4W.0 NORTH OAKVILLE CREEKS SUBWATERSHED (West of Sixteen Mile Creek)

4W.1 Introduction

The study area is bounded by Sixteen Mile Creek to the east, Highway 407 to the north, by Dundas Street to the south and by Tremaine Road to the west. The study area contains the headwaters of the east branch of Fourteen Mile Creek, Taplow Creek, and Glen Oak Creek. Tributaries of Sixteen Mile Creek are also contained within the study area boundaries. The headwaters for the main branch of Fourteen Mile Creek and McCraney Creek are located outside of the study area. **Figure 4W.1.1** shows the catchment boundaries within the study area.

A detailed discussion of the existing land uses, environmental features and processes affecting these features is outlined in the following sections. This "characterization" is based on background data, field information collected, and initial analysis of that data and information.

4W.2 Land Use

Land use within the study area is mostly agricultural with scattered wooded areas. Some residential units are located along the roadways such as Dundas Street West, Burnhamthorpe Road West, Bronte Road, and Tremaine Road.

OPA 198 designates the lands north of Dundas Street as an urban area. OPA 198 has been approved by the Ontario Municipal Board and adopted by Council, but does not have final approval. The Town has adopted a position in response to appeals by certain landowners of their application to amend the official plan for North Oakville, east of 16 Mile Creek (Draft North Oakville East Secondary Plan). The Town has also prepared a conceptual land use plan for the lands in North Oakville West (the North Oakville West Conceptual Land Use Plan). Both the Draft North Oakville East Secondary Plan and the North Oakville East Conceptual Land Use Plan were used in this Subwatersheds Study. These Plans are found at **Figure 4E.2.1** and **Figure 4W.2.1**.

A detailed inventory of the land use has been completed in terms of the terrestrial and aquatic features identified in the field. The complete description is included in **Section 4W.9**.

4W.3 Physiography and Geology

The study area defined above is bounded by physical barriers (*i.e.,* Dundas Street to the south, Highway 407 to the north, Tremaine Road in the west and Sixteen Mile Creek in the east). However, natural features rarely end at municipal or study boundaries. Therefore, the discussion of physiography, geology, and hydrogeology will include land and features beyond the immediate study boundaries.

There are sections of five drainage basins in the study area including Sixteen Mile Creek on the east, and Fourteen Mile Creek on the west. Taplow Creek, McCraney Creek, and Glen Oak Creek are located between the two larger creeks. All these are shown on **Figure 4W.1.1**. Many of these creeks have their headwaters in North Oakville or south Milton, just north of the study area. Sixteen Mile and Fourteen Mile Creeks have headwaters well beyond the study area limits.

The study area is in the Lake Erie Lowland eco-region, which extends from Windsor to Toronto and includes the Niagara peninsula (Environment Canada at http://www.ec.gc.ca/soer-ree/English/Framework/Nardesc/mixpln_e.cfm). This eco-region is generally characterized by humid, warm to hot summers, and snowy, relatively mild winters. Typically, the mean annual precipitation is in the order of 800 to 900mm. The bedrock in this eco-region includes various types of carbonate-rich

Paleozoic rock.

4W.3.1 Physiography

Within Ontario, geological and physiographic distinctions can be made between two major regions; the uplifted Canadian Shield and the surrounding flatter lowlands (Thurston 1991). The study area is located within a broad lowland located west of the Frontenac arch known as the West St. Lawrence Lowlands Physiographic Region. This region is further broken down into smaller units that represent a more localized characterization of the physiography. Since the St. Lawrence Lowlands region was shaped, to a large degree, by the last glaciation, the physiographic units in this part of southern Ontario are often related to the landforms and features that resulted from the last glaciation.

The study area is entirely within the South Slope Physiographic Region of southern Ontario (Chapman and Putnam, 1984). In Halton Region, the South Slope includes the strip of land between the Lake Iroquois shoreline to the south and the Peel Plain to the north. Within this area, the ground surface rises gently upwards to the north (as a sloping till plain that has some gentle undulations and/or fluting). **Photo E.1** in **Appendix E** shows an oblique photo of the west side of the study area. The minor fluting and the gently northward rising till plain are clearly seen.

North of Dundas Street, the gentle slope continues into the area north of Burnhamthorpe Road, where the area referred to as the Trafalgar Moraine is seen as a low ridge. The Trafalgar Moraine is the youngest moraine in the area (Karrow, 1987). As the ice melted, the oscillation of the ice front and/or the resulting melt waters created long grooves, or flutings in the till plain. These are more notable at the west end of the study area, and are particularly notable toward the west end of the moraine in the Burlington and Milton areas.

In the Burlington area, many elongated ridges or flutes can be seen. In the valleys between the ridges, drainage courses have formed in many cases. Between Sixteen Mile Creek and Ninth Line, there are no areas mapped as being fluted as seen in **Figure 4W.3.1**. The only exception is at the far northeast corner of the Town of Oakville near the Highway 407 and 403 interchange and further eastward into Mississauga.

The moraine is particularly distinguishable when driving north on either the Tremaine Road or the Bronte Road, beyond the study area, where the crest of the hill can be readily seen just south of Lower Baseline Road. In general the relief associated with the crest of moraine is about 15m above the surrounding till plain.

East of Bronte Road, the main branch of Sixteen Mile Creek cuts through the moraine in a deeply incised valley. The creek has not only cut through the moraine, but also incised itself well into the underlying bedrock. **Photo E.2** in **Appendix E** shows a picture of the Sixteen Mile Creek valley and the exposed bedrock.

One feature noted in the area is the small depressions at ground surface. These occur randomly throughout the study area. These depressions may be a result of melting ice pieces that remained as the main glacial ice mass receded from the area. These depressions are not isolated to this area. The greatest density of depressions occurs along the crest of the Trafalgar Moraine, west of Bronte Road. There are also some depression features between Sixth Line Road and Trafalgar Road. Both these locations are outside this study area. The relief associated with the depressions is very low, usually less than 50cm. In addition, the historic and current agricultural use of the land has altered the shape and form of some of these depressions.

Overall, the topography in the till plain is gently undulating to fluted with low relief and poor to moderate drainage. Drainage in the study area has a linear pattern, likely a reflection of drainage courses developing in the lower areas in the locally fluted topography.

4W.3.2 Geology

4W.3.2.1 Bedrock Geology

The bedrock in this part of Halton Region is predominantly the soft, red, Upper Ordovician-aged shale of the Queenston Formation (Karrow, 1987; Ostry, 1979; MNR, 1975). To the south and east, the Ordovician-aged Georgian Bay Formation has been mapped. The Georgian Bay formation is a gray to green coloured shale with interbedded siltstone and limestone layers. **Figure 4W.3.2** shows the bedrock geology.

Within the study area, the bedrock is the red Queenston shale. The bedrock is uniform in character with little variation from one locale to another. Overall, the bedrock surface is flat to gently undulating with a southeastward slope. Along the Fourteen Mile Creek valley there is evidence of a buried bedrock valley. The valley appears to trend eastwardly from just northwest of the study area to the area around Upper Middle Road and Bronte Road. Toward the centre of the study area, the valley is in the order of 25m deep. During glacial retreat, the valley was filled with sediments from the receding glaciers.

There are no mapped bedrock exposures in the study area, other than in the Sixteen Mile Creek valley. However, bedrock was observed in the valley walls in the Fourteen Mile Creek valley toward the centre of the study area. **Photo E.3** in **Appendix E** shows a photograph of a bedrock exposure in the Fourteen Mile Creek valley.

4W.3.2.2 Quaternary Geology

Overlying the bedrock is a veneer of till, mapped as the Halton Till (Karrow, 1987), that was deposited during the last major advance of the Laurentide Glaciers, the glacial ice mass that covered most of central and eastern Canada and extended well into the northeastern USA. **Figure 4W.3.1** shows the Quaternary Geology of the study area.

The Halton Till was deposited during the time when the Erie-Ontario lobe of the Laurentide glacier was re-advancing into the eastern end of the Lake Erie Basin (OGS Special Publication 4, 1992). Recent work suggests that the finer grained Wildfield Till in some areas may overlie the Halton Till. However, mapping by Barnett (Chapman and Putnam, 1984) and Karrow (1987) show the two tills as a single Halton Till map unit. Since the tills are similar and have been considered a single map unit by others, for the purposes of this characterization the two tills are considered as the Halton Till.

The Halton Till is characteristically silt to clayey silt till that typically has very low permeability (on the order of 10^{-7}cm/sec). Within the till occasional sandy layers or lenses are sometimes encountered. These lenses tend to be very limited in both aerial extent and thickness. The Halton Till ranges from less than 1m thick in areas south of Dundas Street to about 5m in the area south of Burnhamthorpe Road. Often the upper few meters of the clayey silt till are fractured and weathered.

Within the larger stream valleys, such as the Fourteen Mile Creek and Sixteen Mile Creek valleys, deposits of recent alluvium are found. **Photo E.4** in **Appendix E** shows a photograph of alluvium within the meanders of Fourteen Mile Creek in the wooded area south of Highway 407. These are

predominantly silts and sands placed by various stages of these creeks during recent time (<10,000 yrs), including the deposition presently occurring.

The highest density of wells, hence the largest amount of subsurface information, occurs along Bronte Road and Dundas Street. **Figure 4W.3.3** presents a north to south profile along Bronte Road. The figure shows that both the bedrock surface and the ground surface slope upward at about 0.008m/m (<1%). The stratigraphy throughout this part of the study area appears consistent, with a veneer of clay (interpreted to be the Halton Till) overlying the bedrock.

Going from Tremaine Road in the west along Dundas Street, the ground surface is relatively flat except for the valleys created by the larger creeks. **Figure 4W.3.4** and **Figure 4W.3.5** show the west to east profile along Dundas Street from Tremaine Road to Sixteen Mile Creek. The profile also shows that, using the available water well data, the bedrock surface has a high point just east of Bronte Road and that the bedrock valley in the Fourteen Mile Creek area extends at least as far south as Dundas Street. The results of other studies south of Dundas Street confirm that the bedrock valley extends to the area around Bronte Road and Upper Middle Road.

Along these cross sections the geology is consistent. The Queenston Shale is overlain by a layer of till with only occasional sand or gravel layers encountered. The only exception is the buried valley in the Fourteen Mile Creek area. Wells located along Dundas Street show the top of rock, but stratigraphic information is not readily available.

To better understand the sedimentation in the bedrock valley, a profile was prepared for the area between Tremaine Road and Bronte Road, north of Dundas Street. The profile in **Figure 4W.3.6** shows that the buried valley is about 30m deep and contains some coarser grained sand and gravel deposits. These coarse grained materials range from about 5 to 20m thick and are overlain with about 12m of Halton Till. The coarse grained deposits serve as a local aquifer, providing a private water supply source for industry and private residences in the area.

Although no drilling was done in the study area, existing drilling results from work done on the east side of Sixteen Mile Creek confirm that the Trafalgar Moraine is composed of the silty to clayey silt Halton Till. Grain size testing shows that there is little variation in till composition either with depth or location. The till has 9 to 15% gravel, 11 to 16% sand; 42 to 50% silt; and 22 to 36% clay sizes. Based on grain size testing, the hydraulic conductivity for the Halton Till at the test locations is estimated to range from 9×18^{-8} to 3×10^{-7}cm/sec. These results are consistent with published values for the till.

4W.4 Groundwater Flow System Characterization

Sufficient existing information is available to develop an understanding of groundwater flow systems in the study area. This includes available water well records, the regional groundwater model, and the results from previously completed hydrogeological studies and monitoring. This information was augmented with the data collected as part of this Subwatershed Study.

There are essentially two functions for groundwater. One function is the use of groundwater as a water supply source. Depending on the need, groundwater can be used for activities such as human consumption, irrigation, or other agricultural and commercial uses. The second is the ecological function, primarily the contribution of groundwater to flow in streams and sustaining wetland areas.

4W.4.1 Regional Groundwater Flow

Regionally, the hydrostratigraphic model consists of a surficial till unit (Halton Till) that acts as an aquitard overlying the Queenston Shale bedrock. Although not a good aquifer, the shale is the unit in which most private water supply wells are completed. There are no municipal water supplies being taken from either the shale bedrock or the overburden. Within the Halton Till, occasional coarser soil layers can be found. These layers or lenses are discontinuous and tend not to be thick. They do, in some cases, yield sufficient water for domestic purposes.

The regional water table suggests a southeastward flow of groundwater toward Lake Ontario at a horizontal gradient of about 0.8%. This is similar to the slope of both the ground surface and the bedrock surface in the area. In the shallow bedrock, groundwater flow is also predominantly southeastward toward Lake Ontario. Along the east side of the study area, the presence of Sixteen Mile Creek in the deeply incised valley results in some groundwater flow being directed toward the Sixteen Mile Creek valley. Also, the buried bedrock valley in the vicinity of Fourteen Mile Creek results in a slight deflection of the deeper flow system toward this buried feature.

Based on work by Ostry (1979), Funk (1979) and others, the water table in the till/shallow bedrock appears to be a subdued expression of ground surface. This is confirmed in examining the slope of the regional bedrock surface, ground surface, and the regional water table. Locally, the creeks, swales and other watercourses in the study area that intersect the water table also influence shallow groundwater flow. Close to these watercourses, shallow groundwater flow tends to be toward these surface water features.

4W.4.2 Groundwater Flow in the Study Area

In the study area, local groundwater flow is consistent with the regional model. Throughout the study area, including the area to the north in the vicinity of the Trafalgar Moraine, the shallow flow system is a subdued reflection of the ground surface topography. Shallow groundwater flow is locally toward creeks and watercourses that are deep enough to intersect the water table. At depth, groundwater flow is interpreted to be influenced by the buried bedrock valley, which is partly filled with granular soils. Flow in this system is generally directed southeastward following the trend of the bedrock valley.

As seen previously, **Figures 4W.3.3** through **4W.3.6** show the original water levels measured by drillers when each well was constructed. In a north south direction along Bronte Road (**Figure 4W.3.3**), the water levels show that the water table is just below ground surface throughout much of the area. In the west to east direction, west of Bronte Road (**Figures 4W.3.4** and **4W.3.6**), the buried bedrock valley, along with the lower water levels in wells completed in the valley, can be seen. The lower water levels in the valley imply that flow in the rock close to the valley is directed toward this feature.

Infiltration of precipitation and recharge to the local groundwater flow system occurs throughout the study area, although the amount of water reaching the bedrock is expected to be small because of the low permeability of the soils. Groundwater discharge does occur near the bottoms of some watercourse valleys. **Photo E3** located in **Appendix E** shows the exposed bedrock in the Fourteen Mile Creek valley. At the base of the outcrop, groundwater discharge was observed. Since these observations were made in the spring of 2003, when the water table was high, it is expected that these conditions may be somewhat transient through the year as the water table naturally declines in elevation during the drier summer months.

As part of the Subwatershed Study, mini-piezometers were installed at seven locations throughout the study area. The instruments were usually placed in pairs (13 in total at 7 locations) and most often within a stream valley. **Photo 4W.1** shows a single piezometer in the foreground of the picture and **Photo 4W.2** shows a typical nest of two mini-piezometers.

Water levels were monitored monthly after installation. The results show that in low lying areas, such as the watercourse valleys, shallow vertical groundwater gradients generally appear to be discharge gradients or transient between recharge when the local water table is high and discharge when times when the seasonal water table is lower. Based on the study results, the area has recharge conditions typical of the Halton Till Plain (*i.e.,* low infiltration through clay rich soils).

4W.4.3 Groundwater Use

Groundwater in the study area is used primarily for domestic and agricultural purposes. Based on the house-to-house survey conducted, well yields from the bedrock, the predominant aquifer in the area, are low. In many cases, the well yields are not reliable (too low during the summer) and groundwater quality is poor. Some local residents drink bottled water, only using the well water for non-consumptive purposes. The exception is for wells located in the granular deposits in the buried bedrock valley, where well yield of greater than 60 L/min have been reported from the overburden.

