Air Quality and Climate Change
Management Plan

Plan de gestion de la qualité de l'air et les
changements climatiques

AIR QUALITY & CLIMATE CHANGE MANAGEMENT PLAN

PLAN DE GESTION DE LA QUALITÉ DE L'AIR ET LES CHANGEMENTS CLIMATIQUES

For the City of Ottawa

Air & Energy Initiatives
Environmental Management Division
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Executive Summary

This Air Quality and Climate Change Management Plan is a supporting document to the Environmental Strategy that was approved by City Council in October 2003. This Plan provides a context for climate change and air quality issues within the City, proposes both a Corporate and Community target for greenhouse gas emission reduction and outlines the measures the City should undertake to reach this target. The proposed City target maintains the commitments of former municipalities for a 20% reduction in greenhouse gas (GHG) emissions, relative to 1990 levels. Achievement of this target is proposed by 2007 for Corporate business activities and by 2012 for Community emissions. The community emissions are the greatest challenge, mainly because of both our increased population and increased per capita energy consumption since 1990. For example, between 1990 and 1998, our community emissions increased by 43%, for a total of 9 million tonnes of equivalent carbon dioxide (eCO_2). This reality requires a comprehensive set of measures, from land use planning to reduced consumption to re-use of resources. So far, the City has been leading the way. During this same period, City operations have reduced their emissions by 12%. Implementation of the measures within this Plan will see us continue on this successful track of doing our part.

Air pollution is closely linked with the burning of fossil fuels which cause the accumulation of greenhouse gases. Our fossil fuel use is also responsible for 82% of carbon monoxide (CO) emissions, 57% of sulphur dioxide (SO_2) emissions, 90% of nitric oxides (NO_x) emissions, and 62% of volatile organic compound (VOC) emissions. These emissions can have a considerable impact on human health. Reduced lung capacity in children, asthma for residents of all ages, cardiovascular diseases (heart attacks and strokes), cancer, immunodeficiency and low birth weights are among the consequences of air pollution. The most vulnerable populations are children, the elderly, and those with underlying illnesses. The Ontario Medical Association estimates that air pollution in Ottawa causes hundreds of premature deaths, thousands of hospital admissions and millions of dollars in health costs.

The impact of climate change is also of concern. A temperature change has already been observed in Ottawa with a departure from the normal temperature by $+1^{o}C$ (30-year average), an increase that is twice the global change for the same period ($0.5^{o}C$). Modelled climate variability that is expected in Ottawa suggests more frequent freezing rain events, increased amounts of precipitation and an increase in the number of heat waves. These climatic variations will in turn cause ecosystem shifts such as habitat loss, habitat fragmentation, invasion and threats from non-native species, as well as species extinction. This Plan focuses on mitigation of climate change with some recommendations for adaptive measures, however, adaptation will be addressed more comprehensively as one of this Plan's workplan items.

The measures proposed in this plan to reduce GHG's and our community's contribution to climate change will also reduce our emission of other air contaminants. Within our air, the emission of particulates and gases, such as carbon dioxide, nitrogen oxides and methane, trap long wave energy that is reflected and radiated from the earth. This trapped heat energy increases our atmospheric temperature and serves as a catalyst for chemical reactions amongst the gases, such as the formation of ground level ozone (O_3). Through a loop of human activities and natural processes our energy use impacts our air quality and stimulates climate change that affects both ecosystem and human health. This Plan identifies the health effects of various air contaminants, notes their main sources within Ottawa and proposes measures for reduced air emissions and GHG's.

In Ottawa, transportation and the energy use of building each account for 40% of our community's greenhouse gases. The remaining 20% is generated from the waste sector.

The transportation sector is also responsible for other air contaminant emissions, including over 85% of total NO_x emissions, 90% of CO, 60% of SO_2, and smaller amounts of various carcinogenic substances. Within areas with unpaved roads, up to 60% of particulate matter less than 10 microns (PM_{10}) and 46% of particulate matter less than 2.5 microns ($PM_{2.5}$) can be generated by wind erosion and road travel. In the winter, emissions from year-round fuel consumption activities, such as transportation, combined with on-site fuel consumption for heating (oil, natural gas and wood) and increased vehicle idling can result in poor air quality events when regional air masses stagnate. The main pollutant in this situation is fine particulate matter. Within winter, residential fuelwood combustion contributes approximately 19% of $PM_{2.5}$ within Ontario.

When poor air quality or smog events occur in either summer or winter, there can be serious consequences to our health. Sulphur dioxide decreases pulmonary capacity. Nitrogen oxides are lung irritants and are associated with heart disease. Carbon monoxide is responsible for congestive heart failure and respiratory infections in children and the elderly. Unlike other air pollutants, no safe level exists for particulate matter (PM). Health effects include respiratory infections, cardiovascular diseases, and cancer. Increased levels of ground level ozone that occur during smog events can impact both animal and plant health through such effects as decreasing lung and immune function, causing asthma as well as lowering agricultural productivity and tree health.

Other sources of air pollution include residential cooling, organic matter decomposition, industrial sources (emit 150% more total particulate matter than transportation), waste disposal (responsible for 1200 tonnes of GHG), agricultural processes and road dust. Other air emission contaminants that also impact upon ecosystem and human health include pollen and mould, odours, noise and light. The impacts of all of these on health range from annoyance to serious respiratory and nerve and immunological disorders.

Strategic Directions

This plan proposes a suite of strategic actions to reduce air emissions of concern. Energy and emission reductions from community and City activities will be achieved through programs ranging from land use planning, transportation demand management to use of alternate energy sources. Particular emphasis is placed on reducing GHGs because of their link to air quality.

In 2002, Canada ratified its commitment to greenhouse gas reductions that would meet the Kyoto Accord requirement of 6% below 1990 levels, to be achieved by 2012. The former City of Ottawa and Regional Municipality of Ottawa-Carleton committed to a reduction of 20% below 1990 levels, by 2005 and 2007, respectively. This Plan maintains these former reduction commitments of 20% but extends the deadline to 2012. This will allow for sufficient time to implement measures that can address our increased population and per capita energy use, where the 20% reduction, relative to 1990 levels, now represents 63% of the 1990 GHG emission level. This challenge will require an updated inventory and an aggressive plan that builds on the following existing initiatives:

- Transportation Master Plan;
- Draft Transportation Demand Management Strategy;
- Draft Integrated Waste Management Master Plan;
- Smog and Heat Action Plan;
- Fleet Emissions Reduction Strategy; and
- Water Efficiency Strategy.

To meet the goal of a 20% GHG reduction along with the expected improvement in air quality, four categories of activities are proposed:

1. Public outreach and involvement to ensure that City activities involve the community and that sound environmental choices are easily accessible to the community;
2. Monitoring of our progress in meeting GHG reduction commitments and air quality improvement, including the measurement of key air quality parameters;
3. Specified actions and initiatives to meet the targets; and
4. Identification and adoption of adaptive measures to ensure that, while efforts are being made to reduce emissions and mitigate impacts, the City is also able to adapt to impacts from global warming.

The recommended actions and initiatives include:

1. Promotion and facilitation of alternative energy and conservation programs such as district energy, landfill gas co-generation, water conservation, heat recovery systems, street lighting and employee energy efficiency programs;
2. Implementation of smog control measures that discourage such activities as the use of single occupancy vehicles and high energy- consumption vehicles and appliances, and that promotes walking, cycling and the use public transit, transportation demand management and use of alternative fuels and alternative fuel vehicles (hybrids, biodiesel, ethanol, etc);
3. Control of non-source emissions such as wood combustion and road dust;

4. Promotion of energy efficiency in the residential sector through Local Improvement Charges;
5. Promotion of Green Buildings and alignment of associated regulatory and design considerations. This will include development of an internal policy to achieve LEED status for municipal buildings, then extension and promotion of this standard to the community, in concert with other levels of government;
6. Creation of a Better Buildings Partnership to promote and provide financial incentives for industrial, commercial and institutional bodies to reduce their building energy use;
7. Implementation of sustainable land use planning and community greening by encouraging mixed use development, community energy planning, maintenance of forest cover and use of best management practices for natural areas, greenspaces and agricultural lands;
8. On-going review of municipal regulations and their role in creating a sustainable community, including advocacy for the incorporation of sustainability principles into the Ontario and the National Building Codes; and
9. Implementation of measures to control odours; noise; light pollution and pollen, as significant issues arise.

Many scientists agree that the climate is changing and that global warming will very likely have long term impacts. In Ontario, annual temperatures are predicted to increase between 2-5^{o}C by the latter part of the 21st century. Although this plan focuses mainly on mitigation strategies, there are a few adaptation measures proposed:

- Heat island controlling measures within the urban area, such as promotion of white, reflective pavement and roof surfaces, green roofs and enhanced use of green vegetative covers;
- Coordination of City response to smog and heat alerts; and
- Emergency preparedness.

Implementation of this plan falls within three main phases over the next 8-10 years. These phases align with well-known stages of planning, however, several activities within the phases will occur simultaneously. For example, many initiatives have been initiated at some point over the last 10 years with several activities from Phases I and II currently underway. The categories of work within this Plan include:

- Phase I planning and monitoring of priority actions (already underway);
- Phase II implementation of management strategy and refinement of plan (already underway); and
- Phase III evaluation of management measures.

1. The Air Quality and Climate Change Challenge

Introduction

This is the first comprehensive Air Quality and Climate Change Management Plan for the City of Ottawa. The premise for this plan is a need to improve our air quality and reduce our greenhouse gas (GHG) emissions, largely by reducing energy consumption and the use of non-renewable energy sources.

The reasons to act on this are compelling. The air we breathe, that flows through our bodies at a volume of 65 cubic metres per minute[1], is becoming increasingly dirty. Within Ottawa, in addition to our own emission of air pollutants, we are captive to the long-range transport of materials in a northwesterly direction along the Windsor to Quebec City corridor. And our dirty air is making us sicklier with increased incidence of chronic bronchitis, asthma and premature deaths. The Ontario Medical Association estimates that health costs to Ontario due to poor air quality are in the order of $1 billion per year. That is approximately $82 per person, and over $65 million for the City of Ottawa alone.

Regarding energy use, Canadians' emissions of greenhouse gases are amongst the highest in the world. This is due to the consumer choices that comprise our standard of living, commonly quantified through an indicator known as the ecological footprint. The average Canadian footprint is five times the equivalent of resources available on earth should every person in the world consume at our level. A 2004 report from the Federation of Canadian Municipalities documented the average ecological footprint in major cities as 7.25 hectares per person, ranging from 6.9 to 10.3. Ottawa's consumption habits tended towards the higher end with an average footprint of 8.9 hectares per person. The largest proportion of this land area needed to support each resident is for energy that meets our transportation and household needs and the energy use associated with the commercial and industrial services. Almost all of this energy use is in the form of fossil fuels, which contribute to the accumulation of GHG emissions in the atmosphere. In turn, these gases trap heat energy close to the earth's surface, a potential imbalance that is being observed to cause weather disruptions, ecosystem changes and global warming.

On a positive note, the City of Ottawa has made significant progress in reducing greenhouse gas emissions within its own corporate operations by such measures as improving fleet and building energy efficiency and by using process by-products. For example, the Robert O. Pickard Environmental Centre, our wastewater treatment plant, built a cogeneration facility to use methane produced from the digestion of solids settled from sewage to generate electricity. The electricity is used within the buildings at the wastewater treatment plant, cutting overall GHG emissions through both the use of methane and reduced demand on the Province's current coal-fired electricity sources and saving about $600,000 per year on their electricity bill. More corporate energy efficiency

[1] Heidorn, Keith C. 2004. Breathng the air. http://members.shaw.ca/keithheidorn/lgqarticles/breathing1.htm

plans are underway. These accomplishments were the result of commitments from the former municipalities of the City of Ottawa and Region of Ottawa-Carleton during the mid-1990's to reduce their GHG emissions by 20%, relative to 1990 emission levels.

The next good news item is that the City does not have to tackle this large effort on its own. Climate change awareness and momentum are lining up all levels of government. The federal government is dedicating a broad range of experts to focus on the development of tools, technology and knowledge, development of supporting policy and legislation and transfer of evolving knowledge. Financial support to implement changes in practice, behaviour and the marketplace is also forthcoming to those sectors that engage in greenhouse gas reduction efforts. The Province of Ontario is also taking a lead role by committing to the closure of their coal-fired electrical power plants and encouraging the development of more renewable energy electrical power generation.

The City of Ottawa as a community has an important role to play. Poor air quality and the level of GHGs within our atmosphere are the contributions from our actions and habits. A small reduction by each individual, business and organization in energy use and air emissions will contribute hugely to our overall quality of air. Hence, our quality of life will also improve.

Part of the momentum that will contribute the City's success in air quality improvement is the strong community commitment and awareness. Public consultation through various environmentally focussed surveys and public meetings, particularly during the development of the Ottawa 20/20 plans, often placed air quality as the top environmental concern. City response to this and more focused public input has led to a range of supporting policies in the City's Official Plan and Transportation Master Plan. Compact mixed development and a firm urban boundary will contribute to reduced travel needs. Delivery of a responsive transit system along with other measures to encourage ridership will also contribute to significantly lower per capita energy use. This plan completes the suite of existing and proposed measures that the City can employ to achieve a comprehensive approach to encouraging overall reduced energy consumption and emission of air pollutants.

This plan responds to the environmental goals and commitments for air quality and climate change from the City's Official Plan and Environmental Strategy. Council approved both of these strategic plans in 2003, as part of the City's overall Ottawa 20/20 Growth Management Strategy. Specifically, adoption of this plan and implementation of its measures contributes to all of the Environmental Strategy's commitments. They are to:

- manage our GHG emissions as a partner for climate change;
- manage our human, material and financial resources as efficiently and effectively as possible;
- incorporate environmental factors and costs into City decision-making on its policies, programs and initiatives;
- demonstrate and promote leadership in environmental management;

- take an ecosystem management approach to development and in the protection of the City's natural resource features; and
- measure, assess and report on the City's progress towards these commitments.

The Air Quality and Climate Change Management Plan details the issues and trends of air quality and climate change, proposes projects and activities to reduce air pollutants and GHG emissions, and outlines an implementation strategy to deliver on these actions. It also re-establishes the commitments of two of its former municipalities to reduce GHG emissions by 20%, relative to 1990, within the City as a Corporation and as a Community. The Plan's overall purpose is to improve our local air quality and realize a fair contribution from our community to mitigate global climate change. We want to be the cleanest and smartest city in Canada in tending to our air and in managing our energy use habits. Ultimately, this should be the City's reputation amongst all capital cities.

Overview

Air movement is influenced by terrain and atmospheric circulation patterns. Both the City of Ottawa and the City of Gatineau contribute pollutants to and are affected by the effects of a shared airshed[2]. Statistics Canada reports that the population growth in the National Capital Region is 6.9% (greater than the national average of 4%)[3]. Assuming a continuing upward growth in population and vehicle emissions, we are sure to see increasing levels of smog, comprised mainly of ground-level ozone and fine particulate matter[4].

Some air pollutants have global as well as local effects. The most notable of these emissions accumulate in the atmosphere and accelerate global climate change by trapping much of the heat energy radiated by the earth. This retained heat energy has created temperature and precipitation variations beyond normal recorded weather patterns.

The Intergovernmental Panel on Climate Change (IPCC) with over 1500 scientist worldwide concur that the greatest warming from GHGs will occur in the northern regions of the globe and in the winter. This impact is already noticeable in Ottawa where the normal temperature has increased by 1^oC (30-year average). This is twice the average global increase for the same period (0.5^oC). Climate variability expected in Ottawa may cause more frequent freezing rain events, excessive precipitation and an increase in the number of heat waves. The most notable global change observed so far is retreat of glaciers, of the polar ice cap in the arctic and increased severe weather events.

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[2] A geographical region with natural physical boundaries and which demonstrates common production and exchange of air pollutants. The Ottawa-Gatineau airshed is within the Windsor-Quebec Corridor, downwind from the industrialized Ohio Valley.
[3] These numbers were based on the last five years from 1999 – 2003.
[4] Particulate matter (PM) and ozone are the main components of smog but it also includes carbon monoxide and various oxides responsible for acid rain such as sulphur dioxide (SO_2), sulphates (SO_4), nitric oxide (NO), nitrogen dioxide (NO_2) and nitrates (NO_3).

The disruption to temperature and weather patterns from climate change will also result in human and environmental health effects. Impacts upon human health can include increased mortality and morbidity due to heat stress, severe weather events, vector-borne diseases, water and food-related diseases, and increased exposure to elevated levels of UV-radiation.

Climate change can be managed by both reducing human activities that contribute to retaining heat energy close to the earth's surface, referred to as mitigation and by planning our activities and built environments to withstand climate change effects, or adaptation. This plan focuses on mitigation, techniques that avoid, reduce or delay global warming by reducing those emissions of atmospheric gases that are of human origin or within human control. The main benefit of implementing mitigation measures is two-fold: reducing the effects of global warming and improving air quality. There are, however, many other co-benefits such as economic spin offs from both retrofits and new technologies; and reduced health costs. In general, having greener buildings improves indoor air quality, and having greater vegetation will contribute to our quality of life.

Adaptation measures, those adjustments humans would need to make in the face of inevitable, irreversible climate changes, are not addressed in this plan. These adjustments would be made primarily at the local level. For example, an increase in precipitation would lead to changes in snow removal as well as requiring sewer system adaptations. Even if all GHG emissions were ceased today, the climate would still keep on changing due to the already accumulated pollutants. Thus, adaptation will be a necessity. An adaptation to climate change plan will follow this plan in the near future.

Concrete mitigation measures to improve and/or maintain our air quality are needed. While climate change will exacerbate the frequency of smog episodes and associated health effects, air pollution is already a serious health concern in the Ottawa-Gatineau region and around the world. The local and global effects of mitigation measures will be beneficial to our City as well as the world. It is our responsibility as global citizens to our children, each other and future generations to reduce our emissions of GHGs and improve our air quality.

Outline

This Air Quality and Climate Change Management Plan reviews the concept of air quality, presents it in an Ottawa context, illustrates measurement techniques, describes Ottawa's former climate change plans, and reviews the City's GHG emissions over the past decade. The document provides a comprehensive overview of the toxic compounds that affect air quality (sulphur dioxide (SO_2), oxides of nitrogen (NOx), carbon monoxide (CO), volatile organic compounds (VOC), particulate matter smaller than 10 microns (PM_{10}), and ozone (O_3)) as well as those that affect climate change (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O)). It also explores the sources of emissions (transportation, heating and cooling, wood smoke, forestry, aquatic environments, industrial sources, waste disposal, and agriculture). The relationship between climate change and air quality and between the latter and health are explored. Links between climate change and health, as well as the impacts of climate change on the ecosystem are also included.

The connection between energy use, air quality, and climate change is examined. Additional air quality issues such as hazardous air pollutants particularly related to diesel fuel, pollen and mould, odours and noise are described in less detail. Lastly, the strategic direction is described, presenting targets necessary to improve air quality as well as slow down the rate of climate change, the potential obstacles that would be encountered and projects/activities necessary to meet the targets. Actions cover a wide range of initiatives from removing regulatory obstacles to 'green buildings' to pollution prevention initiatives. An implementation strategy completes the Plan, outlining a comprehensive approach to deliver on identified measures for air quality improvement and climate change mitigation.

2. The Ottawa Valley Airshed in Context

While physical factors influence the persistence and movement of air borne pollutants, the social and economic profile of the City influences their presence through emissions from various human activities. Within the Ottawa Region, current economic development is focussed in four areas: Public Administration (21%), High Technology (15%), Health Care and Social Services (10%) and Retail (10%). Ottawa is expected to experience significant population growth over the next two decades. Projections completed for the new Official Plan predict an increase in population from 817,000 (2002) to 1,192,000 (2021).

A notable feature of the local economic profile is a proportionate low manufacturing sector. Within Canada's economic profile, the manufacturing sector comprises 15% of the total. Within Ottawa it is 6%, with the majority of the City's manufacturing related to high technology. As a result, our local air quality and climate protection action plan will target transportation, energy and waste rather than industrial emissions.

Another major defining City feature that will advise our priorities for air quality and climate protection measures is our land use and population distribution. The City of Ottawa has a large rural area with a thriving agricultural sector and a more densely populated urban centre. Approximately 90% of the City's land area is rural supporting 10% of our population, with 90% of the population located on the remaining 10% of Ottawa's land area.

Meteorology as well as topography determines the air circulation in the Ottawa valley. A description of the meteorology and landscapes in the Ottawa valley will help understand the air circulation and 'hot-spots' of air pollution. This is followed by a description of how air quality and greenhouse gases are monitored.

2.1 Meteorology and Landscapes

Air quality within the Ottawa Valley is due to both its local emissions from human activities and its location on the North American continent. Geographically, the City of Ottawa is located within the Windsor-Quebec Corridor, considered one of the most polluted areas in Canada. The direction of prevailing winds for the period from November to May is from the northwest while from June to October they are from the southwest (Figure 1). High concentrations of ozone and particulate matter are typically associated with hot sunny days in summer and with slow-moving or stagnant high-pressure systems located south of the Great lakes. These warm winds carry contaminant concentrations in the summer from the more populated areas in the south. Within Ottawa, it is estimated that more than 50 percent of ozone and ozone precursors can be attributed to trans-boundary air pollution from the United States. The long-range transport of ground level ozone arrives in Ottawa after 8 pm.

During the winter season, emissions from transportation, vehicle idling and wood burning combined with a thermal inversion traps contaminants locally and results in poor air quality. The main pollutant is fine particulate matter.

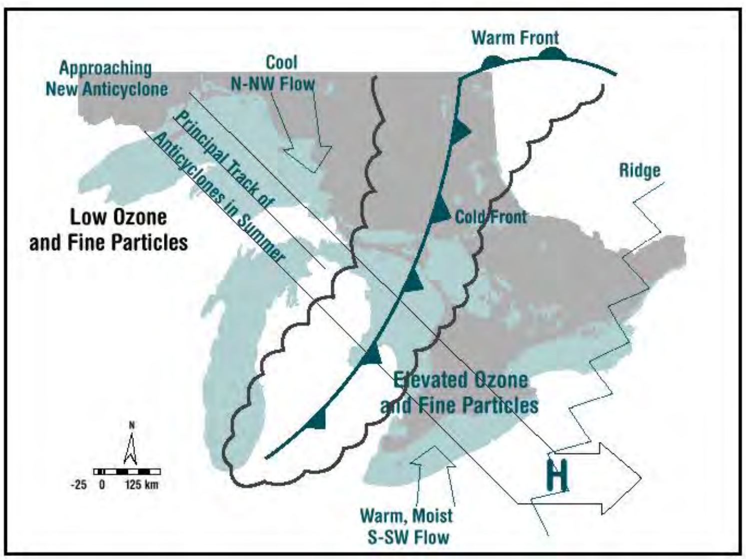

Figure 1. Meteorological conditions associated with high levels of pollution.
Source: MOE, 1999.

Local topographic factors also influence the air quality. The City of Ottawa is located within the Ottawa-St. Lawrence Lowland. To the north of the City are the Gatineau Hills, which rise 250 metres above Ottawa. Overall, with the exception of the Carp Hills, the City is relatively flat. Our highest point is located in Alta Vista, and the lowest points are located in both valleys of the Ottawa and Rideau River Basins.

Both topography and climate play an important role in air quality at both a local and regional scale. For example, pollutants become diluted and dispersed by strong winds and natural ventilation. The Gatineau Hills can block air movement, thus trapping pollutants by reducing the dispersion and ventilation that would normally occur. When this happens, smog events and other air quality issues arise within both Gatineau and Ottawa. The Ottawa River Valley often has surface winds of less than 3 m/s, which can allow airborne pollutants to accumulate.

The micro-climate is also not uniform across an area as large as the City of Ottawa. At a local scale, urban or developed areas are on average a little warmer and less windy than the rural environment. This is known as the Urban Heat Island effect. The local topography in the City of Ottawa intensifies this effect. The temperature difference due to the heat island effect is 2 to 3^oC between the downtown core and the surroundings. This difference is larger on clear, cold, and windless nights. The Urban Heat Island effect has implications for local air quality and energy use for cooling in summer. When afternoon temperatures are lowered 2 to 3^oC, ozone levels fall by 7 to 10 parts-per-billion, a 6 to 8% drop[5].

On the other side of the spectrum, the wind tunnel effect caused by funnelling of the wind between large buildings, causes air quality problems by lifting up road dust and causing pollutant dispersion in street canyons and across roads.

2.2 Measuring Air Pollution and Greenhouse Gases

Air pollution is measured in two ways: through direct monitoring and through emission inventories. Monitoring, among other uses, serves to determine the Air Quality Index (AQI), a composite indicator of outdoor air quality. This information, or AQI, is communicated to the public through the media (television, radio, newspapers) along with recommendations for protection from the effects of poor air quality. Emissions inventories are communicated through emissions inventory reports. Air quality is both a Federal and Provincial responsibility, however not exclusively. Some municipalities such as the Greater Vancouver Region and the City of Montreal monitor their own air quality to address local air quality concerns. Both also contribute to the national air quality database.

Among the greenhouse gases that are more prominent in Ottawa are CO_2, CH_4, N_2O and in less proportion, chlorofluorocarbons (CFCs). These gases are only measured directly in a few instances. For the most part, they are calculated from fuel consumption amounts and from mathematical models. **Greenhouse Gases from burning fossil fuels are closely linked with many pollutants, thus reducing their emissions will result in a significant reduction of a good number but not all air pollutants**.

[5] Bowman, Chris. 2000. Changes in urban landscape can cut smog. http://www.fraqmd.org/Heat%20Island.htm

Harmful air pollutants emitted in large amounts are known as criteria pollutants, or Criteria Air Contaminants (CAC). The three primary CAC are hydrocarbons (HC) or VOC, CO, SO_2, and NO_x. Also of interest are three other criteria pollutants, PM, O_3 and peroxyacetyl nitrate (PAN). Ozone, PAN and in part PM are formed within the atmosphere from the chemical interaction of nitrogen and sulphur oxides, hydrocarbons and oxygen. They are known as secondary pollutants.

