TORONTO AND REGION Conservation for The Living City

Humber River State of the Watershed Report - Air Quality

2008

EXECUTIVE SUMMARY

- "Very good" Air Quality Index[1] scores were achieved only 46% of the time in 2001;
- Air Quality Index scores in the "moderate" to "poor" range occurred 9% of the time;
- Ground-level ozone[2] was the pollutant responsible for poor air quality in all instances where smog advisories were issued in 2001;
- Average annual ambient ozone concentrations recorded at Humber area monitoring stations appear to exhibit a slight, yet steadily increasing trend between 1990 and 2002;
- Hot sunny weather is known to accelerate the chemical reactions that form ground-level ozone and a strong correlation seems to exist between high air temperatures and the number of ozone exceedances observed at Humber area monitoring stations;
- Climate change models predict that average annual air temperatures in the Great Lakes Basin could rise by approximately three degrees Celsius by 2050. If this change results in hotter summers it can be anticipated that the frequency of smog warnings will increase unless emissions of nitrogen oxides and volatile organic compounds are drastically reduced;
- Fine particulate matter[3] concentrations occasionally exceeded the provincial interim 24-hour Ambient Air Quality Criteria of 50 ug/L, a concentration limit for the protection of human health.

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[1] Air Quality Index is based on hourly ambient concentrations of six key pollutants that are known to have adverse effects on human health and the environment: sulphur dioxide, ozone, nitrogen dioxide, total reduced sulphur compounds, carbon monoxide, and suspended particles.

[2] Ozone is a colourless gas produced by photochemical reactions between oxygen, nitrogen oxides and volatile organic compounds in the presence of sunlight. Ozone is not directly emitted into the atmosphere in significant amounts. Studies have demonstrated that ozone impairs the normal function of the lungs, causing alterations in respiration rates, the most characteristic being shallow, rapid breathing. Exposure may result in chest tightness, coughing, and wheezing. Ozone can also cause plants to grow 10 to 40 percent more slowly, age prematurely, lose leaves during the growing season, and produce pollen with shorter life spans.

[3] Fine particulate matter can penetrate deep into the lungs and can aggravate bronchitis, asthma, and other respiratory diseases.

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1.0 INTRODUCTION

In 1997, the Humber Watershed Task Force released the Humber River Watershed Strategy, *Legacy: A Strategy For A Healthy Humber* (MTRCA, 1997), which provided thirty objectives for a healthy, sustainable watershed, and a set of actions necessary to achieve them. It also provided an overview of the state of the Humber River watershed at that time. Since the release of the watershed strategy, a significant amount of new information has become available through monitoring, special studies and the experiences of watershed partners.

In 2004, the Toronto and Region Conservation Authority (TRCA), in partnership with watershed municipalities and the Humber Watershed Alliance initiated a study to develop an integrated watershed management plan for the Humber River. This study was initiated to fulfill the watershed planning requirements of the *Oak Ridges Moraine Conservation Plan*, 2002, and to update the strategies and recommendations of *Legacy,* in light of new information, a stronger scientific foundation and better understanding of the effects of human actions on natural ecosystems. The watershed plan is intended to inform and guide municipalities, provincial and federal governments, TRCA, non-governmental organizations and private landowners regarding management actions needed to maintain and improve watershed health.

This State of the Watershed Report provides updated information on current conditions, emerging trends and identifies key watershed management issues and opportunities in the Humber pertaining to air quality. Indicators of watershed health and associated targets are used to rate current conditions. Ratings for a full suite of indicators of watershed health are summarized in, *Listen to Your River: A Report Card on the Health of the Humber River Watershed* (TRCA, 2007).

This State of the Watershed report begins with an overview of key sources of air pollution and the health effects of each pollutant. Observed pollutant levels are compared to provincial ambient air quality standards. Mitigation strategies for each pollutant are also discussed.

Air is easily overlooked in assessing the impacts of human activity. Yet, as an essential ingredient for life and a medium for the spread of airborne contaminants, air is a critical component of the watershed. Air contaminants are generated from both human activities and natural processes, and may be released from local, regional and even global sources, thereby complicating management efforts. Air pollution affects human, aquatic, and terrestrial health and the built environment. Since some air pollutants are also greenhouse gases, they can even contribute to global warming of the atmosphere; also know as “climate change”. Vegetation plays an essential role in maintaining healthy air, not only by providing oxygen, but also by absorbing contaminants from the atmosphere.

The data summarized in this report are derived from four local monitoring sites, although the atmospheric region of influence, or "airshed", extends far beyond the watershed boundary. Situated in the densely populated Great Lakes Basin, the Toronto Region is affected by long range transport of pollutants from as far away as the Ohio Valley in the USA (Health Canada, 1997). Despite improvements in air quality over the last 30 years, smog remains a concern in southern Ontario, and concentrations of ozone and suspended particulates (major components of smog and greenhouse gases) frequently exceed provincial standards.

2.0 UNDERSTANDING THE SOURCES AND IMPACTS OF AIR POLLUTION

Although both natural and human sources contribute to air pollution, the main contribution comes from everyday human activity (City of Toronto, 2000). Pollutants are released through volcanic eruptions, dust storms, emissions from oceans and vegetation, forest fires, factories, power plants, smelters, planes, trains, and other vehicles. Air pollutants can affect human health, vegetation, buildings and climate. The links between pollutants discussed in this report and various air issues are shown in Table 1. Table 2 provides further details on the sources and effects of pollutants that frequently exceed the Ontario Ambient Air Quality Criteria within the Humber River watershed and surrounding area.

Table 1: **Linkages Between Air Pollutants and Air Issues.**

Pollutant	Smog	Global Warming	Urban Air Quality	Acid Deposition	Health	Aesthetics
Ozone	yes	yes	yes	yes	yes	no
Sulphur Dioxide	yes	yes	yes	yes	yes	yes
Carbon Monoxide	yes	yes	yes	no	no	no
Nitrogen Oxides	yes	yes	yes	yes	yes	yes
Volatile Organic Compounds	yes	yes	yes	no	no	yes
Particulates	yes	yes	yes	yes	yes	yes

Source: Adapted from OMOE, 2002.

Airborne contaminants can originate from both natural and man-made sources. Urban air pollutants arise from a wide variety of sources, although they are mainly a result of combustion processes (Environment Canada, 2001). Today, the largest source of pollution in most urban areas is the motor vehicle, and to a lesser extent, industry (Ontario Ministry of the Environment (OMOE, 2004). As the urban trend for single occupancy vehicle use continues, more and more vehicles enter the road network, creating more trips per day and greater traffic congestion. Trip lengths in the Greater Toronto Area (GTA) will continue to rise as residents relocate to suburban areas.

Table 2: Pollutants that Frequently Exceeded the Ontario Ambient Air Quality Criteria in 2002.