The absence of an extensive overburden aquifer and the poor quality and quantity of groundwater from the bedrock suggest that the potential to develop a large groundwater supply in the study area is generally very low. Although local residents use groundwater as a primary water supply source, many use water from other sources for consumptive purposes.

4W.4.4 Groundwater Quality

As part of the groundwater system characterization, six groundwater samples were collected from domestic wells in the study area. The samples were analyzed in the laboratory for a suite of inorganic parameters including metals, and major anions/cations. The results are presented in **Appendix E** and the well locations can be found by locating the well number on **Figure 4W.4.1** in **Appendix E**.

Based on the sampling of groundwater from the area, quality varied from location to location, as expected. However, there were some trends and characteristics noted. Only one well had nitrate levels that suggested no impact from near surface sources such as septic systems or agricultural activities. All other wells had nitrate concentrations above what can be considered background levels (usually non detect) and one well had a nitrate level that exceeds the Ontario Drinking Water Standard (ODWS) of 10 mg/L.

Other parameters such as chloride and sulfate were also elevated, with two wells having chloride levels that exceed the ODWS of 250 mg/L and two other having high chloride. Only one well had a sulphate level above the ODWS of 500 mg/L. It should be noted that both chloride and sulphate naturally occur at elevated levels in the bedrock aquifer. Thus, the presence of high concentrations of these parameters does not specifically indicate an impact related to activities at the surface.

Overall, groundwater quality in the area is relatively poor. The exception, although no specific data was available, is the water from the buried bedrock valley, which is reportedly good.

4W.5 Groundwater Balance

The water balance for the area was developed as part of the analysis phase of the Subwatershed Study. In completing the water balance analysis, consideration was given to the role that the creeks, geology, and topography have in creating runoff, evapotranspiration and infiltration conditions. Also considered were the results of the modelling done as part of the Halton Region Aquifer Management Plan (Region of Halton). The water balance is based on conditions throughout the study area, but can be applied to specific locations in the area.

When precipitation occurs, a portion of the water infiltrates into the ground. Of the total water entering the ground in the study area, a portion continues to percolate downward to the water table. This component is considered the recharge to the groundwater system. The remaining portion tends to move vertically through the fractures in the shallow overburden, then laterally toward local creeks and surface watercourses. This portion of the infiltration, which is known as interflow, provides some of the water that flows in the various streams.

Preliminary estimates of the total infiltration range from about 50 to 110mm/year. Considering the permeability of the local soils, the amount of recharge reaching the bedrock is estimated to range from as little as 5 to 50mm/year. The range is a function of the range of soil permeability that results from the drying and wetting periods during the year. The remainder of the infiltrating water will move slowly laterally toward nearby surface watercourses.

4W.6 Surface Water – Hydrology

4W.6.1 Introduction

The western portion of the study area is bound by Dundas Street West in the South and Highway 407 in the north, Sixteen Mile Creek to the east and Tremaine Road to the west. The study area is drained by Fourteen Mile Creek, McCraney Creek, Glen Oak Creek, Taplow Creek, and tributaries of Sixteen Mile Creek.

4W.6.2 Climate

A portable weather station was erected at the Moore Reservoir, located to the east of Sixteen Mile Creek. The monitor recorded the following meterological data at 30-minute intervals since March 2003:

- Temperature/Humidity Index;
- Outside Temperature;
- Windchill;
- Pressure;
- Temperature (High/Low);
- Outside Humidity;
- Dewpoint;
- Wind speed/Direction; and
- Precipitation.

Monthly precipitation and mean daily temperatures (from 1971 – 2000) for the Oakville Southeast WPCP gauge are shown in **Table 4W.6.1**. The gauge is located near Winston Churchill Boulevard and Lakeshore Road East. The data is representative of precipitation and temperature data expected to occur within the study area. **Table 4W.6.1** shows mean annual precipitation that can vary as much as 30%

from one year to the next.

Table 4W.6.1
Climate Data, Oakville Southeast WPCP, 1971-2000

	J	F	M	A	M	J	J	A	S	O	N	D	Ann.
Mean Daily Temperatures													
Daily Maximum, °C	-1	0	5	11	18	23	26	25	21	14	8	2	13
Daily Minimum, °C	-9	-9	-4	1	7	12	15	15	10	5	0	-6	3
Mean Daily Precipitation													
Rainfall, mm	31	28	47	65	70	71	73	78	79	69	69	47	726
Snowfall, cm	28	17	15	3	0	0	0	0	0	0	3	18	83
Total, mm	59	44	62	68	70	71	73	78	79	69	72	65	809

The adjacent Burlington Royal Botanical Garden precipitation gauge has an average annual precipitation of approximately 860mm with 730mm of rainfall and 120mm of snowfall. The Royal Botanical Garden gauge has a longer period of record than the Oakville gauge.

4W.6.3 Land Use

As discussed in **Section 4W.2**, the land use is mostly agricultural with some wooded areas. Some residential units are located along the roadways such as Dundas Street West, Burnhamthorpe Road West, Bronte Road, and Tremaine Road. Highway 407 bisects the study area in a west-east direction.

4W.6.4 Topography

Within the study area, runoff drains in a northwest to southeast direction. The maximum study area elevation is approximately 190m. The elevation near Dundas Street West is approximately 145m above mean sea level (AMSL).

4W.6.5 Physiography

Although the physiography of the study area has already been discussed in **Section 4W.3**, this section will consider the effect of physiography with respect to hydrology. The physiography of the study area shown in **Figure 4W.3.2** shows a till moraine, the area referred to as the Trafalgar Moraine, north of the study area. **Figure 4W.3.2** also shows that the entire area is within till plain called Halton Till.

4W.6.6 Soils

Figure 4W.6.1 displays the study area soils. Soils developed in Halton Till include Oneida, Chinguacousy, and Jeddo. Chinguacousy clay loam soils are imperfectly drained and occupy the gentle landscape slopes. Chinguacousy soils have developed in clay and silty clay glacial till deposits. Oneida soils occupy the steeper soils and are well drained. Jeddo clay loam soils are found in slight depressions and are poorly drained. **Table 4W.6.2** shows the United States Soil Conservation Service (US S.C.S) hydrologic soil groups found in the study area.

Table 4W.6.2 US S.C.S. Hydrologic Soil Groups in Study Area	
Soil Type	**Hydrologic Soil Group**
Chinguacousy, clay loam	C
Oneida, clay loam	D
Jeddo, clay loam	C
Trafalgar, clay	B

Although the soils have been classified into four groups from "A" through "D". Hydrologic Soil Group A generates low runoff volumes while hydrologic Soil Group D has the lowest infiltration rates and generates high runoff volumes.

4W.6.7 Flow Monitoring

Information on the flow conditions for the east and west branches of Fourteen Mile Creek was collected in the form of a depth and temperature reading. A monitor was installed in the east branch of Fourteen Mile Creek on October 29, 2002, and the second monitor was installed in the west branch of Fourteen Mile Creek on November 15, 2002. Both monitors were removed on December 3, 2002, to avoid freezing. The monitors were reinstalled at the same locations in the spring of 2003 on March 28 and were still in place at the writing of this report. Data was collected at different time intervals (*i.e.*, 15-minute, 30-minute and hourly) and were periodically downloaded. The depth and temperature data has been graphed versus time and is provided in **Appendix F**.

In addition to the continuous flow monitoring, cross-sections and creek velocities were measured at Sixteen Mile Creek, Fourteen Mile Creek, McCraney Creek and Taplow Creek. **Table 4W.6.3** provides the dry weather flows for the various creeks and the locations are shown on **Figure 4W.6.1.**

Table 4W.6.3 Creek Flows Taken on May 2, 2003 and August 13, 2003							
Sample ID	**Location**	**May 2, 2003**			**August 13, 2003**		
		Cross sectional area (m^2)	**Velocity (m/s)**	**Flow (m^3/s)**	**Cross sectional area (m^2)**	**Velocity (m/s)**	**Flow (m^3/s)**
SM 2	Sixteen Mile Creek	0.0765	0.232	0.0177	No water	N/A	N/A
FM 4	Fourteen Mile Creek	1.52	0.188	0.286	0.104	0	0
FM 3	Fourteen Mile Creek	0.387	0.0455	0.0176	No water	N/A	N/A
FM 2	Fourteen Mile Creek	-	-	-	0.461	0	0
FM 1	Fourteen Mile Creek	1.29	0.442	0.568	0.325	0	0
MC	McCraney Creek	7.07 (culvert full)	N/A	N/A	0.344	0	0
TC	Taplow Creek	0.544	0.204	0.111	0.170	0	0
SM 1	Sixteen Mile Creek	0.0677	no data	no data	0.129	0	0

4W.6.8 Design Flows

In preparation for undertaking an updated hydrologic analysis of the various catchements, previous reports completed by others were reviewed to identify the design flow rates calculated as part of past work completed in the study area. Flows at Dundas Street previously established by means of hydrologic

modelling are summarized in **Table 4W.6.4** and **Table 4W.6.5**, for peak flows under existing land use and future land use, respectively.

Table 4W.6.4
Summary of Peak Flows for Existing Land Use Conditions at Dundas Street from Past Studies

Watercourse	Return Period Flow (m^3/s)								
	1-yr	2-yr	5-yr	10-yr	20-yr	25-yr	50-yr	100-yr	Regional
Sixteen Mile Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fourteen Mile Creek East (Feb 1992)	N/A	2.88	3.89	4.80	N/A	6.61	7.15	8.80	24.00
McCraney Creek (February 1992)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fourteen Mile Creek – West Branch (January 2002)	N/A	2.21	2.99	3.75	N/A	5.53	5.94	7.46	24.80
Fourteen Mile Creek – East Branch (January 2002)	N/A	2.32	3.13	3.86	N/A	5.40	5.82	7.18	20.80
Fourteen Mile Creek – Main Branch (January 2002)	N/A	1.95	2.68	3.37	N/A	4.97	5.35	6.73	22.30
Taplow Creek (February 1992)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glen Oak Creek (December 1993)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 4W.6.5
Summary of Peak Flows for the Future Official Plan at Dundas Street from Past Studies

Watercourse	Return Period Flow (m^3/s)								
	1-yr	2-yr	5-yr	10-yr	20-yr	25-yr	50-yr	100-yr	Regional
Sixteen Mile Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fourteen Mile Creek East (February 1992) Future development	N/A	2.88	3.89	4.80	N/A	6.61	7.15	8.80	24.00
McCraney Creek (February 1992)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fourteen Mile Creek – West Branch (January 2002)	N/A	10.10	13.00	15.00	N/A	18.20	19.80	23.40	29.10
Fourteen Mile Creek – East Branch (January 2002)	N/A	8.42	10.80	12.50	N/A	15.10	16.50	19.40	24.90
Fourteen Mile Creek – Main Branch (January 2002)	N/A	8.53	11.10	12.80	N/A	15.50	16.90	20.00	25.70
Taplow Creek (February 1992)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glen Oak Creek (December 1993)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A – Not Available

4W.6.9 Hydrologic Issues to Be Addressed

As with most subwatershed studies, the key issues to be addressed, as applicable to each watercourse include:

- Peak runoff quantity control;
- Maintenance of base flow rates/water balance;
- Volume of surface runoff;
- Groundwater recharge/discharge;
- Erosion protection; and
- Runoff water quality control.

Measures previously recommended to address each of these issues (if applicable) as a result of past studies are briefly summarized in the following section of this report.

4W.6.10 Previously Recommended Management Alternatives and/or Strategies

Sixteen Mile Creek (Sixteen Mile Creek Watershed Plan, Gore & Storrie Ltd and Ecoplans Ltd., February 1996)

This previous study involved a total of nine subwatersheds tributary to Sixteen Mile Creek for which a number of management criteria/recommendations were established, including:

- Control of peak post development runoff rates to predevelopment levels;
- Quality treatment of all storm runoff prior to discharge to the creek;
- Control of post development runoff to maintain predevelopment flow duration (*i.e.,* runoff hydrograph) characteristics as much as possible, to minimize erosion potential; and
- Maintain existing groundwater recharge rates on an areal basis (*i.e.,* maintain existing infiltration rates to maintain base flow characteristics).

Specific recommendations put forth as a result of this study included:

- Minimize imperviousness by clustering of development, utilizing underground parking, minimizing pavement widths, using grassed ditches instead of curb and gutter, and any other innovative architecture or site layouts that can be identified on a site specific basis. Techniques which encourage infiltration should be emphasized, such as roof downspout disconnection, soakaway pits, grassed filter strips, grassed ditches, swales, depressions, collection of runoff in temporary pooling areas within parks and other open spaces;
- Provide on-site storage equivalent to 5mm over the impervious area through roof and parking lot detention, cisterns, etc;
- Maintain water balances, increase groundwater recharge, and reduce peak runoff rates by encouraging runoff dispersal rather than collection and concentration of runoff;
- Minimize the use of storm sewers and maximize overland drainage and dispersal wherever feasible;
- Extend overland drainage for the greatest distance possible via grassed ditches and swales; and
- Minimize deepening of watercourses to accommodate storm sewer outlets.

It was further concluded that in general, Sixteen Mile Creek will be capable of accommodating the anticipated level of urban development within Milton and North Oakville as defined in the Halton Urban Structure Plan. This would be attainable by maintaining or enhancing the current water quality by implementing appropriate SWM measures. This study also determined that the anticipated levels of future

development would not require updating of the current regulatory flood lines.

Water quality control as based on the MOE/MNR Storm Water Management Plan (SWMP) Design Manual (1994) should be adequate provided the following are taken into account:

- Erosion control should be based on flow duration exceedence characteristics (see Gore & Storrie study);
- Sustenance of base flows should be emphasized based on maintenance of groundwater recharge;
- Ponds should be designed to minimize their impact on water temperature; and
- Enhanced level of protection is afforded to identified sensitive aquatic habitats.

Furthermore, aquifer protection should involve identification of potential contaminant sources, determination of appropriate land uses and monitoring of quality and quantity of groundwater within the watershed. Areas susceptible to groundwater contamination were delineated as part of the Gore & Storrie study.

Recommendations specifically related to agricultural lands included:

- Planting of trees along streams as windbreaks to reduce wind erosion, and to provide riparian habitat, and filter buffers along streams;
- Reconstruction of ponds or pond outfalls or construction of pond bypass channels;
- Fencing to limit cattle access to streams and wetlands; and
- Protection/retention of existing wetlands on agricultural property.

A comprehensive monitoring program was recommended including monitoring of the following:

- Streamflow;
- Water quality including dissolved oxygen, temperature, bacteria, nutrients, pesticides, metals, and suspended solids under dry and wet weather conditions;
- Erosion inventory;
- Groundwater base flow and temperature;
- Infiltration rates in various soil types;
- Water levels in existing wells; and
- Water quality from existing wells.

Fourteen Mile Creek / McCraney Creek (Watershed Planning Study of Fourteen Mile/McCraney Creeks, Triton Engineering Services Limited et al.., February 1992)

This study was done in order to act as an Environmental Study Report under the Province's Environmental Assessment (EA) process. It reviewed the options and the selection of the preferred management approach for SWM policies and facilities in the study area. It included Fourteen Mile Creek, McCraney Creek, as well as the Sixteen Mile Creek Tributary.