The *Canadian Ambient Air Quality Objectives* sets the "maximum desirable," "maximum acceptable" and "maximum tolerable" levels of various air contaminants. These objectives are set to protect human health and the environment. In addition, the Federal government has recently adopted "*Canada-Wide Standards*" for priority air contaminants, including fine particulate and ground level ozone.

The regulatory aspect of air quality is a Federal and Provincial responsibility, thus both levels of government have monitoring stations in the Ottawa area. Environment Canada operates and maintains two stations in Ottawa. The two stations measure the following parameters:

- Hourly: SO_2, CO, O_3, nitrogen dioxide (NO_2) (at 88 Slater, near the Hydro substation, west of Elgin Street); and
- Hourly: SO_2, CO, O_3, and NO_2, on a 24-hour average PM_{10}, on an hourly and 24-hour average PM <2.5 microns ($PM_{2.5}$) (at MacDonald Gardens, corner of Rideau St. and Wurtemburg, west of the Rideau River).

Located just outside the City in Gatineau is another monitoring station, operated and maintained by the Quebec Ministry of the Environment on 255 St-Redempteur in Quebec.

The monitoring stations provide a general indication of outdoor air quality, but pollutant levels throughout the greater geographic area may vary somewhat from the conditions measured at each station due to variable local emission sources and weather conditions. The current monitoring stations may not be well positioned to protect human health or to provide a comprehensive picture of pollutant concentrations.

2.2.1 Air Quality Index

In addition to the federal network, the Ministry of Environment (MOE) monitors ambient air quality, using a composite index that considers the concentrations of each criteria pollutant. The air quality index (AQI) provides the public with a qualitative indication of outdoor air quality. For Ottawa, the ambient air quality has typically fallen within the "very good" to "good" category of the AQI most of the time. This however, is not a guarantee that the levels of pollution are not affecting human health. Relative low levels of pollution when the AQI falls in 'good' category have been linked with health problems[6]. According to Toronto Public Health, more than 90 per cent of all health effects occur during non-smog episodes. Furthermore, there are no known thresholds for ground level ozone or fine particulate matter, suggesting that human health is at risk at even relatively low levels of air pollution. In recent years there has been growing recognition that the present AQI does not properly reflect the health risks associated with the air pollution levels that many regions across Canada experience. Notably a national stakeholder group, led by Environment Canada and Health Canada, is in the process of developing a new national health based air quality index.

The AQI in Ontario (Table 1) has five categories: *very good* (1-15) and *good* (16-31) for measured concentrations of any air contaminant up to the "maximum desirable" objective; as *moderate* (32-49) for concentrations up to the "maximum acceptable" level, and as *poor* (50-99) for concentrations of up to the maximum tolerable levels. The *very poor* category (100+) refers to concentrations exceeding the maximum tolerable levels[7]. This approach is "standards-based" since it refers to the effects on human health and ecosystems. As provinces move towards a "health-based" approach, the categories and criteria for the AQI are expected to change.

[6] Pengelly, D. et al. 2000. Air Pollution Burden of Illness in Toronto. City of Toronto.
Delfino, R.J. et al. 1998. Emergency room visits for respiratory illness among the elderly in Montreal: Association with low level ozone exposure. *Environmental Research*, Section A, Vol. 76: 67-77.
[7] Daily AQI information can be obtained by visiting www.ene.gov.on.ca …

Table 1. Air Quality Index for Ontario[8]

Index & Category	Ozone	Fine PM	NO2	CO	SO_2	Total reduced Sulphur
1-15 Very Good	No Known harmful effects	Sensitive populations may want to exercise caution	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects
16-31 Good	No known harmful effects	Sensitive populations may want to exercise caution	Slight odour	No known harmful effects	Damage some vegetation in combinatio n with ozone	Slight odour
32-49 Moderate	Respiratory irritation in sensitive people during vigorous exercise; people with heart/lung disorders at some risk; damages very sensitive plants	People with respiratory disorders at some risk	Odour	Blood chemistry changes, but not noticeable impairment	Damages some vegetation	Odour
50-99 Poor	Sensitive people may experience irritation when breathing and possible lung damage when physically active; people with heart/lung disorders at greater risk; damages some plants	People with respiratory disease should limit prolonged exercise; general population at some risk	Air smells and looks brown. Some increase in bronchial reactivity in people with asthma	Increase symptoms in smokers with heart disease	Odorous; increasing vegetation damage	Strong odour
100-over Very Poor	Serious respiratory effects, even during light physical activity; people with heart/lung disorders at high risk; more vegetation damage	Serious respiratory effects, even during light physical activity; people with heart disease, the elderly and children at high risk; increased risk for general population	Increasin g sensitivity for people with asthma and bronchitis	Increasing symptoms in non-smokers with heart diseases; blurred vision; some clumsiness	Increasing sensitivity for people with asthma and bronchitis	Severe odour; some people may experience nausea and headaches

[8] Ministry of the Environment. Air Quality in Ontario, 2002 Report. http://www.ene.gov.on.ca/envision/techdocs/4521e01.pdf

Currently, the City relies on federal and provincial monitoring systems and does not monitor either point source emissions or ambient air quality. The City's traffic demand model can be used in conjunction with emission models to estimate base year and forecast emissions from vehicles on major roadways. The Province of Ontario is in the process of introducing new legislation to force large industries to monitor and report on the Criteria Air Contaminants. This requirement will yield valuable data that the City can use in its monitoring and modelling emissions from point/stationary sources.

3. Air Quality and Health

Air pollutants derived from energy-related activities, primarily the combustion of fossil fuels (heating oil, coal, natural gas, gasoline, diesel fuel), are responsible for 82% of carbon monoxide emissions, 57% of SO_2 emissions, 90% of NO_x emissions, and 62% of VOC emissions[9]. What follows is a description of the relationship between air pollutants and health.

The link between air quality and health has long been established. In times past, when woodstoves and fireplaces provided indoor heating, the resulting respiratory illness required people to sleep propped-up by pillows. In 1952, a single smog event in London, England, characterized by very high concentrations of sulphur aerosols from the burning of coal as residential and commercial heating fuel, caused over 4000 deaths. This event and others in major cities across the world have led to the implementation of various measures to reduce the air pollution and therefore decrease the number of deaths. These measures however, have not eliminated mortality due to air pollution. In Canada, at least 5000 deaths are attributed to air pollution annually with over 2000 deaths in Ontario alone.

In urban areas respiratory allergic diseases such as rhinitis and bronchial asthma appear to be on the increase worldwide. In Canada, the rate of asthma among children went from 2.5% in 1978 to 11.2% in 1995[10] (Figure 2). In Ottawa, it is estimated that air pollution is responsible for over 100 premature deaths/year, around 700 hospital admissions, over 900 emergency room visits, and around 65 million dollars are spent annually in respiratory and cardiovascular problems[11]. In Toronto, approximately 35% of excess summer-time respiratory hospital admissions occur in children under 2 years of age[12]. Unfortunately, there are not comparative figures for Ottawa[13]. It is believed that

[9] Environment Canada, forthcoming. National Emissions Inventory of Criteria Air Contaminants. Ottawa. National Indicators and Reporting Office, Environment Canada from the 2000 data
[10] Suzuki Foundation http://www.davidsuzuki.org/WOL/Challenge/Newsletter/sept2004_sprawl/page2.asp
[11] pro-rated from the report "Illness costs of air pollution." Ontario Medical Association. http://www.oma.org/phealth/smogmain.htm.
[12] Stieb, D.M et al. 2002. Air pollution and disability days in Toronto: Results from the National Pollution Health Survey.

air pollution causes sensitization of the airway[14] resulting in high incidence of respiratory illnesses.

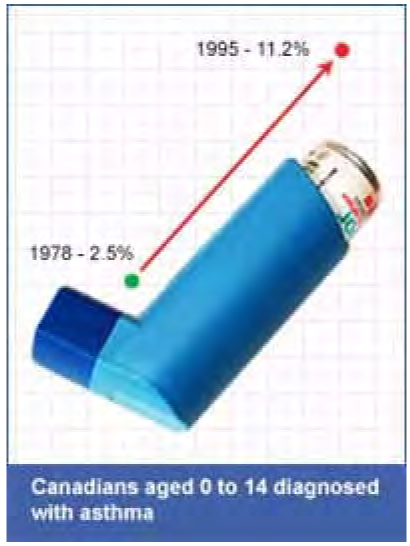

Figure 2. Asthma rate of increase among Canadian children

The most vulnerable populations are children, the elderly, and those with underlying illnesses, particularly heart and lung diseases, such as asthma. Between 5 and 8% of Canadians are asthmatics and this number is growing[15] particularly among children. Children are physiologically and anatomically at greater risk to air pollution than adults because of their growth rate. Children's lungs grow from 3 square metres at birth to 75 square metres by adulthood. Most of the pulmonary alveolar development continues into late childhood. The growing tissue is the most vulnerable to pollution. Children breathe in and out more rapidly than adults: every minute they exchange more air per kilogram of body weight than most adults. Hospital admissions due to respiratory problems for children have increased by 28% between1980 and 1990[15]. Adults over 45 years old are also vulnerable. These two groups currently represent 55% of Ottawa's total population. The vulnerability of our senior populations is also of concern given that their number will double by 2020. Consequently, the impact of air pollution to human health will be much greater in decades to come.

Of all the air contaminants, diesel fuel particulate matter may be responsible for 70%-89% of total cancer risk caused by air pollution[16]. It is estimated that diesel particulate matter may cause 13,600 cases of cancer in Canada. Air pollution has also been linked with reduced weight in newborns and to immunodeficiency. Some researchers note that

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[13] A sample of the impact of air quality in Ottawa from the 10 km road of the Alta Vista Corridor is the estimated one premature death, one more hospitalization and 35,000 to 45,000 minor illnesses.
[14] D'Amato, G. 2002. Environmental urban factors (air pollution and allergens) and the rising trends in allergic respiratory diseases. Allergy, Vol. 57(72): 30-33.
[15] Last, J. K. Trouton, and D. Pengelly. 1998. *Taking our breath away – The health effects of air pollution and climate change*. David Suzuki Foundation. 51 pg.
[16] Sharp, J. 2003. The public health impact of diesel particulate matter. Sierra Club of Canada – Eastern Canadian Chapter.

there is a likelihood of other impacts that still need to be discovered. Recent research in California has shown evidence that air pollution not only triggers asthma attacks, but may in fact be a causal source of the illness[17]. Depending upon the contaminant or its synergistic effects with other compounds, air pollution causes a range of other illnesses including decreased breathing capacity, eye irritation, decreased immune function, chronic respiratory, and chronic diseases and death.

Previously, Canada had stood as a leader in air quality, particularly in its role in the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. Canada acted swiftly to implement, enforce and update regulations to stop the use of most chlorofluorcarbons and other substances that destroy the upper atmosphere ozone layer that prevents excessive ultraviolet radiation. Due to continuous budget reductions at the federal level, Canada has become a country with the worst air emission records among the thirty members developed countries. Its air quality objectives have not changed since the 1970's. A 2004 report from the Organization of Economic Cooperative Development cited Canada as having one of the worst records for air emissions, specifically particulate matter and ground level ozone.

On most days, the air quality in Ottawa is *good* to *very good*, but during the increasing number of summer smog episodes, it is *poor* to *very poor*. As the City's population increases, we will see a rise in the number of cars and trucks on our roads, currently above 0.5 million[18], both for personal transport and to supply goods and services to a larger population. Although improvements to vehicle efficiency and emissions will continue, more vehicles will still result in increased levels of air contaminants. The air quality challenges we face today will be aggravated by climate change with a likely two-fold increase in intensity of impact by 2020.

A detailed description of our key air quality indicators, their trends in our environment and impacts on human and environmental health are presented in Annex 1. A brief description follows:

- **Sulphur oxides**: SO_2 - decreases pulmonary capacity; and SO_4- causes acid rain. Transportation and electricity generation are the greatest contributors.
- **Nitrogen oxides**: NO_2 - a lung irritant can produce pulmonary edema and is associated with heart disease; NO_3, NO; and peroxyacetyl nitrate (PAN) all contribute to ground level ozone. Transportation is responsible for 85% of NOx.
- **Carbon monoxide** reduces the ability of the blood to carry oxygen and contributes to ground level ozone. Transportation is responsible for 73%.

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[17] McConnell, R.; Berhane, K.; Gilliland, F.D.; London, S.J.; Islam, T.; Gauderman, W.J.; Avol, E.; Margolis H.G.and Peters, P.M. 2002. Asthma in Exercising Children Exposed to Ozone, *The Lancet*, Vol. 359, No. 9304, Feb. 2.

[18] Ottawa Road Safety by the numbers.
http://city.ottawa.on.ca/city_services/traffic/road_safety/by_numbers_en.shtml

- **Volatile organic compounds** are organic and elemental carbon that are in contact with NOx produce ground level ozone. Some VOCs, such as benzene, are suspected carcinogenic and neurotoxic. Living organisms or biological processes contribute 83% of VOC emissions.
- **Particulate matter** smaller than 10 microns (PM_{10}) and smaller than 2.5 microns ($PM_{2.5}$) were declared toxic under the *Canadian Environmental Protection Act*. There is no lower safe threshold. They cause respiratory infections, cancer and death. They corrode, soil and damage vegetation as well as reduce visibility. Transportation is responsible for 46% of $PM_{2.5}$ and residential fuelwood combustion for 19% of PM_{10}.
- **Ground level ozone**, a highly irritant gas, has a role in chronic lung disease, eye irritation and hospital admissions, reduces both agricultural productivity and the growth rate in trees; causes lung hemorrhages in birds. Ground level ozone also acts as a greenhouse gas. Smog episodes in Ottawa are steadily increasing. Transportation is the greatest contributor of smog precursors.
- **Greenhouse gases** are considered priority air pollutants. The transportation and residential/commercial sectors each contribute 40%, the remainder 20% coming out of the waste sector.
- **Hazardous air pollutants:** are all of the above plus benzene, 1,3 Butadiene, formaldehyde, acetaldehyde, polycyclic aromatic hydrocarbons (PAHs) most of them the result of transportation.
- **The impacts of mould, pollen, noise, odour and light pollution on human and ecosystem health** range from annoyance, allergic rhinitis to neurological and immunological effects. These are also described in further detail in Annex 1.

4. Emission Sources

Emissions in the Ottawa-Gatineau air basin come from six basic sectors; industrial, non-industrial fuel combustion, transportation, incineration, miscellaneous, and open sources (Table 2). It is the latter that is responsible for the largest particulate matter emissions and also the greatest amount of ammonia (Table 3). Among the open sources, unpaved roads account for 55% of all particulate emissions from all sources, and agriculture is responsible for 42% of the total ammonia (NH3) emitted in Ottawa. Transportation causes the highest levels of SOx, NOx, VOC, and CO. Open sources are the highest contributors of TPM, PM_{10}, $PM_{2.5}$, and NH_3.

Table 2. Key air pollutant emissions (in tonnes) for Ottawa-Gatineau airshed, 1995

Source Category	Total PM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOC	CO	NH_3
Industrial	3,581	1,188	602	3,407	2,016	633	2,738	1,218
Non Industrial Fuel Combustion	3,770	3,690	3,607	1,031	3,653	12,440	26,248	128
Transportation	2,366	2,282	1,928	3,935	**34,943**	**22,540**	**206,466**	718
Incineration	23	11	8	23	36	49	392	5
Miscellaneous	296	270	237	0	1	18,573	479	834
Open Sources[19]	**331,450**	**88,167**	**12,628**	0	0	106	0	**2,115**
Totals	**341,486**	**95,608**	**19,010**	**8,396**	**40,649**	**54,341**	**236,232**	**5,109**

Source: NPRI (1995)

The non-industrial fuel combustion sector accounts for a large amount of PM emissions. $PM_{2.5}$ emissions from fuelwood (the most damaging to human health) amount to 25% of those from the transportation sector. A summary of the top 10 sources of criteria air contaminants points toward the transportation sector being the source of greatest pollution (Table 3). Transportation is responsible for a combination of pollutants that include carcinogenic substances, acid rain forming substances, and is responsible for 30% of the GHG emissions in the Ottawa-Gatineau airshed basin[20].

Table 3. Top 10 sources of pollution in Ottawa-Gatineau (in tonnes)[21]

Contributing Sector	Total PM	PM_{10}	$PM_{2.5}$	SO_x	NO_X	VOC	CO	NH_3
Transportation[22]	**270,966**	**74,161**	**13,557**	**3,530**	**32,226**	21,266	**204,320**	697
Construction	55,810	12,278	249					
Agriculture	6,422	3,149						**2,115**
Residential fuelwood combustion	3,472	3,429	3,362			12,264	25,453	25
Biogenics					2,123	**229,369**		
Residential fuel combustion			136	500	1,344			21
Pulp & Paper Industry		226	166	2,452	1,113		2,373	1,203
Electric power generation				229	1,185			
General solvent use						9,325		
Surface coatings						4,320		

[19] Open sources constitute agriculture, construction, landfill sites, mine tailings, paved roads and un-paved roads. It is the latter the greatest contributor to TPM (97%), PM_{10} (92%) and $PM_{2.5}$ (66%).
[20] McKibbon, Scott. 2004. Pers. Comm. Program Engineer. GHG Inventory Development, Environment Canada.
[21] Ratte, Dominique. 2003. Direction des données sur la pollution, CAC program, Environment Canada
[22] Include unpaved and paved roads, heavy-duty diesel & gasoline trucks, light-duty gasoline vehicles & diesel trucks, off-road use of diesel, asphalt paving industry, off-road use of gasoline, marine & air transportation

Summary of significance

A detailed report on the sources of emissions in Ottawa can be found in Annex 2. Transportation is responsible for hazardous air pollutants as well as over 50% of ground level ozone, for 90% of carbon monoxide, over 85% of oxides of nitrogen, 60% of sulphur oxides, 46% of $PM_{2.5}$, and over 30% of emissions from volatile organic compounds. These pollutants come from burning gasoline as well as from on-road and off-road diesel. The latter has the largest amount of sulphur content (2500 ppm) compared with on-road diesel that contains less than 500 ppm. Federal regulations are being established to reduce sulphur from gasoline and diesel as well as on a energy efficiency system for non-road engines. These regulations are essential to the air quality of our City since the rate of car ownership is greater than the birth rate.

The pollutants from transportation are not limited to the burning of fossil fuels, but are also produced from the wear and tear on cars and on roads, all of which are found in road dust. Approximately 40 to 60% of PM_{10} and 5 to 20% of $PM_{2.5}$ are attributed to urban transportation. The 700 km of unpaved roads in Ottawa are a great source of PM_{10} requiring stabilizers such as calcium chloride. Other sources of PM arise from the 140,000 tonnes of salt per year used here in road maintenance. The greatest gains in emissions reduction would come from the transportation sector.

Residential heating, particularly from wood burning, contributes large amounts of PM as well as other toxic compounds such as benzene, formaldehyde, benzo[a]pyrene, dioxins and furans, and polycyclic aromatic hydrocarbons (PAHs). This sector is also responsible for large quantities of CO and NO_x. Even natural gas emits NOx, SO_2, and traces of toxic compounds. Heating and cooling in residential, commercial, and institutional buildings contribute over 4.5 million tonnes of GHG.

Construction, agriculture and industry also give off large amounts of PM. Agriculture's contribution to ammonia is the highest and is significant for CH_4. Both forestry and natural areas add large amounts of VOCs. The industrial sector, though small, rivals the transportation sector in SO_x emissions. Landfills are a large source of methane.

5. GHG Issues, Links and Trends

It is important to recognize the links between GHG and climate change, and in turn between these and air pollution, human and ecosystem health. These links are briefly explored in an attempt to establish the importance of reducing GHG.

5.1 Links Between Air Quality and Climate Change

The burning of fossil fuels for energy is the main source of air pollutants and of greenhouse gases. Carbon particulates and gases such as ozone, trap long wave energy reflected and radiated from the earth, increasing atmospheric temperature, and serving as catalysts for chemical reactions and the greater formation of ground level ozone. Warmer temperatures favour the emission of volatile organic compounds that in combination with nitrogen oxides and in presence of sunlight turn into ozone. High temperatures also cause the evaporation of toxic substances such as mercury, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), from sediments or areas where they were trapped.

The direct link between climate change and air quality is reinforced with new scientific discoveries. Carbon dioxide increases the production of vegetative matter including weeds and favours higher pollen production. Furthermore, warmer temperatures extend pollen and mould seasons and the resulting increased humidity stimulates spore production.

Climate variability may be associated with climate change, as well as an increased number of stagnant air masses over the region, causing the build up of noxious pollutants. Stagnant air masses are the result of high-pressure systems that bring high temperatures, humid conditions and high amounts of particulate matter on their approach to the Ottawa Valley. In parts of southern Ontario, the frequency of “offensive” or “oppressive” air masses could increase 5 – 8 times current levels with climate change. The number of hot days could increase substantially in southern Ontario, leading to a double health threat of heat stress and air pollution. The synergistic effects of climate change on air pollutants are continuously being explored.

Although many particles or gases known as aerosols cause warming, those containing sulphur and black carbon, act as cooling agents in the atmosphere because they reflect sunlight and indirectly modify the thermal properties of the atmosphere. Aerosols counteract the warming effect of carbon dioxide emissions by about 25 percent[23]. This adds another level of complexity to the air quality and climate change problems. Long-lived CO_2 accumulates in the atmosphere; continued balancing requires a greater and greater aerosol load. Detrimental effects of these aerosols, i.e., acid rain and health impacts, will limit the aerosol amount, and thus further enhance greenhouse warming.

Of greater concern are the indirect effects that climate change could have on air quality in Ottawa by affecting our energy usage. Warmer summer temperatures could lead to greater use of air conditioning, and depending upon the fuel or electricity energy mix, there would be an associated increase in emissions causing

[23] Hansen, J., Mki. Sato, R. Ruedy, A. Lacis, and V. Oinas. 2000. Global warming in the twenty-first century: An alternative scenario. *Proc. Natl. Acad. Sci.* 97, 9875-9880, doi:10.1073/pnas.170278997.

air pollution. The use of air conditioners would increase the 'heat island effect' accelerating smog formation.

5.2 Links Between Energy and both Air Quality and Climate Change

Burning fossil fuels produces energy, essential for various needs such as transportation, heating and/or cooling of home and office, as well as the creation of goods/services, which in turn is the main source of pollutants and of greenhouse gases. The mitigating factor is in both the efficiency and the type of resource used to produce energy. Alternative energy sources that are renewable exist. Examples include wind, geothermal, and solar. They produce no pollution and/or greenhouse gases, though the creation of their infrastructure does.

5.3 Impacts of Climate Change on Ecosystem Health

Climate change will affect the health of ecosystems. It will cause ecosystems to shift resulting in habitat loss, habitat fragmentation, create threats from new species and pests as well as cause species extinctions. As climate conditions change, some areas become inhospitable for certain species because there are changes to the amount of water present, higher or lower temperatures, or their food source is affected. Other areas may become more inviting to new species invading native species' habitat. While some species will adapt their behaviour to new conditions, others will remain trapped in lifecycles that no longer work in the new climatic regime. Rapid temperature changes will also affect the seasons, including shorter winters and variations in season length, which affects biodiversity. This can lead to changes in the growing season, earlier breeding times, earlier spring migrant arrival and later autumn departure dates along with changes in migratory patterns. All these effects are currently being experienced throughout the world.

Analysis of 143 studies showed a consistent temperature-related shift in territories for species ranging from mollusks to mammals and from grasses to trees. A similar study of 1700 species also confirmed climate change predictions, with average range shifts of 6.1 km/decade towards the poles. For example the ranges of North American butterflies and birds are shifting northwards and upwards. The Intergovernmental Panel for Climate Change also reported that the most consistent explanation from studies that show alterations in range or behaviour of animals and plants is climate change[24].

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[24] Santer, B D, T M L Wigley, T P Barnett, and E Anyamba (1996); Detection of climate change and attribution of causes, in Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change [edited by] J T Houghton, L G Meira Filho, B A Callander, N Harris, A Kattenberg, and K Maskell, Cambridge University Press, Cambridge, UK and New York: 407-33

5.4 Former City of Ottawa GHG Management Plans

Although this is the first Air Quality Management Plan for the City of Ottawa, there have been GHG management plans before amalgamation. Indirectly by reducing GHGs the air quality would improve particularly when these emissions are the result of fossil fuels. The former City of Ottawa in 1991 and the Regional Municipality of Ottawa-Carleton (RMOC) in 1997, each committed to the Partners for Climate Protection to reduce their corporate and community CO_2 emissions by 20% below 1990 levels in 10 years. In order to measure the changes in CO_2 emissions, each municipality established 1990 baseline measurements.

The former City of Ottawa's commitment to reducing GHG won them an award from *Canada's Climate Change Voluntary Challenge and Registry Inc. (VCR Inc.).* In 1990, the old City of Ottawa's community released 2,951.8 Kt of CO_2 emissions into the atmosphere. This amounted to 9.3 tonnes per capita, which is lower than the provincial average of 10.4 tonnes per capita. This difference may be attributed to the concentrated development of the old City of Ottawa. Annex 3 Table 13 shows GHG emissions for old City of Ottawa for 1990, 1993, 1996, and 1998. The efforts to decrease emissions resulted in a reduction of 5% below 1990 levels despite a population increase of almost 6% since 1990. Eleven reduction initiatives were put forth by a task force and were implemented (Annex 3, Table 14) to achieve greenhouse gas reductions as mentioned above.

The progress of reaching the 20% corporate CO_2 emissions reduction for the old City of Ottawa is shown in Annex 3 Table 15 for 1990, 1996 and 1998. In 1998 the overall corporate energy use was 12% below 1990 levels and CO_2 levels were 19% below 1990 levels. Overall, corporate CO_2 emission declined reaching a plateau due to changes in the electrical fuel mix.