Pollutant	Sources	Effects
Ozone (O_3)	It is a colourless gas produced by photochemical reaction between nitrogen oxides, volatile organic compounds (typically emitted from internal combustion engines) and air in the presence of sunlight. Ozone is not directly emitted into the atmosphere in significant amounts. Ozone is formed downwind of theses sources and is capable of traveling long distances. A large portion (over 50 percent or greater) of the ground-level ozone concentrations found in Ontario can be attributed to long range transport of ozone and its precursors from industrial states south of the Great Lakes. High levels generally occur from May to September between noon and early evening. In Ontario, the highest concentrations of ozone are on hot and sunny summer days. Ground-level ozone pollution is a primary component of smog.	Human: Ozone is a pulmonary irritant that affects the respiratory mucus membranes, other lung tissues, and respiratory functions. Studies have demonstrated that ozone impairs the normal function of the lungs, causing alterations in respiration rates, the most characteristic being shallow, rapid breathing. People with respiratory and heart problems are at higher risk. Exposure may result in chest tightness, coughing, and wheezing. Vegetation: Injury to vegetation is an early sign of photochemical air pollution. Sensitive plants are useful biological indicators of this type of pollution. Visible signs of injury due to ozone are flecking and leaf discolouration.
Total Suspended Particulates (TSP) Suspended Particulates (SP)	TSP is a generic term for airborne particles including aerosols, smoke, fumes, dust, fly ash and pollen. The composition varies but normally includes soil particulate, organic matter, sulphur and nitrogen compounds and metals such as lead, carbon, or higher hydrocarbons formed by incomplete combustion of hydrocarbon fuels. Size range varies from 0.1 to 100 microns. SP is a relative measure of suspended particulate matter in the atmosphere most likely to reach the lungs (diameter generally less than 10 microns, PM10). These have the greatest effect on health. Particulate matter is emitted from industrial processes including combustion, incineration, construction, metal smelting and processing. In the urban airshed, motor vehicle exhaust, and road dust are major sources of particulate emissions. Natural sources of particulate matter include windblown soil, forest fires, ocean spray, and volcanic activities.	Human: The greatest impact on health is from particles less than 10 microns in diameter which can penetrate deep into the lungs and can aggravate bronchitis, asthma, and other respiratory diseases. More serious health effects may be associated with suspended particulate matter which contains toxic particulate component or which has adsorbed a gaseous pollutant on the surface of the particles. Other effects: Corrosion, soiling of materials, damage to vegetation, and visibility reduction are additional effects.

Unless otherwise noted, Table 1-2 is adapted from OMOE, 1997.

Air pollution affects living organisms and inanimate objects through direct contact with air, chemical loading via dry or wet deposition (i.e., precipitation), and through condensation and absorption processes. Many of the chemicals that are emitted to air settle on surfaces, such as soils or built features, and ultimately enter surface waters and groundwater. Water bodies adjacent to urban areas are impacted by air pollution due to atmospheric deposition. As water moves through the hydrological cycle, it falls as rain or snow and then evaporates to the atmosphere from the land and surface waters. Other substances, including toxic pollutants, follow this same path. Pollutants may evaporate to the atmosphere, where wind currents can carry them for long distances before depositing them.

2.1 Human Health

Poor ambient air quality has an adverse effect on public health. A study conducted by Toronto Public Health in 1999 estimated that there have been between 730 and 1400 premature deaths, and between 3,300 and 7,600 hospital admissions, each year in Toronto associated with air pollution (Toronto Public Health, 2000). The study suggested that nitrogen dioxide (NO_2) is the air pollutant with the greatest impact on human health, followed by carbon monoxide (CO) and sulphur dioxide (SO_2). More recent health research by the Ontario Medical Association (OMA) indicates that there is no "safe" level for common air pollutants such as ozone and particulate matter (OMA, 2001).

Individual reactions to air contaminants depend on several factors such as the type of pollutant, the degree of exposure and how much of the pollutant is present. Age and health are also important factors. Health and health-care system effects of ground-level ozone at levels that occur in Canada include lung inflammation, decreased lung function, airway hyper-reactivity, respiratory symptoms, possible increased medication use and physician/emergency room visits among individuals with heart or lung disease, reduced exercise capacity, increased hospital admissions and possible increased mortality. Similar effects are thought to occur in association with airborne particles, with the exception of inflammatory changes and with the additional effect of increased school absenteeism (OMA, 1998).

2.2 Terrestrial and Aquatic Health

Terrestrial and aquatic systems are affected by poor air quality through direct contact with polluted air. For example, ground-level ozone interferes with the ability of plants to produce and store food, so that growth, reproduction and overall plant life is compromised. Air pollution is a major concern for the agricultural industry. With crops marketed based on appearance and taste, damage such as that detailed in Table 3, can have a substantial affect on sales. How badly the crop is damaged will depend on how long the crop is exposed to the pollutant, the crop species and its stage of development, as well as the environmental factors that influence the build-up of the pollutant and the preconditioning of the plant. The Ontario Ministry of Agriculture (OMAF) has expressed concern for several crop types in Ontario that are susceptible to air pollution, including tomatoes, peppers, beans, potatoes, cucumber, lettuce, onions, sweet corn, spinach and grapes (OMAF, 2002). They have also found some species to be resistant to ozone damage, such as endive, apricot and pear.

Table 3: Air Pollution Damage to Ontario's Crops.

Pollutant	Symptoms/Injury to Crops
Ozone	Symptoms vary depending on the concentration of ozone in the air and the length of exposure. Ozone symptoms characteristically occur on the upper surface of affected leaves and appear as flecking, bronzing or bleaching of the leaf tissues. Although yield reductions are usually with visible foliar injury, crop loss can occur without any sign of pollutant stress. Conversely, some crops can sustain visible foliar injury without any adverse effect on yield. Injury tends to occurs on the most recently emerged leaves.
Sulphur Dioxide	Exposures to high levels will result in light tan to white necrotic areas and yields may be reduced.
Nitric Oxide	Depending on the concentration and extent of exposure, plants may suffer leaf lesions and reduced crop yield.
Peroxyacetyl nitrate (PAN)	Affects tissues on the lower leaf surface, typically causing a gradual glazing or silvering effect in bands or blotches, which may advance to bronzing within two to three days. Small plants and recently matured leaves are most susceptible to PAN injury.

Adapted from OMAF, 2002.

Deposition of pollutants, both wet and dry, into watershed systems also adversely affects terrestrial and aquatic ecosystems. For instance, acid deposition can alter the protective waxy surface of leaves, inhibit plant germination and reproduction, accelerate soil weathering and make some toxic elements, such as aluminum, more soluble which can prevent the uptake and use of nutrients by plants (Environment Canada, 2001). Since air pollution can weaken sensitive vegetation, it makes plants more susceptible to disease, pests, and environmental stresses.

Atmospheric deposition is a significant source of certain toxic pollutants in the aquatic system. In fact, as much as 90 percent of some toxic loadings to the Great Lakes are believed to be the result of airborne deposition. In Ontario, sulphur compounds account for approximately two-thirds of acid deposition while nitrogen compounds account for the remaining portion (Great Lakes Information Network (GLIN), 2003). Key sources of these emissions include gasoline powered vehicles, coal-fired generation of electricity and industrial combustion processes (OMOE, 2003).

