BASEFLOW AND WATER USE

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4.0 BASEFLOW AND WATER USE

Baseflow conditions represent the lowest stream flows that typically occur in a watercourse and usually represent groundwater discharge occurring along the stream corridor and the gradual release of water from wetlands. This consistent and relatively clean source of water maintains aquatic habitat and recreational opportunities (e.g., fishing, boating) during periods of dry weather and in some instances represents a potentially sustainable source of water for human use.

Local factors such as underlying geology, surrounding land use, water withdrawals, urban infrastructure and climate affect the quantity and quality of baseflow. Other sources of water that can contribute to baseflow include shallow groundwater seeping into or flowing alongside storm sewers that is discharged to the watercourse and run-off from outdoor water use in urban areas. These factors are considered in the analysis of low flow measurements collected in the Etobicoke and Mimico Creeks. The term *low flow* refers to the amount of stream flow that is sustained in a watercourse during extended periods of dry weather. In these watersheds, low flow conditions occur in the drier summer season between June and September.

An understanding of major surface water withdrawals from stream flow is not only needed to interpret low flow field measurements, but also to evaluate the impacts of those influences on the surface water regime and comment on the sustainability of the water supply for the particular use. Land use changes and climate change could affect both the demand for water supply and the availability of that supply. This Technical Update provides a basis for further analysis of these potential effects.

This **Baseflow and Water Use Section** provides a more in-depth analysis of the low flow regime in the Etobicoke and Mimico Creeks watersheds than was previously possible, with the benefit of additional low flow and water use survey data and an improved understanding of the groundwater – surface water interactions (see **Section 3.0**). The discussion is guided by the relevant objectives, indicators and targets for surface water quantity, as defined in the previous watershed report card, and recommends a new target. The section presents an updated interpretation of the low flow regime, addressing spatial and temporal patterns, baseflow trends, baseflow index, and water use, including an assessment of surface water vulnerability. The section also presents recommendations for the management of baseflow and water use. Significant reference is made to the new hydrogeological information presented in the **Groundwater Quantity and Quality Section** of this report.

4.1 WATERSHED OBJECTIVES, INDICATORS AND TARGETS

Baseflow and water use are two important factors which impact surface water quantity. As stated in *Turning over a new leaf: The Etobicoke and Mimico Creeks Watersheds Report Card* (2006), the objective for surface water quantity is:

> *The creeks are restored to a more natural flow pattern*

Based on the findings of this Technical Update, TRCA staff recommends the following watershed objectives and targets for Baseflow and Water Use as shown in **Table 4-1.**

Table 4-1: Watershed Objectives, Indicators and Targets

Baseflow and Water Use **Objective: Creek hydrology is restored to a more natural flow pattern**	
Indicator	**Targets**
Baseflow	• Increase baseflow from baseline conditions (as per TRCA Low Flow measurements from 2000)
Surface Water Withdrawals	• Protect Environmental Flow Rates (EFR) in areas of surface water withdrawals (EFR to be established as per individual Water Use Management Plans (WUMPs))

[1] New target developed as part of the Technical Update (TRCA, 2010) to reflect new science available for managing surface water withdrawals.

4.2 OBJECTIVES OF TECHNICAL UPDATE

Since the initial low flow surveys were done as part of the TRCA's Low Flow Program in 2000 and 2002 and water use surveys in 2003, additional surveys have been completed as part of this Technical Update and new hydrogeologic information is available to enable a more informed interpretation of the low flow regime.

The principle objectives of the baseflow and water use component of this Technical Update are as follows:

- Interpret, describe, and present the spatial and temporal low flow regime in the Etobicoke and Mimico Creeks watersheds;
- Identify areas of potential surface water stress based on surface water withdrawals;
- Identify interdependencies among low flow and groundwater systems as a basis for further work on their relationships with important aquatic and terrestrial habitats.

4.3 DATA SOURCES AND METHODS

4.3.1 Baseflow Data

Baseflow spot data were collected by TRCA, based on a protocol originally developed by the Geologic Survey of Canada (GSC) (Hinton, 2005). Baseflow measurements were taken at 70 sites in the Etobicoke and Mimico Creeks in August 2007 (TRCA, 2007). Previous data sets of baseflow measurements, taken at 80 sites in the Etobicoke and Mimico Creeks in the summers of 2000 and 2002, were also used in this analysis (TRCA, 2000 and 2002).

Baseflow mapping was based on 2007 Etobicoke and Mimico Creeks field data, and includes a spatial distribution map of the 70 measured sites, relative changes in baseflow between sampling locations (normalized flow) to illustrate significant recharge and discharge zones; and Etobicoke Creek percent contributions to baseflow by subwatershed.

4.3.2 Groundwater Data

Groundwater measurements were collected in the summers of 2005 and 2006 using mini-piezometers, seepage meters and Guelph Permeameter instruments, in selected areas of the Etobicoke Creek Headwaters and Spring Creek (TRCA, 2005). Groundwater recharge/discharge maps and geologic cross-sections are based on York-Peel-Durham-Toronto - Conservation Authority Moraine Coalition (YPDT-CAMC) groundwater program modelled results (Kassenaar & Wexler, 2006).

4.3.3 Surface Water Use Data

Water use assessments conducted on surface water users in the Etobicoke and Mimico Creeks watersheds were based on TRCA field surveys and additional data from the Ministry of the Environment (MOE) Permit to Take Water (PTTW) database (MOE, 2002; TRCA, 2003).

The 2002 PTTW database was obtained, edited, and updated using air photo reconnaissance. Expired PTTW records were removed from the database if the land use for that location did not match that of the permit. If the land use was found to be the same as the specific permit use, the expired permit was retained, and assumed active until it could be verified in the field. Supplementary data were collected by TRCA staff between 2002 and 2005 to further investigate actual water use by users in the form of a Water Use Survey. Actual water use information was entered into the database, including improved information about the geographic locations of water withdrawals.

Water use mapping was based on field verified data and illustrates all known water users in the watersheds, displayed by water use type. Surface water vulnerability was assessed by comparing the water supply and water demand components; that is, measured summer low flow data to actual withdrawal rates (instantaneous flow rates for both). Summer measurements are used for the supply values because it is within this time period that surface water users are most active. Also, the low flow measurements generally represent the time when watercourses are at their lowest levels and therefore the most vulnerable to water use stress. Surface water vulnerability was then categorized and mapped to show areas of potential high stress.

4.3.4 Streamflow and Climate Data

Continuous streamflow gauging datasets from two streamflow monitoring stations in the Etobicoke and Mimico Creeks watersheds were used for baseflow trend analysis calculations (Environment Canada, 2005). These gauges are located at the outflows of the creeks, before they enter Lake Ontario. In Etobicoke Creek, the gauge is situated south of the Queen Elizabeth Way (QEW) Highway and in Mimico Creek, in the Bloor Street and Islington Avenue area. These gauges are operated and maintained by the Water Survey of Canada (WSC) section of Environment Canada's Meteorological Services, as a part of the Federal/Provincial Hydrometric Network.

Continuous streamflow data were measured at these stations and used to calculate baseflow discharge, using baseflow separation methods (Clarifica Inc., 2002; Pilgrim and Cordery, 1993; Veissman *et al.*, 1989) as well as to analyze and determine flow characteristics and trends over time. It should be noted that some years of data were not included in trend analysis due to limited annual data. These years were 1966 for the Etobicoke Creek at QEW gauge and 1965, 1981 and 1988 for the Mimico Creek at Islington gauge station.

A third streamflow gauge operates in the Etobicoke Creek West Branch within the City of Brampton; however data from this location was not used in the analysis, due to a 10-year data gap from 1994 to 2003 when the gauge was inactive. Three other short-term stream flow gauges operated by the TRCA in the Etobicoke and Mimico Creeks were also not used in any trend analysis due to the short time period of data available from these stations. Details of all six streamflow gauges are listed in **Table 4-2.**

Climate data including daily precipitation and climate normals were obtained from the Toronto Lester B. Pearson Environment Canada weather station (Environment Canada, 2007).

Table 4-2: Streamflow Gauges - Etobicoke and Mimico Creeks

WSC No./TRCA ID	Gauge Name	Location	Operator	Period of Record
02HC017	Etobicoke Creek @ Brampton	Etobicoke Creek West Branch - north of Church Street , near Queen & Main Streets	WSC	1957 -1993, 2003 - Current
02HC030	Etobicoke Creek @ QEW	Lower Etobicoke Creek - south of QEW highway	WSC	1966 – Current
90	Spring Creek	Spring Creek - west of Bramalea Rd. and north of Drew Rd.	TRCA	2003 – Current
91	Etobicoke Creek @ Derry & Dixie	Etobicoke Creek West Branch – north of Derry Rd and east of Dixie Rd.	TRCA	2003 – Current
02HC033	Mimico Creek @ Islington	Mimico Creek – north of Bloor St. and east of Islington Ave.	WSC	1965 – Current
57	Mimico Creek – Wildwood Park	Mimico Creek – south of Derry Rd. and west of Goreway Dr.	TRCA	2003 - Current

[2] WSC - Water Survey of Canada; TRCA - Toronto and Region Conservation Authority

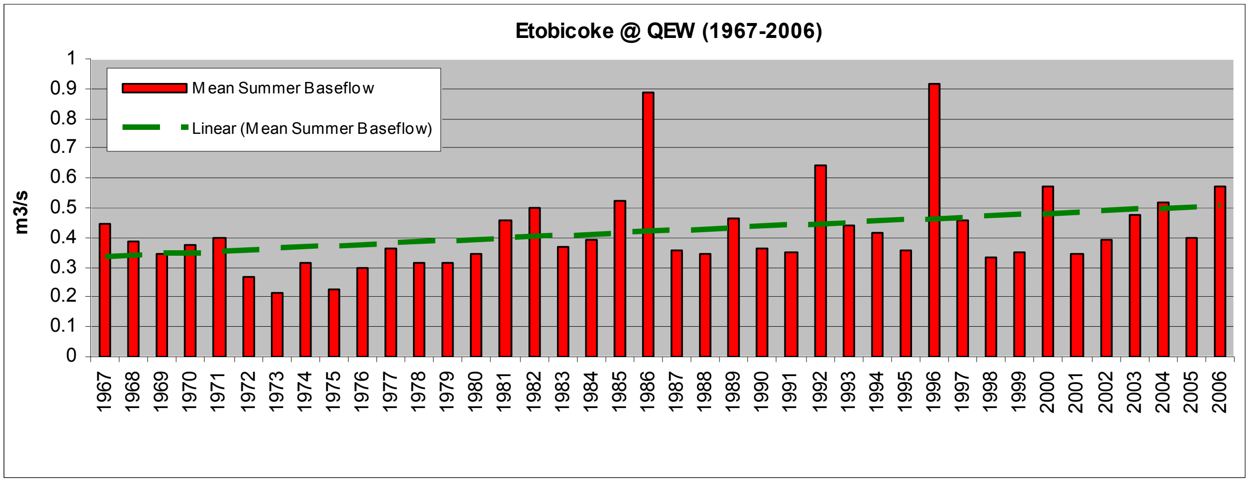
4.4 EXISTING CONDITIONS AND INTERPRETATION