5.5 Former Regional Municipality of Ottawa-Carleton

In 1990, the RMOC corporate emissions totalled 66 Kt of e CO_2. Table 16 in Appendix I illustrates RMOC corporate CO_2 emissions for 1990 and 1997. In the same period corporate energy use increased by 7%, however, emissions decreased by 9%. Part of the emission reduction in 1997 was likely due to lower emissions per unit of electricity produced in 1997 compared to 1990. Also positive changes within the corporation had helped reach this reduction (waste diversion methods within the corporation and at OC Transpo transit stations). Water and sewage treatment and pumping continued to comprise the largest corporate energy use (43%) and the largest proportion of CO_2 emissions (41%). Since 1990, energy use and CO_2 emissions from the vehicle fleet increased by 15% making it the section with the largest growth in emissions.

The former Regional Municipality of Ottawa-Carleton, commissioned a community GHG emissions inventory for the year 1990 and 1997. By 1997 the inventory saw a 78% increase in energy usage in the community and an 88% increase in GHG emissions. The difference in increase between energy usage and CO_2 emission was due to changes in the provincial electricity fuel mix. The commercial sector showed a very high increase in energy usage due to the growth in the high tech sector. The industrial sector experienced an increase in energy use related to the expansion of the production and manufacturing facilities linked to the high tech sector. The increase experienced in the residential sector was proportionally lower. This was in part due to improvements made in energy efficiency (energy efficient appliances, fuel switching, improved construction practices). From 1990 to 1998 the transportation sector CO_2 emissions increased. Most probably this increase was related to the population increase experienced during that time period. The waste sector's increase was most likely related to an increase in population and an increase in consumption (Table 4 below).

5.6 New amalgamated City of Ottawa

The community GHG emissions for the newly amalgamated City of Ottawa correspond to those from the former RMOC community emissions because the geographical areas are precisely the same (Annex 3 Table 17).

The new amalgamated City of Ottawa does not have a corporate emissions inventory. Given their respective responsibilities and size, the combined corporate activities of the former Region and City of Ottawa likely accounted for over 80% of municipal corporate GHG emissions at the time of amalgamation. Table 18, Annex 3 lists proposed actions to reduce community GHG emissions.

Determining a precise figure for 1990 would involve extensive and costly historical analysis of the operations and activities of the other nine local municipalities.

5.7 Summary

In summary, the total emissions produced by the City of Ottawa at a corporate level equalled 98,886 tonnes and 87,151 tonnes for 1990 and 1998, respectively (Table 4). The fleet sector emissions stayed relatively constant between 1990 and 1998 whereas all other sectors substantially decreased theirs. In 1998, the corporations together were 8% away from reaching their 20% reduction goal. It is expected that the City is currently closer to the 20% target, to be confirmed in 2005, due to continuing initiatives for fleet emissions reduction and building retrofits.

Table 4: Summary of CO_2 emissions for the City of Ottawa

City of Ottawa	Tonnes of eCO_2		% Change
	1990	**1998**	**1990/1998**
CORPORATE[25]			
Fleet	16,623	17,007	+ 2%
Buildings/Facilities	44,162	39,024	-12 %
Streetlights	5,699	5,032	-12 %
Water/Sewage	29,473	24,844	-16 %
Waste	2,929	1,244	-58 %
CORPORATE TOTAL	**98,886**	**87,151**	**-12 %**
COMMUNITY			
Transportation	2,353,000	2,476,000	+5 %
Waste	1,237,733	1,968,149	+48 %
Buildings	2,437,332	4,582,457	+47 %
COMMUNITY TOTAL	**6,028,105**	**9,026,606**	**+43 %**

At the community level, total emissions produced within the City of Ottawa equalled 6,028 Kt and 9,027 Kt for 1990 and 1998, respectively. During this period, total community CO_2 emissions increased by 43%, primarily within the waste and building sectors.

6. Strategic Directions

This plan establishes a comprehensive package of strategic actions to reduce our air emissions and energy use. Existing programs, ranging from land use planning to residential energy efficiency to transportation demand management contribute to this overall goal. In addition, programs such as anti-smog campaigns involve warnings to protect vulnerable populations, as well as actions to mitigate smog in both summer and winter. This plan explores the integrated aspect of air quality amongst the range of local initiatives related to land use, urban design, energy efficiency and promotion of alternate energy sources. Particular emphasis is placed on reducing GHGs because of their link to air quality and their representation of the City's local commitment to global environmental improvement.

GHG and Air Quality Reduction Targets

In 1997, Canada joined other developed countries in adopting the Kyoto Protocol under the United Nations Framework on Climate Change. Parliament ratified the Protocol in December 2002. This Protocol will come into effect internationally on February 16, 2005. This commits the country to reducing total GHG emissions to 6% below 1990 levels during the five-year period of 2008 through 2012, a total annual greenhouse gas

[25] These numbers represent the emissions from the former City of Ottawa and the Region of Ottawa-Carleton whose operations represented an estimated 80% of the total.

(GHG) emission reduction of 240 megatonnes (Mt). One of the most significant and far-reaching measures to reach this target, identified in the federal *Climate Change Action Plan,* is to encourage every Canadian to reduce their emissions by one tonne per year before the end of this time period. The federal government will support this task through the provision of incentives, improved information and product availability. The *Climate Change Action Plan* calls for provinces, territories, communities, the private sector and non-governmental organizations to partner to further reduce emissions through a variety of means. It also invites governments at all levels to lead by example.

Implementation of the Kyoto Protocol projects that municipal governments will contribute through:

- Existing underway actions by the Federation of Canadian Municipalities' Partners for Climate Protection (PCP) communities and projects initiated under their Green Municipal Enabling Funds (3 Mt);
- Capture, flaring and use of landfill gas (8 Mt); and
- Further investments in waste diversion, transit supportive land-use planning, renewable electricity and community greening (10 Mt).

Achieving air quality objectives and the reduction of GHG will require a wide range of actions and activities. The Ottawa 20/20 Environmental Strategy (October 2003) proposed targets of 20% reduction from 1990 levels in GHG Emissions within the City's own operations by 2007 and in community emissions by 2012. The approach recommended to reach these targets is as follows:

- The corporate target will be based on a 20% reduction of GHG emissions by 2007, based upon an estimated 1990 baseline. Now that the City has stabilized the majority of its facilities and programs after amalgamation, an updated inventory will be prepared in 2005. Revised targets for further reduction, in consultation with City programs, will be set beyond 2007; and
- The community target of a 20% reduction in GHG emissions by 2012 will also be measured against the 1990 baseline. Although this target is aggressive and exceeds the Kyoto commitment, it can be achieved through several key actions, many of which are already underway. Examples include the landfill gas co-generation initiative (now underway), community energy reductions through the implementation of sustainability principles, and achievement of the transit modal split targets. Confirmation of this 20% target will maintain the City's status as a municipal leader in climate protection.

While it is important to address climate protection through GHG reduction and "to do our part" to meet national and international commitments, it is equally important to remember that many of the actions proposed in this plan have other benefits beyond GHG reduction and Kyoto Protocol commitments. Measures such as cleaner fuels, transportation demand management and community greening all have important environmental, health, economic and quality of life benefits, worth pursuing even if climate change were not an issue. Indirect benefits, which may even exceed the direct ones, include savings involved in converting almost 18,000 commuters from their cars to transit, representing major savings in insurance, road repair, and vehicle maintenance. Reducing the reliance by both the City and its citizens on oil and gas at a time when the cost of this fuel can only increase is another major gain. As well, controlling urban sprawl reduces the need for roads and salt as well as promotes a healthy lifestyle through increased walking and cycling. The greatest benefit of reducing GHG is likely the positive impact of the resulting cleaner air on our health and that of our ecosystem.

Strategic Overview

The challenge inherent in these targets is obvious when reviewing the emissions inventory work completed to date. Table 5 summarizes community GHG emissions in the building, transportation, and waste sectors for 1990, 1998 and a projected level in 2007 if no further reduction measures are implemented (in tonnes of CO_2 equivalent (eCO_2)).

Table 5. Community CO_2 emissions for 1990, 1998 and 2007

	Tonnes of eCO_2		
Sector	**1990**	**1998**	**2007 business as usual forecast**
Buildings	2,437,000	4,582,000	5,139,000
Transportation	2,353,000	2,476,000	3,068,000
Waste	1,238,000	1,968,000	2,430,000
Total	**6,028,000**	**9,026,000**	**10,639,000**

For the year 2007, it would be necessary to reduce GHG emissions by 63% below forecasted levels to reach our 20% GHG reduction target for the community. A target achievement year of 2012 provides additional time to develop strategies and take advantage of emerging technologies as well as evolving provincial and national programs. The measures adopted for GHG reduction must, however, account for the additional growth projected for the City of Ottawa.

To meet these challenges, four general types of activities are required:

1. Public outreach and involvement to ensure that City actions involve the community;
2. Actions and initiatives to meet the GHG reduction targets;
3. Monitoring progress in improvements to air quality and reduced GHG emission commitments, including measurement of key parameters for effective management; and
4. Adaptation to ensure that, while efforts are being made to reduce emissions and mitigate impacts, the City is also able to adapt to changes due to global warming.

The focus of this management plan is largely on the second activity – actions and initiatives, which involve specific programs in order to meet our air quality and GHG objectives. Given the close link between strategies to reduce GHG and improve local air quality, actions related to both objectives are discussed within each theme area.

To develop the measures that will be implemented in order to reduce CO_2 emissions for the amalgamated City of Ottawa, direction was taken from reports prepared by ICLEI (with respect to the building sector) and Jacques Whitford/Torrie Smith[26] (with respect to the transportation and waste sectors). These reports calculated the GHG levels for the City of Ottawa prior to 1999, predicted our future emissions and recommended actions to achieve the target of a 20% reduction of GHGs below 1990 levels. While many of the recommendations in those reports remain valid, this plan also incorporates programs and initiatives that are new since 2002, such as the federal government's One Tonne Challenge and City programs for vehicle anti-idling, the Smog Action Plan, the Fleet Emission Reduction Strategy, and the Transportation Master Plan. In addition, the City has adopted a revised population forecast.

This plan presents actions within theme areas and includes an indication of the relative contribution of these actions as well as recommended priorities. The proposed corporate and community actions are organized into the following theme areas:

- Transportation:
  - Use of alternative fuels (i.e. biodiesel, natural gas, ethanol) and new engine technologies (i.e., hybrid diesel-electric, fuel cells);
  - Increased use of public low or zero emission transit; and
  - Transportation Demand Management i.e. telecommuting, biking, walking, roller blading, car pooling.

- Building Sector:
  - Better Buildings Partnership;
  - Residential Energy Use (Envirocentre partnership); and
  - Green Buildings (LEED, ASHRAE promotion).

- Waste Management:
  - Reduction of packaging, a comprehensive waste reduction with composting and recycling programs;
  - Landfill gas utilization, aerobic digestion; and
  - Green procurement.

- Alternative energy and community energy planning /conservation programs:
  - Efficient appliances;
  - Reduction of water use;
  - District energy;
  - Renewable Energy; and
  - Co-generation.

[26] Jacques Whitford / Torrie Smith. 2002. Greenhouse gas Inventory and Emission Reduction Strategies for the Transportation and Waste Sectors in the City of Ottawa. Report prepared for the City of Ottawa. 90 pg.

- Sustainable land use planning and community greening:
  - Compact development and mixed zoning;
  - Carbon Sinks through tree growing programs; and
  - Urban design for energy conservation.

- Air quality issues:
  - Winter Air Quality programs;
  - Smog Alert programs;
  - Noise and Odours;
  - Street Cleaning; and
  - Pollen reduction measures.

Of course, not all the measures and activities can be completed at once. The approach described at the end of this section involves three phases with particular priorities:

Phase one involves an emphasis on completing inventories and establishing a monitoring system for GHG emissions and other air quality parameters. Monitoring key parameters will allow the City to refine its emission targets and strategies to meet obligations proposed within this Plan and as a Partner for Climate Protection.

Phase Two will entail continued development and implementation of specific medium-term measures.

Phase Three will focus on the evaluation of implemented management measures and on the identification of other long-term actions to further reduce emissions and adapt to climate changes.

The actions and initiatives described in this section involve several types of ongoing activities that are common and necessary in virtually all of the actions, albeit with different approaches and emphasis.

Aligning Regulations with Sustainable Practices

Regulatory barriers to adopting more sustainable practices that use less energy and generate fewer emissions may be either technical (based on strict code requirements) or administrative and interpretative (based on jurisdiction, policies and precedents) in nature. Technical standards issues include the use of unusual materials and components, as well as energy, water and waste management systems. Addressing technical issues often involves providing assurance that the proposed standard changes will achieve an acceptable performance and not increase liability in other areas, such as safety.

With sustainable building projects still being relatively uncommon, project managers may face additional time in education and in proving that their project meets required standards. A project may require a number of permits from different groups with each applying a separate set of standards, guidelines, policies and experiences. In addition, some issues are not clearly addressed by codes or bylaws, but through accepted processes developed through precedents over many years. The accepted approach is sometimes difficult to change.

On a global basis, government agencies are working to incorporate environmental values into land-use policies, building codes and other regulatory instruments. Steps to assist with this process can include developing awareness of the benefits of alternative technologies, often in energy savings. Guidelines are also needed for developers and regulators with respect to the equivalence and performance clauses that allow for an alternative case to be made. As a key regulator in several sectors, the City has a particularly important role in establishing new regulatory approaches, and in continuing to ensure that unnecessary obstacles to innovation are removed.

An opportunity for encouraging more sustainable practices could also be realized through changes to the Ontario Building Code and the National Building Code. Incorporating sustainability principles into these codes will require lobbying efforts from the City. Similar lobbying efforts are suggested to encourage the Provincial and Federal governments to provide incentives that would encourage “green” fuel alternatives to flourish. The results of such changes would help us achieve our GHG emission reduction goal.

Providing Incentives

In the case of a variety of measures, the degree to which they are successful will depend upon the incentives offered. For example, other jurisdictions have seen the participation in adoption of building energy conservation measures increase when incentives are available. Incentives can be both financial (e.g. sales tax rebates on energy star appliances), and qualitative (e.g. making it easier or more attractive for people to take transit). A developer with an innovative idea for energy savings could be given incentives through the building permit or development approvals processes, such as in the City’s recent streamlining of processes for the proposed LEED certified facility at Holland and Wellington.

Educating and Encouraging Behavioural Change

To meet the goals of reducing air emissions, various actions are required that involve lifestyle changes, such as choosing to walk and cycle to local destinations, recycling and choosing products with less packaging. Providing the information necessary for individuals to reduce their personal GHG emission and meet their “one tonne challenge’ will be an ongoing responsibility at all levels of government. The municipality can contribute to the plan by taking action in specific areas to:

- Promote and recognize positive and innovative achievements. It is important to recognize good work and to ensure that lessons learned from innovative projects are communicated; and
- Lead by example with corporate targets and initiatives. The City of Ottawa must continue to “practice what it preaches” and show leadership in all of the theme areas described in this management plan. By setting a challenging and significant corporate GHG reduction target, establishing internal greening projects and procurement approaches, as well as by developing corporate responses to air quality issues such as smog, the City can make a direct contribution to the objectives in this management plan and meet its commitments in the Environmental Strategy. Each theme area includes specific measures that are under our direct corporate control.

Achieving our climate change and air quality objectives can only be successful through a community effort. While the City has direct control over its own operations and has a number of tools available to influence community actions and private choices, many of the actions such as improving energy efficiency and reducing smog rely on public cooperation and individual action to make environmentally sound choices. Public understanding and participation will be key in weighing better environmental choices against their cost-benefit for all of our daily life options. Public outreach, involvement, and education are critical components of the strategy and of the actions outlined in this plan.

What follows is a framework for public outreach and involvement. Specific outreach activities will be designed for individual actions that will then be integrated with other promotional and outreach activities of the City and of other agencies, wherever possible, to most effectively use our resources and gain the attention of residents.

Community Leadership

Involvement of key participants and community leaders on an ongoing basis will be an important part of the outreach strategy. For example, the former City of Ottawa established a Task Force on the Atmosphere with broad representation from the community, business, and government to oversee City activities in climate change programs. Forming a similar Task Force for the amalgamated City will help champion this plan and achieve a broad reach within the community.

Partnerships

Partnerships will be a vital component of most actions, mainly to make best use of existing resources. Existing partnerships with service providers, such as EnviroCentre, will be expanded where appropriate to ensure that actions are delivered in the most cost-effective fashion. Many anticipated actions and partnerships are likely to involve funding or in-kind resources from other agencies and government levels. In particular, the City will work closely with the Federation of Canadian Municipalities and federal funding programs for climate change, air quality and sustainability.

Efforts to collaborate with non-government agencies and with the private sector will also continue. For example, the Business Community is a key partner in two respects, as providers (e.g. Enbridge Gas) and users (Building Owners and Managers Association) of energy.

Currently, City staff work with community environmental groups in advocating energy efficiency and clean air programs. The City has partnered with several NGOs such as EnviroCentre, Friends of the Earth, Pollution Probe, Sierra Club of Canada and federal organizations such as Health Canada, Environment Canada and Natural Resources Canada. The City is also establishing a relationship with the City of Gatineau and with the Association Quebecoise de la Lutte Contre la Pollution Atmospherique, to share experiences and explore the potential for joint delivery of programs such as anti-idling and car scrappage (removing pre-1988 cars from the road). Future shared initiatives of the Cities of Ottawa and Gatineau will likely include smog and wood burning programs. Joint efforts with other municipalities, as well as with Environment Canada and the Ontario Ministry of the Environment, will be explored to address long range pollutants, such as those from the USA, and reduce long-range transport emissions that affect our air quality, particularly during the summer.

Multiple Audiences and Diverse Cultures

Assorted interest groups and people of diverse backgrounds and cultures live, work, and play within the National Capital Region of Ottawa-Gatineau. Each have their own set of values, priorities, needs, and approaches to participation. To ensure success, these groups will have frequent and regular opportunities to review this plan and related actions. Bringing all these interests together requires a thoughtful approach to public outreach and participation utilizing a variety of approaches, tools, and techniques. Our primary tools and techniques for communicating with the public and stakeholder groups include:

- Working with public focus groups and local media;
- Special publications;
- Public workshops;
- Surveys;
- Individual meetings with stakeholder groups;
- Discussions with civic organizations; and
- Establishing an integrated air quality and climate change section on the City Internet web site.

The public and stakeholder outreach work will focus on providing the basic information needed to make informed decisions that help improve air quality and reduce GHGs in the City of Ottawa.

6.1 Monitoring and Baseline Study

In order to progress, as a City we need to understand our current performance on initiatives to mitigate climate change, adapt to it, and improve our air quality. The development of a technical environmental database would aid in establishing and monitoring environmental indicators for the City. This database would assist in providing accurate and timely information when requested. It would also serve as means to compare the City's performance with other communities and in providing our senior management and Council with useful information for decisions on new or changing programs.

The former City of Ottawa and Region each estimated their GHG emissions and defined plans of action. This plan establishes a blueprint for our amalgamated City. Additional inventory and assessment is required as a result of the completion of the Ottawa 20/20 process, and related plans including the Environmental Strategy, the Official Plan, and the Transportation Master Plan. In regards to corporate targets, amalgamation has changed the baseline on which the GHG reduction was determined. An updated corporate inventory will be a priority in 2005.

6.2 Actions and Initiatives to Meet Targets

To be able to meet our goals, an over-riding philosophy of curbing our consumption patterns will not only preserve our natural resources for future generations but will also improve the air quality. Creating a 'no-waste philosophy' within City operations would help influence the community to follow our footsteps. Pollution prevention initiatives within City operations will build on existing energy efficiency through simple policies such as the shutdown of computers and desk lights after work hours, reducing paper consumption, not idling vehicles or machinery, keeping up-to-date in technological advances, etc. Priority areas will be identified through a review in 2005 of existing material and resource use as well as of our policies, as committed with the Environmental Strategy.

To manage our emissions, updated inventories and projections are necessary as a first step in accurately assessing and designing actions against the objectives and targets proposed in this plan. However, many actions are ongoing, and are clearly required as part of any GHG reduction and air emissions management plan. A number of these have also been assessed as part of earlier climate protection work and potential challenges and contributions have been documented. The following suite of actions should therefore be considered a starting point that will provide immediate results, help establish medium term priorities, and give some indication of the challenges and opportunities ahead if targets are to be met.

6.2.1 Transportation

The transportation sector is one of the most significant producers of both GHGs and other air emissions. In Canada, transportation emissions account for approximately 26% of GHG emissions. In Ottawa transportation plays a greater role, contributing approximately 40% of our total GHG emissions.

Given that emissions in Ottawa are heavily dominated by CO_2 from fuel consumption for personal transportation, reducing car use, particularly single occupancy vehicles, represents a significant challenge and opportunity for the transportation sector as well as the overall action plan. Recent projections of on-road CO_2 show a "business-as-usual" estimate for 2010 of approximately 3,500 kilotonnes per year[27]. This compares to a previously calculated 1990 level of approximately 2,300[28]. A 20% reduction on 1990 levels by 2012 in the transportation sector translates into a 52% reduction from the "business-as-usual" level.

Meeting this challenge will require a combination of transit supportive development, transportation demand management (TDM), support for walking and cycling, as well as effective and affordable transit service, social marketing and public information. Many of the most significant transportation measures are presented in the Transportation Master Plan (TMP) and will only be summarized in this management plan.

The TMP sets challenging yet achievable transit modal split afternoon peak hour targets for 2021:

- Increase from the current 17% to 30% across the city;
- Increase to and from trips to the city core from 29% to 50%;
- Increase trips across the Greenbelt from current 17% to 34%;
- Increase trips to and from Gatineau from current 16% to 36%; and
- Increase walking mode from 9.6% to 10% and cycling modes from 1.7% to 3%.

A broad range of strategies designed to meet these targets are provided in the City's TMP, including:

- Shaping development patterns to support transportation goals (compact and transit friendly);
- Implementing TDM measures (reduce automobile dependency);
- Investing in new infrastructure and services (walking, cycling, and transit capacity and service);

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[27] Delcan Corporation. 2003. Transportation Master Plan Support Projects, Assignment 5 - Transportation, Air Quality and Climate Change. Report prepared for the City of Ottawa. 47 pg.
[28] JacquesWhitford/Torrie Smith. 2002.

- Investing in a “Rapid transit network”;
- Incorporating a “Transportation system management”, which include improved signal systems, intersection improvements, queue jumper for buses;
- Instituting an “Intelligent transport system” (highway monitoring and signalling); and
- Using transportation models to forecast and improve transit flow.

The TDM Strategy is a key component. It incorporates measures to improve travel options and encourages personal travel choices that benefit individuals and their communities. It will target employers, universities, and colleges with specific actions to reduce private automobile use.

> Each litre of gasoline translates into 2.4 kg of CO_2
>
> Each driver in Ontario emits 4 tonnes of CO_2 per year

At a corporate level, the Fleet Emissions Reductions Strategy (described in section 6.2.6.1) is a key component of the corporate commitment to improve air quality and reduce GHG as well as contributing to community reductions through measures that will see emission reductions from our transit fleet. The City is also leading by example by integrating supportive philosophies and practices within City departments and other levels of government. The TDM group will reach out to the public through partnerships and other forms of contact to improve public awareness of TDM benefits and encourage their use.

Other strategies that are currently underway to encourage more sustainable transportation choices and environmentally responsible behaviour include:

- Vehicle anti-idling campaign;
- Commuter Challenge;
- International Walk to School Day;
- Car Free Day;
- TravelWise community grants;
- TravelWise Awards;
- Active and Safe Routes to School;
- The Bruce Timmermans Cycling Awards;
- TravelWise Program;
- Community based TDM toolkit; and
- Eco-pass.

Transit trips create just one-third of GHG emissions of the same trip by car, while cyclist and pedestrians create no emissions at all.

Transit is therefore three times more energy efficient than car travel. Energy efficiency is another outcome of implementing TDM measures.

A number of measures have been examined in background reports for the TMP[29] and the climate change program[30]. These include:

- Increasing the number of fuel efficient cars and light trucks;
- Parking supply and pricing;
- Increase efficiency of the commercial fleet;
- Fuel content specifications;
- Development of alternative fuel systems (e.g. hybrid, fuel cell); and
- Tax incentives for alternative fuels.

Annex 4 provides further details on this list of proposed measures along with the City of Ottawa's role in their implementation. Many of these regulatory and promotion measures will see other agencies in a lead role, such as the provincial and federal governments.

Measures that deal with transportation emissions generally fall into three categories:

- Technological changes such as new vehicle pollution mitigation techniques and alternate fuels;
- Regulatory and fiscal incentives (e.g. sulphur levels in gasoline); and
- Behavioural/societal changes: for instance, a reduction in the use of personal vehicles.

In the case of the first two types of measures, the City is setting a sustainable practice example through the technology and type of fuel used in its own fleet of vehicles and buses. The behavioural and social impact the city has on the citizens is by providing education and the opportunity for people to reduce personal vehicle use. On a higher level, the city can only encourage senior governments on transportation issues and help promote private sector initiatives.

While the City may not have direct control over many of the technological and regulatory measures, most of which are initiated on the federal level, these types of measures have the potential to contribute to emission targets. It will be necessary to

[29] Delcan Corporation. 2003. Idem.
[30] Jacques Whitford/Torrie Smith. 2002. Idem.

adjust City actions to reflect progress in technology and in regulations as well as lend support to measures that contribute to overall City objectives.

> If no actions are taken, GHGs due to transportation are projected to exceed 1990 levels by 32% in 2010.
>
> Within Ontario, on-road transportation accounts for 79% of total CO_2 emissions (54% passenger and 25% goods movement).

6.2.2 Building Sector

The building sector (heating, cooling, power usage) equals the transportation sector in its contribution to GHG emissions in Ottawa. Past reports[31] have estimated that there is a potential for reducing eCO_2 emissions by 1,060,000 tonnes in the commercial, industrial, and residential building sectors through a combination of retrofit measures as well as improvements in heating and cooling systems.

Better Buildings Partnership (BBP)

The BBP is a private-public partnership initiative to promote and implement energy efficient retrofits of existing commercial, institutional and multi-residential buildings. This program includes energy efficiency, energy conservation, and water conservation. The use of proven technologies to conserve energy would be encouraged through both promotional materials and financial incentives.

