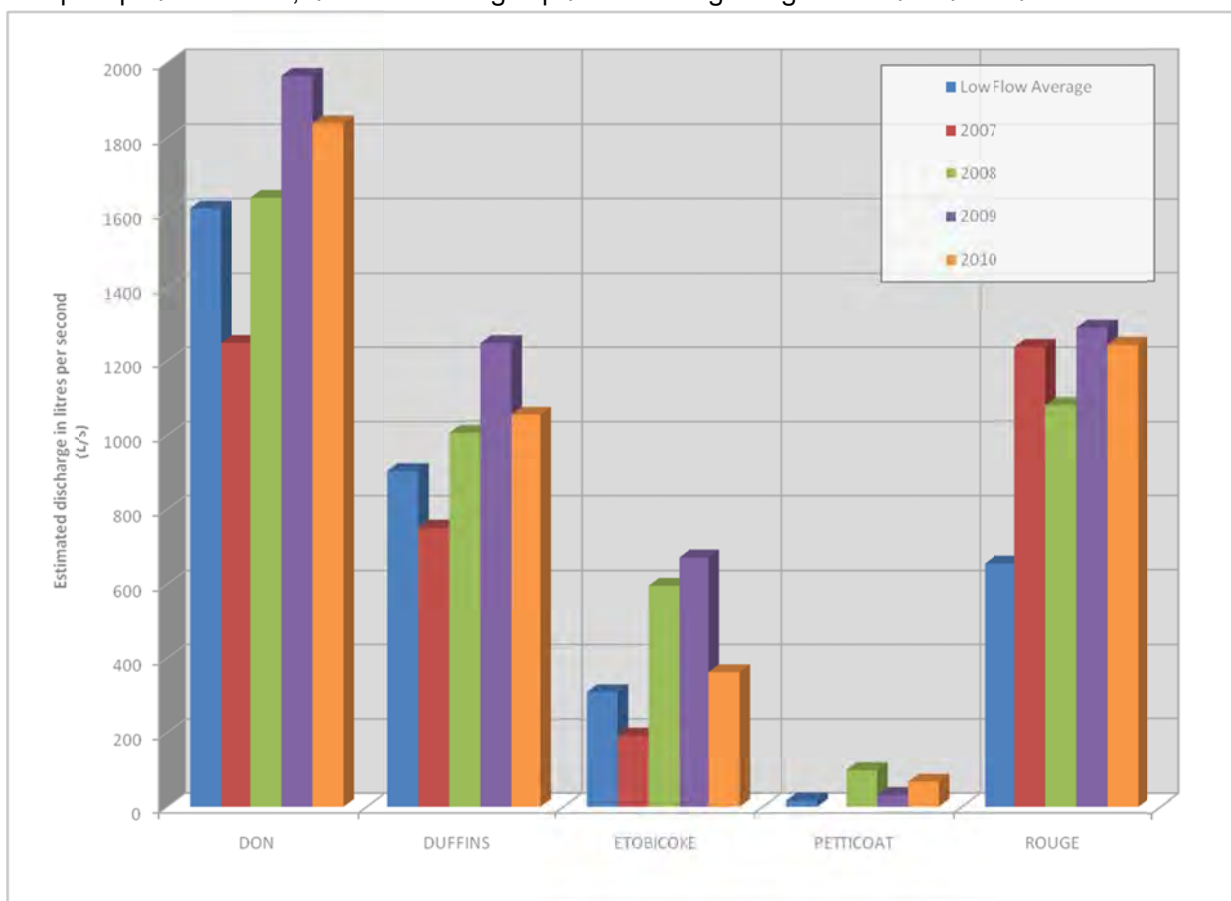


Figure 27. Total estimated baseflow outflow by watershed from in Litres per second (L/s)

Table 7. Percent change in measured 2010 low flow watershed outflows

	Watershed	2010 Watershed Outflows (L/s)	% Change from 2009 Low Flow	% Change from 2008 Low Flow
Don		1,838	-6%	12%
Duffins		1,056	-15%	5%
Etobicoke		363	-46%	-39%
Petticoat		67	>100%	-32%
Rouge		1,244	-4%	15%

