Connecting Sustainability in Halton Region
… From Policy to Practice

April 14, 2009

Phase 3

Sustainable Halton Report 3.11

Halton REGION

Connecting Sustainability in Halton Region … *From Policy to Practice*

1. Introduction

The Region of Halton's efforts to achieve sustainability are reflected in its policies, initiatives and actions. The Region's Strategic Plan speaks to controlling and managing growth for sustainable communities. The goals, objectives and policies of the Regional Official Plan are based on creating sustainable development. The Corporate Sustainability Plan is focusing on developing the Region's internal sustainability practices and programmes. And through the Sustainable Halton process, the Region is looking to further its sustainability efforts by implementing the Provincial Growth Plan and other recent provincial policy initiatives to create complete, healthy and sustainable communities.

While the Region continues to move forward with its sustainability efforts, a number of the key questions keep arising:

- How do we define sustainability?
- What are the key elements of sustainability?
- How do we measure sustainability?
- And, how do we move from our policies that encourage and support sustainability to implementing sustainability through our actions?

This paper addresses these questions. It begins by providing a brief overview of how the sustainability movement originated. From there it moves to providing a definition of sustainability and identifying a number of key attributes of sustainability. Several tools for measuring sustainability are discussed. A "made-in-Halton" approach to evaluating sustainability is then proposed and examples of how this approach has been applied to several Regional initiatives are provided, demonstrating how Halton can move from policy to practice in implementing sustainability.

2. Evolution of Sustainability

During the second half of the 20th century, continuing environmental degradation led not only to local and regional resource depletion and damage to essential ecological functions, but also to cumulative global effects. The concept of sustainability emerged in a series of meetings and reports during the 1970s and 1980s. *Limits to Growth*, published by the Club of Rome in 1972, is considered an important contribution in arousing awareness of future environmental problems that people would face despite its pessimistic approach. *Our Common*

Future, released by the UN-sponsored Brundtland Commission in 1987, is by far the most influential study on sustainable development, which suggests that economic development cannot stop, but must change course to fit within the planet's ecological limits. The Brundtland Commission's work provided the basis for the UN Conference on Environment and Development, also known as the Earth Summit, in Rio de Janeiro in 1992, which aimed at developing a global consensus on measures needed to balance development pressures against an increasingly imperilled global environment. *Agenda 21*, adopted by more than 178 states at the Conference, covers topics on virtually everything regarded important for a sustainable future.

The development of sustainability concept, especially the meaning and implications of sustainability, has not come without debates. While researches vary in emphasis and approach, and are sometimes contradictory on important specifics, there is essential consistency on some basic concerns and principles, such as growth in harmony with our environment, preserving our resource base for our economic well-being, and planning for our children's future. These important consensuses moved government commitments into laws and policies.

Sustainability is the ability to sustain human activity on earth at all geographic scales - global, continental, national, regional, and local. Sustainability is about our relationship with and use of our natural environment, the earth, to ensure that we do not overdraw on the environment's finite resources and its capacity to accommodate human life, today and into the future. It includes, among other things:

- Our ability to realise economic security – employment longevity, growth, and prosperity, both for today and into the future.
- Our ability to have sufficient food, water, and shelter, and healthy human populations, both today and into the future.
- How we live in our communities, the way we think, our value systems, the way we behave, and the choices we make – for ourselves and our family – and the effects on our Earth, today and into the future.
- How we participate in decision-making with our governments, today and into the future.
- Our ability to realise our full potential given our skills, education, experience, as well as our ability to continually learn, today and into the future.
- How we and our governments respond to a constantly changing world from socio-demographic, environmental, economic, and world peace and security perspectives, today and into the future.
- How we see ourselves in the biosphere and protect the natural environment and its biodiversity, today and into the future.

3. Measuring Sustainability

A variety of sustainability management tools are available to assess sustainability. During Phase 2 of Sustainable Halton, ICLEI was retained to examine the appropriateness of using carrying capacity or other sustainability management tools including ecological footprint, global reporting initiative, ecobudget, and triple bottom line to guide decision-making for Sustainable Halton. The report entitled *Carrying Capacity Study* is included as Attachment 1.

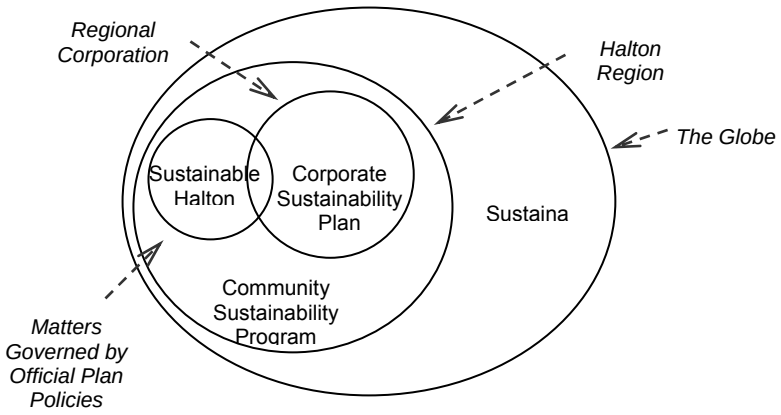
ICLEI undertook a literature search, and analysed each of the previously-noted sustainability management tools from (1) the economic, environmental, and social perspectives; (2) applicability for planning, implementation, and reporting; and, (3) their feasibility and appeal in terms of data accessibility, accuracy, decision-making ability, communication impact, and specific accountability.

ICLEI concluded that each sustainability management tool was valid for assessing sustainability, and that each has varying strengths and weaknesses. Communicating each tool, and establishing the relevance of policy and implementation of land use plans at the Regional level, would be challenging. None of these sustainability management tools can be readily applied to Sustainable Halton, only elements of each could be used. As a result, a Made-In-Halton approach to sustainability is needed to cover the range of sustainability issues in Halton.

4. Sustainability Principles for Halton Region

In this section, a "Made-In-Halton" approach to measuring and achieving sustainability is proposed. It's based on the 10 Draft Sustainability Principles that were presented in the staff report PS-32-09/CA-06-09 *Overview of Sustainability in Halton Region* (Table 1). In addition to identifying these principles, the report makes the point that the Region of Halton alone cannot achieve sustainability. The actions of other individuals, levels of governments and jurisdictions outside Halton's boundaries impact the Region's ability to achieve sustainability.

Table 1. Halton Region's 10 Sustainability Principles

Principle	Sustainability Context
1	Sustainability means a steady state where (adapted for Halton from the Four System Conditions under *The Natural Step*): a) Natural resources are not being over-used; b) Waste generated does not accumulate over time; c) The natural environment is not being degraded; and d) This and future generations' capacity to meet their needs is not being compromised.
2	Sustainability is bigger than the Sustainable Halton process, a Corporate Sustainability Plan and a Community Sustainability Program combined 
3	Sustainability is global in scope and cannot be solely delivered by a single jurisdiction such as Halton Region.
4	Achieving Sustainability is important for human survival and, in spite of the current state of affairs, all individuals and organizations should strive for it. "Think Globally, Act Locally."
5	Sustainable Halton is a process to prescribe a land use plan and policies to move Halton communities towards Sustainability. Halton's Official Plan vision of Landform Permanence captures the spirit of Sustainability by claiming that as growth is being accommodated, Halton should never lose its natural beauty and mix of town, village, countryside and farmlands on the landscape. Landform permanence also strives to protect the Niagara Escarpment, environmentally sensitive areas, wetlands, streams and valley systems, Lake Ontario shoreline, and forests.
6	Under the Sustainable Halton process, a land use plan that best achieves Sustainability will be selected based on an evaluation framework that embraces four Conditions for Sustainability (Table 3).

Principle	Sustainability Context
7	Regional Official Plan policies will implement the selected land use plan by ensuring that all land use decisions are screened through the Four Conditions for Sustainability by the Region.
8	Halton Region is committed to a Corporate Sustainability Plan that will set an example of striving for sustainability by ensuring all corporate decisions and actions adhere to the Four Conditions for Sustainability.
9	Halton Region supports Community Sustainability initiatives that will advocate, encourage and promote the adoption of the Four Primary Conditions for Sustainability in decisions and actions by Halton residents and businesses.
10	Halton Region, in its strive for Sustainability, will dedicate financial and human resources to set targets, monitor results, investigate alternative approaches, and implement corrective actions.

4.1 Definition of Sustainability (Principle 1)

Principle #1 is central to the Sustainability Principles. It is premised on The Natural Step's four conditions for sustainability. The Natural Step is a framework used by many governments, organisations, and companies around the world to integrate decision-making and achieving sustainability. Based on systems thinking and need for common language, the Framework recognises that what happens in one part of a system affects every other part. The Natural Step complements other sustainability tools and methods by providing both context and strategic vision. The Framework is used in problem-solving, strategic planning, and guiding actions.

1) Not Over-Using Natural Resources

The earth is full of natural resources such as water, oil, gas, and mineral deposits. Life on earth requires humanity to use them for every day living. We are living in a critical time in both the history of the planet and human history. At the global level, natural resources are declining while demand is increasing. All natural resources are finite, which means they have definable limits and are not endless; Most natural resources are non-replenishable.

As an example, oil and natural gas are natural resources which are constantly in high demand. Supplies may be at their peak and it is important not to overuse them. Adopting a conservative approach to their use and seeking out alternative and renewable sources of energy is necessary.

This condition directly applies to land use decision-making. It corresponds to the principles of landform permanence and land stewardship in the Regional Official Plan.

2) Accumulation of Waste

Human activity produces waste. The way goods and services are made and delivered to the end user generates waste. Waste is also created from our everyday activities – using disposable plastic bags, diapers, containers and plastic water bottles. Waste is also accumulated in soils over time from various industrial activities.

Society is running out of place to put waste and the Earth has limited capacity to assimilate waste. We need to reduce the resources we use, and not accumulate the waste by reducing, reusing, and recycling. We also need to clean up contaminated and brownfield sites.

This condition responds to the land stewardship principle in the Region's Official Plan. Further, Halton Region has a direct stake with this condition given its responsibility for Waste Management and pursuing initiatives to reduce waste accumulation.

3) No Environmental Degradation

Everyday activities affect the natural environment. Air and water pollution, and soil contamination degrade the environment. Societies need to reduce pollution to the air from the vehicles we drive and various industrial processes. Limiting soil degradation from pesticides and fertilisers and from industrial activities would reduce impacts on native of plant and animal species. Reducing environmental pollution would improve the quality of lakes and streams – our water source for daily activities.

Activities in other places, outside our jurisdiction, pollute our air and water, and activities in one jurisdiction may pollute environments in other jurisdictions. We need to reduce pollutants to the airshed, water bodies, and soils, because it affects our health. Clean-up takes generations and is extremely costly. Adhering to no environmental degradation, requires constant rehabilitation, repair, and enhancement of our environment. This condition is covered by the land stewardship principle of the Regional Official Plan.

4) The Capacity of Future Generations

Perhaps one of the most important aspects of sustainability is ensuring the ability of future generations to live on this earth. While the previous three conditions relate to the environment, this condition attends to the social and economic aspects of every day life. Housing, strong cohesive communities, jobs, health and educational facilities are some important aspects of sustainability. These aspects are necessary for all individuals to realise their full potential and contribute to society. It is important that deficiencies in socio-economic areas are continually addressed so that present and future generations' ability to reach their full potential is not compromised. This condition recognises that human

survival needs to use the Earth's natural resources, but, requires its use in a responsible, sustainable way that would not inhibit future generations' socio-economic goals and well-being.

4.2 Sustainability Is a Global Responsibility (Principles 2, 3, and 4)

Actions around the world contribute to sustainability, as conditions or activities in one area may affect conditions in another. Sustainability is necessary for human survival. Unless societies become more sustainable, human civilisation as we know it would end.

Climate change presents a major challenge to sustainability on Earth. Addressing this and other aspects of sustainability requires full participation of all governments and all peoples around the world.

Halton Region can only influence sustainability in areas where the Region has jurisdiction or legislative authority. As Principle 2 on Table 1 indicates, the Region's primary initiatives reside in the Strategic Plan, Sustainable Halton and the Official Plan, and the Corporate Sustainability Plan. Sustainable Halton is about our future - ensuring people and jobs are placed in areas that do not restrict the Halton community's ability to be sustainable today and into the future. It is about making sure we follow the four conditions of sustainability.

The local municipal partners have discrete and complementary roles to play in pursuing sustainability. Local municipalities are responsible for key areas of the sustainability: transit, community design, building standards, building permits, and development approval. Some municipal partners have a dedicated Office of Sustainability in house and report on the various sustainability endeavours.

Communities and individuals also play key roles and have responsibility for living in a sustainable manner – relying more on active transportation (walking and cycling) and transit instead of using the car, buying locally-grown food, and using less water, natural gas, and electricity.

Sustainability is a shared global responsibility. It is important that Halton does its part, as we cannot achieve sustainability on our own.

4.3 What Halton Region Can Do Towards Sustainability (Principles 5, 6, 7, 8, and 9)

The four conditions for sustainability can be applied to Sustainable Halton, corporate actions for Halton Region, and community initiatives.

Sustainable Halton is a land use planning exercise to determine the appropriate locations for population and employment growth to 2031. It assesses the future possibilities from provincial policy requirements and our current official plan.

Table 2 on the Land Use Evaluation Framework illustrates how the four conditions of sustainability can be applied to planning in Halton. Sustainable Halton embodies the four conditions of sustainability as it strives to assure a future Halton where its natural features are still recognisable and protected on the landscape by protecting what is valuable; building healthy, complete, and sustainable communities; supporting growth with sustainable infrastructure; and promoting health for all. What is interesting is the strong connection that health plays across all conditions. Human health and human survival depend on society's and individual's ability to adhere to the four conditions for sustainability.

Once the new urban areas are selected through Sustainable Halton, implementation of the official plan policies has to occur. The four conditions are appropriate for assessing development applications and land use decision-making under the Regional Official Plan. This would advance Halton's sustainability efforts.

Table 2. Land Use Evaluation Framework

Evaluation Theme	***Conditions for Sustainability***			
	(a) Conserve Resources	*(b) Limit Waste*	*(c)No Environmental Degradation*	*(d)Maintain Capacity to Meet Needs*
Protect What Is Valuable	√		√	
Build Healthy, Complete and Sustainable Communities	√	√		√
Support Growth with Sustainable Infrastructure	√	√		√
Promote Health for All	√	√	√	√

The four conditions of sustainability are universal enough to apply to decision-making on corporate activities. Employing the four conditions would standardise corporate decision-making and increase its transparency. It also has the added benefit of lending consistency to Regional decisions and activities as they pertain to fleet management, buildings, street and traffic lights on Regional Roads, Transportation Demand Management, Green Procurement, Waste Management, and Water Conservation.

Many environmental, business, and interest groups in Halton are pursuing sustainable initiatives of their own. Many individuals and families are also "going green". The four conditions can help the community implement sustainability and respond to situations such as the recent oil price increases and economic downturn.

4.4 Investing in Actions Toward Sustainability (Principles 10)

In using the four conditions of sustainability, Halton Region needs to dedicate resources to realise sustainability. Specifically, the Region needs to invest financial and human resources to implement sustainability. Implementing sustainability involves monitoring and reporting on the effectiveness of the Region's official plan and other policies, and taking corrective actions as required. Social marketing to educate the community on sustainability programmes, investing in green buildings and technologies, investing in transit instead of roads, and adopting green procurement strategies are examples of actions that the Region could take. While in the short-term these initiatives may cost more, they would benefit the Halton community in the long-term.

5. Practising Sustainability

5.1 Implementing Growth Plan Targets

By meeting the Provincial Growth Plan intensification and density targets, the Region would be able to achieve the four system conditions previously-discussed. The Provincial intensification and density targets include:

- At least 40% of all residential development is to occur in the built-up area by 2015 and each year thereafter. The built–up areas in Halton were identified through a collaborative effort between the Province, the Region and the Local Municipalities;
- Urban growth centres must achieve at least 200 persons and jobs per hectare by 2031. In Halton, three urban growth centres have been identified – Downtown Burlington, Downtown Milton, and Mid-Town Oakville; and
- Designated greenfield areas are required to achieve at least 50 persons and jobs per hectare as measured across the entire Region.

These targets require a shift in Halton's housing mix from 59% singles/semis, 30% row and 11% apartments over the period of 2006-2016 to a mix of 38% semis and singles, 31% rows and 31% apartments for the period of 2016 to 2031 (Accommodating Growth to 2031, Table 15, Hemson Consulting). This will result in more complete communities offering a greater choice of housing for Halton's residents, including more affordable housing. Also mixed use communities in the Region's new urban areas will have a range of uses including houses,

businesses, parks, schools and community and human services. This will ensure the Regional move towards sustainability.

Mobility is a key component of the Provincial Growth Plan's focus on building complete communities. The Provincial definition of complete communities includes "convenient access to public transportation and options for safe, non-motorized travel". Certain density levels are required to support transit and ensure its success. The Halton Health Department's recent paper *"Creating Walkable and Transit-Supportive Communities in Halton"* (Pg. 22) identifies the land use densities that Metrolinx suggests can typically support different types of transit service (Attachment 2).

Another recent report from the Region's Health Department, *Protecting Health: Air Quality and Land Use Compatibility*, provides a number of specific directions for consideration in the Sustainable Halton and Regional Official Plan Review processes that focus on planning and air quality, and ultimately sustainability (Attachment 3).