A number of management criteria/recommendations were established. The site specific recommendations included:

- Flood storage facility on Fourteen Mile Creek above the QEW. The storage should use the existing valley system so that there is a minimum disruption to the environment. It should be a dry storage facility and store water only during flood events;
- Channelization in indicated flood damage areas;
- Berms to provide flood protection in residual damage areas;
- Improve the existing diversions on McCraney Creek;
- Use vegetated stream lining, vegetated buffers, and introduce a treed canopy over the system (to be incorporated into the West Oaks Trail Secondary Plan);
- Use vegetative erosion protection where feasible or hardened lining material when vegetative material cannot be used;
- The existing watercourse should be changed as little as possible and a vegetative buffer should be used along the existing watercourse. The buffer width should be 15m from each edge of the streambank on either side with a minimum of 7.5m recommended for the top of the bank. It was recommended that the buffer strip be designated as an EPA under the OP for the Town of Oakville.
- All future development should control peak flow rates to existing levels for the 1:2 to 1:100 year design events inclusively;
- The frequency and magnitude of predevelopment conditions should be controlled as well as the base/groundwater flows;
- SWM for controlling erosion and sedimentation should apply the tractive force approach and/or the flow frequency method;
- For erosion control, the predevelopment conditions should take into account the more frequent storm flow events 1:2 year and 1:5 years;
- Woodlots and wetlands of potential hydrogeological significance were identified and were to be designated;
- A preliminary infiltration target of 5mm from all impervious areas and consideration for lower density development in areas of high infiltration. Store runoff from a 25mm rainfall (duration of 2hrs) for a minimum of 2 to 3 days after rainfall;
- Infiltration requirements should be viewed as first priority for facilities to be integrated with the peak flow control facilities;
- The MOE/MNR Interim Quality Control Guidelines should be used;
- Tighten controls during the urban construction period to prevent silt from entering the creek system; and
- Develop a public education program to stop practices that lead to the detriment of the water quality.

Recommendations for future studies:

- Suggested that additional studies should be carried out to prioritize existing sites requiring erosion control based on the level of damage, the cost, and the rate of bank recession;
- A detailed assessment of each identified woodlot/wetland must be conducted prior to development;
- Perform site specific studies as part of the new development proposals. Refine the level of peak flow control (and volume of storage) needed; and
- Do final flow control requirements for erosion control and water quality to meet targets established in this study.

A comprehensive monitoring program was recommended and included:

- Erosion inventory;
- Spill management; and
- Water quality including temperature, dissolved oxygen, ammonia, turbidity, nutrients, benthic invertebrates, heavy metals, base flow, and bacteria.

Fourteen Mile Creek (Stormwater Management Design Brief for Quality/Quantity SWM Pond and Fourteen Mile Creek Tributary Crossing, Cosburn Patterson Mather Limited, March 1999)

This SWM pond followed the recommendations of the Watershed Plan Study (February 1992) and the development controlled peak flow rates to existing levels for the 1:2 to the 1:100 year design events. It also maintained the existing floodplain and a Level 2 protection was provided with total weighted site imperviousness of approximately 85% for the areas draining into the SWM pond. The Fourteen Mile Creek crossing was sized to pass the Regional Event flow without overtopping the road. As per the recommendations of the Watershed Plan Study, an erosion and sediment control plan was done.

Fourteen Mile Creek (Fourteen Mile Creek East Branch Scoped Subwatershed Plan East of Regional Road 25, Philips Engineering Limited, May 2000)

This study was done parallel to the West and Main Branches of the lands west of Bronte Road. This study was to build on the recommendations of the Watershed Planning Study (February 1992). It assessed the methods and costs of providing the required SWM on and off site. The plan area was located within the Fourteen Mile Creek watershed and dealt with the Main Branch of Fourteen Mile Creek as well as the second (westernmost) East Branch.

The main recommendation was to build a constructed wet pond in the West Oak Trails and North of Dundas Street.

The general recommendations were as follows:

- A Level 1 Protection is to be provided throughout, inclusive of the additional extended detention storage (25mm) provided for off-site protection;
- An erosion assessment demonstrated that providing 25mm of extended detention volume for 24-hours would over-mitigate potential erosion in the creek. Therefore, at subsequent design and planning stages it may be possible to refine the volume required;
- All the Stormwater Quality Facilities are to consider methods that alleviate potential thermal enrichment as outlined in the MOEE 1994 *Stormwater Management Practices Planning and Design Manual*;
- Distributed infiltration practices that were cited throughout the subwatershed plan should be applied to the maximum as part of subsequent planning and design; and
- All storm sewers are to be designed to a five-year standard as outlined in the Town policy.

Fourteen Mile Creek (Fourteen Mile Creek Main and West Branches Subwatershed Plan, Philips Engineering Limited, June 2000, revised January 2002)

This Subwatershed Plan included the lands of the westernmost portion of the West Oak Trails community, the West Oak Trails Employment Lands. The Subwatershed Plan Area addressed the main and west branches of Fourteen Mile Creek, including the sub-tributary referred to as the "East Branch". This study was done to support a secondary plan process to lead to an OP Amendment for the former West Oak Trails

Employment Lands.

The Subwatershed Plan proposed a variety of SWM facilities. A number of general recommendations were also brought forth:

- Level 1 water quality protection is to be supplied throughout, inclusive of the additional extended detention storage (25mm) for off-site protection;
- Erosion control storages are to be discharged over a minimum of 24-hours thereby establishing maximum release rates;
- An erosion assessment demonstrated that providing 25mm of extended detention volume for 24-hours would over-mitigate potential erosion in the creek. Therefore, at subsequent design and planning stages it may be possible to refine the volume required;
- All the stormwater quality facilities are to consider methods that alleviate potential thermal enrichment as outlined in the MOEE 1994 *Stormwater Management Practices Planning and Design Manual*;
- All storm sewers are to be designed to a five year standard as outlined in the Town policy;
- The required 100-year belt width of Fourteen Mile Creek should be examined and accommodated during the detailed design of the facilities;
- The recommended wet pond may be designed as wetlands due to habitat considerations;
- Drainage areas larger than 40 to 80ha may require dedicated overland flow routes in addition to that provided through area roadways. This requirement should be further examined at the Secondary Plan stage;
- As individual applications with SWM facilities are submitted, they should be tested against the Regional flood control criteria;
- The development area north of Dundas Street and south of Highway 407, at the western most limit of the Fourteen Mile Creek Watershed, is in the City of Burlington. This land does not currently (as of January 2002) have an OP land use designation. For the purposes of this study, it was conservatively assumed that these lands were to be future employment lands. Instead of creating extra stand-alone SWM facilities for the City of Burlington, the facilities were sited at Dundas Street and it is intended that the municipalities will discuss future sharing strategies;
- As per the guidelines outlined in the Class Environmental Assessment (EA) process, compliance monitoring should be done as part of the plan implementation;
- Maintaining low constraint watercourse features established within either low or medium constraint terrestrial features should be examined at the Secondary Plan stage;
- Future groundwater related monitoring should involve more detailed investigations in areas of known groundwater discharge. This level of detail should incorporate the installation of monitoring wells to establish the local flow system and supplementary spot baseflow measurements under non-drought conditions to delineate and additional discharge zones;
- The SWM facilities in the vicinity of Upper Middle Road and Bronte Road should promote infiltration of stormwater in the sand and gravel lens identified in the study;
- A watercourse crossing will be necessary for both the future extension of West Oak Trails and the Bronte Creek development;
- With regard to the Natural Heritage System, the five-category management system is to be applied as per LGL 1999;
- The Main Branch of Fourteen Mile Creek has been recognized as one of the primary opportunities for enhancement of the Natural Heritage System and Aquatic Habitats within the study area. Its naturalization should be seen as a long term objective of the Subwatershed Plan. Continuation of usage of land for golf courses within the valley should be discouraged;
- An Environmental Impact Study (EIS) should be prepared for any development of infrastructure

within 50 metres of woodots F14, F15, F16 and the Fourteen Mile Creek Valley;
- Effects of future urban development on adjacent natural heritage resources and functions should be minimized through appropriate re-vegetation, open space management plans, monitoring, landowner education and stewardship programs;
- Open space management plans and monitoring programs should be included in the EIS, in order that the long term objectives of the Town's Natural Heritage System are accomplished; and
- A monitoring plan for the streamflow and rainfall, erosion and creek morphology, groundwater, terrestrial systems, and SWM facilities was provided.

Glen Oak Creek (Glen Oak Creek Subwatershed Impact Management Study, UMA Engineering, December 1993)

This study interpreted the implementation recommendations set forth in the Fourteen Mile Creek/McCraney Creek Watershed Planning Study and focussed on those recommendations that were pertinent to Glen Oak Creek. The specific recommendations are as follows:

- Provide vegetative buffer along the creek in order to maintain the floodplain, provide erosion and sediment control, improve the water quality and supply a natural vegetative corridor.
- Control peak flows to existing levels for 1:2 to 1:100 year design storms in the form of SWM facilities to provide flood damage and erosion control;
- Achieve a 5mm infiltration in the impervious areas in order to maintain or augment base flow as well as provide water quality control;
- In the event that infiltration is not possible, use filtration or extended detention;
- Provide stormwater quality control facilities; and
- Protect woodlots of potential hydrological significance to control the water quality, maintain the base flow and maintain environmental conditions.

4W.6.11 Hydrologic Analysis Approach for the Analytical Phase

A review of the background reports, particularly for hydrologic and hydraulic analysis, was carried out as part of the characterization phase. The investigation included a review of the scope of analysis and modelling, the resulting summary of conditions, design flows developed and any identified requirements from stormwater management. The findings provided preliminary information on hydrologic conditions, watershed conditions and the basis for developing the modelling approach to be used in the analysis phase of this study.

A variety of analytical techniques and models are, or have been available, for undertaking the required hydrological analyses for a subwatershed study. The general approach to modelling can be either single rainfall event driven or based on continuous, multi-event simulations over a long period of time. Other considerations when setting up an appropriate hydrologic model include the level of detail when discretizing drainage areas and sources of rainfall data used to represent weather conditions.

A review of the available background reports from previous studies has revealed inconsistencies in the approaches taken to hydrologic modelling associated with the various watercourses. **Table 4W.6.6** summarizes these approaches in terms of model used, technique employed (continuous versus event modelling), level of detail, and rainfall data used.

Table 4W.6.6
Past Hydrologic Modelling

Watercourse	Hydrologic Modelling Approach				
	Previous Model	**Technique**	**Level Of Detail**	**Streamflow Calibration Data**	**Rainfall Data Source**
Sixteen Mile Creek	Qualhymo	Continuous	9 subwatersheds 33 Catchment Areas	Yes	AES Records Station Unspecified
Fourteen Mile Creek & McCraney Creek & Taplow Creek (February 1992)	GAWSER	Event	20 Catchment Areas	No	Oakville OWRC & Burlington TS weather station
Glen Oak Creek (December 1993)	GAWSER	N/A	4 Catchment Areas	N/A	Water Quantity Resources of Ontario

In developing a modelling approach for the next phase of this study, the background reports and associated modelling were reviewed, as well as the needs to address the issues in this Subwatershed Study. This review was carried out with the Town of Oakville and Conservation Halton staff to review the watershed study needs, as well as future needs by both agencies in the implementation phases. The overall needs of the modelling included:

- Provide a consistent approach across the watersheds (one model);
- Ability to address the watershed analysis needs:
  - model hydrologic response of watersheds for events;
  - provide both event and continuous approach;
  - provide for water balance analysis;
  - provide information to geomorphologic analysis; and
- Provide for the long term analysis of the watersheds as well as the review process during implementation.

4W.6.11.1 Water Balance Model

The expected annual water balance components for the study area include the following:

Precipitation	800 – 900mm
Streamflow	300 – 350mm
Evapotranspiration & Infiltration	500 – 550mm

The computer program chosen to model the hydrologic cycle for the Subwatershed Study is GAWSER. The GAWSER computer program is better suited to model the hydrologic cycle than other programs such as QUALHYMO, SWMMHYMO or Visual OTTHYMO.

The GAWSER computer program:

- Simulates each of the hydrologic cycle components (including snowmelt);
- Simulates the hydrologic cycle values with both short and long time steps for design event or water balance analysis;
- Has been shown to accurately reproduce gauged natural/rural streamflow; and
- Can distribute simulated infiltration to different reaches within the subwatershed model to account for groundwater discharge.

4W.7 Hydraulics

Floodlines were prepared for Fourteen Mile Creek up to Dundas Street in a study by Philips Planning and Engineering (1984), *Flood Damage Reduction Study on the Fourteen Mile Creek*, as well as one by Triton Engineering Services Ltd. (1992), *Fourteen-Mile Creek - McCraney Creek Watershed Planning Study*. These studies identified the width of the regional storm floodplain for the McCraney Creek, Taplow Creek, Glen Oak Creek and the Fourteen Mile Creek.

4W.8 Physical Stream Conditions – Morphology

Geology and hydrology exert the principal natural controls on the form and function of most drainage basins. Local geology influences the drainage pattern, the spatial distribution of water and sediment inputs (*i.e.*, quantity and type). The drainage basin hydrology controls the amount and rate of water entering the channel network. These natural controls are modified by human activity. Channels are modified directly (*e.g.,* channel straightening, realignment and constriction) and indirectly through land use changes which, in turn, influence the hydrologic cycle and sediment inputs (*e.g.,* clearing of land, increased urbanization and impermeable surfaces). These three controls are discussed in detail in **Sections 4W.2** though **4W.6**, providing the background information for the geomorphic analysis presented in this section.

In this portion of the report, the morphology and condition of the streams and creeks within the study area are outlined through characterization of the headwater drainage networks and individual reaches, a historic analysis of the channel network and associated land use, and quantification of channel stability and overall health.

4W.8.1 Headwater Drainage Network: Form and Function

The overall form of the headwater drainage network indicates the function of the system. Where swales (vegetated depressions without a well-defined channel) dominate the headwater, it can be expected that discharge is rarely high enough to erode sediment. The swales observed within this study area are vegetation stabilized – the vegetation retards the flow and the root matrix enhances the sediment's resistance to erosion. These systems are sensitive to land use changes that remove vegetation or increase the amount or intensity of discharge. These changes increase the driving force and diminish the development of resisting forces. Exceeding a certain threshold force causes rills, gullies and, ultimately, the development of defined channels.

Defined headwater channels tend to be erosive, supplying sediment to downstream channels. They also tend to have storm-driven, flashy discharge regimes. Although each headwater channel provides only a small amount of sediment and water to the overall basin, they are numerous. Consequently, any change in their throughput of sediment and water produces cumulative effects throughout the entire watershed.

The study area contains portions of Fourteen Mile Creek (East and West), Sixteen Mile Creek, McCraney Creek, Glen Oak Creek and Taplow Creek as seen in **Figure 4W.8.1**. In the case of Fourteen Mile Creek East, McCraney Creek, Glen Oak Creek and Taplow Creek, the majority of the network within the study area is comprised of headwater swales lacking defined channels. Fourteen Mile Creek West has more substantial channel networks within the study area.

4W.8.2 Reach Morphology

Channel form is a product of the flow, magnitude, frequency, duration and the channel materials (sediment type, supply and bed/bank strength). If one of these is altered, the channel adjusts its form to retain or find a new 'dynamic' equilibrium. The characteristics of the flow or channel materials can and do change along a creek or stream. In order to provide channel measures from homogeneous sections of a creek or stream, channels are separated into reaches – generally several hundred metres to several kilometres in length. In the delineation of reaches, the following measures are considered: sinuosity, gradient, hydrology, local geology, degree of valley confinement, and vegetative control using methods outlined in Parish Geomorphic Ltd. (2001). **Figure 4W.8.1** outlines the reaches within the study area and **Table 4W.8.1** provides appropriate lengths, gradients and sinuosity measurements for each reach.