4.4.1 Baseflow Trends

Mean Summer Baseflow

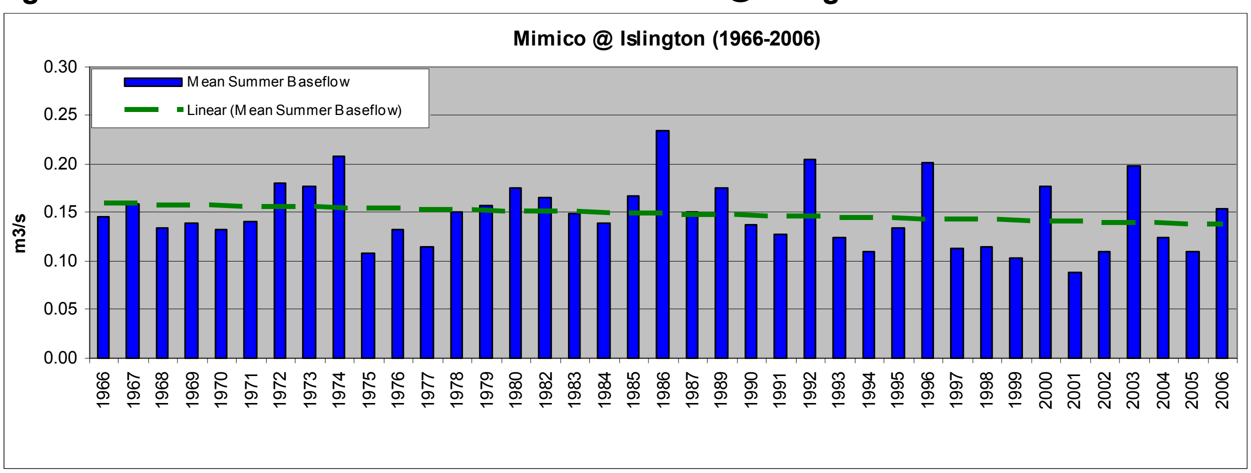
Streamflow measurements have been recorded since 1966 at the Etobicoke Creek streamflow gauge below the QEW. Daily average flow rates (m^3/s) from the summer months (June to September) were used to determine mean summer baseflow values for each year. **Figure 4-1** illustrates that at this gauge location the annual mean summer baseflow has had an overall increase of 51% for its period of record (or 1.3% increase per year).

Figure 4-1: Mean Summer Baseflow - Etobicoke Creek @ QEW



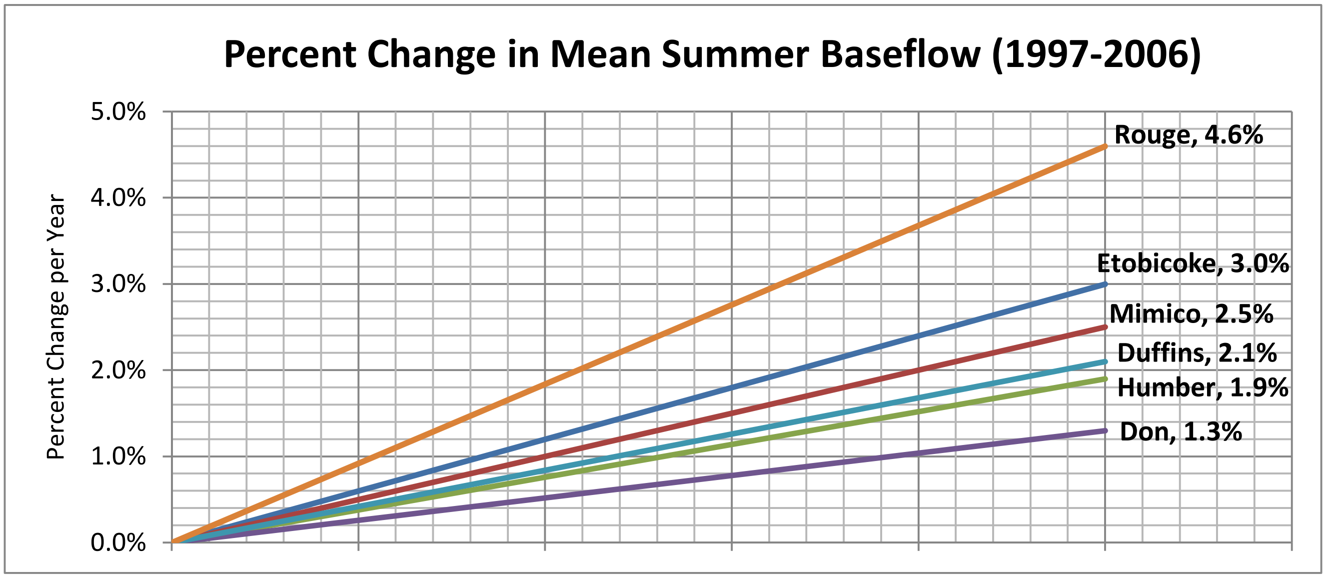
This long-term increasing trend in mean summer baseflow is one of the highest when compared with other TRCA watersheds, and was found to be statistically significant. In contrast, at the Mimico Creek streamflow gauge (Bloor Street and Islington Avenue area) annual mean summer baseflow has decreased 12% since 1966 (or 0.3% per year) as illustrated in **Figure 4-2.** Decreasing trends are sometimes found in flow regime systems in urbanized areas. Therefore the decreasing trend in Mimico Creek is not surprising since this watershed was already mostly developed when streamflow gauging was initiated.

Figure 4-2: Mean Summer Baseflow - Mimico Creek @ Islington



When the most recent 10-year period of data was analyzed (1997-2006), mean summer baseflow showed increasing trends of 30% (or 3% per year) for Etobicoke Creek, and 25% (or 2.5% per year) for Mimico Creek. When compared with other streamflow gauge data in other watersheds, mean summer baseflow trends were also shown to be increasing as shown in **Figure 4-3.**

Figure 4-3: Percent change per year in mean summer baseflow between 1997 to 2006 for Etobicoke Creek (at QEW), Mimico Creek (Islington & Bloor), Main Humber River (at Weston Road), Don River (at Todmorden), Rouge River (near Markham) and Duffins Creek (above Pickering).



The Rouge River had the highest increase in the 10-year period at 4.6% increase per year; however, flows may have been influenced by dewatering activities for the construction of the 16th Avenue Trunk Sewer System (i.e. pumped groundwater was discharged to a surface water stream). The Etobicoke and Mimico Creeks had the next highest increases followed by the Duffins Creek, Humber River and Don River.

These watershed trends may be influenced by a number of factors, including climatic inputs, the location of the streamflow gauge within the watershed as well as the existing land use and infrastructure in the area. The increasing trends are surprising when considering the recent trends in summer precipitation amounts and their influence on mean baseflow levels. Precipitation data from Toronto Pearson International Airport between the years of 1997 to 2006 showed only two *summers* (2000 and 2003) in which the normal summer rainfall amount (305.7mm) was reached. It would be expected with the low amounts of precipitation inputs to have less groundwater recharge. However, 50% of the years in the 10-year period had *annual* precipitation totals that were close to or exceeded the normal amount (792.2mm) in the years 2000 and from 2003 to 2006. The total annual precipitation and its distribution over the year therefore appears to be important in sustaining summer baseflow.

Baseflow Index (BFI)

Other calculations conducted with the continuous streamflow data included the analysis of Baseflow Index (BFI) values, which represent the ratio between annual average baseflow to the total stream flow, expressed as a percentage (Smakhtin, 2001). A higher BFI percentage is indicative of a greater contribution of groundwater to baseflow and to the total flow system allowing for a more stable flow regime. An example is the Main Humber River (north of Palgrave) where 72% of the total stream flow (from 1981 to 1998) is comprised of baseflow. In contrast, lower BFI values may indicate watersheds with a more variant or flashy flow regime typical of urbanized areas, with less inputs to baseflow from groundwater and greater inputs from runoff.

Figure 4-4 shows two graphs displaying the average annual total flow volumes in blue and the portion of that which is the average annual baseflow volume in green, for the Etobicoke and Mimico Creeks stream gauges. Also shown in the graphs is the annual Baseflow Index percentage. Several observations can be made from the graphs:

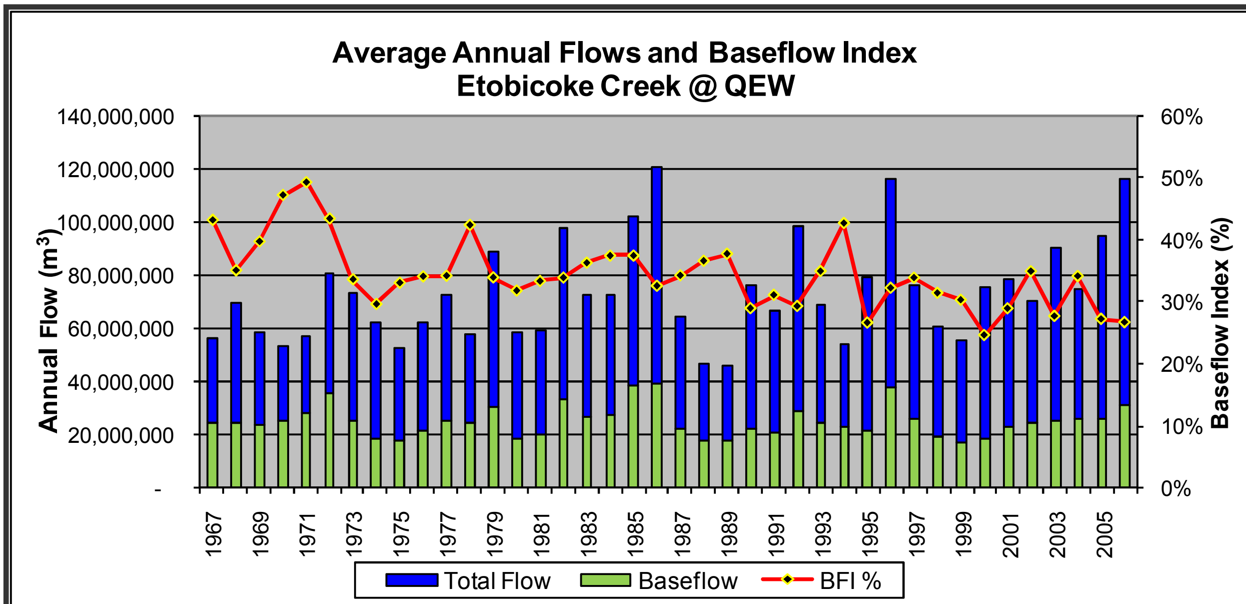
- Both the Etobicoke and Mimico Creeks have a statistically significant decreasing trend in BFI values;
- The average BFI values for the period of record were 34% and 29% for the Etobicoke and Mimico Creeks, respectively;
- In the last ten years of streamflow gauge data (1997-2006), BFI values were found to be below the average at 30% for Etobicoke Creek and 26% for Mimico Creek.
- BFI values ranged from 25 to 49 % in the Etobicoke Creek and between 19 and 39 % in the Mimico Creek.