Figure 28

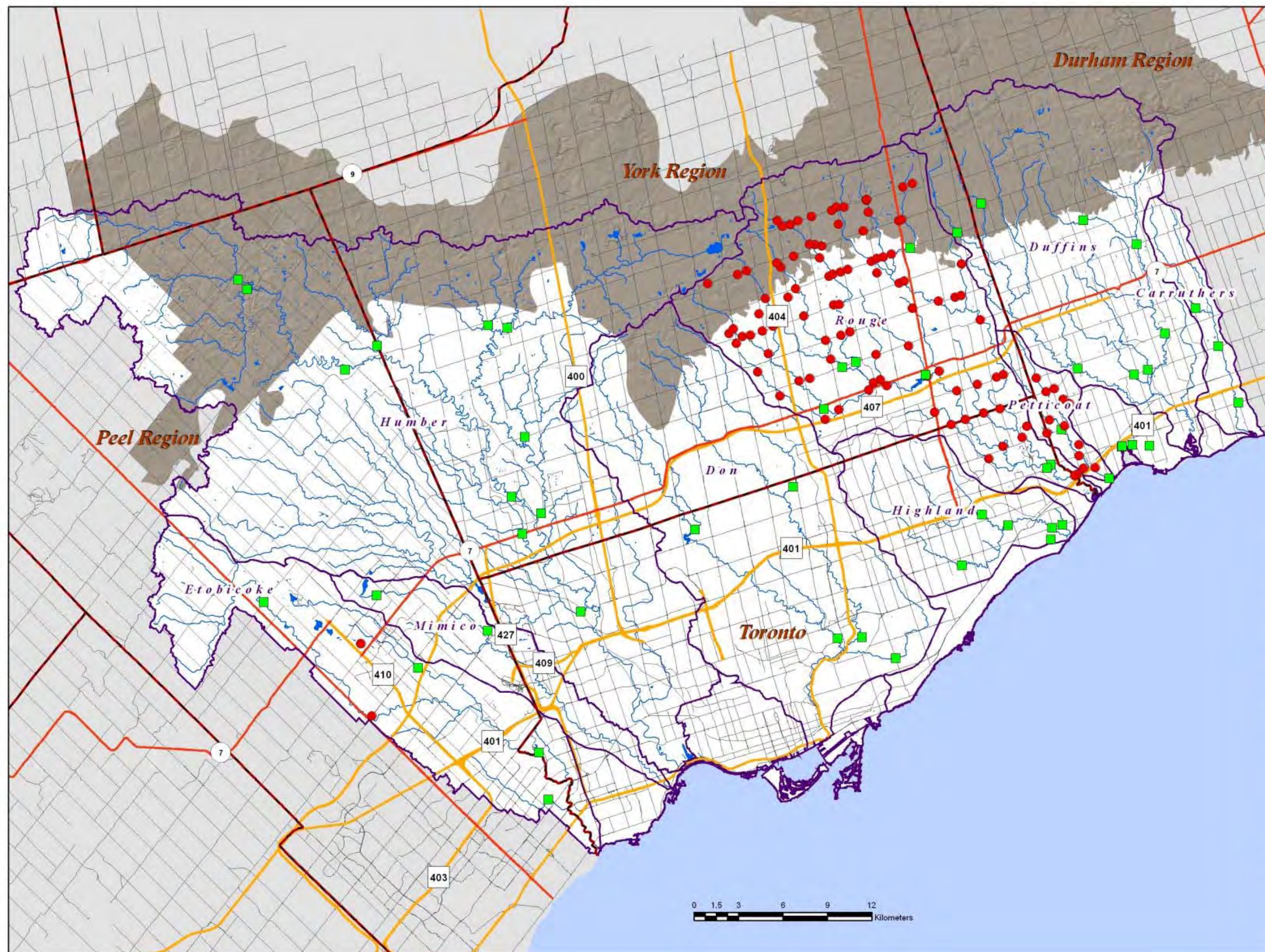
TORONTO AND REGION
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Scale: 1:250,000

Legend

- Indicator Station
- 2010 Baseflow Monitoring Site
- 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



14 Meteorological (Climate Monitoring)

Staff Lead: Derek Smith

Support Staff: Craig Mitchell, Bill Kerr, Rita Lucero, Jamie Duncan and Greg Dillane

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

14.1 Background

No longer just a buzz word, *climate change* has become a national issue for governments and is 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 are 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 is well known 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 29**).