The overall affect of meeting the Growth Plan targets is that the Region and Local Municipalities would be able to minimise the amount of new urban land to 1,680 hectares to accommodate the additional population between 2021 and 2031 (Accommodating Growth to 2031, Hemson page 22). Managing growth this way would ensure that natural resources such as water, natural heritage systems, and agricultural land are not over-used.

All of the densities being planned for Halton's new urban areas meet the minimum level for bus service. Convenient, accessible transit will provide residents of Halton's new communities with an alternative to using their cars to make daily trips. Increased densities and a mix of uses will increase opportunities for active transportation (walking and cycling) and this will minimise impact on the natural environment, protecting it for future generations. The Region will be able to continue efforts aimed at reducing, reusing, and recycling waste in new communities. The human service infrastructure required to support population and employment growth will ensure that current and future generations' ability to meet their needs are not compromised.

6. Conclusion - Official Plan Review Directions

Provincial policy and input on Sustainable Halton identify many opportunities to address sustainability through the official plan review. Thirteen major directions are proposed to move the Region towards sustainability. These directions focus on creating more complete, healthy, and sustainable communities through intensification, mixed uses, transit, and design. Protecting and enhancing what is valuable is another key direction that focuses on the natural heritage system, a viable agricultural industry, and archaeological resource protection. Directions

such as developing an aggregate strategy, protecting strategic employment areas, and moving to greener energies and technologies round out the range of sustainability initiatives that the Region could address in its official plan.

Papers prepared by the Halton Health Department focusing on walkable communities and land use compatibility will improve air quality, and increase sustainability in Halton Region. Although these papers mainly apply to local planning matters, they offer practical perspectives on ways to achieve sustainability in Halton.

Sustainability will remain the focus of many Regional, Local, and community initiatives. The Ten Principles for Sustainability presented in this paper are appropriate for corporate decision-making and decision-making on land use planning matters. Applying these principles in Halton will move the Region closer towards sustainability. Halton Region will continue to consult with the Halton community on these and future sustainability initiatives.

FINAL REPORT

CARRYING CAPACITY STUDY

May 23, 2008

Prepared By:
ICLEI – Canada

Prepared For:
Regional Municipality of Halton

TABLE OF CONTENTS

INTRODUCTION

In response to the projected growth of the Greater Golden Horseshoe Area, municipal and regional governments are currently investigating the most appropriate mechanisms for accommodating the large population influx. This paper has been prepared for the Regional Municipality of Halton (hereafter referred to as Halton Region) as a study of the carrying capacity concept to examine its potential as a tool to assess progress towards sustainability.

Halton Region is in the midst of the Sustainable Halton process, the Region's growth management initiative to plan for growth to 2031. According to the Government of Ontario's Growth Plan for the Greater Golden Horseshoe, the population target for Halton Region and local municipalities is 780,000 people by 2031. The employment target is established as 390,000 jobs and the general intensification target is 40% of new residential units a year, to be accommodated in Halton's built-up area starting in 2015.

This paper was initiated as part of Phase II of *Sustainable Halton*. The Region commissioned the research to explore the concept of carrying capacity and its use within other municipal regions. Additionally, Halton Region was interested in the relationship of carrying capacity to other sustainability management mechanisms or tools.

METHODOLOGY

A three-part methodology was used in carrying out the study: Internet search, literature review, and first person interviews. Resulting from the research were both the full report on carrying capacity and 17 community case studies (see Annex One).

An Internet search was carried out to identify studies, methodologies, policies and educational programs, which included the following search terms: "carrying capacity", "environmental capacity", "methodology" or "assessment", and "development". Of the results this search yielded, the subject pool was narrowed first by focusing on studies that made explicit reference to humans, as many of the studies found focused on the carrying capacity of rangelands and national parks or on the carrying capacity of a particular ecosystem for a terrestrial or aquatic species. These studies were further examined to include only those that discussed carrying capacity or environmental capacity in explicit terms.

Next a literature review was conducted to identify existing carrying capacity studies, methodologies, policies and educational programs. These were then considered in relation to other tools used for sustainability management at the local, regional and other jurisdictional levels. The search for case studies was focused on Ontario, Canada and North America, however international cases were considered if they were particularly interesting or relevant. In order to be considered in the analysis, the jurisdiction had to cite a clear interest in and commitment to sustainability management goals.

Article databases (primarily Scholars Portal Search, Scopus, JSTOR, Elsevier Science Direct, Blackwell Synergy and ESCBOhost) were searched with the previously mentioned terms. To illustrate, when the term "carrying capacity" was entered into a Scholars Portal Search, 253 results were obtained, while the term "environmental capacity" yielded 1266 results. A similar method employed in the Google search was used to narrow the subject pool. In contrast to the

Internet searches conducted, only peer-reviewed articles were examined in detail from the results obtained, although exceptions were made if the result was particularly interesting or relevant.

As mentioned, through the research phase 17 cases were identified in which communities have, to some degree, utilized carrying capacity – or a similar concept – within their sustainability policies. Though most of the cases have not used it to explicitly limit population growth to their community – they have used sustainability management tools to limit tourism within a particular ecosystem, the planning of a subdivision, or raising public awareness on sustainable development (the text boxes below offer a snapshot of the best examples of carrying capacity within local planning).

Finally, telephone interviews were conducted with specific experts and practitioners identified in the research phase. The interviews drew-out undocumented experiences and lessons learned via their initial research, design and implementation of their carrying capacity or sustainability management experience. The interviews examined the strengths and weaknesses of the carrying capacity concept as a mechanism to evaluate, plan and implement sustainability.

DEFINITION OF CARRYING CAPACITY

Carrying capacity refers to the degree of human activity that a region can sustain in a given area without degrading the natural, social, cultural and economic environment for present and future generations (Bishop, 1974). Inherent in this view is the idea that there has to be a limit to population based on the environmental conditions indigenous to the location; accordingly, the rate of use and renewal of the resource base is of essential consideration when planning for population growth.

Although the original interpretation of carrying capacity focused on wildlands and wildlife, the term has been extended to include humans. Human carrying capacity studies aim to determine the level or impact of human population that an area can support based on natural and/or socioeconomic factors (Randolph, 2004) and are used to set the upper limit of population size. However including humans as part of the carrying capacity concept adds complexity, as these carrying capacities are contingent on the structure of production and consumption processes and the ever-changing interactions between the physical and biotic environment (Khanna, 1999). Furthermore, new and/or changing technologies have the potential to change how resources are consumed thus altering the carrying capacity (Hopfenberg, 2003).

A carrying capacity analysis assesses the ability of a natural resource (i.e aquifers, water bodies, woodland, etc.) and/or a built resource (i.e roadways, wastewater treatment plants, etc.) to absorb population growth and the associated physical development without degradation. When that capacity is exceeded, the resource fails to function as planned or desired – resources should be assessed for renewability, mobility, type, and ownership (Khanna, 1999). Within carrying capacity evaluations, it is essential to consider not only the number of individuals within the given ecosystem, but also the ways in which these individuals behave and the quality of life they enjoy.

Box 1.1 – Okotoks, Alberta

The town of Okotoks, Alberta adopted a Municipal Development Plan (MDP) in September 1998 that established growth targets linked to infrastructure development and the environmental carrying capacity of the Sheep River watershed. Here, carrying capacity was determined by the ability to draw water and infuse treated effluent based on provincial regulations. The town decided to cap growth at 25,000 to 30,000 residents. Moreover, a build-out municipal boundary was established, with a comprehensive set of targets and initiatives identified to ensure build-out population could be reached in an environmentally, economically, socially, and fiscally healthy way.

CARRYING CAPACITY FACTORS

Carrying capacity can be defined in a variety of ways depending on which variables (ecological, cultural, social, etc.) are being considered. Variables can include the supplies of materials (i.e. food, clothing, water, and shelter), and natural constraints on population such as climate, topography, or other geographical features. Other variables that influence human carry capacity include: birth/death rates and other demographic aspects (family structure, marriage and migration). Thus it is essential to first specify which variables are going to be measured.

Factors that can determine the carrying capacity of a given geographic area and its ability to support growth include: total land area, area of natural protected areas, soil limitations for septic systems, sewer capacity, stormwater drainage capacity, water supply capacity, air quality and meteorological conditions, urban waste production, waste recycling rate, water quality, urban water consumption per user, number of existing road vehicles, road network availability, public transit capacity, visual quality, school capacity and hospital capacity (Randolph, 2004; UNEP, 2003).

Box 2.2 - El Dorado County, California, USA

The El Dorado County River Management Plan (RMP) focuses on whitewater recreation on the South Fork of the American River in Northern California. It seeks to develop a consensus on what carrying capacity should be established. The environmental impacts of the growth of current and future river use were considered and as such the objectives of developing the carrying capacity framework were to develop a river management tool that was responsive to changing human and environmental conditions. The County will commit to controlling the impacts of future growth in river use through a carrying capacity program. As such, the County will commit to achieving specific performance standards and criteria for carrying capacity, by establishing indicators of carrying capacity and by setting specific thresholds for each indicator that trigger management actions to regain or maintain the thresholds.

REFLECTIONS ON THE APPLICATION OF CARRYING CAPACITY

The research and interview process lead to the identification of some strengths and weaknesses in applying the carrying capacity concept as a sustainability management tool.

Strengths

- Good means of conveying concept of environmental limits;
- Planning and implementation offers meaningful opportunity to engage and educate local stakeholders;
- Tracks specific set of environmental indicators accurately;
- Places local government in an active environmental stewardship role not traditionally seen as its area of expertise; and
- Applies well to community or subdivision developments as opposed to large-scale municipal-wide planning.

Weaknesses

- Limiting growth based only on environmental considerations can negatively impact social and economic considerations;
- Does not account for variances in individual conservation measures, but assumes the lowest common denominator, i.e. assumes a maximum use of resources;
- Does not address quality of life issues and potentially could create inequalities within the community;
- Setting limits to growth in one jurisdiction may lead to unsustainable practices just outside jurisdictional boundaries; and
- Not a holistic approach to ecosystem health, but rather based on individual indicators selected during project design.

OTHER SUSTAINABILITY MANAGEMENT TOOLS

There are a variety of sustainability measurement tools that are available to municipal governments to assess sustainability. The concepts of Ecological Footprint, Global Reporting Initiative, *eco*BUDGET and Triple Bottom Line offer many options for municipalities to assess their progress towards sustainability.

Ecological Footprint

In contrast with carrying capacity, the ecological footprint of a designated population is the area of land and water ecosystems required to produce the resources that the population consumes and take in the wastes that the population produces (Global Footprint Network [GFN], 2006; Rees, 2000). Ecological Footprint calculations have had significant success in communicating the discrepancies between the physical land area that a given population occupies and the land area that the population requires to function. Additionally, footprinting is great at conveying the need for behaviour changes and further fostering that change through the understanding of sustainability that it offers.

Ecological footprints can be calculated for anything from a single individual to an entire country. Perhaps the best-known approach is the national accounts system which consists of using national data sourced largely from United Nations agencies. These approaches can be classified as either ‘compound’ or ‘component’. Compound calculations use the national accounts data and adjust for known variations in local demand (e.g. number of kilometers driven by car per

person). Component calculations are similar to Life Cycle Analysis and work from the actual data held by the regional or local government.

Compound Ecological Footprint reports on resource consumption and answers the question of whether that consumption is ecologically sustainable. Compound EF aggregate data to a single figure on resource consumption based on published national data, however, creating a single number for environmental impact involving disparate variables such as air, land and other resources is too great a simplification, it is however a powerful communication tool, allowing assessment of whether organisational or jurisdictional resource consumption is sustainable.

Component Ecological Footprint broadens the scope and improves the accuracy of the ecofootprinting tool over the compound methodology. Component EF aggregates data to a single figure on resource consumption, based on local data. Since it can be used to estimate the footprint of different policy options at both organizational and community levels, it is more likely a tool that can be used in planning.

Global Reporting Initiative

GRI is a collaborating Centre of the United Nations Development Programme and has recently formed an alliance with the Global Compact. GRI's vision is that reporting on economic, environmental, and social performance by all organisations becomes as routine and comparable as financial reporting. GRI provides a reporting tool, the Sustainability Reporting Guidelines, which assists organisations to inform both stakeholders and internal managers of the organisation's sustainability performance.

The Sustainability Reporting Guidelines comprise principles and indicators that organisations can use to create a credible report. They also have adaptations for specific economic sectors. The Guidelines are performance-based and, over time, allow organisations to track incremental improvements in sustainability performance.

GRI guidelines provide a framework that organisations can use for their reporting. It does not prescribe data gathering procedures nor how the data should be interpreted when assessing impacts. As such it does not facilitate easy comparison between organisations.

*eco*BUDGET

*Eco*BUDGET is a system used for natural resource accounting and distinct from a tool for general environmental management. Following the same principles as financial budgeting, the *eco*BUDGET process sets short-, medium- and long-term targets for natural resources (such as air quality, water, raw materials, climate stability, etc.) creates implementation plans to meet the targets, monitors progress against set targets, and assesses results prior to the reevaluation of targets. Once established as an annual routine, as with financial budgeting, *eco*BUDGET ensures that environmental quality is managed on an ongoing, rational and transparent basis, thus supporting accountability. After the completion of a yearly *eco*BUDGET cycle the reasons for success or failure of meeting the *eco*BUDGET are then reported to the community. Environmental aspects are woven into municipal policy making across departments; making municipal leaders true resource managers, responsible for both financial and natural resources. The system is a crosscutting instrument, suitable for addressing all natural resources and areas of environmental quality.

Triple Bottom Line (TBL)

Adapted for municipalities by the City of Melbourne and the ICLEI Oceania Office, TBL expands the traditional reporting framework to take into account environmental and social performance in addition to financial performance. It is a planning tool that supports 'thinking' as it requires users to consider a series of questions related to environmental, economic and social impacts of proposed actions/policies. Users make a high-level assessment of the nature, magnitude and likelihood of impacts; more detailed assessments are then carried out for the most significant impacts. As this tool is used by mainstream municipal officers rather than by specialist sustainability officers it is much more embedded into planning and policy development versus being isolated within a sustainability department. The cities of Hamilton and Calgary have also developed tools based on triple bottom line analyses.

APPLICATION OF SUSTAINABILITY MANAGEMENT TOOLS

The following table (Table 1) outlines the potential application of the five sustainability management tools based on the three pillars of sustainability (economic, environmental, and social). It is meant to illustrate that each of the tools has a particular phase of the development process that it is most useful for – planning, implementation, or reporting – and also which outcomes it is most applicable to. It is worth noting that all reporting tools generate data that influence planning and implementation decisions. However, what is shown below is whether or not the tool has an explicit capability to generate planning and implementation assessments.

TABLE 1: APPLICATION OF SUSTAINABILITY MANAGEMENT TOOLS

Tool	Outcomes	Planning	Implementation	Reporting
Carrying Capacity	Economic			
	Environmental			
	Social			
GRI	Economic			
	Environmental			
	Social			
Ecological Footprint (compound)	Economic			
	Environmental			
	Social			
Ecological Footprint (component)	Economic			
	Environmental	(emerging)	(potential)	
	Social			
***Eco*BUDGET**	Economic			
	Environmental			
	Social			
Triple Bottom Line	Economic			
	Environmental			
	Social			

The table below (Table 2) offers a comparison of the sustainability management tools outlined in this report. It aims to show both the feasibility of the tool (vis-à-vis the accessibility of data and the accuracy of data) and the appeal of the tool for municipal decision makers (vis-à-vis utility for decision-makers, communication, and accountability). Please note that the column labeled "Accessibility of Data" is a surrogate criterion for the cost of gathering data in terms of both staff time and direct costs. It was used because cost would have been an inverse indicator compared with feasibility using the low-medium-high analysis – i.e. high data accessibility equates to low cost.

TABLE 2: COMPARISON OF SUSTAINABILITY MANAGEMENT TOOLS

Tool	**Feasibility**		**Appeal**		
	Accessibility of data	***Accuracy***	***Utility for decision-making***	***Communication impact***	***Specific accountability***
Carrying Capacity	Low	High	High	Medium	High
GRI	Medium	High	Medium (by aiding review)	Medium	High
Ecological Footprint (compound)	High	Low	Low	High	Low
Ecological Footprint (component)	Variable (Specifically to local government)	High	High	High	Medium
EcoBUDGET	Low	High	High	Medium	Medium
Triple Bottom Line	Medium	Medium	High	Low	High

ALTERNATE MECHANISMS FOR SUSTAINABLE PLANNING

Cluster development also known as conservation design, conservation development or open space development – places development in less sensitive areas while preserving forested land, steep slopes, wetlands, prairies and other ecologically or visually valuable landscape features (Benedict, 2006). Typically 50 to 90 percent of a site is preserved in its existing natural or agricultural state, with the individual lots occupying the remaining acreage. It has been said that conservation design flips the traditional planning process from the traditional applications of lot lines first, then street layout, followed by localization of house sites and lastly preservation of open space to first establishing open space, localization of house sites, placement of street layout and lastly the establishment of lot lines. There are four prevalent types of conservation development: 1) conservation buyer projects, 2) conservation and limited development projects, 3) conservation subdivisions, 4) conservation oriented planned development projects.