The low average BFI values suggest that flow in these watersheds is driven mostly by runoff events with approximately only one third of total flow being contributed by groundwater sources. The low average BFI percentages are somewhat expected given the highly urbanized catchments upstream of these streamflow gauges and the occurrence of impermeable clay till soils and the lack of natural storage areas in the Etobicoke and Mimico Creeks watersheds (TRCA, 2004).

These gauges are located in the lower, mostly densely urbanized portion of the City of Mississauga and Toronto which increases the tendency for the BFI value to be lower than that of less urbanized subwatersheds such as in the Main Humber River. Impervious surfaces would further reduce infiltration to groundwater and increase surface runoff into nearby creeks. The percentage of impervious surfaces by subwatershed ranges from 7% in the headwaters to as high as 58% in the Etobicoke Creek and 57% in the Mimico Creek.

Although Baseflow Index values can be helpful in assessing the relationship between baseflow and total flow, it is also important to investigate the two components separately. **Table 4-3** gives a summary of average annual total flow and baseflow trends from the Etobicoke and Mimico Creeks for the overall period of record and the most recent 10-year period. Where baseflow had been decreasing by 0.1% (Etobicoke) and 0.4% (Mimico) per year over approximately 40 years of record, the 10-year trend is significantly increasing by 4.5% per year in Etobicoke Creek and 2.2% per year in Mimico Creek. This is also supported by the increasing trends in mean summer baseflow in both watersheds discussed previously. For the total flow component, Etobicoke Creek remained relatively steady with an increasing trend for both periods. However in Mimico Creek, total flow for the recent 10-year period has a significantly increasing trend of 7.4% per year as compared to the period of record increase of only 0.7% per year. In this case, BFI values are lower in the Mimico Creek due to total flows increasing at a faster rate than baseflow; where as in the Etobicoke Creek the opposite may be occurring. A likely link between cessation of dewatering at the former Armbro - Bovaird gravel pit and increased baseflow in Etobicoke Creek is discussed in the next section.

Figure 4-4: Average Annual Flows in cubic meters per year and Baseflow Index (BFI) Percentages in Etobicoke and Mimico Creeks (1966-2006)



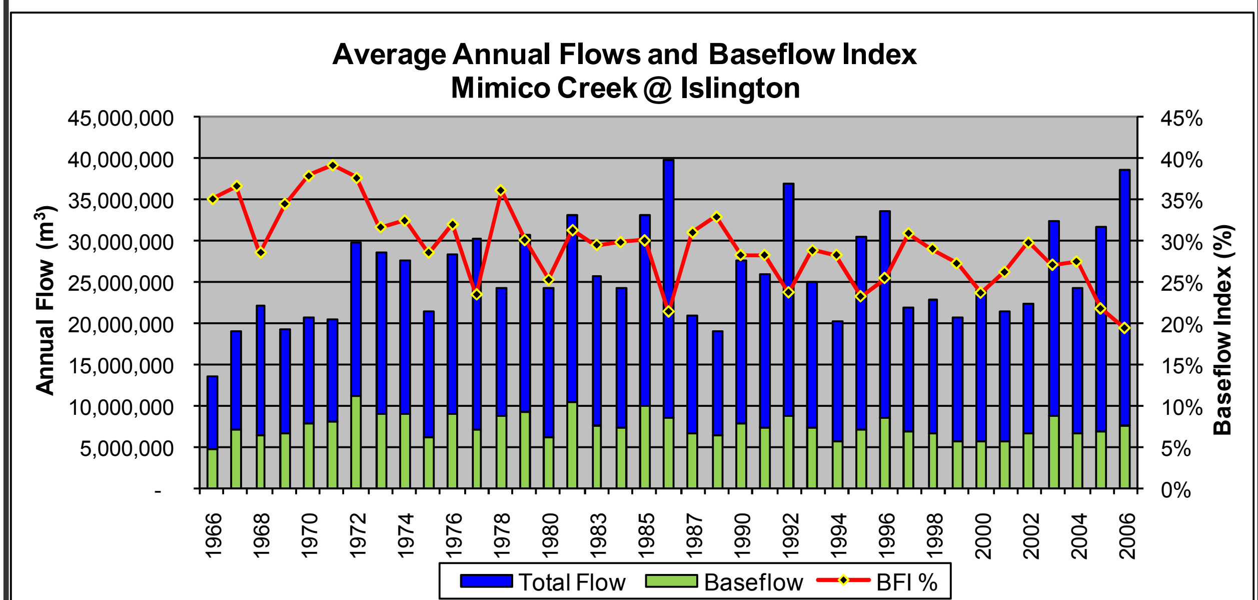


Table 4-3: Etobicoke and Mimico Creeks Average Annual Total Flow and Baseflow Percent Change per Year for Period of Record and 10-year Period (1997-2006)

	ETOBICOKE (1967 – 2006)		MIMICO (1966 – 2006)	
	Total Flow	Baseflow	Total Flow	Baseflow
Period of Record	1.0 %	- 0.1 %	0.7 %	- 0.4 %
1997 - 2006	0.7 %	4.5 %	7.4 %	2.2 %

4.4.2 Measured Baseflow Findings

The physiography of the Etobicoke and Mimico Creeks watersheds and the underlying geology influence ground-surface water interactions. An understanding of this context can help in the interpretation of baseflow findings. Physiography is illustrated in the **Study Area and Physical Setting Section**. In general these watersheds are situated on the South Slope, Peel Plain and Iroquois Sand Plain regions. The South Slope dominates the upper and lower sections of both watersheds. The Peel Plain intersects the middle of the two watersheds, while the Lake Iroquois Sand Plain exists as a narrow strip towards the bottom of both watersheds.

The **Groundwater Quantity and Quality Section** of this report describes the watersheds' hydrogeologic setting, noting outcrops of the Oak Ridges Aquifer (or Equivalent) Complex along Etobicoke Creek south of Bovaird Drive and outcrops of the Thorncliffe Aquifer along the Etobicoke Creek south of Dundas Street and along Mimico Creek south of Eglinton. The Scarborough Aquifer outcrops in the Bloor Street area in both creeks. More detailed references to the physical setting are made throughout the baseflow discussion.

In 2007, seventy baseflow monitoring sites were measured in the Etobicoke and Mimico Creeks watersheds during the month of August, as displayed in **Figure 4-5.** During that summer, precipitation amounts were well below normal levels by almost 55% (at Toronto Pearson International Airport) making 2007 summer rainfall the lowest total amount in over a decade. Summer baseflow levels were also below average when compared to previous years where summer rainfall was also below normal amounts, but higher than in 2007. This dataset will form a baseline to estimate the effects and response of the baseflow regime in these two watersheds under less than ideal climatic conditions, which has been predicted to be more common in the future.

Etobicoke Creek

Unlike other TRCA watersheds, the headwaters of the Etobicoke Creek are not located on the Oak Ridges Moraine (ORM), and therefore are not directly fed by groundwater recharge that is common on this feature. Overall, the Etobicoke Creek headwaters have a low contribution to the watershed's total baseflow, contributing less than 10% of outflow to Lake Ontario. Some of this baseflow is potentially occurring from tile drains for agriculture. Spring Creek, the Etobicoke West Branch and Little Etobicoke Creek provide slightly higher contributions to baseflow, at 12-14% of the total outflow. The Lower Etobicoke contributes 13% which likely emanates from the exposed Scarborough Aquifer Complex. The largest contribution to baseflow comes from the Etobicoke Creek Main Branch at 34%. Smaller contributions in the watershed include 8% from Tributary 3 and less than 1% from Tributary 4 (see **Figure 4-6**).

To illustrate where increases and decreases in flow occur along the watercourse, baseflow data were normalized to stream length, as displayed in **Figure 4-7.** In August of 2007, most of the Etobicoke Creek Headwaters tributaries north of Old School Road and west of Chinguacousy Road were either dry or had no measurable flow (water was present but no velocity was detected). These tributaries that were not flowing but still contained water are likely streams that only flow during times of high runoff, for example, during a precipitation or spring snowmelt event. Previous data collected in 2002 also showed similar results with most tributaries having a dry streambed or disconnected pools of water. There were a few exceptions, however, and the following tributaries were found to be flowing in 2007, and are likely permanently flowing tributaries:

- the northern tributary on Creditview Road between Old School Road and Mayfield Road, (ue029),
- a tributary on Old School Road just west of Hurontario Street (ue042), and
- the upper main branch of the headwaters on Hurontario Street north of Mayfield Road (ue027).

These flowing tributaries are presumed to be fed directly by groundwater discharge from the Oak Ridges Aquifer (or Equivalent), as discussed in more detail later in this section. Baseflow trends at these locations may also be important indicators of groundwater aquifer levels. All other 2007 monitoring sites south of Mayfield Road were measured to be flowing in the Etobicoke Creek Headwaters.

In the headwaters of Spring Creek, baseflow sampling in the upper east tributaries showed Heart Lake itself was not contributing to surface water flows. The primary outlet tributary downstream of the Lake was found to be dry in 2007, consistent with 2002 measurements. However the creek does begin flowing further downstream at Bovaird Drive and Dixie Road.