A large area of Ontario, including Toronto Region, receives acid depositions exceeding the critical load or the concentration above which deleterious effects on human health may occur (City of Toronto, 2000). However, it is unknown at this time what impact acid rain has had on terrestrial and aquatic systems In the GTA. Low pH (acidic conditions) has been linked to reproduction and death of aquatic species and consequent changes in quality and quantity of food for aquatic birds (GLIN, 2003).

With global habitat reduction, some of the natural sources of air pollutants are diminishing, but so are the air quality benefits that natural areas provide. Plants absorb carbon dioxide and release the oxygen that most organisms need to breathe. Forests, in particular, store large quantities of carbon and also sequester it, making them a "carbon sink". They trap and absorb significant amounts of pollutants, as well (Kenney and Associates, 2001). These improvements to air quality may help to counteract the effects of climate change, which results from high concentrations of greenhouse gases in the atmosphere.

Land clearing for rural and urban activities causes a corresponding reduction in the air quality benefits that the natural areas provide. It also results in higher air temperatures. Forests lower air temperature through shading and transpiration. Trees absorb great amounts of water and their leaf surfaces provide large surface areas from which water can evaporate. As a natural cooling process, the evaporation leaves a forest relatively cool. Trees return roughly three-quarters of the water they absorb to the atmosphere through evapotranspiration (Kenney and Associates, 2001). Increased temperatures play a role in accelerating the formation of ground level ozone (OMA, 2001).

2.3 The Built Environment

Artificial surfaces such as asphalt, concrete, roof tops and other manufactured materials, absorb much of the sun's energy and store it, remaining hot long after sunset. In a city where artificial surfaces are highly concentrated, this phenomenon produces a dome of elevated temperatures compared to the air over adjacent rural areas. The higher ambient temperatures of this "heat island" speed up the chemical reactions that produce smog (City of Toronto, 2000). The lower levels of evaporation in city environments are another contributing factor to the heat island effect. Urban surfaces do not hold water like natural ones do. When it rains, most water is collected and diverted into sewers, leaving the city dry and without an important cooling tool. The urban heat island effect is even further exacerbated by the added heat generated in running air conditioners and machinery, and from vehicle exhaust. The increased use of energy for cooling is not only more expensive, but also increases the pollution coming from power plants.

Poor air quality impacts the composition of artificial features in rural and urban landscapes. For example, acid deposition accelerates corrosion, fracturing, and discoloration of buildings, structures, and monuments (Environment Canada, 2001). Restoration of such features is only one of the many costs associated with air pollution in the rural and urban landscape. Lost productivity due to health concerns, increased hospital admissions and crop losses all have economic ramifications.

2.4 Climate Change

Since the industrial revolution, significantly greater volumes and concentrations of carbon dioxide, methane, nitrous oxide, sulphur dioxide and chlorofluorocarbons (CFCs) have entered the Earth's atmosphere. These gases not only impact air quality, but also they trap outgoing radiation and raise the temperature of the Earth's lower atmosphere by creating a "greenhouse effect", resulting in changes to the Earth's climate. In fact, there is some evidence to suggest that climate change is already occurring, resulting in shorter winters, warmer annual average temperatures, shorter lake ice cover, and more frequent heavy rainstorms in the Great Lakes basin (Kling *et al.*, 2003).

Climate change has the potential to cause significant changes to the hydrological cycle in the Rouge River watershed, with associated impacts on land and water resources and human communities. Climate change studies for the Great Lakes region predict changes in the mean and seasonal distribution of precipitation and streamflows, and changes in the frequency and intensity of extreme weather events (e.g., droughts, floods, ice storms, heat waves) (Duncan *et al.*, 2001; Kling *et al.*, 2003).

Climate change may also intensify air pollution. Higher air temperatures combined with air pollutants may increase the concentration of ground-level ozone, thereby reducing air quality and exacerbating human respiratory, cardiovascular disorders and allergy problems (Intergovernmental Panel on Climate Change, 1996).

3.0 MEASURING AIR QUALITY

Ontario's air quality is monitored at a network of monitoring stations operated by the Ontario Ministry of the Environment. Of the 37 continuous monitoring sites across Ontario, there is only one site located within the Humber River watershed boundaries. The York site (No. 36030) is located at Clearview Heights and Keele Street. Other nearby stations include Toronto North (No. 34020), Etobicoke South (No.35033) and Etobicoke West (No. 35003). Collectively, these four monitoring stations will be referred to as the "Humber Watershed and area monitoring stations" in this report.

The Air Quality Index (AQI) measures hourly ambient concentrations of six key contaminants known to have adverse effects on human health and the environment: sulphur dioxide (SO2), ozone (O3), nitrogen dioxide (NO2), total reduced sulphur (TRS) compounds, carbon monoxide (CO) and suspended particles (SP) (OMOE, 2003). AQI values are divided into five levels of severity. Each level has an associated effect on human and ecological health. At the time that the air quality index was established, values of 0 - 31 were believed to have few or no known health effects. An AQI of 32 - 49 can damage vegetation and cause respiratory irritation in sensitive people when active. An AQI of 50 - 99 can cause decreased visibility, irritation for people with sensitive respiratory systems at rest, and damage to some plants. AQI values above 200 may cause severe odour, serious respiratory effects and disorientation, and extensive damage to vegetation. The Ontario Medical Association (2001) has supported the Toronto Public Health's call for a revised air quality index with recognition that all levels of air pollution are harmful. Section 1.3 presents AQI values for the Humber River watershed.

A complete analysis of air quality should include an examination of the potential benefits of vegetation. Improvements in air quality due to vegetation can be estimated based on scientific studies of the uptake and release of chemicals by plants. Recent research has produced statistics for the forests within the City of Toronto (Kenney and Associates, 2001). Toronto's estimated 7.5 million trees store about 900,000 tonnes of carbon and sequester a net 28,000 tonnes of carbon each year. Through this research, it was also found that the treed areas of Toronto absorb:

- 614 tonnes of ozone per year,
- 117 tonnes of sulphur dioxide per year,
- 306 tonnes of nitrogen oxide per year, and
- 452 tonnes of particulate matter (of less than 10 microns) per year.

3.1 Federal and Provincial Criteria

The Ministry of the Environment maintains a listing of more than 300 ambient air quality criteria (AAQC) and the corresponding point of impingement (POI) limits (Table 4). AAQC are used for assessing general air quality and the potential for causing an adverse effect. POI limits are used primarily to review applications for certificates of approval for emissions to air and to assess compliance with Ontario Regulation 346 (General - Air Pollution).

Many of Ontario's air standards were established more than 20 years ago. Since that time, the science of risk assessment has advanced significantly. Accordingly, in both this version of the standards-setting plan, Setting Environmental Quality Standards in Ontario, and the previous version, the ministry has placed particular emphasis on reviewing and updating existing air quality standards to ensure that they are current and provide for adequate protection of human and ecosystem health. Additionally, processes have been developed to identify new substances for which formal standards should be developed.