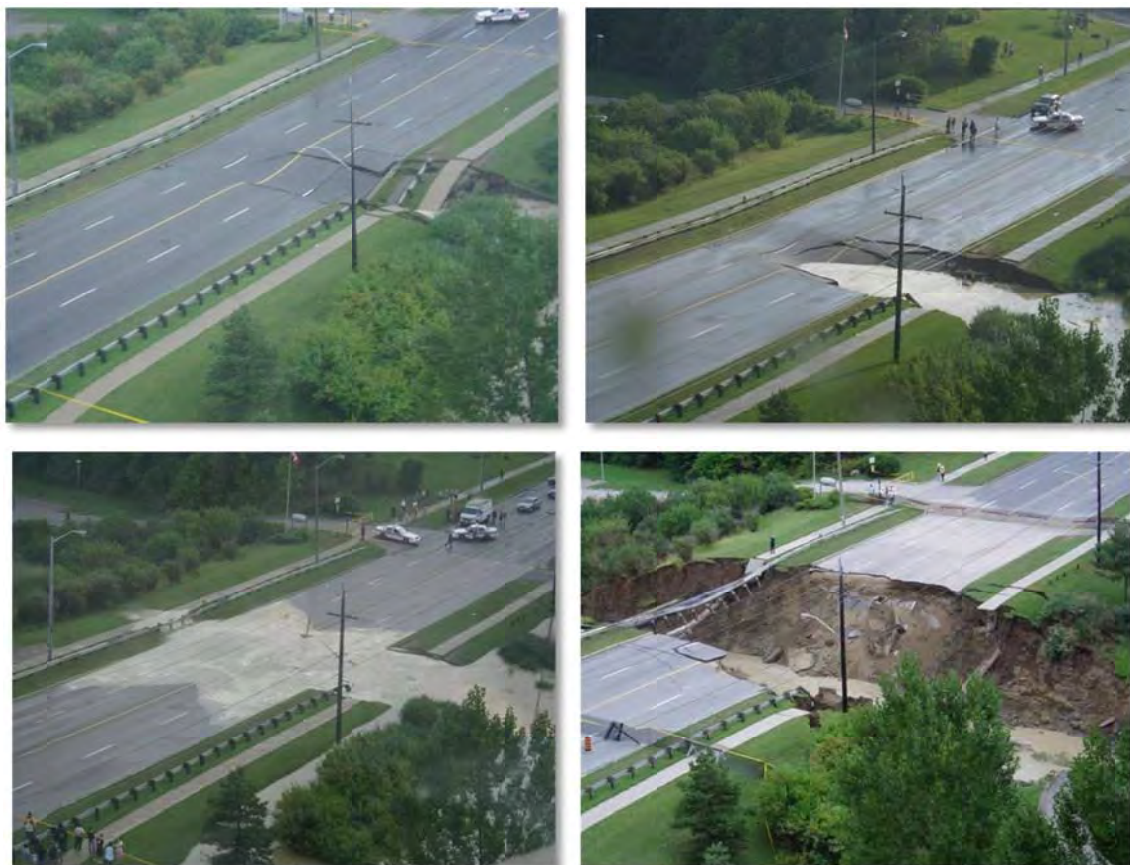


Figure 29. Finch Avenue culvert failure August 19th, 2005 Toronto, Ontario, >125mm in 1 hour.

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 33**).

Currently, the MET network consists of a variety of sensory devices including generic climate stations, evaporation pans, and speciality instrumentation (designed by York University).

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 are expected to be installed (**Figure 30**).

Each station is fully automated and requires little human intervention. Various meteorological and land attributes are recorded every five or fifteen minutes 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 30. 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. Evaporation is measured using a class A evaporation pan and stilling well (**Figure 31**). 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 945 L 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.



Figure 31. Automated evaporation pans located at Glenn Haffey Conservation Area (left) and Kortright Conservation Area (right). Glenn Haffey station depicting operational setup and Kortright station prior to spring deployment.

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 32**). Because of the complexity of ET monitoring, York University maintain the BREB system and use TRCA MET data to determine localized ET. 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 32. 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 biologists with the intent to correlate air temperature fluctuations with tributary water temperatures (**Figure 33**). 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 Natural Resources Canada). The data are entered electronically into spreadsheet format and are stored on the TRCA network. Ultimately the data is uploaded to the TRCA Envirobase and Environment Canada's Inventory of Climate Observing Networks in Ontario (ICONO). 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 connected to the RT network will significantly advance flood warning bulletins.

14.4 2010 Highlights

- All MET stations continued to operate normally in 2010.
- Both the Kortright and Downsview ET monitoring stations continue to operate normally with help from York University.
- York University published its third ET monitoring report with the most recent titled "*Evaporation Comparison between the Kortright Conservation Area and Downsview Park: April to November, 2010*". The 2010 paper continued to summarize the results of the BREB system and ET observations, however, York University has expanded their research objectives to try and simplify the complexity of ET monitoring by utilizing evaporation pan information. A third evaporation pan system is proposed to be installed alongside the Downsview Park BREB station in order to further investigate findings found at the Kortright study area.
- York University and the TRCA have partnered with the Climate Consortium for Research Action and Integration (CC-RAI) in aims to accelerate regional action on climate change by fostering high-quality regional climate research, building capacity through training, and acting as a catalyst for collaborative action (CCRAI 2011). Recently, the TRCA/York University ET study was featured on

the CCRAI website titled "*Where Does the Water Go? Evapotranspiration in Toronto*" and can be found at <http://www.climateconsortium.ca>.

- 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.
- Continued correspondence with Environment Canada has unveiled data sharing and partnership interest for local climate studies needed for the 2015 Pan Am Games.
- Continued air temperature monitoring for TRCA aquatic biology program in 2010.
- Relative humidity and air temperature is now being monitored at the restoration services building in order to monitor local farming growing conditions at the request of restoration services staff.
- Due to the vast amount and complexity of the data collected by the hydrometrics networks (MET, stream, precipitation, snow course), a bi-annual report summarizing jurisdictional observations collected by the Hydrometrics program is expected to coincide with the RWMP report. The first draft is almost complete is expected to be publish in the summer of 2011.

