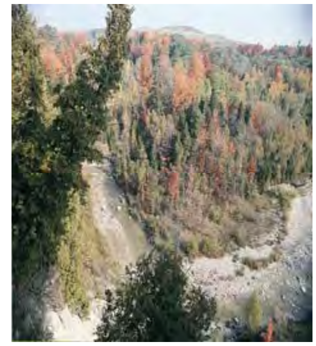
    

Source Water Protection: Surface Water Quality Update

November 2009

Watershed Monitoring and Reporting Section
Ecology Division

Toronto and Region Conservation for The Living City

Report prepared by: Angela Wallace, Watershed Monitoring and Reporting Section, Ecology Division

Reviewed by: Scott Jarvie, Manager Watershed Monitoring and Reporting, Ecology Division
Tim VanSeters, Manager Sustainable Technologies Section, Ecology Division
Don Ford, Manager Geoenvironmental, Ecology Division

This report may be referenced as:
Toronto and Region Conservation Authority (TRCA). 2009. *Source Water Protection: Surface Water Quality Update*. 39 pp + Appendices.

Table of Contents

List of Figures

Table of Contents

List of Tables

Table of Contents

Appendices

1. Introduction

This report provides a summary of the surface water quality across TRCA's jurisdiction. Both trends over time and spatial variations in water quality are described. Where applicable, water quality results are compared to numerical objectives (e.g. Provincial Water Quality Objectives) to determine if surface waters within the jurisdiction are meeting these targets.

1.1 Data Sources

Provincial Water Quality Monitoring Network/Regional Watershed Monitoring Program

The Ontario Ministry of the Environment (OMOE) Provincial Water Quality Monitoring Network (PWQMN) was started in 1964 to collect surface water quality information from rivers and streams at strategic locations throughout Ontario. Over time, stations were added and discontinued in response to changing OMOE and program-specific needs (OMOE 2003). Previously, the OMOE monitored water quality throughout the Toronto region but the PWQMN program was substantially scaled back due to funding issues in the 1990s. Only two stations continued to operate in the Toronto region (06008501402 at the mouth of the Don River, 06008301902 at the mouth of the Humber River). In 2002, TRCA began sampling 11 additional stations as part of the PWQMN, for a total of 13 PWQMN stations in the Toronto Region. The 11 stations are sampled eight times per year on a monthly basis during the ice-free period. Up until the end of 2008, the other two PWQMN stations were sampled by OMOE staff on a minimum bi-weekly basis (and often more frequently), year round. A standard set of water quality indicators (Table 1) is monitored at each PWQMN station, including chloride, nutrients, suspended solids, trace metals and other general chemistry parameters. Disease-causing substances, pesticides and other contaminants are monitored in detailed water quality surveys in priority watersheds.

In addition to the PWQMN stations, TRCA collects water quality samples as part of the Regional Watershed Monitoring Program (RWMP). The RWMP is a comprehensive ecological monitoring program which monitors aquatic habitat and fish community, terrestrial habitats, communities and species, surface water quality and quantity, fluvial geomorphology, groundwater quality and quantity and West Nile virus mosquito vector monitoring.

Since 2002, TRCA has partnered with the City of Toronto to monitor 23 additional surface water quality stations for a total of 36 stations (PWQMN+RWMP) in the TRCA's region (Figure 1). Station location information is provided in Appendix A. The number of stations in each watershed is proportional to the size of the watershed. These sites are sampled for the same standard set of water quality indicators used by the PWQMN (Table 1). In 2004, the TRCA increased its water quality sampling frequency to be year round. This includes sampling the nine PWQMN stations during the four months not covered under the agreement with the OMOE. The RWMP also collects *E. coli* samples from all sites (both RWMP and PWQMN) year round which are analyzed by a private laboratory.

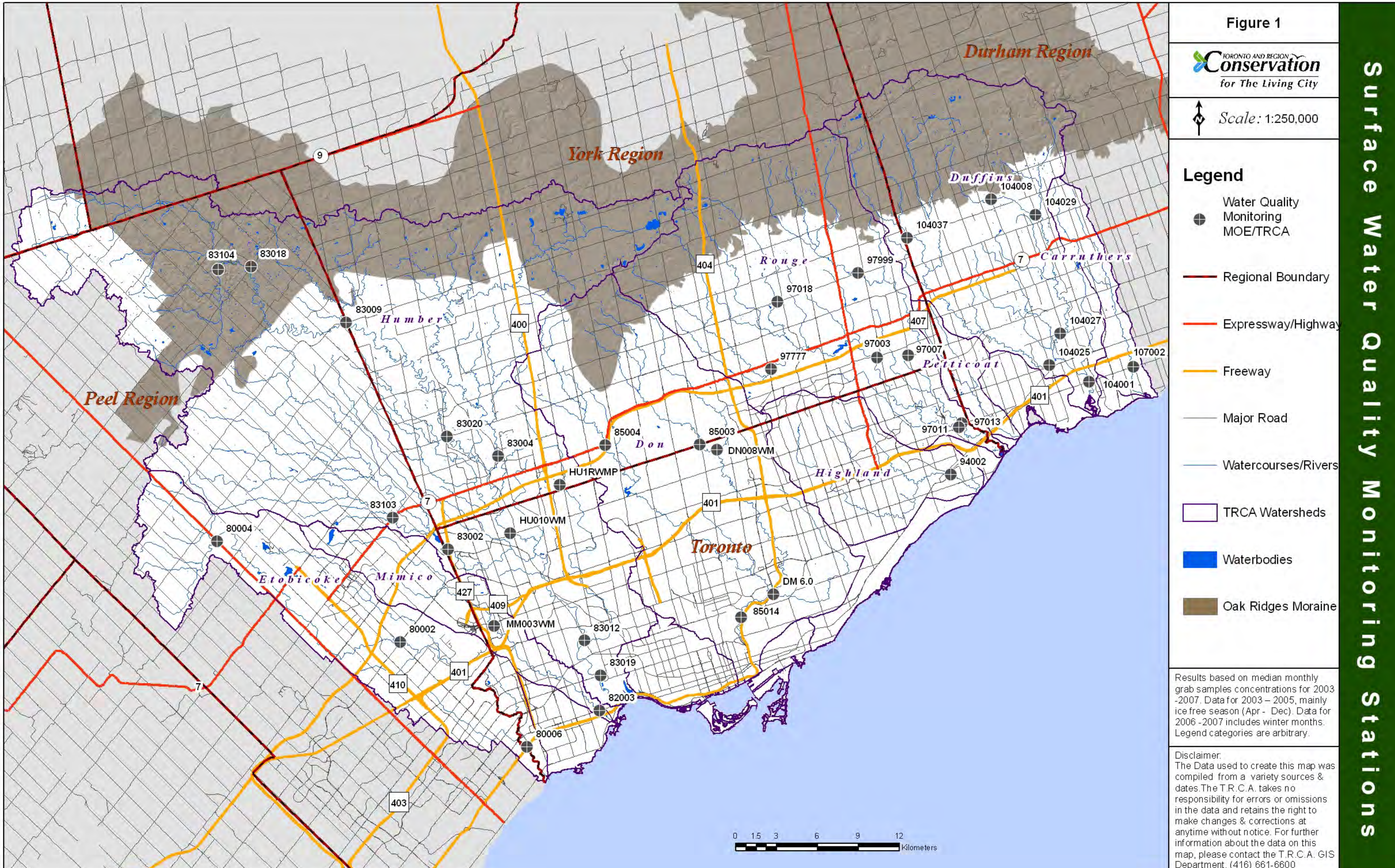


Figure 1
Toronto and Region Conservation for The Living City
Scale: 1:250,000
Surface Water Quality Monitoring Stations
Legend
Water Quality Monitoring MOE/TRCA
Regional Boundary
Expressway/Highway
Freeway
Major Road
Watercourses/Rivers
TRCA Watersheds
Waterbodies
Oak Ridges Moraine
Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 includes winter months. Legend categories are arbitrary.
Disclaimer:
The Data used to create this map was compiled from a variety sources & dates.The T.R.C.A. takes no responsibility for errors or omissions in the data and retains the right to make changes & corrections at anytime without notice. For further information about the data on this map, please contact the T.R.C.A. GIS Department. (416) 661-6600
Durham Region
York Region
Peel Region
Toronto
Humber
Don
Rouge
Duffins
Carruthers
Petticoat
Highland
Etobicoke
Mimico
83104
83018
83009
83020
83004
85004
85003
DN008WM
HU1RWMP
83103
80004
83002
HU010WM
MM003WM
80002
83012
83019
82003
80006
DM 6.0
85014
97777
97018
97999
97003
97007
104037
104008
104029
104027
104025
107002
104001
97011
97013
94002
0 1.5 3 6 9 12 Kilometers

In the spring of 2009, two water quality stations were added to the RWMP in the Petticoat Creek and Frenchman's Bay watersheds. Due to laboratory upgrades at the City of Toronto, RWMP samples are currently (April 2009 onwards) being sent to York-Durham Environmental laboratory during the interim.

Table 1. Standard suite of water quality parameters analyzed for stream samples

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

Note: Additional parameters may be analyzed on a site/project specific basis

Pesticide Data

Pesticide data is not collected as part of TRCA's routine water quality monitoring (i.e. RWMP). The report *Occurrence of Lawn Care and Agricultural Pesticides in the Don and Humber River Watersheds (1998-2002)* (EC *et al*. 2008b) summarizes results from several sites in the Don and Humber River watersheds during both baseflow and rainfall events from 1998 through 2002.

1.2 Indicator Variables

Surface water quality parameters were selected for analysis based on their relevance to common water use concerns. Table 2 outlines the indicator parameters, its sources as well as the effects on the aquatic environment, and the applicable water quality guidelines for comparison.

Table 2. Significance, sources and guidelines for key surface water parameters

Parameter	Significance	Sources (examples)	Guideline
Total Suspended Solids (TSS)	TSS represents the amount of particulate matter (e.g. silt, clay, organic and inorganic matter, etc) suspended in water. TSS can act as a transport vector for contaminants (e.g. metals). Elevated concentrations of TSS can affect aquatic organisms such as fish by reducing water clarity which can inhibit the ability of aquatic organisms to find food. TSS can cause clogging and abrasion of fish gills. TSS can cause habitat changes such as smothering fish spawning and nursery areas.	• Construction sites • Farm fields • Lawns and gardens • Eroding stream channels • Grit accumulation on roads	CWQG[1]: 30 mg/L (background + 25 mg/L)
Total Phosphorus	At elevated concentrations, phosphorus can have unfavourable effects on receiving waters such as eutrophication (enrichment of a waterbody with nutrients). Phosphorus stimulates plant and algae productivity and biomass. Past a certain point, this can cause reduced biodiversity, changes in the dominant biota, decreases in ecologically sensitive species, increases in tolerant species, anoxia, and increases in toxins (e.g. cyanobacteria).	• Fertilizers • Animal wastes • Sanitary sewage	Interim PWQO[2]: 0.03 mg/L
Nitrogen Compounds	Nitrogen compounds (nitrate, nitrite, unionized ammonia) are nutrients with sources and effects similar to phosphorus. Nitrite and unionized ammonia can be potentially toxic to aquatic organisms. The toxicity of unionized ammonia is dependent on pH and water temperature.	• Industrial discharge • Septic tanks • Agricultural runoff • Urban runoff • Fertilizers • Landfill leachate	CWQG[1]: 2.93 mg/L for nitrate PWQO: 0.02 mg/L for unionized ammonia
Chloride	Chloride can be toxic to aquatic organisms with acute effects at high concentrations and chronic effects at lower concentrations.	• Road salt application • Fertilizers • Wastewater treatment • Industrial discharge	BC MOE[3]: 150 mg/L
Escherichia coli (E. coli)	*E. coli* are a large and diverse group of bacteria that are commonly found in the intestines of warm-blooded animals. *E. coli* are used to indicate the presence of fecal waste in water. Some strains of *E. coli* can cause human illness (e.g. diarrhea, urinary tract infections).	• Illegal sewer connections • Combined sewer overflows (CSO) • Inputs from wildlife, livestock and domestic animals • Organic fertilizers	PWQO: 100 CFU/100 mL
Metals	Several heavy metals are toxic to fish and other aquatic organisms at varying concentrations. Most metals enter waterways though surface runoff. Metals bind to sediment and can affect fish (e.g. clogging of gills) and benthic invertebrates (e.g. habitat changes, smothering food sources).	• Urban runoff • Industrial discharge • Sewage treatment • Pesticides • Fertilizers • Atmospheric deposition	PWQO: • Copper – 5 μg/L (interim) • Iron – 300 μg/L • Nickel – 25 μg/L • Zinc – 20 μg/L (interim)
Pesticides	Pesticides consist of various compounds used to control unwanted pests such as weeds and insects. The most obvious effect of pesticides on fish and other wildlife is acute poisoning. Certain pesticides can affect the reproductive potential of certain fish and wildlife. Pesticides can cause health effects in humans such as reproductive effects and cancer.	• Insecticides • Herbicides • Fungicides	CWQG/PWQO: • MCPP – 4 μg/L • Diazinon – 0.08 μg/L • 2,4-D – 4 μg/L

[1]CWQG = Canadian Water Quality Guideline
[2]PWQO = Provincial Water Quality Objective
[3]BC MOE = British Columbia Ministry of the Environment

1.3 Data Analysis

Statistical analysis was completed using JMP 8.0 (SAS Institute, Carrey, North Carolina). When results were below the laboratory detection limit (trace amounts), these values were set conservatively at the laboratory detection for analysis purposes. The OMOE (2003) recommends that for statistical summaries of routine monitoring data a minimum sample size of 30 or greater. Sampling results are presented in box plots (e.g. Figure 2) which summarize the distribution of samples for each site. The ends of the box are the 25th and 75th quartiles. The difference between the quartiles is the interquartile range. The line across the middle of the box identifies the median sample value. “Whiskers” extend from the ends of the box to the outermost data point which is not considered an outlier (upper quartile+1.5*(interquartile range), lower quartile-1.5*(interquartile range)). Sampling stations are arranged along the x-axis by watershed (west to east) from headwaters to outlet.

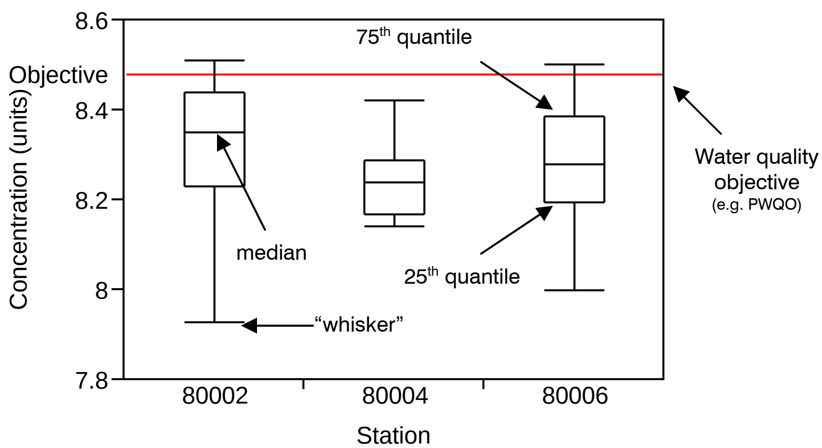


Figure 2. Example box plot graphic

Surface water quality results were compared to the Provincial Water Quality Objectives (PWQO; OMOEE 1994). The PWQO are a set of numerical and narrative criteria which serve as chemical and physical indicators representing a satisfactory level for surface waters which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water. There are also some PWQO which are set for the protection of recreational water uses based on public health and aesthetic considerations. When PWQO were not available, other objectives such as the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Aquatic (CWQG; CCME 2007) were used.

The relationships between median surface water quality results and urban (urban + urbanizing) land cover were also examined using regression analysis. The percentages of rural, urbanizing and urban land cover in the upstream catchment were determined using a Geographic Information System (GIS). Urban land cover was based on 2002 orthoimagery, urbanizing land cover was based on various regional Official Plans (2002-2004) and rural land cover was the remaining areas.

For sites where historical data were available, analysis was completed using Mann-Kendal non-parametric test to determine if temporal trends were significant. The Mann-Kendall test is a non-parametric test for identifying trends in time series data. The test compares the relative magnitude of sample data rather than the data values themselves (Gilbert, 1987). The data values are evaluated as an ordered time series. Each value is compared to each subsequent data values. The initial value of the Mann-Kendall statistic, S, is assumed to be zero (*e.g.*, no trend). If a value from a later time period is higher than a value from an earlier time period, S is incremented by one. On the other hand, if the value from a later time period is lower than a value sampled earlier, S is decremented by one. The net result of all such increments and decrements yields the final value of S. For example, a very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a decreasing trend. Because of the wide range of water quality values (i.e. includes baseflow, low flow and storm events), a significance level (α) of 0.1 was used to determine if temporal trends were significant. The alpha level (α, or significance level) indicates the odds that the observed result is due to chance. If a test of significance gives a p-value lower than the α-level, the null hypothesis (i.e. no difference between what is being tested) is rejected. For example, if the p-value for a Mann-Kendall test is 0.07, the p-value is less than the significance level (α=0.1), and the result is statistically significant.

1.4 Current Conditions

With the exception of the pesticide data, surface water quality results are for the 5-year period from 2003-2007. The pesticide data is for 1998-2002. Results are presented using RWMP station names which are often a derivative of the (current/historic) 11-digit OMOE PWQMN name. For example, PWQMN station 06008000202 is presented as station 80002. Stations which do not have corresponding PWQMN names have text names rather than numeric codes. Summary maps are presented in Appendix B.

It is important to note that samples were collected on varying field dates, under a variety of weather conditions, and analyzed at several laboratories. Water quality samples collected as part of the PWQMN/RWMP are collected independent of weather conditions. Monthly water quality data should represent the range of water quality conditions that affect the aquatic system (e.g. streamflow conditions including snowmelt, runoff from rain events of varying magnitude and baseflow conditions during varying seasons). By proportion, low flow conditions predominate the samples, therefore, by using five years of monthly water quality data, median values should represent ambient water quality conditions. Since specific wet-weather events are not targeted, contaminant concentrations presented in this report may be significantly lower than what would be measured during a storm event. Urban runoff can contain high concentrations of contaminants (e.g. sediments, nutrients, road salts, heavy metals, petroleum products, bacteria) which are washed off impervious surfaces such as roads and parking lots. Agricultural runoff can also contain high levels of contaminants such a sediment, pesticides, nutrients and bacteria. In addition, winter water quality samples were not collected in 2003, collected periodically from 2004-2005 and collected monthly from 2006-2007. Therefore, interpretation of water quality results presented in this report should consider the above noted limitations regarding the frequency and timing of sample collections.

1.4.1 Total Suspended Solids

A total suspended solids (TSS) value represents the amount of particulate matter (e.g. silt, clay, organic and inorganic matter, soluble organic compounds, plankton, other microscopic organisms) suspended in water. Suspended sediments can act as a transport vector for a wide range of contaminants (e.g. metals are charged particles that can bind with sediment) and can affect aquatic organisms. Direct negative effects to fish include clogging and abrasion of gills, behavioural effects (e.g., movement and migration), blanketing of spawning gravels and other habitat changes, the formation of physical constraints disabling proper egg and fry development, and reduced feeding (CCME 2002). Effects to benthic invertebrates include physical habitat changes, smothering of benthic communities, clogging of interstices between gravel, cobbles, and boulders affecting invertebrate microhabitat, abrasion of respiratory surfaces, and interference of food intake for filter-feeding invertebrates (CCME 2002).

TSS concentrations are presented in Figure 3 and Appendix B1. Currently, there is no PWQO for suspended sediments that can be easily applied to stream water quality samples. The CWQG's contain a narrative guideline for TSS which recommends that during periods of "clear flow" water (ambient, baseflow conditions), the maximum increase of TSS should be no more than 25 mg/L from background levels for any short-term exposure (e.g. 24-h period) and only a maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 h and 30 d). During periods of "high flow" (e.g. after a precipitation event), the guideline recommends a maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L or levels should not increase more than 10% of background levels when background is >250 mg/L (CCME 2002). For this report, an objective of 30 mg/L was used which assumes a background TSS concentration of 5 mg/L.