Measured low flow data did not confirm direct, in-stream groundwater contributions to baseflow from the Brampton Esker feature. However site field visits to a series of esker lakes and stormwater management ponds along the Brampton Esker have partially confirmed that ground and surface water interactions are occurring in these features, and are contributing to stream baseflows. A series of ponds and lakes, beginning at Esker Lakes North and South, located at Bovaird Drive and Highway 410, and running south-east through Major Oaks Park down through Parr Lake North and South are connected via underground piping, and were observed to be flowing under dry weather conditions. As there was no run-off in the system, this is believed to be groundwater discharge to the connecting pipes and ponds themselves.

Figure 4-5: Etobicoke and Mimico Creeks - 2007 Baseflow Monitoring Sites

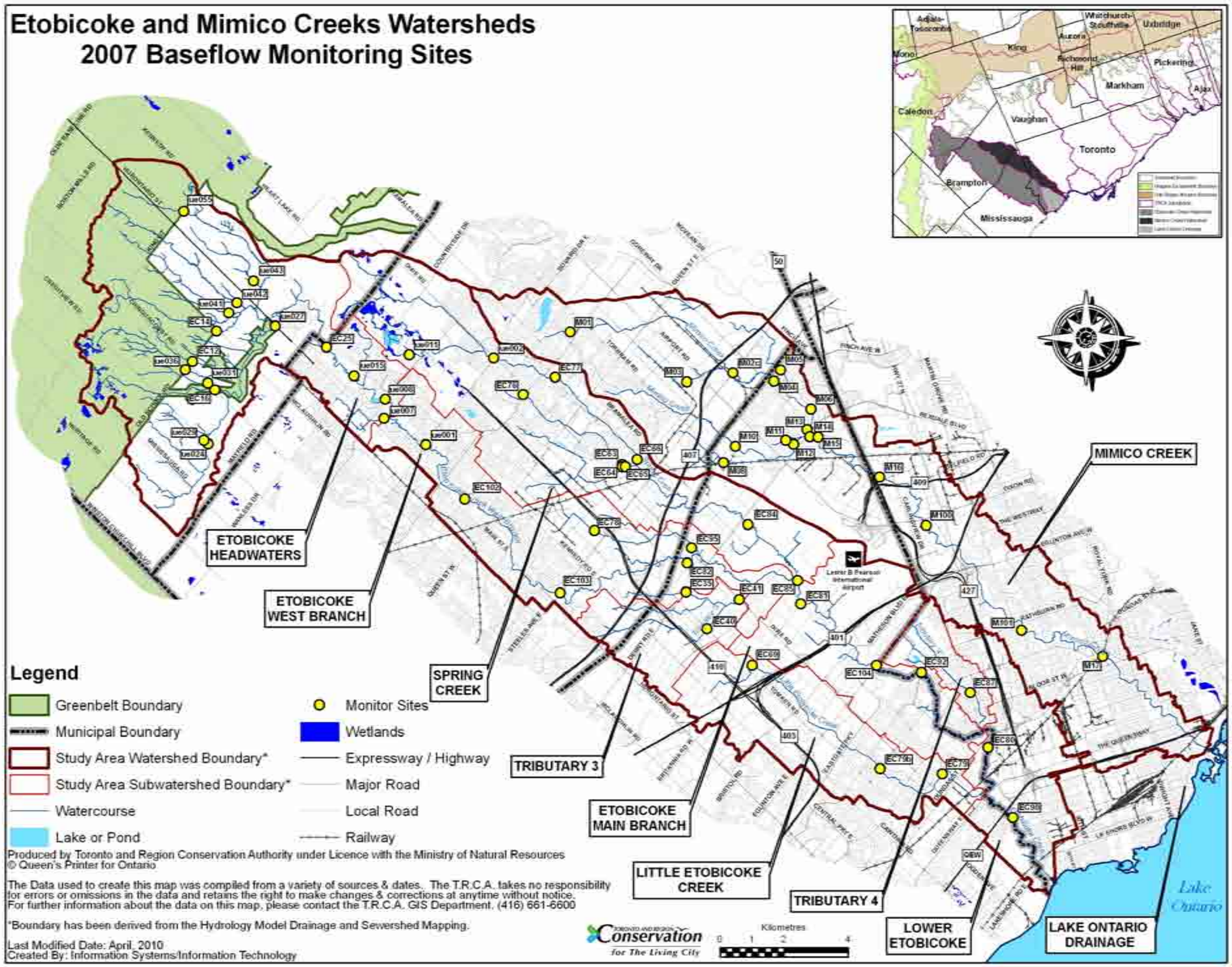


Figure 4-6: Etobicoke Creek - 2007 Percent Contributions to Baseflow by Subwatershed

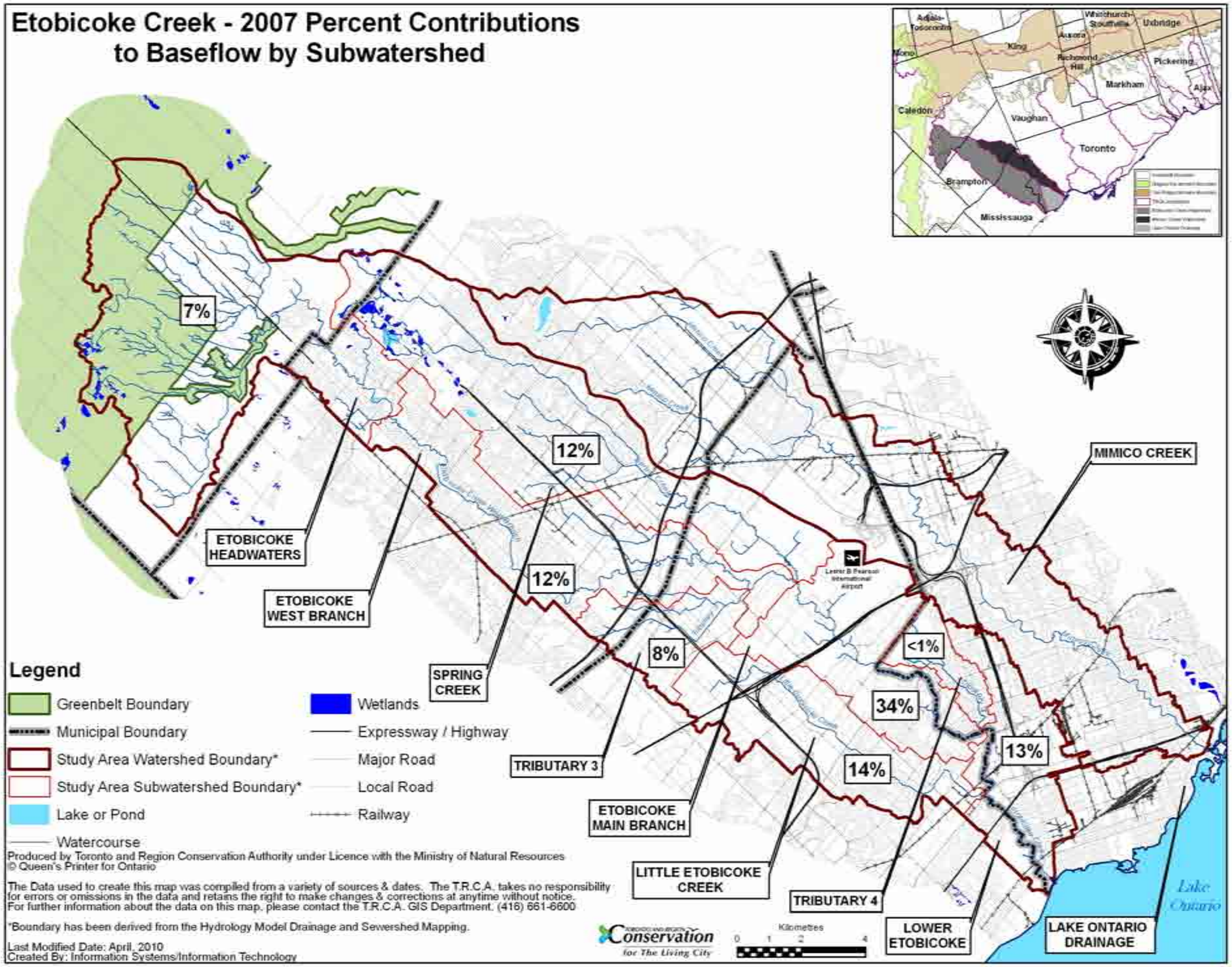
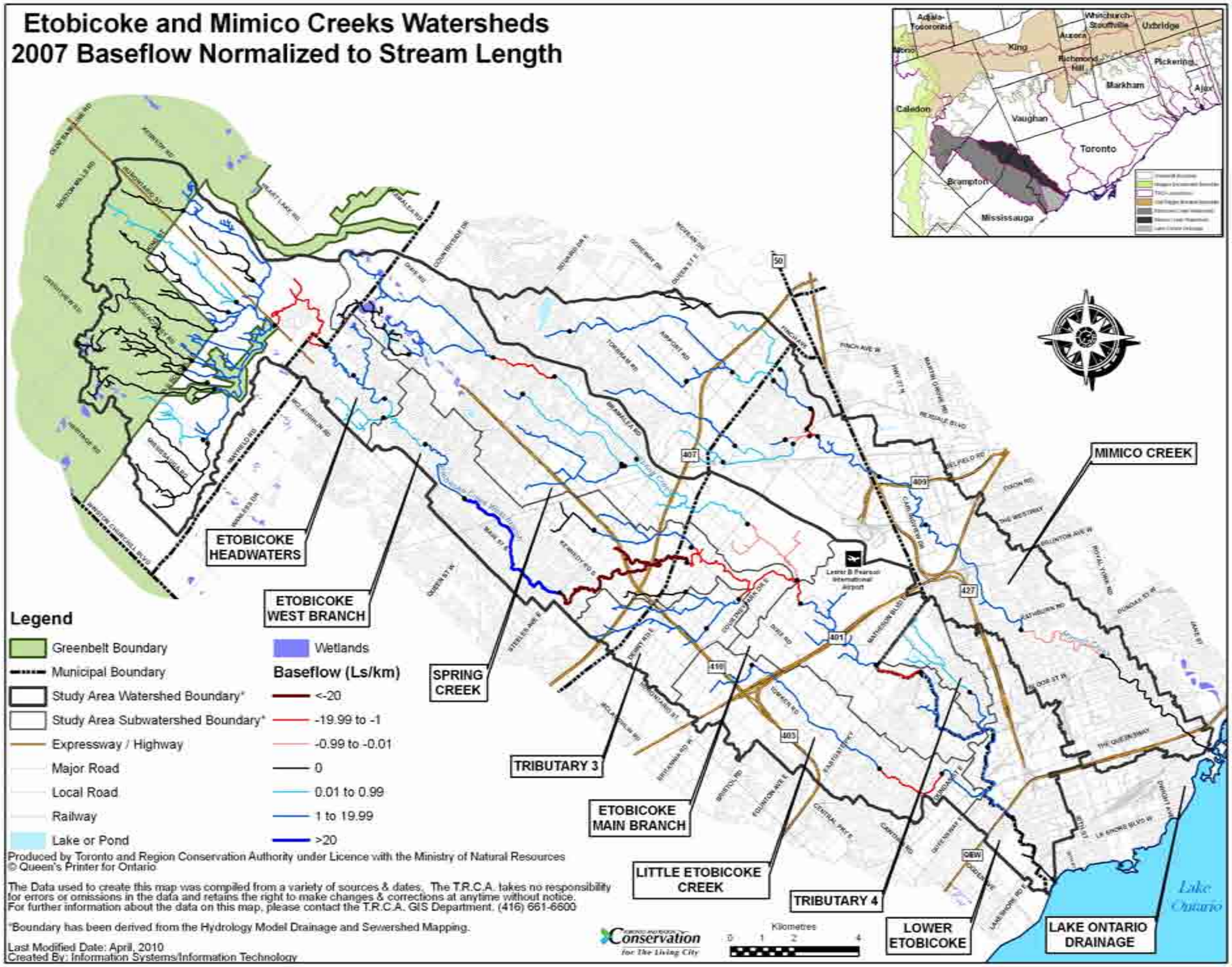