The advantages of conservation subdivisions over conventional "cookie-cutter" subdivisions include reduced land consumption, less damage to the environment, and the preservation of open space. Fundamental to conservation design is the belief that open space serves important ecological roles by providing natural habitat, reducing water runoff volumes, limiting landscaping and lawn maintenance, and providing natural cooling (Mohamed, 2006). Conservation design for subdivisions, as a planning tool, is currently being employed at several development sites in Dieppe, New Brunswick. The goals of the project site in Dieppe include:

- Increase in density for residential development (as requested by the City);
- Protection of wetlands & mature trees;
- Reduction in impervious surface (help with water recharge);
- Connection with other green areas & trails; and
- Support for increased social interaction.

Although this is one of few examples in Canada, there are numerous sites that have used this development tool throughout the US.

CONCLUSION AND RECOMMENDATIONS

This report was meant to provide an overview of the carrying capacity concept and the utility of it for local governments as a method for assessing sustainability. Through research, both first person interviews and a literature review, it became apparent that it is not a concept that is frequently used within the municipalities for sustainability planning. Though the concept has clear value for assessing the tolerance of an ecosystem to populations (both current and future) it does not put any emphasis on the quality of life and economic considerations of planning decisions.

There are several "next steps" that would have to be considered prior to progressing with carrying capacity as a sustainability management tool. In order for carrying capacity to play a key role in policy development, plan preparation, and decision-making, the following issues would require consideration:

- Clarity on the criteria, indicators and targets that should be used to measure carrying capacity;
- Identification of the key information and environmental data needed in order to inform decisions relevant to carrying capacity;
- Definition of all environmental indicators (not only watersheds) and their interrelationship in order to holistically assess the carrying capacity of the local environment;
- Elaboration of the methodology to include quality of life issues within the rubric of carrying capacity;
- Development of specific tools and techniques that bring together different aspects of the environment in order to understand, measure and monitor their cumulative impacts; and
- Better understanding of carrying capacity at different scales (regional, sub-regional, local, individual settlements and sites), as well as its links with wider economic and social objectives.

With a few notable exceptions, the application of carrying capacity and environmental capacity concepts to planning has been mainly theoretical and focused on a restricted range of environmental issues. The complexity of the environment makes determination of overall

carrying capacity very difficult. As outlined above, in order for the concept to be used practically, the development of a suitable and agreed methodology, the availability of the appropriate data and the development of a rigorous quantitative method would be required. In addition, there is a need to account for uncertainty throughout this type of study and the fact that the social, political, and natural environments are bound to change over time requiring further carrying capacity studies in the future. Thus the difficulty lies in moving from a theoretically derived carrying capacity to an identifiable and quantifiable one.

As the concept of carrying capacity has difficulty in assessing quality of life issues on a municipal or regional level, it is perhaps most relevant for use in guiding the location, scale and quality of specific site developments. In this regard, carrying capacity could serve as a potential public outreach tool as it has the ability to convey a simple message about environmental impacts of a specific development to both the community and decision makers. Fundamental to the principal of sustainability however, is the notion that where understanding of carrying capacity is not well developed, but the risks associated with a potential breach of capacity are high, then the precautionary principle should apply.

It is clear that in order for growth within Halton Region to be sustainable, there needs to be cooperation on a regional level to prevent a situation where limiting growth in one jurisdiction would lead to unsustainable growth practices just outside jurisdictional boundaries. Additionally, cooperation with the provincial government would lead to a more holistic approach towards population growth management.

Along with carrying capacity, there are a variety of sustainability management tools that could be utilized by Halton Region as part of the Sustainable Halton process. The applicability of each of these is dependent on the specific issues within the community, and the growth challenges it is facing. Each of the tools has associated strengths and weaknesses, which would need further evaluation if chosen as a management option. Regardless of which tool is chosen, a large part of sustainability management is knowing the environmental and social makeup of the community and as such, the appropriate baseline environmental data will need to be collected to identify gaps in knowledge and information within the Region.

ANNEX ONE – LIST OF CASES

Examples from Canada
Town of Okotoks, AB
District of Muskoka, ON
Province of Manitoba

Examples from U.S.A.
El Dorado County, CA
Monroe County, FL
Douglas County, CO

International Examples
East of England, UK
Chester, UK
Lesvos, Greece

Examples of Other Management Tools
Ville de Dieppe, New Brunswick
Prairie Crossing, IL
Blue Mountain Lake, Hamilton County, NY
Tryon Farm, IN
Hidden Creek, OH
Rains County, TX
Bethel Township, PA

TOWN OF OKOTOKS, ALBERTA

The town of Okotoks adopted a Municipal Development Plan (MDP) in September 1998 that established growth targets linked to infrastructure development and the environmental carrying capacity of the Sheep River watershed. In this situation carrying capacity was determined by the ability to draw water and infuse treated effluent based on provincial regulations. The town decided to cap growth and urban boundaries at 25,000 to 30,000 residents. A community survey showed that 82% of all households in 2003 supported the cap. Further the town decided to size infrastructure for an ultimate population of 25,000 to 30,000 residents. Moreover, a build-out municipal boundary was established, with a comprehensive set of targets (See Table 1.1) and initiatives identified to ensure build-out population could be reached in an environmentally, economically, socially, and fiscally healthy way thus encapsulating the four foundations for a Sustainable Okotoks which were established as: 1) Environmental stewardship; 2) Economic Opportunity; 3) Social Conscience; and 4) Fiscal Responsibility.

Table 1.1: Key Sustainable Okotoks targets

Target	In 1998	In 2005
40% of labor force commutes outside Okotoks	60%	55%
22% of total assessment base is commercial	11.7%	13.9%
20% of total land area is open space	20%	21%
30% of total housing stock is “non-traditional”	17%	27%
100% of river edge lands owned by Town	80%	85%
Density 11.5 residential units per gross hectare	11.5	11.5
63 gallons/capita water use per day	110	82
30% per capita reduction in landfill tonnage by 2015	---	0%

As a result of this plan a variety of programs and initiatives have been developed and implemented. One of the subdivisions (Drake Landing - 840 residential units) adopted legally-binding (Restrictive Covenant) water conservation measures in new home construction. In addition, the ground work was established for the installation of solar seasonal storage technology in 52 homes in north east Okotoks. Similarly, the Outdoor Watering Bylaw (restriction and-Low Flow Water Fixture Bylaw) was enacted. Although developers and undeveloped land area was allocated a density target, developers could increase the density beyond the allocated density by a limit of 10% only if mandatory water conservation features were instituted to both encourage the required 30% per capita reduction and a proportionate reduction in line with density increase. This was seen as a collaborative conservation measure. An initiative, which applied sustainable neighbourhood design principles to undeveloped land, was partially funded by the Canada Mortgage and Housing and completed by the Faculty of Environmental Design at the University of Calgary. It has served as a guide for negotiations with the remainder of the development community in Okotoks, and has resulted in several advancements including: overland storm drainage filtration, linked open space systems, mixed land use in close proximity, residential home occupation housing, walking distances to destinations, multi-family housing targets and urban forest targets.

DISTRICT OF MUSKOKA, ONTARIO

The population of Muskoka is projected to increase to 75,040 by the year 2016 from 50 305 in 1996. As such, the District of Muskoka Planning and Economic Development Department developed the Official Plan of the Muskoka District Area. This plan consists of a set of policies that will help guide the economic, environmental and community-building decisions affecting the use of land. In addition, the Plan provides a framework to coordinate planning with adjacent municipalities. Since, the Official Plan sets the overall direction for growth in Muskoka it includes strategic land use designations, and environmental and infrastructure policies to help ensure the long-term economic, social and environmental health of Muskoka. The vision for Muskoka is of a predominately forested landscape that supports diverse and functioning ecosystems including lakes, wetlands, forests, barrens and open fields. This vision will be implemented through policies based on five principles. One of the principles is that "development will be based on the principle of a carrying capacity to ensure that the quality of the environment is maintained". Moreover it was established that "the growth permitted by the Plan will be monitored and reviewed on a regular basis to ensure that the carrying capacity of the natural environment is not significantly affected in the adverse and the development pattern as identified in the Plan is achieved in a fiscally and socially sound manner". The department recognizes that "the growth and development of Muskoka will determine what resources [they] leave our children", and that in order to leave these resources "development that has, or may have, a significant detrimental impact on the environment cannot be permitted".

Section F of the Official Plan outlines resource management policies and constraints or influences to development within the District. It recognizes the need to maintain and improve public access to and opportunities for public enjoyment and use of the lakes and rivers of Muskoka in a manner which is compatible with established uses and the recreational carrying capacity of these waterways. Further, there is an understanding that special provisions may be established in documents implementing this Plan to prevent and restrict the construction of buildings, structures or other facilities permitted on adjacent lands from causing a destruction of habitat, or other significant heritage areas, as a result of erosion, surface water runoff, structural development or fill, or the migration of chemical or other elements. As part of the Lake System Health program, the District of Muskoka will, in collaboration with the Area Municipalities and other stakeholders, undertake limits to growth assessments for waterbodies in Muskoka. Limits to growth assessments are intended to identify the development limits of a waterbody by using existing base data and applying the various applicable official plan policies to determine potential development capacity. These limits to growth assessments will provide background information for local municipal planning decisions and initiatives and lake plans.

PROVINCE OF MANITOBA

The Manitoba Round Table for Sustainable Development was responsible for preparing a draft set of indicators, consulting with the public on the draft indicators and submitting a report to the minister on a final set of recommended indicators and any related issues. In order to meet these requirements, a 40-member Sustainability Indicators Working Group was formed, with representation from all provincial government departments, the City of Winnipeg, Environment Canada and a number of non-government organizations in the province. The Sustainability Reporting Subcommittee of the Manitoba Round Table for Sustainable Development oversaw the working group's activities. As such, a working group was formed and public participation was sought through the distribution of 2000 workbooks with questionnaires, nine public workshops, written submission and website postings. A total of 23 indicators were identified.

Resource Conservation Manitoba submitted a response entitled: Provincial Sustainability Indicators: Resource Conservation Manitoba's Perspective on What They Should Be. It was in this submission that maintaining the carrying capacity of the natural environment and that economic and social practice must conform to the limits and requirements imposed by the limited capacity of the natural environment to absorb human demands upon it was brought up. Further, stating that "the core set of sustainability indicators must describe those characteristics of our natural environment which tell us whether and to what extent we are exceeding the several carrying capacities of the natural environment".

EL DORADO COUNTY, CALIFORNIA, USA

The El Dorado County River Management Plan (RMP) focused on whitewater recreation on the South Fork of the American River in Northern California and sought to develop a consensus on what carrying capacity should be established. The environmental impacts of the growth of current and future river use were considered and as such the objectives of developing the carrying capacity framework were to develop a river management tool that was responsive to changing human and environmental conditions.

The County will commit to controlling the impacts of future growth in river use through a carrying capacity program. The County will commit to achieving specific performance standards and criteria for carrying capacity, by establishing indicators of carrying capacity and by setting specific thresholds for each indicator that trigger management actions to regain or maintain the thresholds.

The El Dorado County Board of Supervisors and The El Dorado County Carrying Capacity Working Group looked at existing conditions for possible impact indicators based on various categories and then developed potential actions that could be taken. These indicators include land use impact indicators and actions and geology and soils impact indicators and actions. Water quality sampling and riverbank surveillance could provide quantitative and qualitative information on streambank and riverside erosion problems. Water resources impact indicators and actions could provide quantitative and qualitative information on septic system malfunctions and riverside erosion problems. Biological resources impact indicators and actions could identify and track the loss of riparian habitat. Transportation and circulation impact indicators, such as traffic counts, and actions could develop and provide annual reports on the status and operations of project area roadways and intersections, as well as cataloging traffic accidents in the project area. Other categories include: recreational resources impact indicators and actions, parking impact indicators and actions, public safety impact indicators and actions, social conditions impact indicators and actions.

FLORIDA KEYS, MONROE COUNTY

Monroe County contains many valuable natural, environmental, historical, and economic resources that require thoughtful management. The Florida Keys are the third largest barrier reef ecosystem in the world and the only one of its kind in the United States. In 1996, as a result of many years of discussion, negotiation, and litigation, the Florida Administration Commission issued an Executive Order requiring the preparation of a "carrying capacity analysis" for the Florida Keys. The key component of this study was a carrying capacity analysis model (CCAM) that provided a technical tool for state and local jurisdictions to "determine the ability of the Florida Keys ecosystem, and the various segments thereof, to withstand all impacts of additional land development activities."

The Draft CCAM is composed of several modules: Socioeconomic, Fiscal, Human Infrastructure, Integrated Water, Marine, and Terrestrial. These modules are designed to work together to evaluate the impact of further development in the Florida Keys. In addition, the Draft CCAM includes a Graphic User Interface (GUI) for a Scenario Generator, a tool that allows the user (through a series of menus) to specify different land use change scenarios, including new development, redevelopment of existing urban uses, and restoration of disturbed or developed land as well as the type and intensity of land use change at scales ranging from individual parcels to whole-island planning units. However it lacks a method to interpret the impacts of tourism.

The Socioeconomic Module produces population estimates however it uses 1990 U.S. census data. The Fiscal Module produces indicators of fiscal impact however it assumes constant demographic composition. The Human Infrastructure Module deals exclusively with traffic impacts. The Integrated Water Module produces estimates of wastewater and storm-water generation and seasonal average pollutant loads to marine waters. The Terrestrial Module produces a number of measures of environmental impact, particularly with regard to a representative set of species (including endangered species).

> Some of the carrying capacity indicators for the Florida Keys are: population demand for non-residential uses, business demand for employees, per capita government expenditures, hurricane evacuation clearance time, permitted volume of water supply, minimum patch size for upland Keys forests, lower Keys marsh rabbit habitat, Key deer habitat, patch size requirement for forest- nesting birds in the Florida Keys. While measures of income, fishing, recreation and various other social indicators were not used as carrying capacity indicators.

In its present stage of development, the CCAM and the current knowledge base in the environmental and social sciences is simply not yet adequate to enable anyone to "determine the ability of the Florida Keys ecosystem . . . to withstand all impacts of additional land development activities." It is not as comprehensive as was intended, and although it does not estimate carrying capacity in the ecologically relevant sense of the term, it is nonetheless an important piece of work and has the potential to be a useful tool in managing the fragile ecosystems of the Florida Keys.

DOUGLAS COUNTY, COLORADO

The County is approximately 844 square miles, 71 square miles of which are permanently protected land through the Douglas County Open Space Program. As of 2008, the County is home to seven incorporated municipalities including Castle Rock, Larkspur, Lone Tree, Castle Pines North, Parker, Littleton, and Aurora. Population estimates as of January 1, 2008 for Douglas County is 286,622 persons with a 4.5% annual growth rate. The median age of Douglas County residents is 33.7, and one third of the population is under the age of 19.

Douglas County's 2030 Comprehensive Master Plan establishes a common vision for what the County will look like over the next 20 to 30 years. The plan notes that sensitivity to the real carrying capacity of the land in the County is critical. This sensitivity involves constant oversight, through the application of Comprehensive Master Plan policies, in the following areas:

- Water quality and supply
- Wildlife habitat and movement corridors
- Open space and view corridors
- A healthy balance between urban, agricultural and equestrian lifestyles
- Adequate infrastructure
- Affordable housing mix
- Adequate and alternative modes of transportation and sufficient road development
- Preservation and recognition of pre-historic and recorded County history

Numerous goals, objectives and policies are outlined within the document. Goals provide general statements reflecting County desires regarding land-use, decision-making processes. Objectives establish a more specific framework for the larger goal. Policies provide the guidelines for direction or action. The Plan's components address growth-related topics such as land use, transportation, community resources, parks and open space, water supply, environmental quality, and wildlife.

To protect rural lands and associated patterns of development, the County has adopted policies that guide growth to designated urban areas and municipalities in the northern portion of the County. Ninety percent of the County's population lives in the designated urban areas which make up a mere one fifth of the County's land. Further to ensure balance is maintained as a growth of 75 000 people by 2030 is projected to occur, the County recognizes that it must have equally strong building blocks of sustainability. Each building block is described below:

- Economic – ensure goods and services are easily distributed. The County must have jobs to ensure a strong tax base so services can be maintained.
- Social – have services and governance so County residents' needs can be met and maintained over time.
- Environmental – maintain or improve the quality of the environment and preserve natural resources through such means as implementation of green infrastructure principles.

ST. CHARLES COUNTY, ST. LOUIS

St. Charles County is in the western portion of the St. Louis Metropolitan Statistical Area (MSA). This MSA had an estimated population of 2,663,480 in 2006. The St. Louis MSA consists of the city of St. Louis, the Missouri counties of Franklin, Jefferson, St. Charles, Lincoln, and Warren, and the Illinois counties of Jersey, Madison, Monroe, and St. Clair.

The St. Charles County Community Development Department has prepared a population projection for St. Charles County utilizing the logistical equation technique. Essentially what the logistical equation does is to acknowledge that, when a population is small, there are relatively few density-dependent constraints on its growth. This allows the population to grow exponentially. However, as the population increases, density-dependent factors (e.g., available home sites, etc.) come into play and begin to reduce the rate at which the population is increasing. Eventually, the population's growth decelerates and approaches zero. At this point the population is near its carrying capacity, or the maximum population size that can be supported given available resources and constraints on development patterns.

The carrying capacity is the maximum population size determined by calculating developable acreage and using assumptions based on the number of housing units per acre and people per household. The holding capacity for the county is calculated to be 644,417 based upon an expected average household size of 2.66, the average number of units per acre at 2.7 and 37,338 acres of land and 12,220 existing lots/parcels that could be residentially developed. A household size of 2.66 was used (2.76 people per household - 2000 Census) to adjust for normal decennial census declines in household sizes.