Table 4W.8.1
Length, Gradient and Sinuosity for Each Reach

Reach	Stream Length (m)	Sinuosity	Gradient (%)
Fourteen Mile Creek (East)			
14E-1	228	1.11	0.22
14E-2	453	1.11	0.66
14E-2a	663	1.12	0.53
14E-3	520	1.45	0.29
14E-3a	296	1.02	0.71
14E-4	1105	1.05	0.68
14E-5	473	1.03	0.52
14E-6	388	1.16	0.52
14E-7	763	1.12	0.85
14E-8	545	1.00	0.73
14E-8A	389	1.02	0.26
14E-9	390	1.07	0.51
14E-10	473	1.08	0.63
Fourteen Mile Creek (West)			
14W-1	122	1.07	0.41
14W-1a	509	1.12	0.49
14W-2	356	1.14	0.56
14W-3	649	1.37	1.08
14W-4	544	1.58	0.83
14W-5	222	1.25	0.59
14W-5A	509	1.03	1.04
14W-5B	677	1.05	0.80
14W-6	196	1.14	0.41
14W-7	445	1.10	1.10
14W-8	345	1.01	0.72
14W-9	153	1.21	0.98
14W-9A	181	1.08	1.65
14W-10	775	1.04	0.64

Table 4W.8.1 Length, Gradient and Sinuosity for Each Reach			
Reach	**Stream Length (m)**	**Sinuosity**	**Gradient (%)**
14W-10A	372	1.13	1.61
14W-11	601	1.13	1.08
14W-11A	373	1.02	0.8
14W-12	720	1.15	0.76
14W-13	1025	1.02	0.35
14W-14	865	1.01	0.69
14W-14A	POND		
14W-15	871	1.01	0.76
14W-16	811	1.05	0.5
14W-17	541	1.02	2.77
14W-19	634	1.17	0.94
14W-20	800	1.10	1.97
14W-20A	502	1.07	0.57
McCraney Creek			
MC-1	834	1.04	0.72
MC-2	1181	1.03	0.59
MC-3	308	1.08	0.81
MC-4	833	1.05	0.67
MC-4A	325	1.02	0.78
Taplow Creek			
TC-1	222	1.03	0.68
TC-2	1242	1.02	0.56
TC-2A	585	1.03	0.85
Sixteen Mile Creek			
16W-1	215	1.02	0.93
16W-2	297	1.08	2.02
16W-3	501	1.09	5.44
16W-4	376	1.16	1.57
16WA-1	398	1.19	0.88
16WA-1A	221	1.04	0.23
16WA 2	312	1.00	0.32
16WA-3	320	1.05	0.31
16WA-4	400	1.03	0.63
16WA-5	125	1.04	0.40
16WA-6	929	1.07	0.56
16WA-7	549	1.00	0.27
16WA-8	264	1.03	0.49
16WA-8A	194	1.02	0.49
Glen Oak Creek			
GO-1	774	1.03	0.45

4W.8.3 Historic Analysis

Historical land use and channel changes were evaluated over a 45-year time period for the entire study area. An examination of historical aerial photographs allows the natural tendencies of a river through time to be determined. Moreover, changes in land use and the subsequent response of the channel can be identified. Included in the historical analyses were aerial photographs take in 1954 (scale 1:15,800), 1979 (scale 1:20,750) and 1999 (digital aerial photographs). Due to the scale of the aerial photographs, the size of some of the channels and the ephemeral nature of swales, channel patterns could not always be observed.

In general, most of the alterations to the channel network occurred prior to 1954. Land use over the entire historic record consists primarily of agriculture with some woodlots and minimal development along Dundas Street and Bronte Road. Most of the streams and swales within the study area were treated as 'drains' and straightened for agricultural purposes prior to the 1954 coverage. Consequently, there was little observable change to the channel planform of the streams and swales on the agricultural lands. This land use generally increases the potential source of finer sediments and reduces the development of stabilizing riparian vegetation if proper management practices are not followed.

The only notable changes in land use were an increase in residential development along Bronte Road, an increase in commercial development along Dundas Street and an overall increase in woodlot size from 1954 to 1999. The ponds associated with Reaches 14W-14A and 14E-1 were not in existence in 1954, although a dry, low-lying area could be noted at the downstream end of 14W-14A. Both ponds are evident, however, in the 1979 air photos. The deep meander bend in Reach 14E-3 is not evident in 1954 but does show up in the 1979 series. The woodlot surrounding Reach 14E-7 increases in size to cover the entire extent of the reach in 1999 (formerly, it only extended half way down the reach) although a portion of the woodlot bordering on Bronte Road was converted into residential development prior to 1999. Finally, the riparian buffer along Reaches 14W-1/1a and 14W-2 consisted solely of a tree line at the top of valley in 1954. By 1999, this riparian buffer has developed to include shrubs and denser vegetation.

Overall, the land use changes associated with the development occurring in the study area has resulted in an increase in manicured grass and impermeable surfaces. These land use changes tend to decrease the supply of sediment and increase surface runoff. Little to no change, however, in the planform of the channel network could be noted since 1954.

4W.8.4 Field Investigations

The mapping and aerial photograph analyses provide insight into the controls, modifying influences and general characteristics of the channels. However, they do not provide insight into the condition (*e.g.,* stable, stressed) of the channel. Also, channel processes that were inferred in the mapping and aerial photograph analysis can only be confirmed through field investigation.

During the field investigation, Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Technique (RSAT) were conducted on each reach with a defined channel. Stability of each reach was quantified with an RGA, which documents observed indicators of channel erosion and deposition (MOE 1999). Observations are quantified using an index that identifies channel sensitivity to aggradation, degradation, channel widening and planimetric adjustment. The index produces values that indicate whether the channel is "in regime" or stable (<0.20), stressed/transitional (0.21-0.40) or adjusting (e.g. incising, widening and/or aggrading) (>0.41).

The RSAT provides a broader view of the system by also considering the ecological functioning of the stream (Galli, 1996). This includes observations of channel stability, scour/deposition, instream habitat, water quality, riparian conditions and the presence of different biological indicators. Each indicator was ranked numerically, a lower value indicates poorer stream health and a higher value represents a rich, healthy stream. The RSAT score ranks the channel as maintaining a low (<20), moderate (20-35) or high (>35) degree of stream health. Also included in the RSAT are general observations of channel dimensions, such as bankfull width and depth, substrate size, bank height, vegetation cover, channel hardening and other disturbances. Photographs were also taken at this time of all reaches under study (**Appendix CC**).

4W.8.5 Channel Function: Data and Analysis

Figure 4W.8.2 and **Table 4W.8.2** summarize the findings of the field investigation of the individual reaches undertaken between December 5, 2002 and July 21, 2003. **Figure 4W.8.2** shows that much of the drainage network within the study area was comprised of vegetated swales. The majority of these swales were treated as 'drains' and straightened for agricultural purposes. Of the reaches consisting of defined channels, few were stable (14W-4, 14W-10, 16WA-1 and GO-1, while the remainder were considered either transitional or in a state of adjustment. Reaches with defined channels were generally the higher order streams, located in the vicinity of Dundas Street.

Figure 4W.8.2 shows the majority of streams as swales. This is problematic because some of the reaches shown as swales, we have actually identified as high constraint red streams or medium constraint blue streams. The best examples are in the east branch of Fourteen Mile Creek.

Also note that Glen Oaks Creek is one reach GO-1 now and part of what used to be designated as Glen Oak reaches have now been reassigned to Sixteen Mile Creek.

Table 4W.8.2
Scores for the RGA and RSAT for Each Reach

Reach	RGA	Condition	RSAT	Condition
Fourteen Mile Creek East				
14E-1	--	Pond	--	Pond
14E-2	--	Swale	--	Swale
14E-2a	--	Swale	--	Swale
*14E-3	--	--	--	--
*14E-3a	--	--	--	--
14E-4	--	Swale	--	Swale
14E-5	0.11	In Regime	12	Low
14E-6	--	Swale	--	Swale
14E-7	0.14	In Regime	13	Low
14E-8	--	Swale	--	Swale
14E-8a	--	Swale	--	Swale
14E-9	--	Swale	--	Swale
14E-10	--	Swale	--	Swale
Fourteen Mile Creek West				
[1]14W-1	0.48	In Adjustment	20	Moderate
14W-1a	0.48	In Adjustment	20	Moderate
14W-2	0.22	Transitional	26.5	Moderate
14W-3	0.47	In Adjustment	17	Low
14W-4	0.14	In Regime	18	Low

Table 4W.8.2 Scores for the RGA and RSAT for Each Reach				
Reach	**RGA**	**Condition**	**RSAT**	**Condition**
14W-5	--	Swale	--	Swale
14W-5a	--	Swale	--	Swale
14W-5b	--	Swale	--	Swale
14W-6	0.25	Transitional	12.5	Low
[2]14W-7	0.44	In Adjustment	14.5	Low
14W-8	--	Swale	--	Swale
14W-9	0.43	In Adjustment	15	Low
14W-9a	0.43	In Adjustment	15	Low
14W-10	0.14	In Regime	17	Low
14W-10a	--	Swale	--	Swale
14W-11	0.33	Transitional	20	Moderate
14W-11a	0.33	Transitional	20	Moderate
14W-12	0.32	Transitional	17	Low
14W-13	--	Swale	--	Swale
14W-14	0.32	Transitional	17	Moderate
14W-14a	Pond	Pond	NA	Pond
14W-15	--	Swale	--	Swale
14W-16	--	Swale	--	Swale
14W-17	--	Swale	--	Swale
*14W-19	--	--	--	--
14W-20	0.34	Transitional	26	Moderate
14W-20a	0.34	Transitional	26	Moderate
McCraney Creek				
MC-1	0.11	In Regime	8	Low
MC-2	--	Swale	--	Swale
MC-3	--	Swale	--	Swale
MC-4	--	Swale	--	Swale
MC-4a	0.11	In Regime	9	Low
Taplow Creek				
TC-1	0.21	Transitional	10	Low
TC-2	--	Swale	--	Swale
TC-2a	--	Swale	--	Swale
Sixteen Mile Creek				
*16W-1	--	--	--	--
*16W-2	--	--	--	--
*16W-3	--	--	--	--
*16W-4	--	--	--	--
[1]16WA-1	0.15	In Regime	12	Low
16WA-1a	0.07	In Regime	13	Low
16WA-2	--	Swale	--	Swale
16WA-3	--	Swale	--	Swale
16WA-4	--	Swale	--	Swale
16WA-5	12	Low	0.07	In Regime
16WA-6	--	Swale	--	Swale
16WA-7	--	Swale	--	Swale

Table 4W.8.2 Scores for the RGA and RSAT for Each Reach				
Reach	**RGA**	**Condition**	**RSAT**	**Condition**
16WA-8	--	Swale	--	Swale
16WA-8a	--	Swale	--	Swale
Glen Oak Creek				
GO-1	--	Swale	--	Swale
*No information available [1]Detailed Field Site [2]Monitoring Cross section				

Existing Conditions

Fourteen Mile Creek (East and West)

Fourteen Mile Creek East, with the exception of 14E-1, was comprised mainly of swales with poorly defined banks and bed morphology. All of the reaches showed indications of straightening and substrate was comprised primarily of sands with some silt and clay. At the time of the field investigation, the agricultural season had ended and the majority of the reaches had been ploughed. A site visit to 14E-1, meanwhile, revealed that the reach was comprised entirely of a pond. This pond is known locally as the Palermo Pond.

Fourteen Mile Creek West consisted of two main branches, defined by 14W-1 and 14W-12, respectively. 14W-1 and 14W-1a, just upstream of Dundas Street were well-defined channels with dense grasses and herbaceous species along both banks, along with some shrubs and mature trees. Any stream alterations did not appear to be recent as the reaches maintained a moderately sinuous planform. Stream morphology consisted of riffle-pool sequences and the bed substrate was comprised of sands to gravel with exposed shale bedrock in sections. Bank erosion was prevalent and siltation was occurring in both the riffles and pools.

14W-2 had a similar substrate to 14W-1 and 14W-1a. The reach showed signs of aggradation, degradation and widening in the form of siltation in pools, embedded riffles, exposed shale bedrock, fallen and leaning trees and exposed tree roots. Channel disturbances consisted of a small pedestrian crossing.

14W-3 did not show any signs of stream alteration. Riparian vegetation consisted of hardwood forest with little ground cover. Although the morphology was well-defined, excessive bank erosion and valley wall contact were noted. The channel exhibited evidence of aggradation, degradation, widening and planimetric adjustment in the form of medial bar formation, suspended armour layers, exposed bedrock, fallen and leaning trees and the formation of chutes.

Channel morphology for Reach 14W-4 was only moderately defined and had experienced alteration due to the construction of Highway 407. The stream primarily showed signs of widening with exposed tree roots and the occurrence of large organic debris. Embedded riffles and exposed bedrock also indicated aggradational and degradational processes. Riparian vegetation was hummocky scrubland and banks showed signs of erosion and slumping. Valley wall contact occurred just upstream of the confluence with 14W-3.

Land surrounding Reach 14W-6 was also hummocky and land use consisted of agriculture (corn crops) with a tractor crossing noted across the stream bed. Bed morphology was poorly defined and an on-line pond was noted just upstream of the Highway 407 crossing. In addition to the highway crossing, three

culverts and rip rap protection were noted as existing channel disturbances. Overall, the reach exhibited signs of aggradation, widening and planimetric adjustment. Evidence of these processes included siltation in pools, poor longitudinal sorting of bed materials, large organic debris, evolution of low bed relief form and single thread to multiple channel formation.

Vegetation surrounding Reach 14W-7 consisted of hardwood forest with sparse ground vegetation. The primary geomorphic process in this section was widening, with indicators such as fallen and leaning trees, basal scour on the inside of meander bends and both sides of riffles, and fracture lines observed. Embedded riffles, siltation in pools, cut face on bar forms and poorly formed bars also indicated aggradation, degradation and planimetric adjustment. While the channel remained well-defined through the downstream section of the reach, it evolved into an undefined swale at the upstream boundary.

14W-9 and 9a were generally well defined with riffle-pool morphology. Several pedestrian bridges along with top of bank walking trails were noted at this section. The primary geomorphic processes influencing the stream were degradation and widening. Evidence of these processes occurred in the form of suspended armour layers, terrace cutting through bar materials, fallen and leaning trees and basal scour along pools and riffles.

14W-10, meanwhile, showed evidence of agricultural influences in the form of ploughing and was generally poorly defined. The channel appeared to have been straightened and showed signs of aggradation such as siltation and poor longitudinal sorting of bed materials.

On the second branch of Fourteen Mile Creek West, 14W-12 was the only reach observed to have a defined channel. This definition occurred immediately upstream of Dundas Street and evolved into a poorly defined swale at the upstream extent of the reach. Channel disturbances consisted of the Dundas Street crossing, concrete revetments and farm crossings. Surrounding land use was agricultural and livestock were noted as having access to the stream. The primary geomorphic processes influencing this reach were aggradation and widening. Fallen and leaning trees, exposed tree roots, poorly formed bars, siltation in pools and riffles and accretion on point bars were noted at the site.

The remaining reaches on Fourteen Mile Creek were poorly defined vegetated swales. The majority of these reaches showed signs of straightening and agricultural influences. In general, substrate consisted of silt and sand with some clay. Riparian vegetation consisted of scrubland and agriculture.

McCraney Creek

All five reaches on McCraney Creek were vegetated swales. MC-1 had poorly defined morphology with eroded vertical banks in sections and substrate consisted of cobble, gravel and sands. The reach appeared to have been straightened. MC-2 had poorly defined bed morphology and banks with sand to clay substrate and had been ploughed. MC-3 had no observable definition and was influenced by agricultural land use. The same could be said for MC-4, except at the confluence with MC-1 (MC-4a). Substrate consisted of sand and silt.

Taplow Creek

Immediately upstream of Dundas Street, TC-1 was a poorly defined, vegetated channel with eroding and slumping banks. Widening was the dominant geomorphic process along the reach with fallen and leaning trees, large organic debris and basal scour along riffles and meander bends. Substrate was comprised of sand and silt.

Glen Oak Creek

Upstream of Dundas Street, Glen Oaks Creek consisted of poorly defined, straightened swales that flow through active agricultural lands. As a result, virtually all of the reaches initially identified at the beginning of this study have since been plowed over. The only surviving reach is GO-1, which was highly vegetated, poorly defined and displayed fine, silty substrates.