Figure 4-7: Etobicoke and Mimico Creeks Watersheds - 2007 Baseflow Normalized to Stream Length



Because this area contains numerous old gravel pits in which historical dewatering was occurring and has now ceased, there is reason to believe that groundwater levels are rebounding. As discussed in the **Groundwater Quantity and Quality Section**, groundwater monitoring wells in the Heart Lake area have recorded up to a 4m rise in water level since 2003, which would lead to an increase in the amount of baseflow discharge to the West Branch of the Main Etobicoke Creek. An increase in baseflow discharge would also be expected in the downstream tributaries of the southern-most pond, Parr Lake South, which discharges directly into the unnamed middle tributary of the west branch of Spring Creek (refer to **Groundwater Quantity and Quality Section** for more details).

Three areas of the Etobicoke Creek watershed had high increases measured in baseflow; that is, significantly higher baseflow measured downstream as compared to upstream measured sites. These gaining reaches could potentially coincide with groundwater discharge locations. Gaining reaches are displayed as blue sections of streams along the watercourse (see **Figure 4-7)**. These areas were located in: the Etobicoke Creek Headwaters upstream of Hurontario Street, the Etobicoke West Branch north of Steeles Avenue and in the lower portion of the Main Etobicoke Creek Branch near Burnhamthorpe Road and are discussed below.

In the Etobicoke Creek Headwaters there was a large increase in baseflow of 52 L/s measured at Hurontario Street, which is 20 times more than what was measured at sites upstream. This is assumed to be groundwater as the majority of the feeder tributaries upstream of this location were established to be dry or immeasurable. The regional numerical model predicts groundwater discharge occurring in this area due to high hydraulic head gradient. Furthermore, seepage meter measurements in this area conducted in 2005 confirm groundwater discharge at an average rate of 1.05 mL/min. However, a geologic cross-section from the YPDT data set show a thick till cap over the Oak Ridges Aquifer (or Equivalent) deposits in this reach, which would limit linkages between surface and groundwater. However the Oak Ridges Aquifer (or Equivalent) is known to be thick north of Mayfield Road and given the scale of the model, there are likely localized outcropping pockets of the Oak Ridges Aquifer in the area. This aquifer unit is known to be a significant contributor to dry weather flows in neighbouring watersheds.

In the Etobicoke Creek West Branch there is a major gaining reach with the most significant increases in discharge occurring between Williams Parkway and Steeles Avenue. Baseflow was measured in excess of 269 L/s, which is almost a six fold increase in baseflow. This discharge observed in the Etobicoke Creek West Branch confirms the previous monitoring data, which also showed baseflow gains through this reach. This large increase in baseflow corresponds to with a major groundwater discharge area, south of Bovaird Drive and near Steeles Avenue where the Oak Ridges Aquifer (or Equivalent) outcrops (as discussed in the **Groundwater Quantity and Quality Section**). Additionally, increases in baseflow in this area may already be reflecting the rise in groundwater levels (as noted in two PGMN wells in Heart Lake Conservation Area), in part due to cessation of dewatering of the former Armbro – Bovaird gravel pit.

The last area identified to be a major gaining discharge reach was in the lower section of the Main Etobicoke Creek Branch between Burnhamthorpe Road and Dundas Street. Flow in this stream segment was measured in excess of approximately 110 L/s, which is a 77% increase from upstream baseflow. The lower end of this reach cuts into the underlying Scarborough Aquifer Formation, which is likely the source of the discharges.

There were also some significant losing reaches (i.e. decreases in baseflow) measured in Etobicoke Creek in 2007. Losing reaches are sections of stream that have measured lower total discharges than the baseflow measured upstream. Usually this is caused by local geology or water withdrawals. Significant losing reaches are displayed in red sections of stream along the watercourse (see **Figure 4-7)**. Two sites of significance are: Spring Creek, between Bovaird Drive and Williams Parkway and Etobicoke Creek West Branch between Steeles Avenue and Dixie Road.

Data from 2007 illustrated that in Spring Creek, a small reach between Bovaird Drive and Williams Parkway had a decrease in baseflow of about 15 L/s, or a 68% loss from measured baseflow upstream. The interpolated geology from the regional geologic model shows a dominant thick till cap over top Oak Ridges Aquifer (or Equivalent) deposits in this area which would impede any interactions between ground and surface water. However there may be some areas where this till layer is thinner near the surface, therefore allowing some water interaction to occur.

The area between Steeles Avenue and Dixie Road in the Etobicoke Creek West Branch was measured as a very significant losing reach. Approximately 209 L/s of water is lost in this reach; a 65% loss from upstream at Steeles Avenue. This loss is contrary to previous baseflow monitoring data from 2000 and 2002. This particular measurement occurs directly downstream of an identified major groundwater discharge area between Bovaird Drive and Steeles Avenue, discussed previously. The surrounding geology in the area is similar to that of the Etobicoke Creek Headwaters and Spring Creek, where Halton Till deposits dominate the surface. Two surface water users are noted in this area and may be contributing to this deficit, however their rates of withdrawal could only account for a small portion of the loss. The losing trend continues further downstream past Dixie Road and into the Toronto Lester B. Pearson International Airport Lands, to Britannia Road. This segment of stream accounts for a loss of 56 L/s or 29% from baseflow measured upstream. This latter loss in baseflow near the Toronto International Airport was also measured in previous data collected in 2002.

In reviewing continuous stream flow gauging data from 2003 to 2005, both upstream (WSC gauge 02HC017, Brampton) and downstream (TRCA gauge #91, Derry and Dixie) of this large losing reach, values showed total discharge to be variable. In some instances this reach was found to be gaining flow, however at other times, specifically during the mid to late summer, it was found to be a losing reach. When compared with precipitation data from the Pearson Airport weather station, some of these instances where the reach was losing flow, coincided with periods of no rainfall events or periods where precipitation amounts were less than normal, particularly in 2005. The variable gains and losses in this reach combined with the lack of aquifer system, suggest that there may be interaction between the stream and the alluvium deposits adjacent to the watercourse.

Other minor baseflow losses of less than 20% were measured in the lower part of the Main Etobicoke Creek between Eglinton Avenue and Burnhamthorpe Road, and in the Little Etobicoke Creek, south of Burnhamthorpe Road. These losses can be attributed to porous sand and gravel deposits associated with the Iroquois Shoreline feature.

Mimico Creek

Mimico Creek begins south of Bovaird Drive in the City of Brampton, just south of Professor's Lake. Similar to the Etobicoke Creek watershed, the Mimico Creek is not directly fed by the Oak Ridges Moraine feature. However the flow distribution of Mimico Creek is similar to that of watersheds that are directly influenced by the ORM, where the headwaters contribute approximately 50% of the watershed's total discharge. The headwaters of Mimico Creek do not have evenly distributed flows however, and 43% of the total watershed baseflow emanates from the Upper East Mimico Creek, while the Upper West tributaries contribute only 7%. The physiography of the Mimico Creek headwaters is distinct, and situated predominantly over the Peel Plain, while only a small portion lies on the South Slope. The regional geologic model shows thicker Oak Ridges Aquifer (or Equivalent) deposits in the Upper East Mimico Creek than in the Upper West Mimico portion. Therefore the likely source of baseflow contributions in the Upper Mimico is the Oak Ridges Aquifer; however the field and modeled data is not at a high enough resolution to confirm which tributaries are contributing more and from where.

None of the baseflow monitoring sites measured in 2007 were sampled as dry; however some were immeasurable due to accessibility issues. Baseflow measured in 2007 showed a relatively consistent and increasing groundwater trend traveling downstream in this watershed as shown in **Figure 4-7**. There were two main areas of interest in Mimico Creek, both of which were located in the Upper East Mimico Branch. Significant flow volumes greater than 80 L/s (or 20 times greater than upstream) begin north of Steeles Avenue in two of the eastern tributaries, which is the most significant discharge measured in Mimico Creek from the 2007 data. The headwaters of these eastern tributaries begin at Professor's Lake, which was the site of an old gravel pit, located just south-west of Bovaird Drive and Torbram Road. This reach between Williams Parkway and Steeles Avenue coincides with the significant discharge reach in the West Branch of the Etobicoke Creek. There is little from the underlying geology of this area which would be a likely aquifer source of these discharges and there are no known water users in the area. Furthermore, unlike in the Etobicoke West Branch there is no outcropping of the Oak Ridges Aquifer and the cross-section does not show a very thick layer of the aquifer in the area. The regional groundwater flow model does not predict high discharge in this reach, but does show some pick-up in groundwater discharge south of Steeles Avenue.

The second area of interest in Mimico Creek was a losing reach in the Upper East Mimico Branch, upstream of the confluence with the main Mimico Creek channel. A loss of 61 L/s or 56% was measured between Etude Drive to just south of Derry Road. There is one known commercial water user located just south of Steeles Avenue however this user is too far upstream from the measured losses in baseflow. Geology also does not explain any surface and groundwater interactions in this reach. Therefore, it is not clear as to the cause of this loss, and further investigation would be needed into the interactions between surface and groundwater in this area to explain this finding.