EAST OF ENGLAND, UK

The East of England Regional Assembly (EERA) commissioned a study to investigate the practical application of an environmental capacity approach to the process of spatial planning in the East of England. In considering environmental capacity issues, decision makers want to know how much development could be accommodated in an area without causing an unacceptable decline in environmental quality and the benefits or services that people derived from it. The methodology developed was applied through a pilot study in the Haven Gateway sub-region. As such, environmental capacity refers to the capacity of the environment to perform its natural functions. While, an environmental limit is the level at which the environment is unable to accommodate a particular activity or rate activity without sustaining unacceptable or irreversible change. This work builds on an earlier piece of work commissioned by the East of England Environment Forum.

A key output of the characterization and stakeholder consultation was a set of indicators, which could be used to represent the current state of each environmental asset or issue in Haven Gateway using available data. These indicators are shown below:

Asset/ issue	**Indicator**	**Data Source**
Air Quality	Air Quality Objectives (AQO) monitoring	Local authorities
Water Quality	River Quality Objectives (RQO) monitoring	Environment Agency
Water Quantity	CAMS water availability status	Environment Agency
Soils	*Not identified*	N/A
Geology	SSSI unit condition	Natural England
Biodiversity	SSSI unit condition	Natural England
Landscape	*Not identified*	N/A
Tranquility	Intrusion mapping	CPRE
Open Space	Accessible Natural Greenspace standards	Open space strategy
Historic Environment	Grade I and II* listed buildings at risk	English Heritage

Once the indicators had been defined, limits were established. In addition a few possible indicative policy implications were determined by this study. Further, pressures (including climate change), which may alter the current condition of environmental assets within the Haven Gateway were determined. This approach facilitates analysis of the extent to which current policies are likely to ensure that the pressures are controlled sufficiently to ensure that environmental limits are not breached.

This study focused on developing an environmental limits method, which utilized existing data sets and on refining the method through its application in Haven Gateway. The absence of sufficient data to fully assess the current state of some aspects of the environment, coupled with the limited stakeholder involvement in setting limits, meant that the findings of the Haven Gateway case study were insufficiently robust to support planning policy decisions.

CHESTER, ENGLAND

Chester covers an area of approximately 448 square kilometers. The district shares a boundary with Wales to the west, and the county of Shropshire to the south. Chester district has a population of 118 600, a relatively constant figure since 1971.

The *Environmental Capacity Study - Chester: the Future of an Historic City* was commissioned by the City and County Councils and English Heritage and carried out by consultants. One of the main aims of the Study was to reach conclusions about the "environmental capacity" of Chester to accommodate development and activity without having a detrimental impact on the special character of the City, and to suggest how far and in which ways this could be achieved. As defined by the Study, where development takes place it should respect the environmental capacity of the City. A framework for measuring environmental capacity was put forward, consisting of a series of "capacity guidelines" against which development strategies could be assessed. There was a limited capacity for peripheral development, with the greatest potential being to the south and west of the City.

The study identified five possible city development paths. Major growth was rejected by the study as being non sustainable in environmental terms whilst reduction and a third option, minimal growth, were rejected as likely to be harmful to the historic built environment because of the likely withdrawal from the city of the investment necessary to maintain buildings. The recommended course of action was to follow a composite of the two remaining options both of which suggested managed development concentrating on a selected growth sector.

LESVOS, GREECE

The island of Lesvos, Greece served as a case study for research examining *A Decision Support System for Regional Sustainable Development*. This island is predominantly used for agriculture and has a population of 90 000 people.

The notion of carrying capacity is of great importance, as it indicates the maximum environmental resource use that is still (marginally) compatible with an ecologically sustainable economic development. This means that this concept refers to a threshold value that cannot be exceeded without causing unacceptably high damage and risk to the environment. In order to emphasize the need for unambiguous quantification, the notion of a critical threshold value (CTV) was used. For each sustainability indicator, whether environmental or socio-economic, a CTV was specified, so that the entire set of CTV's acted as a reference system for judging actual states or future outcomes of scenario experiments.

The indicators were classified as economic, social and environmental. Economic indicators included: general & structural indicators (i.e. GDP of the primary sector as a percentage of total GDP); livestock numbers; production figures (i.e. production of olives, meat and milk in tons per year); land use (i.e. total agricultural land in use (in ha). Social indicators include: the total population, economically active in primary sector. Environmental indicators include: i.e. number of sheep and goats per hectare of land.

DIEPPE, NEW BRUNSWICK
(In 2006 the population of Dieppe was approximately 18 000)

Conservation Design for Subdivisions is a planning tool for managing development growth and protecting natural areas by designating about half or more of the buildable area as protected area. This tool strategically concentrates home construction on the development site in order to protect sensitive and valuable open space, habitat, and other environmental resources. Conservation Design for subdivision is a concept that requires education for all stakeholders and partners. The entire team has to understand and agree on basic principles before implementation. The associated benefits with this tool are:

- Protected water quality
- Protected wildlife habitat
- Reduced infrastructure construction costs
- Reduced maintenance costs
- Reduced demand for publicly funded greenspace
- Means for expanding public trails and greenways

The objectives of the project site in Dieppe, New Brunswick are:

- Increase density for residential development (Request from the City)
- Protect wetlands & mature trees
- Reduce impervious surface (Help water recharge)
- Connect with other green areas & trails
- Encourage social interaction

This site is located close to Dieppe's downtown area (approximately 3.5 km from the city center) in a zone where there is pressure to develop. The area is about is 25.7 acres (10.053 ha) and is zoned for low density development (about five units for the whole property). However, the City wanted revenue from the residential subdivision to pay for the services and expenditures it would create. The project used a "traffic light colours" analogy to determine where development will occur. Further the project will include best management practices for stormwater management.

PRAIRIE CROSSING, GRAYSLAKE, ILLINOIS

Prairie Crossing is a 677-acre development and acclaimed Conservation Community. It consists of 359 single-family homes and 36 condominiums as well as a restored prairie, wetlands, a lake, an organic farm, and a surface storm water management and treatment system

The community was designed to combine responsible development, the preservation of open land and easy commuting by rail. The first homeowners moved to Prairie Crossing 10 years ago and the new construction single-family homes have all been sold. Within Prairie Crossing there are 350 acres that are legally protected from development.

All of the residents receive a newsletter called "EcoNotes," which covers such topics as the burning of the prairie, the impact of yard management on the lake, the use and benefits of landscaping with native plants, how to use stormwater to build "a small pond and wetland area" in one's yard or with one's neighbours, and how to attract beneficial or attractive insects. This is done to ensure that residents are educated. Further, when residents moved in they were required to devote at least 20 percent of their yard to very unconventional prairie plantings.

The community's founders established 10 important principles to guide Prairie Crossing. These principles provide the framework "for a way of life that respects the environment and enables residents to experience a strong connection between community and the land" (Prairie Crossing, 2008). The 10 principles are:

1) Environmental protection and
    a. There are 350 acres that are legally protected from development. In addition, Prairie Crossing is part of the Liberty Prairie Reserve which consists of over 5 000 acres of publicly and privately held land that includes nature and forest preserves, farms and trails.
2) A healthy lifestyle
    a. Ten miles of trails and a large lake provide opportunities for healthy outdoor exercise. The organic farm supplies fresh vegetables, flowers, and fruits to the community, while individual garden plots are available to residents at a small cost. Moroever, Lake Forest Hospital has built a new facility at Prairie Crossing.
3) A sense of place
    a. The landscape and architecture of Prairie Crossing were inspired by the prairies, marshes, and farms in the area, while streets were named after prairie plants and early settlers who frequented the area. The house colours were chosen based on the warm tones of the native landscape. Historic buildings including: a barn, a schoolhouse, and a farmhouse remained in the community to remind the residents that others had lived on this land before them and that others will follow.
4) A sense of community
    a. The Homeowners Association in Prairie Crossing is responsible for the community amenities, design review, and other aspects of community life. Volunteer stewardship activities are organized by the Liberty Prairie Conservancy, which conducts environmental programs throughout the Liberty Prairie Reserve.
5) Economic and racial diversity

    a. Prairie Crossing welcomes residents of all races and as such has attempted to keep costs and prices down so that some homes will be within the range of families needing affordable housing.
6) Convenient and efficient transportation
    a. Prairie Crossing is located an hour from Chicago by train or car. There are two stations adjoining the site with rail service to Chicago and O'Hare Airport. Trails within the community lead to the train station, the College of Lake County, the University Center of Lake County, the Liberty Prairie Reserve, Grayslake High School, and local stores and restaurants.
7) Energy conservation
    a. Homes have been constructed using techniques that reduce energy consumption by approximately 50 percent in comparison to new homes in the area. There are community-wide recycling and composting programs in effect. A wind turbine provides 30,000-40,000 kilowatt-hours (kwh) per year, Half the capital expense of the wind turbine came from a grant from Illinois' Renewable Energy Resources Program. The Prairie Crossing Charter School buildings are designed to Leadership in Energy and Environmental Design (LEED) standards.
8) Lifelong learning and education
    a. An environmental curriculum has been embedded into The Prairie Crossing Charter School, which offers elementary to two local school districts.
9) Aesthetic design and high-quality construction
    a. The condominiums at Station Square have attained Energy Star’s highest rating for energy efficiency.
10) Economic viability
    a. Prairie Crossing is being developed by families who have made every effort to ensure that the project is economically feasible.

Development potential of the watershed was determined by examining the land classifications within the watershed and the existing development within the watershed. This was calculated by examining the number and location of structures in Blue Mountain. A conservative value of 130 dwellings was used. The zone of influence can be described as that area within 200 meters of surface water. The maximum number of homes within the zone of influence was calculated by dividing the amount of shorefront in a given zone by the minimum lot width for that classification (shorefront/minimum lot width) and taking into account the minimum lot size. The maximum number of shorefront homes was calculated by subtracting the number of shorefront homes within a given land class from the total amount of homes that could be built within that land class on an area basis (# of shorefront homes minus zone area divided by minimum lot size). This type of analysis may tend to overestimate the number of allowable homes, since actual home construction is limited by suitable site conditions for the construction of homes, septic systems, roads and utility access.

Per capita estimates, the number of person-years spent near the lake, is an important consideration. These numbers provide a basis for gauging predictive performance and can be modified to simulate various development scenarios within the watershed. In addition to homes and camps, the Adirondack Museum is the only other major source that contributes to phosphorus loading within the watershed. Assuming 100,000 visitors per year with an average length of visit of 2 to 4 hours, the Adirondack Museum occupancy is between 23 and 46 capita years. This is the equivalent of 6.5 to 13 year-round homes or 26 to 53 seasonal homes. Median total phosphorus concentrations from the Blue Mountain tributaries were used as input to the geographic information system (GIS) model used to analyze land use and zoning. Undeveloped areas (forest) were assigned the lowest tributary median total phosphorus value, which was 0.009 mg/. Developed areas were assigned the highest tributary median value, which was 0.024 mg/L. Modeling for a decrease in water quality to a chlorophyll *a* concentration of 2 ppb predicted a total allowable new development consisting of 38 seasonal and 20 year-round homes.

TRYON FARM, INDIANA

Tryon Farm is an environmentally sensitive farm-based development in northwest Indiana. The site is located one hour from Chicago. Groups of 8 to 20 homes are clustered close together in eight "settlements," each separated from the others by expanses of field, woods or meadows. Approximately three-quarters of the 170-acre landscape will always be preserved as rolling pasture, meadows, woods and ponds. Buyers own their own homes and a small skirt of land around the building, but the rest of the land is shared in common ownership for which residents pay a monthly fee to a homeowners' association. The project, which was approved under the planned unit development provision of Michigan City's zoning code, allowed 150 homes on the property. One of the most ambitious aspects of Tryon Farm is that waste water from homes is treated not in septic systems or carried away in a city sewer but cleansed in a series of constructed wetlands that also serve as habitat for wading birds that flock to the farm. Tryon Farm is self-governed by the Tryon Farm Homeowners Association with an elected Board responsible for the overall governance and elected settlement committees responsible for the unique requirements of each settlement.

HIDDEN CREEK, OHIO

Hidden Creek at the Darby is a residential development located in West Jefferson, Ohio. It is 17 miles from Columbus and offers a unique approach to a planned residential community. Located on over 600 acres, there are only 120 homesites. 230 acres of the riparian stream corridor and adjacent wetlands within the development have been protected via a conservation easement held by the Natural Resources Conservation Service. In addition, a program has been developed to educate homeowners and housing contractors about watershed protection and related deed restrictions attached to each property. Efforts were made to leave trees and vegetation in place in order to maintain optimal temperatures for aquatic life indigenous to the riparian corridor. Native plantings of trees and other vegetation were part of the overall management of the project. Prairie burns will be practiced as part of a prairie management program in fields and meadows that were previously farmed. Trails that meander through the protected open space are managed as mowed grass in order to reduce soil erosion and increase water filtration processes.

WOODSON PLACE, RAINS COUNTY, TEXAS

The Woodson place is located about 80 miles east of Dallas. The Woodson Place consists of 38 home sites (1/2 acre) on 66 acres. Over half of the land will be preserved as beautiful open space managed for wildlife habitat and accessible only to property owners and select land management professionals. The development goal is to reduce the neighborhood's ecological footprint by clustering groups of homes to preserve significant, contiguous open spaces, enhancing sustainability through water conservation and energy efficient practices. When the project was initiated in 1999, the property had been severely overgrazed. A native prairie restoration effort consisting of wildflower seed plantings, as well as the first controlled burn in 2007 has helped the land recover dramatically.

GARNET OAKS, BETHEL TOWNSHIP, DELAWARE COUNTY

Garnet Oaks made use of cluster development techniques to preserve open space and environmentally sensitive areas. Garnet Oaks consists of 80 single-family home sites on 58 acres in Bethel Township, Delaware County, Pennsylvania and 51% of land is preserved as open space. Further, the site ensures the Preservation of woodlands and specimen trees as well as the preservation of structures from original estate. A site analysis identified the areas best suited for development as well as the sensitive areas to be left undisturbed, including steep slopes, buffer areas adjoining wetlands, prime recreation areas, perimeter buffer areas, and specimen trees. Home sites were clustered to capitalize on the several unique open space features.

Tree preservation was the guiding principle behind many of the innovative land planning and construction techniques incorporated into Garnet Oaks. Before the design phase, the development team located specimen trees through aerial photography and field surveys and analyzed grading to minimize adverse effects on trees.

An in-stream storm water management system was designed to reduce the clearing requirements associated with a typical detention basin. The system allowed for the preservation of two acres of woodlands that would have otherwise been cleared.

REFERENCES

Benedict, Mark A. and McMahon, Edward T. (2006). Green Infrastructure: Linking Landscapes and Communities. Island Press Publishing.

Chester City Council. (2007). Environmental Capacity Study - Chester: the Future of an Historic City. Retrieved at: http://www.chester.gov.uk/council_services/planning_and_building_control/chester_district_local_plan/chester_district_local_plan/aim_of_the_plan.aspx

City of Dieppe. (2004). What is SCD. Retrieved at: http://dieppe.ca/dieppe_dev_en.cfm

Committee to Review the Florida Keys Carrying Capacity Study, National Research Council. (2002).A Review of the Florida Keys Carrying Capacity Study. National Academy of Sciences.

Douglas County Government. (2008). Douglas County Comprehensive Master Plan. Retrieved at: http://www.douglas.co.us/CMP2030/

Douglas, Jonathan. (2001). Carrying capacity and the comprehensive plan: Establishing and defending limits to growth. Boston College Environmental Affairs Law Review.

Environmental Stewardship & Planning. (2000). El Dorado County River Management Plan Carrying Capacity White Paper. Retrieved at: http://co.el-dorado.ca.us/parks/pdf/CC_Final_7-26-00.pdf

Global Footprint Network. (2006). Ecological Footprint Overview. http://www.footprintnetwork.org/gfn_sub.php?content=footprint_overview

Hidden Creek at the Darby. (2003). Hidden Creek at the Darby. Retrieved at: http://www.hiddencreekdarby.com/home.asp

Hopfenberg, Russel. (2003). Human Carrying Capacity Is Determined by Food Availability. Population and Environment **25**(2): 109-117.

Land Use Consultants. (2008). Environmental Capacity in the East of England: Applying an environmental limits approach to the Haven Gateway Final Report.

Manitoba Round Table for Sustainable Development. (2000). Provincial Sustainability Indicators: What you told us…Development in Harmony with our Environment. Retrieved at: http://www.gov.mb.ca/conservation/susresmb/indicators/sustainability_indicators.pdf

Martin, Michael R. (1998). The Carrying Capacity of Blue Mountain Lake: An analysis of water quality and land use. Retrieved at: http://www.cedareden.com/BLMTN-model.PDF

MCM Developments. (2007). The Woodson Place: Come Build your Place in the County. Retrieved at: http://www.woodsonplace.com/index.htm

Mohamed, Rayman. (2006). The Economics of Conservation Subdivisions: Price Premiums, Improvement Costs, and Absorption Rates. Urban Affairs Review **41**(3): 376-399.