Initial discussions to create a partnership among Ontario Hydro, Ottawa Hydro, Enbridge, and the City of Ottawa to develop and implement this community-integrated program occurred in 2001. Stakeholders such as community groups, home owners, home heating oil companies, educational institutions, industry and commerce will be invited to participate in or contribute to the program. The City of Ottawa will function as a 'clearing house' and, in partnership with the initiators, will manage and co-ordinate all aspects of the program.

The proposed program would undergo regular evaluations to determine its overall impact and to record key issues. In Toronto, the BBP is aiming at retrofitting 40% of the commercial/institutional floor space. It would be possible to do the same in Ottawa. Both the City of Toronto and Natural Resources Canada office of Energy Efficiency are willing to use their knowledge and experience to guide Ottawa through the process of initiating and implementing this program.

[31] ICLEI. 2001. Greenhouse Gas Inventory and Emission Reduction Strategies for Buildings in the City of Ottawa. 43 pg.

Promotion of Green Buildings

Residential and Industrial/Commercial/Institutional (ICI) buildings consume large amounts of resources (energy, materials, water) and generate significant amounts of waste and air emissions. One of the main opportunities to reduce GHG and air emissions is to construct new or retrofit existing buildings in such a way as to reduce these impacts. Sustainable design and construction can yield a range of impacts including reduced GHG emissions, air pollution, and water consumption.

There are several tools for promoting Green Buildings, one of which is the Leadership in Energy & Environmental Design (LEED) certification program. Another tool consists of the guidelines established by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). Both programs aim at reducing the ecological footprint of development by assessing new design projects or existing buildings based on:

- Sustainable sites;
- Energy and water efficiency;
- Materials and resource selection;
- Indoor environmental air quality; and
- Outdoor emissions from light pollution, noise and harmful pollutants.

The City of Ottawa is developing an internal policy to use the LEED system within City buildings, based upon the excellent results from pilot projects for the Bridlewood Community Centre and the Plant Recreation Project. To persuade the community to follow the LEED system, the City is leading by example. Also, the City will promote green buildings to the development community with the help of the National Capital Green Building Association, the Ontario Association of Architects, Building Owners and Managers Association, Home Owners Association, and others. As a first initiative, the City hosted a Green Roofs development workshop in early 2004. Further promotion and development of a Green Roofs policy are underway.

Aligning Regulatory Requirements to promote Green Buildings

Sustainable buildings have been around for many decades. In the past, innovative buildings have faced challenges in obtaining approvals including inflexible regulatory requirements that preclude sustainable approaches. For instance, municipal regulations requiring traditional water and sewage hook-ups, would not allow a sustainable house to be designed without these services. The Canada Mortgage and Housing Corporation suggests a “regulatory dialogue” amongst relevant stakeholders to identify a way to align existing regulations and supporting processes to achieve more sustainable or “green” building practices. In addition, some changes to the national and provincial building codes are required to significantly advance private sustainable building design, a change that is already building in momentum among municipalities across the country.

City Building Retrofit and Energy Audits

The energy efficiency retrofit program for city buildings is being implemented in response to energy audits conducted on 49 City buildings. An Energy Services Company (ESCO) contract is in place and over the next two years, retrofits will result in savings of 2,913,000 kWh and 15,000 cubic meters of water usage. Further opportunities for retrofitting will be explored, particularly longer payback time retrofitting.

In order to manage energy use, regular energy audits will be encouraged among City buildings. These audits may arise from grass roots, i.e. manager attuned to technology changes, through asset management groups, or through formal professional audits depending on available resources.

Residential Sector

One of the key programs to improve energy conservation in the residential sector is the federal Energuide for Houses program. This program has been delivered locally for several years by EnviroCentre, a non-profit organization which receives in kind support from the City, notably office space. To meet the growing demand, other organizations have joined in its delivery, advising residents on the most cost-effective ways to make homes more energy-efficient and healthier to live in. Based on an average GHG reduction of 3 tonnes per household, the program has the potential of reducing 10,000 tonnes of GHGs.

EnviroCentre also helps low-income households keep their electricity consumption below 750 kwh per month. Currently, it is also working with the City to help ensure that new social housing is more energy-efficient and thus more affordable to operate. EnviroCentre also plans to work with private housing builders to investigate the potential for synergy between the City's inspection process and better energy efficiency and ventilation levels in new home construction. Continuing and strengthening this partnership will contribute greatly to reducing energy use in the residential sector.

To finance building energy efficiency improvements (EEI), the Pembina Institute[32] is developing the concept of using Local Improvement Charges (LIC). This proposal would function in a similar fashion to existing LIC programs in the City with the key difference being the application of the charge to an individual property

[32] Pembina Institute for Appropriate Development. 2004. Using Local Improvement Charges for finance building energy efficiency improvements – A concept report, 23 pg.

rather than a larger benefiting group such as a community. A property owner would decide to incorporate EEI, and then contact the municipality who would have a list of eligible contractors and technologies. Once selected, the contractor and the owner would discuss options, keeping in mind the eligible technologies listed by the municipality. Once a contract is signed; the municipality would inspect the job and pay the contractor. The costs are then spread over 5, 10 or 15 years at the Bank of Canada rate, appearing as a separate item on the tax bill. The charge is attached to the property, not to the owner, with the payments set slightly below the actual energy savings.

This method provides an immediate benefit in homeowner energy savings and removes barriers that prevent investing in energy efficiency such as:

- Hesitancy to accept long paybacks;
- Lack of access to capital to improve existing buildings or to build efficient new buildings; and
- Attribution of the energy savings directly to the investor.

This is a relatively new concept. Additional work will be completed in 2005 to define more precisely the potential application of this program in the City of Ottawa. Such considerations as administrative expenses and financing costs, as well as legal mandate and any necessary changes in the *Municipal Act*, will have to be carefully weighed against the potential benefits.

6.2.3 Waste

Waste management measures that involve reducing the amount of material sent to landfills contribute to both air quality management and GHG reduction. The City's draft Integrated Waste Management Master Plan (IWMMP) provides an overall plan for community waste reduction, diversion and management.

With implementation of measures such as the landfill gas cogeneration and programs within the IWMMP, the waste sector will make a significant contribution towards meeting the City's GHG reduction targets. The current direction for the IWMMP is to:

- Increase waste diversion toward a 40% goal - 1st phase;
- Increase diversion rates to at least 50% - 2nd phase, through potential initiatives such as bag limits and curb-side collection of organics;
- Monitor, test, evaluate, and implement initiatives that leverage technology or environmental benefits; and
- Thermal treatment of contaminated soil to produce inert soil.

Waste Diversion Goal Motivation

The Ontario Government is currently examining setting mandatory waste diversion targets for municipalities. The diversion rates would be based on the population of the municipality.

6.2.4 Alternative Energy and Conservation Programs

Further contributions to meeting our GHG reduction target of 20% by 2012 can be achieved with the implementation of programs for energy efficiency, energy conservation, and changes to energy supply. Some of these programs are in the initial stages of development while others already underway. The programs aimed at energy savings to combat the effects of climate change and air quality are outlined below.

District Energy

District energy refers to a group of buildings sharing one energy supply for both heating and cooling. The efficiency of these systems is achieved through reduced energy losses because of local provision, use of readily available and local fuel sources and the potential to use heat that is a by-product of other processes. Ottawa is well situated to have several or one large district energy system due to the proximity of many large commercial and industrial buildings, particularly in the downtown area. The fuel used for space heating could be natural gas, locally produced waste or low-grade heat from E.B. Eddy, further reducing the fossil fuel use. The latter would use heat now being discharged into the Ottawa River.

Energy Ottawa, in association with the City, has conducted a feasibility study to implement a small-scale district energy system in the downtown core. This study has recommended a system, which could potentially reduce GHG by 12,000 tonnes per year. Further district energy potential will be explored and encouraged.

Wind Energy

Although the Ottawa Valley is not conducive to large windmills, the City will explore the potential for energy generation from small wind turbines. A wind map of the city would help identify feasible areas for energy production. Transmission of this energy might need to be coupled with new and emerging technologies.

At present, a potential community wind energy project of approximately 5 Megawatts (MW) is being explored for a location near Galetta. This project, if realized, could reduce GHG emissions by approximately 12,000 tonnes. The City will continue to support additional wind energy projects, where feasible.

Landfill Gas Co-generation

The potential exists to generate between 5 to 9 MW of electricity from landfill gas co-generation, enough to heat between 5000 and 6000 homes. The City has entered in a partnership agreement with Energy Ottawa to utilize the gas from the Trail Road and Nepean landfill sites, which is slated to start production by the end of 2005. This project will produce 5 MW and reduce a large amount of GHGs representing 6 to 12% of community emissions from 1990 levels. There are also private landfill sites such as Carp with the potential to produce 4 MW. The City will continue to promote and encourage energy projects such as these to help us reduce our community GHGs while providing green energy to displace provincial coal-generated electricity.

Water Consumption and Energy Use

Each day an average resident of Ottawa uses approximately 250 litres of water. Water consumption affects energy use due to the energy consumed to treat and distribute drinking water, collect and treat wastewater, and in the heating of water for showers, laundry and dishwashing. In Ottawa over 20% of the corporate electricity and natural gas energy budget goes into water and wastewater services.

A Water Efficiency Program prepared for the City concludes that the following measures would be cost effective, when comparing the cost of each water efficiency measure to the equivalent cost to expand capacity by the projected water savings for that measure. The program proposes the following five strategies:

- An *Outdoor Water Use Strategy* aims to reduce lawn watering and hence peak summer water demand. This element was implemented in the Summer 2004 Water Wise Education Program;
- A *Non-Revenue Water Strategy* focuses on a diagnostic approach in finding non-revenue water. Its largest component is distribution system leakage. The City has an ongoing leak detection program and is starting to use District Meter Areas as a new method of leak detection;
- An *Indoor Water Use Strategy* with many possible components including indoor water audits for municipal facilities, a residential toilet replacement or retrofit program, a horizontal axis washing machine rebate program, a showerhead replacement program, sink aerators, and indoor water audits for the Industrial/Commercial/Institutional (ICI) sector;
- An *Education and Awareness Strategy* is a component of all three strategies above with a strong potential for integration with other City

initiatives such as the Healthy Lawn campaign and campaigns to promote energy conservation; and

- A *Monitoring and Reporting Strategy* to support fine-tuning of programs and strategies to maximize effectiveness.

There is great potential for joint delivery of water efficiency and energy conservation programs. For example, the Better Buildings program could encompass indoor and outdoor water audits as well as energy considerations. Every effort will be made to identify and exploit these opportunities as both initiatives move forward.

Streetlighting

Over the last decade, measures have been undertaken to improve the energy efficiency of traffic signals and street lighting. Traffic signals have been improved through reduced bulb wattage. Light emitting diode (LED) technology will replace more of these in the near future once challenges related to high capital costs and long pay back periods are overcome.

A set of guidelines aimed to reduce light pollution will be incorporated into the City's urban design guidelines in 2005.

Employee Energy Efficiency Program

The existing Employee Energy Efficiency Program is an internal program for City employees to undertake energy and water efficiency improvements in their own homes as well as at the office. This program consists of an education campaign to make employees aware of the many ways in which they can contribute to the GHG reduction strategy. Over the last few years, some aspects of this program have been delivered through the City's Green Rep Program. An expansion of information materials, with the potential for additional resources, will be needed to achieve a comprehensive program.

Heat Recovery Systems

Households, city operations, industries and commercial facilities all have the potential to recover heat for water, such as groundwater or wastewater, as an alternative to using new sources of energy. Within the City, we will explore the potential for further tapping into energy resources at the Robert O. Pickard Environmental Centre (ROPEC). This facility has already set up a cost-effective cogeneration facility, using methane from biosolids digestion as an energy source, to heat buildings at this center and thus lower our electricity bills. The potential exists to also recover heat from the facility's effluent, which averages 10^{o}C in the winter.

Similar systems exist to recover the heat from household wastewater and from operations that discharge large amounts of heated wastewater. The greatest savings can be realized in buildings with a large number of showers and laundry facilities.

Provincial Initiatives

The province of Ontario introduced Bill 100 -The Electricity Restructuring Act - to the Legislature on June 15, 2004. The intent is to promote the expansion of electricity supply and capacity, particularly for alternative and renewable energy sources. In addition, the Bill contains provisions that would promote conservation, energy efficiency and load management. If the Bill is accepted, Ottawa community members will benefit from more education on conservation and energy efficiency thus leading to a better electricity demand management. Bill 100 will impact GHGs by helping municipalities to further support energy efficiency and develop alternative energy sources.

6.2.5 Sustainable Land Use Planning and Community Greening

Although their contribution is difficult to quantify, sustainable land use planning and community greening also reduce GHGs and improve air quality. Many of these measures are already established in the Ottawa 20/20 plans, in particular the Official Plan, the Environmental Strategy and their supporting plans (e.g. Greenspace Master Plan, Forest Strategy). The recently adopted Official Plan for the City of Ottawa creates the foundation for establishing actions and measures within the sustainable land use planning and community greening action area by including the following policies:

- *Maintaining current urban boundaries;*
- *Following a watershed/subwatershed planning approach;*
- *Provisions for compact and mixed-use development linked to transit;*
- *Increasing transit use and walking and cycling;*
- *Design provisions for energy conservation; and*
- *Maintaining and enhancing forest cover, protecting wetlands as carbon sinks and natural filters of pollutants (Annex 2).*

There are also other land use provisions that relate to general community and urban design. Sustainable development supported by public transit is a fundamental principle of the overall Ottawa 20/20 Growth Management Strategy and in particular for the City's new Official Plan. Both the Official Plan and the Environmental Strategy promote higher development densities, brownfield development, less area for parking, as well as more bicycle and shower facilities.

Community Design Plans represent an opportunity to incorporate energy efficiency at a community level through street orientation principles, location of major land uses, forest protection and transit supportive design. South-facing buildings and windows maximize solar energy potential. Landscaping can provide summer shade and protection from winter winds. New development is now required to take advantage of energy conservation design techniques.

Land use planning provisions are established at several levels including policies in the Official Plan but the most direct impact occurs at the zoning and site plan approval stage where policies become practice. The environmental recommendations to the current zoning by-law cover transportation, building, waste, land use planning, and community greening. The zoning and site planning process provides a number of opportunities as illustrated by the examples in Table 6.

Table 6. Zoning/Site Plan Implementation of Environmental Objectives

Category	Recommendation	Possible Zoning By-law/Site Plan Approval Implementation Techniques
Transportation	Encourage behavioural/societal changes such as a reduction in the use of personal vehicles.	Reduce minimum parking requirements to better reflect policy objectives, rather than a traditional demand-based approach
		Impose maximum parking requirements near rapid transit service to encourage transit usage
		Provide for the provision of transit facilities on private lands (e.g. bus waiting areas at shopping centres, office buildings)
		Require bicycle parking facilities as an alternative to the motor vehicle; and provide incentives for the provision of cycle parking facilities by reducing motor vehicle parking requirements
		Reduce required size of parking spaces, driveways and aisles to reduced amounts of paved areas
		Allow sharing of parking facilities between complementary uses to reduce need for parking space development
		Encourage telecommuting by continuing to permit home-based businesses to reduce number of home-work trips
		Permit rapid transit service to locate in any zone, to remove obstacles to expansion of facilities
Buildings	Align Regulatory Requirements to Promote Green Buildings	Allow the location of solar panels, collectors and other similar “green” systems on roof tops above the normal height limit, or in all yards on every lot
		Allow windmills for power generation to project beyond the normal height limits
Sustainable Land Use Planning and Community Greening	Provide for compact and mixed-use development linked to transit	Allow or require mixed-use development in the vicinity of transit stations
		Provide more flexibility in zones by eliminating unnecessary regulations to facilitate increased densities
	Maintain and enhance forest cover, protecting wetlands as carbon sinks and natural filters of pollutants	Place restrictive zoning on environmentally significant areas to discourage destruction of natural resources
		Require landscaping in all new developments
		Require landscaping of all parking lots (both perimeter and interior landscaping); require additional landscaping in parking lots where more parking is proposed to be provided than that which is required by the zoning by-law
		Allow flexibility in the location and design of amenity space in multiple unit residential development (rooftops, yards) to encourage increased use of landscaping
		Create more flexible landscaped open space requirements to allow for greater range of design options
		Allow development of community gardens in all zones
		Restrict the amount of yard space that may be used for parking and require greater amounts of landscaped open space

Community Greening and Forest Cover

Forests and green spaces contribute to GHG reduction targets and air quality improvements through a range of measures including the natural filtration of pollutants, energy efficiency through shading, and carbon sequestration. It is also an area where co-benefits increase substantially due to the importance the community places on other values of forests and green spaces.

The Official Plan establishes an overall target of 30% forest cover (current level is approximately 27%). The Forest Strategy will refine this target to provide the most appropriate approach for area specific targets, likely to differ amongst rural, urban, and developing community areas. From an Air Quality and Climate Change management perspective, the City will assess greenspace according to concepts such as carbon sequestration potential, reduction of our urban heat island effect, and capture of particulate matter by forest cover.

One of the initial priorities in this area will be to establish a regular system of assessing the amount and health of forest cover in the rural and urban areas. This will begin in 2005 with an overall assessment of forest cover through a classified remote sensing image to be conducted jointly with the Eastern Ontario Model Forest, Conservation Authorities, and the Ministry of Natural Resources. A detailed forest cover inventory will be completed over a two-year period. This initiative will also be a critical component of the Ottawa Forest Strategy as described in the Environmental Strategy (Oct. 2003) and scheduled for completion in 2005. Other components that will be developed in more detail in the Forest Strategy include:

- ***Analytical tools to establish forest value:***
  In order to factor the value of forests for their air quality enhancement and GHG reduction potential into policy and planning decisions, some new analytical tools are needed to assess the contribution of urban forests to the carbon sink. The City will explore and develop these approaches beginning with a pilot project with the Tree Canada Foundation and the Federation of Canadian Municipalities' Green Municipal Enabling Funds to apply City Green, a GIS based analytical tool, to assess the contribution of forest cover for a range of values including air quality, energy conservation, and GHG reduction.
- ***Programs for forest cover enhancement:***
  The City participates in several programs to enhance forest cover. In particular, the Green Acres program establishes new forest cover on previously un-forested land in the rural portion of the city. The City will explore possibilities of expanding the program by acquiring climate change funding, an option that is likely to be realized by the Rideau Valley Conservation Authority. The City's Municipal Street Tree Planting program plants approximately 1,000 trees every year and will explore increasing this amount.

- ***Programs for forest protection:***
  In addition to forest enhancement, the City has a number of programs to protect forests that include:
  - Draft *Good Forestry Practices Bylaw In Sensitive Environmental Areas*;
  - Requiring all subdivisions and site plans to be supported by tree retention and planting plans, as required by the City's Official Plan. The City will continue to work with the development community to improve tree preservation; and
  - Sub-watershed planning that identifies significant features for woodland protection and enhancement, particularly in their contribution to subwatershed health.

Agricultural practices and land Management

Agricultural crops and forage remove carbon dioxide from the atmosphere (through photosynthesis), storing it in plant material above and below ground and then adding organic carbon to the soil as the plant materials decompose. Plant materials can be used as a carbon sink when stored for long periods of time or as products, like ethanol, which replace fossil fuel.

When crops are harvested, some of the carbon (as plant material) is removed as food for livestock or human needs with much of the remaining plant residue incorporated into the soil, to be released slowly through decomposition processes. The Canadian Agricultural Kyoto Table outlines the following farming practices that can slow carbon loss and increase long-term soil organic carbon within agricultural lands (SOC):

- Conservation tillage or no-till farming - reduces soil disturbance, maintain plant residue in larger pieces that do not decompose as quickly and reduces fossil fuel emissions from farm machinery (fewer passes across the fields).

- Encourage re-establishment of native or perennial vegetation on lower capability agricultural lands - this practice increases SOC in previously cultivated soils. Converted marginal croplands can also act as shelterbelts for enhanced wildlife habitat and to provide a windbreak that reduces soil erosion as well as a protection for aquatic resources when native vegetation is re-established along watercourses.

- Reduce summer fallow - continuous, rotated, cropping practices result in a higher SOC than those with a high frequency of fallow.

- Include perennial forages - they have longer growing seasons than annual crops. Regularly including perennial forages in crop rotations increases SOC.

- Integrate grazing management systems, feeding strategies, and zero tillage cropping systems to maintain high SOC.

The above suggested practices to maintain good levels of soil organic carbon are also recognized as good management practices for maintaining productive soils. Although the primary responsibility for promoting agricultural best management practices rests with the Ontario Ministry of Agriculture and Food, supported by such organizations as the Soil and Crop Improvement Association (Environmental Farm Plan program), the City can support many of the above practices by:

- Promoting agricultural best management practices through implementation of interagency stewardship recommendations in watershed and sub-watershed plans. In addition to maintaining productive agricultural lands, these BMP's also contribute to maintaining and enhancing water quality, aquatic and terrestrial habitat, and contributing to overall watershed health; and
- Continuing the Rural Clean Water program to provide financial incentives to farmers for specified agricultural BMP's.

6.2.6 Towards controlling smog

The Ministry of Environment of Ontario is aiming to reduce smog episodes by 75% within the Province. This plan requires an aggressive emission reporting system and the development of smog action plans by municipalities. The City of Ottawa's smog action plan targets the reduction of smog-causing emissions and provides an emergency response of additional measures on smog alert days.

To reduce smog causing emissions, the City plan, approved in 2004, has two main components - one focused on actions within City operations and one that is for the community, with partners from all types of organizations. Corporately, the City will:

- Keep up with technological advancements relating to fuels;
- Use low-sulphur diesel;
- Test City vehicles for compliance with Ontario's Drive Clean Program;
- Develop and implement pollution prevention initiatives; and
- Implement the approved smog action plan (based upon Ministry of Environment suggestions), including:
    - Postponing re-fuelling until dark;
    - Instituting a Transportation Demand Management program for employees; and
    - Developing a procurement policy that buys energy efficient equipment, cleaner fuels, and adjusts contracting practices over time to reduce emissions from surface operations i.e. grass cutting, asphalt laying, etc.

External initiatives include:

- Coordinating smog response efforts with the City of Gatineau;
- Developing partnerships with other public and private agencies such as the Ontario and Quebec Ministry of the Environment, Environment Canada, Building Owners and Managers Association, Enbridge Consumers Gas, Ottawa Hydro, Quebec Hydro, non-government organizations, Ottawa School Boards, Rideau Valley Conservation Authority, NRCan, other Federal government departments, and the NCC;
- Continuing initiatives to reduce vehicle idling;
- Reducing the heat-island effect by increasing vegetative cover and reflective surfaces (i.e. parking lots and roofs);
- Establishing an air quality monitoring network with special attention to roadways with heavy traffic, where appropriate; and
- Promoting cleaner transportation alternatives such as hybrid vehicles, electric power-assisted bicycles, cycling, walking and transit.

Emergency response for smog alert days will include automatic notification to health care centres, senior citizen centres, and to vulnerable populations to stay indoors and reduce their physical activity. The City is also working towards having this notification trigger fuel use reduction actions such as:

- Reducing the use of two and four cycle engines (during smog alert days). Examples include vehicle use as well as use of weed-eaters, lawnmowers, cement mixers, small boat engines, etc.;
- Telecommuting;
- Postponing of street sweeping; and
- Postponing of asphalt laying and oil-based painting until after 4:00 pm.

In summary, the same measures and programs instituted for energy savings are also effective in reducing smog.

6.2.6.1 Fleet Emission Reduction Strategy

In 2002, City Council approved the Fleet Emissions Reduction Strategy (FERS)[33], updated in 2004 and is currently being implemented. The FERS is comprised of several initiatives for reducing exhaust emissions from the City's fleet over three major time periods. These are summarized below:

[33] http://ottawa.ca/calendar/ottawa/citycouncil/occ/2004/06-23/trc/ACS2004-TUP-FLT-0001.htm

Short-Term (within 3 years)

The City Fleet operates in conformance with the City's Corporate Vehicle and Equipment Idling Policy[34]. The main requirement of this policy is that City vehicles be turned off whenever idling time is expected to exceed one minute, between spring and fall, thereby alleviating unnecessary emissions. For our transit bus fleet, special procedures are in place to prevent engine overheating and failure to start, and to accommodate space-heating and cooling requirements for passengers in the appropriate season.

Refuelling options to reduce emissions from the City fleet are at various stages of implementation:

- Most of the City's gasoline refuelling sites have been converted to E-10, a blend of 10 per cent ethanol and 90 per cent gasoline, resulting in a significant net reduction in ground-level ozone-forming emissions. In addition, CO and CO_2 emissions are reduced by 1 tonne and 250 tonnes per year, respectively, when compared to using conventional gasoline;
- The City continues to procure diesel fuel with progressively decreasing sulphur levels and last year began purchasing ultra-low sulphur diesel (15 ppm) - one of the first Canadian cities to do so - for our newest articulated buses. The presence of sulphur in diesel fuel and gasoline forms SO_x upon combustion. Sulphur dioxides produce acid rain, causes respiratory problems, and contributes to smog formation; and
- The use of alternative diesel fuels for the City fleet continues to be assessed. As a result, biodiesel - derived from a blend of normal diesel fuel and renewable biological sources - will be considered for near-term use because of its significant environmental benefits through reduced CO_2 and criteria air contaminant emissions.

All of the City's transit buses procured since 1997 (about half of the fleet) are equipped with exhaust after-treatment systems that incorporate either particulate traps or oxidation catalysts, sometimes in combination with exhaust gas re-circulation systems. The use of these technologies can significantly reduce criteria air contaminant emissions; for example particulate traps can reduce PM emissions by 50-90 %. A limited number of these devices, sponsored by Environment Canada, are also being retrofitted to older buses in the fleet.