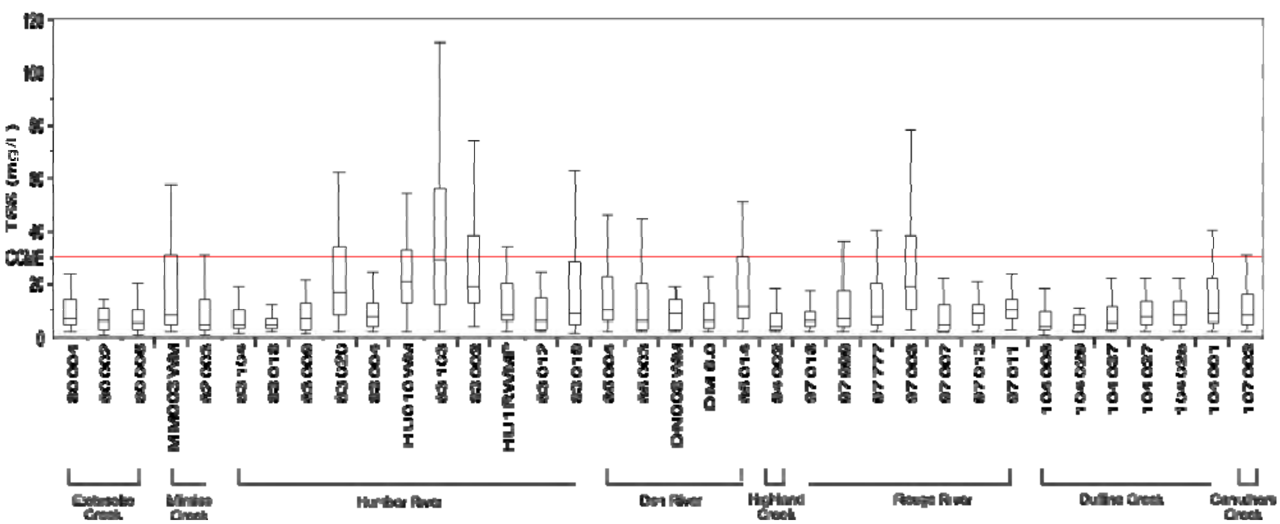
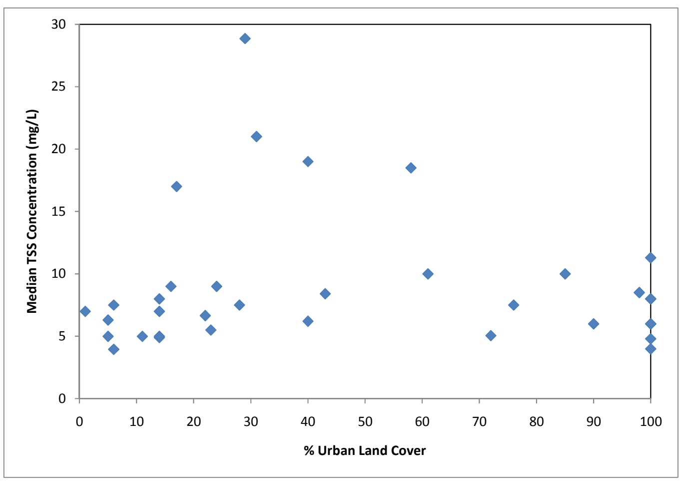


Figure 3. TSS concentrations (mg/L) across the TRCA jurisdiction (2003-2007)

Figure 3 shows that no stations had median TSS concentrations higher than the 30 mg/L objective but many stations did have individual readings which were over this objective. The highest median TSS concentrations were in the Humber and Rouge River watersheds. Stations 83103, HU010WM, 83002, 83020 are located in the mid-reaches of the Humber River watershed near or just north of Highway 7. This area underwent (and continues to undergo) large scale development (change from agricultural to urban) which may have contributed to the sediment in the streams. Station 97003 is located in the Little Rouge subwatershed. Sources of suspended sediment in at this station may include agriculture, in-stream erosion, and development (e.g. Town of Stouffville). The predominance of highly erodible soils at these stations may also influence TSS concentrations.

There was no significant relationship between TSS and urban land cover ($F=0.14$, $p=0.71$) as shown in Figure 4. Finkenbine *et al*. (2000) found that the age of urban land use may influence sediment loads (e.g. sediment loads may decline in streams draining older urban areas).



Note: % Urban land cover = urban + urbanizing land use

Figure 4. Median TSS concentrations (2003-2007) in relation to urban land cover

1.4.2 Chloride

Chloride can be toxic to aquatic organisms with acute affects at high concentrations and chronic effects (e.g. growth, reproduction) at lower concentrations (OMOE 2003). Chloride in our waterways is due to the use of road salts which are mainly used as de-icing and anti-icing agents during winter road maintenance. The predominant chloride salt used as a de-icer in North America is sodium chloride, which is composed of about 40% sodium and 60% chloride by weight. Trace elements, including trace metals, may represent up to 5% of the total salt weight. Additional sources of chloride include waterwater treatment, industry discharge and fertilizers (OMOE 2003). Natural background concentrations of chloride in water are generally no more than a few milligrams per litre, with some local or regional instances of higher natural salinity (EC & HC 2001).

Chloride is a highly soluble and mobile ion that does not volatilize or easily precipitate or adsorb onto surfaces of particulates. Road salts enter the environment through runoff/melt-water, losses at salt storage and snow disposal sites, or from the release of salts stored in surface soils. There are no major removal mechanisms, such as volatilization, degradation (photodegradation, biodegradation), sorption (to particulates) or oxidation, that would remove the salts from surface waters. Because chloride ions are persistent and are entrained in the hydrological cycle, all chloride ions applied to roadways as road salts and/or released from storage yards or snow disposal sites can be expected to be ultimately found in surface water.

Presently, there is no Provincial or Canadian water quality guideline for chloride. A comprehensive five-year scientific assessment by Environment Canada and Health Canada (EC & HC 2001) determined that in sufficient concentrations, road salts pose a risk to plants, animals and the aquatic environment. The report noted that an estimated 5% of aquatic species would be affected (median lethal concentration) at chloride concentrations of about 210 mg/L, and 10% of species would be affected at chloride concentrations of about 240 mg/L. It also noted that changes in populations or community structure can occur at lower concentrations. The British Columbia Ministry of the Environment (BC MOE) has a chloride guideline which states that the average concentration of chloride (mg/L as NaCl) should not exceed 150 mg/L (based on an arithmetic mean computed from five samples collected over a 30-day period) to protect freshwater aquatic life from acute and lethal effects, the maximum concentration of chloride (mg/L as NaCl) at any time should not exceed 600 mg/L (BC MOE 2003). The 150 mg/L value includes a safety factor of five because chronic effects data in the literature are limited and the 600 mg/L acute value includes a safety factor of two because of the relative strength of the data set. Nationally, water quality is summarized as part of the Canadian Environmental Sustainability Indicators (CESI) report series (e.g. EC *et al*. 2008) produced by the Government of Canada (Environment Canada, Statistics Canada, Health Canada). The CESI report authors have interpreted the aforementioned studies and used an objective of 150 mg/L to protect aquatic life (EC 2005). An objective concentration of 150 mg/L was used for this report.

Chloride concentrations for the 5-year period of 2003-2007 are presented in Figure 5 and Appendix B2. Only limited winter sampling was conducted for this period. There is also limited data on small order streams which have low dilution potential due to their limited volume. Keeping these data limitations in mind, the chloride concentrations presented in Figure 5 suggest that only the Duffins Creek and Carruthers Creek watersheds are meeting the 150 mg/L chloride objective. In general, chloride concentrations are highest near the outlets of the systems and decrease toward the headwaters. Seven sites (80006, MM003WM, 82003, HU1RWMP, 83012, DM 6.0, 94002) had over 90% of the samples collected exceed the objective of 150 mg/L. Six sites (80006, 82003, DM 6.0, 94002, 97011, HU1RWMP) had maximum individual concentrations greater than 5000 mg/L. Of the 36 sites sampled, the 75th percentile at 11 sites (30%) was greater than the 600 mg/L upper limit suggested by the BC MOE. This includes two sites (82003: mouth of Mimico Creek, HU1RWMP: mid-Humber River) which had median concentrations above the suggested 600 mg/L upper limit. Six sites (83018, 83009, 97018, 104008, 104029, 104025) had maximum concentrations below 150 mg/L. These stations are located in the upper reaches of the Humber River, Rouge River and Duffins Creek.

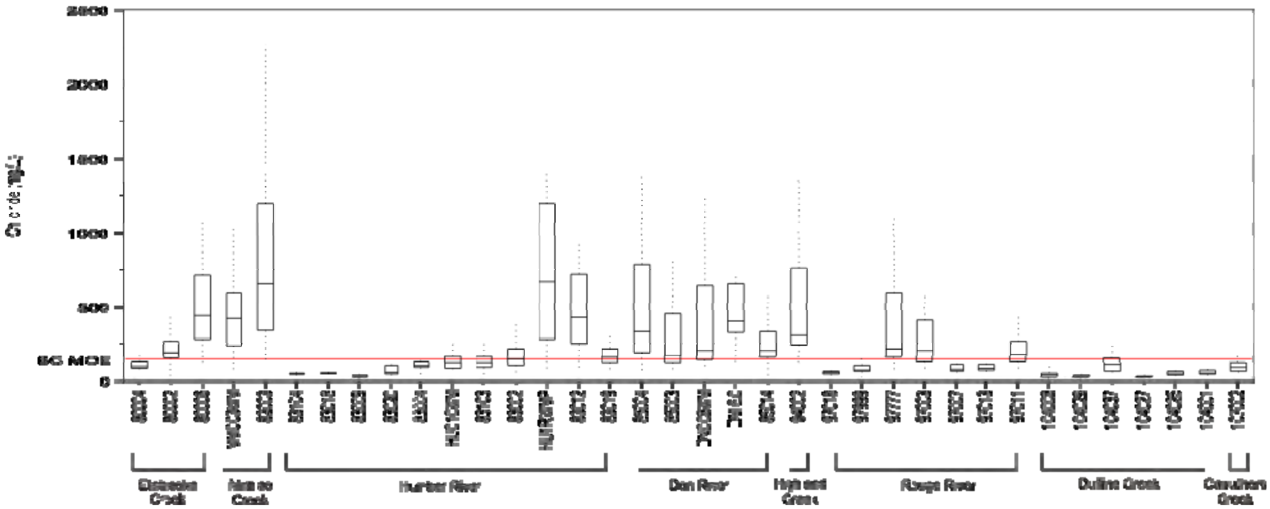
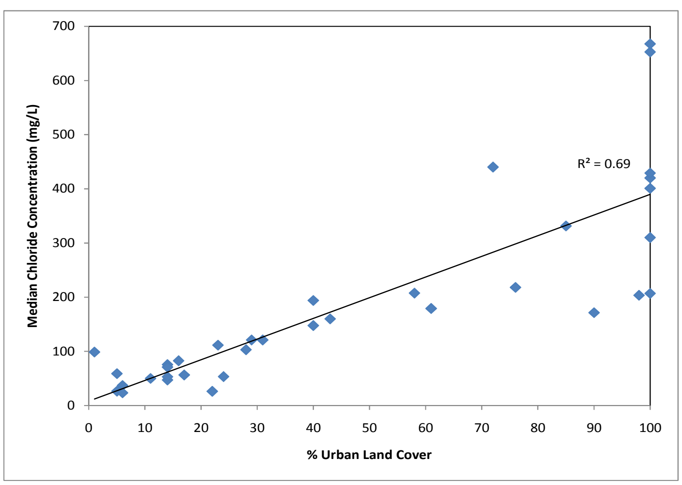


Figure 5. Chloride concentrations (mg/L) across the TRCA jurisdiction (2003-2007)

The relationship between urban land cover and 2003-2007 median chloride concentrations is presented in Figure 6. There is a significant increasing linear relationship (F=73.15, $p<0.01$) and the model is quite tight (R^2=0.69) between these two variables. The relationship is very tight along the lower spectrum of urban land cover. The relationship weakens above 75% urban land cover. This may be an artifact of the method used to determine urbanizing land cover. Because urbanizing land cover was based on future planning zones, some area may not actually be built out (i.e. these areas will be urbanized in the future) but have been counted in the urbanizing category.



Note: % Urban land cover = urban + urbanizing land use

Figure 6. Median chloride concentrations (2003-2007) in relation to urban land cover

1.4.3 Total Phosphorus

Phosphorus is an essential nutrient for all living organisms but in excess, it can have unfavorable effects. Phosphorus is associated with eutrophication – the enrichment of a water body with nutrients. Water bodies containing low phosphorus concentrations typically support relatively diverse and abundant aquatic life that are self-sustaining and support various water uses. However, elevated phosphorus concentrations can adversely affect aquatic ecosystems (CCME 2004). Additional inputs of phosphorus to an aquatic system can cause increased plant and algal productivity and biomass. Although this may be desirable in some cases, beyond a certain point, further phosphorus additions may cause undesirable effects such as decreased biodiversity and changes in dominant biota, decline in ecologically sensitive species, increase in tolerant species, increase in plant and animal biomass, and anoxic conditions (EC 2004). When the excessive plant growth includes certain species of cyanobacteria, toxins may be produced, causing increased risk to aquatic life, livestock, and human health (CCME 2004). The potential human quality of life concerns that may relate to eutrophication include difficulties treating potable water which can lead to increased cost, drinking water taste or odour problems, decreased aesthetic/ recreational value, excessive macrophyte growth that may impede water flow and navigation, and a decrease in commercial and recreational fish (EC 2004).

The interim PWQO for total phosphorus is 0.03 mg/L. This concentration is intended to prevent excessive plant growth in rivers and streams. Phosphorus results for 2003-2007 are presented in Figure 7 and Appendix B3. The results show that all stations exceed the PWQO of 0.03 mg/L for phosphorus on a regular basis. Only 8 sites had median phosphorous concentrations at or below 0.03 mg/L, of which, 5 stations were in the Duffins Creek watershed. The highest median phosphorous concentration (0.16 mg/L) was measured at station 85014 at the mouth of the Don River and had a maximum concentration of 0.91 mg/L measured on October 11, 2006. Station 85014 is located downstream of the North Toronto wastewater treatment plant.

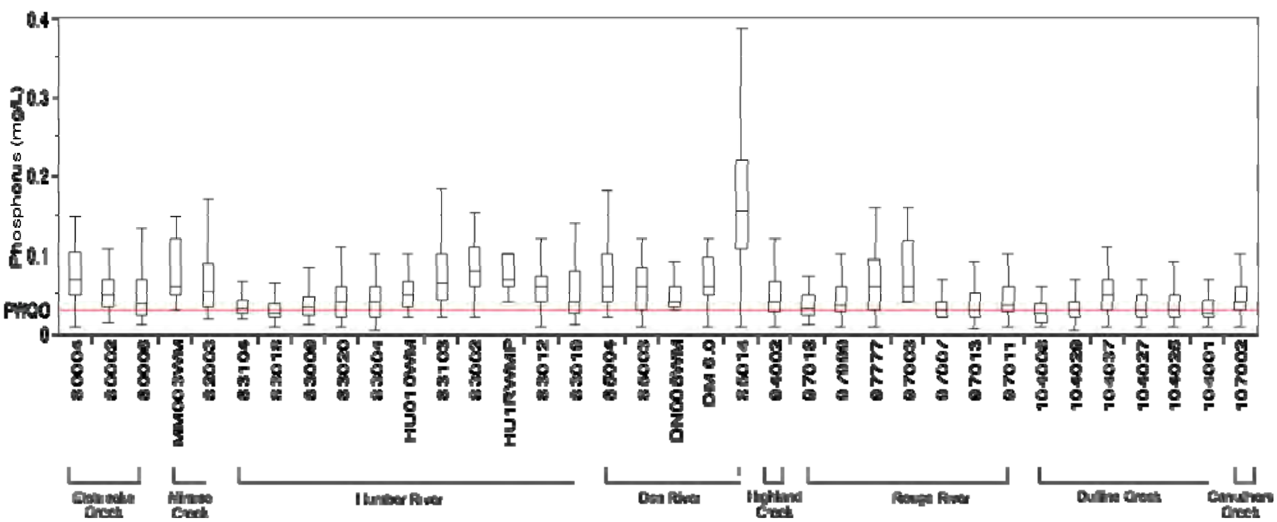
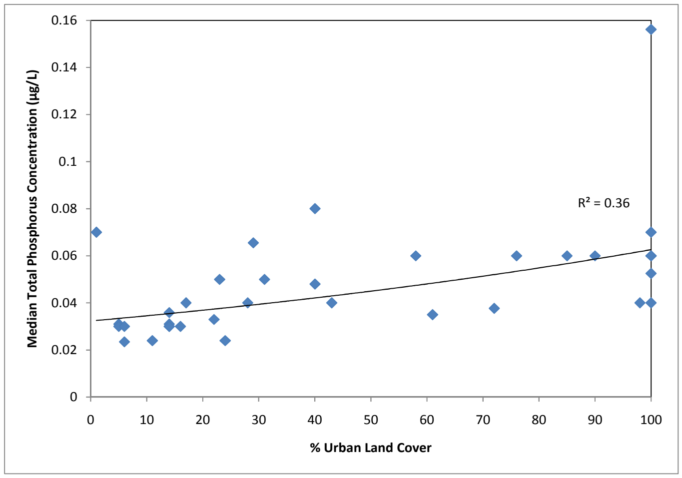


Figure 7. Phosphorus concentrations (mg/L) across the TRCA jurisdiction (2003-2007)

A significant exponential relationship exists between the median total phosphorus concentrations and urban land cover ($F=18.60$, $p<0.01$) and is presented in Figure 8. Although significant, there is a lot of scatter amongst the data points ($R^2=0.36$) indicating that some data does not fit the exponential model.



Note: % Urban land cover = urban + urbanizing land use

Figure 8. Median total phosphorus concentrations (2003-2007) in relation to urban land cover

1.4.4 Nitrogen Compounds

In the majority of water bodies, phosphorus is normally the limiting nutrient for algal growth but nitrogen compounds can also play a role in the eutrophication process. Three nitrogen compounds are analyzed as part of the PWQMN/RWMP: nitrate (NO_3), nitrite (NO_2) and total ammonia (NH_3 + NH_4^+). Anthropogenic discharges of nitrogen can include municipal and industrial wastewaters, septic tanks, agricultural runoff, feedlot discharges, urban runoff, lawn fertilizers, landfill leachate, nitric oxide and nitrogen dioxide from vehicular exhaust, and storm sewer overflow (CCME 2003). Natural sources of ammonia include the decomposition or breakdown of organic waste matter, gas exchange with the atmosphere, forest fires, animal waste, human breath, the discharge of ammonia by biota, and nitrogen fixation processes (CCME 2003). Nitrate serves as the primary source of nitrogen for aquatic plants in well oxygenated systems, and as nitrate levels increase, there is an increasing risk of algal blooms and eutrophication in surface waters. Nitrite and unionized ammonia can be toxic to fish and other aquatic organisms at relatively low concentrations.

Nitrate results are presented in Figure 9 and Appendix B4. CESI (EC *et al*. 2008) interpreted the interim CWQG for nitrate as 2.93 mg/L (EC 2005). All stations had median water quality values below the 2.93 mg/L objective. Several sites had individual sampling points which were above the objective. In particular, Station DM 6.0 at the outlet of Taylor-Massey Creek in the Don River watershed had the highest median nitrate value at 2.34 mg/L followed by station 104037 in Mitchell's Creek (Duffins Creek watershed) with a median value of 2.06 mg/L. The reason for the high nitrate levels at DM 6.0 are unclear but Station 104037 is located less than 1 km downstream from John Evelyns Golf Club which may be influencing the nitrate concentrations at this station. Some of the nitrate values may be exaggerated as samples analyzed at the City of Toronto laboratory with nitrate concentrations greater than 1 mg/L were determined to be elevated in comparison to other laboratories when split sampling results were compared (TRCA, unpublished data).

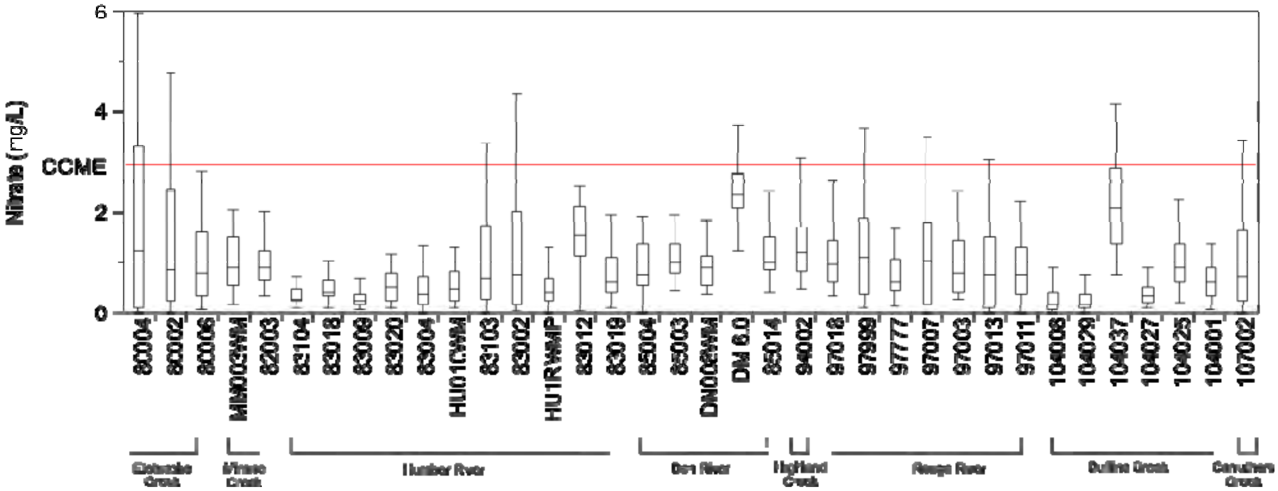


Figure 9. **Nitrate concentrations (mg/L) across the TRCA jurisdiction (2003-2007)**

The relationship between nitrate and urban land cover is presented in Figure 10. A significant exponential relationship exists between the two variables (F=7.69, p<0.01).

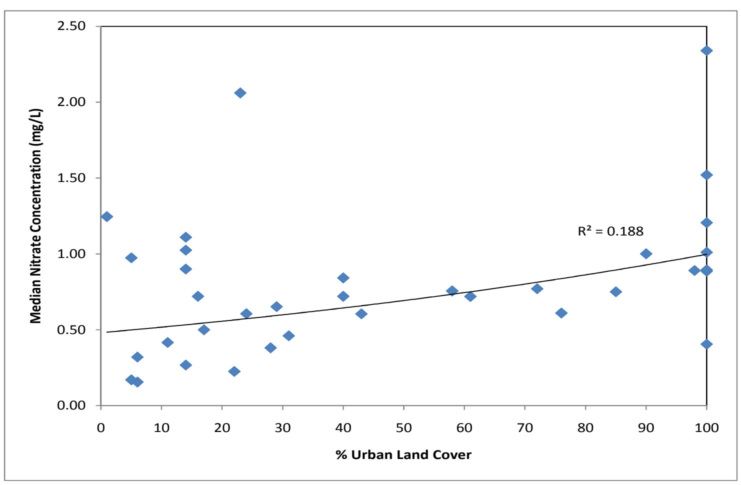


Figure 10. **Median nitrate concentrations (2003-2007) in relation to urban land cover**

Nitrite results are presented in Figure 11. There is no PWQO or CWQG for nitrite in surface water. The BC MOE has an objective for nitrite which is chloride concentration dependent (BC MOE 2001). Since most sites (89%) had minimum chloride concentrations greater than 10 mg/L, the objective of 0.6 mg/L of nitrite was used for this study. Median nitrite concentrations for all stations were below the 0.6 mg/L objective. The highest median nitrite value was recorded at station 85014 at the mouth of the Don River with a value of 0.139 mg/L. Station 85014 is located downstream of the North Toronto Wastewater Treatment Plant.