Although the exact source or cause of the measured gain and loss is unclear, it is interesting to note that this occurrence is also paralleled in the Etobicoke Creek West Branch from Williams Parkway down to Derry Road. Therefore, these two reaches might be hydraulically linked. The likely source of the gains in the Upper East portion of Mimico Creek would be isolated patches of the Oak Ridges Aquifer (or Equivalent) deposits that may be interacting with the surface water. However, further measurements would be needed to investigate the interactions with groundwater in this area, as well as in the Etobicoke West Branch reach.

The Upper West Mimico tributaries flowing south beyond Steeles Avenue do not exceed 10 L/s. As the Mimico Creek flows into a single long watercourse, groundwater discharge is relatively evenly distributed throughout the remaining downstream reaches with up to 20 L/s between baseflow stations. One stretch between Dixon Road and Rathburn Roads increases by 50% to 38 L/s, likely due to the presence of the lower aquifers, mainly the Thorncliffe Aquifer. The effects of the pervious Iroquois sand plain deposits are also apparent in the sampled data, where a minor loss is observed as Mimico Creek flows from the South Slope and over the Iroquois Shoreline.

4.4.3 Etobicoke and Mimico Creek Water Use

Water use within the Etobicoke and Mimico Creeks watersheds was analyzed using 2002 MOE data and TRCA actual surveyed information from 2003 including, water user locations, sources and withdrawal rates. Withdrawal rates used for calculations are based on actual takings, with the exception of three users where this information was not available. Maximum permitted rates were used in place of actual withdrawal amounts for one miscellaneous user in the Lower Etobicoke Creek and two commercial users in the Etobicoke West Branch and Mimico Creek. Caution should be applied when interpreting the amounts for these sectors and subwatersheds, as the permitted maximum rates are typically three times as much as the actual withdrawals.

In total, there are 48 known surface and groundwater users in the Etobicoke and Mimico Creeks watersheds, with only three being located in Mimico Creek (see **Figure 4-8**). The majority of the users operate in the Etobicoke Headwaters (71% of total users); however the Etobicoke West Branch has the highest total withdrawal rates followed by the Mimico Creek, having only four and six percent of total users respectively in these subwatersheds (see **Figure 4-9** and **Figure 4-10**). In terms of water use sectors, livestock watering contains the largest number of users in its category with 61% of total users, followed by commercial use, which includes golf courses, at 21%. In contrast, commercial users are potentially withdrawing the largest amounts of water at over 1,200,000 cubic meters per year (93% of total withdrawals), followed distantly by livestock watering at over 40,000 cubic meters per year or 3% of total withdrawals. Other water use sectors in the Etobicoke and Mimico Creeks include agricultural, miscellaneous and remediation purposes. Some users are not classified into a sector and are grouped together as unknowns (see **Figure 4-11** and **Figure 4-12**). Two municipal potable wells taking from groundwater sources have been identified as part of the water use analysis. However, they were not included in any of the statistics or calculations in this section due to the wells being located outside the boundaries of the Etobicoke Creek watershed in the area of Caledon known as Cheltenham.

Figure 4-8: Etobicoke and Mimico Creeks Watersheds - Known Water Users by Type and Source

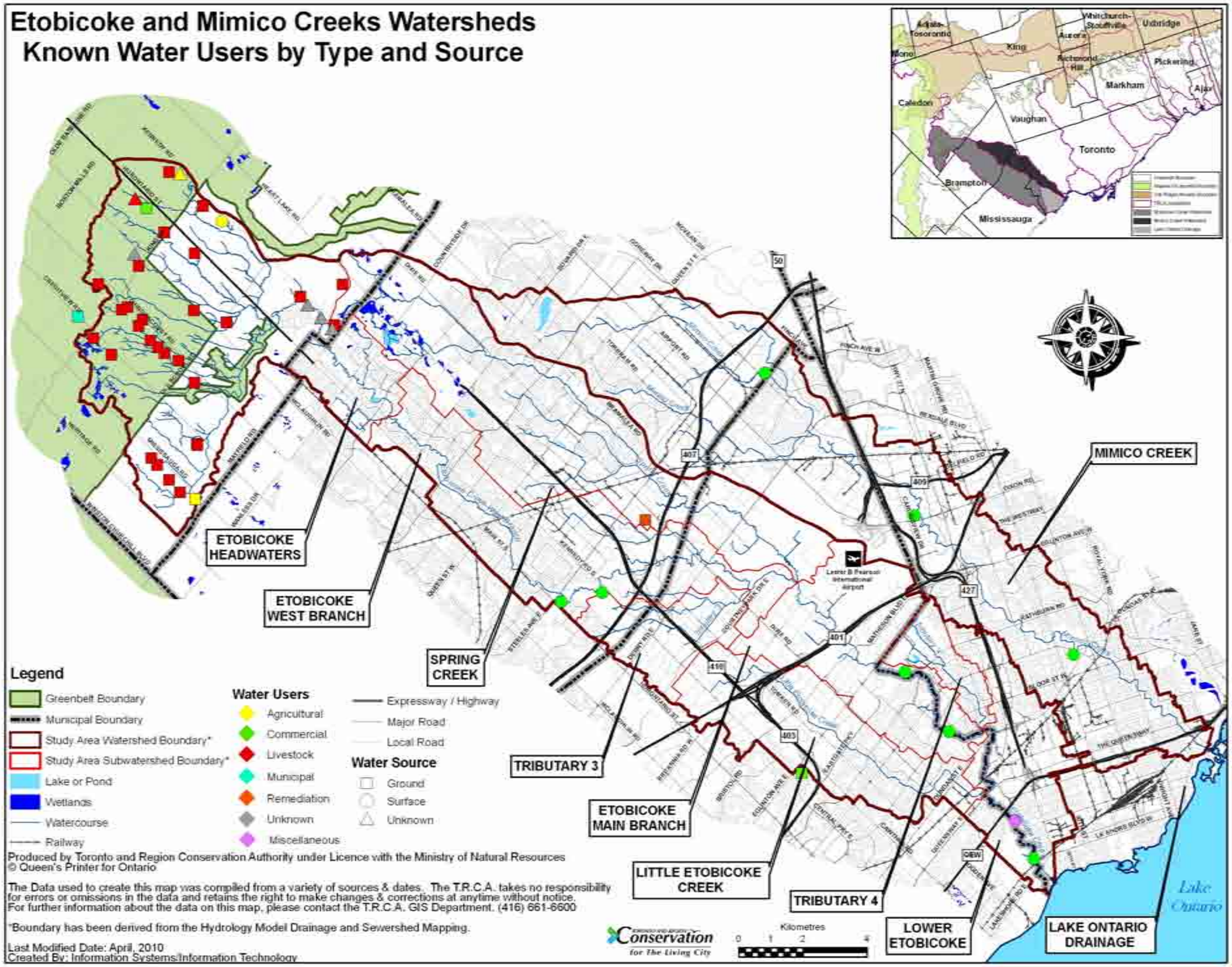


Figure 4-9: Percent of all Surveyed Water Users Categorized by Subwatershed (MOE, 2002: TRCA, 2003)

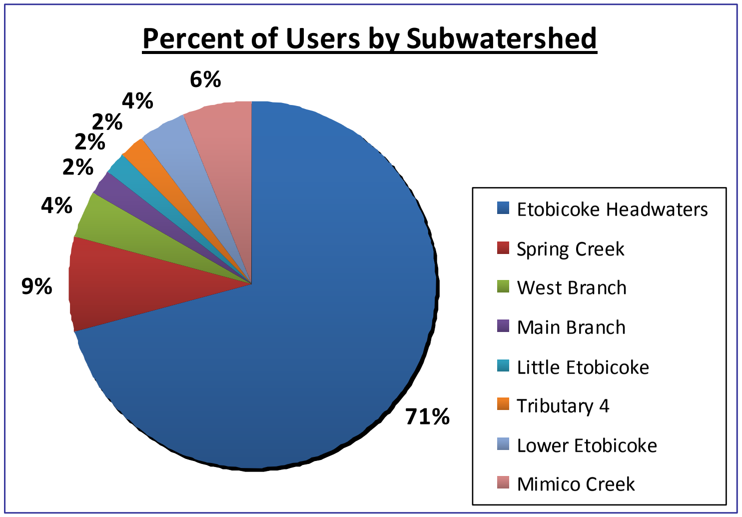


Figure 4-10: Total Annual Withdrawals for all Surveyed Water Users Categorized by Subwatershed (MOE, 2002: TRCA, 2003)

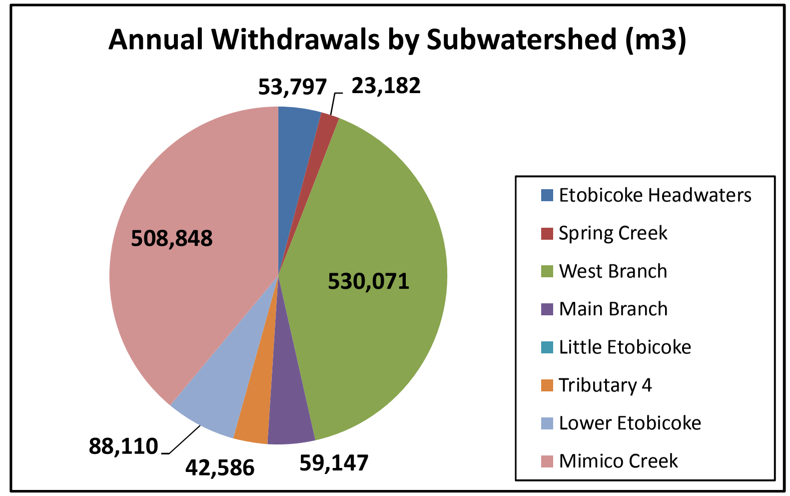


Figure 4-11: Percent of all Surveyed Water Users Categorized by Purpose (MOE, 2002: TRCA, 2003)