National Association of Home Builders. (2008). Smart Growth Cases Study: Garnet Oaks. Retrieved at: http://www.nahb.org/generic.aspx?genericContentID=493

Ouwersloot, Peter Nijkamp Hans. (Date Unavailable). A Decision Support System for Regional Sustainable Development: The Flag Model. Retrieved: http://www.tinbergen.nl/discussionpapers/97074.pdf

P. Khanna, P. Ram Babu and M. Suju George. (1999). Carrying-capacity as a Basis for Sustainable Development: a case study of National Capital Region in India. Progress in Planning **52**(2): 101-166

Prairie Crossing. (2008). Prairie Crossing: A Conservation Community. Retrieved at: http://www.prairiecrossing.com/pc/site/index.html

Randolph, John. (2004). Environmental Land Use Planning and Management. Island Press Publishing.

Rees, W. E. (2000). Eco-footprint Analysis: merits and brickbats. Ecological Economics, **32**: 317-374.

Regional Municipality of Halton. (2008). Sustainable Halton. http://www.halton.ca/ppw/planning/SustainableHalton/default.htm

State of Rhode Island: Department of Environmental Management. (2001). South County Design Manual. Retrieved at http://www.dem.ri.gov/programs/bpoladm/suswshed/desmanul/chapter3_rural.html

The District of Muskoka Planning and Economic Development Department. (2007). Office Consolidation of the Official Plan of the Muskoka Planning Area. Retrieved at: http://www.muskoka.on.ca/planningeconomic/Official%20Plan.pdf

Town of Okotoks, Alberta. (2005). The International Awards for Liveable Communities (The LivCom Awards) Submission: Sustainable Okotoks: Leaving a Legacy. Retrieved on March 13, 2008. Retrieved at http://www.okotoks.ca/pdf/Sustainable/LIVCOM%20AWARDS%202005submission.pdf

Tyron Farm Partners Ltd. (2007). Tyron Farm. Retrieved at: http://www.tryonfarm.com/main.html

United Nations Environment Programme [UNEP]. (2003). Guide to Good Practice in Tourism Carrying Capacity Assessment.

Creating Walkable and Transit-Supportive Communities in Halton

Dr. Bob Nosal
Medical Officer of Health
Halton Region Health Department

February 2009

Reference:
Halton Region Health Department, *Creating Walkable and Transit-Supportive Communities in Halton.* Oakville, Ontario: 2009

Authors:
Kristie Daniel, Senior Policy Analyst
Kim Perrotta, Senior Health and Environment Advisor

Reviewers:
This report has benefited greatly by the expertise, policy direction and editorial advice offered by the following reviewers in Halton Region Health Department:

- Gena Ali, Environmental Health Senior Policy Analyst
- Dr. Monir Taha, Associate Medical Officer of Health
- Peter Steer, Environmental Health Senior Policy Analyst
- Dr. Bob Nosal, Medical Officer of Health
- Pat Hewitt, Manager, Public Health Administration
- Joyce See, Director, Community Health Services
- Mary Ann Carson, Director, Health Protection Services

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Studies have repeatedly shown that community design and development has a significant impact on: emissions of air pollutants and greenhouse gases; levels of physical activity and social cohesion; and rates of injuries and fatalities related to motor vehicles, which may include pedestrians and cyclists. This discussion paper is intended to: review the best available evidence related to health and land use planning in terms of walkability; define what is meant by "walkable and transit-supportive communities"; identify the opportunities for realizing these attributes within a Halton context; and, suggest the parameters that can inform the Sustainable Halton and Regional Official Plan review processes with respect to walkability. It is recognized that future public and agency consultation on this paper will take place through these processes and that some elements of this paper, such as community design and transit, fall under local municipal purview.

Poor air quality is a significant public health concern for people living in southern Ontario. The Ontario Medical Association estimates that air pollution in Ontario contributes to 9,500 premature deaths each year (OMA, 2008). Climate change, associated with long-term shifts in air and water temperatures, precipitation, water and food supplies, and will present significant direct and indirect risks to human health and security in the coming decades. Physical activity, even at moderate levels, reduces the risk of developing numerous chronic diseases. There are many shifts in policy and behaviour that are needed within Canadian society to reduce emissions of air pollutants and greenhouse gases and to increase physical activity. One of the important policy shifts required relates to the patterns of development within our communities.

There are several models and frameworks that help define the dimensions of the built environment that are most closely associated with walkability and public transit use. The Health Department has chosen to use the "3 D" model to organize this paper: density, diversity (mixed use), and design. *Density* refers to the number of households and jobs per hectare. *Diversity*, also called *mixed use,* refers to land use mix, housing diversity and the presence of neighbourhood retail/service opportunities. *Design* refers to street design, street connectivity for both pedestrian and cyclists, and the quality of the pedestrian environment.

On the basis of our review of the health and planning literature and best practices, the Health Department recommends consideration of the following parameters in order to support the development of walkable and transit-friendly communities during the Sustainable Halton and Regional Official Plan Review processes:

1. To create transit-supportive densities:
    - Locate neighbourhoods and employment areas within a 400 m to 800 m radius around activity nodes, transit nodes, or activity corridors
    - Activity nodes, transit nodes and the 400 m radius around them have a minimum of 200 residents and jobs per gross hectare
    - Activity corridors have a minimum of 80 residents and jobs per gross hectare

- Transitional zones within 800 m of activity nodes and transit nodes in greenfield communities have a minimum 75 residents and jobs per gross hectare
- Stable communities and employment areas achieve a minimum 50 residents and jobs per gross hectare whenever possible

2. To provide appropriate housing for people at all stages of life and income, align the housing mix with the density targets for activity nodes, transit nodes and activity corridors. It is important to monitor the average density of new housing for each housing type yearly to ensure that the overall density targets have been achieved.

3. Residents live within 400 m of six diverse uses and within 800 m of 17 diverse uses. Because of the important role that access to retail food markets plays in creating complete communities and ensuring access to healthy foods, the best practice literature suggests that residents live within 800 m of a planned or existing retail food market such as a supermarket, grocery store, or produce store.

4. Locate the land set aside for elementary schools within 1500 m of residents to maximize the numbers of students walking; and, locate the land set aside for secondary schools within 3000 m of residents and on local transit routes. Lands declared surplus by the school boards in Halton have public value and consideration should be given to purchasing these lands for public use.

5. Design communities so that residents are within 400 m of an existing or planned transit stop. In addition, when developing new communities, adopt a "transit-first" principle.

6. Residents have access to a full range of parks described in the parkland hierarchy. Ideally residents will live within 400 m of a village square/parkette and within 800 m of a neighbourhood park. In addition, locate community parks, town/city wide parks and recreational facilities on local transit routes.

7. Consider "sense of place" when identifying and selecting preferred road alternatives.

8. Incorporate a *walking and cycling review* for pedestrian connectivity and safety at each stage in the planning process, which would include:
   - Residents have access to continuous sidewalks or equivalent provisions for walking along both sides of all streets. New sidewalks in residential areas should be at least 1.5 metres wide. Equivalent provisions for walking include footpaths
   - Commercial areas have continuous sidewalks or equivalent provisions for walking along both sides of all streets. New sidewalks in commercial areas should be at least 4.0 metres wide

- Design streets on the basis of medium to short block lengths with a recommended maximum block perimeter that does not exceed 250 metres. Where block perimeter exceeds 250 metres, a block pedestrian linkage is provided
- Neighbourhoods have a linked open space system that interconnects allowing pedestrian, bicycle and other recreational activities continuously throughout the community
- Neighbourhoods built on a cul-de-sac street pattern system are connected to arterial and collector roads by looking for direct pathways that link residents to these areas

9. Incorporate a *walking and cycling review* for cycling connectivity and safety, at each stage in the planning process, which would include:
    - Neighbourhoods and communities accommodate a cycling network that includes bike lanes and off-road cycling or multi-use trails
    - Roads with speeds over 60 km/h have separated lanes that are part of the road, not sidewalk, infrastructure
    - Roads with speeds between 50-60 km/h have marked bicycle lanes
    - Roads with speeds under 40 km/h are shared
    - Priority for cyclists in intersections
    - Reduce overly frequent stops or places where reduced cycling speeds are necessary
    - Residents have access to trip end facilities such as secure long-term bicycle parking such as lockers, secure short-term bicycle parking such as bicycle racks and showers in commercial buildings
    - All streets, roadways, and designated bike routes are maintained to be free of deterrents to bicycling (such as potholes, debris, and overgrown landscaping)

10. Incorporate a *walking and cycling review* to consider the appeal of the pedestrian and cycling environment at each stage in the planning process, which would include:
    - Building frontages that positively address the street, with active uses at ground and first floors
    - All ground level non-residential interior spaces that face a public space have transparent glass on the ground level façade
    - Consideration of the length of blank walls (without doors or windows) along sidewalks
    - Commercial buildings designed and built so that each building has a front façade and at least one entrance that faces a publicly accessible area such as a street, square or plaza
    - On street parking provided on selected streets
    - All off-street parking facilities located at the side or rear of buildings, leaving building frontages and streetscapes free of parking facilities
    - Each transit stop with at least one bench and, where appropriate, sufficiently sheltered

- Sidewalks connect directly to transit shelters
- Place transit shelters in such a way as to not impede pedestrian traffic
- Street trees occur between the vehicle travel way and sidewalk
- Universal design options are addressed

GLOSSARY OF TERMS

General Terms

Active transportation	Any form of human-powered transportation.
Activity corridor	An area of street-oriented uses which incorporate a mix of retail, employment and residential uses located along arterial or collector roads serving as major transit routes.
Activity node	A compact, transit-oriented, pedestrian-friendly area where the highest concentrations of residential, employment, retail and other uses in the urban area are located. Activity nodes are generally located at points where two or more transit routes or travel modes intersect.
Bike box	Designated, marked area at a signalized intersection that places bicycles at the front of the queue.
Built environment	Comprises urban design, land use, and the transportation system, and encompasses patterns of human activity within the physical environment.
Climate change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.
Complete community	Complete communities meet people's needs for daily living throughout an entire lifetime by providing convenient access to an appropriate mix of jobs, local services, a full range of housing, and community infrastructure, include affordable housing, schools, recreation and open space for their residents. Convenient access to public transportation and options for safe, non-motorized travel is also provided.
Connectivity	The directness of travel to destinations.
Density	Typically measured as employment or population per square kilometre/mile.
Gross density	Is the total population of a given area divided by the total amount of land including roads, parks, and other natural features. This measure of density needs to be measured carefully because it includes all land in a given area, even land that cannot be developed.

Health	A state of complete physical, mental and social well-being, not merely the absence of disease.
Land use	Refers to the distribution of activities across space, including the location and density of different activities, where activities are grouped into relatively coarse categories such as residential, commercial, office, industrial and other activities.
Land-use mix	Diversity or variety of land uses.
Mixed-use	Development that combines two or more of the types of development: residential, commercial, office, industrial or institutional.
Net density	The number of people, houses, or jobs in an area net of land that is not for private use. So, net density excludes roads, parks, public infrastructure and other natural features.
Non-motorized travel	Travel by non-motorized means, including walking, cycling, small-wheeled transport (e.g., skates, skateboards, push scooters, hand carts), and wheelchair.
Physical activity	Any body movement that results in energy expenditure.
Recreational physical activity	Activity that takes place during one's spare time.
Sense of place	The role a street plays in creating an urban identity for an area that supports pedestrian and cycling activity.
Transit node	A point where two or more transit routes intersect.
Transit-supportive	Makes transit viable and improves the quality of the experience of using transit. When used in reference to development, it often refers to compact, mixed-use development that has a high level of employment and residential densities to support frequent transit service. When used in reference to urban design, it often refers to design principles that make development more accessible for transit users, such as roads laid out in a grid network rather than a discontinuous network; pedestrian-friendly built environment along roads to encourage walking to transit; reduced setbacks and placing parking at the sides/rear of buildings; and improved access between arterial roads and interior blocks in residential areas.
Transitional zone	Transitional zones surround activity nodes and transit nodes and are located within an 800 m radius or a 10 minute walk of the centre.

Urban design	Refers to the design of the city and the physical elements within it, including both their arrangement and their appearance and is concerned with the function and appeal of public spaces.
Utilitarian physical activity	Activities that serve a practical purpose of transporting someone from one place to another.
Walkable	The extent to which the built environment is friendly to the presence of people living, shopping, visiting, enjoying or spending time in an area. Factors affecting walkability include, but are not limited to: land use mix; street connectivity; residential density (residential units per area of residential use); “transparency" which includes amount of glass in windows and doors, as well as orientation and proximity of homes and buildings to watch over the street; plenty of places to go to near the majority of homes; placemaking, street designs that work for people, not just cars and retail floor area ratio. Major infrastructural factors include access to mass transit, presence and quality walkways, buffers to moving traffic (planter strips, on-street parking or bike lanes) and pedestrian crossings, aesthetics, nearby local destinations, air quality, shade or sun in appropriate seasons, street furniture, traffic volume and speed and wind conditions. One of the best ways to quickly determine how walkable a block, corridor or neighborhood is to count the number of people walking, lingering and enjoying a space. The diversity of people, and especially the presence of children, seniors and people with disabilities, denotes the quality, completeness and wholesomeness of a walkable space.

Units of Measurement

ppha	population per net hectare
ppgh	population per gross hectare
upha	units per net hectare
VKT	vehicle kilometres travelled

Abbreviated Organization Names

OMA	Ontario Medical Association
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

1. INTRODUCTION

a. Background

High levels of population growth are projected for Halton Region. Between 2001 and 2031 the region is expected to grow from 375,000 to a population size of approximately 780,000 people. Such high levels of growth have major implications for the health and wellbeing of both current and future residents. Studies have repeatedly shown that how our communities are designed has significant impacts on the population's exposure to outdoor air pollution, physical activity levels, social cohesion, and injury due to motor vehicle and pedestrian/cyclist collisions.

In 2007 and 2008, Regional Council authorized the Halton Region Health Department to undertake policy development work related to the land use planning process. This work will assist in minimizing the negative air quality impacts that can be associated with growth and development (MO-12-07, MO-35-07, MO-57-07, MO-04-08). This discussion paper responds to direction from Regional Council and addresses the following actions in the 2007 Planning and Public Works Committee Plan:

- Theme 1, Goal 1, Action g) - "Develop a policy framework that integrates public health objectives, relating to air quality, injury prevention and healthy weight, with long-term land use and transportation planning."
- Theme 2, Goal 1, Action a) - "Define, in conjunction with the development of Healthy Communities principles, a framework of policies leading to improved air quality, to be implemented through the Sustainable Halton Plan and the resulting Official Plan."

This paper has been produced to ensure that communities within Halton Region are more walkable and transit-supportive in the future. This discussion paper is based on the review of the best available health evidence related to health and land-use planning and provides a common definition of what it means to be a "walkable and transit-supportive community" in a Halton context. The Halton Region Health Department is frequently asked to provide health comments on a number of land-use issues and this paper will provide the structure for the walkability aspects of those comments.

While the Halton Region Health Department recognizes that each land-use planning situation is different and needs to be examined in context, there are health-based parameters that can be applied to most land-use planning situations. The parameters identified in this paper are forwarded to the Sustainable Halton and Regional Official Plan review processes for consideration and possible inclusion. It is recognized that future public and agency consultation on these papers will take place through these processes and that the suggested direction on community design and transit fall under local municipal purview.

In addition to the main purposes outlined above, this paper will be used to inform community groups about the Health Department's view of what makes a walkable community based on health rationale.

b. Walkability and Human Health

i. Air Quality

Poor air quality is a significant public health concern for people living in southern Ontario. The five common air pollutants—ground-level ozone, fine particulate matter, sulphur dioxide, nitrogen dioxide and carbon monoxide—have been clearly and consistently linked to acute health impacts such as increases in non-traumatic deaths, hospital admissions for heart and lung conditions, emergency room visits, and asthma symptoms at concentrations that are commonly experienced in southern Ontario (OMA, 2005; Toronto Public Health, 2004; Stieb, 2005; WHO-Europe, 2004; US EPA 2004). A growing body of scientific literature indicates that these common air pollutants also contribute to chronic heart and lung diseases including lung cancer and asthma (US EPA, 2004; Krewski, 2000; Samet, 2000). The Ontario Medical Association (OMA) estimates that air quality in Ontario contributes to 9,500 premature deaths each year (OMA, 2008). While everyone can be negatively affected by poor air quality, the research demonstrates that newborns, children, the elderly, and people with pre-existing health conditions such as heart disease, asthma and diabetes, are particularly sensitive to the adverse effects of air pollution (Stieb, 2005; WHO-Europe, 2004; US EPA 2004).

Emission inventories indicate that the transportation sector is one of the most important sources of air pollutants and greenhouse gases within Halton Region, Ontario and Canada (Halton Region Health Department, 2007). In addition, a large number of traffic corridor studies have demonstrated that health impacts such as hospitalizations for asthma and deaths from strokes are significantly higher among those people who live in close proximity to busy highways than among those who live further away (van Vliet, 1997; Lin et al, 2002; Crosignani, 2004; Hansen, 1998; Smargiassi, 2005; Hoek, 2002). While a great deal of progress has been made to reduce emissions from individual vehicles, this progress has been offset to some extent by the increasing number of vehicles on the road and the increasing number of kilometres travelled by Canadians.