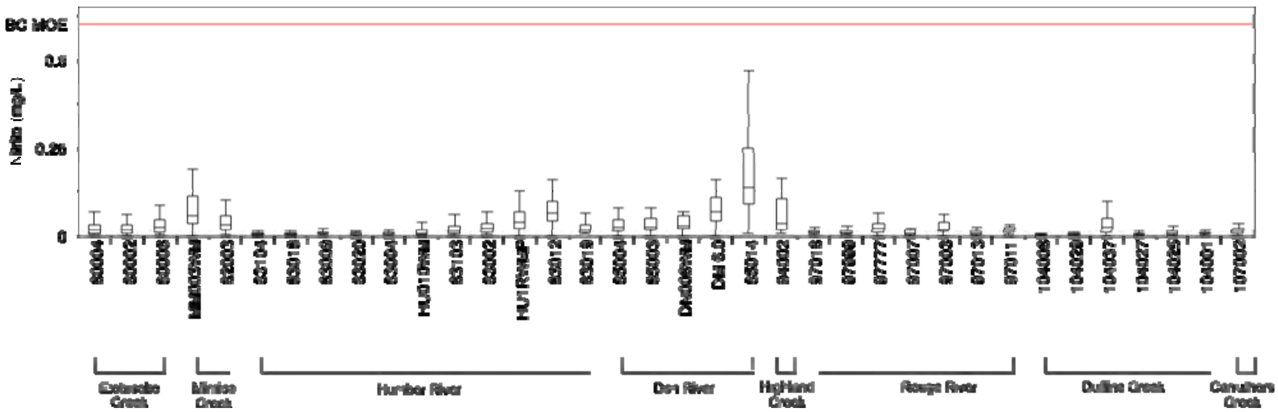


Figure 11. Nitrite concentrations (mg/L) across the TRCA jurisdiction (2003-2007)

The relationship between nitrite and urban land cover is presented in Figure 12. A strongly significant exponential relationship exists between the two variables (F=100.78, $p<0.01$).

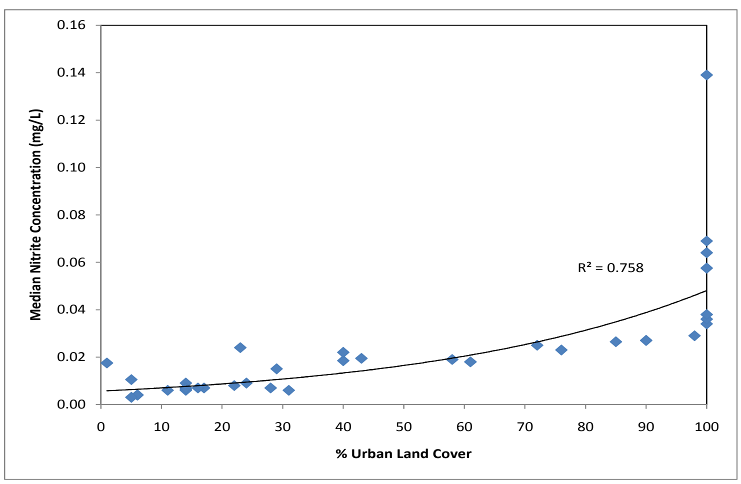


Figure 12. Median nitrite concentrations (2003-2007) in relation to urban land cover

Unionized ammonia is the only nitrogen compound which has a PWQO (0.02 mg/L). Unionized ammonia concentrations are presented in Figure 13 and Appendix B6. Unionized ammonia values are calculated from total ammonia values and depend on the pH and temperature of the water. Raising pH by one unit can cause the unionized ammonia concentration to increase nearly tenfold, while a 5°C temperature increase can cause an increase of 40-50% (CCME 2000). The median and 75th percentile of unionized ammonia concentrations at almost all stations were less than the PWQO. However, one station at the mouth of the Don River (85014) had significantly higher concentrations unionized ammonia. The median unionized ammonia concentration at this station was 0.06 mg/L which exceeds the PWQO of 0.02 mg/L. Station 85014 is located approximately 1.5 km downstream from the North Toronto Wastewater Treatment Plant. Several studies have determined that concentrations greater than 0.04 mg/L

(CCME 2000) can cause pathological lesions in the gills, tissue degradation in the kidneys and reduction in growth and reproduction in fish. The median concentration at station 85014 exceeded 0.04 mg/L of unionized ammonia and individual sampling concentrations often exceeded more than 5 times this amount.

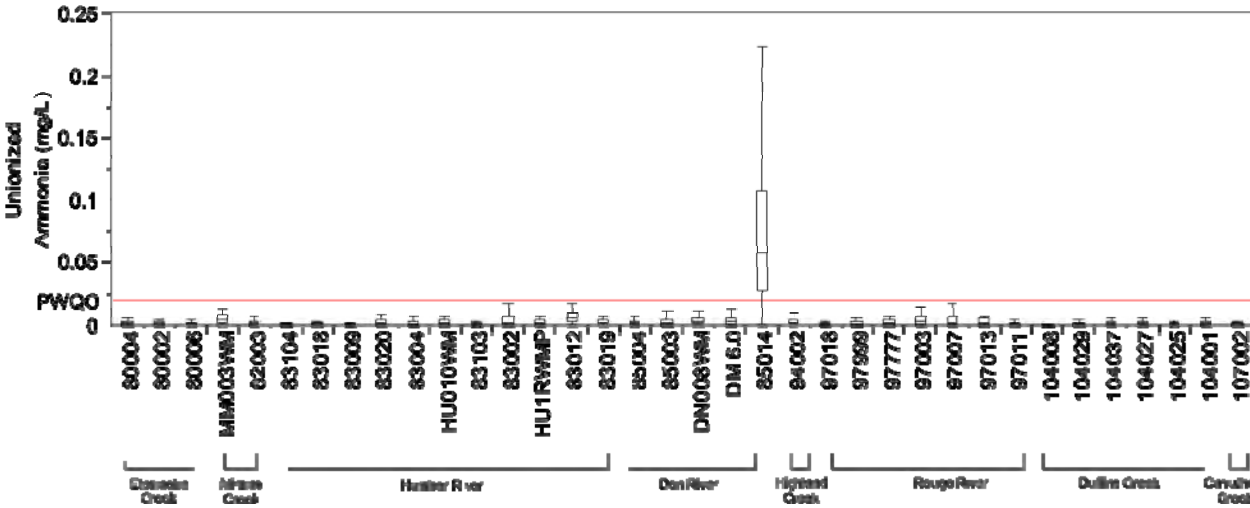
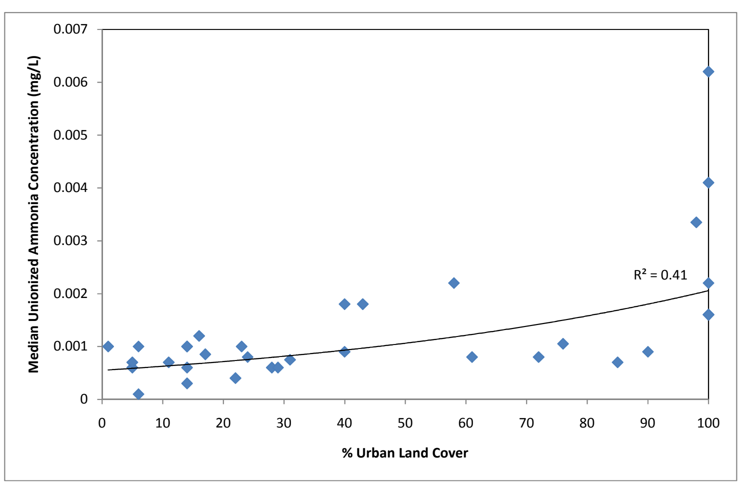


Figure 13. Unionized ammonia concentrations (mg/L) across the TRCA jurisdiction (2003-2007)

The relationship between unionized ammonia and urban land cover is presented in Figure 14. The median concentration for Station 85014 located at the mouth of the Don River was removed from analysis because it was an obvious outlier. A significant exponential relationship exists between the two variables (F=18.71, $p<0.01$).



Note: % Urban land cover = urban + urbanizing land use

Figure 14. Median unionized ammonia concentrations (2003-2007) in relation to urban land cover

1.4.5 E. coli

Escherichia coli (*E. coli*) are a large and diverse group of bacteria that are commonly found in the intestines of warm blooded animals. Although most strains of *E. coli* are harmless, others can cause human illness (e.g. diarrhea, urinary tract infections, respiratory illness, pneumonia) (CDC 2008). *E. coli* are often used to indicate the presence of fecal wastes and other harmful bacteria in lakes and streams. Bacteria enters waterways via a variety of sources including sewer systems (e.g. combined sewer overflows), septic systems, wildlife, livestock, pets, waterfowl, and organic fertilizers.

E. coli results are presented in Figure 15 and Appendix B7. Samples were collected for the entire 2003-2007 period but it was determined that laboratory error overestimated *E. coli* counts from July 2003 through to May 2006 and therefore these data were not included in the analysis. The PWQO for *E. coli* is 100 colony forming units (CFU) per 100 mL. The PWQO for *E. coli* is a recreational water quality guideline for swimming. It is based upon a geometric mean of at least five samples per site taken within a one month period. Only one sample was collected monthly for this program and therefore median results are presented rather than geometric means. Maximum *E. coli* values were capped at 20000 CFU for analysis as this was the maximum value counted by one of the laboratories. This suggests that some sites may have higher median *E. coli* values than what are presented in Figure 15. In general, *E. coli* concentrations were lowest in the headwaters and increased downstream toward the stream outlets. Median *E. coli* levels at 89% of the sites monitored were above the PWQO of 100 CFU/100 mL. The highest *E. coli* concentrations were measured in the Don River watershed and high concentrations of *E. coli* were also found near the mouths of the other watersheds. Samples in the Don watershed and older urbanized portions of the Humber, Etobicoke and Mimico watersheds often receive untreated stormwater and some areas also have combined sewer overflow (CSO) sewer systems. Sanitary sewage and stormwater runoff are conveyed in a single pipe. This means that during precipitation events, the pipe can exceed capacity and flow directly into the river or waterfront. Four sites (83018, 83004, 97013, 104029) had median E. coli values less than the 100 CFU/100 mL objective. With the exception of 97013, these sites were located in the upper reaches of the Humber River and Duffins Creek watersheds. Station 97013 is located at the outlet of the Little Rouge Creek subwatershed, not far upstream from the mouth of the main Rouge River.

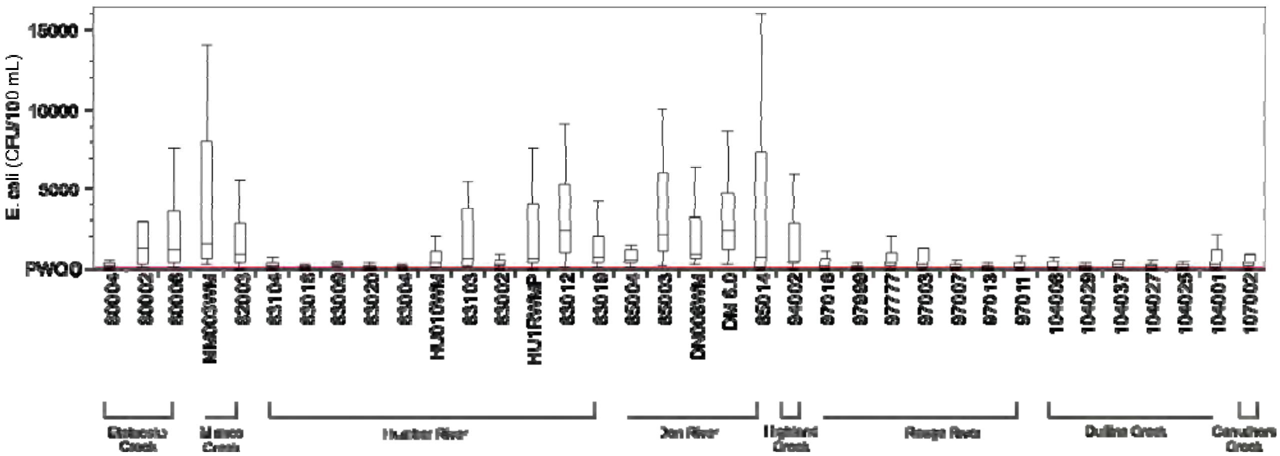
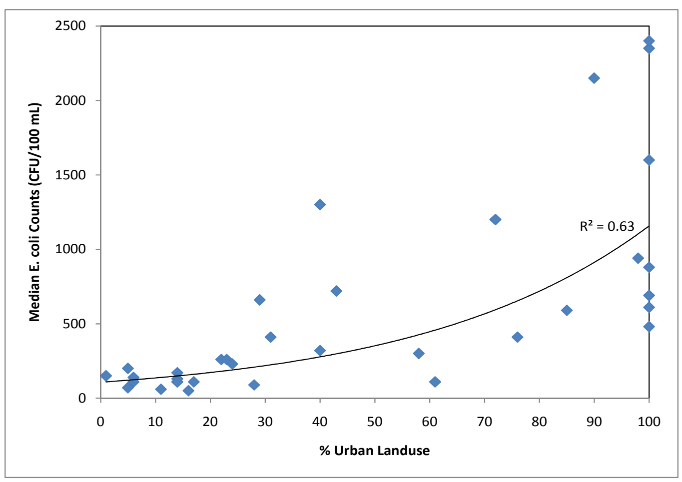


Figure 15. ***E. coli* concentrations (mg/L) across the TRCA jurisdiction (2003-2007)**

The relationship between urban land cover and median *E. coli* counts is presented in Figure 16. A significant exponential relationship exists between the two variables (F=57.25, $p<0.001$). Areas with high levels of urban land cover usually have much higher counts of *E. coli* than areas with lower levels of urbanization.



Note: % Urban land cover = urban + urbanizing land use

Figure 16. **Median *E. coli* counts (2003-2007) in relation to urban land cover**

1.4.6 Copper

Copper is an essential trace element that can be toxic to aquatic biota at elevated concentrations. It enters aquatic systems through aerial deposition or surface runoff. Sources of copper include the weathering of copper minerals and numerous sources from human activities (e.g. copper pipe, metal alloys, wiring, fungicides and insecticides). Copper strongly adsorbs to particulate matter (e.g. soil particles), and tends to accumulate in sediments. Because a variety of organisms live in, or are in contact with, the stream bed, sediments act as an important route of exposure to aquatic organisms (CCME 1999a). High levels of copper in the aquatic environment are usually found in more urbanized and industrial areas (OMOE 2003).

Copper results are presented in Figure 17 and Appendix B8. The median results for most stations are below the interim PWQO of 5 μg/L. Three stations (MM003WM, HU1RWMP, 83012) had median copper concentrations exceeding the PWQO. MM003WM is located downstream of Pearson International Airport and HU1RWMP and 83012 are located in the Black Creek subwatershed which is part of the Humber River watershed. Three stations (DN008WM, DM6.0, 85014) in the Don River watershed had median concentrations at or approaching the PWQO. The lowest median copper concentrations were recorded at station 83104 and 97018 which are located in the headwaters of the Humber River and Rouge River, respectively.

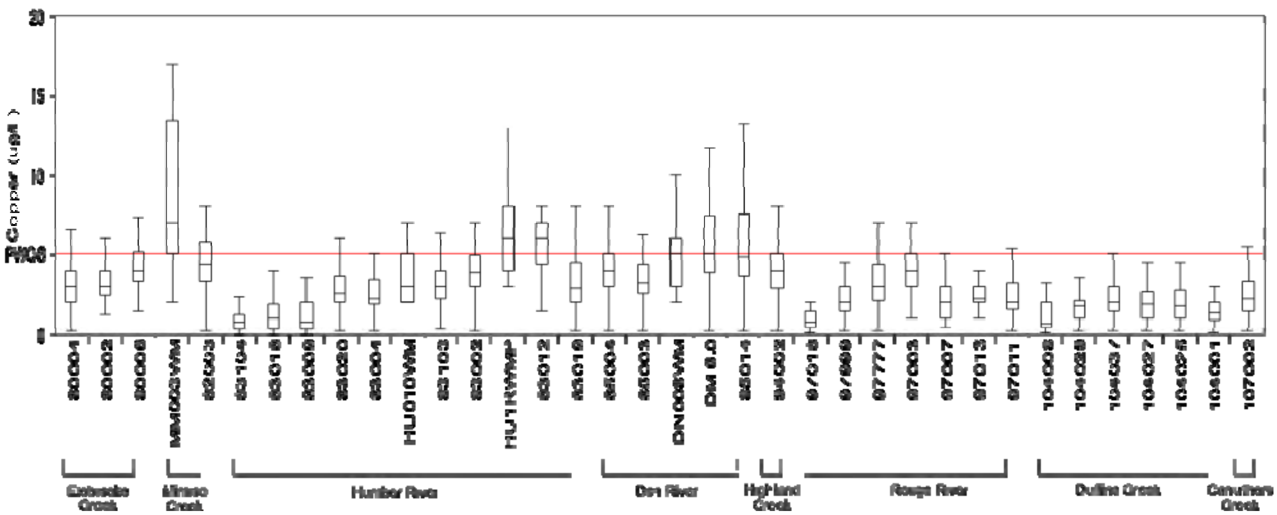
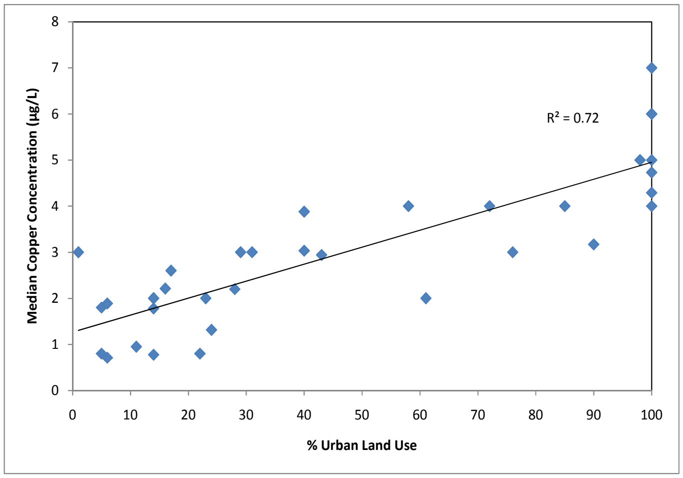


Figure 17. Copper concentrations (μg/L) across the TRCA jurisdiction (2003-2007)

The relationship between median copper concentrations and urban land cover are shown in Figure 18. There is a strong, significant increasing linear relationship between median copper concentrations and urban land cover ($F=84.36$, $p<0.01$). Much of the copper found in aquatic systems comes from human activities. This is evident in Figure 18 as the concentration of copper in streams increases significantly with increasing urban land cover.



Note: % Urban land cover = urban + urbanizing land use

Figure 18. Median copper concentrations (2003-2007) in relation to urban land cover

1.4.7 Iron

Iron is required for all forms of life but it can be potentially toxic at high concentrations. The relationship between the insoluble and soluble forms (bioavailable) depends on several factors including pH, dissolved oxygen, dissolved and total organic carbon, humic and other organic substances, exposure to light and chloride concentrations (BC MOE 2008). Anthropogenic sources of iron include mining activities, water purification and sewage treatment, pesticides, and fertilizers. Iron bound to other substances (e.g. sediment) can affect aquatic ecosystems. In fish, the clogging of gills which reduces respiratory potential and therefore overall survival can be caused by iron. It can also decrease the number of benthic invertebrates (which serve as the food supply for fish) directly or through changes to aquatic habitat.

Iron results are presented in Figure 19 and Appendix B9. Several sites (13) had median iron concentration above the PWQO of 300 µg/L. Highland Creek, Duffins Creek and Carruthers Creek did not have any sites where the median iron concentration exceeded the PWQO. The highest median iron concentration was measured at HU010WM with a concentration of 710 µg/L. The majority of the other sites which exceeded the PWQO were located in the mid to lower reaches of the watersheds.

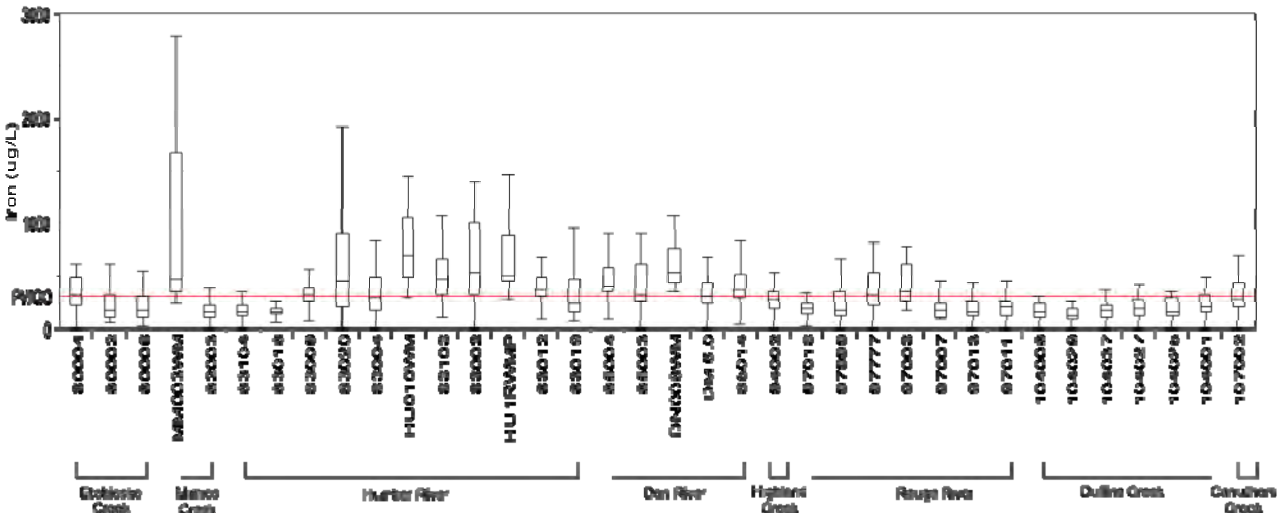
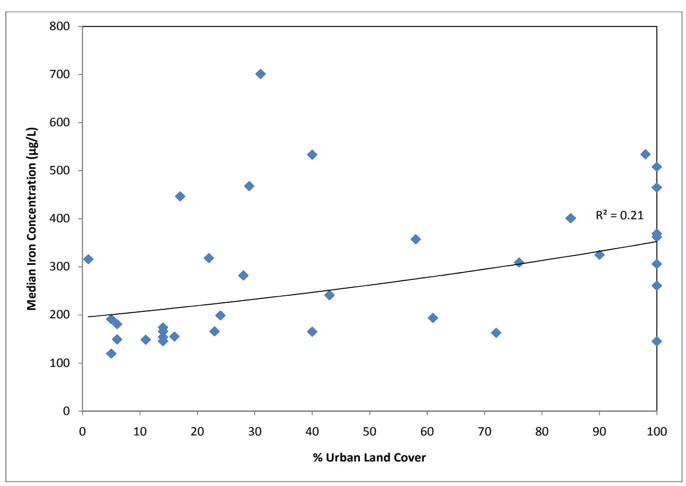


Figure 19. Iron concentrations (μg/L) across the TRCA jurisdiction (2003-2007)

The relationship between median iron concentrations and urban land cover is presented in Figure 20. There is a significant exponential relationship between these two variables (F=8.56, p<0.01) but there is quite a bit of scatter in the data (R^2=0.21) indicating that the model does not fit all data points.