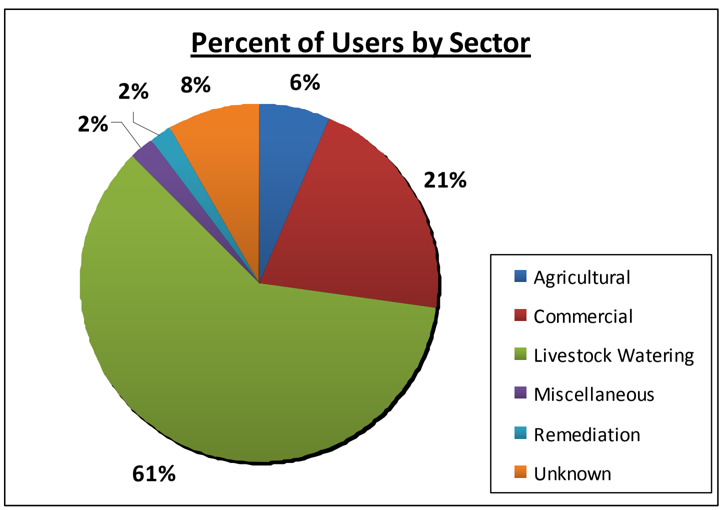
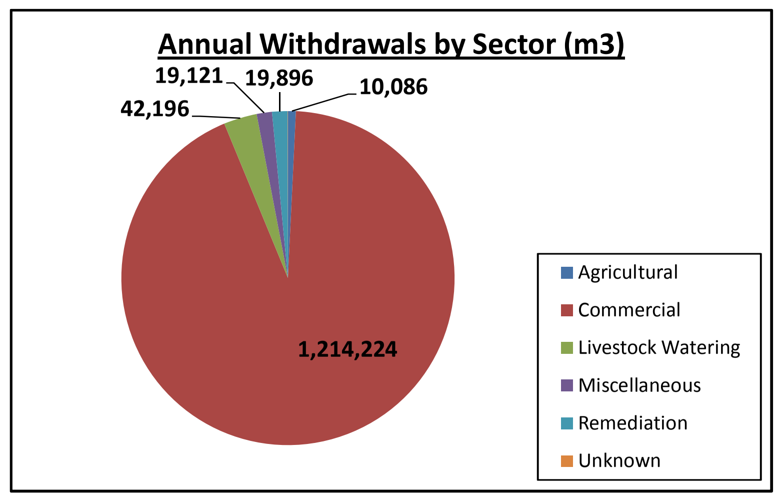


Figure 4-12: Total Annual Withdrawals for all Surveyed Water Users Categorized by Purpose (MOE, 2002: TRCA, 2003)



Surface Water Use
About 21% of total users in Etobicoke and Mimico Creeks watersheds take from surface water sources; namely from surface ponds or directly from stream channels. Surface water withdrawals in both the Etobicoke and Mimico Creeks are primarily from golf course operations (which belong to the commercial sector) and make up 80% of the 10 surface water users. The remaining 20% are from a single nursery operation and a miscellaneous water user. Golf course irrigation is typically a high demand and high consumption water use and tends to be from a surface water source, whereas, groundwater usage is limited to livestock operations and some groundwater remediation.

Table 4-4 provides a summary of all water users (including surface water users) by subwatershed and type of water source. Also included in this table are the percentages of summer baseflow potentially removed for surface water withdrawals in each subwatershed. For most of the subwatersheds, the percentage of baseflow that can potentially be withdrawn is less than 20 percent. However, water users in Etobicoke Creek West Branch and Mimico Creek are potentially withdrawing the highest proportion of baseflow at 18 and 15 percent respectively, among all subwatersheds. Values which were calculated using maximum permitted withdrawal rates are identified in **Table 4-4.**

A surface water vulnerability assessment was completed, based on known surface withdrawals in both the Etobicoke and Mimico Creeks, highlighting reaches which are subject to potentially significant withdrawals. The purpose of the assessment is to target and identify reaches that may potentially become stressed under low flow conditions when the users are actively withdrawing water. Those reaches with users withdrawing greater than 25% of available baseflow are categorized into high vulnerability; between 5 -25% are medium vulnerability; and those withdrawing less than 5% are low vulnerability (see **Table 4-5**). The surface water vulnerability assessment categorized three reaches as high potential stress to baseflow, another four reaches as medium potential stress, and one reach was classified as low potential stress. **Figure 4-13** displays these assessed reaches accordingly. Due to the time of baseflow sampling, the assessment represents vulnerability under low flow summer conditions. Note that these percentages are cumulative if more than one user occurs along a particular portion of stream. A stream segment is categorized as having no known impact if there are no known users in the area or if users have been identified as having no impact on the low flow system based on their withdrawal structure. As noted earlier, maximum permitted withdrawal rates were used for three users, therefore the classifications for the reaches in which these users are located may be overestimated as calculations are normally carried out with actual water withdrawal rates.

Table 4-4: Water Use Summary by Subwatershed

Total Annual Withdrawals by Source (m^3 / year)								
Sub-watershed	**# of Users**	**% of Users**	**Surface**	**Ground**	**Unknown**	**Total Annual Withdrawals (m^3)**	**Measured Summer Baseflow Discharge (m^3/yr)**	**% of Measured Discharge (surfaces takings only)**
Etobicoke Headwaters	34	71%	218	46,588	6,991	53,797	764,748	0.03%
Spring Creek	4	8%	-	23,106	76	23,182	1,351,633	-
Etobicoke West Branch	2	4%	530,071 *	-	-	530,071 *	2,938,840	18.0% *
Main Etobicoke	1	2%	59,147	-	-	59,147	7,993,430	0.7%
Little Etobicoke	1	2%	-	85	-	85	1,548,102	-
Tributary 4	1	2%	42,586	-	-	42,586	883,639	4.8%
Lower Etobicoke	2	4%	88,110*	-	-	88,110 *	10,955,291	0.8% *
Mimico Creek	3	6%	508,848*	-	-	508,848 *	3,464,230	14.7% *
TOTAL	**48**	**100%**	**1,228,981***	**69,779**	**7,067**	**1,305,826 ***	**14,419,521**	**8.5% ***

****NOTE*: Maximum permitted withdrawal rates used for calculations***

Table 4-5: Vulnerability Assessment Category Classification

Percent of 2007 Measured Baseflow	Vulnerability Category
0	No Known Impact
0.1-5 %	Low Impact
5-25 %	Medium Impact
>25 %	High Impact

The three reaches identified as high potential stress areas are located in the Etobicoke Headwaters, Tributary 4 of Etobicoke Creek and in the Lower Mimico Creek as displayed in **Figure 4-13.** A small nursery operation and two golf courses are among the users located in these reaches. In the Etobicoke Headwaters, the user does not have a particularly large withdrawal rate however it is classified as high potential stress due to the limited amount of surface water supply available at their location. In this case, available baseflow supplied upstream was recorded as zero due to dry conditions. Similarly, in Tributary 4 of Etobicoke Creek, one golf course operation also did not have a particularly high withdrawal rate (in comparison to other golf courses in Etobicoke and Mimico Creeks), but because of its location and the distribution of baseflow sites, there is no measured flow upstream to calculate its vulnerability. However, the nearest downstream site had a flow rate less than that of the withdrawal rate, classifying this stream reach, in the potential high impact category. The second golf course located in the lower portion of Mimico Creek withdraws approximately 21 L/s (or 63,560 m^3/year) from the stream, which comprises more than 25% of the available baseflow as measured in 2007. It should be noted that this assessment may overestimate vulnerability due to the low baseflow levels experienced in the summer months of 2007.

Four reaches were classified as medium potential stress areas and are potentially subject to withdrawals between 5 and 25 percent of measured baseflow at these locations (see **Figure 4-13**). These reaches include the lower portions of the Etobicoke West Branch, Upper East Mimico, Main Etobicoke and Mimico Creek. Two golf courses along the same reach of the Etobicoke West Branch were calculated to potentially withdraw 12% of measured baseflow cumulatively. Similarly, another golf course operation in the Upper East Mimico could potentially withdraw approximately 20% of measured low flow. However, maximum permitted withdrawal rates were used for some of these golf courses in order to calculate vulnerability values, therefore caution should be taken when considering their potential impact to surface water stress. The other two medium vulnerability reaches in the lower Main Etobicoke and Mimico Creek are the result of water use by two golf course operations.

One area of the Lower Etobicoke Creek was assessed to be low potential stress and includes the withdrawals of one golf course and one miscellaneous user. Cumulatively, these two users could be taking 3.6% of measured baseflow supply combined. It should also be noted that their percentage may be lower due to the larger volumes of available water supply generally found in the lower downstream portions of watersheds. However, these downstream locations with higher volumes are more vulnerable to cumulative takings from upstream users.

4.4.4 Summary of Findings

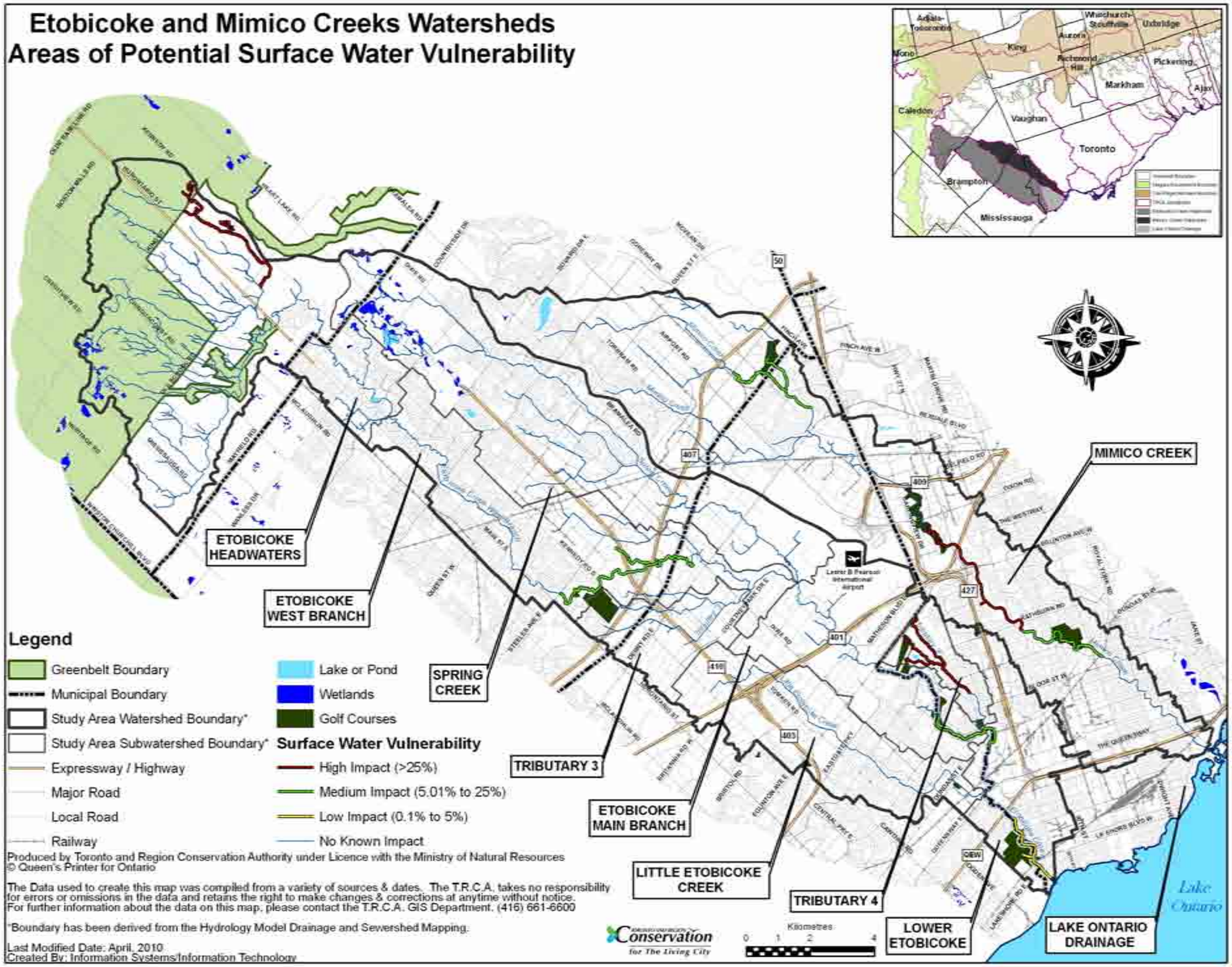
Although baseflow trends calculated with continuous streamflow gauge data may be highly influenced by climatic inputs, (such as precipitation and runoff), gauge location and urban development, the increasing trend of 1.3% per year in mean summer baseflow in Etobicoke Creek since 1967, is significant. Even the most recent 10-year period of record from 1997 to 2006, shows large increasing trends in summer baseflow for Etobicoke Creek as well as Mimico Creek. These increasing trends are among the highest between other TRCA watersheds, such as the Humber River and Duffins Creek.