Recent studies have demonstrated that local transportation and planning decisions can have a significant impact on emissions, local air quality, and human health. For example, the California Air Resources Board (1997) found that compact neighbourhoods built around public transit with a variety of services within a five minute walk can reduce vehicle-related air emissions by up to 20 percent relative to traditional sprawled neighbourhoods that are separated from public transit, commercial services and recreational facilities. In the City of Atlanta, researchers found that the alternative transportation strategy introduced during the 1996 summer Olympics, which shifted people from their vehicles into public transit, reduced traffic counts by 22.5 percent, peak ozone levels by almost 28 percent, and asthma-related hospital admissions

among children by 11 to 44 percent during the Olympics relative to the weeks leading up to the Olympics (Friedman et al., 2001).

ii. Climate Change

It is now commonly accepted that climate change is happening and that humans are significant contributors to the process. In the last few years, the public has come to accept these two statements as fact as their experience of local and global weather affirms the predictions by scientists from the International Panel on Climate Change (IPCC).

In the last decade, there have been significant increases in extreme weather both within and outside of Canada. Within Canada, we have experienced greater swings in weather, longer droughts, deeper heat waves, a greater number of tornados, more frequent and severe thunderstorms, greater rainfall or snowfall in shorter periods of time, and more frequent floods over the last decade, all of which were predicted by the IPCC in the 1990s and 2001 (Canada, 2007; IPCC, 2001).

While these weather-related changes are the most apparent changes associated with climate change in Canada, they are not the most significant impacts associated with climate change. More worrisome are the long-term shifts in climate that are expected to melt ice caps, raise water levels and shift water temperatures in oceans , change ocean currents world-wide, and deepen droughts in areas that are already vulnerable to droughts (IPCC, 2001; IPCC, 2007). These climatic changes could produce profound dislocation, hunger, and economic insecurity among human populations around the world as land masses are lost to flooding, land-based food supplies and water supplies are threatened by droughts, and water-based food supplies shift or collapse in response to changing temperatures and currents (IPCC, 2001: IPCC, 2007).

There are many shifts in policy and behaviour that are needed within Canadian society to reduce our share of greenhouse gases (GHG) that contribute to climate change. One of the important shifts required relates to patterns of development within our communities.

The transportation sector in the United States is responsible for about one third of all of the greenhouse gases emitted in our two countries (Ewing et al., 2008). The transportation sector was responsible for 31 percent of Ontario's total GHG emissions, making it the largest single source of GHG emissions in Ontario (Environmental Commissioner of Ontario, 2008). This amounts to the equivalent of approximately 65 mega tonnes of carbon dioxide (CO_2) per year. Within the transportation sector, three significant changes are needed to reduce greenhouse gases: vehicle fuel efficiency must be significantly increased; the carbon content of the fuel must be significantly reduced; and vehicle kilometres travelled (VKT) must be reduced. The first two changes are the domain of the federal and provincial governments although local and regional governments can support these two with corporate policies directed at their corporate fleets. The third change is one over which local and regional governments

can have a profound effect. The number of VKT are related to the way in which our communities are designed. They are affected by the distance between homes and jobs, homes and schools, and homes and services (Ewing et al., 2008).

Research demonstrates that technological improvements in vehicles and fuels (i.e., the first two changes identified above) are likely to be offset by growth in the number of VKT (Ewing, 2008). Over the last three decades, the number of VKT has grown faster than the population in both Canada and the U.S. People are driving longer distances, taking more trips by vehicle, relying less on public transit, and walking less (Probe, 2004; Ewing et al., 2008; Halton Region Health Department, 2007).

The body of research demonstrates that the best way to reduce VKT is to build communities that are walkable and transit-supportive. The weight of evidence suggests that people who live in more compact, mixed-use communities, drive 20 to 40 percent less (Ewing, 2008).

iii. Physical Activity

Physical activity, even at moderate levels, reduces the risk of developing numerous chronic diseases. The Public Health Agency of Canada (2003) summarized the research that supports the role of physical activity in disease prevention. Specifically, the Agency found that:

- Physical inactivity is a recognized risk factor for cardiovascular disease along with smoking, high blood pressure and high blood cholesterol.
- Since physical inactivity is more prevalent than the other factors, increasing physical activity has the highest potential to reduce population cardiovascular disease.
- Physical activity can reduce the risk of colon cancer by as much as 50 percent. Research also shows that physical activity may protect against breast cancer in women.
- Physical activity can reduce the risk of developing type-2 diabetes by as much as 50 percent.
- The risk of osteoporosis is reduced through regular physical activity during childhood and adolescence and there is also evidence for maintenance of bone mass through physical activity and calcium supplementation in adulthood.
- Regular physical activity improves function and relieves symptoms among people with osteoarthritis and rheumatoid arthritis. In many cases, fewer medications are then necessary.

It is important to encourage people to be more physically active every day. Utilitarian physical activity refers to those activities that serve practical purposes such as transporting someone from one place to another, substituting for an automobile trip. Another common term for this type of activity is “active transportation,” which refers to any form of human-powered transportation. There are many modes of active transportation such as in-line skating and skateboarding. However, walking and cycling are the most common forms.

There is an opportunity to increase the total number of walking and cycling trips through active transportation strategies. Studies indicate that between 70 and 83 percent of all trips are short, for non-work purposes and take place relatively close to home (Pulleyblank-Patrick et al., 2006). There is a high degree of willingness among Canadians to walk (82 percent) or cycle (66 percent) instead of driving if there are safe and convenient facilities (Go for Green/ Environics, 1998). It makes sense to focus on active transportation as one solution to encourage people to be more active and drive less as it allows walking or cycling to serve a dual purpose of exercise and transportation (Lee & Moudon, 2004). A built environment that has facilities for active transportation close to where people live can support physical activity and can help reduce driving.

It is also important to consider the role that public transit can play in supporting walkable communities. Transit is an important factor in reducing emissions from air pollutants and greenhouse gases. Public transit allows people to visit destinations outside of their immediate neighbourhood. This is particularly important if we are encouraging people to move away from using a car more often. Transit also has the potential to increase physical activity levels since people tend to walk or cycle to reach local public transit. Transit use can support people in achieving their 30 to 60 minutes of daily physical activity. A study by Besser and Dannenberg (2005) examined the transit-oriented walking times for transit users. Their results showed that participants who used transit spend a median of 19 minutes daily walking to and from transit and 29 percent achieved 30 minutes or more of physical activity daily solely by walking to and from transit.

In summary, walkable communities are considered those communities that support recreational physical activity, active transportation and public transit.

c. The Halton Region Official Plan

The Halton Region Official Plan provides key insight into the value that the Region places on Healthy Communities. The Plan's goal for healthy communities is to:

> "achieve a high-quality environment, for this and future generations, that will sustain life, maintain health and improve the quality of living."

The healthy communities policies describe how the Region plans to achieve a high-quality physical environment through careful use of air, water and land resources. The Region plans to achieve healthy communities by fostering a high standard of public safety, social support services, cultural and recreational services, health services, heritage protection, economic development, transportation and servicing infrastructure. Two key components of the Official Plan include:

- Encouraging alternative transportation modes (e.g., active transportation such as walking and cycling, and public transit);

- Developing Healthy Communities Guidelines in conjunction with local municipalities (e.g., guidelines for land use mix, community and physical design, zoning, site plans).

These two Official Plan components have clear implications for the importance of ensuring that we have communities that support recreational physical activity, active transportation, and transit.

d. The Provincial Policy Statement and Growth Plan

In addition to the importance that the Region places on healthy communities, the Province of Ontario has provided clear direction on the value it place on healthy, complete communities through the *Provincial Policy Statement* (2005) and *Places to Grow*, *the Growth Plan for the Greater Golden Horseshoe* (2006)(the *Growth Plan)*.

The *Provincial Policy Statement* provides policy direction on matters of Provincial interest related to land use planning and development. It sets the policy foundation for regulating the development and use of land. It also supports the Provincial goal to enhance the quality of life for the citizens of Ontario.

The *Growth Plan* is a framework for implementing the Government of Ontario's vision for building stronger, prosperous communities by better managing growth in the Greater Golden Horseshoe region to 2031. It guides decisions on a wide range of issues such as transportation, infrastructure planning, land-use planning, urban form, housing, natural heritage and resource protection. The *Plan* builds on other key government initiatives including: the *Greenbelt Plan, Planning Act* reform and the *Provincial Policy Statement.*

These provincial policy documents promote development that has the ability to foster close live-work arrangements and access to public amenity space. For example, the *Growth Plan* supports the idea of mixed-use development that is pedestrian- friendly. The *Provincial Policy Statement* promotes the concept of complete communities by requiring a mix of housing types to meet a variety of lifestyles and incomes. Planning for a wide variety of housing within the community enables citizens from a range of economic levels, age groups and family structures to live within the same community, creating a balanced social diversity/cross section. It also allows people to remain in the same neighbourhood as they go through the different stages of their life.

The *Provincial Policy Statement* and the *Growth Plan* promote development that is transit-supportive and provides enhanced transit amenities. Access to transit is considered to be a fundamental aspect of neighbourhood design, as it offers residents and commuters an alternative to auto-oriented travel. The *Growth Plan* in particular requires that new development be designed in a manner that creates street configurations, densities and an urban form that is compatible with pedestrian and transit activities. The *Provincial Policy Statement* directs new development to areas that

have or are planned to have the necessary infrastructure (for example, water, sewer services, public transit, walking and cycling facilities) to accommodate growth.

2. What Makes a Walkable and Transit-Supportive Community?

Attention needs to be paid to the built environment in order to increase the proportion of the population that engages in physical activity and to increase the number of people who take transit. Making healthy choices the easiest choices through the built environment involves ensuring that the communities where people live, work and play allow everyone the option to choose to be active. Research has demonstrated that the way our communities are designed has an impact on physical activity and transit levels (Frank & Engelke, 2001; Frank, Engelke & Schmid, 2003; Humpel, Owen & Leslie 2002). Addressing issues that have an impact on physical activity levels is important because even a small increase in walking would help to substantially improve the health and quality of life of most people (Handy, Boarnet, Ewing, & Killingsworth, 2002).

The reasons why people are not physically active are numerous. There are *personal barriers* that restrict a person's motivation to be active such as lack of time, inability, lack of social support, and child-care responsibilities. There are also *environmental barriers* that are related to the conditions within our surroundings that make physical activity difficult or impossible. These barriers include lack of bike lanes, lack of facilities such as bicycle parking, safety, and lack of places to go (Frank & Engelke, 2001). Figure 1 outlines the factors that are related to walking and cycling in a neighbourhood.

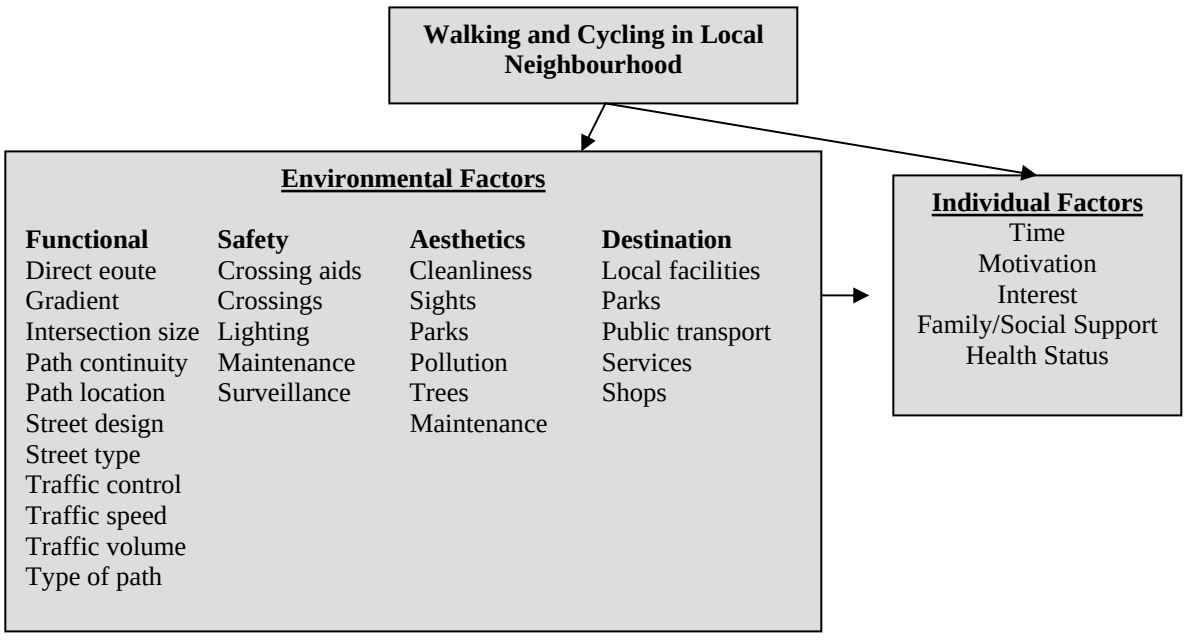


Figure 1: Factors related to Walking and Cycling in Local Neighbourhoods
Source: Region of Waterloo Public Health (2005).

In addition, there are numerous personal and environmental barriers that prevent people from taking public transit. Personal barriers include motivation, interest, and attitudes towards transit. Environmental barriers include availability of transit routes,

reliability of service, cost, and availability of retail, service, and entertainment at trip destination. This paper is focused on the environmental factors associated with walking, cycling and public transit as they are factors influenced by the design of our communities.

There are several models and frameworks that help define the dimensions of the built environment that are most closely associated with physical activity and transit. The Health Department has chosen to use the “3 D” model to organize this paper: density, diversity, and design (Sallis et al., 2006). *Density* refers to the number of households per hectare and the number of jobs per hectare. *Diversity* refers to land use mix, housing diversity and the presence of neighbourhood retail/service opportunities. For the purposes of this paper, we are referring to *diversity* as *mixed-use* because this is the term that is most frequently used in Halton. *Design* refers to street design, street connectivity indicators for both pedestrian and cyclists, and the quality of the pedestrian environment.

Each section will outline the health literature and best practices that support the policies related to encouraging alternative modes of transportation. Although each of these sections is considered separately, it is important to note that they work together to create an overall framework. No one parameter can achieve a walkable community on its own.

3. Density

Density, when discussed in the context of land-use planning, typically refers to either the number of people in an area, the number of jobs in an area, or both. Density affects travel behaviour by impacting the distances between destinations and the number of destinations that can be reached by active modes and transit. Having a concentration of jobs and households in a given area makes transit more viable and provides the critical mass necessary for supporting retail development (Frank, Kavage, & Litman, 2006). Research has demonstrated that as density increases, per capita hours and VKT decline and walking, bicycling, and transit use increase (Frank & Engelke, 2001; Saelens, Sallis, & Frank, 2003, Pulleyblank-Patrick et al., 2006; Holtzclaw, Clear, Dittmar, Goldstein, & Haas, 2002).

Research conducted by Holtzclaw et al. (2002) illustrates the relationship between driving and residential density. An examination of the San Francisco, Los Angeles and Chicago regions found that there was a very strong correlation between residential density and driving in all three regions studied. This relationship is illustrated in Figure 2.

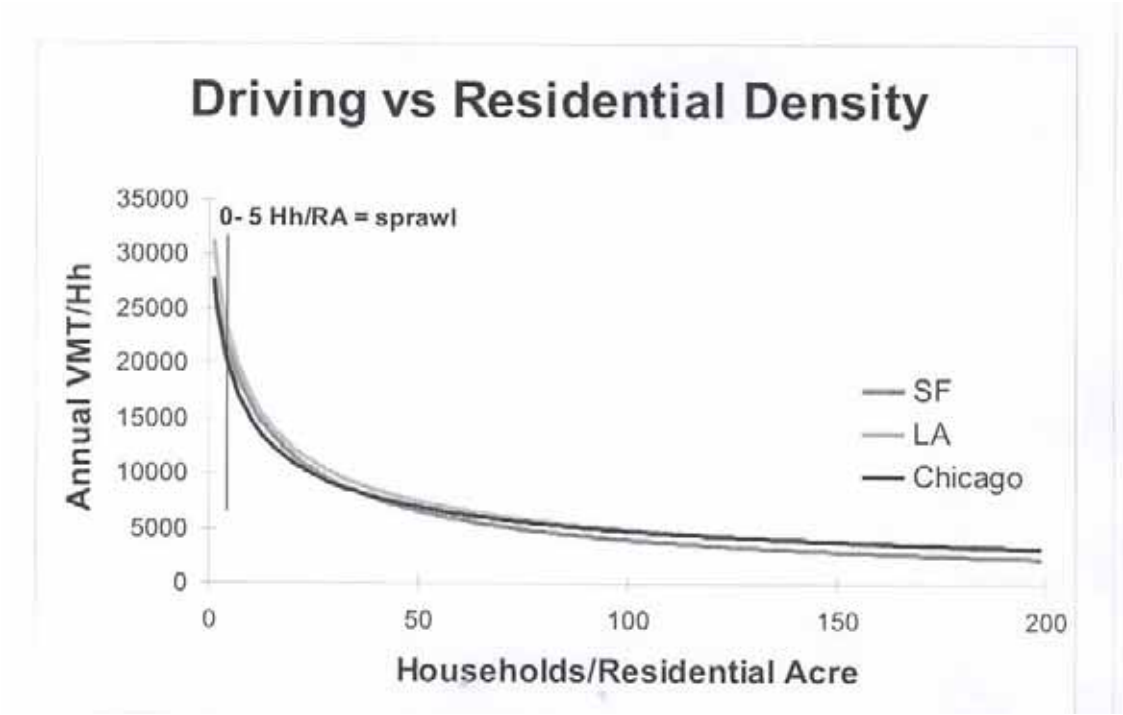


Figure 2. The Reduction in vehicle miles travelled per household as residential density increases. Source: Holtzclaw et al., 2002. VMT/Hh = vehicle miles travelled per household.