Note: % Urban land cover = urban + urbanizing land use

Figure 20. Median iron concentrations (2003-2007) in relation to urban land cover

1.4.8 Nickel

Nickel is an abundant element and is a naturally occurring chemical element, related to iron. It is naturally found in soils, waters, and foods, and is emitted from volcanoes. The metal is used extensively in corrosion-resistant alloys, such as stainless steel (US EPA 2006). Nickel is commonly alloyed with iron, copper, chromium, aluminum and zinc. Alloys are used in the making of metal coins and jewellery and, in industry, for making metal items. Nickel and nickel compounds are used for nickel electroplating, to colour ceramics, to make batteries, for permanent magnet materials, and as catalysts. Nickel is one of the most mobile of the heavy metals in the aquatic environment. The mobility of nickel is controlled largely by the capability of various sorbents (e.g. sediment, organic material) to bind with it and remove it from solution. Very small amounts of nickel have been shown to be essential for normal growth and reproduction in some species of animals but can be toxic at high concentrations. Nickel toxicity to aquatic organisms is determined by water hardness - the softer the water, the higher the toxicity.

Nickel results are presented in Figure 21 and Appendix B10. In a recent split sample comparison of various laboratories, results from the City of Toronto laboratory were significantly higher than other laboratories (TRCA, unpublished data), therefore, the data should be interpreted with caution. Despite the laboratory issues, all stations had median nickel concentrations lower than the PWQO of 25 μg/L. Because of the differing minimum detection limits, the relationship between median nickel concentrations and urban land cover was not analyzed.

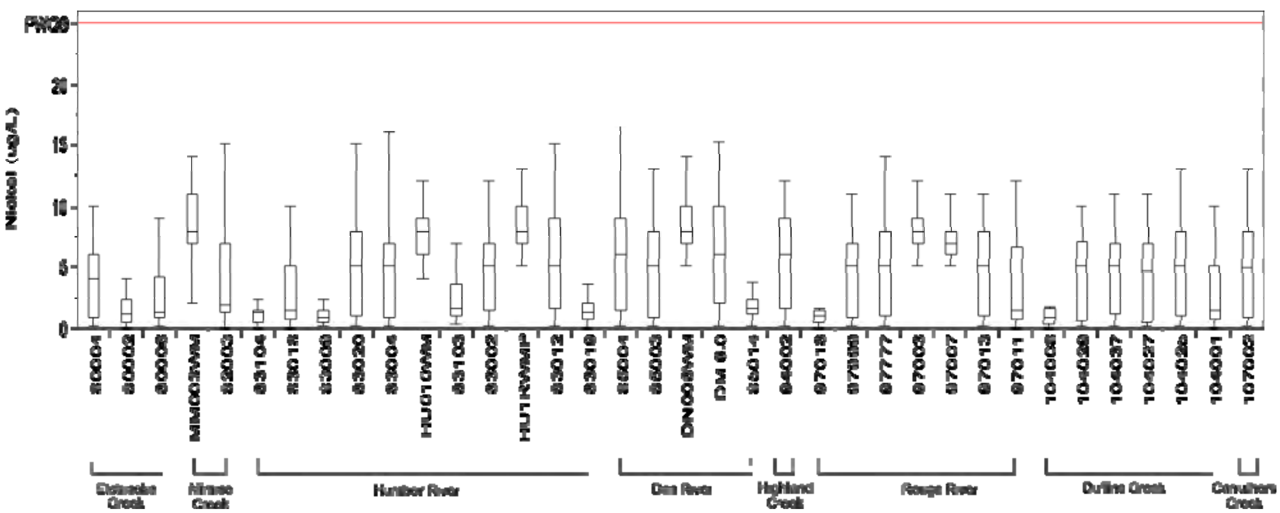


Figure 21. Nickel concentrations (μg/L) in the TRCA jurisdiction (2003-2007)

1.4.9 Zinc

Zinc is an essential trace element that is toxic to aquatic organisms at elevated levels causing increased behavioural changes and mortality as well as decreased benthic invertebrate diversity and abundance (OMOE 2003). Zinc can enter aquatic systems through aerial deposition or surface runoff. The primary use of zinc is for galvanized products for the automotive and construction industry. Sources of anthropogenic zinc include electroplaters, smelting and ore processing, domestic and industrial sewage, combustion of solid wastes and fossil fuels, corrosion of zinc alloy and galvanized surfaces and soil erosion (OMOE 2003). Aquatic organisms are exposed to both particulate and dissolved (bioavailable) forms of zinc. Zinc has a strong affinity for aquatic particles (especially organic matter) and tends to accumulate in bed sediments. A wide variety of organisms live in contact with the sediments of aquatic systems. Sediments therefore act as an important route of exposure to zinc for aquatic organisms (CCME 1999b).

Zinc results are presented in Figure 22 and Appendix B11. Three stations (MM003WM, HU1RWMP, 83012) had median zinc concentration above the interim PWQO of 20 μg/L. MM003WM is located in the Mimico Creek watershed, immediately downstream of the Pearson International Airport. HU1RWMP and 83012 are located in the Black Creek subwatershed within the Humber River watershed.

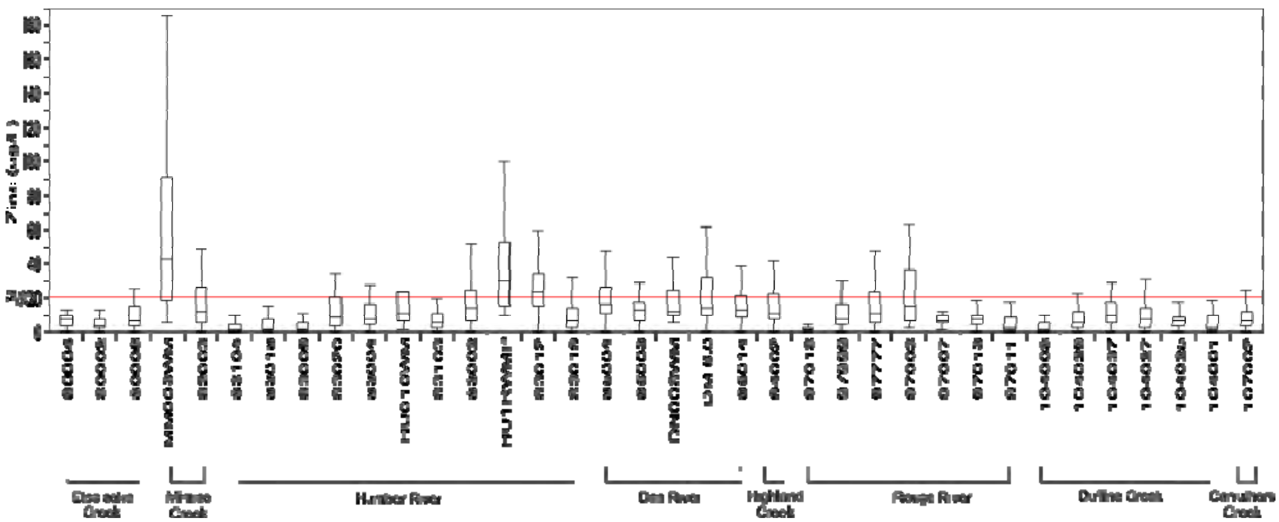
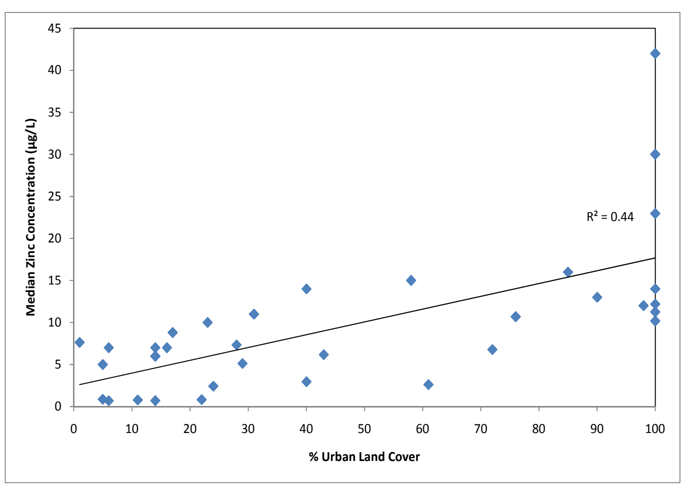


Figure 22. Zinc concentrations (μg/L) across the TRCA jurisdiction (2003-2007)

A significant increasing linear relationship exists between median zinc concentrations and urban land cover (F=26.31, p<0.01) and is shown in Figure 23. As urban land cover increases, the amount of zinc in the aquatic system also increases.



Note: % Urban land cover = urban + urbanizing land use

Figure 23. Median zinc concentrations (2003-2007) in relation to urban land cover

1.4.10 Pesticides

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. Examples of beneficial uses of pesticides include: disease prevention (e.g. killing of vector species (e.g. mosquitoes) which can transmit potentially deadly diseases such as West Nile virus, yellow fever, and malaria) and increased agricultural crop yield. Although there are benefits to the use of pesticides, there are also drawbacks, such as potential toxicity to humans and other animals.

Pesticide samples for the Don River and Humber River were collected from 1998-2002 as part of the *Occurrence of Lawn Care and Agricultural Pesticides in the Don and Humber River Watersheds* (1998-2002) report (EC *et al*. 2008). Four sites were sampled in each of the watersheds with a total of 262 samples collected over the 5-year period. Sampling frequency varied from year to year and of the 262 samples, 139 samples were described as dry events and 123 samples were wet events. Samples were analyzed at the University of Guelph for phenoxy acid herbicides, organophosphorus insecticides and carbamate pesticides. Many of these pesticides are used in both lawn care and agricultural pest control programs. In addition, samples were also analyzed for triazine herbicides which are used exclusively in agriculture.

Eleven pesticides and one metabolite were detected in surface waters of the Don and Humber Rivers or their tributaries. These included 2,4-D, atrazine, bromacil, carbofuran, chlorpyrifos, cypermethrin, diazinon, dicamba, MCPP, metolachlor, metribuzin, and an atrazine metabolite (des-ethyl atrazine). Approximately 72% of samples contained at least one pesticide attributed to lawn care.

Water quality criteria (CWQG or PWQO) were exceeded for four pesticides: diazinon, atrazine, carbofuran, and chlorpyrifos. Diazinon exceeded the PWQO for 28% of the samples taken. For the other three pesticides, less than 1% of the samples taken exceeded their respective objectives. Since diazinon was the pesticide most frequently detected above its water quality criteria, it can be suggested that the occurrence of this pesticide could have the greatest potential to impact the health of aquatic organisms.

Statistical analysis showed that concentrations and frequency of detection of pesticides were not significantly different between the upstream and downstream locations on the Don and Humber Rivers with the exception of atrazine in the Humber River watershed. Atrazine, which is used only in agriculture, was significantly elevated in the Humber River watershed at upstream locations compared to downstream locations. Atrazine was also found at statistically significant higher concentrations and more frequently in the Humber River watershed compared to the Don River watershed. The difference in watersheds may reflect land use patterns as the Humber River has more agricultural area than the Don River. Diazinon was the only pesticide to be detected more frequently during wet events compared to dry events.

Several regulatory changes have come into effect since this study was conducted. Sale of diazinon was ended in 2004 by the Pest Management Regulatory Agency of Health Canada. Use of the product was allowed for one year after the end of sales, therefore, 2006 was the first year where diazinon was no longer in use for urban lawn care. The City of Toronto passed a municipal by-law that restricts the use of pesticides by both homeowners and professional applicators for cosmetic purposes (except under circumstances of infestations) in 2004 and the Province of Ontario passed a cosmetic pesticides ban in March 2009 which came into effect in April 2009. The provincial ban prohibits the use of pesticides for cosmetic purposes on lawns, vegetable and ornamental gardens, patios, driveways, cemeteries, and in parks and school yards. There are no exceptions for pest infestations (insects, fungi or weeds) in these areas, as lower risk pesticides, biopesticides and alternatives to pesticides exist. More than 250 pesticide products are banned for sale and over 80 pesticide ingredients are banned for cosmetic uses (OMOE 2009)

1.5 Trends

The following section examines historical water quality trends within the TRCA's jurisdiction. The trend analysis is broken down into two sections: trends by parameter and trends at sentinel sites (river mouths). In both cases, data for chloride, total phosphorus and TSS are presented. Results for metals are not presented due to changes in analytical laboratory methodologies over time. Trend analysis was completed using the Mann-Kendall non-parametric test with a significance level of $p<0.1$.

1.5.1 By Parameter

Data were broken down into 5-year intervals (beginning at 2007 and working backwards) and median values for the 5-year intervals are presented. Sites with data for four or more time periods are presented. Trends were analyzed using the Mann-Kendall test with significance set as $p<0.1$.

Chloride

Trend analysis data for chloride is presented in Table 3 and Figure 24. All stations (12 of 12) showed an increasing trend for chloride concentrations ($S>0$) with 7 of the 12 stations having a statistically significant increasing trend.

There were four stations with sufficient data in the Humber River watershed. The sites range from the mouth of the Humber River to mid-way up the watershed. All sites showed an increasing trend for chloride with the trends at stations 83002 and 83004 being significant. These stations are located in the middle of the watershed. Station 83012, located at the mouth of the Black Creek, had the highest chloride concentrations of all the stations during each time period monitored. Median chloride values ranged from 276-429 mg/L from 1974-2007. These values are 4 to 7 times higher than other stations in the watershed and 8 to 15 times the median concentrations in the other watersheds sampled.

Three stations in the Don River watershed had sufficient surface water quality data for trend analysis. Two stations (85003, 85004) are located in the middle of the watershed and one station (85014) is located at the mouth of the Don River. All three stations showed an increasing trend in median chloride concentrations over time but the trends were not significant. Station 85004 showed a major increase in median chloride concentrations during the 2003-2007 sampling period. From 1968-1987, median chloride concentrations were less than 165 mg/L but the median chloride concentration more than doubled during the 2003-2007 sampling period to over 300 mg/L. This site is downstream of the Canadian Pacific Rail Vaughan Intermodal Terminal which opened in 1991 and underwent a major expansion in 2001 (Old Time Trains 2009). In addition, the area has undergone considerable urbanization over the past few decades.

There were three stations (97003, 97013, 97011) in the Rouge River watershed which had adequate chloride data for trend analyses. All three stations showed a significant increase in median chloride concentrations over time.

The Highland Creek and Duffins Creek had one station in each watershed with sufficient chloride data for trend analysis. Station 94002 at the mouth of Highland Creek and Station 104001 at the mouth of the Duffins Creek showed a significant increase in median chloride concentrations over time. The Duffins Creek site has continually had the lowest median chloride concentrations of all the sites with information. This watershed was and continues to be mainly rural (76% rural in 2002).

Table 3. Chloride trend analyses over time

		Median Chloride Concentrations in mg/L (N)											
Watershed	**Station**	**63-67**	**68-72**	**73-77**	**78-82**	**83-87**	**88-92**	**93-97**	**98-02**	**03-07**	**S**	***p***	**R^2**
Humber	83004		29 (46)	41 (53)	43 (36)	54 (54)				103 (45)	2.21	0.03*	0.98
	83002		39 (47)	41 (52)	48 (36)	61 (55)				148 (41)	2.21	0.03*	0.94
	83012			288 (45)	308 (45)	276 (54)				429 (43)	0.34	0.73	0.83
	83019						100 (236)	114 (273)	113 (105)	160 (111)	1.02	0.31	0.77
Don	85004		145 (47)	165 (53)	106 (43)	111 (54)				332 (42)	0.25	0.81	0.64
	85003		73 (47)	110 (53)	88 (46)	68 (53)				**172** (42)	0.25	0.81	0.64
	85014						**158** (250)	**177** (278)	148 (101)	**207** (111)	0.34	0.73	0.35
Highland	94002			140 (67)	**155** (62)	**199** (58)	**209** (58)			**306** (41)	2.21	0.03*	0.98
Rouge	97003		55 (34)	64 (48)	55 (57)	64 (59)	80 (52)				1.71	0.09*	0.62
	97013				39 (54)	40 (58)	56 (58)			81 (31)	1.70	0.09*	0.97
	97011				63 (56)	69 (59)	82 (58)			**167** (46)	1.70	0.09*	0.95
Duffins	104001	14 (44)	15 (87)	20 (67)	21 (57)	22 (58)	36 (59)	39 (33)		53 (37)	3.34	<0.01*	0.92

Notes: * = significant $p<0.1$
Bolded values indicate exceedance of 150 mg/L objective

Total Phosphorus

Trend analyses for total phosphorus are presented in Table 4 and Figure 25. With the exception of two stations (83004, 97013), the remaining stations showed a decrease in total phosphorus over time (S<0). Seven of the ten stations with decreasing trends had statistically significant trends ($p<0.1$). Station 830045, located at the mouth of the East Humber River, had relatively similar median total phosphorus concentrations from 1965-2008 (0.02-0.04 mg/L).

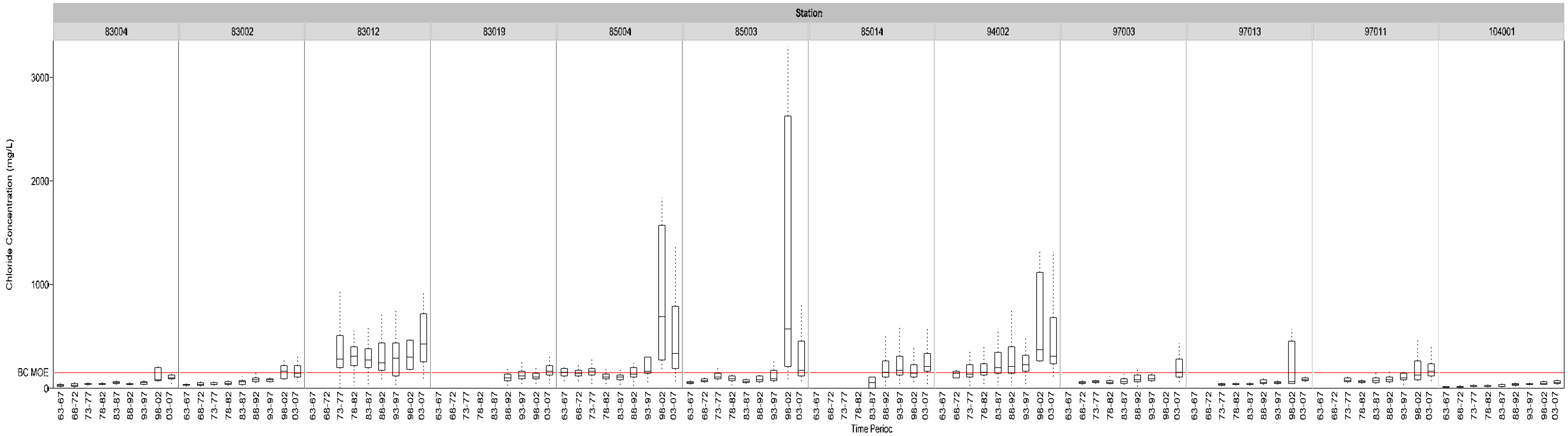


Figure 24. **Chloride concentrations (mg/L) over time**

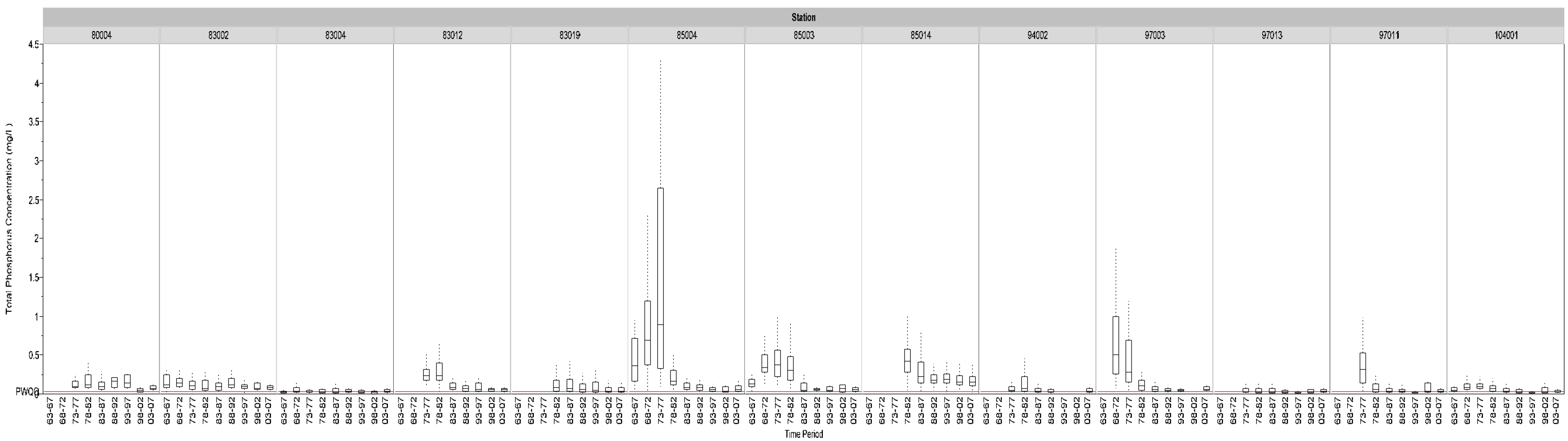


Figure 25. **Total phosphorus concentrations (mg/L) over time**

The East Humber subwatershed continues to be mainly agricultural and the total phosphorus concentrations may not have decreased over time due to the use of fertilizers in this area. Station 97013 located at the mouth of Little Rouge Creek, near the outlet of the Rouge River, showed a slight increasing trend over time but the trend was not significant. The median chloride concentrations at this site were quite similar over time ranging from 0.02 to 0.03 mg/L.