Figure 33



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Scale: 1:250,000

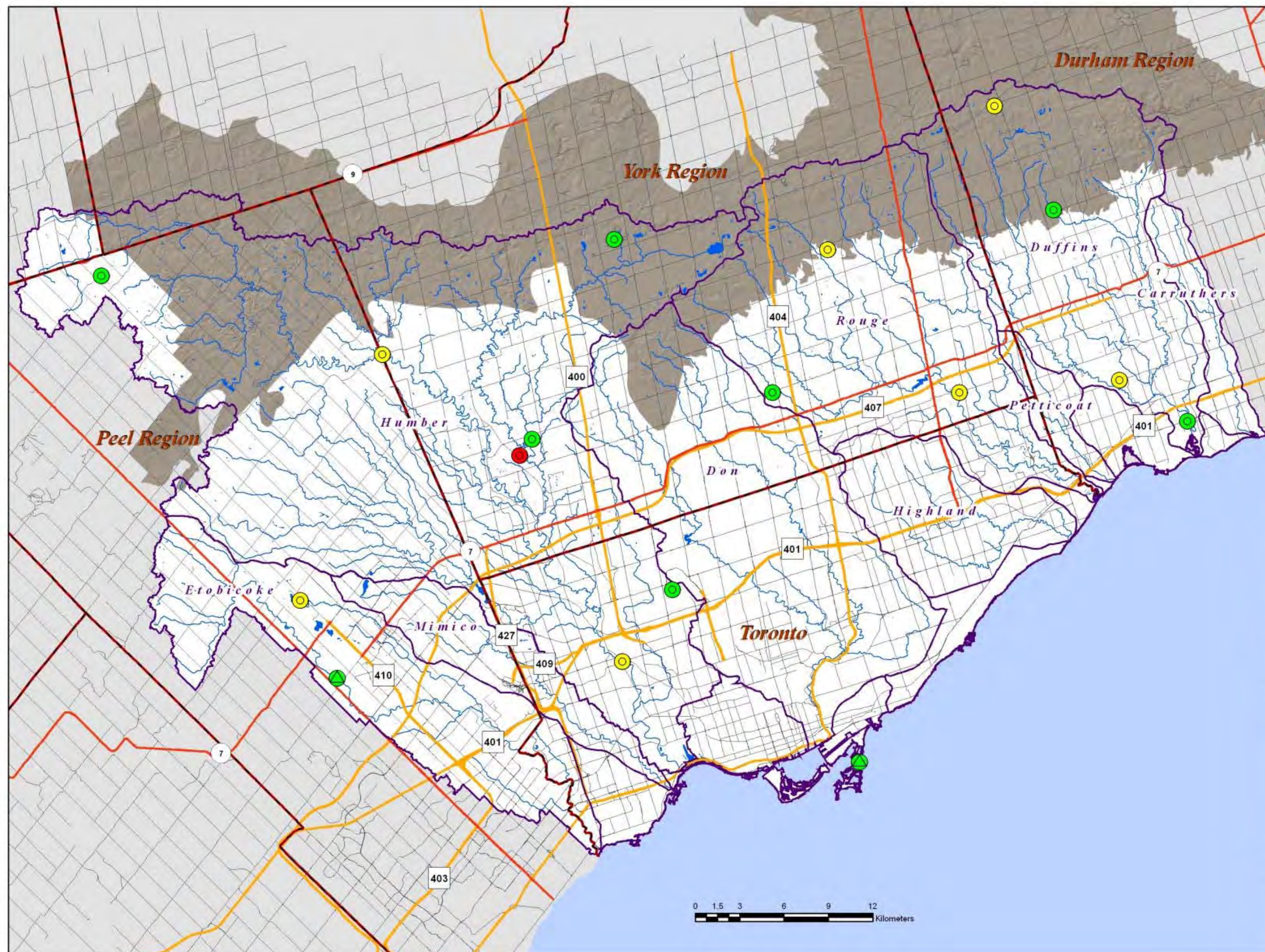
Legend

Meteorological Monitoring Stations

-  open
-  proposed
-  climate
-  air temp only
-  air temp/relative humidity

-  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

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Catherine Polcz
Annette Lambert
Daniel Morodvanschi
Damian Khan
Chris Cummings
Ellen Fanning
Lori Knight
Sarah Scharfenberg
Deborah Silver
Mark Szonda

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, staff in the Watershed Monitoring and Reporting Section conducted several workshops for both internal and external participants.

15.2.1 Conducted by TRCA Staff

- Terrestrial Volunteer Monitoring Seasonal Training conducted during November/December 2009, March 2010, May 2010 and September 2010 with a total of 126 attendees (Theresa McKenzie)
- WNV vector mosquito larvae Identification Course conducted for 19 people (Durham, Hamilton and Halton Health Unit staff), during April – May at Boyd Office (Thilaka Krishnaraj)
- Algae Bioassessment Protocol sample collection training conducted for nine internal TRCA staff, in July 2010 at Boyd office (Cheryl Goncalves)

- Second Annual TRCA Stream Flow Monitoring Course, June 3rd, 2010, Albion Hills Conservation Area (Derek Smith, Jamie Duncan, Rita Lucero).
- Class 2 Backpack Crew Leader Electrofishing Course conducted for 20 people (6 internal, 14 external), on June 2 2010 at Boyd Office (Jeff Vandenberg, Nelson Amaral, Scott Jarvie, Lindsay Code)
- Ontario Stream Assessment Protocol Training course – Durham College, Oshawa. June 7-11, 2010. (Scott Jarvie – course administration)