The reason for these trends is not evident; however some of the increases in the Etobicoke Creek may be attributed to the increasing groundwater levels in the Brampton Esker area. Baseflow Index (BFI) values were also considered, which can be an important indicator of changing baseflow volumes with respect to total discharge over time. The decreasing BFI trend found in both the Etobicoke and Mimico Creeks watersheds could be influenced by a multitude of factors, including climate patterns. However, even with an overall decreasing trend in BFI percentages, the most recent 10-year period of gauging data found that percentages were influenced more by increasing baseflow levels in the Etobicoke and by increasing total flows in the Mimico Creek. In the case of Mimico Creek, it is not surprising that the watershed would be highly runoff driven due to its fully urbanized nature. However, for the Etobicoke Creek, the rate at which average annual baseflow has been increasing between 1997 and 2006 (by 4.5% per year) is high, and similar to baseflow trends found in the Main Rouge River. Again, some of the increases in baseflow in the Etobicoke Creek can potentially be linked back to the increasing trend in groundwater levels since 2003. Further analysis into a water budget would be required to determine possible reasons for these notable trends in both watersheds.

The headwaters of Etobicoke Creek did not show a significant baseflow contribution to the overall outflow measured at the mouth of the watershed. However, inputs to baseflow, believed from the Oak Ridges Aquifer (or Equivalent), were measured in the headwaters and throughout both the Etobicoke and Mimico Creeks watersheds. One of the important findings in the Etobicoke Creek headwaters was the large number of dry tributaries; consistent with previous monitoring data. Yet, there were locally significant groundwater contributions to baseflow measured in the headwaters. The Brampton Esker feature in Spring Creek was also deemed an important source of groundwater inputs with local contributions to baseflow from Esker Lakes and stormwater management ponds (former aggregate pit operations) located within the Esker feature. Future groundwater contributions in this area are expected to increase.

In addition, there were significant groundwater contributions in the Etobicoke West Branch between Bovaird Drive and Steeles Avenue, which seemed to be paralleled in Mimico Creek where large gains were measured in the headwaters north of Steeles Avenue. Significant losing reaches were also identified when analyzing the baseflow data, particularly one reach in Etobicoke Creek south of Steeles Avenue which also occurs in the Upper Mimico Creek tributaries to below Derry Road. The baseflow gains in the Etobicoke West Branch have been attributed to an exposed outcrop of the Oak Ridges Aquifer (or Equivalent) deposits and have been identified as a major discharge area. What is interesting to note is that the ORAC unit feeds the headwaters of other TRCA watersheds, such as the Humber, Rouge and Duffins, however it appears to only be providing significant baseflow in the middle reaches of the Etobicoke Creek.

Figure 4-13: Etobicoke and Mimico Creeks Areas of Potential Surface Water Vulnerability



Differences in the resolution of the regional groundwater modeling results and TRCA measured baseflow values led to difficulties in assessing the specific causes of gaining and losing reaches, specifically in the Upper East Mimico Creek. Further investigation into cross-sections also did not provide clarification, because in most cases geology showed thick layers of impermeable Halton Till deposits sitting on top of aquifer units. However, with the known presence of the Oak Ridges Moraine Aquifer (or Equivalent) and its influence in other TRCA watersheds, it is believed that this unit is the most likely and most significant groundwater contributor to baseflow throughout the Etobicoke and Mimico Creeks watersheds. Other possibilities include interaction between stream and alluvium deposits, varying hydraulic head pressures in the local groundwater system or influences by the rising groundwater levels in the Brampton Esker - Heart Lake Wetland Complex area. Further investigation into the likely source or cause of baseflow fluctuations in the identified reaches is recommended. With additional monitoring data and refinements to the regional groundwater model, the local geologic and groundwater conditions may be better defined.

The majority of the 48 known water users (surface and groundwater) in Etobicoke and Mimico Creeks watersheds are located in the Etobicoke Creek headwaters with the water withdrawn for livestock watering purposes. However, the greatest volume of water withdrawals (from all sources) per year occurs in the Etobicoke West Branch and Mimico Creek for golf course irrigation, from solely surface water sources. There are ten known surface water users within the Etobicoke and Mimico Creeks watersheds which include eight golf course operations who potentially withdraw over 1,200,000 cubic meters of water a year. A vulnerability assessment was able to classify three highly vulnerable stream reaches in which water users could potentially take more than 25% of measured baseflow. However, two of these reaches were classified as such due to having dry stream conditions during the 2007 field measurements.

4.5 MANAGEMENT RECOMMENDATIONS

Baseflow is an important indicator of groundwater discharge and must be maintained to support important ecological functions. There are many controlling factors that determine the amount of baseflow present in a stream both natural and non-natural. To protect and manage baseflow volumes and functions, the following must be considered:

1. Management of current and future water use (surface and groundwater).
2. Protection of important recharge and discharge areas, including natural features such as the Oak Ridges Moraine (or Equivalent) and the Brampton Esker.
3. Continued baseflow monitoring within the Etobicoke and Mimico Creeks.
4. Investigating ways to identify stream reaches that may be sensitive to baseflow fluctuations due to climate change.

Even though a small percentage of total known water users are presently taking from surface water sources, water withdrawals from the system may pose a threat to the aquatic habitat and introduce conflicts among users in some areas of the Etobicoke and Mimico Creeks watersheds. Users taking from groundwater sources will have an effect on the water table and its connected streams. Hence, water use information is becoming increasingly important in order to properly quantify and manage the demands for water. The TRCA is currently developing new water withdrawal guidelines, which will require water users to develop Water Use Management Plans (WUMPs) and Environmental Management Plans (EMPs). These plans will aim to increase sustainability and reduce the negative impacts of water withdrawals from both surface and groundwater supplies through monitoring and adaptive management. Ultimately, these documents will provide guidelines to assist water users in developing drought risk assessments, a drought response plan for operational changes under drought conditions and establishing environmental flow rates. Other details may also be included such as information on fixed intake systems, storage and reservoir space, in order to determine the most optimal water withdrawal and efficient water use for the users.

Measured baseflow data can provide important insight into possible groundwater recharge and discharge areas within watersheds. From the 2007 baseflow data it was determined that large groundwater contributions from the Oak Ridges Aquifer (or Equivalent) were common in the Etobicoke and Mimico Creeks. Protection of the natural form and function of the Oak Ridges Moraine (or Equivalent) and other headwater features, such as the Brampton Esker, is needed to preserve important groundwater recharge areas as well as discharge areas whose influences are not limited to the physical boundaries of the Moraine. Essentially, if important recharge areas are protected, the connected discharge areas in other parts of the watershed will also be preserved.

Monitoring of baseflow should continue in the Etobicoke and Mimico Creeks to further understand interactions of ground and surface water in these watersheds. Annual summer baseflow measurements from six indicator stations within the Etobicoke and Mimico Creeks will continue to be carried out as part of the TRCA Low Flow Monitoring Program's ongoing monitoring. In addition to these stations, monitoring of low flow for the Mayfield-West Phase II Master Environmental Servicing Plan (MESP) study in Caledon will also continue. Due to the number of areas that were found to have unexplained high increases or decreases from the 2007 data set, additional monitoring sites are recommended. If funding becomes available, as many as seven additional stations may be needed to further investigate some of the long and short-term trends measured in the 2007 data set, as well as to fill in data gaps that exist with geological data. Some of these sites would include monitoring in the Etobicoke West Branch near Steeles Avenue, in the upper tributaries of Spring Creek downstream of Heart Lake and the Brampton Esker, as well as two sites in the upper and lower main channel of Mimico Creek. Depending on available funds, options for monitoring may include spot measurements incorporated into the annual Low Flow Monitoring Program, or installing a continuous flow gauge.

Identifying areas of stream where baseflow levels may be more sensitive to changes in recharge due to climate change is difficult to assess because of the varying trends found from year to year. Methods of quantifying baseflow sensitivity should be investigated especially with regards to climate change. The 2007 baseflow measurements, collected at a time when precipitation inputs were below normal is beneficial for studying climate extremes, and will become an important data set in which to study the response of the low flow regime. In the future, climate change has been predicted to cause more extreme conditions and identifying areas of stream that are more sensitive to climatic changes and inputs is the first step in their protection.

While the flow data collected and the mapping products prepared through the Low Flow Management Program provide valuable information and direction on their own, some of the key uses of the information come from identifying and integrating the information into the development of other water management strategies. For baseflow, areas of regeneration priorities must be coupled with other water balance components such as groundwater and storm water management in order to maintain or enhance the flow regime in the Etobicoke and Mimico Creeks.

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