Sixteen Mile Creek

With the exception of 16WA-1/1A and 16W-1 through 4, all of the reaches within the study area on Sixteen Mile Creek were poorly defined, straightened swales with substrate consisting of sand and silt with some clay. 16WA-1 and 16WA-1A, located upstream of Dundas Street, were situated within scrubland. Dense grasses and herbaceous species covered the banks, which were vertical and eroded. Exposed Halton Till subpavement was also noted at the site. Fallen and leaning trees, exposed tree roots, large organic debris and basal erosion along meander bends and riffles indicated that widening was the primary geomorphic process within the area.

Field Sites

Utilizing the combined RGA and RSAT scores, three reaches were chosen for more extensive characterization (see **Figure 4W.8.2**). At each of the two detailed sites (14W-1 and 16WA-1 cross-section, bankfull width and depth, entrenchment, as well as low flow dimensions were recorded. Substrate was sampled using a modified Wolman pebble count. Sub-pavement was also characterized at each cross-section. Bank assessment included measurements of height, angle, bank composition, in-situ shear strength, vegetation and rooting depth. These 10 cross-sections were placed over a minimum of two meander wavelengths and included one control cross section located at top of bank. This control cross section involved the installation of permanent pins in order to allow for future monitoring. Five erosion pins were also installed at each site to monitor rates of migration within the reach. A level survey of the site extending upstream and downstream of the 10 cross-section locations was also conducted. The survey included bankfull elevations, maximum pool depth, top and bottom of riffles and any obstruction to flow and provided measures of energy gradient, inter-pool gradient and riffle gradient. Geomorphic summary tables of the detailed field sites can be found in **Appendix CC.**

In addition to the two detailed field investigation sites, a third reach (14W-7) was chosen for monitoring (**Figure 4W.8.2**). At this site, a control cross section was established and a modified Wolman pebble count was performed. Two erosion pins were installed at the control cross section to monitor bank erosion. A cursory level survey was also conducted at the site to capture the channel gradient.

Located upstream of Dundas Street just east of Bronte Road, land use surrounding 14W-1 consists of scrubland with riparian vegetation including tall grasses and herbaceous species along with a few trees. Banks are hummocky with some slumping evident and the channel is vegetated in a number of areas. Bank material is generally composed of clay and silt with very fine sand and a mid-channel vegetated bar was noted at the site.

16WA-1, upstream of Dundas Street, flows through scrubland with dense grasses and herbaceous species on the banks. The channel was dry and narrow, with an average bankfull width of 1.87m. Bank materials consist primarily of clay and 25% of the banks are undercut, indicating widening. Subpavement is comprised entirely of clay till.

14W-7 flows through hardwood forest. Banks are composed of clay with minimal vegetative protection. The site is moderately sinuous with substrate ranging from pebbles to clay. Banks are eroded and vertical with fracture lines noted in some areas.

Erosion Thresholds

The collection of detailed field information is pertinent to modelling erosion thresholds. An erosion threshold represents the point at which sustained flows will tend to entrain and transport sediment. The calculations performed to determine critical discharge for bed materials were based on formulas for critical shear stress. Selection of appropriate thresholds was, in part, dictated by indicators of active processes (*e.g.,* widening or entrenchment), and channel substrate. Multiple analytical methods (critical shear and threshold velocity models) were applied to the data to define threshold flows for the bed and banks of the sensitive reaches. The model results were examined for convergence and compatibility with field observations to provide appropriate and meaningful erosion thresholds.

Generally, shear stress equations for non-cohesive materials were applied to the bed materials (Chow 1959, Miller *et al*., 1977; Fischenich, 2001). The erosion thresholds were based on the threshold for the D_{50} (median grain size), which is the general practice. If a large portion of the bed material was cohesive and the erosion threshold associated with cohesive component was greater than the threshold associated with the D_{50}, then the cohesive materials estimated shear strength was used to provide a characteristic threshold. These thresholds were based on tables provided in Chow (1959) and Fischenich (2001). This was the case for all the erosion thresholds provided. Finally, if there was evidence of excessive bank erosion, a threshold related to the bank material was also calculated. The relative proportion of bank shear stress to the maximum shear stress was calculated. Threshold depths were based on this proportion. The lower of bank and bed threshold (or more conservative measure) was used to define the critical threshold for the channel. In this case, similarity in bed and bank materials and the prevalence of till or stiff in the clay in the banks meant that bed shears were always the more conservative.

As many of the models are based on a simplified cross sectional geometry, a single characteristic riffle cross section was extracted from each detailed site for threshold analysis. The depth and the corresponding simplified geometry were used to produce a meaningful threshold discharge. In all cases, a comparison between the flow competence (based on non-cohesive strength) and bankfull velocity indicates that the bed is fully mobilized around bankfull flows. This implies that sediment can be entrained below bankfull flows and that any increase in discharge within these systems will lead to increased transport and would likely exacerbate channel erosion. **Table 4W.8.3** provides both bankfull characteristics and erosion threshold parameters.

Table 4W.8.3
Bankfull Conditions, Bed Material Size and Erosion Threshold Measures

Parameter	14W-1	GO-1	14W-7
Average Bankfull Width (m)	3.81	1.87	2.65
Average Bankfull Depth (m)	0.34	0.26	0.17
Bankfull Gradient (%)	0.18	0.66	0.52
Bed Material D_{50} (m)	0.00006	0.0036	0.0036
Bed Material D_{84} (m)	0.015	0.035	0.011
Bedrock Exposure/Control	Yes	Yes	No
Bank Materials	Si/cl/vfs	Clay	Clay
Manning's n at Bankfull	0.035	0.035	0.035

Table 4W.8.3 Bankfull Conditions, Bed Material Size and Erosion Threshold Measures			
Parameter	**14W-1**	**GO-1**	**14W-7**
Average Bankfull Velocity (ms^{-1})	0.59	0.95	0.63
Average Bankfull Discharge (m^3s^{-1})	0.76	0.46	0.28
Flow competence (ms^{-1}) @ D_{50}	–	0.36	0.54
Flow competence (ms^{-1}) @ D_{84}	0.69	0.73	0.61
Tractive Force at Bankfull (Nm^{-2})	6.00	16.82	8.88
Critical Shear (Nm^{-2})	4.8	7.7	7.7
Stream Power per Unit Width (Wm^{-2})	13.5	29.75	14.52
Critical Discharge (m^3s^{-1})	0.248	0.087	0139
Critical Depth (m)	0.27	0.12	0.15
Critical Velocity (ms^{-1})	0.51	0.56	0.58
Site Description	Mid-channel vegetated bar, eroded banks, siltation in pools and exposed tree roots.	Dry channel, exposed clay till subpavement, eroded banks, exposed tree roots, island formation and dense vegetation on banks.	Dry channel, vertical banks, little bank vegetation, exposed tree roots.
Method	Chow (1959)	Chow (1959)	Chow (1959)

4W.8.6 Conclusions

A geomorphic characterization study was completed for the western portion of North Oakville in order to catalogue channel characteristics, determine processes operating within the channels and identify sensitive reaches. Upon field investigation and aerial photograph analysis, it was found that much of the drainage network within the study area was comprised of small head water channels and swales. The defined channels tended to be the higher order streams located primarily near Dundas Street (the downstream extent of the study area). These areas were often associated with low gradient, agricultural or wooded areas and generally showed signs of instability such as degradation, widening and planimetric adjustment.

4W.9 Natural Environment Existing Conditions

As noted in **Section 4E.9**, field surveys on the North Oakville lands were performed on the following dates listed in **Table 4W.9.1.**

Table 4W.9.1
North Oakville Creeks Subwatershed Field Survey Dates

	2002	2003	2004	2005	2006
January		16			23
February		10, 24			13, 24
March					
April	7, 16, 19, 23	22, 24, 30		4, 29	
May	2, 10, 16, 17, 22, 23, 29	1, 15, 30		9, 20	
June	6, 7, 10, 25, 27, 28	13, 17, 30	2	3, 15, 30	26,27
July	12	18			
August		6			
September	11, 12, 24	4			
October					
November					
December		9			

Aerial surveys using a fixed wing airplane were conducted on February 10, 2003 and May 30, 2003.

This section of the report focuses on the lands west of Sixteen Mile Creek. For the first three-years of this study, the Sixteen Mile Creek Valley was not analysed in detail as it had been extensively studied. However in 2005 and 2006 some field surveys of the Sixteen Mile Creek valley were conducted. The lands east of Sixteen Mile Creek were also surveyed and are documented in **Section 4E** of this report.

A series of studies were conducted by other teams within the study area during this project. Several of these studies yielded detailed data that has been included in this characterization where possible. A key series of investigations were conducted by the MNR which culminated in reports on wetlands, candidate ANSIs (north of the western study area), and wildlife in May 2003. The original work completed by the MNR included vegetation community mapping and species inventories. Extensive detailed mapping of wetlands occurred in 2002 and 2003 by staff of the MNR and NRSI. This included a series of meetings to review field mapping and data, as well as review of oblique aerial photographs and the May 2003 fly-over. At the time of preparing this report, the wetlands within the study area had not been formally evaluated using the standard MNR Wetland Evaluation system.

As discussed in **Section 4E.9**, "habitat units" were delineated based on variables such as proximity and connectivity. Two habitat units were delineated by NRSI in the west study area: Units 1 and 2 (Units 3 - 22 are located in the lands east of Sixteen Mile Creek). These units are based on those utilized by LGL (1999), *e.g.,* Unit 1 = F2, Unit 2 = F4. Units 1 and 2 are delineated in **Figure 4W.9.1**.

The sources of status listings for vascular plants and wildlife are listed in **Table 4E.9**.

4W.9.1 Vegetation

Vegetation surveys were performed on the dates listed above. Aerial surveys in February and May 2003 were also used to supplement field surveys. In addition, a series of oblique aerial photographs (April 2003, May 2003, and April 2005) were reviewed to assist with vegetation mapping.

Vascular plant inventories, as well as vegetation community descriptions, were made for each habitat unit and are delineated in **Figure 4W.9.1**. Additional plant records were compiled from background

information reports and field surveys, including inventories conducted by the MNR in the spring of 2003 (MNR, 2003a, c, d).

For further information see **Section 4E.9.1.**

4W.9.1.1 Vascular Flora

A list of vascular flora is included in **Appendix G**. A total of 681 species of vascular plants are known from the study area, of which 383 were found in the west portion of the study area.

Of the vascular plant species reported from the study area, a total of 172 are either provincially rare, rare in Site Region 7, locally rare in Site District 7E4, or rare in Halton Region (see **Table 4E.9.3** for status codes). Of these, 41 were found in the west portion of the study area. None of these species are nationally rare. **Table 4W.9.2** includes a list of the rare plant species from the west of Sixteen Mile Creek.

Table 4W.9.2
Significant Flora Reported from the North Oakville Lands West of Sixteen Mile Creek

Status/Rank	Common Name	Scientific Name
L	Autumn Bent Grass	*Agrostis perennans*
L	Wild Garlic	*Allium oleraceum*
L	Long-fruited Anemone	*Anemone cylindrica*
L,h	Arrow-leaved Aster	*Aster urophyllus*
L	Beggarticks	*Bidens tripartitus*
L	Fringed Brome	*Bromus ciliatus*
L	Water-arum (Wild Calla)	*Calla palustris*
L	Bitter Cress	*Cardamine pensylvanica*
L,h	Brownish Sedge	*Carex brunnescens*
L	Fringed Sedge	*Carex crinita*
P,R,L,h	Slender Sedge	*Carex gracillescens*
L,h	Sedge	*Carex grayi*
L	Inland Sedge	*Carex interior*
L	Sedge	*Carex projecta*
L,h	Pointed broom sedge	*Carex scoparia*
L	Blunt-broom Sedge	*Carex tribuloides*
L	Sedge	*Carex tuckermani*
L	Wood's Sedge	*Carex woodii*
L,h	Buttonbush	*Cephalanthus occidentalis*
L,h	Coontail	*Ceratophyllum demersum*
L	Bluebead-lily	*Clintonia borealis*
L	Emerson's Hawthorn	*Crataegus submollis*
L	Blunt Spike Rush	*Eleocharis obtusa*
P	Honey Locust	*Gleditsia triacanthos*
L	Eastern Manna Grass	*Glyceria septentrionalis*
L	Winterberry	*Ilex verticillata*
L	White Grass	*Leersia virginica*

Table 4W.9.2 Significant Flora Reported from the North Oakville Lands West of Sixteen Mile Creek		
Status/Rank	**Common Name**	**Scientific Name**
L,h	Star Duckweed	*Lemna trisulca*
P	Scentless Chamomile	*Matricaria maritima*
L	American Royal Fern	*Osmunda regalis*
L,h	Leafy Pondweed	*Potamogeton foliosus*
L,h	Black Oak	*Quercus velutina*
L,h	Black Willow	*Salix nigra*
L	Slender Willow	*Salix petiolaris*
R,L,h	River Bulrush	*Scirpus fluviatilis*
L	Meadowsweet	*Spiraea alba*
L,h	Greater Duckweed	*Spirodela polyrhiza*
L,h	Wood Sage	*Teucrium canadense*
L	Downy Arrow-wood	*Viburnum rafinesquianam*
L,h	Northern Water-meal	*Wolffia borealis*
L	Prickly-ash	*Zanthoxylum americanum*
Status Codes: P = Provincially Rare (SRank S1 – 3) R = Regionally Rare in Site Region 7 L = Locally rare in Site District 7E4 h = Locally rare in the RM of Halton		

4W.9.1.2 Vegetation Types

Vegetation communities were mapped and described during this study based on background information from the above reports, aerial photograph interpretation, and field surveys. The ELC method was used to distinguish and name communities with some modifications (Lee *et al*., 1998). Vegetation communities were described to the "vegetation type" level in the ELC system, with the exception of cultural thickets (CUT) that were classified to the "ecosite" level (cultural vegetation community designations are currently under review by the MNR). LGL's (1999) woodlot tree tally data were also reviewed and compared to the current conditions in the surveyed woodlots. Vegetation communities delineated in this study are shown on **Figure 4W.9.1**. A sample ELC data form is included in **Appendix H**.

Previous studies focused on mapping woodlots found within the North Oakville lands, whereas this study included woodlots, as well as hedgerows and early successional growth (*e.g.,* old field and scrub). The polygons delineated in this study were comparable to past studies (*e.g.,* MMM and LGL, 1992; Ecoplans, 1995; LGL, 1999) although most background studies utilized the NHIC vegetation community classification system developed by Bakowsky (1996) or another classification system prior to the development of ELC (Lee *et al.,* 1998). Discrepancies in the description of cultural vegetation units occurred in some occasions, as cultural woodlands (CUW) were reclassified as cultural thickets (CUT 1). MNR staff provided some vegetation community description information for Habitat Unit #2 (east of Bronte Road – Regional Road 25), which was used as input to the mapping and descriptions in this report (MNR, 2003a).

Upland Units

Table 4W.9.3 shows the types of the upland vegetation communities found in the western portion of the subwatershed study area. A total of ten terrestrial vegetation communities were observed, three of which

are considered cultural. One community type, the Dry-Fresh Hickory Deciduous Forest Type (FOD 2-3), is considered uncommon in Ontario (Bakowsky, 1996). This community was observed in Habitat Unit #2. The habitat units surveyed in this study are primarily associated with creek valleys of Fourteen Mile Creek. Smaller isolated tableland woodlands are found on the lands between Fourteen and Sixteen Mile Creeks.