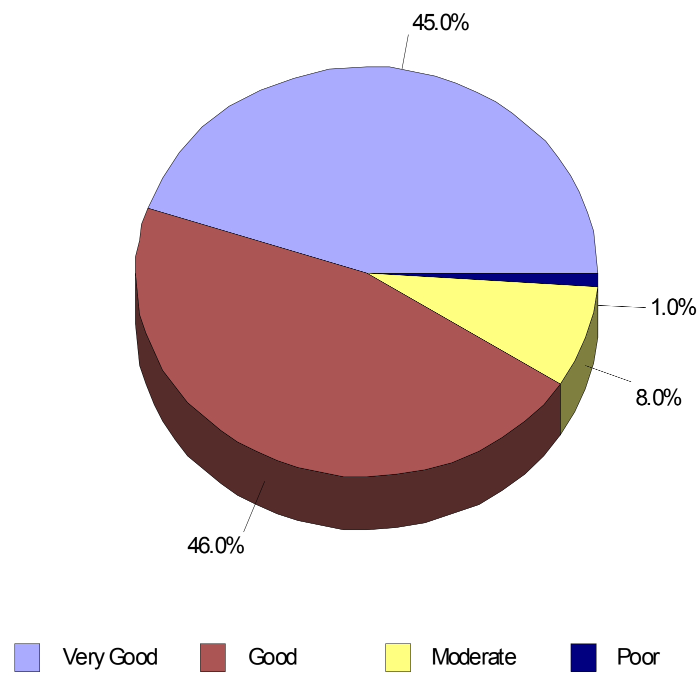
Table 4: Ambient Air Quality Criteria (AAQC) for Air Quality Index (AQI) Pollutants.

Pollutant	1-hour AAQC	24-hour AAQC
Ozone	80 ppb	n/a
Nitrogen Dioxide (NO_2)	200 ppb	100 ppb
Carbon Monoxide (CO)	30 ppm	n/a
Sulphur Dioxide (SO_2)	250 ppb	100 ppb
Respirable Particles ($PM_{2.5}$)	n/a	30 ug/m^3

4.0 CURRENT CONDITIONS IN THE HUMBER RIVER WATERSHED

According to the AQI scores for the Toronto North and Etobicoke South monitoring sites, the Humber watershed has “Good” air quality conditions most of the time, as illustrated by Figure 1. In 2001, scores of “Good” to “Very Good” (AQI values of 0-31) were recorded 93% of the time. Air quality was in the “Poor” range only 1 per cent of the time (an average of 13 days was recorded at these sites when AQI levels were in exceedance of 49 for 1 hour or more). In each case, ozone was the pollutant responsible for the exceedance. The following sections report on levels of the key contributing pollutants to the AQI: sulphur dioxide, ozone, nitrogen dioxide, total reduced sulphur compounds, carbon monoxide (CO) and suspended particles (SP). Not all the Humber area stations are used in the assessment of each pollutant. Insufficient sampling periodically occurs at some stations.

Figure 1: 2001 AQI Scores for Humber Watershed and Area Monitoring Stations.



4.1 Ground Level Ozone (O_3)

Nature and Source of the Pollutant

Ozone is a colourless, nearly odourless, toxic gas. In the upper atmosphere (stratosphere), ozone protects us from the sun's damaging ultraviolet light, but at ground-level, ozone is unhealthy. Ground-level ozone is formed by a reaction between oxygen, volatile organic compounds (VOCs) and oxides of nitrogen (NOx) when they are exposed to ultraviolet light (sunlight). Nitrogen oxides and volatile organic compounds are emitted from a variety of sources, including internal combustion processes (e.g., vehicle use, power generation), consumer and commercial products, and many industrial processes.

Health and Environmental Effects

Short term (1 to 3 hours) and prolonged (6 to 8 hours) exposure to ambient ozone has been linked to a number of health effects. Ground-level ozone can inflame breathing passages, decreasing the working capacity of the lungs. Symptoms can include shortness of breath, pain when inhaling deeply, wheezing and coughing (Toronto Public Health, 2004). Ozone also affects vegetation and ecosystems, leading to reductions in agricultural and commercial forest yields, and reduced growth and survivability of tree seedlings. Ground-level ozone can decrease the aesthetic value of ornamental species, as well as the beauty of our parks and recreation areas.

Trends in Ozone Levels

The Ambient Air Quality Criteria (AAQC) for ozone is 80 parts per billion, averaged over a one hour period. This standard represents the average ozone concentration at which exposure for a one hour period is believed to have no significant impact on human health. Exceedances of the standard result in a smog warning being issued by the local public health authority. Figure 3 illustrates average annual ozone levels recorded at Humber area monitoring stations. The average annual levels appear to exhibit a slight, yet steady increasing trend. However, the significance of this apparent trend remains questionable, especially when the influence of air temperature is taken into account. As demonstrated in Figure 2, a strong correlation seems to exist between high air temperatures and the number of ozone exceedances observed, making it difficult to predict future trends. Hot sunny weather accelerates the chemical reactions that form ground-level ozone. The high number of days when ozone concentrations exceeded the AAQC standard in 2002 can be attributed to the especially hot summer weather that occurred that year. When compared to 2002, the summer of 2000 was much cooler and fewer ozone exceedance days were observed.

Figure 2: Trend of Ozone Exceedance Days VS. "Hot Days" in the Humber River Watershed (1990 - 2002).