This study found that differences in density and transit availability explained over 33 percent of the variation in vehicle miles driven per household for a constant level of income and household size. The Holtzclaw et al. study and other land-use and auto-

use research found that doubling residential density reduced VKT by 20 to 30 percent (Newman & Kenworthy, 1989; Holtzclaw et al., 2002; Frank & Pivo, 1995).

Density decreases VKT, in part, because density increases the opportunities for transit, retail and services. The greater the number of people, jobs and retail in a given area, the more likely it is that someone will be able to take transit or use active transportation. Studies support the important role that density plays as a predictor of transit and active transportation viability. King County, in Washington State, conducted the *Land Use, Transportation, Air Quality and Health Study* (LUTAQH) to measure how specific land use and transportation actions affect air quality, mobility, congestion, and public health. This study found that for each 25 percent increase in residential density there was a 23 percent increase in the odds of walking for non-work travel after controlling for income, age, educational attainment and gender (King County, 2005).

There are very few studies that specify the exact number of people or jobs per hectare that are needed for transit and retail to be viable. And there are many variables, such as mixed land uses, connectivity, safety and road design that interact to determine whether active transportation and transit are viable options in each unique community. However, one important study by Frank and Pivo (1995) attempted to address the issue of how much density is needed to see a shift in travel mode from vehicles to transit or active transportation. This study found that nearly all travel was done by car until residential density levels reached 32 persons per gross hectare[1]. They further found that employment density levels greater than 185 employees per gross hectare were necessary before there was a substantial increase in transit and pedestrian travel for work trips. While these density levels represent the minimum thresholds for walkability, a desirable level of density would be greater. In addition, this research highlights the need to address the issue of both residential and employment density.

[1] Gross density is the total population of a given area divided by the total amount of land including roads, parks, and other natural features. This measure of density needs to be measured carefully because it includes all land in a given area, even land that cannot be developed (Halton Region, 2007).

a. Residential Density

Given the significant role that transit can play in reducing emissions of air pollutants and greenhouse gases (Halton Region Health Department, 2007) it is important to give consideration to densities that support public transit. As discussed earlier, transit modes and services that are appropriate to a given neighbourhood can be determined in part by land-use density in the surrounding area.

The Province's *Growth Plan* includes two major policies that are directed at ensuring that the growth expected by 2031 is accommodated with increased densities. First, regions are required to ensure better use of land and infrastructure by directing growth to existing urban areas. The *Growth Plan* mandates increasing intensification of the existing built-up area, with a focus on urban growth centres, intensification corridors, and major transit station areas. This concentration of development provides a focus for

transit and infrastructure investments to support future growth. Secondly, the *Growth Plan* requires that greenfield development is compact development. Both policies will reduce the rate at which land is consumed.

The Growth Plan directs communities to grow at transit-supportive densities. The *Growth Plan* requires that a minimum of 40 percent of new growth occurs in the already existing urban boundary with densities of 200 residents and jobs per gross hectare[2] for downtown Burlington, downtown Milton, and mid-town Oakville. The *Growth Plan* requires that greenfield developments be planned to achieve a minimum density target of 50 residents and jobs per gross hectare.

Residential density is therefore an issue for new developments and already developed communities. As mentioned earlier, there are very few formal studies that specify the exact number of people and jobs per hectare that are necessary for transit to be viable. The Frank and Pivo study suggested 32 people per gross hectare for residential areas as a minimum threshold. In addition to the empirical research, there has been real world study and application of density requirements necessary to support transit. Cervero et al. (2004), in their review of the transit-supportive development literature, found that a basic rule of thumb regarding density is that basic bus service can be provided at approximately 17 units per net hectare, premium bus service can be provided at 37 units per net hectare, and rail service can be provided at 50 to 75 units per net hectare.

[2] The density measure that the *Growth Plan* refers to is a gross measure that is a combination of people and jobs over the entire land area net of environmentally protected areas for greenfield and a combination of people and jobs over the entire land area in the urban growth centres (Halton Region, 2007).

[3] Net density is the number of people, houses, or jobs in an area net of land that is not for private use. Therefore, net density excludes roads, parks, public infrastructure and other natural features.

Metrolinx, the Ontario agency with the mandate to improve the coordination and integration of all modes of transportation in the Greater Toronto and Hamilton area, has examined the research and defined the densities needed to support different types of transit service. Table 1 outlines the types of land use densities that Metrolinx suggests can typically support and be well-served by different types of transit.

Table 1: Relationship between Land Use Density and Transit Potential. Source: Modified from Metro Toronto Building Ltd., 1990; Hemson et al., 1993; Lehman & Associates with IBI et al., 1995 as cited in Metrolinx, 2008.

Population Per Net Hectare (ppha)	Population Per Gross Hectare (ppgh)[4]	Units per Net Hectare (upha)	Residential Type	Type of Transit Service
Less than 20 ppha	Less than 10 ppgh	Less than seven upha	Single detached	None. Requires dial-up cabs, jitneys etc.
Up to 40 ppha	Up to 25 ppgh	15 upha	Single detached	Marginal transit. Buses every half-hour. Rush hour express bus.
Up to 90 ppha	Up to 50 ppgh	35 upha	Semi-detached, townhouses	Good bus service.[5]
120 to 130 ppha	70 to 75 ppgh	52 upha	Duplex, rows, triplex	Excellent bus service, possibly light rail (LRT).
140 to 250 ppha	80 to 140 ppgh	75 to 160 upha	Row houses, low-rise apartments	Bus, LRT, streetcar.
200 to 350 ppha	115 to 195 ppgh	175 to 300 upha	Medium-rise apartment plus high-rise	Can support subway and feeder bus network.

[4] The population per gross hectare numbers were calculated assuming that net density is approximately 1.8 times the gross density (based on the density values provided in Table 2).
[5]Although "Good Bus Service" is not defined, based on the chart, it is reasonable to assume that good bus service provides more frequent service than buses every half-hour and rush hour express bus.

Using Table 1, we can see that the research is fairly consistent. The Frank and Pivo study suggests that a minimum residential density of 32 people per gross hectare is required to see a shift in transit. This falls just above the transit service range considered "marginal" by Metrolinx. The numbers provided by Cervero et al. suggest that basic bus service is similar to marginal transit, and premium bus service is similar to good bus service. In addition, the *Growth Plan* threshold of 50 residents and jobs per gross hectare would support bus service considered "good" by Metrolinx, and the 200 residents and jobs per gross hectare for Urban Growth Centres would, according to Metrolinx, support at least light rail transit and streetcar networks.

The current urban residential densities of each of the four municipalities in Halton Region for both existing and planned communities are outlined in Table 2:

Table 2: Urban Residential Densities in Halton Region's Municipalities. Source: Halton Region, 2007.

Municipality	Units Per Net Hectare	Population per net hectare	Population per gross hectare[6]
Halton Hills (Georgetown)	23	64	36
Old Milton Milton HUSP	14 35	39 109	22 61
Oakville North Oakville	19 41	53 107	30 60
Burlington	24	60	34

[6] Gross hectare is based on the Growth Plan gross hectare

When comparing the Halton data to the Metrolinx figures, Table 2 illustrates that only Milton HUSP and the planned North Oakville community have overall population levels that can support good bus service. These communities illustrate that higher densities are possible within a Halton context. In addition, the *Growth Plan* mandates that a minimum of 40 percent of the new growth occurring in Halton must be accommodated within the existing communities. This increase in population will have the effect of boosting the residential densities of already existing communities, which has the potential to bring the overall densities closer to the 50 residents and jobs per gross hectare. However, it would be unrealistic to think that this intensification could happen uniformly across the Region. Instead, it makes sense to focus the minimum 40 percent intensification strategically to minimize disruption in existing communities and to maximize the number of walkable communities that could support good bus service.

In their review of the transit-supportive development literature, Cervero et al. (2004) found that common practices within cities and towns suggest that it is important to put the highest densities close to the transit or activity node and have densities decline as you move away from these areas. Some cities and towns have used a measure of 400 m around the transit node to differentiate various density zones. Each zone has a different density target, which creates a mix of housing throughout the community while still providing enough density to support various types of transit.

Figure 3 illustrates how residential density can gradually decline from an urban transit node using three different examples. The overall density of each of these areas is 44 units per hectare.

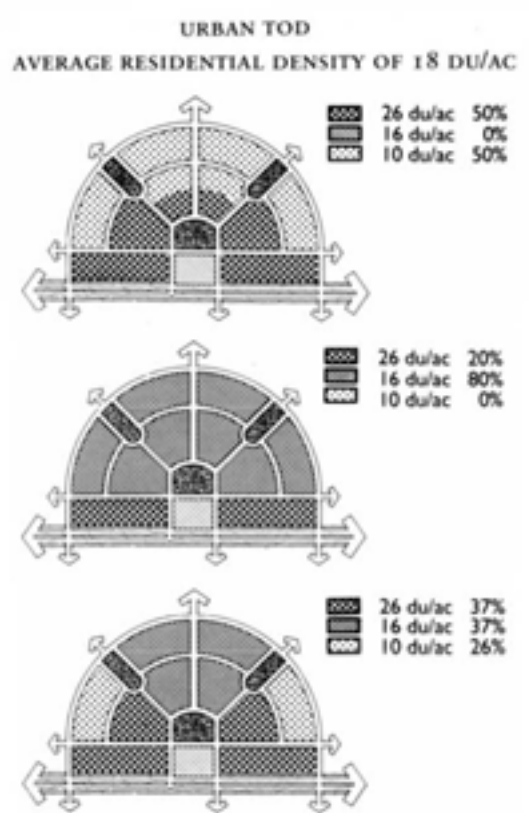


Figure 3. Density Gradations for an Urban Transit-Oriented Development at 18 Dwelling Units per Acre (du/ac). Source: P. Cathorpe as cited in Cervero et al, (2004).

This figure illustrates that there can be a mix of densities within a given community and there is more than one way to achieve an overall transit-supportive density.

Transit nodes[7], activity nodes[8], and the 400 m radius around them, would receive the greatest amount of density and would have the highest number of uses. The *Growth Plan* mandates 200 residents and jobs per gross hectare for the Urban Growth Centres. Looking at just the residential density requirement, this is a realistic target for comparable activity nodes and transit nodes. This level of density has the potential to support subway transit. Transitional zones that surround activity nodes and transit nodes would be located within an 800 m radius or a 10 minute walk of the centre. Existing residential communities located within the to 800 m radius should strive to achieve residential densities of at least 50 residents per hectare, thereby meeting the *Growth Plan* and achieving density that could support good bus service. However, it is possible to achieve higher density targets in greenfield areas so the recommended level of population density would be 75

[7] Transit node is a point where two or more transit routes intersect.

[8] Activity node is a compact, transit-oriented, pedestrian-friendly area where the highest concentrations of residential, employment, retail and other uses in the urban area are located. Activity nodes are generally located at points where two or more transit routes or travel modes intersect.
(Ministry of Municipal Affairs and Housing, 2007)

residents per gross hectare, which has the potential to support excellent bus service as a minimum.

An additional area highlighted by the Ministry of Municipal Affairs and Housing is the activity corridor[9]. These areas are located along arterial or collector roads and serve as major transit routes. The Ministry suggests that activity corridors should achieve medium densities, which would be defined by Metrolinx as a minimum of 80 residents per gross hectare, which could support excellent bus, light rail transit and streetcar service.

[9] Activity corridors are an area of street-oriented uses which incorporate a mix of retail, employment and residential uses located along arterial or collector roads serving as major transit routes.
(Ministry of Municipal Affairs and Housing, 2007)

Finally, the research does not directly address the issue of already existing stable neighbourhoods that are beyond the transitional zone. Intensifying already existing, stable communities can be a challenge and will not be possible in every community, which suggests that intensification cannot happen uniformly in Halton Region. Therefore, already existing non-transitional areas should strive for densities that provide good bus service, recognizing that will not be possible in every neighbourhood.

One example that accommodates the direction from the *Growth Plan* to incorporate a range of densities that can support transit and a mix of housing is the North Oakville East Secondary Plan (NOESP). It establishes the highest densities, between 50 to 300 upha, along major traffic corridors. The higher end of this density range could potentially support a subway network. In addition, activity nodes of mixed-use development have been created with higher densities that can support good to excellent bus service. NOESP sets a range of density requirements depending on land designation. The sub-urban area within NOESP has density targets of 15 to 35 upha, which are below the level needed to support good bus service. However, these sub-urban areas are located within five-minute walks of an activity node that has high enough densities to support good bus service. By creating neighbourhoods that form a concentric circle around an activity node, NOESP has created transit-supportive densities despite having a range of densities within the concentric circle.

b. Employment Densities

Similar to residential density, employment density is also an important factor in determining levels of transit use. Cervero and Duncan (2006) found that achieving a jobs-housing balance is one of the most important ways land use planning can contribute to reduced motorized travel. Their study found that having plentiful jobs within approximately 6 kilometres of homes significantly reduced vehicle kilometres travelled (VKT) for work trips.

As with residential density, there are very few formal studies that specify the number of people and jobs per hectare that are necessary for transit to be viable. The Frank and Pivo (1995) study found that employment density levels greater than 185 employees per

gross hectare were necessary before there was an increase in transit and pedestrian travel for work trips. This suggests that employment densities need to be approximately six times residential densities in order to support transit[10].

[10] 185 employment density divided by 32 residential density equals 5.8, which is how the 6 times was derived.

However, there is some evidence that local cities and towns are able to support transit with fewer jobs per gross hectare. The Cervero et al. (2004) review examined the employment densities achieved in the Puget Sound area. This region found that 61 jobs per gross hectare would support frequent, high capacity transit service, which translates into approximately 15,000 jobs within an 800 m radius of a transit station. In addition, they found that approximately 125 jobs per gross hectare would be needed to support light rail service.

The *Places to Grow* forecasts suggest that by 2031 Halton Region should accommodate 390,000 jobs, which is an additional 159,300 jobs from the 2006 employment figures (Halton Region, 2006). In all likelihood, these employment opportunities will service not only Halton residents but people living outside of the Region. Therefore it is important to centre employment areas around transit nodes as this has the greatest potential for providing the critical mass necessary to support efficient public transit.

The *Growth Plan* has provisions for the density of employment lands. The Plan requires that "an adequate supply of lands providing locations for a variety of appropriate employment uses will be maintained to accommodate the growth forecasts". As stated earlier, the *Growth Plan* requires 200 residents and jobs per gross hectare for downtown Burlington, downtown Milton and mid-town Oakville and that greenfield developments will be planned to achieve a minimum density target that is not less than 50 residents and jobs combined per gross hectare.

Employment densities vary within Halton's municipalities. Table 3 illustrates the current employment densities across the Region. Employment is defined as all lands used for employment activities including industrial, commercial, service, retail and institutional activities. Thus, it includes lands in residential areas which are used for local retail, places of worship, and elementary school functions.

Table 3: Urban Employment Densities in Halton Region's Municipalities. Source: Halton Region, 2007.

Municipality	Net Employment Density (jobs/ha)	Gross Employment Density (jobs/ha) [11]
Halton Hills	45	29
Milton	33	21
Oakville	38	24
Burlington	46	29

[11] Gross hectare is based on the Growth Plan gross hectare

As previously noted, the Frank and Pivo study found that density levels greater than 185 employees per gross hectare were necessary before a substantial increase in transit

and pedestrian travel for work trips is realised. However, the Puget Sound area found that 61 jobs per gross hectare were sufficient to support high capacity transit. Using the density numbers outlined in Table 1, the employment density levels in these two studies fall between good and excellent bus service. These two studies and the Metrolinx density numbers suggest that the 2007 gross employment densities for Halton municipalities, provided in Table 3, are too low to support transit use and increased pedestrian travel.

As with residential density, it makes sense to consider the range of employment density that should be located in different zones within a community. The highest amount of employment density would occur within the Urban Growth Centres, transit nodes and activity nodes. The *Growth Plan* mandates 200 residents and jobs per gross hectare for the Urban Growth Centres and it makes sense to extend this to the transit and activity nodes. Transitional zones are those areas that surround activity nodes and transit nodes and would be located within an 800 m radius or a 10 minute walk of the centre. Existing employment areas located within the 800 m radius should strive to achieve residential and employment densities of at least 50 jobs per hectare, thereby meeting the *Growth Plan* and achieving density that could support good bus service. However, it is possible to achieve higher employment density targets in greenfield areas so the recommended level of combined residential and employment density would be 75 jobs per gross hectare, which has the potential to support excellent bus service.

An additional area highlighted in the *Growth Plan* is the activity corridor. These areas are located along arterial or collector roads and serve as major transit routes. The *Growth Plan* suggests that activity corridors should achieve medium densities, which based on the Metrolinx data suggests a minimum density of 80 employees per gross hectare, which could support excellent bus, light rail transit and streetcar service.

The *Growth Plan* prescribes densities for residents and employment combined. The combination for greenfield areas could mean either 50 residents or 50 jobs, or 25 residents and 25 jobs, or anywhere along the range, as long as the total combined density is 50 residents and jobs per gross hectare. Therefore, using the same rationale as contained in the *Growth Plan's* densities, it could be argued that densities for transit nodes, activity nodes, activity corridors and transitional areas should be combined residential and employment densities. However, mixed densities are not appropriate for all types of employment. Retail, service and office employment opportunities are the types of employment that have the potential to be compatible with surrounding residential neighbourhoods. However, heavy industrial uses would be better situated away from sensitive (vulnerable) uses. For more direction on appropriate separation distances, refer to the Halton Region Health Department's paper titled "*Air Quality, Human Health and Incompatible Land Uses*". It is still ideal to situate heavy industrial uses around transit nodes and activity corridors. However, for these types of employment uses, the density numbers should reflect jobs per gross hectare with no residential.