15.2.2 Attended by TRCA Staff

- Ontario Benthos Biomonitoring Network (OBBN) workshop. February 4, 2010 (Thilaka Krishnaraj and Angela Wallace)
- 2010 MOE Monitoring Network Partners Workshop PWQMN workshop. February 3, 2010 (Nelson Amaral)
- Living Plants, Living Communities: sustainable horticulture, Royal Botanical Gardens. February 2010 (Gavin Miller)
- Social Marketing and Chelonian Sustainability Workshop: Changing Minds to Change the Fate of Turtles, Toronto Zoo. March 2010 (Paul Prior).
- York University Incubation Day of Excellence: Presentations on WNV modelling and forecasting, York University, Downsview. December 1, 2010. (Thilaka Krishnaraj)
- 45th Central Canadian Symposium on Water Quality Research, Burlington. February 22, 23 2010 (Cheryl Goncalves).
- Campbell Scientific Advanced Programming and Logic for Meteorological Monitoring Stations, Black Creek Pioneer Village. June 10-12, 2010 (Derek Smith).
- A.D. Latornell Conservation Symposium. Conservation Ontario. November 17-19, 2010. (Scott Jarvie, Gavin Miller, Paul Prior, and Natasha Gonsalves)
- American Fisheries Society Ontario Chapter Annual Meeting. March 4-6, 2010. (Scott Jarvie)
- Communicating the Science Workshop. Conservation Ontario. May 11-12, 2010 (Scott Jarvie)
- International Association of Great Lakes Research (IAGLR). May 17-21, 2010 (Scott Jarvie and Claire Holeyton)
- Aquatic Toxicity Workshop. Ministry of the Environment. October 6, 2010 (Scott Jarvie)

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

- International Association on Great Lakes Research. *Long-term Water Quality Monitoring: Trends in the Toronto and Region AOC*. Poster presentation. April 2010 (Claire Holeyton)
- GTA Conservation Authorities Watershed Monitoring Forum, April 2010:
 - TRCA Terrestrial Volunteer Monitoring Program Highlights and Invasive Species Monitoring Results (Theresa McKenzie)
 - Terrestrial Fixed Plot Monitoring: Measurement, Observation, Action! (Natasha Gonsalves).
 - Multi-Scaled Data Use in an Urbanizing Region (Sue Hayes).
 - Wetlands and West Nile Virus: facts and fiction (Thilaka Krishnaraj)
 - Algae Biomonitoring: when inverts are not enough (Cheryl Goncalves)
 - The Value of Long-term Monitoring Data (Scott Jarvie)
 - TRCA's Regional Watershed Monitoring Program (Scott Jarvie)
 - Multiscale Analysis and Interpretation of Low Flows in TRCA Watersheds (Jamie Duncan)
- TRCA – Lunch & Learn. Role of Amphibians in Terrestrial Ecosystems. April 2010 (Sue Hayes).
- A.D. Latornell Conservation Symposium. Green Roofs for Urban Biodiversity. November 2010 (Gavin Miller)
- York University – LAMPs Weekly seminar: Wetlands and West Nile Virus: facts and fiction November 22, 2010 (Thilaka Krishnaraj)
- Rouge Park Natural Heritage Committee Meeting. Water Quality Monitoring and Trends in Toronto Region Streams. October 20, 2010 (Scott Jarvie)
- What is a "SMART"? American Fisheries Society – Ontario Chapter Annual Meeting March 2010. (Scott Jarvie)

15.3.2 Reports and Publications

- 2009 Surface Water Quality Report. March 2010.
- 2009 Bathurst Glen Golf Course Assessment Report. February 2010.
- Terrestrial Biological Inventory and Assessments
 - Maple Nature Reserve. March 2010
 - Black Creek Pioneer Village. June 2010
 - Beechwood Wetland and Cottonwood Flats. December 2010
 - Bartley Smith Greenway (Section North of Jacob Keffer). December 2010
 - Teston/Pine Valley. March 2010
 - Mimico Waterfront Park. May 2010
 - East Duffins Headwaters. July 2010
 - Petticoat Creek CA. September 2010.
 - West Gormley Lands. March 2010.
 - Natural Channel Design: 5 Year Progress Report. November 2010.
- Ontario Power Generation: Terrestrial Long-term Monitoring Project (Year 1). March 2010.
- Caledon East: Terrestrial Long-term Monitoring Project (Year 1). February 2010.
- Annual Report: West Nile Virus Vector Mosquito larval Monitoring and Surveillance- 2009.
- 2009 Algae Bioassessment Summary Reports

- Ausable Bayfield Conservation Authority. October 2010.
- Cataraqui River Conservation Authority. October 2010
- Credit Valley Conservation. October 2010
- Nottawasaga Valley Conservation Authority. October 2010
- Saugeen Valley Conservation Authority. October 2010
- Poster – Long-term Water Quality Monitoring: Trends in the Toronto and Region AOC. For International Association for Great Lakes Research Conference May 17-21, 2010.