Mid-Term (4 to 10 years)

The centrepiece of the mid-term component of the FERS is procurement of hybrid diesel-electric transit buses. These will serve as a transition vehicle leading to zero

[34] http://moe/main/me_corp/policies/doc32_en.asp

exhaust emissions (long term) that use some form of electric propulsion based on fuel-cell technology. Current indications are that improvements in exhaust emissions and fuel economy will be substantial with hybrid buses. Tests performed by Environment Canada, using the hybrid and conventional diesel buses in service at New York City Transit (NYCT), have demonstrated very positive results. In these tests the following reductions were obtained:

- 38% of CO_2;
- 49% of NOx;
- 60% of PM;
- 38% of CO; and
- 59% of fuel consumption.

The results of emissions testing of NYCT buses also demonstrated that emissions reduction using hybrid-diesel electric technology is generally comparable to compressed natural gas (CNG) technology. In fact, in most-cases, the hybrids set the performance benchmark for all buses tested. The results also demonstrated that, when operated under severe duty cycles, the performance of the hybrid buses was significantly superior to that of the CNG buses.

Long-Term (11 to 20 years)

The long-term component of the FERS is the conversion of the transit bus fleet to zero tailpipe emissions. This technology of using electric propulsion based on fuel cell technology, will be adopted once commercially available. Hydrogen fuel cells are recognized as the most promising technology for future powering of the world's fleets of ground vehicles that are now dependent upon fossil fuels. Significant progress has been made in the development and demonstration of this technology, however, performance, reliability and durability have yet to be proven, particularly in a transit bus environment. Additionally, the most significant challenge to the commercialization of fuel cell technology continues to be infrastructure. Hydrogen is the world's most abundant fuel and is found in several forms including water, oil, natural gas and biomass. However, providing a cost-effective and environmentally sound source of pure hydrogen, which must compete favourably with today's petroleum-based fuel supplies, is a significant challenge. The economical and safe delivery and storage of hydrogen, either as a compressed gas, a super-cooled liquid, or as a solid - in metal hydride form - is a considerable barrier to commercial availability.

6.2.6.2 Use of Road Salt

Road salt is a potential source of pollution to land, water and air. Particulate matter becomes airborne from the thousands of tonnes of salt used each winter. As a pollution prevention measure, the City of Ottawa developed its own salt management plan to reduce road salt use, mainly for environmental protection. This plan follows many of the control measures suggested by Environment Canada's Code of Practice for the Environmental Management of Road Salts, published in the Canada Gazette April 2004:

- Better storage and handling techniques around salt storage sites;
- Improved salt application technologies and practices;
- Use of alternative products; and
- Meteorological forecasting tools that allow the reduction of salt use.

Appropriate planning and design of snow disposal facilities can be used to manage contaminated runoff. Pre-wetting and anti-icing techniques on paved surfaces assist in reducing application rates. Weather information along with sophisticated electronic spreader control equipment allow the accurate placement of precise amounts of salt on the road surface.

The City of Ottawa is actively working with Environment Canada and other municipalities to further develop Salt Best Management Practices for winter maintenance operations.

6.2.7 Towards Controlling Non-Point Source Emissions

The City is aiming to control non-point source emissions because their additional impact on air quality and subsequently upon human and ecosystem health. In this plan, non-point source emissions are those fugitive emissions from different types of human activities such as: wood combustion, road dust, odours, noise, light pollution, and pollen. A series of pollution prevention initiatives are suggested.

6.2.7.1 Wood Combustion

In combination with other fuel combustion emissions, our winter air quality is affected by local wood combustion, topographic features and meteorological factors. Wood is a renewable resource that offers the potential to displace fossil fuels as a heat energy source. However, inefficient wood stoves or poor burning practices have as much to do with poor local winter air quality as the meteorology and geography of our area. This situation can be improved through education to encourage residents to acquire certified wood stoves and to implement better burning practices. In addition, regulations could be considered to lower levels of $PM_{2.5}$.

The promotion of efficient certified wood stoves and good burning practices to maintain good indoor and outdoor air quality started in the Fall of 2003. This program will continue in partnership with Environment Canada and NRCan. The

City will also lobby the federal government for the Canadian certification of efficient wood stoves.

Another measure to deal with poor winter air quality from wood burning can be achieved through forecasting. Fortunately, the technology exists to forecast poor atmospheric dispersion. In December 2000, Environment Canada launched a monitoring program for winter air dispersion in Montreal. The City of Ottawa will explore establishing a partnership with the Meteorological Service of Canada, particularly with the atmospheric divisions of the Ontario and Quebec Regions as well as the City of Gatineau, to implement a winter air quality program. This program would involve weather forecasting and a warning system similar to the one in Montreal where people are advised to avoid wood burning during poor atmospheric dispersion periods.

6.2.7.2 Road Dust and Street Spring Cleaning

Spring is the period with the highest PM count. In part, this is due to the use of abrasive material during the winter such as sand and salt and to higher wind speeds and unprotected soil associated with spring.

Currently the purpose of street sweeping in the City of Ottawa is not for the removal of inhalable or respirable particles but for aesthetic reasons. There are two ways to control PM emissions from paved roads:

1. Preventative controls (prevent materials from being deposited onto the surface); or
2. Mitigation (remove deposited material from travel lanes).

The former can only be obtained with intensive Transportation Demand Management programs. The latter would require programs that are designed to reduce PM emissions in a more aggressive way than for aesthetic reasons. The City will continue towards improvement in best practices in the control PM.

6.2.7.3 Pesticide Reduction Strategy

Pesticide use impacts air quality because application often leads to aerial dispersion of the applied compounds beyond where they were meant to go. Although not definitive, human and ecosystem health effects have been linked to exposure to chemical pesticides. To respond to this finding that is increasing in certainty along with the public concern with this issue, the City implemented a formal pesticide reduction strategy in 2002. The strategy included reduction targets for cosmetic pesticide use to be reached by the end of the 2005 growing season. If these targets are not met, the City will consider a regulatory approach.

6.2.7.4 Measures to Control Odours

Odours are an indication of an air quality problem. As such, the City in conjunction with the provincial government may require the adoption of best available practices to reduce emissions. In the future, an odour management approach could include[35]:

- Reduction of emissions from identified sources and fugitive emissions;
- Regular inspection regime to ensure that no new sources of fugitive emissions arise;
- Maintenance of separation distances to allow for process upsets;
- Monitor community complaints as an indicator of environmental performance and respond, as appropriate;
- Use of modeling to predict "worse case" scenarios; and
- Measurement of emissions, installation of weather stations, and use of controlling and abatement techniques.

The City also encompasses a large rural area that supports livestock operations. Although land use separation distances are used to reduce conflicts between different land uses, such as odour, normal farming practices do produce occasional odour issues. As noted above, the City, in concert with other agencies, will encourage agricultural and manure best management practices and the use of new technologies to control odours, where appropriate. In terms of City facilities, the most significant sources include the wastewater treatment plant and landfills, both of which have odour management strategies.

6.2.7.5 Measures to Control Noise

Although noise is a part of modern life, above certain levels it becomes an air pollutant.

The Official Plan has a set of policies to address noise from rail, road and rapid-transit, airports and stationary sources. In addition, the City enforces its Noise By-Law to control types, levels and timing of noise that is acceptable within the City. As the population increases or should noise become more of an issue, the City will refine its existing policies and approach.

6.2.7.6 Measures to Control Light Pollution

The intensity of our urban lighting is of concern to astronomers as well as to residents and drivers, both for quality of life and safety reasons.

[35] EPA. 2001. Approaches to odour management. http://www.epa.vio.gov.au, Australia

The solution to light pollution is to eliminate all unshielded fixtures and light trespassing. It is important to control glare and contain light within a designated area. Lighting should be designed to the lowest possible level of light while maintaining safety, security, identification, way finding, and aesthetics. Full-cut off luminaries and/or shielded fixtures control stray light use (down-lighting technique rather than up lighting). High or low-pressure sodium lights are recommended. Education is required to work towards the minimization or elimination of landscape feature lighting.

The City is currently preparing a plan for urban lighting, to be discussed through 2005.

6.2.7.7 Measures to Control Pollen

The large number of people suffering from allergies in the spring is a consequence of the increasing sensitivity to pollution. It is important to reduce the exposure to pollen and mould, where possible.

Recently disturbed areas where the natural vegetation has been removed for development tend to have higher amounts of ragweed. Residents and developers should be advised to avoid excessive clearing of vegetation and to keep the period between clearing and development short.

The use of trees in landscaping could be planned to avoid excessive amounts of pollen. It has been noticed that productivity is reduced by 2% in buildings with higher pollen count. The use of cultivars, which produce sterile trees for planting around office environments, might help solve this problem. This type of information will be distributed to owners and managers of buildings to avoid pollution by pollen.

6.2.8 Air Quality Modelling

Since air quality is not evenly distributed across an urban area, it is important to identify local air quality conditions, trends, and trouble spots. Using models to combine the emission information with meteorology and other factors to simulate actual measured air quality in the Ottawa Valley, allows testing of hypothetical emission reduction strategies. Modelling and emission inventory techniques will be key analysis tools used to support the development of air quality strategy options.

Modelling is a powerful tool for interpretation, prediction, and optimization of implementable control strategies. Modelling, however, must be verified against real data, hence the importance of air quality modeling. The City will explore the best approach for modeling of air quality concerns for the community.

6.3 Adaptation Measures

Regardless of the effectiveness of actions and measures, the climate is changing and climate change will very likely have some long-term impacts. In Ontario, annual temperatures are predicted to increase between 2-5^{o}C by the latter part of the 21st century. Potential impacts include:

- Increases in the frequency and intensity of pollution episodes;
- Increased heat stress;
- Changes in the frequency or intensity of extreme weather events;
- Changes in biodiversity and increased risks from invasive/exotic species;
- Changes in surface and groundwater supply;
- Changes in snow cover; and
- Changes in growing season and agricultural potential.

As climate changes occur, the City of Ottawa will need to have adaptation measures ready. These measures include considering possible changes when planning and investing in infrastructure, taking precautionary approaches, and initiating programs to lessen the impact of air quality and climate change concerns on health, safety, and general environmental quality.

An adaptation strategy will be developed in more detail during Phase 2 of the implementation of this management plan. The immediate priority as outlined in this management plan will be placed on adaptation measures which are related to human health and which serve immediate objectives with respect to air quality and addressing current conditions.

The most important effective mitigation and adaptation measure is a positive change in behaviour. Behaviour changes will occur only if it is preceded by education and awareness. This allows individuals in the community to form their own educated opinions and act upon them. Adaptation measures that the City of Ottawa will or has implemented are:

- Heat island controlling measures (white surfaces, green covers, reflective roofs, etc.);
- Heat alerts (open community centers);
- Smog alerts; and
- West Nile Disease control measures such as spraying at larval state.

Climate change will not only raise the temperature in Ottawa but will also affect our air quality through: increased smog episodes; a more intense heat island effect; additional heat stress events; added challenges to new and more virulent diseases such as West Nile; and increased climate variability. All of these impacts will require adaptation measures. The City will meet this challenge by developing an adaptation plan to climate change.

6.3.1 Heat Island Controlling Measures

Vegetation cover is one method to control the heat island effect. Besides lowering the temperature, vegetation removes particulates from the air by acting as filters. Due to the short life span of urban trees in Ottawa (7 years) that endure large quantities of salt in the winter and physical abuse from snow removal, the following measures will help in controlling the heat island effect: garden, reflective or green roofs; reflective parking surfaces (using cooling concrete instead of asphalt); and encouragement of tree planting wherever possible. These simple measures will be encouraged particularly in infill development.

6.3.2 Heat Alert

Ottawa residents are more vulnerable to sudden heat waves than people from lower latitudes because the population is not adapted to irregular, intense heat waves. Excessive hot weather kills. With climate change upon us, heat episodes will be more numerous and appear earlier in the year. It is important, therefore, to develop an adaptation measure involving a heat watch warning system similar to the one developed for Toronto. These systems are usually based on a heat index value, cloud cover, wind speed, cumulative impact of several consecutive days of oppressive weather, and the point in the season it occurs[36].

The heat load on dwellings and people is increased by clear skies and higher wind speeds. Heat waves that occur earlier in the summer create more of a health danger because people have not been acclimatized to the heat. The complexity of determining when these heat episodes will occur would require the involvement of several agencies including the Meteorological Service of Canada (MSC).

The MSC can provide the forecasts of oppressive air masses. The City's approved Smog Action Plan includes a heat alert that will mobilize a team of volunteers and municipal staff to warn vulnerable populations to stay indoors in cool air-conditioned areas. Community centres will be opened for these special occasions for those without air conditioning at home.

6.3.3 Emergency Preparedness

The climate norm has recently been plagued by extreme weather events. Freezing rain events, flush floods, and forest fires are not unheard of today. Each

[36] Kalkstein, L. 1999. Climate-Health showcase projects: International Heat/Health watch-warning systems. Proceedings from the Biometeorology and urban climatology at the turn of the Millennium: ICB-ICUC Sydney, 8-12 Nov. 1999.

municipality is mandated to have an emergency preparedness plan to deal with these types of events as well as other major threats.

The Emergency Management Unit at the City of Ottawa is prepared to deal with the aftermaths of any disaster. Depending on the level of the disaster the provincial and federal governments can be called in to help.

Reducing the impact of these disasters requires the development of an adaptation program. Our ability to cope with disasters hinges on factors such as the ability of the infrastructure to handle greater than 100-year events (i.e. rain and snow storms). The City of Ottawa is in the position to influence our ability to adapt to these events by writing and implementing policy. This may mean that community centres may need access to emergency heat or energy sources in the event of a power outage. Adaptation to sudden changes will reduce their impact.

In conjunction with the Emergency Management Unit, the Environmental Management Division will evaluate the best ways to link extreme weather events with emergency preparedness. The Environmental Management Division and the Public Health Branch will also be keeping abreast of literature related to environmental emergency impacts and response.

6.4 Air Quality and Climate Change Implementation Strategy

This management strategy will be implemented in three phases (Table 7). Phase I will involve the planning and monitoring aspect of the plan, including air quality modelling. Phase II entails implementation of the management strategy. Phase III will concentrate on the evaluating the management measures and long-term trends.

Table 7. Air Quality and Climate Change Management Strategy

Phase I: Planning and Monitoring	Schedule
1. **Refine Corporate Inventory of GHG emissions** to incorporate the complete dataset from the amalgamated municipalities and contributions of existing Corporate actions and programs to reduced greenhouse gas and air contaminant emissions.	**January 2005 – June 2005**
2. **Prepare a preliminary air emissions inventory** and air quality data summary report to present current knowledge of ambient air quality within the community.	**January 2005 – June 2005**
3. **Set-up and/or enhance an ambient air quality monitoring program** within the City, in partnership with the provincial governments of Quebec and Ontario and the federal government. Explore the acquisition of a mobile $PM_{2.5}$ monitoring station and the possibility of adding ambient air monitoring analyzers to the existing complement.	**January 2005 – March 2005**
4. **Identify steps to improve air quality** in the community for such issues as smog, wood burning, road dust, etc..	**2005 – ongoing**
5. **Refine the community GHG emissions inventory** for present status and to model the future GHG emission levels.	**May 2005 – May 2006**

6.	**Refine priority air contaminant emissions data** (include all sources such as road dust, mobile sources, heating and cooling, etc.)	**May 2005 – May 2006**
7.	**Initiate air quality source monitoring.** Determine source apportionment of priority contaminants through modelling/ambient monitoring in partnership with National Research Council, the Province or universities.	**2006 – ongoing**
8.	**Stay current with climate change and air quality management initiatives** in other Canadian and international cities.	**Ongoing**
	Phase II: Implementation of the Management Strategy and Refinement of the Plan	
9.	**Research and implement possible regulatory changes for enhanced air quality and energy efficiency.** Explore the possibility of advocating for enhanced building energy efficiency considerations as changes to the Ontario and the National Building Codes. Identify potential changes related to energy efficiency and air quality responsibilities and requirements through the current update of the City of Ottawa Act.	**November 2004 – 2005**
10.	**Complete already underway management actions** as follows: • Continue community/corporate vehicle anti-idling campaign • Continue City's corporate building retrofits • Review/enhance EnviroCentre partnership • Conduct LEED training among City planners, regulators and identify additional LEED implementation in City projects • Promote waste reduction & diversion and landfill gas co-generation (Energy Ottawa) in conjunction with Solid Waste Services • Continue District Energy project in partnership with Energy Ottawa • Update forest cover and carbon sink modelling through initiation of City Green feasibility project	**2004 – until completion/ ongoing**
11.	**Implement the Smog Action Plan** approved by Planning & Environment Committee in 2004. This includes refinement of the City's corporate actions during smog events and development of enhanced messaging for the community in 2005. Investigate the feasibility of implementing episode management plans during other periods of poor air quality (smog action plan, heat and cold warnings, winter smog/poor air quality events, etc.).	**June 2004 – ongoing**
12.	**Public Outreach and Involvement** • Identify community and agency stakeholders for the range of measures identified within this Plan. Develop partnerships where objectives and timelines are common for the range of measures relating to information, education and influencing of behavioural change for improved air quality and reduced energy use. • Develop additional promotional materials on air quality and climate change impacts within Ottawa and the proposed measures to address these issues. Materials will be developed only if needed to augment existing materials from federal or provincial governments or non-government organizations.	**August 2004 – ongoing**

13. Implement new management measures: • Review current resource use (energy) and set targets for reduction; • Develop a corporate green procurement policy; • Establish BBP partnership and or institute Local Improvement Charges; • Inventory green roofs in Ottawa, develop screening criteria to assess the potential for the incorporation of green roofs into development projects; • Develop and implement driver education for targeted commercial fleets and for the public (with federal government); • Implement freight fleet efficiency programs (with federal government); • Develop building, site and community Design Guidelines to help guide and encourage energy efficient developments, green buildings and green roofs; • Promote and facilitate the development of new alternative energy projects using green or renewable energy sources such as wind, solar, heat recovery and use of process by-products.	**2005 – 2008**
14. Develop a Climate Change Adaptation Strategy • Reduce heat island effect • Climate change emergency response programs.	**2005-2006**
15. Refine Corporate GHG Reduction Target for 2007-2012	**2005-2006**
Phase III Evaluation of Management Measures	
16. Evaluate and, if necessary, redesign **the monitoring program** to monitor long-term trends for parameters of concern	**2006-2009**
17. Evaluate measures to reduce energy consumption and monitor GHG emissions trend	
18. Assess status of progress in achieving the goals of this plan. Refine the Strategy as needed.	**2009**

7. Final Recommendations

Putting this Plan into action will involve coordinating the delivery of many different measures by working with community experts of all kinds for the realization of projects and to distribute information to help residents and businesses make energy efficient and clean air choices. With a global commitment through the Kyoto Accord to reducing GHG emissions, there will be increasing momentum and opportunities for resourcing and funding of programs. Still, funding will continue to be a challenge. The advantage we have is that all levels of government have a stake in the successful delivery of GHG reductions and air quality improvement. The City of Ottawa will work closely with the City of Gatineau, the Provinces of Ontario and Quebec and federal government departments such as Environment Canada, Natural Resources Canada and Health Canada. Delivery of this plan will factor in the actions underway by all levels of government.

This comprehensive approach provides a road map for the City to achieve the goal of protecting and improving the air quality in the City of Ottawa, a fundamental part of the natural environment within which we live. As stated in this Plan, working towards clean air is complex. The most essential requirement is the commitment to proceed from decision-makers within all participating organizations and from the residents of Ottawa. With such a commitment, we can fulfill all of the monitoring, funding, coordination, evaluation and delivery challenges that we face in achieving 20% reduction in GHGs and in the improvement of our air quality by 2012.

This is a plan; as such it will go through revisions and changes. The proposed measures require monitoring of their impact through sound and regular environmental audits. When the City of Ottawa meets this Plan’s goals in 2012, our work will not be complete. We will maintain **a commitment to continuous improvement and maintain our vision to be the cleanest and smartest city in Canada in the tending to our air and in the management of our energy use habits**.

Annexes

Annex 1. Health, environmental impacts and trends of air contaminants

The health impacts of air pollution have been known for centuries. Our ability to determine the impact of each compound on human and ecosystem health is still developing. Nevertheless, we know enough to be able to establish policies to protect our citizens' health and our environment.

Pollutants, which are regulated are known as the "criteria air contaminants," among them are sulphur oxides (SOx), nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOCs). A sub-group known as the "priority air pollutants" because of their impact on human and ecosystem health include ground level ozone (O3), as well as particulate matter smaller than 10 microns (PM_{10}) and smaller than 2.5 microns ($PM_{2.5}$). Since most of these contaminants contribute to smog episodes in Ottawa, its trends are presented in a graph. There is also a special section on the health impacts of wood smoke.

Besides criteria air contaminants, greenhouse gases (GHGs) are also discusses and their trends depicted. The link between GHG and air pollution is emphasised by the sensitizing of our populations to natural air contaminants such as pollen and mold. Warmer temperatures will extend the pollen and mold season and increase smog episodes.

In a separate section the impacts of other air contaminants such as hazardous pollutants, odours, noise, and light pollution are discussed in detail. Some of the impacts might be classified as nuisance, while others may have impacts on the immunological and the central nervous system.

Criteria Air Contaminants

Sulphur dioxides (SO_2)

In Ottawa, SO_2 emissions have ranged between 1 and 6 parts per billion (ppb) between 1991 and 2000 (Figure 3), which is consistent with the provincial mean. By way of comparison, the annual mean concentration for Sarnia, Ontario was in the order of 10.4 ppb. The transportation sector contributes 60% of SO_2emissions.

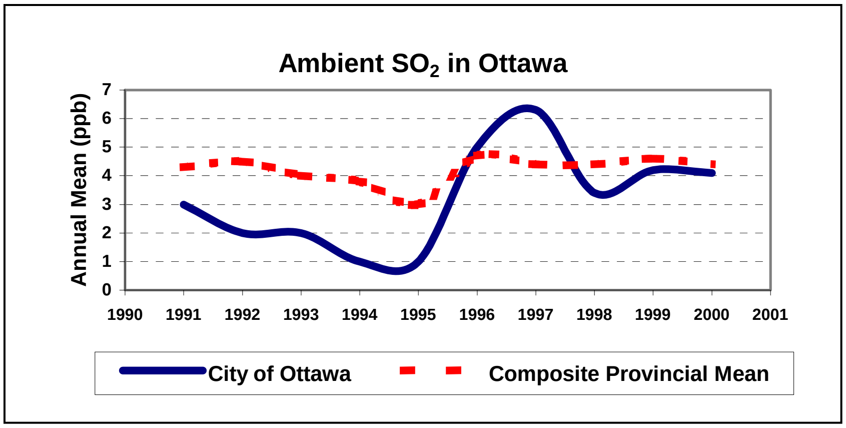

Figure 3. Ambient levels of SO_2 in Ottawa, Air quality

Source: Environment Canada PDB (1995 data)

Sulphur dioxide transforms into sulphates either as particulate or droplets. In either case, SO_2 has been found to affect the respiratory system. Asthma sufferers are particularly sensitive. Sulphate decreases the pulmonary capacity. Annual means of 20 ppb for SO_2 and 50 ppb for nitrogen dioxide (NO_2), although below the Canadian Ambient Air Quality objectives, significantly decrease pulmonary volume in children. This information was quantified in a 1994 study between children living in southern Ontario as compared to those living in Saskatchewan[37]. An increase in particulate sulphate of 26 ppb is associated with 2.2% increase in mortality[38].

Nitrogen Oxides (NO_x)

Nitric oxide (NO) is the major NO_x component and oxidizes into NO_2 in the presence of hydrocarbons and sunlight. The annual mean concentrations of NO_x in Ottawa have been relatively steady between 1991 and 2000; and have always been less than the provincial average (Figures 5 & 6). In 2000 provincial NO_x emissions were 6% lower than in 1991, a reduction that may be attributed to the reduction in emissions from the transportation and industrial sectors in the early 1990's, the former being the main source of pollution.

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[37] Stern, B.R. ; M. E. Raisenne, R.T. Burnett; L. Jones; J. Kearny and C.A. Franflin. 1994. Air pollution and childhood respiratory health: Exposure to sulphate and ozone in 10 Canadian rural communities. Environmental Research, Vol. 66: 125-142.

[38] Burnett, T.R.; S. Cakamk and J.R. Brook. 1998. The effect of urban ambient air pollution mix and daily mortality rates in 11 Canadian Cities. Revue Canadienne de Sante Publique, Vol. 89(3): 152-156.