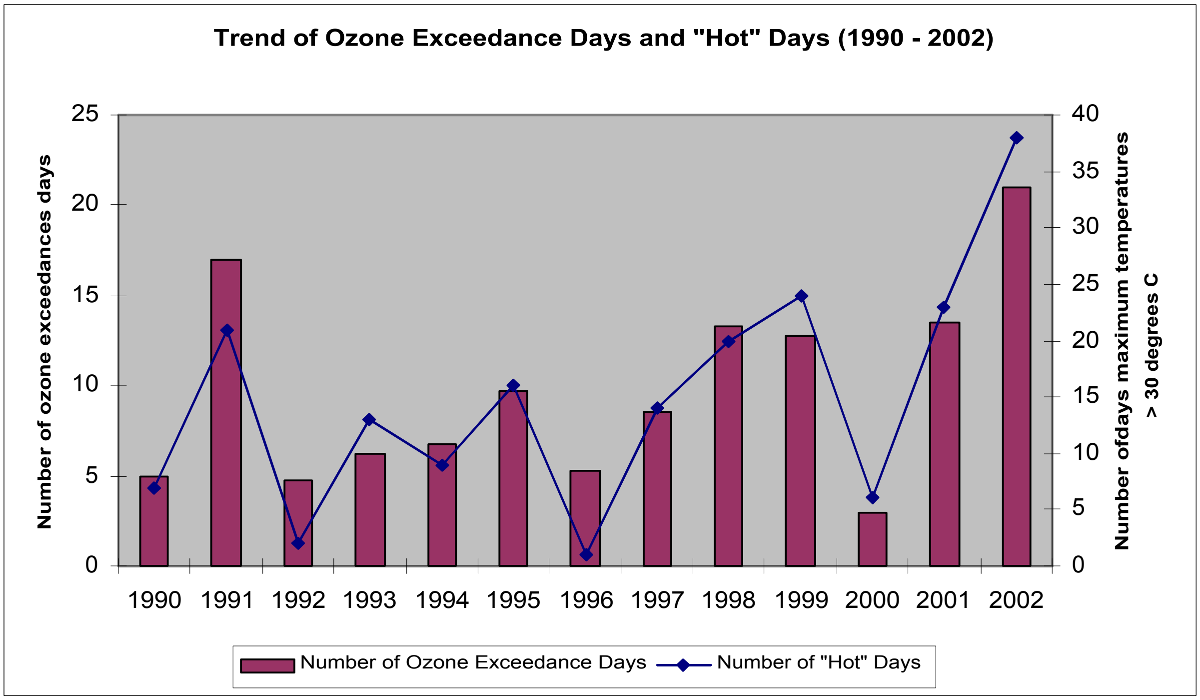
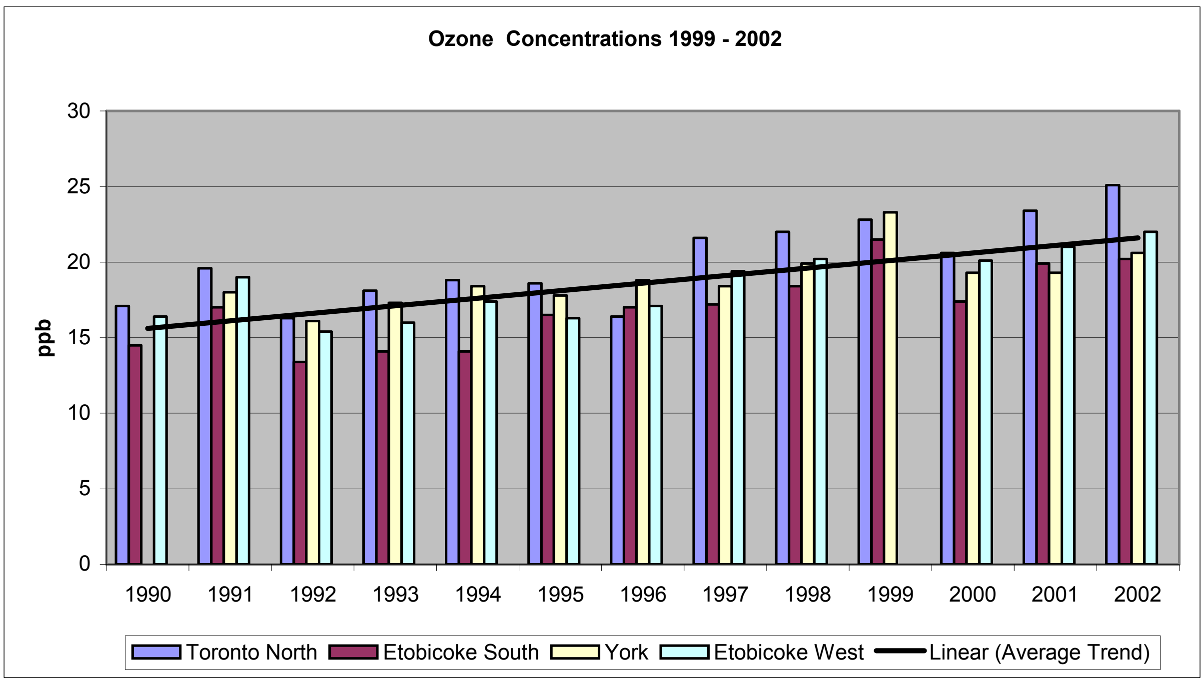


Figure 3: Average Annual Ozone Concentrations at Humber Watershed and Area Monitoring Stations.



4.2 Particulate Matter (PM)

Nature and Source of the Pollutant

Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air. There are two standards for particulate matter. PM_{10} refers to particles with a diameter of ten microns or less. PM_{10} is also referred to as coarse particulates as it is composed largely of primary particles emitted from industrial sources and motor vehicle exhaust, which come from a variety of stationary, mobile, and natural sources. $PM_{2.5}$ refers to particles with a diameter of 2.5 microns or less. $PM_{2.5}$ is also referred to as fine particulates, composed mostly of secondary particles originating from chemical reactions in the atmosphere and through combustion.

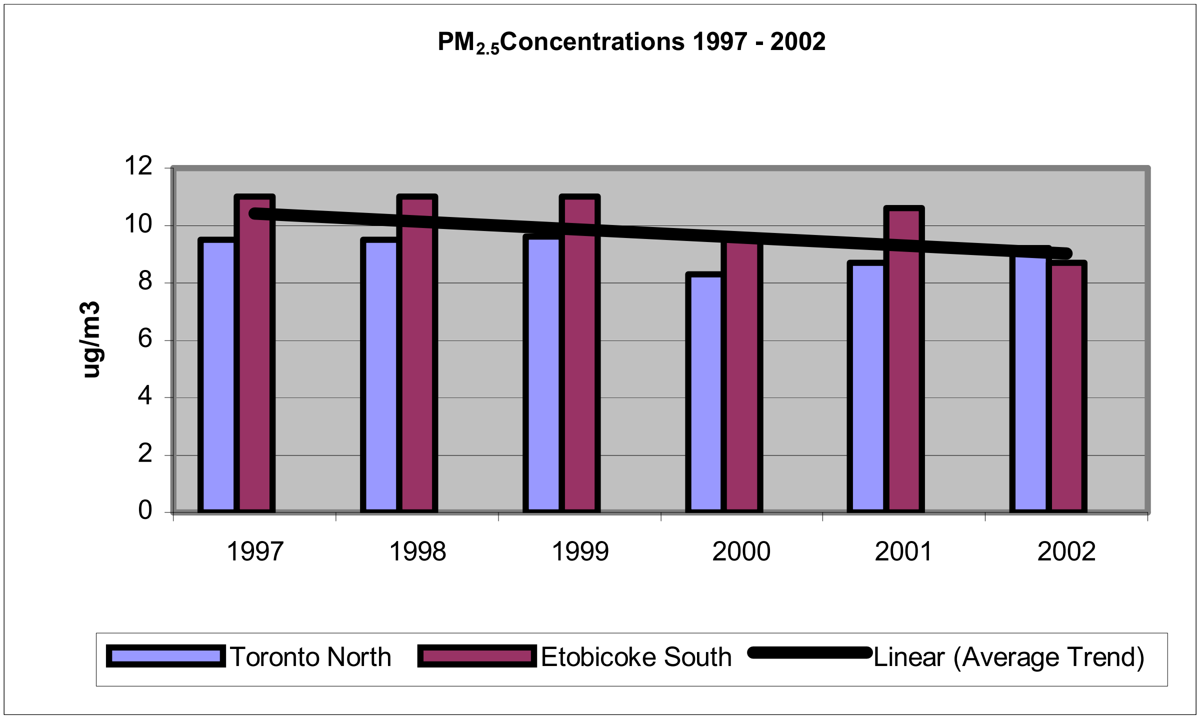
Health and Environmental Effects

The effects of particulates on health are directly related to their size and chemical composition. Once emitted, suspended particulates can reduce visibility, produce soiling when settled, damage vegetation, and increase corrosion. Particulates can penetrate lungs and contribute to respiratory disease.