15.4 Committees

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

- Database Working Group – Toronto and Region Conservation (Scott Jarvie, Angela Wallace, Nelson Amaral)
- Southern Ontario Stream Monitoring and Research Team (SOSMART) (Scott Jarvie)
- Southern Ontario Conservation Authorities Terrestrial Monitoring Network – Toronto & Region Conservation, Conservation Halton, Credit Valley Conservation, Central Lake Ontario Conservation (Theresa McKenzie)
- Ontario Ministry of Natural Resources Ecological Land Classification Update Technical Team (Gavin Miller)
- City of Toronto Biodiversity Series: Reptiles and Amphibians of Toronto Guide Production Team (Paul Prior)
- 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 East Staff Steering Committee – Toronto and Region Conservation Authority (Sue Hayes)
- Durham Regional Health WNV Committee meeting, Whitby, March 24, 2010 (Thilaka Krishnaraj)
- York Regional Health WNV Committee meeting, Aurora, March 18, 2010 (Thilaka Krishnaraj)
- Southern Ontario Stream Monitoring and Research Team (SOSMART). (Scott Jarvie)
- Conservation Ontario Watershed Report Card – Technical Working Group
- York Region Low Water Response Team – York Region (Jamie Duncan and Rita Lucero)

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Appendix A

Appendix A. 2010 Regional Watershed Monitoring Activities by Watershed

		Etobicoke	Mimico	Humber	Don	Highland	Rouge	Petticoat	Duffins	Carruthers	Other¹	Total
Regional Watershed Monitoring Program	Fish Species & Aquatic Habitat	13	0	35	2	4	6	0	4	0	0	64
	Algae Biomonitoring	2	1	12	5	4	5	2	8	0	0	39
	Benthic Invertebrates	13	5	37	24	14	26	4	26	3	4	156
	Fluvial Geomorphology	10	5	35	0	0	0	0	0	0	0	50
	West Nile Virus Monitoring	2	0	17	6	2	3	1	7	2	7	47
	Surface Water Quality	3	2	11	5	1	7	1	6	1	1	38
	Baseflow	7	2	11	5	6	100	14	8	3	4	160
	Stream Flow	3	1	7	7	2	3	1	6	1	2	33
	Precipitation	4	0	9	5	2	4	1	5	0	1	31
	Snow	1	0	3	1	0	0	2	3	0	0	10
	Groundwater Quality & Quantity	2	0	9	1	0	3	0	6	0	0	21
	Terrestrial Natural Heritage²	77	0	500	265	0	380	11	327	0	0	1560
	Terrestrial Volunteer Monitoring	5	1	20	8	2	7	1	7	1	3	55
	Meteorological (Climate Monitoring)³	1	0	7	0	0	3	0	4	0	0	15
	Water Temperature	14	0	38	0	0	0	0	8	0	0	60

¹Other minor watersheds including tributaries of Frenchman's Bay and Toronto Waterfront

²Italicized numbers are the number of hectares monitored

³Includes both meteorological stations and "stand alone" air temperature stations

Appendix B

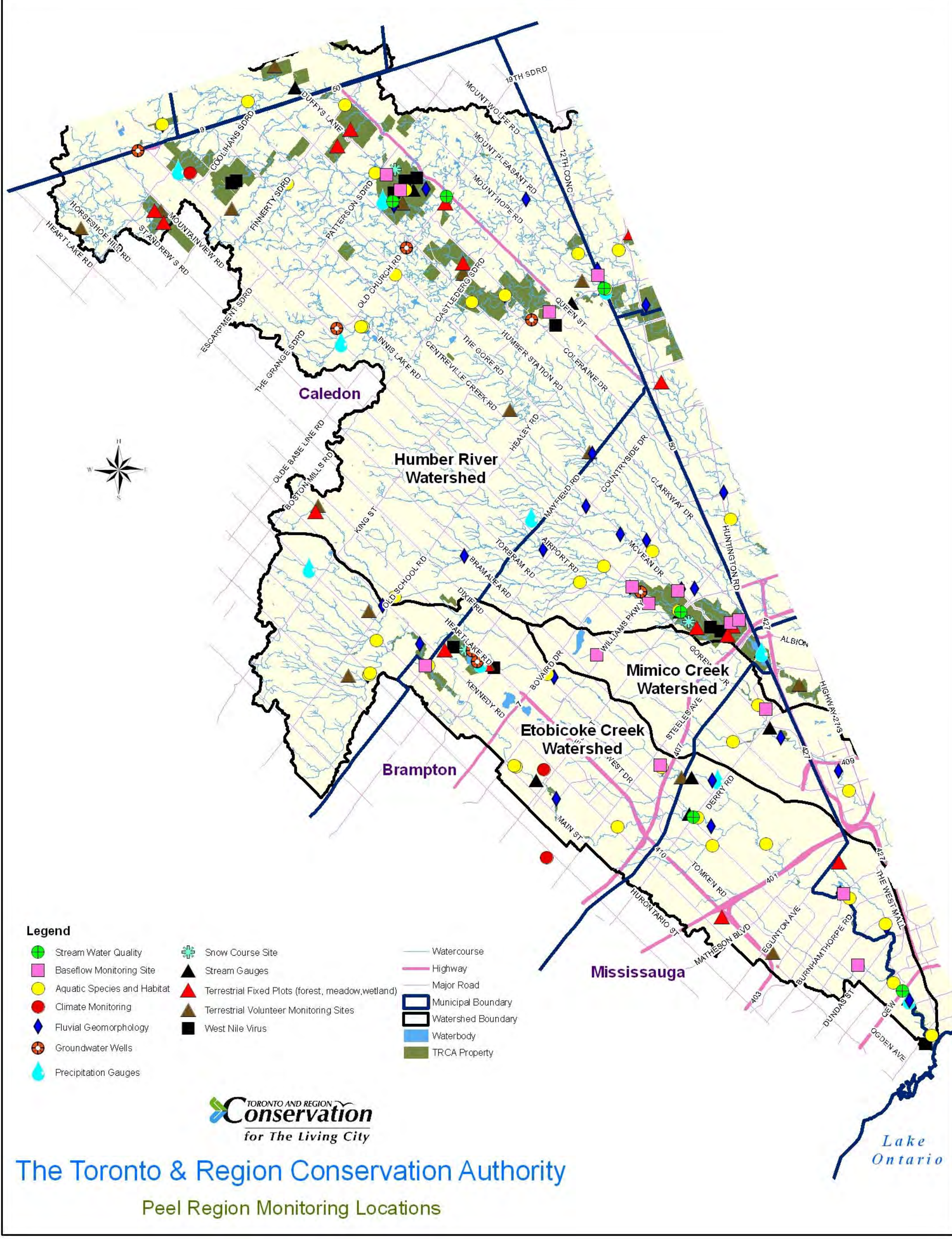
Appendix B. 2010 Regional Watershed Monitoring Activities by Region