Table 4W.9.3
Upland Vegetation Communities found in the North Oakville Study Area West of Sixteen Mile Creek

ELC Vegetation Type	Description
FOD 2-3 Dry-Fresh Hickory Deciduous Forest Type	This forest type is predominantly represented by hickory species (bitternut hickory > shagbark hickory). This forest type is considered uncommon (S3S4) in Ontario.
FOD 2-4 Dry-Fresh Oak-Hardwood Deciduous Forest Type	This forest is oak dominant with sugar maple, white ash, beech, basswood, ironwood, and black cherry associates (where sugar maple is ≤ 25% cover).
FOD 5-1 Dry-Fresh Sugar Maple Deciduous Forest Type	This forest type is almost entirely dominated by sugar maple with an understorey consisting of species like trilliums, raspberry, wild sarsaparilla, and jack-in-the-pulpit.
FOD 5-3 Dry-Fresh Sugar Maple-Oak Deciduous Forest Type	This forest type is similar to the previous, but is represented by a mixture of predominantly sugar maple and red oak >> white oak.
FOD 5-5 Dry-Fresh Sugar Maple-Hickory Deciduous Forest Type	Also similar to above, sugar maple tends to dominate in these forest types with bitternut hickory >> shagbark hickory.
FOD 7-1 Fresh-Moist White Elm Lowland Deciduous Forest Type	This white elm dominated forest tends to have more open canopies (< 60% cover), and a mix of herbs from wetland and terrestrial ecosystems like sensitive fern, spotted touch-me-not, foam flower, with blue cohosh, wild leek, and jack-in-the-pulpit.
FOD 7-2 Fresh-Moist Ash Lowland Deciduous Forest Type	This forest type is similar to above, but consists of a mixture of green ash and black ash.
CUM 1-1 Dry-Moist Old Field Meadow Type	Cultural habitats originate from and are maintained by anthropogenic disturbances (agriculture, clearing, grazing), and often have a large number of introduced species. Old field ecosystems are characterized by low tree or shrub coverage (<25%), with many herbaceous and grass species.
CUT 1 Mineral Cultural Thicket Ecosite	This cultural ecosite has < 25% tree cover, and > 25% shrub cover. Many sites are often dominated by shrub species such as hawthorns, elms, ashes, and buckthorns.
CUS 1 Mineral Cultural Savannah	Trees dominate this ecosite, with very few shrubs. Tree coverage is fairly low, however, with tree cover between 25 and 35%.

Wetland Units

Wetlands in the study area were extensively studied by the MNR as well as staff of NRSI. As part of the IAR process, the wetland areas mapped by the MNR and staff of NRSI were compared and an agreed-upon mapping of wetlands produced for the lands within the study area. See **Section 4E.9.1.2** for a further discussion of wetlands within the study area, as wetlands are discussed as a whole, and not divided between east and west.

4W.9.2 Wildlife

The North Oakville lands have been described in background reports as supporting important wildlife habitat features such as areas of seasonal wildlife concentration, specialized wildlife habitats, habitat for species of concern, and wildlife movement corridors. Background reports, especially LGL (1999),

describe locally significant numbers of migrant land birds being attracted to the larger woodlands, as well as locally significant numbers of diurnal birds of prey. LGL (1999) also noted that extensive vernal pooling on the agricultural lands played a key role in the spring migration of waterfowl (*e.g.,* Mallard, Blue-winged Teal, and Canada Goose) and the reproduction of amphibians (*e.g.,* frogs, toads, salamanders, and newts). Reproducing amphibians also find refuge in the numerous wetlands and watercourses found throughout the site (LGL, 1999). Many mammal species rely on the blend of forest, hedgerow, and agricultural habitats found in the North Oakville lands, including white-tailed deer, raccoon, coyote, and red fox. As a result of the diversity of habitats contained within the study area, a substantial number of wildlife species of conservation concern utilize these lands for all or some portion of their life cycle.

4W.9.2.1 Birds

A variety of bird surveys were undertaken within the study area, as well as a background review of existing sources. Breeding bird observations were made in: 2002 on April 7 and 23, May 2, 17, 22, 23, 29, June 7, 10, 27, and 28; 2003 on May 30 and June 13, 17, and 30; 2004 on June 2; and 2005 on April 29, May 9, and 20, June 3, 15, and 30. The activity of bird species encountered during visits was documented using standard breeding bird monitoring methodology outlined in the OBBA (CWS, 2001). The surveys consisted of point counts as well as transect surveys through the area. Winter bird surveys were undertaken January 23, February 13 and 24, 2006. All station and survey locations are shown on **Figure 4.9.2**. Besides reviewing bird species recorded from the study area in other reports (see **Appendix I** legend for reports reviewed), the OBBA was consulted, as well as the CBC for the area. The study area falls within squares 17NJ90, 17NJ91, and 17PJ01 of the OBBA, and the Peel-Halton Counties CBC count circle (CBC count code: ONPH).

A complete list of bird species observed in the study area is included in **Appendix I**. A total of 217 bird species were recorded. Where possible, breeding evidence has been noted for the reported bird species (**Appendix I**). From the west side of the study area 113 bird species are known. Of these, 11 are rare and 19 are considered priority species by the Ontario Partners in Flight (2005).

A list of rare bird species reported from the west side study area is included in **Table 4W.9.4.** One bird that is not included in the complete bird list for North Oakville (**Appendix I**) is Dickcissel (*Spiza americana*). Although it was not previously known from the area, a pair of Dickcissels were confirmed just outside the study area in the summer of 2005, southwest of Dundas Street and Tremaine Road. They were recorded as probable breeders. Dickcissel is considered extremely rare nationally, and is a breeding migrant/vagrant in the province (but not a VTE species).

Table 4W.9.4
Significant Bird Species Reported from the Subwatershed Study Area, West Side

Common Name	Scientific Name	Status	Typical Habitat	Habitat in Eastern Portion of Study Area? Breeding Evidence?
Black-crowned Night Heron	*Nycticorax nycticorax*	P	deciduous woodland swamps, cattail marshes, islands, wooded river and lake banks, coastal wetlands	-habitat is present within the study area, but this species has only been recorded as migrant. -OBBA does not indicate records of this species in vicinity of the study area
Turkey Vulture	*Cathartes aura*	L	bottomland hardwood forests and thickets, rocky cliffs, various	-habitat is present in study area, but not recorded as breeding -noted to breed throughout the

Table 4W.9.4
Significant Bird Species Reported from the Subwatershed Study Area, West Side

Common Name	Scientific Name	Status	Typical Habitat	Habitat in Eastern Portion of Study Area? Breeding Evidence?
			habitats, except heavy unbroken forest; roost in tall woods of live or dead trees with limbs >18 inches diameter; feed on carrion	vicinity of the study area in OBBA
Cooper's Hawk	*Accipiter cooperii*	L,h	dense, extensive mixed or deciduous forests, preferably in Carolinian forest zone; usually near pools of water or streams; woodlots interspersed with open fields; floodplain forests and wooded swamps; will nest near human activity where habitat and food are available; nesting territory must be at least 6 ha with 60 to 70% canopy closure; hunting territory extends over 3 to 5 km2; requires minimum of 10 to 15 ha of habitat, but prefers forests > 50 ha	-habitat present in study area, and noted as possible breeder (in east study area) or probable breeder (west study area) -noted to breed throughout the vicinity of the study area in OBBA
Rough-legged Hawk	*Buteo lagopus*	P	tundra, farmland, marshes and other expansive open habitats; nests on cliff ledges or in conifer tree in tundra	-species noted as migrant only -study area not within typical breeding range of this species
Caspian Tern	*Sterna caspia*	P	open habitat near large lakes or rivers, beaches, shorelines, rocky or sandy beaches, offshore islands; negatively affected by elevated water levels during nesting season; feeds on fish; found in association with Ring-billed Gulls	-species noted as migrant only -study area not within typical breeding range of this species
Red-headed Woodpecker	*Melanerpes erythrocephalus*	P, SC, VUL	open, deciduous forest with little understory; fields or pasture lands with scattered large trees; wooded swamps;	-habitat present in study area, and reported as observed during breeding season -confirmed breeder from the first OBBA, but not recorded in the

Table 4W.9.4
Significant Bird Species Reported from the Subwatershed Study Area, West Side

Common Name	Scientific Name	Status	Typical Habitat	Habitat in Eastern Portion of Study Area? Breeding Evidence?
			orchards, small woodlots or forest edges; groves of dead or dying trees; feeds on insects and stores nuts or acorns for winter; loss of habitat is limiting factor; requires cavity trees with at least 40 cm dbh; require about 4 ha for a territory	second atlas
Pine Warbler	*Dendroica pinus*	L	mature white pine (red to lesser degree) forests that are somewhat open; 40 to 50 year old pine plantations; area sensitive needing at least 15-30 ha	-very limited amount of pine dominated habitat in study area, but reported as breeder -reported from the vicinity of the study area in OBBA
Black-throated Green Warbler	*Dendroica virens*	L	prefer dense, mixed forest, but also coniferous or more open woods; hemlock, fir are favoured conifers; wet cedar swamps; beech, maple, birches with multi-layered canopy and well developed shrub layer; requires about 30 ha	-habitat present in study area, and reported as possible breeder (especially in Fourteen Mile Creek valley and Habitat Unit 5) -reported from lands west of study area in OBBA
Black-and-white Warbler	*Mniotilta varia*	L	breeds at edges of large continuous stands of mature or old second growth deciduous or mixed forest; cedar swamps or bogs; riparian habitat; during migration prefer bottomland forests and forest edges; nests in interior in the south; area sensitive, requiring in excess of 100 ha of continuous forest	-habitat present in study area (but few of preferred size), and reported as possible breeder in larger woodlots like Habitat Unit 5, 8 and 21
Nashville Warbler	*Vermivora ruficapilla*	L	wet, open coniferous, deciduous or mixed woods of young secondary growth; cedar, spruce swamps;	-habitat present in study area but scattered, and reported as breeding -reported in OBBA and by NRSI

Table 4W.9.4 Significant Bird Species Reported from the Subwatershed Study Area, West Side				
Common Name	**Scientific Name**	**Status**	**Typical Habitat**	**Habitat in Eastern Portion of Study Area? Breeding Evidence?**
			dry or moist overgrown pastures and old field with scattered trees and shrubs; edges; nests in depressions in ground under dead, dry bracken fern	
Orchard Oriole	*Icterus spurius*	h	Wood edges, orchards, shade trees, scrub, open woodland.	-habitat present in study area, and reported as breeder in Joshua Creek area -reported in the vicinity in OBBA

A variety of habitat types are used by the significant bird species observed in the study area. The study area provides habitat for many interior forest bird species. A further discussion of forest interior and area-sensitive bird species is included in **Section 5.0**. Although the majority of these species rely on forest or forest edge habitats, many also rely on early successional habitats such as old field, meadows, agricultural lands, and thickets that have become increasingly vulnerable to fragmentation and development.

4W.9.2.2 Mammals

Data for mammals was collected based on both direct observations during all field surveys and signs/material evidence (*e.g.,* tracks, scat, carcass, bones, and raptor pellets). Additional mammal records were compiled from background information reports and field surveys.

A list of mammals observed in the study area is included in **Appendix J**. A total of 33 mammals were recorded, of which 21 were reported from the western portion of the study area. One of these, Norway Rat is only known from the west side, and not from the east side of Sixteen Mile Creek. None of the mammals reported from the western portion of the study area are provincially, regionally or locally rare.

4W.9.2.3 Reptiles and Amphibians

Reptile and amphibian observations were made during all field surveys but specific observations were made in 2002 on April 7, 19, May 2, 22, 23, 17, June 7, and 27, as well as in 2003 on April 22, 24, 30, and May 1, 15, 30. Breeding amphibian call monitoring followed the Great Lakes Marsh Monitoring Program protocol (BSC, 2001). The locations of the point count stations in the study area are shown on **Figure 4W.9.2**. These stations were selected based on field reconnaissance within the study area, revealing the presence of wetlands in these locations. Data included direct observations in suitable habitat (*e.g.,* salamanders under debris and frogs in vernal pools and creeks). Additional reptile and amphibian records were compiled from background information reports and field surveys. An extensive amphibian call survey was conducted by staff of Conservation Halton on the ORC lands between Bronte Road (Regional Road 25) and Sixteen Mile Creek (Conservation Halton, 2002).

A list of reptiles and amphibians observed in the entire study area is included in **Appendix K**. A total of 13 reptile species and 15 amphibian species (excluding hybrids) have been recorded in the vicinity of the study area, of which several were only reported from the Ontario Herpetofaunal database and no specific records were found within the study area.

Within the western portion of the study area, four reptiles and nine amphibians were reported. A single provincially and locally rare reptile, the Eastern Milksnake (*Lampropeltis triangulum triangulum*), was reported from the western portion of the study area. This species is also described as being of "special concern" by COSEWIC. The milksnake is found in a variety of habitats ranging from open woodlands to wetlands, but is often found associated with old stone foundations, rock piles, and fences.

4W.9.2.4 Butterflies

Butterfly observations were recorded during all field surveys. Data for butterflies was collected based on direct observations during other field investigations. As such it is presumed that the list of species observed is a subset of butterflies that could occur in this area.

Background information reports and field surveys were reviewed to extract additional butterfly records, however few background sources were found to include butterfly sightings and it is assumed that this list represents a limited number of the butterflies that would be found in the study area. A list of butterfly species observed in the study area is included in **Appendix L**. Many of the butterfly species included in this appendix are from the Ontario Butterfly Atlas, and as such locational information specific to the study area can only be approximated based on the mapping within the atlas.

A total of 65 butterfly species have been recorded in the vicinity of the study area. Of these, 12 species were observed in the western portion of the study area during the field surveys. Please refer to the East Characterization Chapter, **Table 4E.9.10**, for a summary of the rare butterflies that were reported from the atlas in the vicinity of the study area. The table identifies typical habitats and notes whether that type of habitat is present in the eastern portion of the study area. Habitat for all rare butterfly species is found in the study area. Only Monarch (*Danaus plexippus*), however, was observed by NRSI in the study area.

Monarch butterfly is considered to be of special concern (SC) in Canada (MNR, 2001), but was not considered rare in Halton Region by Philips Engineering Ltd. (2000b). An assessment of butterfly statuses within the region has not been completed at the time of preparing this report.

The species observed in the western portion of the study area were associated with a range of open and wooded habitats. It is anticipated that a number of butterfly species are found widespread throughout the remainder of the study area but were not noted during the field surveys.

4W.9.3 Aquatic Resources

4W.9.3.1 Aquatic Habitats

For a detailed description of the background documents available which deal with aquatic resources in the study area, the reader is referred to **Section 4E.9.3.1**.

Aquatic habitat investigations and mapping were initiated in April 2002, with detailed mapping of habitats between April 30 and July 10, 2002 and in July of 2003. Subsequent habitat refinements occurred through the duration of the study. Headwater reaches were assessed earlier in the season such

that habitat assessments could be made while there was a greater chance of observing flowing water. The various streams were divided into reaches, as seen in **Figure 4W.9.3**, based on the homogeneity of habitat. In addition, the attributes of the habitats observed in each homogenous reach were recorded on field data forms (a copy of the field form can be found in **Appendix M**). The habitat characteristics recorded for the surveyed reaches is included in **Appendix N**.

Fourteen Mile Creek

Fourteen Mile Creek drains a watershed area of approximately 40 km^2, containing several large tributaries, *e.g.,* McCraney Creek (SNC – Lavalin Ferrovial, 1999). Fourteen Mile Creek is a direct tributary of Lake Ontario. Its headwaters consist of three branches originating north of Hwy 407. Also, there are numerous tributaries that originate from woodlots and agricultural lands located north of the study area. Within the study area, Fourteen Mile Creek consists of several branches that originate north of Highway 407 and enter the study area via culverts under the highway Ecoplans (1995) categorized these reaches as warmwater baitfish streams while LGL (1999) categorized them as having warmwater baitfish and forage fish potential. A manmade pond (Palermo Pond) in the vicinity of Dundas Street at Highway 25 (Reach 14E-1) on the east branch of the Fourteen Mile Creek supports a warmwater baitfish and sportfish community (LGL 1999). A second pond (Reach 14-14A) is located on the west branch of the creek.