Trends in $PM_{2.5}$ Levels

Figure 4 shows the distribution of 24-hour $PM_{2.5}$ annual geometric means from 1997 to 2002 in the Humber watershed. $PM_{2.5}$ is monitored at only two of the Humber area monitoring stations. Collection of this information began in 1997. No statistically significant trend has been observed in $PM_{2.5}$ levels during the period from 1997 to 2002. $PM_{2.5}$ levels occasionally exceeded the provincial interim 24-hour criteria of 50 ug/L (a concentration limit for the protection of human health).

Figure 4: $PM_{2.5}$ Concentrations at Humber Watershed and Area Monitoring Stations.



4.3 Nitrogen Dioxide (NO_2)

<u>Nature and Sources of Pollutant</u>

Nitrogen dioxide (NO_2) is a reddish-brown, highly reactive gas that is formed through the oxidation of nitric oxide (NO). Nitrogen oxides (NOx) is the term used to describe the sum of NO, $NO_{2,}$ and other oxides of nitrogen. They play a major role in the formation of ground-level ozone, particulate matter, haze and acid rain. The major anthropogenic sources of NOx emissions in the Humber River watershed area are from motor vehicle exhaust and coal-fired power generating plants (i.e., high temperature combustion processes).

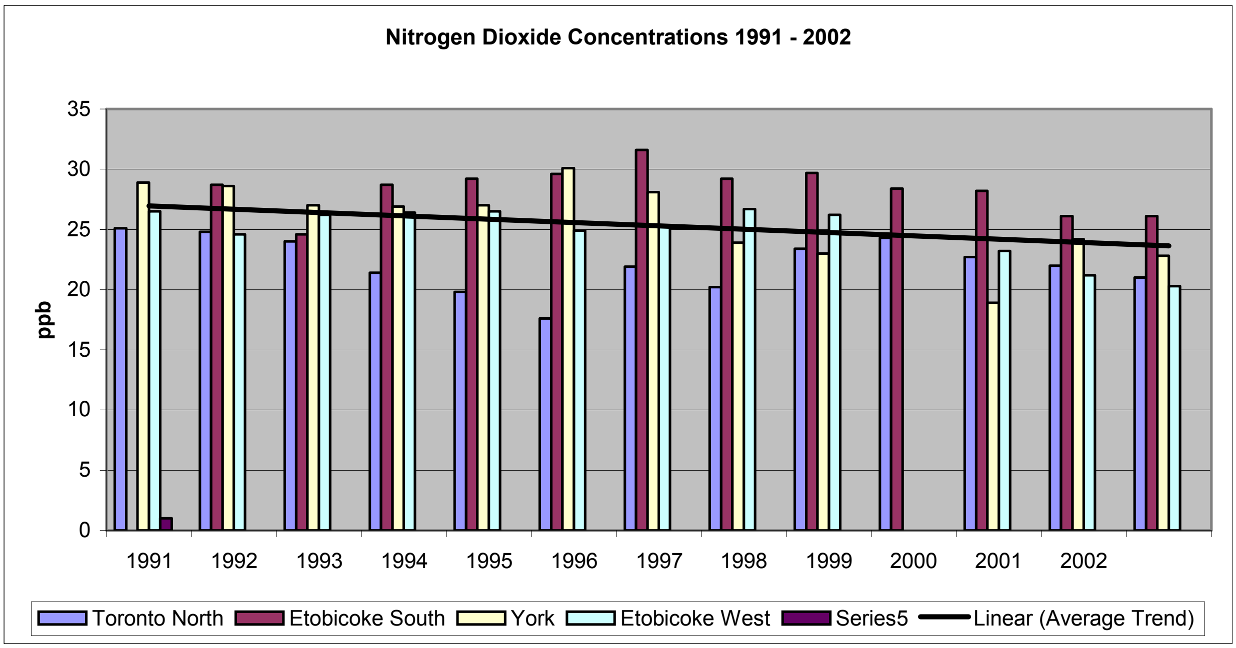
<u>Health and Environmental Effects</u>

Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infection. Its derivatives can damage trees and crops, contribute to the acidification of lakes and streams, and cause deterioration and fading of certain fabrics and corrosion of statues and monuments. By itself, the effects of NO_2 are more of a chronic concern. However, the short term mixing of NO_2 with VOCs can lead to the formation of ground-level ozone.

Trends in NO_2 Levels

Average concentrations are highest in urban centers such as the Greater Toronto Area which includes the monitoring stations discussed in this report. Average NO_2 concentrations have remained relatively constant over the 12 year period (1990 - 2002) (Figure 5). There were no incidences recorded of levels above Ontario's ambient air quality criteria (1 hr- 200ppb, 24 hr - 100 ppb)

Figure 5: Nitrogen Dioxide Concentrations at Humber Watershed and Area Monitoring Stations.



4.4 Carbon Monoxide (CO)

Nature and Sources of the Pollutant

Carbon monoxide (CO) is a colourless and odourless gas which is formed by incomplete burning of fossil fuels. High concentrations of CO are typically associated with larger cities where high energy use occurs. Other sources of CO emissions include industrial processes, non-transportation fuel combustion and natural sources, such as wildfires. Peak CO emissions occur during the colder months, when CO emissions are trapped near the ground beneath a layer of warm air.