		Durham	Peel	Toronto	York	Other ¹	Total
Regional Watershed Monitoring Program	Fish Species & Aquatic Habitat	4	24	15	19	2	64
	Algae Biomonitoring	9	7	13	9	1	39
	Benthic Invertebrates	35	26	46	47	2	156
	Fluvial Geomorphology	0	21	12	16	1	50
	West Nile Virus Monitoring	10	9	12	16	0	47
	Surface Water Quality	9	5	13	11	0	38
	Baseflow	27	12	24	97	0	160
	Stream Flow	10	6	8	5	4	33
	Precipitation	5	8	8	10	0	31
	Snow	3	3	1	3	0	10
	Groundwater	6	7	2	6	0	21
	Terrestrial Natural Heritage ²	327	365	788	80	0	1560
	Terrestrial Volunteer Monitoring	10	13	19	13	0	55
	Meteorological (Climate Monitoring) ³	4	2	2	7	0	15
	Water Temperature	2	23	12	14	9	60

¹Dufferin/Simcoe

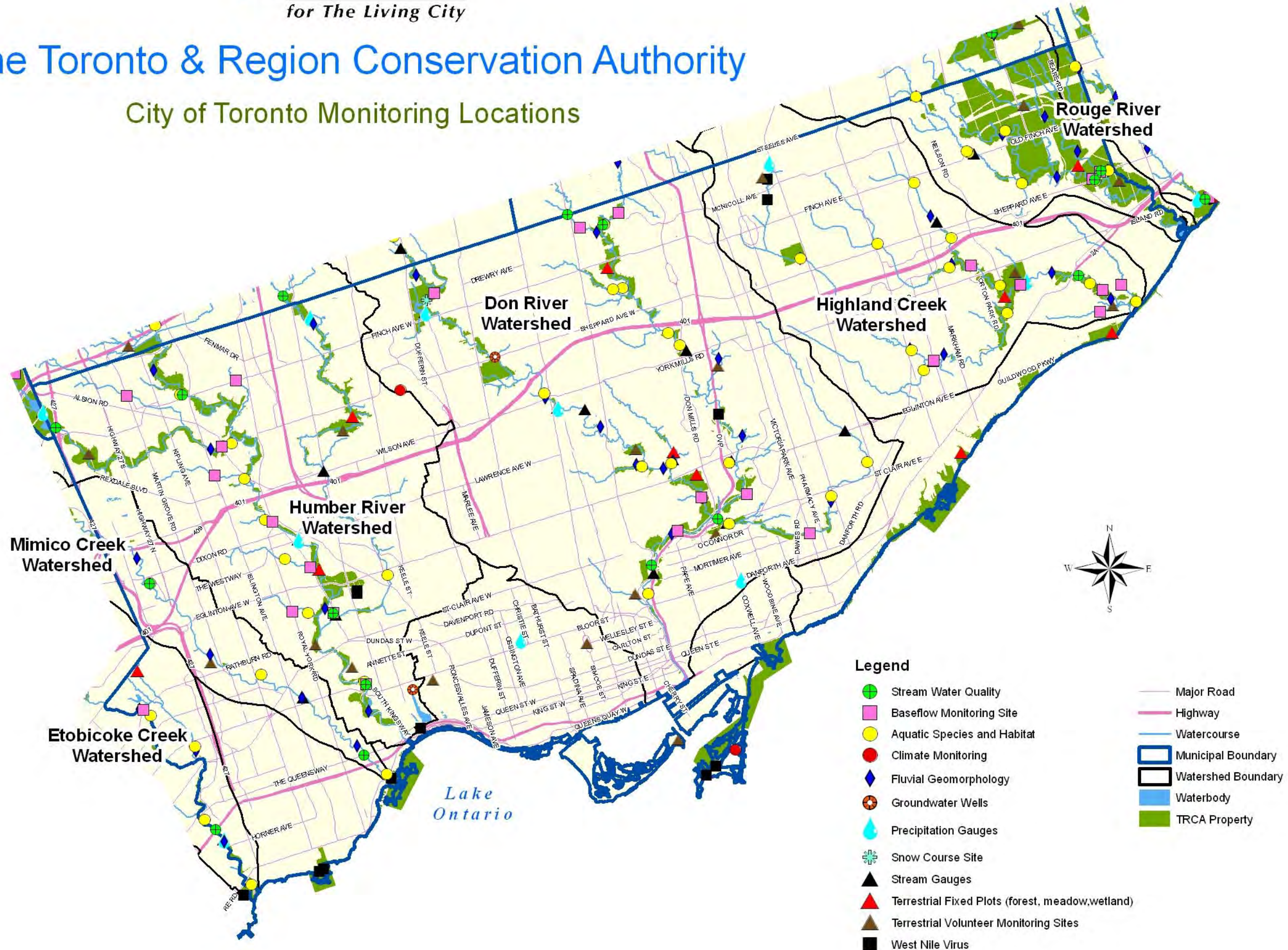
²Italicized numbers are the number of hectares monitored