The west and central branches of Fourteen Mile Creek were assessed on May 7, 2002 and the east branch was assessed on May 23, 2002.

Entering the study area from the north (immediately south of Hwy 407), the west branch flows through agricultural fields (14W-13, 14, 16, 17). The aquatic habitat within these headwater reaches is primarily terrestrial vegetation and isolated pools. The channel substrate consists of silt and muck. There is no defined channel and little to no buffer is present. In areas, tributaries of the west branch are channelized with little meander present. There is a small (*i.e.,* 1 metre or less) grassed riparian buffer present. In the lower reaches near Dundas Street, the aquatic habitat substantially improves (14W-12). The presence of riffle, pool, boulder, undercut banks and woody debris provides shelter and food for a diverse fish community. Redside dace were sampled at this location. There is a manmade online pond (14W-14A) located in the vicinity of Dundas Street. Shoreline habitat of this pond consists of cattails, stumps and woody debris. Underwater habitat throughout the pond is unknown. Substrate consists of silt and muck. This pond supports a warmwater baitfish and sportfish community (LGL 1999, NRSI 2005). The presence of sportfish indicates that the pond is productive as largemouth bass are the top level predator species requiring a substantive forage base.

The central branch of Fourteen Mile Creek originates from a woodlot north of Hwy 407 and flows south through the study area. Within the study area the central branch was divided into 12 habitat reaches (14W-1,1A,2,3,4,9,9A,10,11,11A,18,20). Additional reaches were sampled north of the study area. Just south of Hwy 407, the instream habitat has been clearly influenced by the construction of Hwy 407. There is rock and boulder in this section of the creek as a result of rock riprap placed along the creek during construction. There is one tributary of the central branch (14W-11 and 14W11A) that flows through meadow. This tributary has a large riparian buffer consisting of grasses and shrubs, however there is very little canopy. Channel substrate consists of silt, clay, muck, gravel and cobble and there is boulder present in isolated areas. Instream habitat consists of small riffles and pools, woody debris, boulders, isolated undercut banks and terrestrial vegetation. Water temperature was 11^{o}C at the upstream (north) end of the study area and 14^{o}C at the downstream (south) end where it joins the main branch (May 7, 2002).

The remaining two tributaries of the central branch flow through a woodlot just east of the Zenon property. Upstream of the woodlot, the creeks flow through meadow with a riparian buffer of greater than 5m. The water temperature ranged from 16°C to 21.5°C (May 7, 2002). Instream habitat is poor and the channel substrate consists of silt and muck. The tributaries then flow into a woodlot where riffle: pool sequences are present, with backwater areas, undercut banks and woody debris structure. There is a large riparian buffer present (>100m) provided by a large mature woodlot. Water temperature was 16°C (May 7, 2002). South of the woodlot extending to Dundas Street, the creeks flow through a large meadow where the riparian buffer consists of grasses, trees and shrubs (14W-1A and 14W-2). Channel substrate is silt, clay, muck, cobble, sand and gravel. Habitat features are riffle, pool sequences, woody debris, boulder and backwater. Water temperature was consistent with that of the woodlot at 16°C.

The east branch of Fourteen Mile Creek flows south of Hwy 407 through agricultural fields. Within the study area this branch was divided into 11 reaches (14E-1,2,2A,3,3A,4,6,7,8,9,10). There is an online storm water management pond near Highway 407 which treats highway runoff. Shoreline habitat of the pond consists of cattails and terrestrial vegetation. Substrate of the pond consists of silt and muck. Water temperature for the pond was 22°C. Downstream of the north confluence the creek flows through agricultural lands. A small riparian buffer is present that consists of grasses, trees and shrubs providing good canopy for the creek. The channel substrate is silt, muck, sand, gravel, cobble and isolated boulders. Instream habitat features include riffle, pool sequences, boulder, undercut banks, woody debris and terrestrial vegetation. Water temperature was 22°C (May 23, 2002). Downstream, the tributary runs parallel to Regional Road 25 where it enters the main branch of Fourteen Mile Creek just upstream of an online pond (14E-1 Palerrmo Pond) at Dundas Street. Throughout this section, the tributary flows through a woodlot before entering a large meadow. The reach located within the woodlot exhibits instream habitat including woody debris, undercut banks and terrestrial vegetation (14E-7). The woodlot provides adequate canopy (> 50%) for the creek. The channel substrate consists of silt, muck, clay, gravels, cobble and isolated boulder. Once the creek enters the meadow, the canopy is significantly reduced however the instream habitat is consistent with the upstream reach. Water temperature through this section of the creek was 23°C (May 23, 2002).

McCraney Creek, Taplow Creek, and Glen Oak Creek

McCraney Creek, Taplow Creek and Glen Oak Creek act primarily as intermittent, poorly defined agricultural swales, with little or no riparian vegetation or fish habitat (LGL, 1999). Previous studies classified these streams as Type 4 streams with no fisheries potential (LGL, 1999). This study has confirmed this finding with the exception of the lower reaches of McCraney Creek, near Dundas Street (see below). This lower reach has not been ploughed through and so has retained a limited riparian buffer.

McCraney Creek

McCraney Creek is a direct tributary of Lake Ontario and originates north of Highway 407. It was assessed on May 6, 2002 and divided into four reaches MC-1, 2, 4, and 4A. It flows through agricultural croplands where there is little to no riparian buffer or canopy for the creek. The creek is ploughed through and has been channelized at the north end of the study area. The channel substrate is consistent throughout this creek consisting of silt, clay, muck, and areas of isolated gravel. Substrate conditions in the reach closest to Dundas Street (MC-1) provide some limited habitat potential for invertebrate production. Terrestrial vegetation and small pools are present. Water temperature was 18.5°C (May 6, 2002).

Taplow Creek

Taplow Creek, a tributary to McCraney Creek was assessed on April 30, 2002 and divided into three reaches, TC-1, TC-2 and TC-2A. This creek is intermittent throughout most of the year and flows through agricultural cropland with the exception of one small woodlot. No canopy is present. The creek has been channelized and is ploughed through. There is no insitu fish habitat features available and channel substrate consists of silt and muck. Water temperature was 11°C (April 30, 2002).

Glen Oak Creek

Glen Oak Creek, a tributary to McCraney Creek, was assessed on May 6, 2002 (GO-1). It is an intermittent creek and is dry for most of the summer months. Adjacent land use is agricultural croplands. Channel substrate consists of silt, clay, muck, and some gravel. There is no riparian buffer or canopy present. On May 6, 2002, the creek was dry with standing water observed in isolated pools. Water temperature taken from the isolated pools was 18°C.

Sixteen Mile Creek

The reader is referred to Section 4.9.3E for an overview discussion of Sixteen Mile Creek. The field investigations did not include examinations of the main creek, but did include a number of the tributaries.

Tributary (westerly) of Sixteen Mile Creek

The westerly tributary of Sixteen Mile Creek was assessed on July 10, 2002 and was divided into 10 reaches (16WA-1, 1A, 2, 3, 4, 5, 6, 7, 8, an 8A). This creek flows through a woodlot in the northern portion of the study area. The woodlot provides excellent canopy for the creek and contributes woody debris to the aquatic habitat. However, the creek is intermittent with only seasonal flow. Downstream of the woodlot, the creek flows through agricultural croplands where there is no riparian buffer. Channel substrate is silt and muck with some isolated gravel. Just upstream from Dundas Street, cobble is present in the channel and a riparian buffer (treed meadow) is present. The creek was dry on the day of the habitat assessment, and therefore no water temperature was recorded.

Tributary (northerly) of Sixteen Mile Creek

The northerly tributary to Sixteen Mile Creek was assessed on July 10, 2002 and divided into 4 reaches (16W-1 to 16W-4). This tributary originates from a woodlot north of the study area (north of Hwy 407). As the creek enters the study area it flows through a woodlot adjacent to the main channel of Sixteen Mile Creek. The woodlot provides excellent canopy for the creek. The instream habitat is largely represented by woody debris and boulder. The water temperature was 18^{o}C (July 10, 2002).

4W.9.3.2 Fish Species

A complete list of fish species known from all tributaries of each creek is included in **Appendix O.** This list was prepared using all available background reports as well as from sampling efforts for this study and in 2002/2003 by MNR. A total of 24 fish species were observed in the study area.

One nationally, provincially and regionally significant species, redside dace (*Clinostomus elongates)* has been observed previously in Fourteen Mile Creek (Holm and Crossman, 1986; MNR, 2001; LGL, 1999).

A *Recovery Strategy for Redside Dace in Canada, 2005 – 2009 (Draft)* was prepared by the RDRT in 2001 (Dextrase *et al.,* 2005). For a more detailed discussion of the status of redside dace, both nationally and provincially, see **Section 4.9.3.1E**.

Fish Surveys

Fish sampling occurred in April and May 2002, and April 2005. The sampling technique was backpack electrofishing with the use of a Smith Root Model 12 backpack electrofishing unit. Results for the fish sampling are presented in **Appendix P.** See **Section 4E.9.3.1** for a more detailed description of the methods used to collect fish for this study.

Sampling was conducted at 14 stations in the following watercourses: Fourteen Mile Creek; McCraney Creek; Taplow Creek; and Glen Oak Creek. Sample locations are provided on **Figure 4E.9.2**.

A total of seven species (goldfish, creek chub, brook stickleback, white sucker, fathead minnow, redside dace, largemouth bass, brown bullhead, and blacknose dace) were sampled from Fourteen Mile Creek. No fish were found in any of the remaining streams (Taplow Creek, Glen Oak Creek, and McCraney Creek).

The majority of the fish assemblage for Fourteen Mile Creek is comprised of generalist species, which are tolerant of warmwater temperatures with moderate amounts of organic enrichment. However the redside dace requires cool, clear flowing water with riffle-pool sequences and overhanging bank vegetation for its survival (Dextrase *et al*., 2005).

The MNR conducted fish sampling in 2002/2003 in the study area (MNR, 2003g). Data tables and sampling locations provided by MNR are included in **Appendix Q**. The MNR sampled a small number of species that were not found during the 2002 or 2005 fish surveys conducted for this Subwatershed Study. These species are as follows:

- Common shiner, and fantail darter in Fourteen Mile Creek;
- Blacknose Dace in McCraney Creek (south of study area at Upper Middle Road West); and
- Creek chub in Taplow Creek (south of study area at Upper Middle Road West).

None of these fish are VTE species and all are demonstrably secure in the Province of Ontario. The species captured by MNR confirm the warmwater status of the creeks within the study area.

Benthic Invertebrate Communities

Study Design

For a complete description of the invertebrate study design, factors for station selection and sampling methodologies, the reader is referred to Section 4.9.3.5E. Four stations were sampled as shown of **Figure 4W.9.2.**

Habitat Conditions

A brief summary listing the instream habitat found and qualitatively sampled at the four stations is provided in **Table 4W.9.5**.

Table 4W.9.5 **Summary of Instream and Bank Habitat Present at the Four Benthic Invertebrate Sampling Stations**		
Station #	**Watercourse**	*Instream and Bank Habitat*
1	Fourteen Mile Creek (West Branch)	Riffle, pool, rock, cobble/gravels, woody debris, backwater areas, margins, instream vegetation and overhanging vegetative areas.
2	Fourteen Mile Creek (East Branch)	Riffle, pool, boulder, cobbles/gravels, woody debris, backwater areas, margins, undercut banks, instream vegetation and overhanging vegetative areas.
3	Fourteen Mile Creek (tributary)	Riffle, boulder, cobbles/gravels, undercut banks, instream vegetation and overhanging vegetation.
4	Sixteen Mile Creek (tributary)	Riffle, boulder, cobbles/gravels, woody debris, backwater areas, instream vegetation and overhanging vegetative areas.

The Aquatic Habitat Assessment - Benthic Invertebrate Monitoring Form designed specifically for the Subwatershed Study may be found in **Appendix T**.

Data Analysis

The reader is referred to Section **4E.9.3.2** for a description of the methods and indices used in interpreting benthic results

Results

There were a total of 12 samples taken from 4 stations west of Sixteen Mile Creek the study area. A total of 59 taxa were identified and samples generally contained a healthy number of specimens (total abundance ranged from 40 to 684). There was a general consistency in the invertebrate community among the stations, which suggests uniformity in the habitat present in the watercourses for the study area.

The results of the benthic invertebrate sampling are summarized in **Table 4W.9.6**. The benthic invertebrate identification and enumeration raw data is presented in **Appendix V**.

Table 4W.9.6
Summary of Results for Benthic Invertebrate Sampling for Fourteen Mile Creek (West And East Branches), Fourteen Mile Creek Tributary and Sixteen Mile Creek Tributary

Watercourse	Station	Replicate	BioMAP (d)	Criteria for impairment category	Assessment	BioMAP (q)	Criteria for impairment category	Assessment	PMA	Criteria for impairment category	Assessment	Species Richness	Criteria for impairment category	Assessment	EPT	Criteria for impairment category	Assessment
Fourteen Mile Creek (west branch)	1	1	4.74	< 14	impaired							11	11-18	mod. impact			
		2	5.34	< 14	impaired							12	11-18	mod. impact			
		3							35.44	35-49	mod. impact	17	11-18	mod. impact	2	2-5	mod. impact
		pooled*				2.50	< 3.2	impaired									
Fourteen Mile Creek (central branch)	2	1	8.6	< 14	impaired							11	11-18	mod. impact			
		2	5.4	< 14	impaired							12	11-18	mod. impact			
		3							48.00	35-49	mod. impact	23	19-26	slight impact	5	2-5	mod. impact
		pooled*				2.6	< 3.2	impaired									
Fourteen Mile Creek (east branch)	3	1	4.8	< 14	impaired							13	11-18	mod. impact			
		2	4.3	< 14	impaired							10	0-10	sev. impact			
		3							38.50	35-49	mod. impact	16	11-18	mod. impact	2	2-5	mod. impact
		pooled*				2.40	< 3.2	impaired									
Sixteen Mile Creek (tributary)	4	1	5.6	< 14	impaired							7	0-10	sev. impact			
		2	4.2	< 14	impaired							6	0-10	sev. impact			
		3							44.27	35-49	mod. impact	14	11-18	mod. impact	1	0-1	sev. impact
		pooled*				2.3	< 3.2	impaired									

* All the taxa from both the quantitative, replicates 1 and 2 (surber sampler) and the qualitative, replicate 3 (kick and sweep) samples are pooled into a single list for the analysis of BioMAP (q).

Fourteen Mile Creek (west branch)

The BioMAP (d) and (q) analysis indicates that the water quality of the west branch of Fourteen Mile Creek is impaired. The PMA, Species Richness and EPT indices results showed a moderate impact to stream health, which supports the BioMAP assessment.

Fourteen Mile Creek (central branch)

The BioMAP (d) and (q) analysis indicates that the water quality of the central branch of Fourteen Mile Creek is impaired. The PMA, Species Richness and EPT indices support this finding by showing a moderate degree of impairment, with the exception of the qualitative Kick and Sweep sample indicating a slight impairment to water quality.

Fourteen Mile Creek (east branch)

The BioMAP (d) and (q) analysis indicates that the water quality for the east branch of Fourteen Mile Creek is impaired. The PMA, Species Richness and EPT indices support this finding by showing a moderate degree of impairment, with the exception of the quantitative Surber sample (Replicate 2) indicating a severe impairment to water quality.

Sixteen Mile Creek (tributary)

The BioMAP (d) and (q) analysis for the tributary to Sixteen Mile Creek indicates impaired water quality conditions. The results of the PMA analysis indicate a moderate impairment, which supports the BioMAP assessment. The Species Richness and EPT indices indicate a severe impairment to water quality, with the exception of the qualitative Kick and Sweep sample indicating a moderate impairment to water quality, which also supports the BioMAP and PMA results.