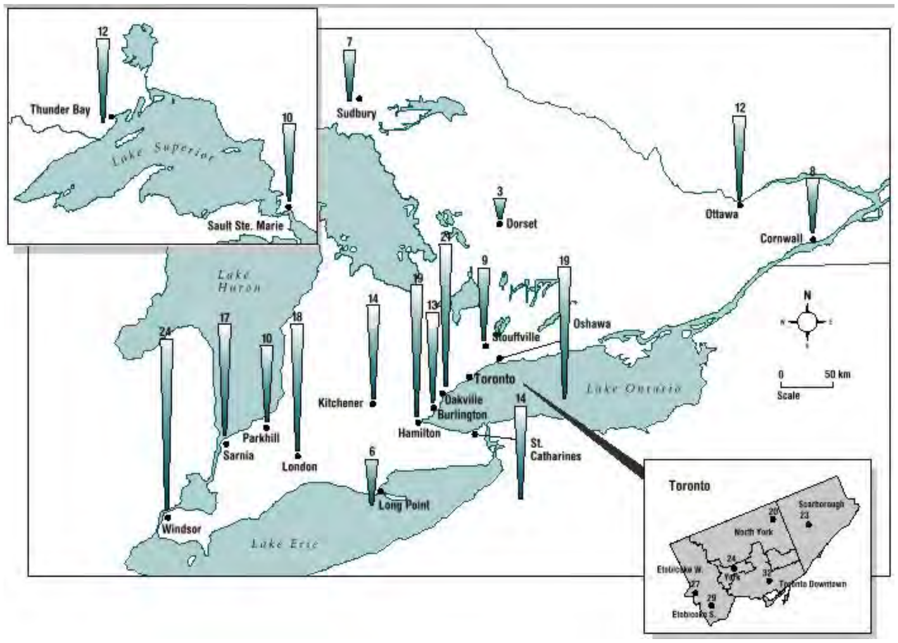

Figure 4. Average NO_2 for Ontario

Source: MOE, 1999[39]

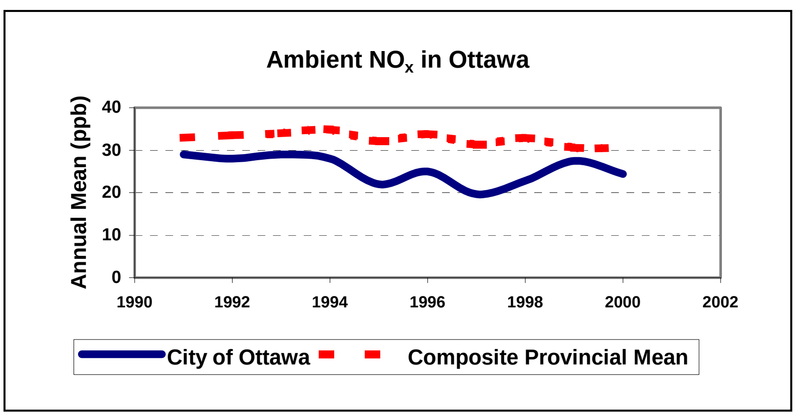

Figure 5. Ambient NO_x levels in Ottawa

Source: Environment Canada PDB (1995 data)

The health impacts of NO_x are numerous. In particular NO_2 is a lung irritant, which can produce pulmonary edema at high concentrations and is also associated with ischemic heart disease. In Toronto, NO_2 is the air pollutant with the greatest adverse impact on human health, being responsible for 40% of air-related premature mortality and 60% of

[39] Ministry of the Environment. 1999. *Air Quality in Ontario - A Concise Report on the State of Air Quality in the Province of Ontario 1997*. Canada.

cardiorespiratory admissions to hospitals. It contributes to ground-level ozone formation, stratospheric ozone depletion and is a main contributor to odours, which has also been associated to health impacts.

The transportation sector is responsible for over 85% of total NO_x emissions (Table 3). Since 1990, there has been a reduction of NO_x emission, which is attributable to improved standards for on-road vehicles.

Carbon monoxide (CO)

Carbon monoxide is a colourless, odourless and tasteless gas produced through the incomplete combustion of organic materials. Personal vehicles are one of the main sources of CO, accounting for 54% of total CO emissions. Cars operating at colder temperatures (during winter or engine warm-up) produce significant quantities of this poisonous gas.

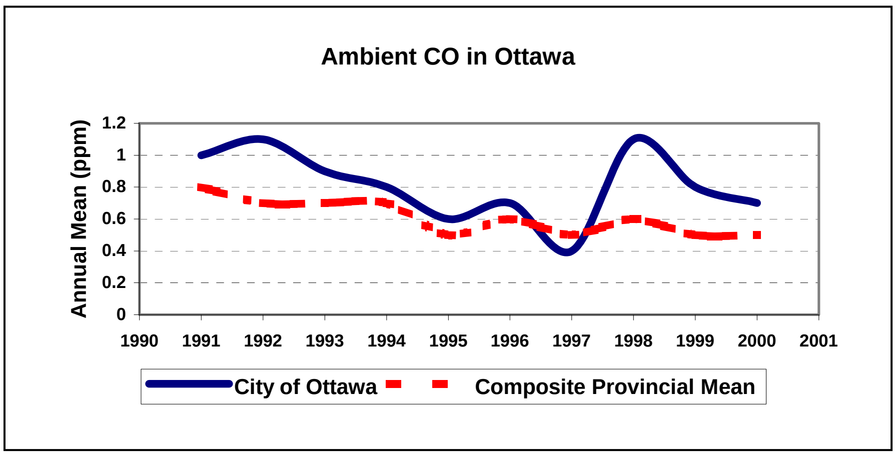

Figure 6. Ambient CO levels in Ottawa

Source: Environment Canada PDB (1995 data)

Annual mean concentrations of CO in Ottawa have declined steadily between 1991 and 1997 (Figure 6). According to Environment Canada the numbers have gone down to 1996 levels. Ottawa is noted to generally experience a slightly higher annual mean relative to the composite provincial mean (Figure 7).

Ambient average CO levels in Ontario have decreased by 25% over the past 10 years despite a 20% increase in vehicle kilometers traveled[40]. This is due to a more stringent emission standards in newer vehicles. This decrease is expected to continue after the provincial “Drive Clean” program was introduced in July 2002.

[40] Delcan Corp. 2003. Transportation Master Plan Support Projects- Transportation, Air Quality and Climate Change.

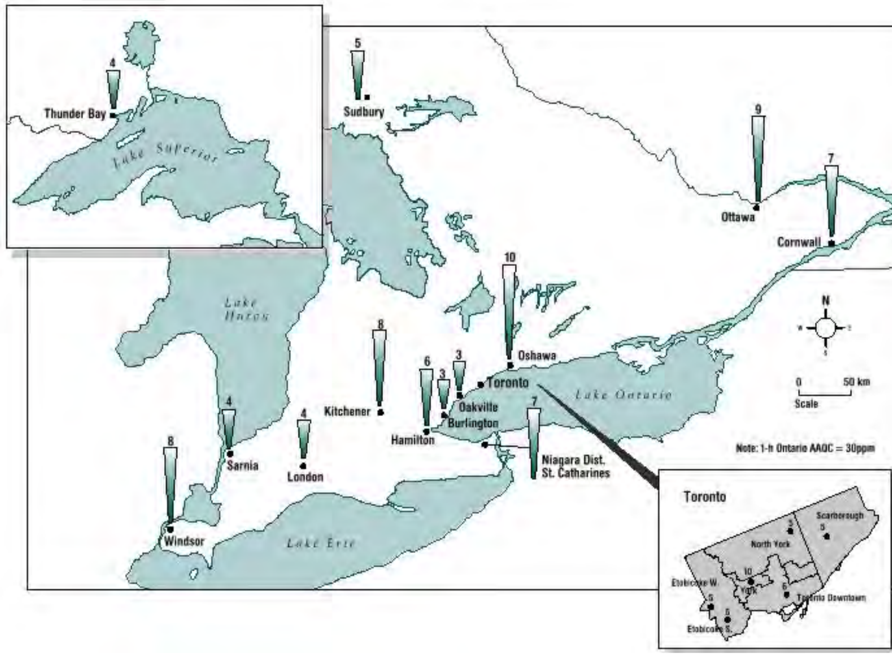

Figure 7. Average CO levels in Ontario
Source: MOE, 1999[41]

Carbon monoxide has severe health effects because it reduces the ability of the blood to carry oxygen. It is known to be responsible for congestive heart failure in the elderly, the impact of which is manifested on the same day. Smokers, persons with heart disease, and those with anemia are especially sensitive. It is responsible for greater susceptibility to respiratory infections in children and elderly.

Another environmental impact of CO is its capacity to deplete the atmosphere's supply of OH (hydroxyl radical), which is the main natural cleansing agent of the atmosphere. As a result, CO emissions contribute to increases in methane, partially halogenated CFCs and the formation of ground level ozone under certain NO_x conditions.

The on-road transportation sector in Ottawa accounts for 73% of total CO emissions. This is followed by residential fuelwood combustion (11%).

Volatile organic compounds (VOC)

The great majority of VOCs, which are the product of unburned hydrocarbons do not represent a serious threat to air quality until they react with nitrogen oxides. They are important in the formation of ozone, which at ground-level is a key ingredient to urban smog. Some VOCs such as benzene are suspected of having human health effects

[41] Ministry of the Environment. 1999. *Air Quality in Ontario - A Concise Report on the State of Air Quality in the Province of Ontario 1997*. Canada.

ranging from carcinogenicity to neurotoxicity. Hydrocarbons (HCs) from diesel emissions are also carcinogenic. Others such as those from paints, cleaners, etc. cause unpleasant odours.

The biogenics industry is responsible for 82% of VOC emissions. Following this sector is transportation and residential fuelwood combustion. Overall in the province there has been a 17% reduction in VOC emissions from 1991 to 2000. Within the transportation sector, VOC emissions have declined steadily since 1990 as a result of several initiatives, including new vehicle emission standards (early 1990's), lower gasoline volatility, and the implementation of Ontario's Drive Clean vehicle inspection program.

When fine particles reach the alveolus they trigger the defence mechanism, which consist of macrophages that act as vacuum cleaners. The particles are then expelled in the mucus. If the concentration of particles increases, so does the macrophage, causing an overload and therefore diminishing the lung capacity. This effect is compounded in the elderly by their reduced lung capacity due to the normal aging process. Metal or acid particles may create scars in the alveolus reducing their functionality permanently. Because each alveolus is composed of a single cell wall for the transfer of oxygen to the blood, some of these particles are able to penetrate into the blood system. Higher pollution levels induce thickening of the blood, explaining the relationship between pollution and cardiovascular problems.

Priority Air Pollutant Issues

Ground level ozone and particulate matter were named 'priority air pollutants' because of their impact on human and ecosystem health. They are the result of chemical reactions between the above-mentioned compounds or the result of changes in their physical structure that cause transformations that increase their negative impact.

As recently as July 2, 2003 ground level O_3 and PM_{10} have been included in Schedule 1 of the Canadian Environmental Protection Act (CEPA) list. Placing the precursor gases on Schedule 1 gives the Government of Canada the authority to take action to meet its federal commitments under its Clean Air Agenda. This provides the federal government with the authority to demand reduction of the emission of these pollutants.

Particulate Matter (PM)

Particulate matter is the general term used for a mixture of solid particles and liquid droplets found in the air. These particles, which come in a wide range of sizes, originate from many different stationary and mobile sources, as well as from natural sources (i.e., wind-blown soil, forest fires, ocean spray, and volcanic activity). The particles include aerosols, smoke, fumes, dust, fly ash, pollen, and mold. Particles less than 10 microns are defined as inhalable particles (PM_{10}) and respirable particles ($PM_{2.5}$), respectively. It is the fine particles $<2.5\mu$ that are critical since they can penetrate deep into the respiratory system. For this reason, fine particles have been declared toxic under CEPA (2000). The Canada-Wide Standard includes a 24-hour average of 30 µg/m^3 for $PM_{2.5.}$ However, recent scientific studies indicate that there is no lower safe threshold for PM as a health threat, unlike other pollutants, which can be considered non-hazardous below a certain concentration.

The provincial compounded annual mean for $PM_{2.5}$ is 11.2 µg/m^3. Ottawa's average is 9 µg/m^3, while Hamilton recorded a maximum of 15 µg/m^3. In 2000, Ottawa recorded a one day occurrence when the proposed Canada-wide standard for 24-hour $PM_{2.5}$ (30 µg/m^3) was exceeded. Periods of higher $PM_{2.5}$ count occur during the summer and fall (Figure 8), while the secondary winter high is in all probability due to wood smoke and thermal winter inversions[42].

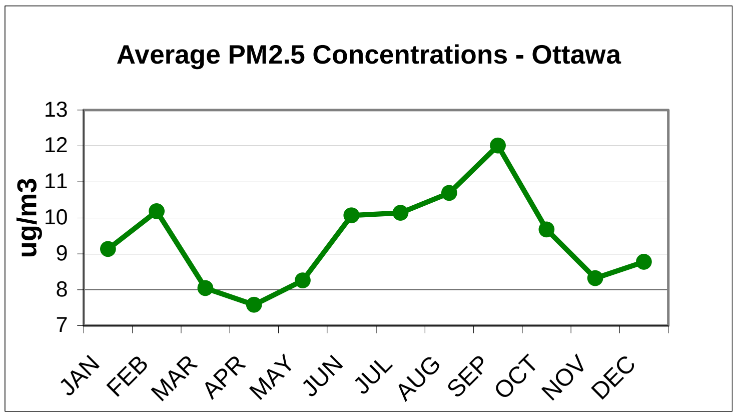

Figure 8. Average $PM_{2.5}$ concentrations and seasonal variability in Ottawa

Source: Data obtained from Environment Canada

Although the health effects of particulate matter vary with the type of particulate and the size, there is no lower safe threshold. The smaller the particle size, the further it will penetrate into the lungs causing respiratory infections. Sulphate, in the form of fine particulates ($PM_{2.5}$), is associated with higher mortality rates. Each µg/m^3 of fine particulate is associated with 8 deaths/year/100,000 persons in the population. Many of the toxic components of $PM_{2.5}$ can be taken into the blood stream. The most pervasive type is diesel particulate matter (DPM), where 50-90% falls within the ultra-fine particle size (aerodynamic diameter of less than 0.1 µg). DPM is responsible for 70-89% of the total cancer risk caused by air pollution[43].

For areas where $PM_{2.5}$ measurements are not available, PM_{10} can be used as an indicator. Studies suggest that a 100 µg/m^3 increase in PM_{10} concentration will increase the

[42] Environment Canada. 2002. Residential Wood Combustion. http://www.rsqa.qc.ca/pdf/chaufboisangl-200400.pdf
[43] Sharp, J. 2003. The public health impact of diesel particulate matter. Sierra Club of Canada – Eastern Canadian Chapter.

mortality rate by 4.2% in the following day.[44] The risk for infants is even higher, where a 10 μg/m^3 increase in PM_{10} is associated with a 1.04 % increase in mortality[45].

High concentrations of PM are also responsible for corrosion, soiling, damage to vegetation and reduction in visibility.

The main sources of both PM_{10} and $PM_{2.5}$ in Ottawa are unpaved and paved roads, followed by construction and residential fuelwood combustion. Unpaved roads are responsible for 60% of PM_{10} and 46% of $PM_{2.5}$. Residential fuelwood combustion contributes 19% of $PM_{2.5}$, much higher than the contribution from the heavy-duty diesel sector. Residential wood burning could be the single biggest source in the coldest months of the year.

While staying indoors during high ozone episodes might reduce exposure, there is no such relief when dealing with PM. Levels of PM are the same indoors and outdoors, making the need to reduce emissions all the more necessary[46].

Ground-level Ozone (O_3)

Ground-level ozone is a colorless and highly irritating gas that forms just above the earth's surface. It is called a "secondary" pollutant because it is produced in stagnant air when two primary pollutants, namely NO_x and VOC, react in sunlight. Higher ambient temperatures accelerate the process. The *Canadian Ambient Air Quality Objective* for 1-hour average concentration is 51 ppb (maximum desirable), 82 ppb (maximum acceptable), and 153 ppb (maximum tolerable). The Canada-Wide Standard for O_3 includes an 8-hour average of 65 ppb.

The health impacts of ground level ozone include:

- Decrease in lung function;
- Eye irritation;
- Decreased immune function;
- Possible long term role in the development of chronic lung disease;
- Induced epithelial inflammation, interstitial edema, interstitial cell hypertrophy, and macrophage influx, with acute exposure which subside after 3 weeks; and
- Epithelial inflammation, interstitial fibrosis in the alveolar region, and bronchiolar epithelial cell injury with chronic exposure.

The hospital admissions associated with ozone are well documented (Figure 9). In Montreal, under low levels of ozone[47], an increase of 38 ppb over 8-hrs leads to a 22%

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[44] Dockery, D.W.; J. Schwartz and J.D. Spengler. 1992. Air pollution and daily mortality: Association with particulates and acid aerosols. *Environ. Res*. Vol. 59: 362-373.
[45] Davis, L.D. et al. 1997. Short-term improvements in public health from global-climate policies on fossil-fuel combustion: an interim report. *The Lancet*, Vol. 350(8): 1341-1349.
[46] Miller, D. 2003. Per. Comm. Senior Advisor, Health Canada.

increase in hospital admissions for individuals over 64 years of age. Infants react almost immediately. An increase of 36 ppb in 1-hour was associated with a 21% increase in emergency visits.

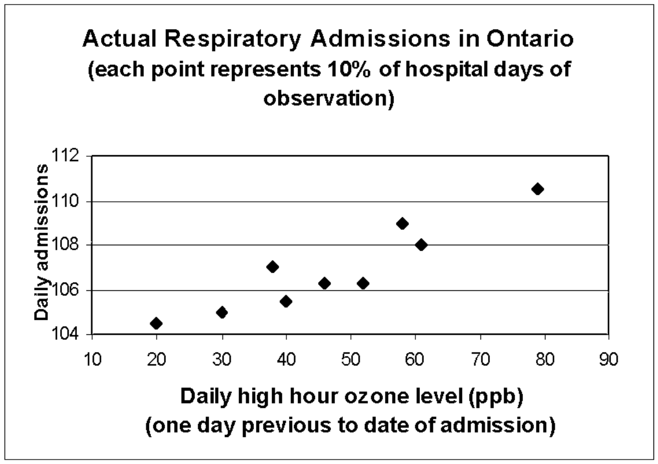

Figure 9. Hospital admissions due to respiratory problems.
Source: Burnett et al. (1997)[48]

Further environmental impacts of ozone include reduced agricultural productivity in crops, including brussel sprouts, soybeans, tomatoes, potatoes and corn; and a reduced growth rate in trees, including red spruce, yellow pine and sugar maple. Damage to vegetation has been observed at 60 ppb, which is less than the 82 ppb threshold for humans. Ozone is also linked to detrimental effects in the respiratory systems of animals, such as lung hemorrhages in birds[49]. Ground-level ozone is also a global warming agent.

Trends in Ottawa reveal that smog episodes are steadily increasing (Figure 10). In 1993, when reporting first began, there were no incidents. By 2003, 3 episodes were reported. The highest number of smog episodes (14) occurred in 2001. Exceptional rainfall amounts occurred in 2000 contributing to cleaner air by washing out the pollutants from the lower atmosphere.

[47] Delfino, R.J. et al. 1998. Emergency room visits for respiratory illness among the elderly in Montreal: Associations with low level ozone exposure. *Environmental Research*, Section A, Vol. 76: 67-77.
[48] Burnett, R.T.; J.R. Brook; W.T. Yung and R.E. Dales. 1997. Association between ozone and hospitalization for respiratory diseases in 16 Canadian Cities. *Environmental Research*, Vol. 72:24-31 pp
[49] Ground-Level Ozone - Science Assessment Document (SAD), Federal-Provincial Working Group on Air Quality Objectives and Guidelines for the Canada-Wide Standards (CWS) process (Feb. 1999).

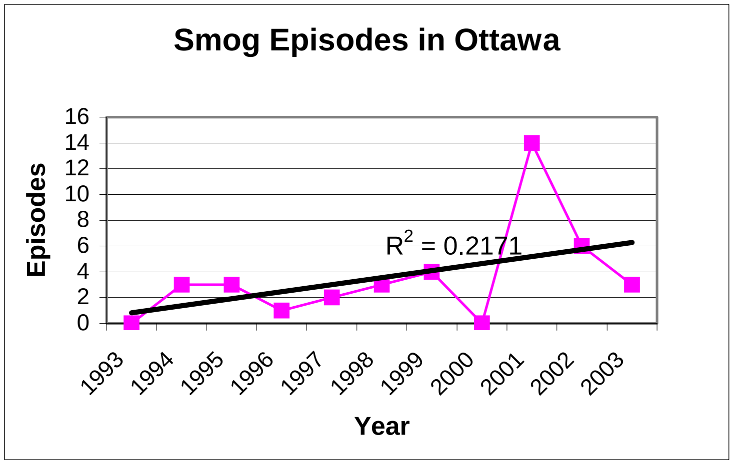

Figure 10. Occurrence of smog episodes in Ottawa

Source: Data provided by Environment Canada

Ground level ozone is likely to affect our rural areas located downwind from Ottawa (Figure 11). Cities act as O_3 sinks since fresh NO_x react with the O_3 doing the equation back to reactants. When NO_x and VOC travel long distances in the presence of sunlight they convert into O_3. This explains why some rural areas show higher concentrations of ozone than the urban sources of pollution.

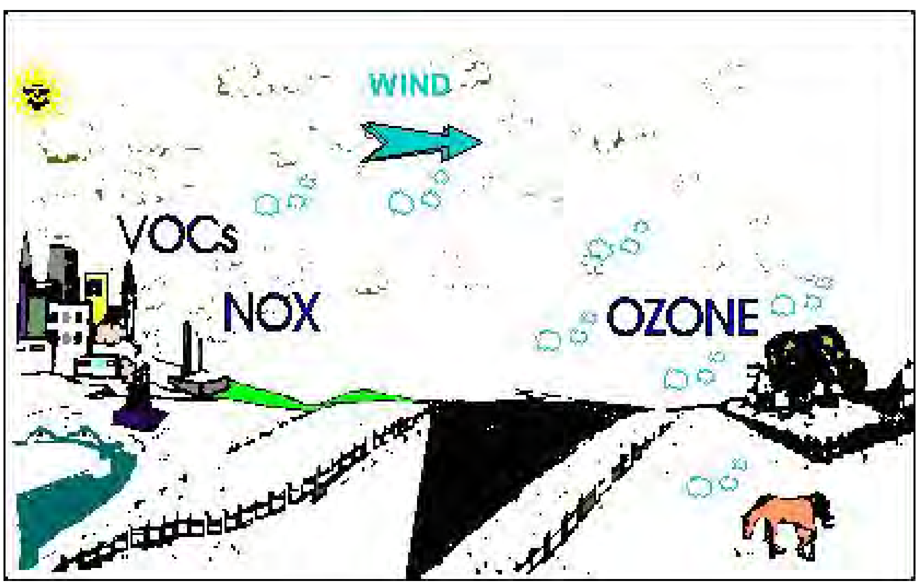

Figure 11. Rural areas affected by O_3, precursors of which originated in urban areas

Greenhouse Gases (GHGs)

Greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) exist naturally in the atmosphere, trapping heat and warming the air in much the same way glass warms the inside of a greenhouse. Without GHGs, the mean temperature of the earth would be $-15^{o}C$. Although GHG make our planet livable, the additional GHG by the combustion of fossil fuel (i.e. gasoline, natural gas and diesel) produced by human activities since the industrial revolution is upsetting the balance and is contributing to global warming. The most significant GHG in the context of climate change is carbon dioxide because of the sheer volume. Therefore, the contributions by the other greenhouse gases are usually expressed as CO_2 equivalents (eCO_2).

Carbon dioxide (CO_2)

Carbon dioxide is a gas that is produced by the decay of materials, respiration of plants and animal life, and the natural as well as human-induced combustion of materials and fuels. Currently there is no outdoor air quality standard for GHGs, although on a national level the federal government has committed to reducing its emissions by 6% from 1990 emission levels by the years 2008 to 2012 (according to its ratification of the Kyoto Protocol in December 2002). In Ontario, stationary combustion (electricity and heat generation, fossil fuel industries, residential, commercial and institutional) is the biggest contributor of CO_2. The second largest is the transportation sector (Figure 12).

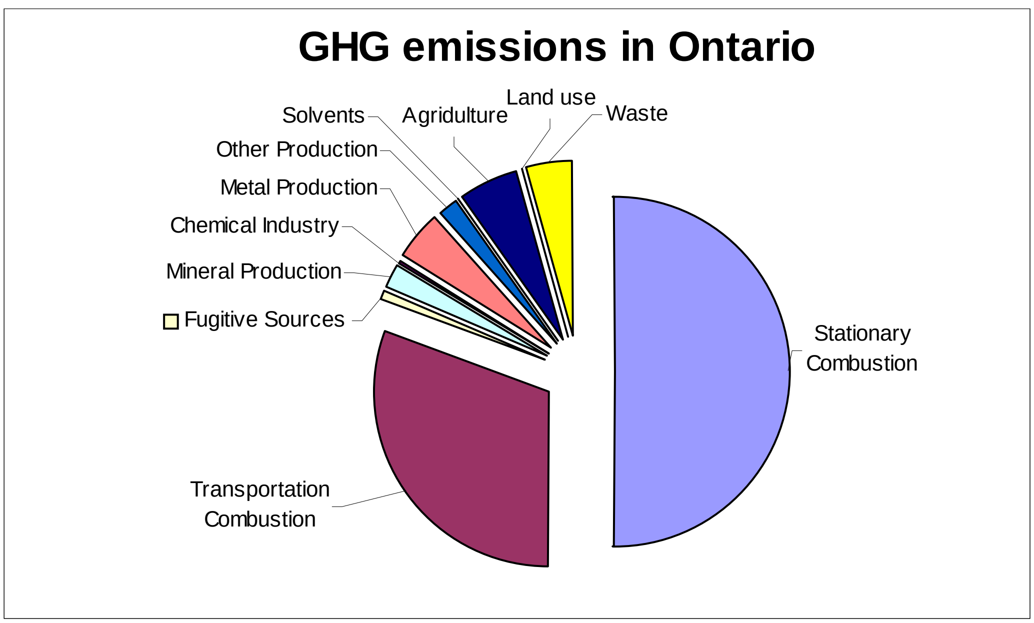

Figure 12. CO_2 concentration by sector in Ontario

Source: Environment Canada 1990-2001 Inventory[50]

[50] National and Provincial Greenhouse Gas Emission Trends, 1990-2001. http://www.ec.gc.ca/pdb/ghg/1990_01_report/Annex10_e.cfm

Health impacts resulting from an increase in CO_2 are indirectly related to changes induced in climate and the effect that weather has on humans and nature. The most common impacts are heat waves, climate variability such as ice storms, increased transmission of vector-borne and infectious diseases, invasion of foreign species, and the loss of biodiversity.

The steady variation in CO_2 concentration over the centuries has been altered by human action starting in the industrial revolution. The speed at which CO_2 concentrations are increasing is altering our global climate (Figure 13).