The majority of the median values are above the PWQO of 0.03 mg/L. In general, total phosphorous concentrations have decreased over time. Most stations are currently only slightly above the PWQO with three stations (97013, 97011, 104001) at the PWQO. Station 85014 near the mouth of the Don River is an exception to this. The median total phosphorous concentration for 2003-2007 was 0.15 mg/L which is 5 times the PWQO. Station 85014 is located downstream of the North Toronto wastewater treatment plant.

Table 4. Total phosphorus trend analyses over time

		Median Total Phosphorus Concentrations in mg/L (N)											
Watershed	**Station**	**63-67**	**68-72**	**73-77**	**78-82**	**83-87**	**88-92**	**93-97**	**98-02**	**03-07**	**S**	***p***	**R^2**
Etobicoke	80004			**0.10** (47)	**0.12** (37)	**0.09** (54)				**0.07** (56)	-1.02	0.30	0.71
Humber	83002		**0.14** (47)	**0.11** (52)	**0.07** (45)	**0.09** (55)				**0.08** (62)	-1.23	0.22	0.42
	83004		**0.04** (46)	0.02 (53)	0.03 (45)	0.02 (54)				**0.04** (66)	0.00	1.00	0.13
	83012			**0.23** (45)	**0.23** (46)	**0.08** (55)				**0.06** (65)	-1.70	0.09*	0.68
	83019				**0.08** (116)	**0.07** (108)	**0.06** (263)	**0.05** (272)	**0.04** (106)	**0.04** (134)	-2.25	0.02*	0.94
Don	85004		**0.69** (47)	**0.89** (53)	**0.17** (43)	**0.09** (54)				**0.06** (60)	-1.71	0.09*	0.53
	85003		**0.34** (47)	**0.38** (54)	**0.31** (46)	**0.05** (53)				**0.06** (62)	-1.22	0.22	0.65
	85014				**0.43** (114)	**0.23** (102)	**0.18** (267)	**0.19** (275)	**0.16** (101)	**0.15** (121)	-2.25	0.02*	0.66
Highland	94002			**0.04** (67)	**0.07** (62)	0.03 (57)	0.03 (58)			**0.04** (60)	-0.73	0.46	0.10
Rouge	97003		**0.50** (35)	**0.28** (48)	**0.10** (57)	**0.06** (59)	**0.05** (52)				-2.20	0.03*	0.85
	97013			0.03 (59)	0.02 (55)	0.02 (59)	0.03 (58)			0.03 (49)	0.73	0.46	0.43
	97011			**0.32** (62)	**0.06** (56)	**0.04** (59)	0.03 (58)			0.03 (67)	-1.71	0.09*	0.41
Duffins	104001	**0.05** (45)	**0.09** (88)	**0.09** (67)	**0.07** (57)	**0.04** (58)	0.03 (59)	0.02 (34)		0.03 (40)	-1.86	0.06*	0.54

Notes: * = significant $p<0.1$

Bolded values indicate exceedance of 0.03 mg/L objective

Total Suspended Solids

Trend analyses for TSS concentrations are presented in Table 5 and Figure 26. With the exception of one site (85003), the remaining stations showed a decreasing trend in TSS concentrations (S<0). Station 83019 at the mouth of the Humber River and Station 85014 at the mouth of the Don River both had statistically significant decreasing trends in TSS concentrations.

Table 5. Total suspended solids (TSS) trend analyses over time

		Median TSS Concentrations in mg/L (N)											
Watershed	**Station**	**63-67**	**68-72**	**73-77**	**78-82**	**83-87**	**88-92**	**93-97**	**98-02**	**03-07**	**S**	***p***	**R^2**
Humber	83019				24 (114)	23 (107)	19 (266)	20 (272)	10 (104)	8 (109)	-2.25	0.02*	0.85
Don	85004		30 (47)	**35** (45)						10 (43)	0.00	1.00	0.90
	85003		20 (47)	28 (46)	25 (31)					6 (43)	-0.34	0.73	0.73
	85014				22 (113)	18 (101)	17 (254)	14 (278)	11 (99)	11 (108)	-2.25	0.02*	0.94
Highland	94002			22 (56)	24 (59)	7 (56)	9 (54)			4 (43)	-1.22	0.22	0.68
Duffins	104001	20 (45)	19 (87)	22 (63)	20 (36)					9 (36)	-0.49	0.62	0.79

Notes: * = significant $p<0.1$
Bolded values indicate exceedance of 30 mg/L objective

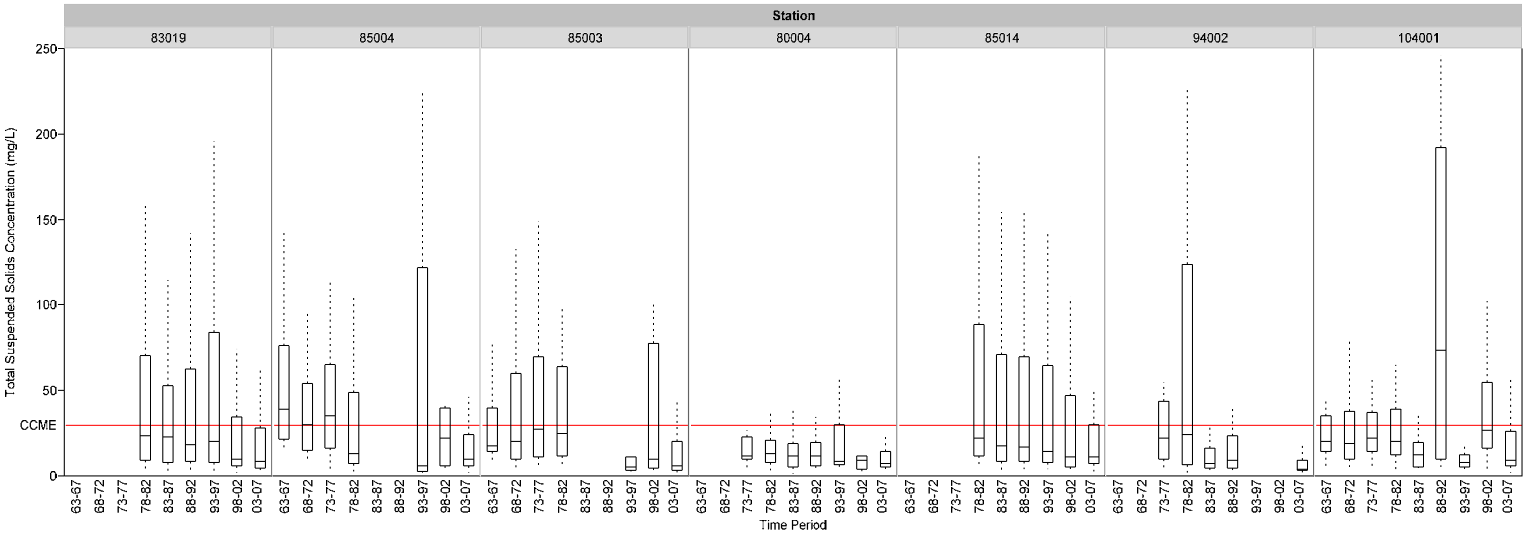


Figure 26. Total suspended solids (TSS) concentration (mg/L) over time

1.5.2 By Watershed Mouths

Data (n>30 for 5-year intervals) were available for five sites located at the mouths of Humber River (83019), Don River (85014), Highland Creek (94002), Rouge River (97011) and Duffins Creek (104001). Watershed mouths are important sentinel sites because the incorporate the water quality of all the incoming tributaries at a single point before the water enters Lake Ontario.

Total Suspended Solids

TSS results are the mouths of the Humber River, Don Diver, Highland Creek and Duffins Creek are presented in Figure 27. All stations had median values below the CCME derived guideline of 30 mg/L for all time periods. All stations showed decreasing trend in TSS concentrations over time (Figure 28) but only the Humber and Don River mouths trends were statistically significant (Table 6). The non-significant trend at the Duffins Creek site was most likely due to the lack of data from 1983-2002.

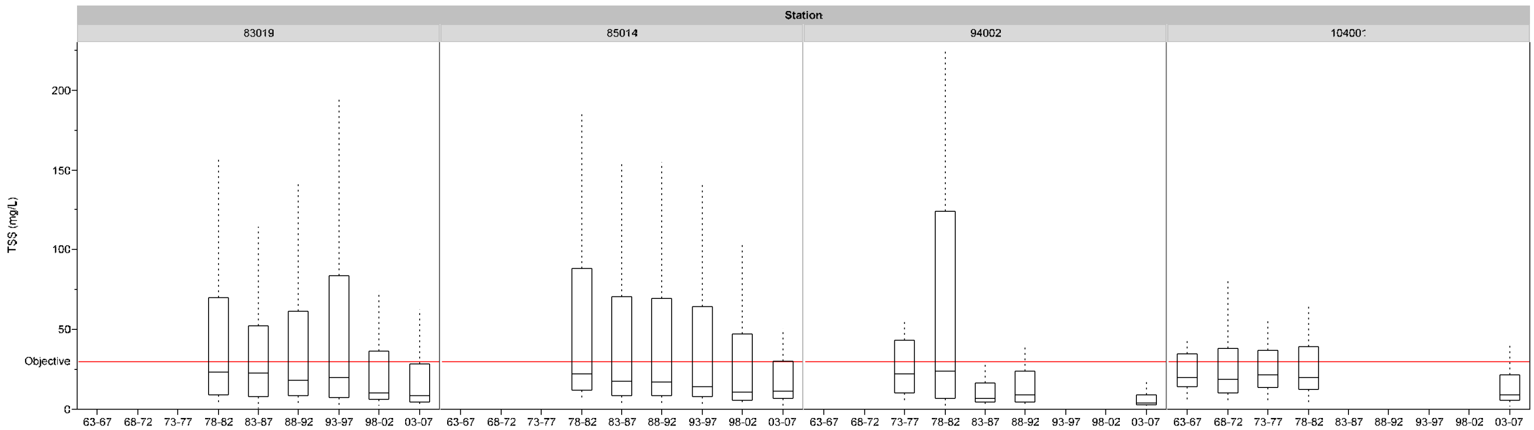
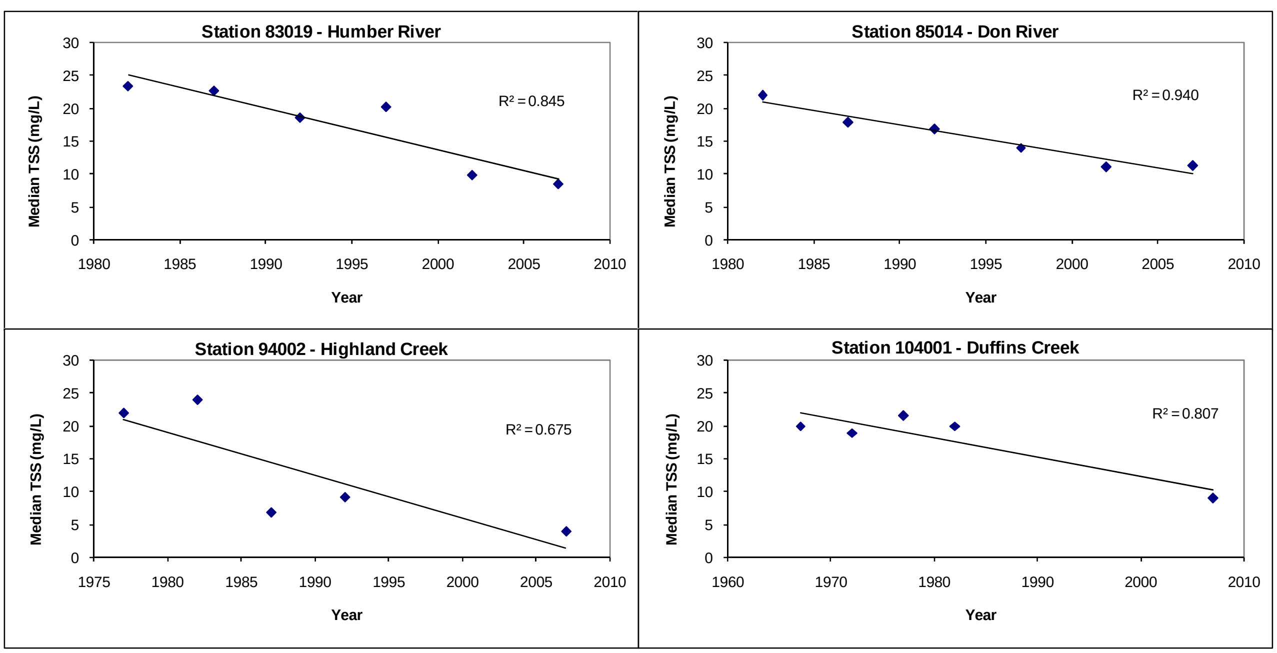


Figure 27. Total suspended solids (TSS) concentrations for the mouths of the Humber River (83019), Don River (85014), Highland Creek (94002), and Duffins Creek (104001) over time

Table 6. Mann-Kendall and regression statistics for TSS trend analysis

		Mann-Kendall		Regression
Watershed	**Station**	**S**	***p***	**R^2**
Humber River	83019	-2.25	0.02*	0.85
Don River	85014	-2.25	0.02*	0.94
Highland Creek	94002	-1.22	0.22	0.68
Duffins Creek	104001	-0.49	0.62	0.81

* = significant (p<0.1)



Note: Y-axis values differ amongst stations

Figure 28. Median total suspended solids (TSS) trend over time at the mouths of the Humber River, Don River, Highland Creek, and Duffins Creek

Chloride

Chloride results are presented in Figure 29 for the mouths of the Humber River (83019), Don River (85014), Highland Creek (94002), Rouge River (97011), and Duffins Creek (104001). All five stations showed an increasing trend in chloride concentrations (Figure 30). Highland Creek, Rouge River and Duffins Creek all had statistically significant increasing trends. The lack of significance at the Humber River and Don River sites is most likely due to the lack of data (only four sampling points). With the exception of the Duffins Creek watershed, the median chloride concentration exceeded the BC MOE water quality objective of 150 mg/L for at least one time period. The first watersheds to exceed the median chloride concentrations of 150 mg/L were the Don River (1988-1992) and Highland Creek (1978-1982) stations. Figure 29 shows that the 2003-2007 time period was the first time that the mouths of the Humber and Rouge Rivers exceeded the 150 mg/L objective. The median chloride concentration at the Duffins Creek site ranged from 14 mg/L from 1963-1967 to 53 mg/L from 2003-2007. It is important to note that winter samples (when chloride concentrations are expected to be the highest due to road salting activities) were not collected during every time period. At the Duffins Creek site, winter sampling began in 1965. Winter samples were collected at the Rouge River and Highland Creek beginning in the mid-1970s and winter sampling did not start at the Humber River and Don River stations until 1990. This suggests that median chloride concentrations may be higher than what is presented in Figures 29 and 30 during periods when winter sampling did not occur.

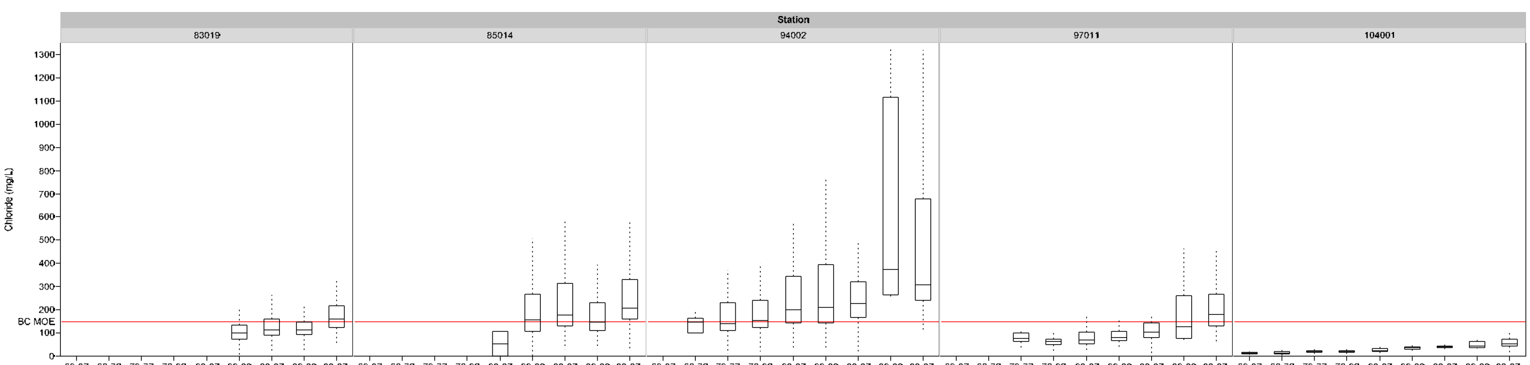
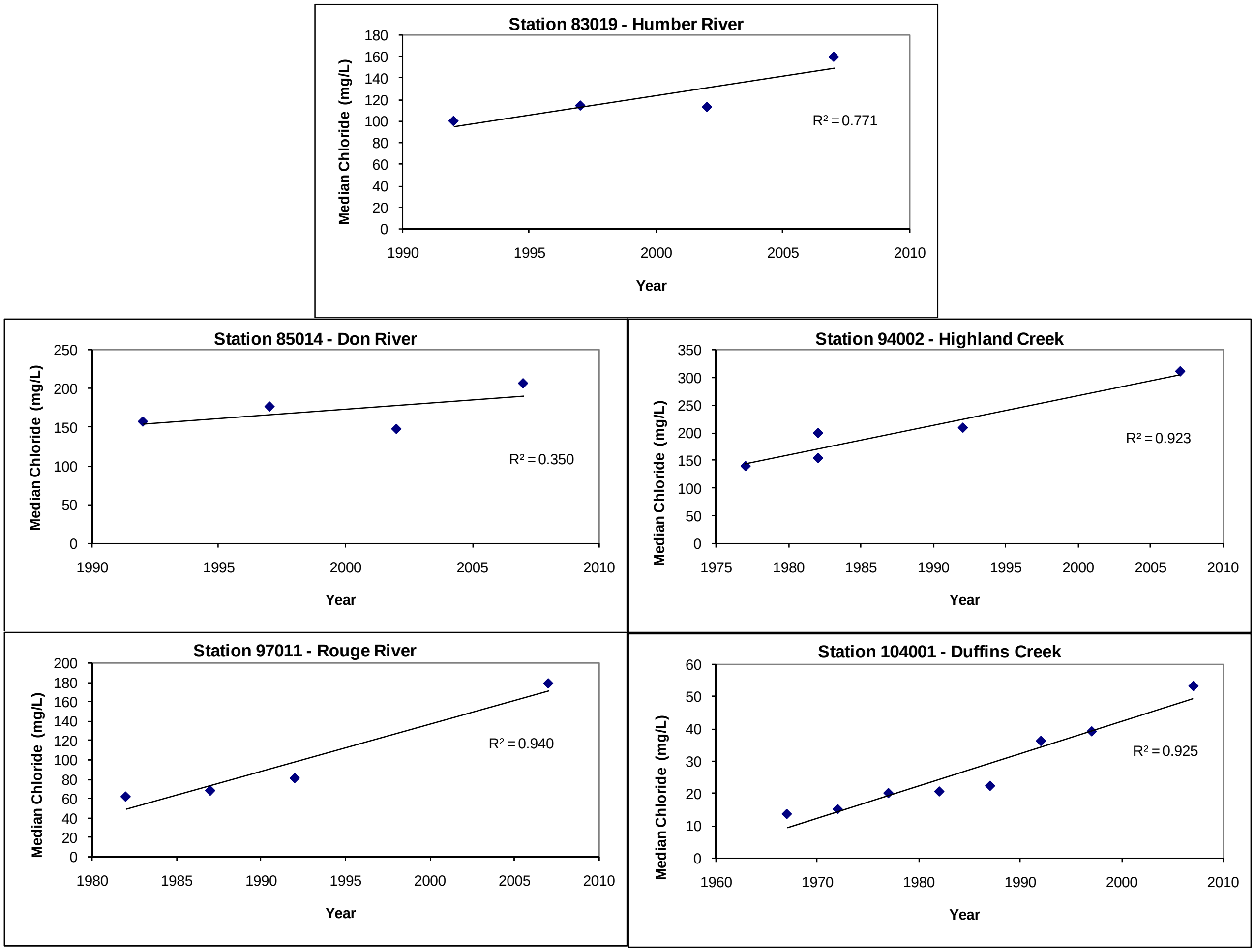


Figure 29. Chloride concentrations for the mouth of the Humber River, Don River, Highland Creek, Rouge River and Duffins Creek over time



Note: Both X- and Y-axis values differ amongst stations

Figure 30. Median chloride trends over time at the mouths of the Humber River (83019), Don River (85014), Highland Creek (94002), Rouge River (97011), and Duffins Creek (104011)

Table 7. Mann-Kendall and regression statistics for chloride trend analysis based on median values at 5-year intervals

		Mann-Kendall		Regression
Watershed	**Station**	**S**	***p***	**R^2**
Humber River	83019	1.02	0.31	0.77
Don River	85014	0.34	0.73	0.35
Highland Creek	94002	2.20	0.03*	0.93
Rouge River	97011	1.70	0.09*	0.94
Duffins Creek	104001	3.34	<0.01*	0.93

* = significant ($p<0.1$)

Total Phosphorus

Total phosphorus concentrations for the mouth of the Humber River (83019), Don River (85014), Highland Creek (94002), Rouge River (97011) and Duffins Creek (104001) are presented in Figure 31. All five watersheds have shown significant decreases in phosphorous since the 1970s and 1980s (Figure 32). With the exception of Highland Creek, the decreasing trends in phosphorus concentrations at the other four stations were significant (Table 8). The reduction in phosphorus is associated with the decommissioning of several sewage treatment plants within the TRCA's jurisdiction. Total phosphorus concentrations at the Don River station (85014) were significantly higher than those recorded at any other station. This is due to the North Toronto wastewater treatment plant (operated by the City of Toronto) which is located upstream of the monitoring station. The Duffins Creek station (104001) was the only station to have a median total phosphorus concentration below the PWQO of 0.03 during the most recent time period (2003-2007).