To summarize, the results of the benthic invertebrate samples are consistent throughout the study area, generally indicating a moderate and in some instances, severe impact to water quality. Moderate and severely impacted streams reflect a benthic invertebrate community that is altered to a large degree from a pristine state (Novak and Bode, 1992). Given the impacts of agricultural activities, including channelization and removal of riparian cover, the impairment of water quality in these streams is expected.

4W.9.4 Ecological Linkages

See **Section 4.9.4E** for a discussion of linkages in the subwatershed.

Observations of wildlife movement within the study area included direct observations of wildlife during field surveys, as well as a winter (February 2003) aerial survey of wildlife tracks. Staff of the MNR also conducted winter wildlife tracks surveys in 2002 (MNR, 2003d). The main valley of Fourteen Mile Creek was noted to include numerous white-tailed deer tracks with a number of beds adjacent to tributaries south of Highway 407.

Potential ecological linkages and restoration areas were identified in the report prepared by LGL (1999). These linkages connected most the currently isolated wooded habitats within the study area. The potential linkage of habitats is further assessed in **Section 5.0** of this report.

4W.10 Water Quality

Water quality sampling stations were set up at 9 locations on tributaries draining across the Oakville West properties. Locations are shown on **Figure 4W.10.1** with the Sample ID listed below in **Table 4W.10.1**.

Table 4W.10.1
Water Quality Sampling Program

Sample ID	*Description*	**Sample Dates**	**Parameters**
SM 1	Sixteen Mile Creek	26 Nov. 02 - Dry 20 Dec 02 - Wet 2 May 03 – Wet (metals and pesticides sampled on Aug. 13 2003 only)	• E. coli/Fecal Coliform • Total Phosphorus • Ammonia • Total Kjeldahl Nitrogen • Nitrite and Nitrate – nitrogen • Biological Oxygen Demand • Total Suspended Solids • Chemical Oxygen Demand • Chlorides • Pesticides • Total Metals
SM 2	Sixteen Mile Creek		
TC	Taplow Creek		
MC	McCraney Creek		
FM 1	Fourteen Mile Creek		
FM2	Fourteen Mile Creek		
FM 3	Fourteen Mile Creek		
FM 4	Fourteen Mile Creek		
FM 5	Fourteen Mile Creek		

Significance and Results

The data are presented in detail in **Appendix W**. It is useful to compare results to PWQO. These are criteria (numerical values) established to ensure that the surface waters of the province are of a quality that is satisfactory for aquatic life and recreation.

- **Bacteria (E. coli and Fecal Coliform)** – High levels indicate a potential health risk, primarily to body contact recreation. Levels of E. coli should be below the PWQO of 100 counts per 100 mL to protect public health at bathing beaches. In this study, **l**evels of E. coli are often above the PWQO with wet weather data being consistently higher than the dry weather case. This is an expected result and probably results from farming activity or wildlife.
- **Total Phosphorus** – PWQO of 0.03 mg/L established to prevent nuisance aquatic growths of algae and plants. Phosphorus and algae are also a problem on the Lake Ontario shoreline of Oakville, which is the ultimate receiver of the flows from these tributaries. For this study, all samples were above the PWQO with wet sample results the dry weather sample. This is likely the result of agricultural activities in general and the resulting soil erosion during wet weather.
- **Ammonia nitrogen, Total Kjeldahl Nitrogen (TKN), Nitrite and Nitrate Nitrogen** – A portion (un-ionized ammonia) of the ammonia is toxic to aquatic life, depending on the temperature and pH of the water. TKN represents the organic nitrogen plus the ammonia. Nitrite and nitrate are nutrients similar to phosphorus and can stimulate plant growths. Nitrate has no PWQO, however a Canadian Water Quality Guideline of 2.93 mg/L (NO3 - N) has been set to protect fishery spawning areas. For this study although the pH and temperature are not available for the specific sampling times, to calculate the un-ionized fraction the levels of ammonia are generally not toxic at temperatures and pH expected in spring (pH 8.0 and T of 10°C) and winter (pH 8 an T of 5ºC), However, the high value of 1.37 mg/L for the May sample in Fourteen Mile Creek tributary (FM 4) is likely toxic to aquatic organisms (at pH 8.0 and T of 10°C). TKN levels are fairly stable with higher levels in wet weather indicating washoff of organic plant material. The levels of nitrate nitrogen often exceed the guideline level indicating a potential problem for aquatic life.

- **Chloride:** A component of road salt, this ion is receiving increasing scrutiny from the federal government. It provides a good measure of urbanization and road activity. No PWQO is available, however Environment Canada has designating road salt as a Toxic Substance (Canada Gazzette Notice, April 2005), referring to levels above 250 mg/L as a cause for concern for aquatic organisms. The November and December 2002 samples examined for this study were typically well above the 250 mg/L guideline, with an average level over all streams of approximately 1200 mg/L. The highest levels were observed for Sixteen Mile Creek. The May 2003 samples had dropped considerably to more acceptable levels (but just below the guideline level), possibly due to more dilution from runoff.
- **Total Suspended Solids (TSS)** – Targets are often set on this parameter for control of urban runoff. TSS is a good surrogate for other water quality parameters. No PWQO is available. For this study, the levels vary significantly with expected higher values in wet weather not being observed consistently, likely because most of the watershed is well vegetated and limited construction is occurring. Also there was a significantly high value of 540 mg/L in dry weather samples at FM 4 in November 2002.
- **Chemical Oxygen Demand (COD)/Biological Oxygen Demand (BOD)** – These parameters measure the oxygen requirement to decompose material in the water, bacterially with the BOD test and chemically with COD tests. There is no PWQO for either parameter. High levels of BOD can indicate organic pollution from human wastes or manure, while high levels of COD can indicate presence of other organic material including leaf litter and woody debris. For this study, low levels of BOD were measured, usually below the lab detection level of 3 mg/L. COD results were fairly consistent with no large differences between dry and wet samples. Levels likely indicate the presence of plant litter material in the water from natural sources which is not a cause for concern.
- **Metals** – Heavy metals in runoff can indicate urban or highway runoff or the presence of an industrial discharge. Also, metals are sometimes high due to natural sources. PWQO exist for many of the metals tested. Only one sample was taken in dry weather for this study. Aluminium was above the PWQO for all of the locations, likely due to the presence of clay in the sample (The PWQO is for clay free water). Copper was marginally above the PWQO for 5 out of 6 stations, a result noted for many other southern Ontario locations, likely due to background mineral sources. Iron was above the PWQO likely due to the characteristic red soils in the area which are high in iron. Other metals were occasionally high for nickel, Zinc and zirconium, mostly in Sixteen Mile and Fourteen Mile Creeks. These systems are larger than the other catchments, with more variety of upstream land-uses. Additional upstream sampling would be needed to establish if this is a recurring issue and to identify sources.
- **Pesticides** – These are applied to agricultural fields, golf courses and urban areas and present in runoff from these areas. . Many have PWQO as indicated in the **Appendix W**. Only one sample was taken – in dry weather – and all results were “non detect” at the lab detection limit.

4W.11 Servicing

A review of the water and wastewater servicing maps in support of the Halton Urban Structure Plan (HUSP) has identified a number of proposed water and wastewater servicing facilities within the study area. The types of facilities include trunk servicing watermains, as well as sanitary sewers and forcemains.

Several watermains and sanitary sewers will be constructed at locations in proximity to local watercourses as seen in **Table 4W.11.1**. The extent of the potential impacts of these proposed works will need to be established. Furthermore, a more complete review of these crossings after obtaining the Water and Wastewater Master Plan will be required.

Appropriate mitigative measures will need to be identified and implemented to address potential impacts on surface water and groundwater associated with each servicing project at the time of construction.

Table 4W.11.1
Servicing Infrastructure
Halton Urban Structure Plan (HUSP)

Infrastructure Location	Servicing/Facility Type	Stream Crossings
Water Servicing		
South Easement – Tremaine Road to 3rd Line	Trunk	Fourteen Mile Creek West Fourteen Mile Creek East McCraney Creek Taplow Creek
North Easement – Bronte Road to 3rd Line	Trunk	Fourteen Mile Creek East McCraney Creek Taplow Creek
Dundas Street – Bronte Road to Neyagawa Road	Trunk	Fourteen Mile Creek East McCraney Creek Taplow Creek Glen Oak Creek Sixteen Mile Creek
Tremaine Road – South Easement to Dundas	Trunk	None
Bronte Road – North Easement to West Oak Trail	Trunk	Fourteen Mile Creek East
3rd Line – North Easement past West Oak Trail	Trunk	Taplow Creek McCraney Creek Glen Oak Creek
Wastewater Servicing		
Dundas Street – Tremaine Road to midway to Bronte Road	Sanitary Sewer Main	Fourteen Mile Creek West
Easement – Lower Baseline to Dundas Street	Sanitary Sewer Main	Glen Oak Creek
Dundas Street – 3rd Line to Forcemain at Sixteen Mile Creek	Sanitary Sewer Main	Glen Oak Creek

4W.12 Characterization Summary

The characteristics of the North Oakville Creeks Subwatershed, based upon background review and collected field data, are outlined in the preceding sections. This information provided the basis of the analysis (**Section 5.0**) which was carried out to further detail the subwatershed processes (function) that influence the subwatershed form as well as the potential impacts of land use and activity changes and potential management opportunities.

A brief summary of key items identified in the characterization is provided in this section.

- The topography in the till plain is gently undulating to fluted with low relief and poor to moderate drainage. Drainage in the study area has a linear pattern, likely a reflection of drainage courses developing in the lower areas in the locally fluted topography.
- The watercourses are typically not well defined except for the lower reaches of Fourteen Mile and Sixteen Mile Creeks.

- The area referred to as the Trafalgar Moraine is located to the north of the study area. One of the features noted in the area is a number of small depressions. Although the depressions are not isolated to the study area, they do occur randomly throughout it. It is interpreted that these depressions could be a result of melting ice pieces that remained as the main glacial ice mass receded from the area.
- Shallow groundwater flow is locally toward creeks and watercourses that are deep enough to intersect the water table. At depth, groundwater flow is influenced by the buried bedrock valley, which is partly filled with granular soils. Flow in this system is generally directed southeastward towards Lake Ontario, following the trend of the bedrock valley.
- Groundwater discharge does occur near the bottoms of some watercourse valleys, specifically in the Fourteen Mile Creek valley where groundwater discharge was observed. Since these observations were made in the spring of 2003, when the water table was high, it is expected that these conditions may be somewhat transient through the year as the water table naturally declines in elevation during the drier summer months.
- In many cases, the well yields are not reliable (too low during the summer) and groundwater quality is poor and often used only for non-consumptive purposes. The exception is for wells completed in the granular deposits in the buried bedrock valley, where more substantial well yields have been reported from the overburden. The potential to develop a large groundwater supply in the study area is very low.
- The available background reports provide preliminary information on design flows and recommended SWM requirements. The information, being developed at different times for varying purposes, is somewhat inconsistent and incomplete. In general, however, the need for SWM for water quantity, quality and erosion control has been recognized in the past reports.
- Much of the drainage network within the study area is comprised of swales without defined channels. The defined channels tended to be the higher order streams located primarily near Dundas Street. These areas were often associated with low gradient, agricultural or wooded areas and generally showed signs of instability. Erosion threshold analysis indicated that the bed in these sensitive reaches is fully mobilized around bankfull flows, making them sensitive to increases in discharge.
- Downstream of Dundas Street, most of the stream reaches have been altered through urbanization.
- The habitat function of a number of the terrestrial units appear to be interrelated based upon the field work carried out.
- A number of provincially and regionally rare plant species have been found.
- Linkages between habitats results from physical connections such as hedgerows, agricultural fields, riparian habitats and contiguous woodlands, as well as functionally through proximity of habitats. Existing road systems and remnant habitats outside the study area affect the connections
- The study area provides a diversity of habitats with a substantial number of provincially and regionally rare wildlife species utilizing these lands for all or part of their life cycles.
- The creeks upstream of Dundas Street appear to have intermittent flow. The presence of flow during summer months in each of the streams is dependant upon the level of average precipitation. Fourteen Mile Creek was observed as having the highest potential for permanent flow during summer months.
- One nationally, provincially and regionally significant species of fish (*i.e.*, the redside dace) has been observed in Fourteen Mile Creek (MNR 2001, LGL 1999, Holm & Crossman 1986).
- During the characterization field surveys, the fish assemblage for Fourteen Mile Creek was comprised predominantly of generalist species, tolerant of warmwater temperatures with moderate amounts of organic enrichment.
- Riparian cover varies considerably along the creeks. The riparian cover that does exist was found to improve aquatic conditions (*i.e.,* temperature, habitat).
- Channel substrate varies from watercourse to watercourse, but is generally comprised of silts and

clay with some sand and gravel. Typically, the substrate was found to be poor for benthic production.

- Two wet weather and two dry weather surface water quality samples were collected and analyzed. The results include: bacteria often above the PWQO (especially under wet conditions), total phosphorus consistently above PWQO in wet conditions (probably due to agricultural land use in area), ammonia/nitrogen were fairly stable with some exceedances which may affect fish spawning activities, chlorides levels were higher in winter months than summer (likely due to use of road salts), BOD/COD was relatively low indicating no real influence from human wastes or manure.
- Information from the HUSP indicates a number of creek crossings for servicing. The crossings and potential impacts will be considered in the strategy development.

4.13 Watershed Goals and Objectives

The watershed goals and objectives as outlined in **Section 13.1** are repeated in **Table 4.13.1**. The preliminary considerations that will affect the strategy development based on the findings to date are outlined.

Table 4.13.1
Preliminary Analysis Considerations Based Upon Characterization (Phase I)

#	Objective	Preliminary Considerations
1)	To develop a management plan for North Oakville Creeks Subwatershed such that the watershed goals and objectives can be met in view of the combined impacts of all land use and land use changes existing or expected in this watershed. Such impacts include urban development, regional/municipal service infrastructure, rural residential development, recreation (golf courses), and agriculture. To streamline land use planning and approvals, by determining the boundaries of environmental areas that fall under current regulations or are identified for protection.	Potential impacts and management needs will be identified and developed in the second study phase.
2)	To integrate the Subwatershed Planning process with other related processes (Secondary Plans, Comprehensive Environmental Impact Studies under the Provincial Policy Statement, Class Environmental Assessments for Water Management and Municipal Works, Community Plan)	Integration with other processes will be developed in the Implementation Strategy.
3)	To protect, restore and enhance groundwater quantity and quality.	Groundwater infiltration processes and related quality appear to be primarily influenced by the relatively low imperviousness across the site as well as existence of surface depression areas. In addition groundwater supplies at depth are influenced primarily by bedrock conditions at depth. Some local recharge/discharge and baseflow processes within the creeks exist in a relatively limited form. Regardless, the linkage between streamflows (base flow) and groundwater conditions, needs to be evaluated.
4)	To conserve, protect and restore the natural water, forest, and wildlife resources of the North Oakville Creeks Subwatershed.	Terrestrial resources and linkages need to be protected and enhanced.
5)	To restore, protect and enhance water quality and associated aquatic resources and water supplies.	Aquatic conditions are relatively poor and degraded. Water quality appears to be degraded by current agricultural practices. The management approach needs to address both conditions in the study area and the generally

Table 4.13.1 Preliminary Analysis Considerations Based Upon Characterization (Phase I)		
#	**Objective**	**Preliminary Considerations**
		better conditions that exist in the downstream reaches.
6)	To minimize the threat to life and the destruction of property and natural resources from flooding and erosion, and preserve natural flood plain hydrologic functions.	Current streambank erosion is relatively low. Protection from increased erosion potential is needed.
7)	To ensure public participation in the planning, development, implementation, and monitoring of the watershed management plan	Public participation in the strategy will be outlined in the implementation.
8)	To provide information on natural heritage features and areas which assists municipalities in addressing the provincial policy statement, while respecting the rights of individual landowners	This will be part of the management strategy.
9)	To identify stewardship opportunities for the watershed.	Stewardship opportunities will be outlined in implementation.