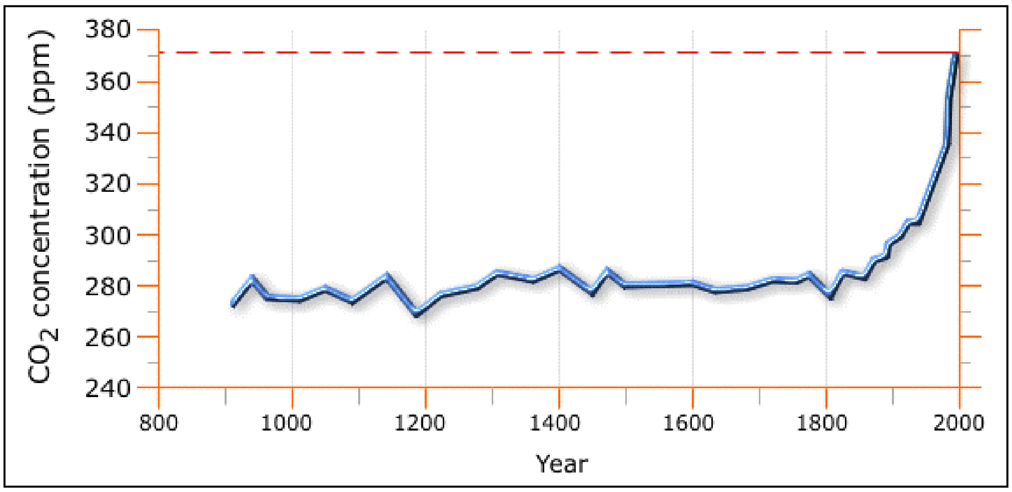

Figure 13. Pre-industrial concentration of CO_2

Source: www.landcareresearch.co.nz/research/greenhouse/climate_change.asp

Methane (CH_4)

Methane's global warming potential is 23 times that of CO_2, while its atmospheric life is shorter, -around 9 years- compared to 50-200 years for CO_2. The volume of methane in the atmosphere is much less than CO_2. Methane concentrations are on the increase (Figure 14) due in part to domestic animals (cows), rice paddies, gas and mining leaks, biomass burning, and landfills. CH_4 comes from natural sources like bogs, where it is produced from the decay of organic matter without oxygen. Major sources in Ottawa include landfills, livestock, and manure storage and handling.

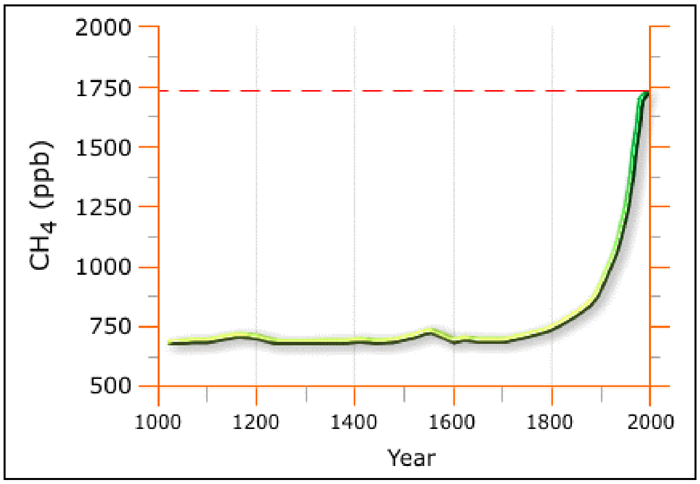

Figure 14. Pre-industrial and present CH_4 concentrations
Source: www.landcareresearch.co.nz/research/greenhouse/climate_change.asp

Nitrous oxide (N_2O)

The global warming potential of N_2O is 310 times that of CO_2 and its atmospheric life is 120 years. Fossil and biomass burning are the primary man-made sources for this gas. Nitrous oxide is emitted from agricultural soils and from burning of field residues. In the agricultural area the application of nitrogen fertilizers is the main source of N_2O.

Chlorofluorocarbons (CFCs)

These man-made chemicals are powerful greenhouse gases with long atmospheric lives of 90 to 160 years. CFCs can trap over 10,000 times more heat per molecule than CO_2. These compounds were banned in Canada and in most of the world in the early 1980's after discovering that they are responsible for the destruction of the stratospheric ozone.

Wood Smoke

Winter air quality is emerging as an important issue. The biggest source of emissions during this season is fine PM from wood burning. Wood burning has been part of the tradition in many households and is deeply ingrained in Canadian lifestyle and history. Wood smoke from wood stoves and fireplaces is one of the largest sources of PM_{10} and $PM_{2.5}$, especially in Quebec and Ontario. Following the ice storm in 1998, there seems to have been an increase in the demand for wood stoves[51].

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[51] Duhaime, C. 2003. Per. Comm. Senior Scientific Advisor. Quebec Region- Environment Canada, Sep 11th.

Winter air quality problems prompted a study of air pollution in the Greater Montreal[52] area where wood combustion was identified as a major source of air pollution. In fact, there are several pollutants that are emitted through wood combustion i.e. polycyclic aromatic hydrocarbons (PAH), VOCs, $PM_{2.5}$, and some metals.

Polycyclic aromatic hydrocarbons are a mixture of organic compounds released into the atmosphere as gases or particles during the incomplete combustion of organic material and may cause cancer in animals and humans. The Montreal study showed that residential wood combustion increased PAHs by 45% and concentrations were higher (76.8 ng/m^3) in residential areas than in downtown Montreal (40 ng/m^3). These amounts were even higher on weekends (87.9 ng/m^3) and also during the evenings there was twice the amount of PAHs than during the day. Christmas evening wood burning resulted in two times the PAHs than during Christmas day.

Volatile organic compounds increased by up 200% during wood burning. Transportation emissions drop to second place in residential areas where wood burning occurs. Fine particulate matter also increased (12.9 $\mu g/m^3$), surpassing levels in the polluted downtown area (10.4 $\mu g/m^3$) and was 74% greater than in semi-urban areas.

Winter air quality deteriorates when a surface inversion is present and topographic conditions exist to trap air pollutants. Valleys provide ideal conditions for poor air dispersion. Atmospheric dispersion refers to the capacity of the atmosphere to dilute pollutants and is considered poor when wind speeds are low and the vertical profile of temperature is very stable (when the air temperature increases with height above ground). The lower layer of the troposphere acts as a lid to vertical atmospheric motion contributing to poor air quality.

Other Air Quality Issues

Hazardous air pollutants

Transportation is the main source of toxic substances in Ottawa. Diesel fuel alone is responsible for 139 hazardous air pollutants[53]. Among the most common toxic substances resulting from the transportation sector are benzene, 1,3 Butadiene, formaldehyde, acetaldehyde, and PAHs. Each mile traveled using diesel produces an average 47.2 mg of toxic substances. A light duty vehicle would emit 1.1 mg/mi[54] and considering their large numbers, their contribution is significant. Transportation is the main source of toxic substances in Ottawa.

[52] Environment Canada. 2002. Residential Wood Combustion. http://www.rsqa.qc.ca/pdf/chaufboisangl-200400.pdf

[53] Wargo, J. et al. 2002. Children's exposure to diesel exhaust on school buses. Environment & Human Health Inc. 76 pg.

[54] Little, A.D. 2002. Benefits of reducing demand for gasoline and diesel, Vol. 3 task 1 Report prepared for the California Air Resource Board & the California Energy Commission.

Pollen and Mold

A large number of people are susceptible to pollen and suffer from allergenic rhinitis during pollen season, which in Ottawa generally lasts from mid spring to early fall (first frost). Urban environments are warmer than surrounding rural areas and contain significant atmospheric concentrations of CO_2, both of which provide perfect conditions for earlier pollen production. With climate change upon us, it is expected that pollen season will occur earlier each year. There is already evidence of this in Japan where the allergenic rhinitis is affecting the sensitive population 17 days earlier than 20 years ago, and for longer[55] periods of time. This corresponded to a change in temperature of 1^oC over 20 years. Similar effects would occur in Ottawa where the increase in temperature in the last ten years has also been 1^oC[56]. In the state of Maryland, USA, it has been determined that ragweed grows faster, flowers earlier, and produces significantly greater ragweed pollen in urban locations than in rural ones[57]. Although floral development in ragweed is generally controlled by the length of the photoperiod it can also be a function of temperature and CO_2 concentrations.

The reaction to mold by those suffering from asthma is more severe and could be fatal. Mold releases are closely linked with relative humidity, atmospheric pressure, and temperature. Those sensitive to mold must deal with outdoor and indoor mold episodes. A clear link between mold episodes and climate change has been recently established in Victoria, BC where a New Zealand variety of spore appeared in the winter (2003)[58].

Odours

Odours, particularly the offensive type, can have an immediate impact on the public, sometimes causing physiological and mental stress. In addition, detection of an odour can be an indication of exposure to harmful substances, including odourous compounds such as acetone, formaldehyde, stryene, or isocyanates. The health impact of odours is becoming an important air quality issue, one that is difficult to assess given that the mental and physiological response to odours often differs with the individual. In some cases, significant reactions are at levels below conventional air quality standards[59].

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[55] Teranishi, H. et al. 2000. Possible role of climate change in the pollen scatter of Japanese cedar Cryptomeria japonica in Japan. *Climate Research*, Vol. 15: 65-70

[56] A climatological study of the last 30 years by Environment Canada found that the greatest increase happen in the last 10 years (MacIver, D. 2003. Personal communication. Senior Scientific Advisor, Meteorological Services Of Canada)

[57] Zizka, L.H.; D.E.Gebhard; D.A. Frenz; S. Faulkner; B.D. Singer, and J,G. Straka. 2003. Cities as harbingers of climate change: Common ragweed, urbanization, and public health. *J. Allergy Clin Immunol*. Vol. 111(2): 290-295.

[58] Miller, D. 2003. Per. Comm. Health Canada Advisor and Carleton University Professor.

[59] SENES consultants Ltd. 1999. State-of-the –scientific-knowledge linking odours to adverse human health impacts. Report prepared for the Public Health Services of the City of Toronto, pg.43.

There are three ways[60] in which odours can affect health. Firstly, the odorant can induce sensory or respiratory irritation. Samples of substances that invoke this reaction are ammonia, chlorine, formaldehyde (e.g. from building products), acrolein, acetaldehyde, and organic acids (e.g. from cigarettes). The odour is merely a warning of potential health effects at elevated concentrations.

Secondly, exposure to odours may produce health symptoms. This can occur, for example, with exposure to certain odorant classes such as sulphur-containing compounds (e.g. total reduced sulphur, hydrogen sulphide, mercaptans, or thiophenes). Pulp and paper operations in the City of Gatineau are responsible for these types of emissions being blown into Ottawa by wind under certain conditions. Those exposed to these odours experience sore throat, cough, chest tightness, breathlessness, thirst, sweating, irritability, and loss of libido. Severity of symptoms is dose related. In severe cases, deteriorating respiratory symptoms and lung function have been observed. The health effects are not well understood, but psychological as well as physiological factors may play a role.

The third way in which odours may be associated with symptoms is one in which the odorant is part of a mixture that contains a co-pollutant that is responsible for the reported health symptom. Odorous airborne emissions from confined animal operations, composting facilities, and industrial sources often contain other components that may be the cause of the symptoms such as endotoxin, feed dust, airborne manure particulates, glucans, allergens, microorganisms, or toxins. Thus, an individual may encounter odours from swine facilities while simultaneously being exposed to gram-negative endotoxin. In this case, the symptoms or health effects are more likely to result from endotoxin exposure than the odour. That is, odour is a “potential cofounder”.

Current pollution levels are in part responsible for the sensitivity to perfumes and other substances that produce odours. The reported reactions to perfumes is long and may include[61]: watery eyes, double vision, sneezing, stuffiness, allergic rhinitis, sinusitis, tinnitus, dizziness, vertigo, coughing, bronchitis, difficulty breathing, chest tightness, asthma, anaphylaxis, headache, migraine, cluster headaches, seizures, convulsions, fatigue, confusion, disorientation, incoherence, short term memory loss, anxiety, irritability, depression, mood swings, rashes, hives, eczema, flushing, muscle and joint inflammation, pain and weakness, and irregular or rapid heartbeat hypertension. Voluntary compliance on avoiding the use of scents on public places has been ineffective.

The City of Ottawa encompasses a large rural area and the probability of swine and livestock operations being an air quality issue exists. This is particularly true in confined and intense animal production, which causes malodors resulting in complaints from those living around these farms. Techniques to reduce odours exist. A good example of

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[60] Schiffman, S.S. 2000. Abstract of a workshop on the health effects of odours. Duke University Medical Centre. Department of Animal Science.
[61] Mary Lamielle, 1990. Press release, president of the National Center for Environmental Health Strategies.

managing odours is the City's sewage treatment plant, which has extensive and effective carbon filters.

Noise

There is increasing evidence of health implications of noise, ranging from:

- Annoyance;
- Sleep disturbance;
- Stress-related psycho-physiological effects, such as increases in blood pressure;
- Work-related performance;
- Interference with communication and ability to learn; to
- Children exposed to loud noise showing impairment in learning and problem solving abilities[62].

People living close to airports suffer more from noise pollution. Aircraft noise impacts children's health. Higher systolic and diastolic blood pressures were found in children living near the Los Angeles airport than in children living further away. Studies also found a relationship between chronic noise exposure, elevated neuroendocrine, and cardiovascular measures for children living near Munich's International Airport. Further, the subjects who were bothered by aircraft noise were more likely to complain of sleep difficulties and were more likely to perceive themselves to be in poorer health.

There are however, a large number of other noise polluters in the residential, industrial/commercial, and transportation sectors. Examples include cars, trucks, buses (most common), leaf blowers, lawn mowers, air conditioning units, construction sites, stereos, boats, heat pumps, swimming pool pumps, etc.

Light Pollution

Light pollution is defined as light that is created from excessive illumination, by unshielded or misaligned light fixtures, and by inefficient lamp sources. Light pollution affects bird migration, nocturnal animals, vehicle/aircraft safety, public health, the environment at large, and budgets. The energy used for lighting, if produced from fossil fuels, contributes to climate change.

Birds/Animals

[62] World Health Organization. 2003. HEARTS: health impacts of transport, integrating noise in a broad assessment tool. http://www.who.dk/transport/HIA/20030129_4

Light pollution is particularly harmful to nocturnal and migratory animals and to animals in flight. This has confused nocturnal animals. Migratory birds often collide with skyscrapers when they are lit at night. It is estimated that 100 million birds die annually in North America alone due to uncontrolled urban lighting. It has also been observed that once birds, attracted to the light source, passed within the beam, they suffered temporary disorientation. Songbirds are most at risk since they fly at low altitudes dominated by artificial light.

The alteration or extension of day-length due to artificial lighting disrupts natural diurnal rhythms of organisms and may even be the cause of deaths. Lighting can affect certain photoperiodic behaviour such as foraging, reproduction, and changes to the quality of habitats.

Vehicle/Aircraft Safety

It is estimated that 35-50% of all light pollution is produced by roadway lighting[63]. Improper lighting is composed of light trespass, glare, and urban sky glow. Light trespass is considered the effect of light that strays from its intended purpose. On roadways, it is the light that should be directed onto the roadway and not the adjacent area. The unwanted source of luminance produces glare and is experienced by both vehicle and aircraft operators. The operators' safety is put at risk due to blinding glare (so intense that once the light source is removed, no object can be seen or easily distinguished), disability glare (reduces the driver's ability to distinguish objects clearly), and discomfort glare (causes fatigue and driver error).

Public Health

Exposure to bright lights can disrupt various circadian[64] cycles. These cycles affect behavioural rhythms, daily changes in blood and urine chemistry, and the production of melatonin. The disruption of biological rhythms can produce grogginess, depression, and impaired thinking. Over a longer time frame, it is theorized that chronic disruptions in melatonin production can contribute to the development of hormone-related cancers and breast and colorectal cancers.

Night Sky Viewing

Light pollution is urban sky glow, the brightening of the natural sky background level. It is detrimental to astronomers because it reduces the number of distant stars that can be observed. It also impedes the simple enjoyment of the night sky as more wavelengths are emitted than are needed to be visible to the naked eye. Light pollution in the form of

[63] Carl Shaflik (Peng). 1997. Environmental Effects of Roadway Lighting. Technical Paper prepared at University of British Columbia, Department of Civil Engineering ://www.darksky.org/infoshts/is125.html
[64] of or relating to biological processes occurring at 24-hour intervals

“trespass,” (as in overextending lighting requirements) can also create poor neighbour relations.

Environment/Climate Change

Light pollution affects air quality and climate change because it represents wasted energy. The by-products of the needless burning of coal, oil, and natural gas cause acid rain, smoke, and carbon dioxide emissions.

Municipal Budget

Managing light pollution can produce large energy savings for municipalities since 35-50% of all light pollution is produced by roadway lighting and 95% of the light directed down to the ground is reflected upwards. A Massachusetts town of 25,000-30,000 people with ~3,500 streetlights spend as much as $500,000 per year to keep them lit all night long. Many towns are usually finding that turning off lights does not increase either crime or traffic-accident rates (in fact, both rates sometimes decrease when glaring lights are turned off). It can also reduce infrastructure and maintenance costs, as well as energy use.

Annex 2. Air quality and climate change emission sources

Emission sources of both air pollutants and GHG can be grouped in the following sector: transportation, residential heating/cooling, forestry and natural areas, aquatic environments, industrial sources, waste disposal, and agriculture. Although transportation alone is responsible for the greatest amount of pollutants in all categories of criteria air contaminants, each of these sectors offers reduction emission opportunities.

Transportation

Transportation is responsible for 50% of O_3. It is also responsible for PM_{10}, $PM_{2.5}$,, and toxic substances with carcinogenic properties such as benzene, 1,3 butadiene, formaldehyde, acetaldehyde, and polychrome aromatic hydrocarbons (PAHs). Transportation is responsible for 90% of CO, over 85% of the total NOx, 60% of the SO_2 and for over 30% of VOC emissions.

According to the United Nations Environmental Program (1993), each tonne of GHG from the transportation sector emits 0.5 kg of SO_2 and 9 kg of NO_x. The latest emission inventory (1998) of GHGs suggests that the transportation sector in Ottawa is responsible for 2,476,000 tonnes of equivalent CO_2 (eCO_2). However, this is a conservative number, since fleets that obtain their fuel on a wholesale basis were not included in the inventory. Ottawa emissions alone are responsible for thousands of tonnes of SO_2 and NO_x emissions (Table 8).

Table 8. SO_2 and NO_x emissions from the transportation sector in Ottawa

	Tonnes of eCO_2
SO_2	1,238
NO_x	22,284

The two pollutants SO_2 and NO_x are not only responsible for acid rain and the precursors of PM, but ultimately for smog formation.

The emissions from transportation are primarily a function of the technology utilized in a specific engine and the properties of the fuel used. For internal combustion engines, air-fuel ratio and degree of mixing, fuel injection timing, compression ratio, and the temperature and composition of the fuel charge are primary engine variables, all affecting the emissions generated during the combustion process. In-cylinder temperature, which is a function of the primary engine variables, is an important parameter for emission control. For example, NO_x formation is heavily dependent on flame temperature, the higher the temperature the more NO_x that is produced. Conversely, high combustion temperatures also allow the fuel to burn out more effectively thereby minimizing PM formation. In modern engines, simultaneous control of the primary engine variables allows optimization across the full range of engine operating conditions, and consequently exhaust emissions are minimized.

Generally, newer vehicles emit fewer emissions than older ones; diesel engines emit more NO_x and PM than gasoline engines; e-diesel, compressed natural gas and propane emit reduced emissions, as compared with conventional diesel, and bio-diesel even less.

The City's fleet is becoming progressively less polluting as the older vehicles are retired and replaced with vehicles that incorporate state-of-the-art technologies for emissions control. The newest articulated buses in the transit fleet exemplify the new emission control technologies. These buses incorporate enhanced software control, improved exhaust gas recirculation, new exhaust after-treatment systems, and use ultra-low sulphur fuel. They provide up to a 90% reduction in PM and a 50% reduction in NO_x emissions compared to engines produced as late as 1999, and meet the 2004 emission requirements.

For many diesel engine applications requiring energy efficiency and high power at slow speeds, the use of e-diesel or biodiesel fuels is a possibility. Other technologies are also being employed to reduce emissions of diesel engines such as improved efficiencies by reducing weight, rolling resistance and aerodynamic drag, and by recovering brake energy and reducing engine size through the use of hybrid drive systems.

There are two types of diesel fuel: "on-road" diesel used on roads and the "off-road" diesel used in engines and vehicles that are not licensed for use on roads. Off-road diesel fleets can include back loaders, large lawn mowers, back-hoes, sidewalk cleaners, asphalt machines, and ferries. Diesel used in on-road vehicles is often called "low sulphur diesel." In 2001 the average sulphur level in on-road diesel was 360 ppm, and ranged from 278 to 437 ppm (Table 9). As of July 2002, a federal regulation required that "on-road" diesel contain a maximum 500 ppm of sulphur until July 2006 when the limit will be reduced to 15 ppm.

Table 9. Sulphur levels (ppm) in on-road diesel, by refinery or importer, 2001

Imperial Oil *Sarnia*	Imperial Oil *Nanticoke*	Shell *Sarnia*	Petro Canada *Oakville*	Sunoco *Sarnia*	*Robbins *Oakville*	*Sunoco *Sarnia*
349	356	392	278	437	289	430

Source: Env. Canada (2001) – Volume Weighted, Annual Average
* Selected importers

Off-road diesel has much higher sulphur rates with a 2001 average of 2,890 ppm and a range between 1,297 to 3,676 ppm (Table 10). The United States and Canada are drafting new rules to reduce emissions from off-road diesel by 95% to 15 ppm by 2010.

Table 10. Sulphur levels (ppm) in off-road diesel, by refinery or importer, 2001

Imperial Oil *Sarnia*	Imperial Oil *Nanticoke*	Shell *Sarnia*	Petro Canada *Oakville*	Sunoco *Sarnia*	*Petro Canada *Oakville*	*Olco *Hamilton*
1297	N/R	3676	2839	2291	2812	N/R

Source: Env. Canada (2001) – Volume Weighted, Annual Average
* Selected importers; N/R= Not Reported

Since 1990, off-road engines are responsible for NO_x and VOCs emission increases of 20 and 10 kilotonnes respectively. In 1999, they accounted for 20% of NO_x emissions in Ontario.

Ontario had the highest sulphur content in gasoline in the western world. In 2001, sulphur levels in gasoline produced in or imported into Ontario averaged 390 ppm and ranged from 180 to 610 ppm (Table 11). Federal regulations have been adopted to reduce the amount of sulphur in gasoline. Commencing January 1, 2005, the limit of sulphur in gasoline has been set to 30 ppm. Table 11 also shows the reduced sulphur levels in gasoline that had been achieved by mid-2004.

Table 11. Sulphur levels (ppm) in gasoline, by refinery, 2001 and 2004

Year	Imperial Oil *Sarnia*	Imperial Oil *Nanticoke*	Shell *Sarnia*	Petro Canada *Oakville*	Sunoco *Sarnia* Suncor (2004)
2001	610	370	460	420	180
2004	25	20	64	141	97

Source: Ontario Ministry of Environment Sulphur-in-Gas Reporting

The variability of sulphur level among suppliers makes the task of choosing the cleanest gasoline difficult. Sulphur levels vary not just between refineries but also within them. Consumers can identify the cleanest gasoline by using the Ministry of Environment's web page, which reports sulphur levels in gasoline quarterly by supplier (http://www.ene.gov.on.ca/envision/air/sig/index.htm).

High levels of sulphur in gasoline lead to pollution in two ways[65]:

1. Contribute to PM and acid rain; and
2. Increased vehicle emissions of NO_x and VOCs.

There are more opportunities to reduce GHGs and CACs by reducing travel by single occupant vehicle. Figure 15 shows the breakdown of transportation by mode in Ottawa. Auto drivers constitute 57% of the total road transportation. Programs to reduce single occupant vehicles would contribute significantly to the air quality issue.

[65] MOEE. 2002. Ontario's Anti-Smog Action Plan. 45 pp.

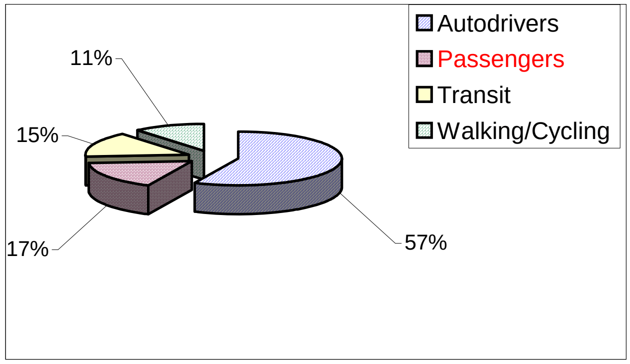

Figure 15. Transportation distribution in Ottawa

Road dust

Wear and tear of roads as well as cars end up as “primary” particulate matter as opposed to “secondary”, which are the result of chemical reactions from the exhaust fumes in the atmosphere (i.e. sulphates and nitrates). Approximately 40 to 60% of PM_{10} and 5 to 20% of $PM_{2.5}$ in urban areas are attributed to geological sources[66]. Unpaved roads, paved roads, construction, and wind erosion contribute 70 to 90% of primary PM_{10} and 50 to 80% of $PM_{2.5}$. Most of the PM_{10} remains between 1 to 2 meters from the source. Ottawa has 700 km of unpaved roads that require dust stabilizers, which at the present is calcium chloride.

The dust loading on paved roads are the result of:

- Being tracked out from unpaved areas such as construction sites, unpaved roads, parking lots and shoulders,
- Spilled from trucks carrying dirt and other particulate materials,
- Deposited from dirt collected on vehicles undercarriages,
- Wearing of vehicle components such as tires, brakes, clutches and exhaust system components,
- Wearing of the pavement surface,
- Deposition of suspended particles from other emission sources,
- Water and wind erosion from adjacent areas, and
- Snow melting particulate such as sand and salt.

The use of salt in Ottawa to meet approved maintenance standards is significant, with an annual average of 140,000 tonnes. Road salts are persistent in the environment. They are responsible for the burnt vegetation along roadways where salt is heavily used. Road

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[66] SENES Consultants Ltd. 2000. Particulate Matter Arising from Paved Roads. Report prepared for the CCME, 52 pg.

salts affect vegetation up to 200 meters from treated roadways. Road salts harm fresh water plants, fish, and other microorganisms that cannot survive in salty waters. One of the components of road salt is ferrocyanide, which is very persistent but is of low toxicity. However, in solution and in the presence of light, it can dissociate to form cyanide. In turn, the cyanide ion may volatilize and dissipate fairly quickly. The ultimate effects of ferrocyanides therefore depend on the complex balance between photolysis and volatilization, which in turn depend on environmental factors. Modelling studies undertaken in support of Environment Canada's Road Salt Environmental Assessment indicate that there is a potential for certain aquatic organisms to be adversely affected by cyanide in areas of high use of road salts.