Nutrient enrichment continues to be a significant problem in Lake Ontario. Historically, large phosphorus loads were contributed to the lake water which had limited assimilative capacity. Previously (prior to the 1980s), there was a problem with lake shore fouling with the green alga *Cladophora*. Recently, *Cladophora* problems have returned and it is possible that phosphorus levels are increasing locally along some areas of shoreline and contributing to the enhanced growth of algae (OMOE 2009). This appears to be the case for the mouth of the Highland Creek, Rouge River and Duffins Creek which all showed slight increases in median phosphorus concentrations during the 2003-2007 time period. Caution should be taken when interpreting these results as several laboratories conducted the phosphorus analysis and may have had varying analytical detection limits.

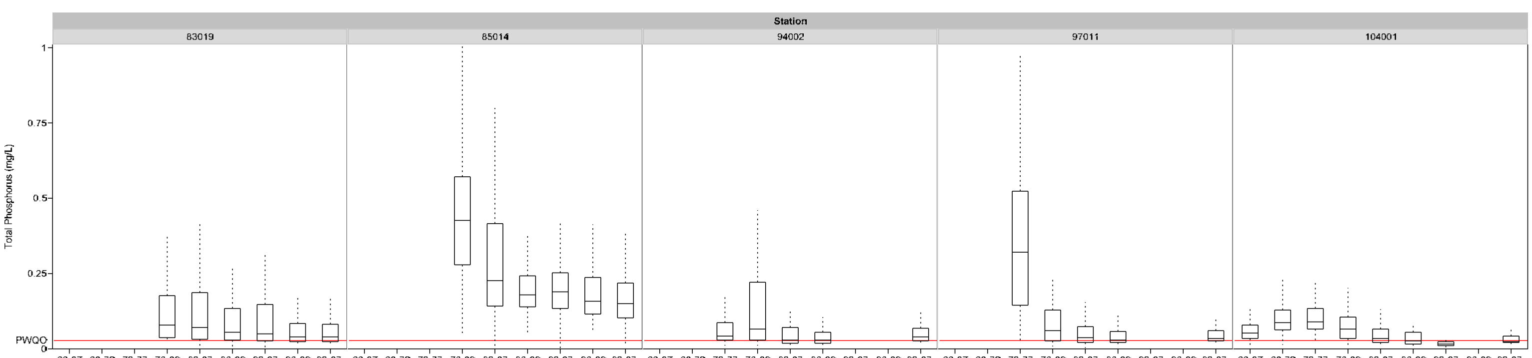
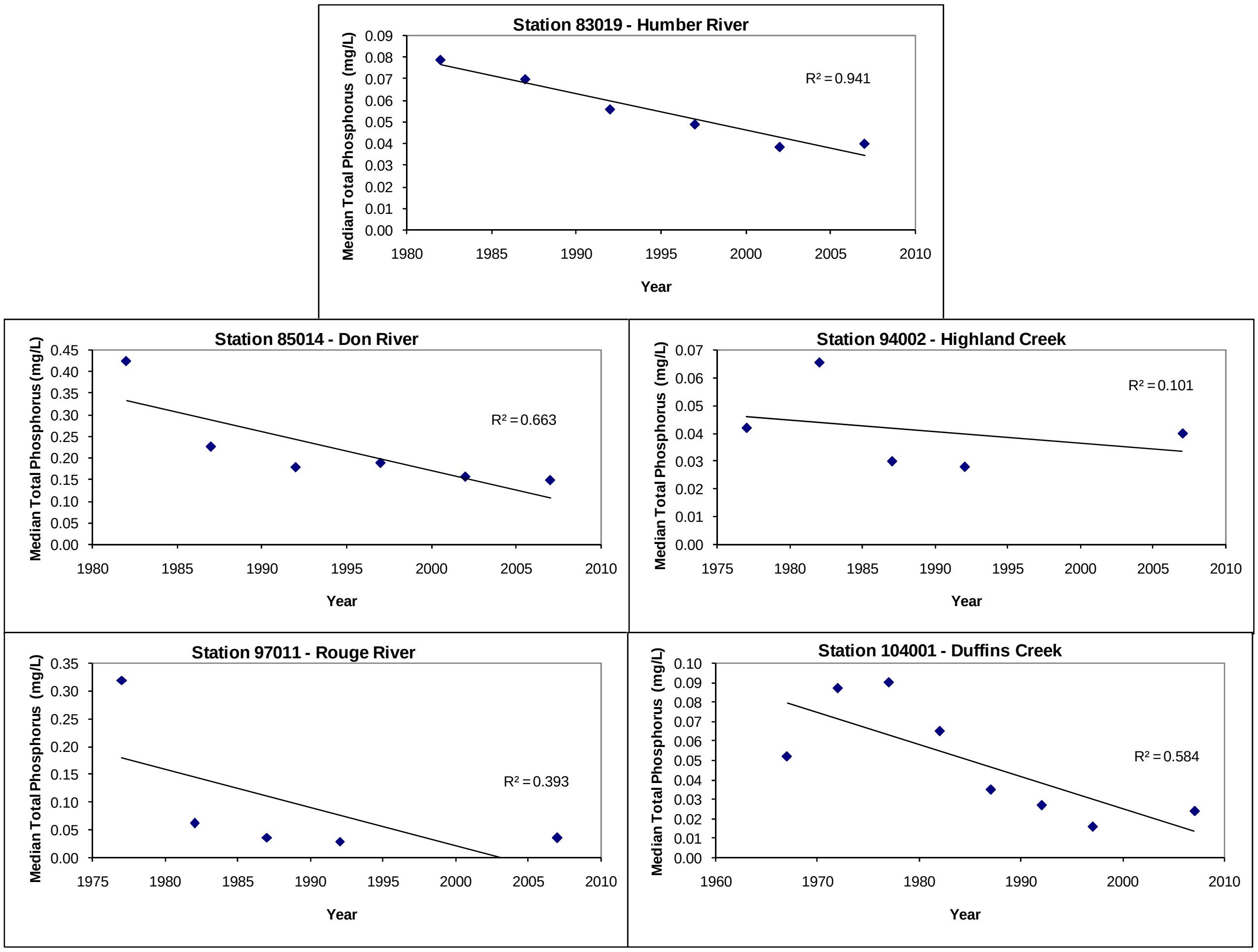


Figure 31. Total phosphorus concentrations for the mouth of the Humber River (83019), Don River (85014), Highland Creek (94002), Rouge River (97011) and Duffins Creek (104001) over time



Note: Both *X- and Y-axis values differ amongst stations*

Figure 32. Median total phosphorus trends over time at the mouths of the Humber River, Don River, Highland Creek, Rouge River, and Duffins Creek

Table 8. Mann-Kendall and regression statistics for total phosphorus trend analysis based on median values at 5-year intervals

		Mann-Kendall		Regression
Watershed	**Station**	**S**	***p***	**R^2**
Humber River	83019	-2.25	0.02*	0.94
Don River	85014	-2.25	0.02*	0.66
Highland Creek	94002	-0.73	0.46	0.10
Rouge River	97011	-1.71	0.09*	0.39
Duffins Creek	104001	-2.10	0.04*	0.58

* = significant (p<0.1)

1.6 Summary

Surface water quality for the Toronto and Region Conservation Authority's jurisdiction has been analyzed several times (e.g. TRCA 1998, TRCA 2003) with the general conclusion that water quality issues are correlated to the amount of urbanization within a watershed. The 2003-2007 results are consistent with this broad finding. The Duffins Creek watershed along with the upper Humber River and Rouge River continue to exhibit the best water quality within the TRCA's jurisdiction; lower levels of urbanization, larger riparian buffers, and groundwater contributions may play a role in the water quality in these areas.

TSS

- TSS concentrations were elevated in the mid-reaches of the Humber River and Rouge River
- There was no relationship between TSS concentrations and urban land cover
- TSS concentrations have decreased (↓) over time

Chloride

- Median chloride concentrations for 44% of the sites monitored exceeded the suggested 150 mg/L objective
- The median at two sites (5% of total) exceeded the BC MOE 600 mg/L maximum objective
- Numerous individual sampling points often exceeded the maximum 600 mg/L objective
- Median chloride concentrations were highest at station 82003 at the mouth of the Mimico Creek and lowest in the Duffins Creek watershed and the upper reaches of the Humber River
- Chloride concentrations have increased (↑) over time

Total Phosphorus

- Median phosphorus concentrations for 77% of the sites monitored exceeded the interim PWQO of 0.03 mg/L
- High levels of total phosphorus and unionized ammonia were measured at the mouth of the Don River (station 85014), downstream of the North Toronto wastewater treatment plant
- There was an exponential relationships between total phosphorus and urban land cover
- Total phosphorus has decreased (↓) over time

Nitrogen Compounds

- All stations had nitrate values less than the CWQG of 2.93 mg/L
- Median nitite concentrations at all stations were below the BC MOE objective of 0.6 mg/L
- With the exception of one site, all stations had median unionized ammonia values less than the PWQO of 0.02 mg/L
- Station 85014, located at the mouth of the Don River, had elevated concentrations of nitrite and unionized ammonia which can be toxic to aquatic organisms
- An exponential relationship existed between all three nitrogen compounds (nitrate, nitrite and unionized ammonia) and urban land cover

E. coli

- Median *E. coli* levels at 89% of the sites monitored were above the PWQO of 100 CFU/100 mL
- Individual sampling points often exceeded 20 000 CFU/100 mL at many sites; high *E. coli* loadings from tributaries may contribute to waterfront beach closings
- The lowest *E. coli* concentrations were in the Duffins Creek and the upper reaches of the Humber River and Rouge River where urbanization is lowest
- *E. coli* had exponential relationships with urban land cover

Metals

- Iron was the metal which most commonly exceeded its PWQO with 55% of the median values exceeding the PWQO
- Nickel was below the PWQO for all sites
- Median copper and zinc concentrations exceeded their respective PWQO at three sites: MM003WM in the Mimico watershed downstream of Pearson International Airport and HU1RWMP and 83012 which are both in the Black Creek subwatershed of the Humber River watershed
- Copper and zinc had positive linear relationships with urban land cover
- Iron had exponential relationships with urban land cover

Pesticides

- Eleven pesticides and one metabolite were detected in the surface waters of the Don and Humber Rivers from 1998-2002
- Approximately 72% of the samples contained at least one pesticide attribute to lawn care
- Diazinon exceeded the PWQO of 0.08 μg/L for 28% of samples and diazinon was detected more frequently during wet events compared to dry events

General

The assessment of long-term water quality changes across a large region is a challenging task. Differences in the number of samples collected, the parameters analyzed, the analytical capabilities of laboratories completing the analysis, improvements in laboratory analysis techniques (e.g. lower detection levels) and varying stream flow complicate water quality analysis. Several of these factors confounded water quality analysis within the TRCA's jurisdiction. For example, the majority of the results for lead and cadmium, two metals commonly associated with urbanization, did not have low enough detection limits to compare against the PWQO.

Storm runoff is one of the main contributors to degraded water quality. Separation of wet weather flow (i.e. storm flow) from base flow samples should be completed to quantify and characterize the inputs from non-point source pollution (e.g. storm runoff). Currently only 14 of the 36 monitoring sites have associated with stream flow monitoring. Sampling is completed more frequently at the mouth of the Humber and Don Rivers, two stations which do have associated flow monitoring. These stations could be used as sentinel stations for the TRCA's jurisdiction. Detailed water quality and quantity analysis could be performed at these two stations to help determine the success of investments and efforts by governments, industry and individuals to protect the water quality in the Toronto region. For example, several initiatives including watershed planning, natural channel design, erosion controls, and stormwater management have all been instituted within the last twenty years. In essence, several multi-disciplinary actions have been taken to address the quality and quantity of urban runoff as it reaches our stream and rivers. By performing detailed water quality and quantity analysis at these two sites, responses to these efforts to protect water quality in the Toronto region may be revealed. In 2008/2009, the City of Toronto in partnership with the TRCA, installed several wet weather flow monitoring stations. These stations consist of automated water samplers which are triggered by flow events. This project will increase the understanding of wet weather flow within the City of Toronto and help to assess the benefits of initiatives being carried out through the Wet Weather Flow Management Master Plan.

Overall, the monitoring results presented in this report show that water quality is linked to the amount of urbanization upstream of a monitoring station. Non-point sources of contamination from urbanization continue to be the largest contaminant contributor to water within the TRCA's jurisdiction. Point sources of contamination such as wastewater treatment plants and Pearson International Airport also contribute to the degradation of water quality in the Toronto area. Certain contaminants (e.g. TSS, total phosphorus) have decreased over the past twenty years while chloride concentrations show an increasing trend. Continued routine efforts such as the treatment of urban runoff via stormwater ponds as well as innovative actions (e.g. biophosphorus removal at wastewater treatment) are required to maintain and improve the water quality in the Toronto region.

1.7 References

British Columbia Ministry of the Environment (BC MOE). 2008. *Ambient Water Quality Guidelines for Iron*. http://www.env.gov.bc.ca/wat/wq/BCguidelines/iron/iron_tech.pdf. Accessed April 8, 2008.

British Columbia Ministry of the Environment (BC MOE). 2003. *Ambient Water Quality Guidelines for Chloride - Overview Report*. http://www.env.gov.bc.ca/wat/wq/BCguidelines/chloride/chloride.html. Accessed March 30, 2008.

Canadian Council of Ministers of the Environment (CCME), 2007. *Summary of Canadian water quality guidelines for the protection of aquatic life*. In: Canadian Environmental Quality Guidelines, 2007, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment (CCME), 2004. *Canadian water quality guidelines for the protection of aquatic life: Phosphorus*. In: Canadian Environmental Quality Guidelines, 2004, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment (CCME), 2003. *Canadian water quality guidelines for the protection of aquatic life: Nitrate Ion*. In: Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment (CCME), 2002. *Canadian water quality guidelines for the protection of aquatic life: Total particulate matter*. In: Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment (CCME), 2000. *Canadian water quality guidelines for the protection of aquatic life: Ammonia*. In: Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment. 1999a. *Canadian sediment quality guidelines for the protection of aquatic life: Copper*. In: Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment. 1999b. *Canadian sediment quality guidelines for the protection of aquatic life: Zinc*. In: Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Centre for Disease Control (CDC). 2008. U.S. Centre for Disease Control and Prevention. Atlanta, GA. http://www.cdc.gov/nczved/dfbmd/disease_listing/stec_gi.html. Accessed April 2, 2009.

Environment Canada, Health Canada, Statistics Canada. 2008a. Canadian *Environmental Sustainability Indicators 2007: Freshwater Quality Indicator Data Sources and Methods*. Ottawa, ON.

Environment Canada, Ontario Ministry of the Environment, City of Toronto. 2008b. *Occurrence of Lawn Care and Agricultural Pesticides in the Don and Humber River Watersheds (1998-2002)*. Prepared for the 2002 Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem. Toronto, ON.

Environment Canada (EC). 2004. Canadian Guidance Framework for the management of phosphorus in freshwater systems. Scientific Supporting Document, National Guidelines and Standards Office, Water Policy and Coordination Directorate, Environment Canada, Ottawa, ON.

Environment Canada (EC). 2005. *Recommended Water Quality Guidelines for the Protection of Aquatic Life for Use in the 2005 National Water Quality Indicators under the Canadian Environmental Sustainability Indicators (CESI) Initiative* [draft]. National Guidelines and Standards Office, Environment Canada, Gatineau, Quebec. June 23, 2005.

Environment Canada & Health Canada (EC & HC). 2001. *Priority Substance List Assessment Report: Ammonia in the Aquatic Environment*. ISBN: 0-662-29192-1.

Finkekenbine JK, Atwater JW, Mavinic DS. 2000. *Stream health after urbanization*. Journal of the American Water Resources Association 36:1149-1160.

Gilbert, RO. 1987. *Statistical methods for environmental pollution monitoring.* Van Nostrand Reinhold: New York, NY.

Old Time Trains. 2007. http://trainweb.org/oldtimetrains/CPR_Bruce/vaughan.htm. Accessed October 5, 2009.

Ontario Ministry of the Environment (OMOE). 2009. *Water Quality in Ontario Report 2008*. Queen's Printer for Ontario. Toronto, ON.

Ontario Ministry of the Environment (OMOE). 2009. http://www.ene.gov.on.ca/en/news/2009/030401mb.php. Accessed September 23, 2009.

Ontario Ministry of the Environment (OMOE). 2003. *Water Sampling and Data Analysis Manual for Partners in the Ontario Provincial Water Quality Monitoring Network*.

Ontario Ministry Environment and Energy (OMOEE). 1994. *Policies Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy*. Queen's Printer for Ontario. Toronto, ON.

Toronto and Region Conservation Authority (TRCA). 2003. *A Summary of Water Quality Data in the Region from 1996 to 2002*. Toronto, ON.

Toronto and Region Conservation Authority (TRCA). 1998. *1990-1996 Water Quality Data for the Toronto RAP Watershed*. Toronto, ON.

United States Environmental Protection Agency (US EPA). 2006. Technical Fact Sheet: Nickel. http://www.epa.gov/ogwdw/dwh/t-ioc/nickel.html. Accessed April 8, 2009.