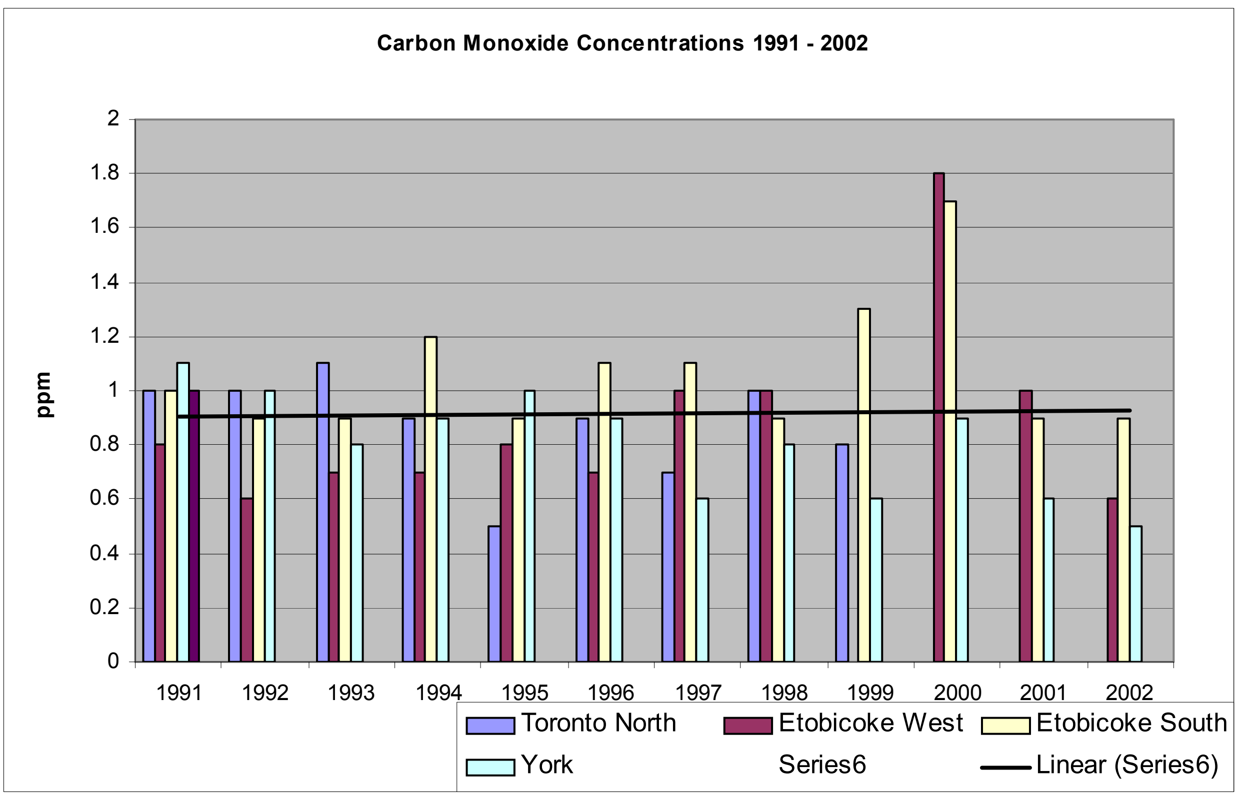
Health and Environmental Effects

The toxic effects of high concentrations of CO on the body are well known. CO is absorbed by the lungs and reacts with hemoglobin to form carboxyhemoglobin. This reaction reduces the oxygen carrying capacity of the blood. CO can also cause permanent damage to the nervous system. Carbon monoxide increases the amount of other greenhouse gases (e.g., methane), and eventually oxidizes into the greenhouse gas, carbon dioxide. Greenhouse gases are linked to global warming.

Trends in CO Levels

The highest average annual CO concentrations in Ontario are recorded in the urban centres of Toronto and Mississauga. However, during the period of 1991 to 2002 at Humber area monitoring stations, no incidences were recorded of CO concentrations above the one hour Ambient Air Quality Criteria standard of 30 ppm (Figure 6).

Figure 6: Carbon Monoxide Concentrations at Humber Watershed and Area Monitoring Stations.



4.5 Sulphur Dioxide (SO2)

Nature and Sources of Pollutant

Sulphur dioxide (SO_2) is a gas formed from fossil fuel combustion, industrial processes such as wood pulping, paper manufacture, petroleum and metal refining and metal smelting, particularly from sulfide containing ores (e.g. lead, silver and zinc ores). Sulphur dioxide is also produced from the natural decay of vegetation on land and in wetlands. Emissions from high temperature combustion processes, largely from coal-fired power generating plants, accounts for majority of SO_2 emissions occurring in the Humber watershed area.

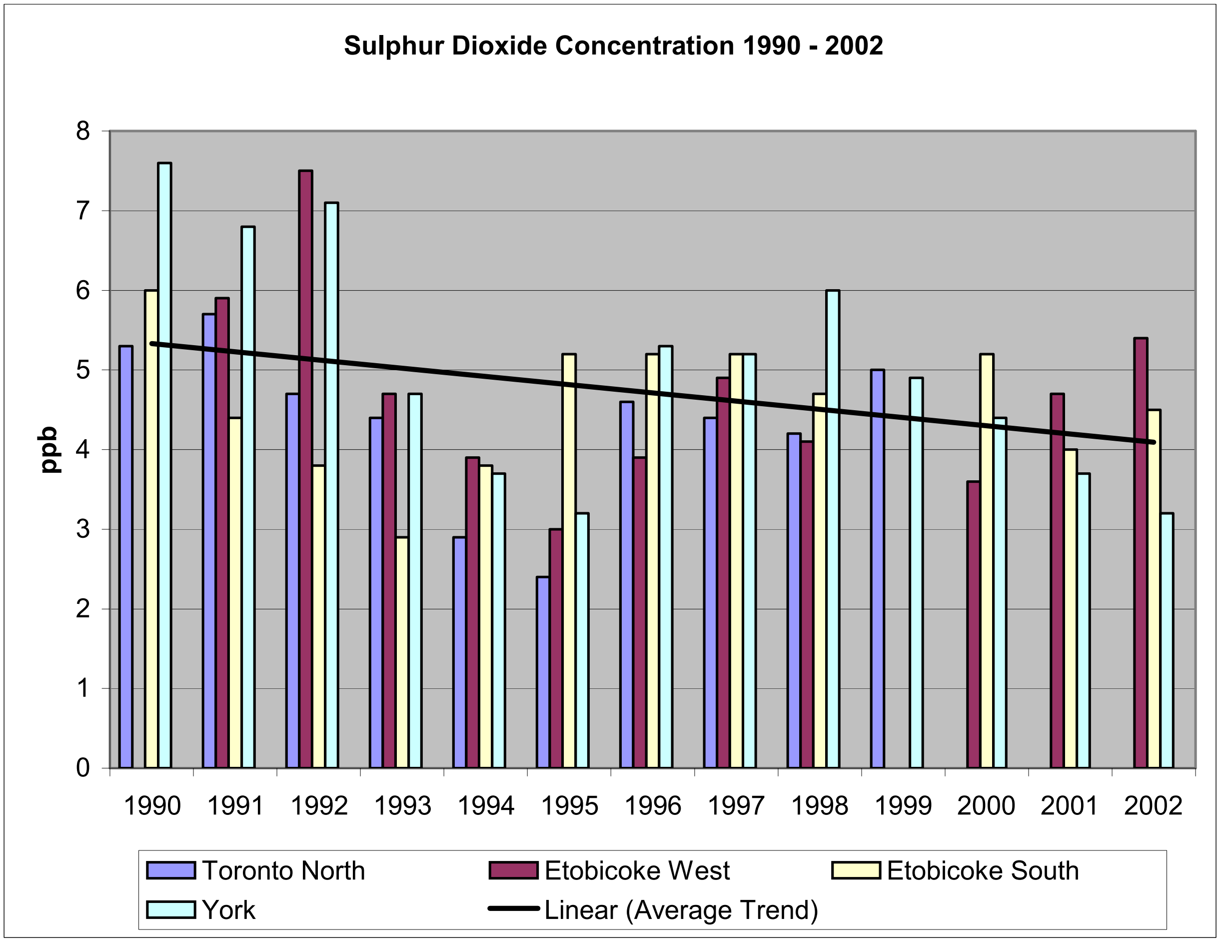
Health and Environmental Effects

Repeated or prolonged exposure to moderate concentrations of Sulphur dioxide may cause inflammation of the respiratory tract, wheezing and lung damage. It has also been observed to harm the reproductive systems of laboratory animals and cause developmental changes in their newborn. Even low concentrations of sulfur dioxide can harm plants and trees and reduce crop productivity. Acid deposition (i.e., acid rain) occurs when sulphur dioxide combines with water vapor and gets deposited through precipitation. Acid deposition is known to have many adverse affects on both aquatic and terrestrial ecosystem health.