Residential Heating/Cooling of Buildings

Residential heating, particularly from wood burning, is the largest contributor of PM in winter, besides contributing to other toxic compounds such as benzene, formaldehyde, benzo[a]pyrene, dioxins and furans, and PAHs. This sector is also responsible for large quantities of CO and NO_x. Large apartments or office buildings have their own boilers, many running on natural gas. Although natural gas is cleaner than oil, the air emissions from their operations of heating and cooling would contain NO_x, SO_2, GHGs, and traces of toxic compounds. Our residential, commercial and institutional buildings in Ottawa are the source of over 4.5 million tonnes of eCO_2[67]. The air emissions that result from this sector are summarized in Table 12.

Table 12. Emissions from Residential Sector (in tonnes)

Source Sector	Tot. PM	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOC	CO	Ammonia (NH_3)
Commercial Fuel Combustion	89	81	76	257	831	83	174	76
Electric Power Generation	52	37	32	229	1,185	8	115	7
Residential Fuel Combustion	158	142	136	500	1,344	86	507	21
Residential Fuel-wood Combustion	3,472	3,429	3,362	44	293	12,264	25,453	25
Totals	**3,771**	**3,690**	**3,607**	**1,031**	**3,653**	**12,440**	**26,248**	**128**

Source: Environment Canada[68]

Forestry and Natural Areas

Forests, bogs and natural areas emit VOCs, CO_2, CH_4, NH_3, and nitrous oxide (N_2O). The city of Ottawa has 27% forest cover, with an additional 3% in open wetlands

[67] equivalent CO_2 from carbon dioxide, CFCs, methane or any other greenhouse gas
[68] Ratte, Dominique. 2003. Direction des données sur la pollution, CAC program, Environment Canada

(fens/bogs) and 11% in transitional scrub or meadow vegetative communities. This forest cover is not uniformly distributed across the City. Rural areas, primarily those underlain by pre-Cambrian bedrock or limestone plain formations in the western portion of the City, have relatively extensive forest cover while areas in the sand and clay plain areas, which have been subject to far greater urban and agricultural development pressures, have much less than 30% forest cover. A study of land cover in the former City of Ottawa (urban environment) in 1993 found that 4.5% of the City was wooded.

Forests, wetlands, and agricultural lands are the main VOC emitters in Ottawa-Gatineau. They are responsible for 229,369 tonnes/year of VOC.

The urban forest, on the other hand, plays an important role in three respects:

- Trees can reduce demands for seasonal heating and cooling. When the right tree is planted in the right location (e.g. coniferous trees along the northern exposure, deciduous trees along a western exposure) it can make a significant contribution to the reduction of energy usage. A study in the City of Chicago estimated that increasing tree cover by 10% could reduce building energy use by 5-10%.
- Trees in an urban environment remove air pollutants such as NO_2, SO_2, O_3, CO, and PM_{10}. However, urban trees also contribute emissions of VOCs and PM particularly pollen.
- It is not only the rural forests that can play a role in carbon storage. A study in 1996 found that above ground tree biomass in a mature neighbourhood in Halifax was only slightly smaller than that in a nearby natural forest.

Aquatic Environments

Aquatic environments are sources of air pollution when they collect volatile pollutants such as pesticides, PCBs and mercury. In cool temperatures, aquatic environments tend to act as sinks, but in warmer temperatures, they act as sources. These air pollutants travel long distances and are bio-accumulative. They can also sink into the sediment. Dredging of sediment releases these pollutants back into the air and water, allowing them to travel further or become ingested by aquatic species. Climate change is exposing the sediment of lakes and rivers in recent years, as seen in the Great Lakes that is now a source of atmospheric pollution particularly for PCBs and mercury.

Wetlands

Wetlands can be both GHG sinks and sources. Scientists found that mature intact beaver ponds emitted both CO_2 and CH_4 to the atmosphere by an order of magnitude greater than from the surrounding wetland. These emissions from wetland species are regulated by water levels and peat temperature. Changes to these controls will affect how wetlands act. Warmer winters due to climate change might allow gas production to occur year-round. Methane production will increase dramatically, because the CH_4 pathway is more sensitive to temperature variations. Dryer summers will lower the water table, increasing the size of the aerobic zone and dramatically increasing CO_2 flux. A warmer climate could conceivably lead to the destruction of the bogs themselves, as the peat decomposes and new species move in to take advantage of the warm climate[69]. On the other hand, if summers were wetter, vegetation would be submerged and CH_4 formation would increase and the wetland would increase.

While wetlands may be the source of some emissions as described above, the ecological benefits of wetlands are much greater than their role as potential emissions sources. Wetlands are carbon sinks and peat removal or draining of wetlands would cause significant GHG emissions. Wetlands also contribute to environmental health by providing for groundwater recharge/discharge and flood attenuation, improving water quality through natural filtration and treatment, and supporting biodiversity by providing increasingly scarce habitat for wetland species. The importance of this contribution is recognized in the Environmental Strategy and through protective policies in the Official Plan.

Industrial sources

The City has few large point sources of industrial emissions, but there are significant local sources of air pollution that cumulatively merit consideration for the Air Quality and Climate Change Action Plan. The industrial sector of both Gatineau and Ottawa contribute with similar amounts of PM as the transportation section. In Ottawa, most are smaller industrial and commercial operations and can include:

- Perchloroethlyene from dry cleaning operations;
- Particulates, solvents and particulate metals from auto body repair and paint shops;
- Volatile Organic Compounds from the biogenic industry, general solvent use, gas stations, printing and copying shops, and some high tech manufacturing operations;
- Particulate matter from quarry operations, construction, and charcoal industry;
- Nitrogen oxides from the pulp and paper, commercial fuel combustion, electric power generation, etc.; and
- Sulphur dioxide from the pulp & paper sector.

[69] Gorham, Eville. 1995. "The biogeochemistry of northern peatlands and its possible responses to global warming." Biotic Feedbacks in the Global Climatic System. New York, Oxford University Press, p171-181.

These sources emit relatively small amounts of pollutants on an individual basis and their emissions are usually diluted and dispersed into the atmosphere fairly quickly. However, the cumulative impact within and beyond the City of these sources has not been studied and there is no routine monitoring of impacts of these emissions.

Waste disposal

Waste disposal produces emission in two ways: one during collection and the other from the landfill. The GHG inventory from the former Region suggests that this activity is responsible for 1,244 tones of GHG.

Ottawa has 80 active and inactive landfills. Few are active, and from those fewer yet collect the methane that is produced and flare it. Emissions from landfills contain not only methane, which is 23 times more powerful than CO_2, but also numerous VOCs. Some of these VOCs are major precursors of smog formation and others, such as freons, are known to be stratospheric ozone-depleting substances. Among the VOCs, there are substances such as vinyl chloride and 1,3-butadiene, which are known carcinogenic compounds. Flaring landfill gases eliminates between 95 to 99% of the VOCs.

The Trail Road and Nepean landfill sites collect landfill gas. By flaring the landfill gases from these two sites, the City was able to reduce 234,406 tonnes of eCO_2 per year, which represents 2.6% of the total community emissions.

Agriculture

The Canadian Agricultural Kyoto Table[70] estimates that 9.5% of Canadian GHG emissions are attributed to agricultural production activities not including the use of fossil fuels or the indirect GHG emissions from fertilizer production. Emissions from agriculture are primarily N_2O associated with fertilizer and animal manure use, and CH_4 associated with cattle and livestock manure.

Agriculture is the primary source of ammonia in the Ottawa-Gatineau area (2,115 tonnes/year). Methane is the next significant pollutant of this activity being emitted as part of the normal digestive process of livestock (an adult cow emits between 80-120 kgs of CH_4 per year). Methane is also a by-product of livestock manure management.

Agricultural soils are the largest contributor of N_2O emissions (nearly two thirds of all N_2O emissions). Nitrous oxide emissions increase through the application of fertilizers, production of nitrogen fixing crops, cultivation of high organic content soils, spreading of livestock wastes on cropland and pasture, and the direct deposition of wastes by grazing livestock. It is emitted from a variety of natural and anthropogenic sources. Amounts of

[70] Options Report. 2000. Reducing Greenhouse Gas Emissions for Canadian Agriculture. Agriculture and Agri-food Climate Change Table.

N_2O have risen by only 13% over the last 200 years, and certainly represent a small fraction of the GHG emissions profile in Ottawa[71]. Nevertheless, N_2O is estimated to be 310 times more effective at trapping heat in the atmosphere than CO_2. Every bit of reduction in N_2O is very beneficial.

In the City of Ottawa, agricultural activity is an important component of the rural economy. In the last census of agriculture, Statistics Canada found that[72]:

- There were 1455 farms in 1996 of 120,114 ha (or 43.5% of the land in the City). In 2001, the number of farms dropped to 1,318;
- Average farm size was 82.55 ha;
- Livestock operations (cattle 26.3% and dairy 22.3%), crops (19%) and miscellaneous specialty crops (21%) accounted for almost 90% of the farm receipts;
- The number of intensive livestock operations has dropped from 20 in 1996 to 17 in 2001; and
- The numbers of diary (287-220) and beef cattle (528-445), pigs (58-46) and sheep (103-91) all declined between 1996 and 2001 while poultry increased (143-156).

In general, Ottawa has a higher proportion of livestock operations than the rest of the Province.

[71] USEPA. 2001. Non-Co2 Greenhouse gas emissions from developed countries: 1990-2010.
[72] Statistics Canada Census 2001.

Annex 3. GHG reduction achievements

Table 13. Old City of Ottawa community CO_2 emissions for 1990 to 1998

Sector	Tonnes of eCO_2			
	1990	1993	1996	1998
Residential	537,588	484,310	479,080	1,573,163*
Commercial	1,109,844	855,284	938,650	
Total Commercial & Residential	1,647,432	1,339,594	1,417,730	1,573,163
Transportation	846,293	855,284	839,003	853,800*1
Methane	457,770	429,013	386,060	375,370*2
Total Emissions	**2,951,796**	**2,718,731**	**2,642,793**	**2,802,333**

* Aggregate of all CO_2 from electricity, natural gas, and fuel oil. No breakdown available by sector.
*1 Information from R.Parfett and Associates. GIS-Based Sustainable Urban Planning Tool V1.0.
*2 Assumption given recent trend.

Table 14. Recommended initiatives on energy use by Atmosphere Action Plan,1995

Establish Ottawa's CO_2 Corporate Challenge	Set up/operate an Information and Referral Service
Implement an Employee-based TDM program	Disseminate Federal Buildings Initiative info
Establish a Transportation Awareness Program	Establish Alternative Fuels Demonstration Project
Expand the role of Energy Service Companies	Track progress towards 20% reduction target
Work with financial institutions to encourage energy retrofits	Put in place Energy Rating Systems for residential and commercial buildings
Set up a Contractor Certification Program	

Table 15. City of Ottawa corporate CO_2 emissions for 1990, 1996, and 1998

Sector	Tonnes of eCO2		
	1990	1996	1998
Streetlighting	4,683	2,368	4,112
Fleet	6,441	5,317	5,064
Facilities	21,711	15,777	17,380
Total	**32,835**	**23,462**	**26,556**

Table 16. RMOC corporate CO_2 emissions for 1990 and 1997

Sector	Tonnes of eCO_2		Percent Growth
	1990	1997	
Buildings	22,451	21,644	-3.6
Vehicle Fleet	10,182	11,944	15
Traffic Lights	1,016	919	-10
Water/ Sewage Facilities	29,473	24,844	-19
Waste	2,929	1,243	-42
Total	**66,051**	**60,595**	**-9**

Table 17. RMOC community CO_2 emissions for 1990 and 1998

Sector	Tonnes of eCO_2 1990	Tonnes of eCO_2 1998	Percent Growth
Residential	1,469,003	1,960,142	33
Commercial	625,535	1,866,044	198
Industrial	342,794	756,271	121
Buildings Total	**2,437,332**	**4,582,457**	**88**
Transportation	2,353,000	2,476,000	5
Waste	1,237,773	1,968,149	59
TOTAL	**6,028,105**	**6,553,082**	**9**

Table 18. Summary of RMOC corporate action plan

Energy efficiency building retrofits
Fuel switching for fleet
Landfill gas
Waste management (recycling, reduction, composting)
Water/Sewage Treatment (energy efficiency in buildings, equipment, lighting, treatment process, change in energy source,)
Traffic signals
Employee Awareness (Green Steering Committee, Green Rep Program, TDM, Energy efficiency week, Earth week, Commuter Challenge, Waste reduction week)
Urban greening (Tree planting program)
Monitoring (recommend 3 staff)
Impact statement (integrate GHG reductions with corporate purchasing policies/practices)

Annex 4. GHG reduction recommendations

Table 19. GHG reduction recommendations.

Measure	How to	Feasibility
TRANSPORTATION		
Measure Increase Fuel efficiency in new car purchasing (increase the number of fuel efficient cars) by 15% (community) **Effects** Lowers fuel consumption per VKT in the community	**Obstacle** No direct municipal control but education with an emphasis on financial savings is possible **Action** Lobby senior governments for tax incentives	Reduction assumes 75% uptake. Depend upon incentives such as gas prices, etc. **Reduction potential** 170,000 tonnes
Measure Replace 20% of municipal fleets with more fuel efficient vehicles on an annual basis – buy fuel efficient vehicles during normal replacement cycle **Effect** Lowers fuel consumption per VKT in the corporation	**Action** Fleet emissions reduction policy – green procurement Educate and lobby senior governments	Reduction assumes that 80% of the fleet can be replaced with more fuel-efficient vehicles. **Reduction potential** 3,200 tonnes
Increase efficiency of passenger cars by 2% overall	Education Drive Clean	Mandatory Drive Clean would go along way **Reduction potential** 50,000 tonnes
Have 50% of OC Transpo at zero emissions by 2007	E or bio-diesel	**Reduction potential** 51,000 tonnes
Increase the number of dwelling units inside the Greenbelt by 4,500 dwelling units	Planning/Zoning Development Charges	Brownfield development **Reduction potential** 13,000 tonnes per year
Increase Mixed use development		**Reduction potential** To be evaluated
Increase Transit rider ship by 4.5% per year to increase modal share. Control Parking Supply and pricing.		**Reduction potential** 9,000 tonnes per year
Increase Biking and		**Reduction potential**

Measure	How to	Feasibility
Walking Modal Share. Switch .5% of personal auto use to biking and walking		11,500 tonnes
Encourage telecommuting – target of 50,000 workers per week		**Reduction potential** 18,400 tonnes per year
Promote Traffic Management/Smoothing – assume 0.5% gain in efficiency		**Reduction potential** 15,000 tonnes per year
Increase commercial fleet efficiency – replace 10% of heavy commercial vehicles with zero-emissions, increase overall fuel efficiency by 20%		**Reduction potential** 104,000 tonnes per year
ALTERNATIVE ENERGY AND ENERGY CONSERVATION		
District Energy	Participate and support District Energy Hubs in Downtown Ottawa	Depends on successful marketing by Ottawa Energy. Feasibility study complete and positive on potential application **Reduction potential** Phase I=12,000/year
Co-generation	Landfill gas from Trail Road	234,406 tonnes/year
Water Conservation	It is estimated that just a 10% reduction in Water Use could reduce energy consumption at treatment plants by approx. 17,000 GJ	Very achievable with standard water conservation measures **Reduction potential** 1,000 tonnes
WASTE		
Waste diversion	40 to 50% by 2006 and 2010 respectively	**Reduction potential** To be estimated
Integrated waste management	Institute Green Procurement within the corporation, lead by example.	**Reduction potential** To be estimated
SUSTAINABLE PLANNING/Community Greening		
Implementation of City Green and forest cover assessment	Complete pilot project through FCM Green Funds	**Reduction potential** To be estimated
Planting on City properties and rights of way		**Reduction potential** To be estimated

Measure	**How to**	**Feasibility**
Compact Development	Official Plan	**Reduction potential** To be estimated
BUILDINGS		
Corporate building retrofit	Continue retrofits of 49 City building through Energy Performance Contract	Initial work with 5-6 year pay back is very feasible. More significant gains in City facilities will require acceptance of longer pay back periods. **Reduction potential** To be estimated
Fuel switch in City facilities		**Reduction potential** To be estimated
Application of advanced design in new buildings, including use of LEEDS system		**Reduction potential** To be estimated
Exploration of alternative energy sources for City Buildings		Longer term initiative which relies on technology available and pay-back period policies **Reduction potential** To be estimated
Better Building Partnership		**Reduction potential** To be estimated

Glossary

Acid Rain - a term for the conversion of sulphur oxide and nitrogen oxide emissions into acidic compounds, which precipitate in rain, snow, fog, or dry particles.

Adverse Health Effects - health effects from exposure to air contaminants that may range from relatively mild temporary conditions, such as minor eye or throat irritations, shortness of breath, or headaches, to permanent and serious conditions such as birth defects, cancer, or damage to lungs, nerves, liver, heart, or other organs.

Aerosol - particle of solid or liquid matter that can remain suspended in the air because of its small size (generally under one micron).

Air Monitoring - sampling for and measuring of pollutants present in the atmosphere.

Air Pollution - the presence of polluting gases and suspended particles in the atmosphere in excess of air quality standards.

Air Quality Criteria - the varying amounts of pollution and lengths of exposure at which specific adverse effects to health and comfort take place.

Air Quality Standard - the prescribed level of a pollutant in the outside air that should not be exceeded during a specific time period to protect public health.

Airshed - a term denoting a geographical area of which, because of topography, meteorology, and climate, shares the same air. In the Ottawa case, it is downwind from the Ohio Valley in the Windsor-Quebec Corridor.

Alveolus - a small depression, sac, or vesicle.

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers that set guidelines for ecological footprint reduction.

Asthma - a medical condition characterized by abnormal restriction of breathing, especially in response to allergens or air contaminants.

Biodiesel - a cleaner-burning diesel replacement fuel made from natural, renewable sources such as new and used vegetable oils and animal fats. Like petroleum diesel, biodiesel operates in compression-ignition engines. Blends of up to 20% biodiesel (mixed with petroleum diesel fuels) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment. These low level blends (20% and less) do not require any engine modifications and can provide the same payload capacity as diesel. Using biodiesel in a conventional diesel engine substantially reduces emissions.

Biogenic industry - biogenic substance is one that is produced by natural processes. It refers to emissions from plants or animals that are raised for industrial purposes.

Carbon Dioxide (CO_2) - a colorless, odorless, non-poisonous gas that results from fossil fuel combustion and is a normal constituent of ambient air.

Carbon Monoxide (CO) - a colorless, odorless, toxic gas produced by the incomplete combustion of carbon-containing substances. One of the major air pollutants, it is emitted in large quantities by exhaust from gasoline-powered vehicles.

Carcinogen - any substance that can cause or contribute to the production of cancer.

Chlorofluorocarbons (CFCs) - a family of inert, nontoxic, and easily liquified chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere they drift into the upper atmosphere where their chlorine components destroy the ozone layer.

Criteria Air Contaminants (CAC) - as required by the Canadian Wide Standards, the Canadian Environmental Protection Act (CEPA) identifies and set standards to protect human health and welfare for six pollutants: ozone, carbon monoxide, particulate matter (PM_{10}), sulfur dioxide, nitrogen oxide and volatile organic compounds. The CEPA periodically reviews new scientific data and may propose revisions to the standards as a result.

Dust - solid particulate matter that can become airborne.

Emission inventory - list of air pollutants emitted into a community's atmosphere, in amounts (commonly tonnes) per day or year, and by type of source.

Epithelial inflammation - the inflammation of the tissue that covers the external surface of the body (nose cheeks) and lines hollow structures inside the body (respiratory system).

Ethanol - ethyl alcohol, a volatile alcohol containing two carbons (CH_3CH_2OH). For fuel use, it would be produced by fermentation of corn or other plant products.

Fossil Fuels - coal, oil, and natural gas; so-called because they are the remains of ancient plant and animal life.

Health Risk - the probability that exposure to a given set of toxic air contaminants will result in an adverse health effect. The health risk is affected by several factors: the amount and toxicity of emissions; the weather; how far sources are from people; the distance between sources; and the age, health and lifestyle of the people living and working at the receptor location. The term "risk" usually refers to the increased chance of contracting cancer as a result of an exposure and is expressed as a probability, e.g., chances-in-a-million.

Hot Spot - a location where emissions from specific sources may expose individuals and population groups to elevated risks of adverse health effects, including but not limited to cancer, and contribute to the cumulative health risks of emissions from other sources in the area.

Hydrogen Sulfide (H_2S) - a gas characterized by a "rotten egg" smell that is often produced by and found in the vicinity of oil refineries, pulp and paper plants, chemical plants, and sewage treatment plants.

ICI - institutional, commercial, and industrial.

Incineration - the burning of household or industrial waste in a combustion chamber.

Inversion - the phenomenon of a layer of warm air pressing down on cooler air below it. Inversions are a special problem because they prevent the natural dispersion and dilution of air contaminants.

LEED - Leadership in Energy & Environmental Design, a certification program for Green Buildings.

Macrophages - a phagocytic tissue cell (can engulf particles) of the mononuclear phagocyte system that may be fixed or freely mobile, and functions in the protection of the body against infection and noxious substances.

Megatonne (Mt) – is equivalent to 1,000,000 tonnes (t).

Modal Split - refers to the proportion of transit trips by motorized modes (transit and automobile).

Modal Share - refers to the percentage of person trips made by one travel mode relative to the total number of person-trips made by all modes.

Nitric Oxides (NO_x) - gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and pressure; considered a major air pollutant and a precursor of ozone. These gases are precursors of ozone, nitric oxide, nitrogen dioxide, and nitrate. The latter becomes involved in the photochemical process and/or particulate formation.

Nitrous Oxide (N_2O) - is a colorless, almost odorless gas, and possess painkilling qualities. It is a greenhouse gas that contributes to climate change and has a lifespan of 150 years. Humans contribute to nitrous oxide emissions through soil cultivation and the use of nitrogen fertilizers, nylon production and the burning of organic material and fossil fuels. Combustion and biomass burning are sources of nitrous oxide emissions. Agricultural practices may stimulate emissions of nitrous oxide from soils and play a major role in the build-up of nitrous oxide in the atmosphere.

Organic Compounds - a large group of chemical compounds that contain carbon. All living organisms are made up of organic compounds. Some types of organic gases, including olefins, substituted aromatics and aldehydes, have high ozone-producing potential.

Ozone (O_3) - a pungent, colorless, toxic gas. Close to the earth's surface it is produced photochemically from hydrocarbons, oxides of nitrogen and sunlight and is a major component of smog. At very high altitudes, it protects the earth from harmful ultraviolet radiation.

Ozone Depletion - destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation. This destruction is caused by the breakdown of certain chlorine and/or bromine-containing compounds (chlorofluorocarbons or halons) that catalytically destroy ozone molecules in the stratosphere.

Particulate - a particle of solid or liquid matter; soot, dust, aerosols, fumes, and mists.

Parts Per Million (ppm) - the number of parts of a given pollutant in a million parts of air.

Peroxyacetyl Nitrate (PAN) - is an organic compound consisting of oxygen, nitrogen, and a short hydrocarbon chain. It is a principle secondary polutant in photochemical smog. PAN is both toxic and irritating. At very low concentrations of only a few parts per billion it causes eye irritation. Plants are very sensitive: a fraction of 1 ppm causes extensive damage to vegetation.

Photochemical Process - the process by which sunlight acts upon various compounds, causing a chemical reaction to occur.

Photochemical Smog (O_3) – see smog.

Particulate Matter less than 2.5 microns ($PM_{2.5}$) - tiny solid or liquid particules, generally soot and aerosols. The size of the particles (2.5 microns or smaller, about 0.0025 millimetre or less) allows them to easily enter the air sacs deep in the lungs where they may cause adverse health effects; $PM_{2.5}$ also causes visibility reduction.

Particulate Matter less than 10 microns (PM_{10}) - tiny solid or liquid particles of soot, dust, smoke, fumes, and aerosols. The size of the particles (10 microns or smaller, about 0.010 millimetre or less) allows them to easily enter the air sacs in the lungs where they may be deposited, resulting in adverse health effects; PM_{10} also causes visibility reduction and is a criteria air pollutant.

Polycyclic Aromatic Hydrocarbons (PAHs) - are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot. It is known to cause health problems including cancer as well as birth defects in animals.

Polychlorinated Biphenyls (PCBs) - are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist in a gaseous state. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the U.S.A by the trade name Aroclor. They build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.

Precursor - compounds that change chemically or physically after being emitted into the air and eventually produce air pollutants.

Smog (O_3) - produced when hydrocarbons and oxides of nitrogen combine in the presence of sunlight to form ground level ozone.

Stratosphere - the portion of the atmosphere that is 10 to 25 miles above the earth's surface.

Sulphur Oxides (SO_x) - pungent, colorless gases formed primarily by the combustion of sulphur-containing fossil fuels, especially coal and oil. Considered major air pollutants, sulphur oxides may impact human health and damage vegetation.

Total Suspended Particulates (TSP) - particles of solid or liquid matter - such as soot, dust, aerosols, fumes, and mist - up to approximately 30 microns in size.

Toxic Air Pollutants - air pollutants that may cause or contribute to an increase in mortality or in serious illness or which may pose a present or potential hazard to human health.

Troposphere - the layer of the atmosphere nearest the earth's surface. The troposphere extends outward about 5 miles at the poles and 10 miles at the equator.

Volatile Organic Compound (VOC) - an organic compound that evaporates readily at atmospheric temperatures, a major precursor of ozone.

Wood Burning Pollution - air pollution caused by emissions of particulate matter, carbon monoxide, and odorous and toxic substances from wood burning stoves and fireplaces.