³ Includes both meteorological stations and "stand alone" air temperature stations



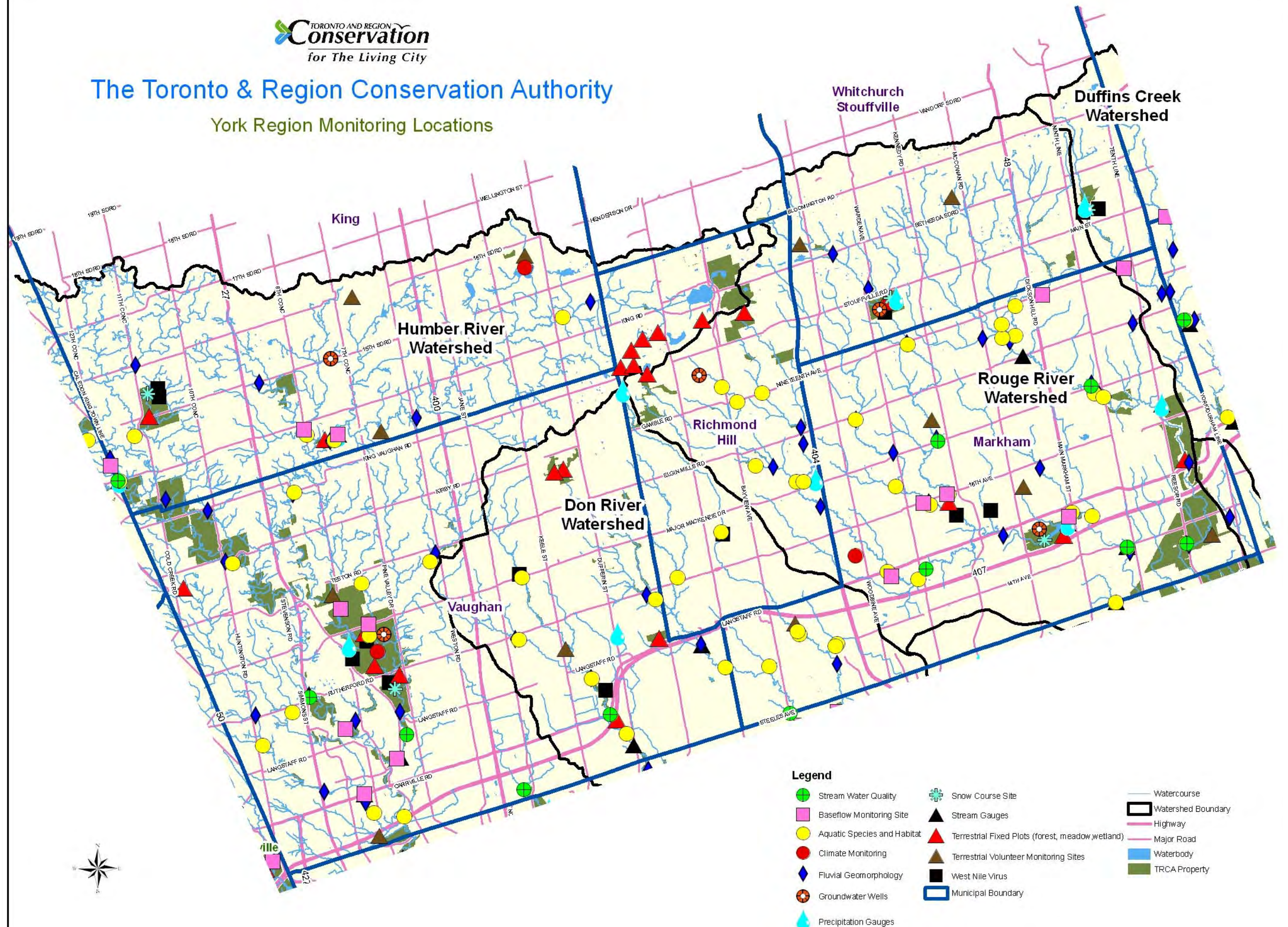
The Toronto & Region Conservation Authority

City of Toronto Monitoring Locations



The Toronto & Region Conservation Authority

York Region Monitoring Locations



The Toronto & Region Conservation Authority

Durham Region Monitoring Locations