Trends in Sulphur Dioxide Levels

Sulphur dioxide levels have remained fairly constant over the 12 year period (1990-2002). There were no incidences recorded within this period of levels above Ontario's ambient air quality criteria of 20 ppb. Ontario Regulations 346 and 350 regulate emissions from smelting operations. The Countdown Acid Rain program resulted in significant decreases of SO2 emissions in the early 1990s (see Figure 7).

Figure 7: Sulphur Dioxide Concentrations at Humber Watershed and Area Monitoring Stations.



4.6 Air Toxics

Naturally Occurring and Human-Made Sources

Air toxics, otherwise known as hazardous air pollutants, are air pollutants that are known or suspected to cause serious health effects. Air toxics can exist as particulate matter or as a gas. Some examples are arsenic, asbestos, benzenem vimyl chloride, mercury, chromium, toluene and beryllium. Most air toxics originate from man-made sources, including mobile sources (emissions from vehicle exhaust), stationary sources (emissions from factories, refineries, power plants), as well as indoor sources (some building materials, pesticides and cleaning solvents). Some air toxics are released from natural sources such as forest fires.

Health and Environmental Effects

Depending on which air toxic a person is exposed to, health effects can include damage to the immune system, as well as neurological, reproductive, developmental, and respiratory problems. Toxic air pollutants deposited on soils or surface waters can have a wide range of environmental impacts. Numerous studies have observed that deposited air toxics contribute to birth defects, reproductive failure, and disease in laboratory animals. Toxic pollutants that accumulate in the environment can lead to harmful affects on plant and animal health and on person consuming these plants and animals (e.g., mercury levels in fish).

4.7 Watershed Report Card Rating

Based on Humber River watershed strategy objective to “reduce air pollution to levels that protect human health, natural ecosystems and crops, and does not exacerbate global climate change”, the following set of indicators, measures and targets have been established to evaluate progress towards achieving the objective and to assign watershed report card ratings. The following summarizes the results of the most recent evaluation and includes an updated watershed report card overall rating.

Objective: Reduce air pollution to levels that protect human health, natural ecosystems and crops, and does not exacerbate global climate change		**Overall Rating** **D**
Indicator	**Measures**	**Targets**
Air Chemistry	Air Quality Index (AQI) Number of exceedances of Ambient Air Quality Criteria (AAQC) for the following pollutants: - ground-level ozone (ppb); - particulate matter (ug/m^3); - sulphur dioxide (ppb); - carbon monoxide (ppb); and, - nitrogen dioxide (ppb)	Air Quality Index of “Very Good” (AQI does not exceed 15) No smog advisories are issued
Air Toxics	National Pollutant Release Inventory	TBD
Lichen	Index of Atmospheric Purity (IAP)	TBD

The overall rating of “D” is based on available air chemistry information from 2001. Currently, there is a lack of adequate lichen survey data to develop Index of Atmospheric Purity values for the Humber River watershed and the National Pollutant Release Inventory data is still being processed.

The overall rating represents the average of a failing grade for the Air Quality Index (AQI) target, having only achieved a “very good” AQI 45% of the time in 2001, and a fair grade for the number of exceedances target, having no exceedances for only three of five pollutant criteria (60%). The average of the two grades (45% and 60%) is 52%, which translates to an overall rating of “D”, indicating that very little, or “poor” progress has been made towards achieving this objective.

5.0 SUMMARY AND MANAGEMENT CONSIDERATIONS

Emissions of airborne contaminants from motor vehicle use are anticipated to continue to rise. The number of personal vehicles on the road has increased rapidly in recent years. In 1998, the Ministry of Transportation reported 2,121,328 registered vehicles in the regions of Peel, York and the City of Toronto. As of 2004, this number has increased by 31% to 2,768,636 registered vehicles. Population in the City of Toronto, Region of Peel and Region of York is anticipated to grow by approximately 1.8 million people by 2031 (Hemson Consulting Ltd., 2005). The growth of urban settlements in the Humber watershed will occur primarily in the City of Brampton, City of Vaughan and Town of Caledon. Unless this urban growth is accompanied by major investments to improve and expand public transit systems, this will result in a greater reliance on the automobile as the primary means of transportation. Average trip lengths in the Greater Toronto Area (GTA) will likely continue to rise as residents relocate to suburban areas. For example, in comparison to the average Ontario resident, residents of York Region commute longer distances to work, drive their cars to work more often, and use public transit or other modes of transportation less often (Region of York, 2000).

As the Province of Ontario has pledged to close all coal-fired power generating plants by 2007, emissions of airborne contaminants from the energy sector are anticipated to decrease in the next few years. The Lakeview power generating plant in Mississauga, which opened in 1962, has been a target of criticism because prevailing winds from the west push its nitrogen oxides and sulphur dioxide emissions across Mississauga, Toronto and communities to the east. The plant was shut down in 2005.

Clean air is important to human health, environmental health and economic health. Poor air quality will adversely affect the overall health of the Humber River watershed. In the past, clean air was believed to be a limitless resource. As the effects of a changing climate are beginning to be observed with the melting of the polar ice caps, and as smog advisories in the Greater Toronto Area become more frequent, we now know that it is not so. Consideration needs to be given to the impacts that our daily activities have on air quality and climate. Clean air needs to be thought of and managed as a renewable resource, much like clean water and fertile soils are today. Air quality and climate change must become important considerations in land use planning and decision-making processes in order to improve the sustainability of the communities we are building.

Air quality at Humber area monitoring stations exceeded Ambient Air Quality Criteria (AAQC) standards for ground-level ozone on a number of occasions in 2002, particularly in the warm summer months. AAQC standards for particulates were also occasionally exceeded. The major sources of airborne contaminants that lead to ozone and particulate exceedances are emissions from internal combustion processes (e.g., motor vehicle use, power generation) and industrial and manufacturing processes.

In the Humber River watershed, great progress towards improving air quality and reducing air pollution could be made by increasing sustainable public transportation opportunities within and between the City of Toronto, Region of Peel and Region of York. Other actions that would help to achieve this objective include setting standards for cleaner burning fuels and more fuel efficient automobiles, improving the energy efficiency of buildings, conserving energy in the home and workplace, and restoring natural cover (trees in particular) to rural and urban landscapes.

To be effective, air quality monitoring networks and studies must extend over a wide area and be capable of correlating observed conditions or effects with trends in known stressors. While detailed studies have been completed on specific aspects of air quality problems affecting the Greater Toronto Area (e.g. air quality conditions, health impacts, trends in energy use), there have been no studies of how multiple aspects or components are linked and what implications the linkages have with respect to overall management of air quality. A regional-scale assessment that summarizes and interprets air quality data collected in the Greater Toronto Area within the context of energy use trends would contribute to all TRCA watershed management plans/strategies and would also serve as a reference document for the various monitoring and reporting initiatives (e.g. watershed report cards, state of the environment reports, etc.).

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