APPENDIX A

Appendix A – Current Site Descriptions

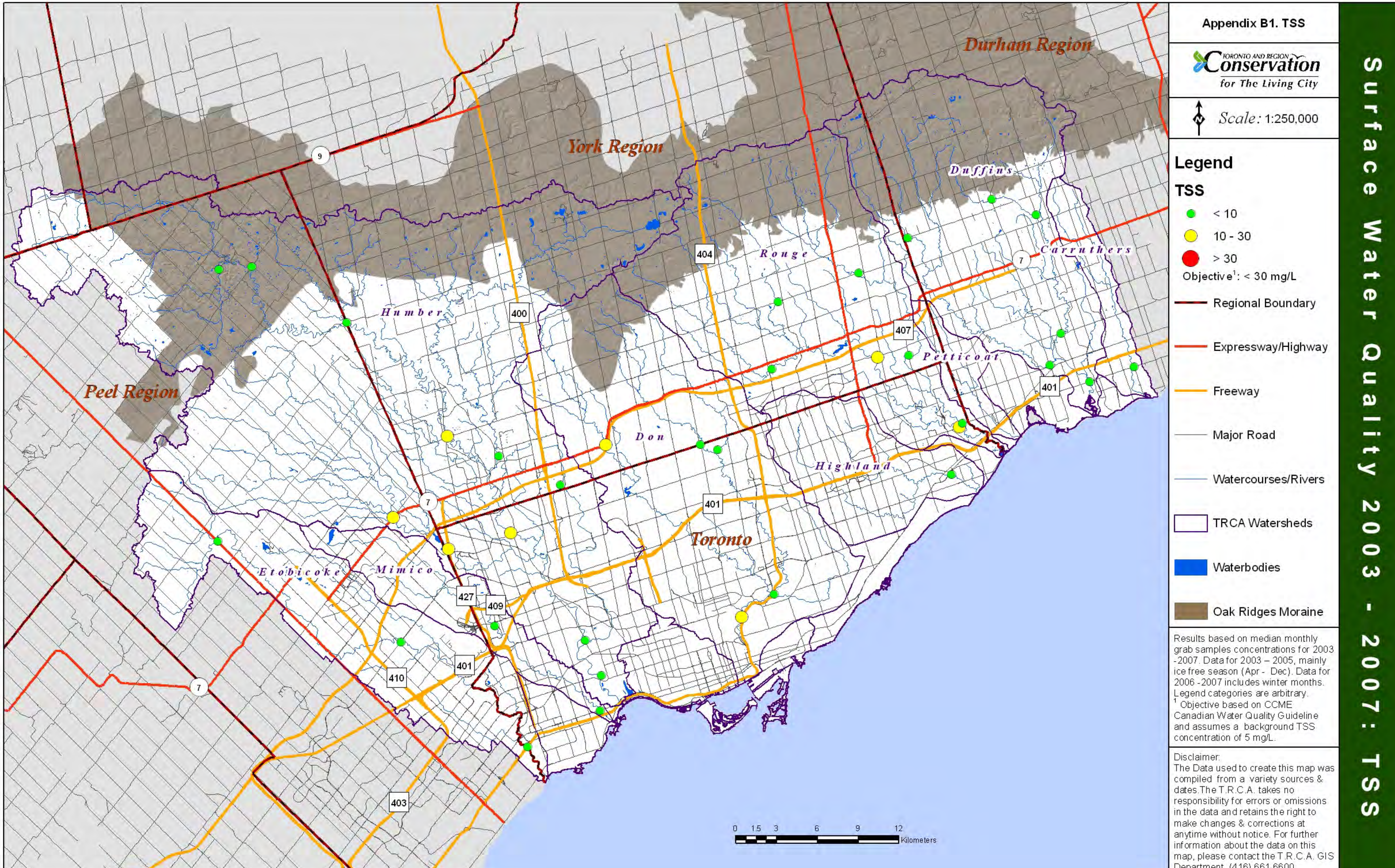
Watershed	Station	Alternate Name	Northing	Easting	Subwatershed	Township	Municipality	Location Description	Flow Station	Proprietor	Period of Record	Longest Continuous Record (Approx. Years)[1]	Stream Order[2]	% Urban Land Cover[3]
Etobicoke Creek	80007	06008000702/E14.9	4836746	606933	Upper Etobicoke Creek	Mississauga	Peel	Northwest of Derry Rd and Dixie Rd, Mississauga		PWQMN	2003-2009	6	6	40
	80006	06008000602/E2.8	4829016	616234	Lower Etobicoke Creek	Toronto	Toronto	Southwest of the QEW and Brown's Line	02HC030	PWQMN	2002-2009	7	6 (mouth)	72
	80004	Mayfield/06008000402/E28.2	4843488	595028	Upper Etobicoke Creek	Brampton	Peel	Southeast of Mayfield Road and Hwy 10		RWMP	1973-1988, 1991-1995, 2002-2009	15	6	1
Mimico Creek	MM003WM	MM003WM	4837916	613849	Lower Mimico	Toronto	Toronto	Southwest of Dixon Rd. and Hwy 27, in Royal Woodbine Golf Club		City of Toronto	2006-2009	3	3	100
	82003	06008200302/M1.4	4831713	621585	Lower Mimico	Toronto	Toronto	Southwest of Park Lawn Rd. and The Queensway, Etobicoke		PWQMN	1994-1995, 2001-2009	8	3 (mouth)	100
Humber River	83002	06008300202/HW16.9	4843562	610459	West Humber River	Toronto	Toronto	Northeast of Hwy 427 and Finch Ave., downstream (east) of Claireville dam outlet	02HC034	City of Toronto	1966-1988, 1991-1993, 1996-1997, 2001-2009	22	6	40
	83012	06008301202/HB5.6	4836845	620488	Black Creek	Toronto	Toronto	Northeast of Scarlett Rd. and St. Clair Ave.	02HC027	City of Toronto	1974-1988, 1991-1993, 1996-1997, 2001-2009	14	3	100
	HU010WM	HU010WM	4844744	615027	Lower Main Humber	Toronto	Toronto	Northwest of Finch Ave. and Islington Ave. in Rowntree Mills Park		City of Toronto	2006-2009	3	7	31
	HU1RWMP	HU1RWMP	4848311	618678	Black Creek	Vaughan	York	Northwest of Steeles Ave. and Jane St.		City of Toronto	2006-2009	3	3	100
	83009	06008300902/H35.0	4860243	602980	Main Humber	King	York	Northeast of King Rd. and Caledon-King Townline	02HC023	PWQMN	1969-1971, 2002-2009	7	6	22
	83018	06008301802/H42.5	4864329	595961	Main Humber	Caledon	Peel	Southwest of Old Church Rd. and Hwy 50, downstream Albion Hills CA	02HC012	PWQMN	1975-1988, 1991-1997, 2001-2009	13	6	11
	83019	06008301902/H2.9	4834265	621663	Lower Main Humber	Toronto	Toronto	Northwest of Old Mill Dr. and Old Mill Rd. in Etobicoke	02HC003	PWQMN	1979-2009	30	7 (mouth)	43
	83103	06008310302/HW22.0	4845870	606385	West Humber River	Brampton	Peel	Northwest of Hwy 7 and McVean Dr, upstream (north) of Claireville	02HC031	PWQMN	2002-2009	7	5	29
	83104	06008310402/H43.9	4864112	593560	Main Humber	Caledon	Peel	Northwest of Old Church Rd. and Hwy 50, in Albion Hills CA, at blue gauge station	02HC051	PWQMN	2002-2009	7	5	14
	83004	06008300402/HE20.7	4850423	614148	East Humber River	Vaughan	York	At bridge Pine Grove Rd, west of Pine Valley Dr, Woodbridge	02HC009	RWMP	1965-1988, 1991-1997, 2001-2009	23	6	28
	83020	06008302002/H23.9	4851861	610386	Main Humber	Vaughan	York	Northeast of Rutherford Rd. and Hwy 27 at first bridge		RWMP	1996, 2001-2009	8	7	17
Don River	85003	06008500302/DE17.9	4851256	628954	Upper East Don	Markham	York	Northwest of Steeles Ave. and Bayview Ave.		City of Toronto	1966-1988, 1991-1995, 1997, 2001-2009	22	3	90
	85004	06008500402/DW20.6	4851207	622014	Upper West Don	Vaughan	York	Northwest of Hwy 7 and Centre St.		City of Toronto	1966-1988, 1991-1995, 1997, 2001-2009	22	4	85
	DM 6.0	DM 6.0	4840251	634378	Taylor/Massey Creek	Toronto	Toronto	West of the DVP and east of Don Mills Rd.		City of Toronto	2001-2009	8	3	100
	DN008WM	DN008WM	4850889	630236	German Mills Creek	Toronto	Toronto	Northeast of Cummer Ave. and Bayview Ave.		City of Toronto	2006-2009	3	3	98
	85014	06008501402/D4.5	4838576	632000	Lower Don	Toronto	Toronto	Pottery Rd, Toronto	02HC024	PWQMN	1979-2009	30	5 (mouth)	100
Highland Creek	94002	06009400202/Hi2.5	4849056	647429	Main Highland Creek	Toronto	Toronto	South of Kingston Rd. and Colonel Danforth Trail	02HC013	City of Toronto	1972-1995, 1997, 2001-2009	23	4 (mouth)	100
Rouge River	97003	RG008WM/06009700302	4857669	641985	Lower Rouge Creek	Markham	York	Southwest of 9th Line and 14th Ave.	02HC022	City of Toronto	1968-1995, 2006-2009	27	5	58

Watershed	Station	Alternate Name	Northing	Easting	Subwatershed	Township	Municipality	Location Description	Flow Station	Proprietor	Period of Record	Longest Continuous Record (Approx. Years)[1]	Stream Order[2]	% Urban Land Cover[3]
	97007	RG007WM/06009700702/RL9.0	4857816	644300	Little Rouge Creek	Markham	York	Southwest of 14th Ave. and Reesor Rd.		City of Toronto	1972-1974, 2006-2009	3	5	14
	97013	06009701302/R4.2	4852830	648243	Little Rouge Creek	Toronto	Toronto	East of Twyn Rivers Dr.		City of Toronto	1973-1997, 2001-2009	24	5	16
	97011	06009701102/RL4.1	4852511	648007	Lower Rouge Creek	Toronto	Toronto	Southeast of Twyn Rivers Dr. and Sheppard Ave.	02HC103	PWQMN	1973-1996, 2001-2009	23	5 (mouth)	61
	97018	06009701802/RB20.1	4861770	634680	Bruce Creek	Markham	York	Northwest of Major Mackenzie Dr. and Kennedy Rd.		PWQMN	2002-2009	7	3	5
	97777	97777/R18.4	4856823	634214	Middle Rouge/Beaver	Markham	York	Northwest of Hwy 407 and Warden Ave.		RWMP	2001-2009	8	4	76
	97999	97999/RL17.4	4863887	640589	Little Rouge Creek	Markham	York	Northwest of Major Mackenzie Rd. and 9th Line		RWMP	1972-1977, 2001-2009	2	5	14
Duffins Creek	104001	06010400102/Annadale Golf Course/Du2.4	4855880	657579	Lower Main Duffins	Ajax	Durham	Southwest of Bayly St. and Westney Rd.		PWQMN	1964-1997, 2002-2009	33	6(mouth)	24
	104008	06010400802/DuE17.5	4869299	650372	East Duffins Creek	Pickering	Durham	Northwest of Brock Rd and 8th Concession	02HC045	PWQMN	1972-1976, 1988, 1995-1996, 2002-2009	7	3	6
	104025	Brock Ridge/06010402502/DuW5.3	4857115	654656	West Duffins Creek	Pickering	Durham	West of Brock Rd and North of Finch Ave		RWMP	1973-1974, 1995-1996, 2002-2009	7	5	14
	104027	Paulyn Park/06010402702/DuE6.8	4859419	655458	East Duffins Creek	Ajax	Durham	North of Rossland Rd and West of Church St		RWMP	1973-1974, 1995-1996, 2002-2009	7	4	6
	104029	7th Concession/06010402902/DuE15.4	4868158	653641	East Duffins Creek	Pickering	Durham	Northeast of 7th Concession and Sideline 12		RWMP	1973-1974, 1995-1996, 2002-2009	7	3	5
	104037	8th Concession/06010403702/DuW19.3	4866462	644191	West Duffins Creek	Pickering	Durham	Southeast of York-Durham Line and 8th Concession		RWMP	1973-1974, 1995, - 2002-2009	7	4	23
Carruthers Creek	107002	Shoal Point/06010700202/C2.8	4856972	660850	Carruthers Creek	Ajax	Durham	Northwest of Bayly St. and Shoal Point Rd.		RWMP	2002-2009	7	4 (mouth)	98

Current as of December 2009.
[1] At least one parameter measured per year
[2] Strahler stream order
[3] Urban + urbanizing land cover

APPENDIX B

Appendix B - Summary Surface Water Quality Maps

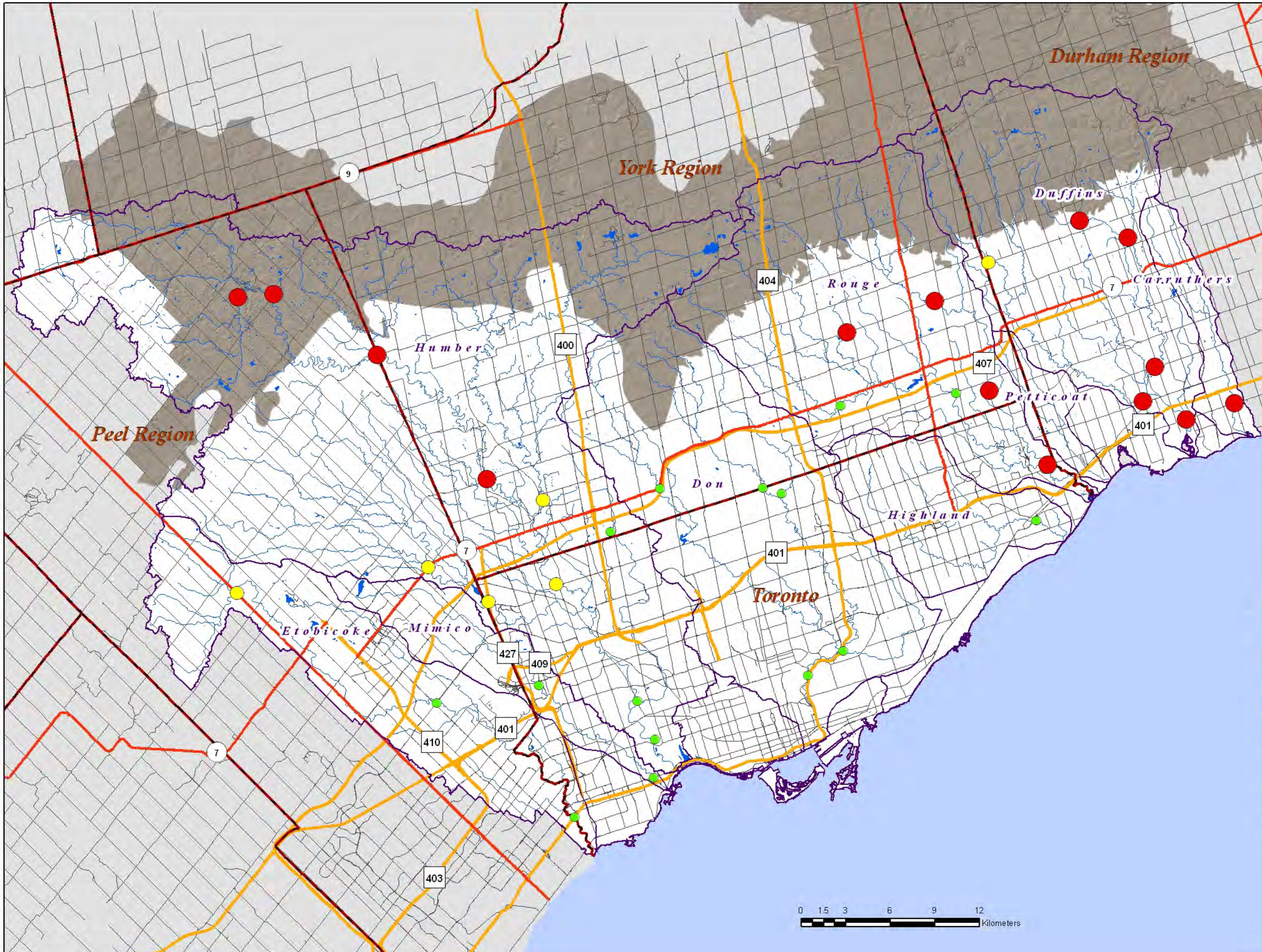

Appendix B1. TSS
TORONTO AND REGION Conservation for The Living City
Scale: 1:250,000
Surface Water Quality 2003 - 2007: TSS
Legend
TSS
< 10
10 - 30
> 30
Objective[1]: < 30 mg/L
Regional Boundary
Expressway/Highway
Freeway
Major Road
Watercourses/Rivers
TRCA Watersheds
Waterbodies
Oak Ridges Moraine
Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 includes winter months. Legend categories are arbitrary.
[1] Objective based on CCME Canadian Water Quality Guideline and assumes a background TSS concentration of 5 mg/L.
Disclaimer:
The Data used to create this map was compiled from a variety sources & dates.The T.R.C.A. takes no responsibility for errors or omissions in the data and retains the right to make changes & corrections at anytime without notice. For further information about the data on this map, please contact the T.R.C.A. GIS Department. (416) 661-6600
Durham Region
York Region
Peel Region
Toronto
Duffins
Carruthers
Rouge
Petticoat
Highland
Don
Humber
Etobicoke
Mimico
9
7
400
404
407
401
427
409
410
403
0 1.5 3 6 9 12
Kilometers

Surface Water Quality 2003 - 2007: Chloride

Appendix B2.

Toronto and Region Conservation for The Living City

Scale: 1:250,000



Legend

CHLORIDE (mg/L)

- < 100
- 100 - 150
- > 150

Objective [1]: < 150 mg/L

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

Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 includes winter months. Legend categories are arbitrary.

[1] Objective based on BC MOE's objective of 150 mg/L.

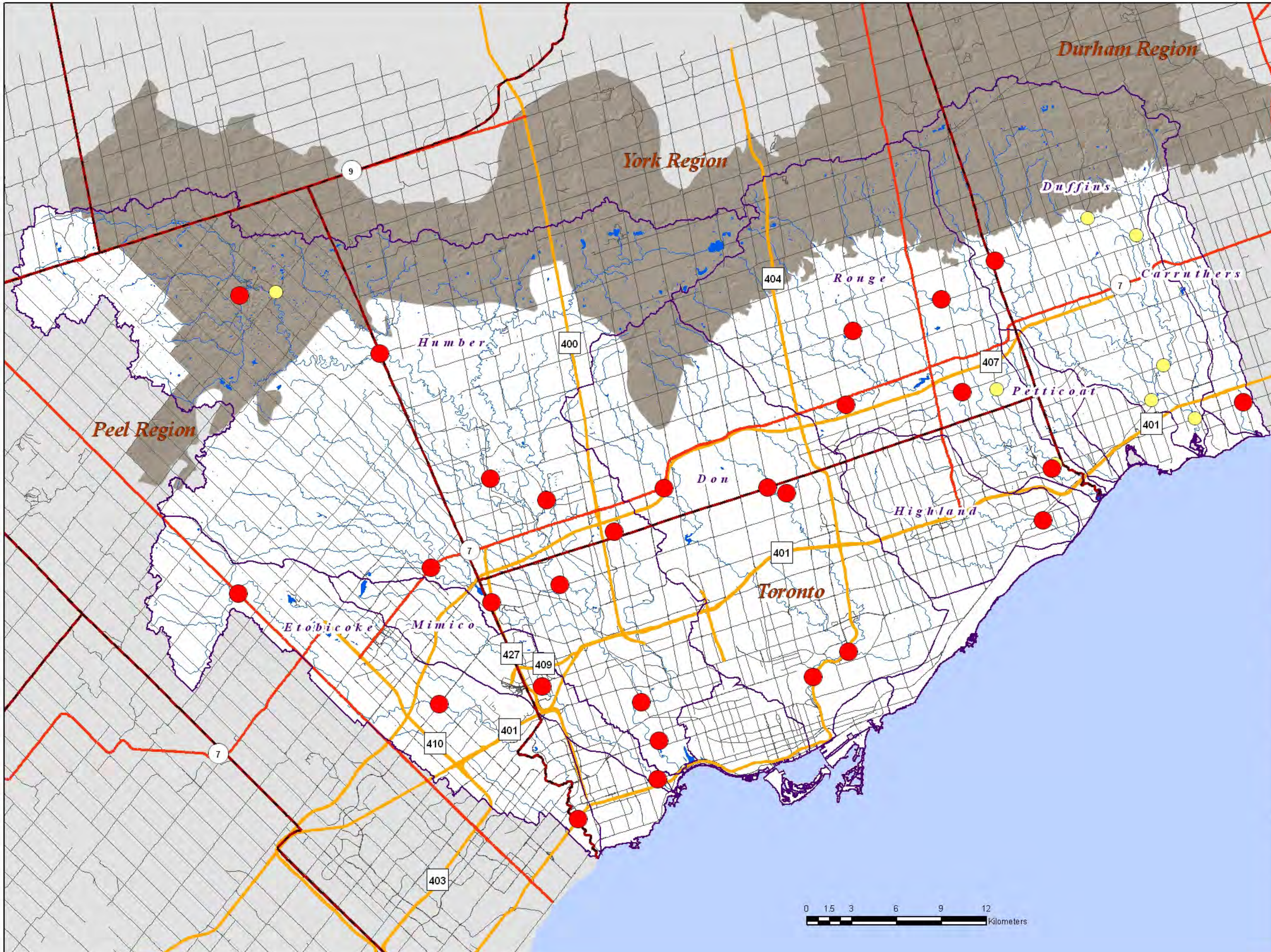
Disclaimer:
The Data used to create this map was compiled from a variety sources & dates. The T.R.C.A. takes no responsibility for errors or omissions in the data and retains the right to make changes & corrections at anytime without notice. For further information about the data on this map, please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

Surface Water Quality 2003 - 2007: Phosphorus

Appendix B3

Toronto and Region Conservation for The Living City

Scale: 1:250,000



Legend

PHOSPHOROUS (mg/L)

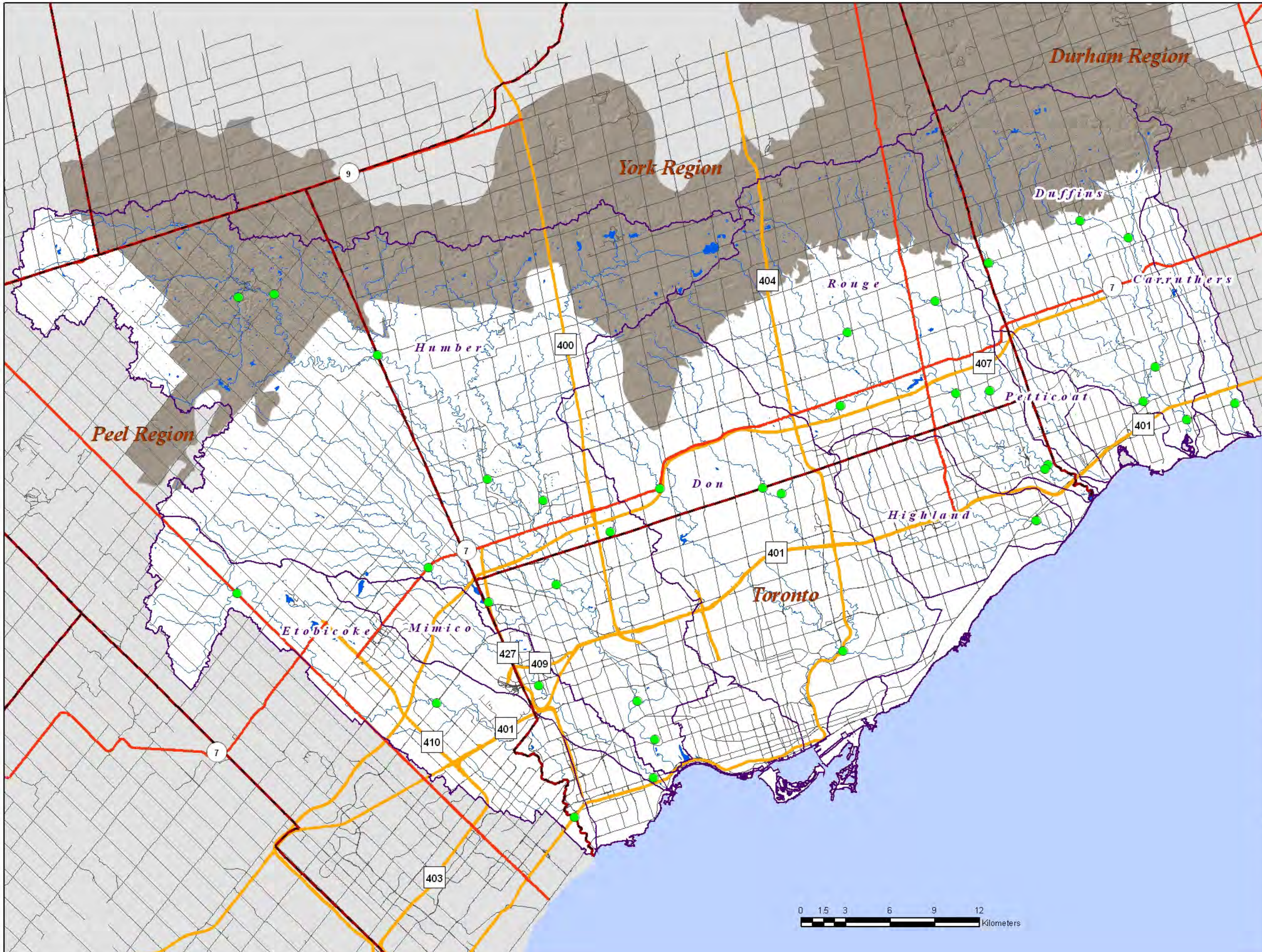
PHOSPHORUS

- < 0.02
- 0.020 - 0.030
- > 0.03

PWQO: <0.03 mg/L

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

Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 included winter months. Legend categories are arbitrary.



Appendix B4. Ammonia

Toronto and Region Conservation for The Living City

Scale: 1:250,000

Legend

Median (Un-Ionized NH3 (mg/L))

Un-Ionized Ammonia

- < 0.01
- 0.01 - 0.02
- > 0.02

Objective [1]: < 0.02 mg/L

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

Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 includes winter months. Legend categories are arbitrary.
[1] Objective based on BC MOE's objective of 150 mg/L.

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

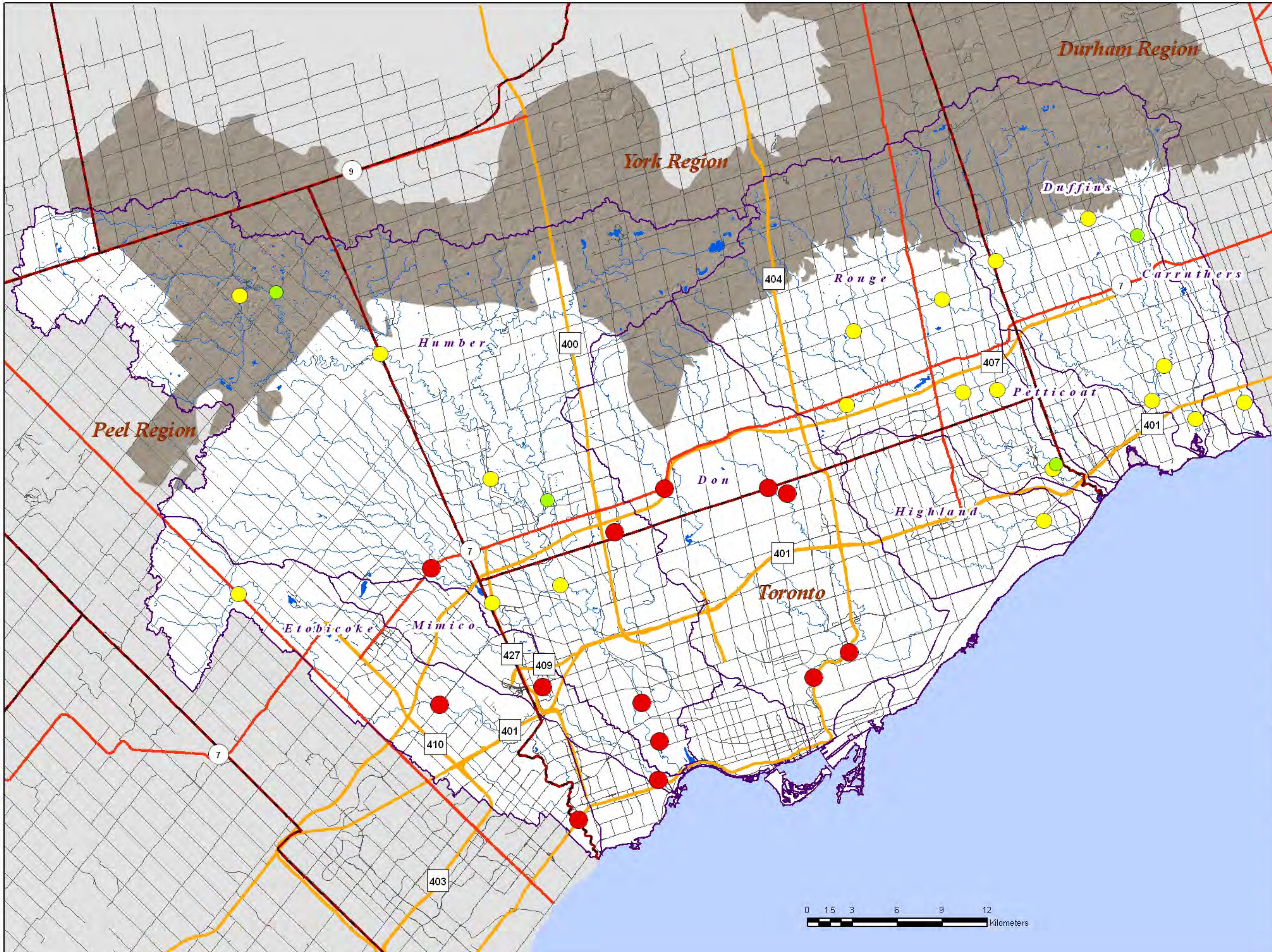
Surface Water Quality 2003 - 2007: Ammonia

Surface Water Quality 2003 - 2007: *E. coli*

Appendix B5.

Toronto and Region Conservation for The Living City

Scale: 1:250,000



Legend

E. coli (CFU/100ml)

- < 100
- 100 - 500
- > 500

PWQO: < 100 CFU/100 mL

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

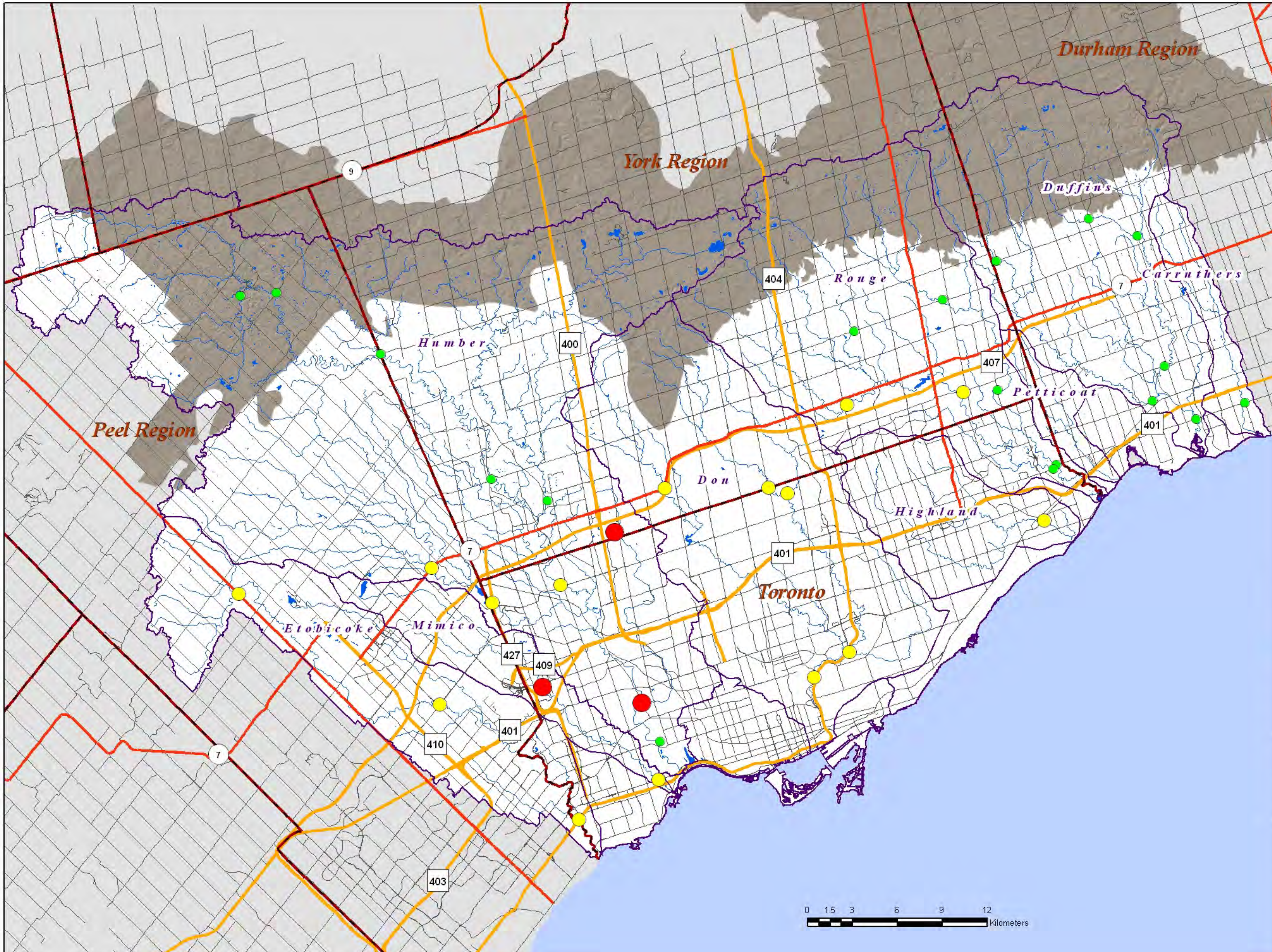
Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 includes winter months. Most data from Jun 2006 – Dec 2007. Legend categories are arbitrary.

Surface Water Quality 2003 - 2007: Copper

Appendix B6. Copper

Toronto and Region Conservation for The Living City

Scale: 1:250,000



Legend

COPPER (mg/L)

- < 3
- 3.0 - 5.0
- > 5

PWQO: < 5mg/L

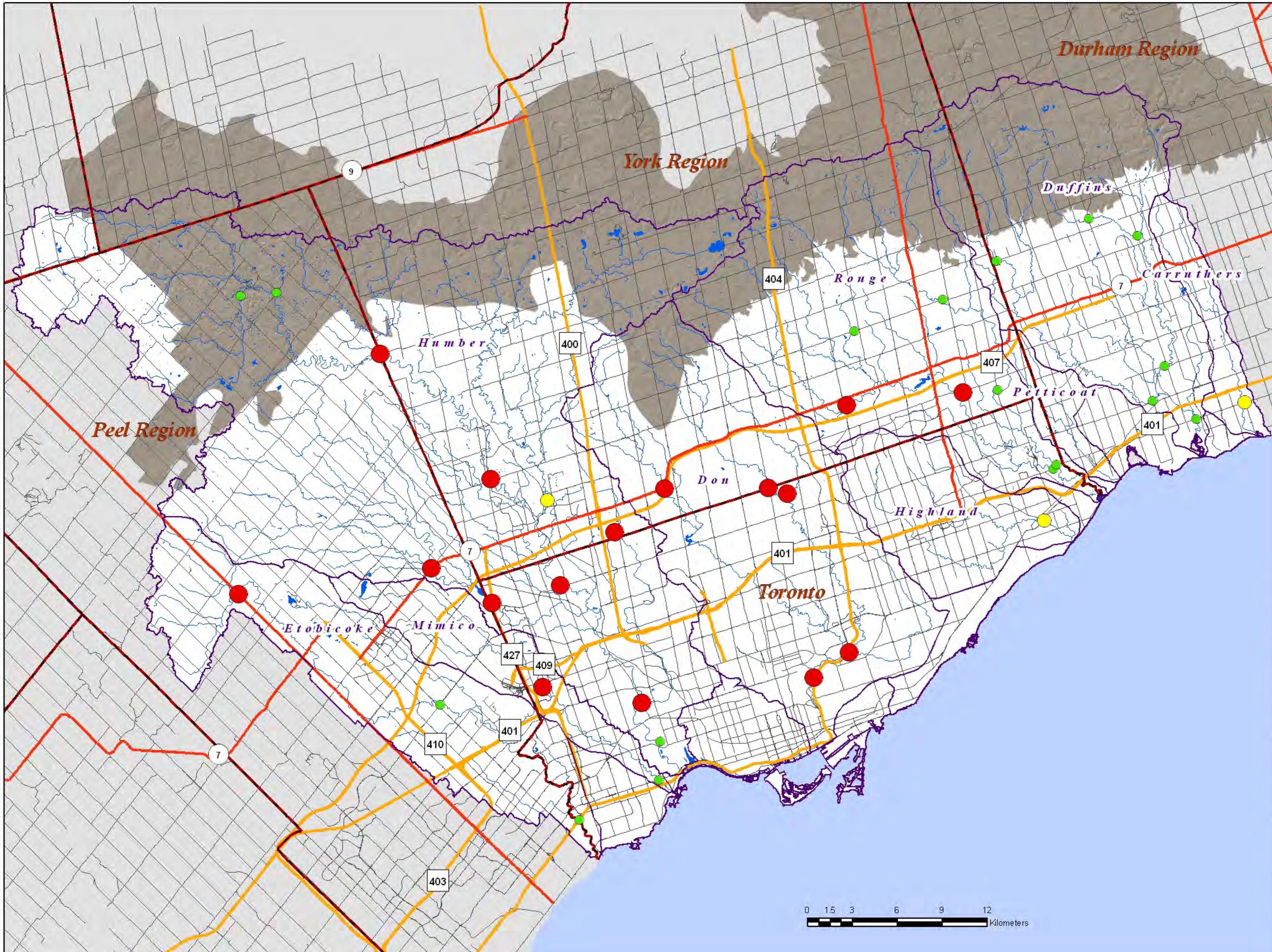
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 includes winter months. Legend categories are arbitrary.

Surface Water Quality 2003 - 2007: Iron

Appendix B7. Iron

Scale: 1:250,000



Legend

IRON (mg/L)

- < 250
- 250 - 300
- > 300

PWQO: < 300 mg/L

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

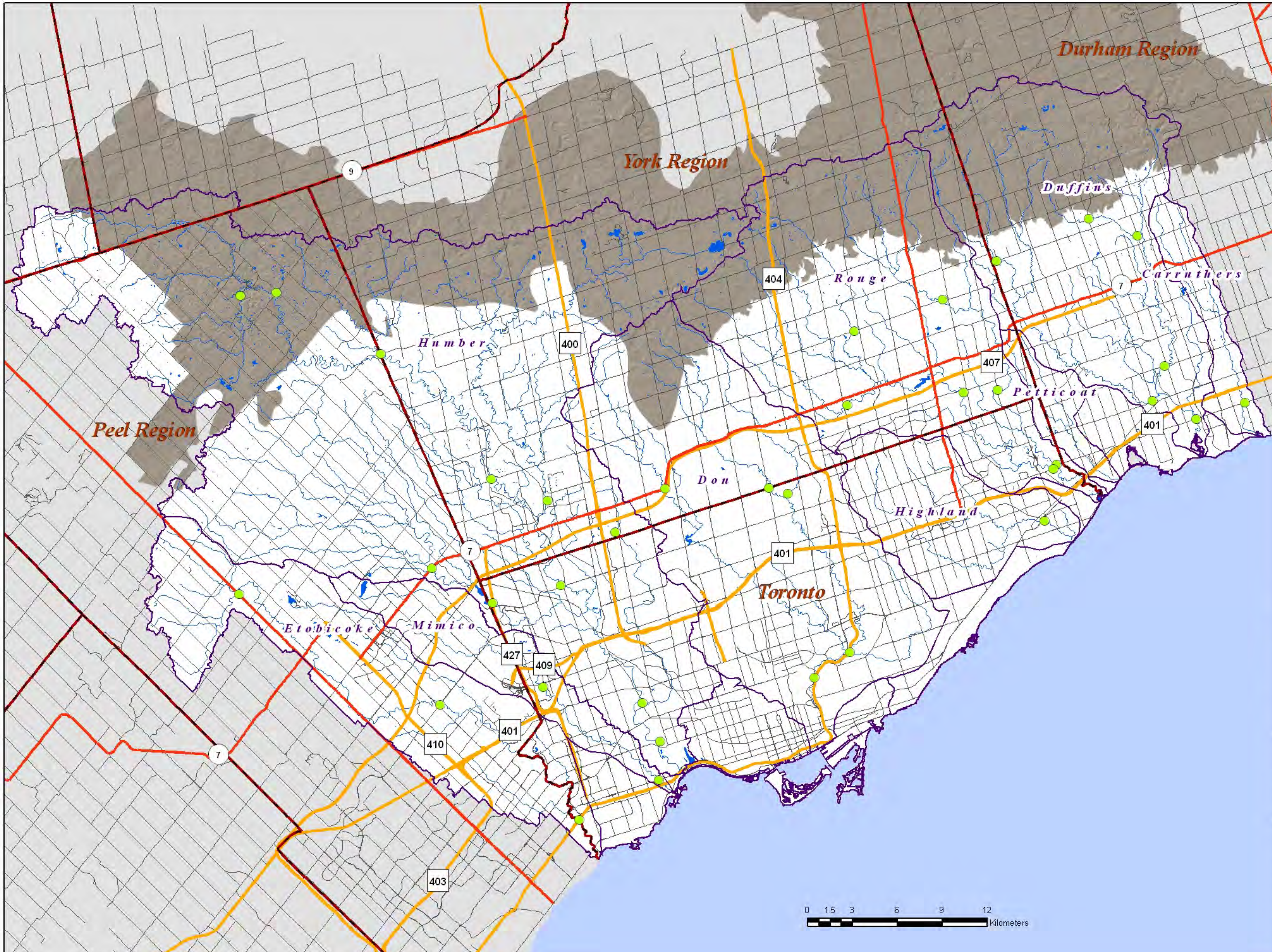
Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 includes winter months. Legend categories are arbitrary.

Surface Water Quality 2003 - 2007: Nickel

Appendix B8. Nickel

Toronto and Region Conservation for The Living City

Scale: 1:250,000



Legend

NICKEL (mg/L)

- < 10
- 10 - 25
- > 25

PWQO: <25 mg/L

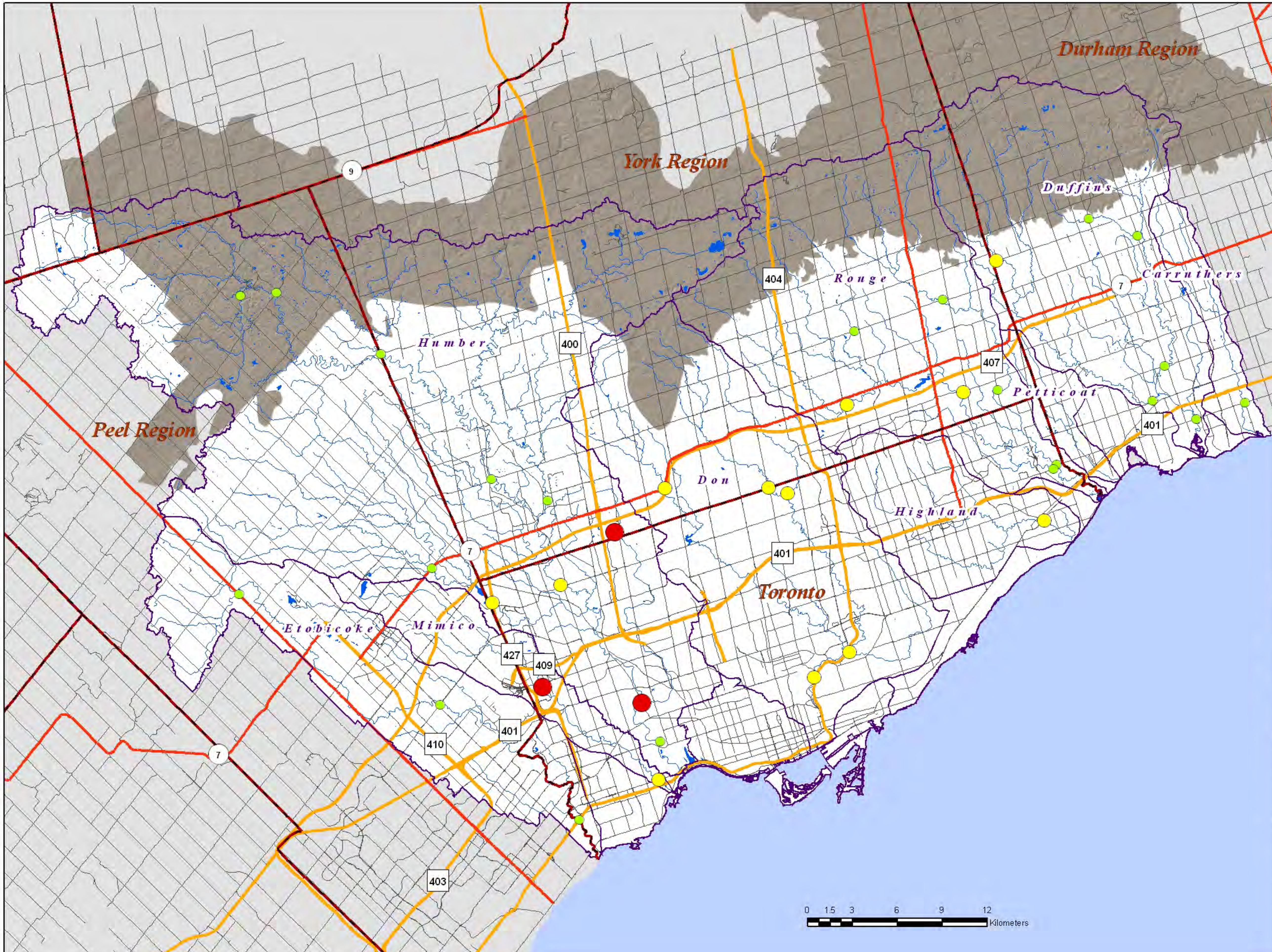
- Regional Boundary
- Expressway/Highway
- Freeway
- Major Road
- Watercourses/Rivers
- TRCA Watersheds
- Waterbodies
- Oak Ridges Moraine

Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 included winter months. Legend categories are arbitrary.

Appendix B9. Zinc

Toronto and Region Conservation for The Living City

Scale: 1:250,000



Legend

ZINC (mg/L)

- < 10
- 10.0 - 20.0
- > 20

PWQO : <20mg/L

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

Results based on median monthly grab samples concentrations for 2003 -2007. Data for 2003 – 2005, mainly ice free season (Apr - Dec). Data for 2006 -2007 includes winter months. Legend categories are arbitrary.

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

Surface Water Quality 2003 - 2007: Zinc