Given the important role that transit plays in creating complete communities and in reducing emissions of air pollutants and greenhouses gases, it is important to create densities that have the potential to support transit service. The literature and best practices review suggests that transit-supportive communities have:

- **Neighbourhoods and employment areas located within a 400 m to 800 m radius around activity nodes, transit nodes, or activity corridors**
- **Activity nodes, transit nodes and the 400 m radius around them with a minimum of 200 residents and jobs per gross hectare**
- **Activity corridors with a minimum of 80 residents and jobs per gross hectare**
- **Transitional zones within 800 m of activity nodes and transit nodes in greenfield communities with a minimum 75 residents and jobs per gross hectare**
- **Stable communities and employment areas which achieve a minimum 50 residents and jobs per gross hectare whenever possible**

c. Implementation Issues

There are numerous implementation issues that have been identified in relation to residential and employment density targets. First, there are factors that influence density that are difficult to change through land use planning. Halton Region (2007), in a density report prepared by Hemson Consulting, highlights the difficulty the Region has in influencing household size for a given housing type through the planning process.

This report further identified market forces as a possible barrier for creating higher densities in Halton. They suggest that development within the Region has been driven by the desire for suburban living, single-family homes and large-scale retail shopping centres. However, it is difficult to know whether this is a preference of the population or if this is driven by the demands of the development industry. Research from the United States suggests that there may be a large percentage of the population that would prefer to live in higher density walkable communities but are unable because this option does not exist. Levine, Inam and Torng (2005) studied people's preferred neighbourhood and the choices available in Atlanta. They found that the people with the strongest preferences for pedestrian and transit neighbourhoods had only a 48 percent probability of living in an area that was considered pedestrian/transit friendly. This means that there is a large percentage of the population in Atlanta who would prefer to walk or cycle but live in communities that do not support them in making that choice. Although no such study has been completed for Halton, it seems likely that because of our current housing mix, there is a gap between the supply of walkable communities and the demand for them. In addition, there is a realistic expectation that this demand will increase as health and planning professionals continue to raise awareness about the importance of building healthy communities.

However, there will be challenges in changing community perception to accept an increase in density. Many of our municipalities have struggled with increasing density with existing residents. This will especially be a problem for the already built areas. It

is not uncommon for the municipalities to meet resistance and opposition from residents when intensification is proposed. This poses a serious problem for ensuring densities that support public transit.

In terms of employment density, Halton Region's report identifies that the Region is unable to dictate the type of employment that will locate in Halton, which is a major barrier for implementing employment densities. The densities provided by industrial and warehouse employment are considerably less than the densities that an office building could support. In addition, the *Growth Plan* makes it clear that downtown Toronto will remain the primary centre for international finance and commerce. Therefore, it is unclear whether Halton would be able to attract the level of employment density that would support high order transit services such as LRT or subway. A key consideration is how the new growth will be distributed as this will determine whether Halton is able to create walkable, complete communities.

Finally, there is a perception that higher densities are unattractive and encourage higher crime (Urban Land Institute, 2005). However, there are many factors that can affect the perception of attractiveness and many of these will be addressed in the "*Design*" section of this paper. In addition, a report conducted by the Urban Land Institute found that there is no relationship between housing density and crime. An important element in creating walkable communities is to encourage community support. Although outside of the scope of this paper, the Health Department can play a role in helping to educate the community about the benefits of healthy communities and how land use changes may help build such communities.

4. Mixed-Use

The term “mixed-use” refers to the degree to which different activities, such as residential, commercial and retail/service, are located within close proximity to one another. Mixed-use also refers to the variety of options available for each of the different activities. A mixed-use neighbourhood has a variety of homes, workplaces, amenities and services that are all easily accessible by walking, cycling or public transit. Mixed-use refers to both the existence of an activity (does the store exist?) and how close that activity is to residents (how close is the store?).

Studies have repeatedly shown that there is a relationship between mixed land use and walking and cycling patterns (Saelens et al., 2003; Lund, 2003; Lee and Moudon, 2004). Mixed land use is considered the community design variable most likely to affect the walkability of neighbourhoods (Saelens et al., 2003). Mixed land use impacts walking and cycling by influencing the accessibility and convenience of locations. The proximity of residents to services and amenities plays a key role in determining the mode of transportation individuals will choose to reach their destination. When destinations are within walking distance of people’s homes and workplaces, people are more likely to choose an active form of transportation over use of their automobile. The planning literature defines a comfortable walking distance as a five to 10 minute walk or a distance of 400 m to 800 m (Lund, 2003). This distance is based on an average walking speed of 4.5 kilometres per hour.

The relationship between mixed land use and walking and cycling applies to both the places that people live and the places they work. Land-use mix influences decisions about how people choose to go to work and therefore influences the mode by which they will travel throughout the day (Pulleyblank-Patrick et al., 2006). Often people need to run errands or attend appointments at some point during the work day. If services and amenities are not close to where people work, it will not be possible for them to use active transportation or public transit. This highlights the importance of ensuring that both residential communities and employment areas are mixed-use and have services and amenities close by in order to encourage active transportation and reduce driving.

These findings tell us that distance to destination is a key determining factor for transportation mode choice. The province’s *Growth Plan* also provides policy direction in terms of mixed-use. Section 2.2.2 “Managing Growth” clearly states that communities are to be a diverse mix of uses:

> 1. *Population and employment growth will be accommodated by –*
>
> *h) encouraging cities and towns to develop as complete communities with a diverse mix of land uses, a range and mix of employment and housing types, high quality public open space and easy access to local stores and services*

All of the municipal Official Plans in Halton encourage a mix of uses within neighbourhoods. The City of Burlington Official Plan encourages:

comprehensively planned mixed-use employment, shopping and residential areas that provide for the integration of uses such as retail stores, offices, hotels, institutional and entertainment uses with residential uses, community facilities, institutions and open space while retaining compatibility with nearby land uses.

The Town of Halton Hills has as one of their Urban Character strategic objectives:

To ensure that neighbourhoods are compact and pedestrian-friendly with a mix of housing types, community facilities, commercial centres and open spaces.

The Town of Milton Official Plan encourages:

Development which promotes the integration of the community and accessibility by residents to public service facilities inside and outside Milton, including physical features such as mixed-use developments.

The Town of Oakville Official Plan states:

Access to a full range of community facilities will be provided in neighbourhoods in order to develop a number of unique complete neighbourhoods throughout the Town.

Given the importance of mixed land use, it is important to consider what the appropriate amount of public space, employment/retail/service and housing is needed to support walking, cycling and public transit use. Cervero et al. (2004), in their review of transit-oriented development, cited the work of noted designer Peter Calthorpe. Calthorpe suggests that land-use mixes should have an increasing amount of employment and commercial components as an area becomes more urban. Calthorpe suggests that neighbourhoods, such as transitional and non-transitional areas, should have:

- 10-15 percent of the area allocated to public spaces
- 10-40 percent of the area allocated to commercial and employment uses
- 50-80 percent of the area allocated to housing

Cathorpe further suggests that urban areas, such as Urban Growth Areas, transit nodes and activities nodes should have the suggested mix of:

- 5-15 percent of the area allocated to public space
- 30-70 percent of the area allocated to commercial and employment uses
- 20-60 percent of the area allocated to housing

The above guidelines have been used by communities in United States such as Portland, Salt Lake City and Minneapolis. Figure 4 illustrates examples of how the suggested mix could be distributed through neighbourhood transit-oriented developments and urban transit-oriented developments.

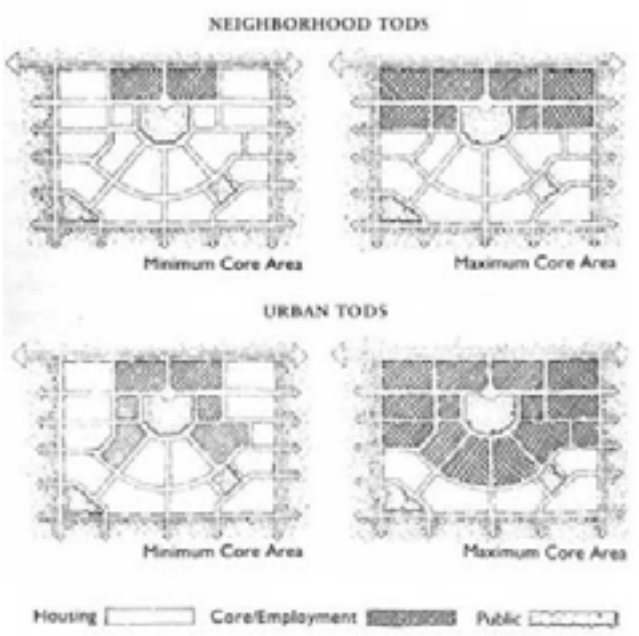


Figure 4. Land-Use Prototypes for Transit-Oriented Developments. Source: P. Cathorpe as cited in Cervero et al, (2004).

It is important to examine the specific components of mixed land use that allow for a healthy community. The following sections review the necessary elements of a neighbourhood to provide appropriate diversity to reduce automobile travel and increase transit and active transportation.

a. Diversity of Housing

The types of housing available in a community influence the diversity of people living in a community and affect the density a community is able to achieve. People's housing needs differ with changes in their lives related to age, family size, health, and social and economic circumstances. Ensuring a diversity of housing creates a situation in which people from all income levels can live in the communities in which they work. Without a broad mix of housing, people who work in certain sectors of the economy within Halton Region (e.g., retail, institutional, and service industry) will have to drive to their places of work. This creates a burden of transportation costs for people in low paying jobs (Ong and Blumenberg, 1998) and adds to emissions of air pollutants and greenhouse gases. It is important for the health and vibrancy of a community to have a mix of age- and income-appropriate housing in order to allow individuals to age in place. This means that it is necessary to have life-cycle housing that is suitable for people at different life stages and includes a mix of apartments, townhouses, and single family dwellings.

To highlight the importance of providing a range of housing, we can examine the current make-up of households in Ontario. Figure 5 depicts the distribution of households by household structure from the 2006 Census. "Couples with children" refers to households

that include a couple with at least one child aged 24 and under at home. “Couples without children” refers to households that include a couple without children as well as couples with children aged 25 and over at home. “Other” includes lone-parent households, multiple-family households, and non-family households other than one-person households.

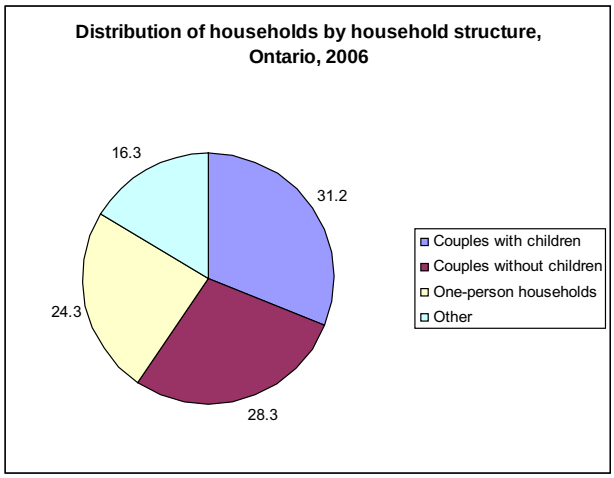


Figure 5. Distribution of Households by household structure, Ontario, 2006. Source: Statistics Canada, Census of Population, 2006.

Figure 5 shows that couples with children represent approximately 31 percent of all households. It is realistic to think that people in the other household categories, which represent 69 percent of the population, would have housing needs that are different from people who are couples with children.

However, Halton does not currently have a mix of age and income appropriate housing. The *Halton Region 2007 Annual Housing Report* monitors housing activity and issues such as new residential development, housing prices, the supply and demand for assisted and affordable housing, special needs housing and the extent of homelessness in Halton. Figure 6 depicts the housing continuum with the “Assisted” and “Affordable” housing cost/income thresholds and the current gap in availability of certain housing.

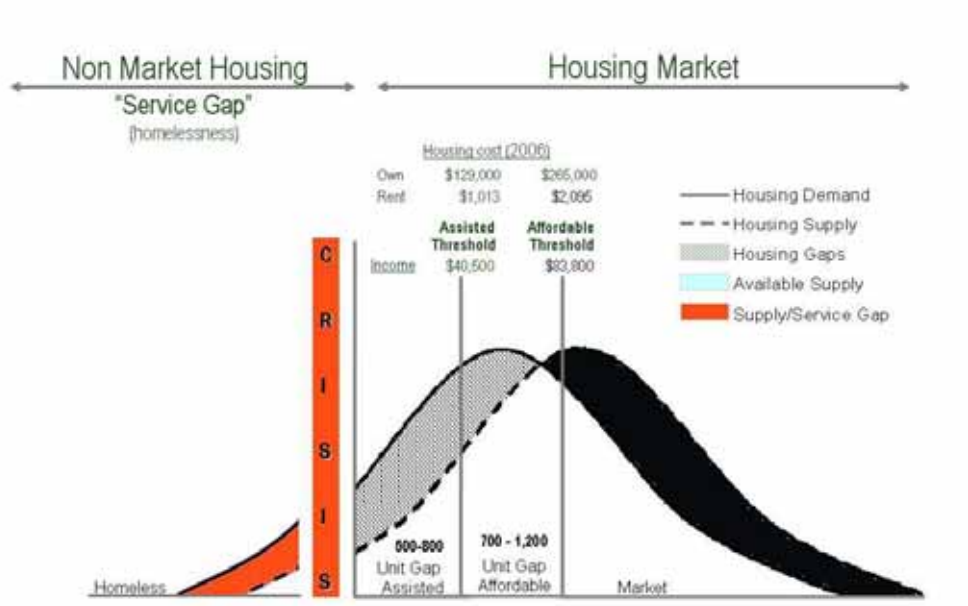


Figure 6. The Housing "Gaps" in Halton Region's Housing Continuum for 2006. Source: Halton Region, 2008.

The 2007 report found that the Region's housing demand model identified a gap for assisted housing and for affordable housing. The report also found that while the assisted gap remained similar to the gap from 2006, the affordable housing gap almost doubled.

The 2006-2015+ "*A Comprehensive Housing Strategy for Halton Region (CHS)*" recognizes the important role that an adequate range and mix of housing in supporting and sustaining healthy communities. The *CHS* outlines many important actions that need to be taken in Halton in order to support the creation of a healthy range and mix of housing. To specifically address the issue of housing type and form, the *CHS* includes the following action:

> *1.3 Require a percentage of each type of housing form (i.e. singles, semis, townhouses, and apartments) within each community (secondary plan area) to support the development of a variety of affordable housing types and meet the intensification targets of the proposed Provincial Growth Plan*

The purpose of this action is to assist in meeting the overall housing mix set out in Halton's Municipal Housing Statement, which has established an overall housing mix target of:

- Low density – 50 percent (single detached)
- Medium density – 30 percent (semi-detached houses and row houses) and
- High density – 20 percent (apartment)

In addition, individual targets were set for each of the Local Municipalities to assist the Region in achieving its overall housing targets. The targets were established to provide choices for a wider income range of individuals and families and to provide the type of housing needed to accommodate Halton's maturing population. This will allow more people to remain in their own communities as they age.

The *Halton Region 2007 Annual Housing Report* found that low density housing has continued to dominate the Region's housing market. Low density housing, which is typically intended for families with children, accounts for 58 percent of all completions in Halton. However, couples with children represent approximately 31 percent of all households in Ontario. Medium density housing has accounted for one-third of all completions since 2001, which surpasses the 30 percent target, and apartments have only accounted for eight percent of all completions since 2001. These findings speak directly to the need to provide a diversity of housing in Halton.

There is increasing evidence that residents are accepting of higher density housing. A recent survey examined the acceptability of different housing types in the Greater Toronto Area (GTA) and found that although many home owners continue to regard the single detached and semi-detached house as the most acceptable, there is considerable support for high density housing types such as apartments and townhouses (Sustainable Urban Development Association, 2008). The survey also found that there were no significant differences between respondents living in the City of Toronto and respondents living in the neighbouring municipalities in the degree of acceptability for condominium apartments and townhouses. The survey found that over 50 percent of respondents would accept or could accept living in a condominium apartment, which suggests that there is room within the housing mix for higher density housing (SUDA, 2008).

One method to measure the variety of housing sizes and types in a neighbourhood is to use the Simpson Diversity Index score (U.S. Green Building Council, 2007). This score measures the total number of dwellings in a single category to the total number of dwellings in all categories:

Simpson Diversity Index Score = $1- \sum(n/N)^2$

where n= the total number of dwellings in a single category and N= the total number of dwellings in all categories.

At this time, the Simpson Diversity Index Score is not used by any Halton municipality to measure the diversity of housing in a neighbourhood. However, the Leadership in Energy and Environmental Design for Neighbourhood Developments (LEED-ND) rating system uses the score as a way of determining if there is a sufficient variety of housing sizes and types and outlines 16 different housing type and size categories. The greater the mix of sizes and types, the higher the score the development receives. The measure used is as follows:

Include a sufficient variety of housing sizes and types in the neighbourhood such that the total variety of housing within the project or within a ¼ mile of the centre, achieves at least 0.5 corresponding to the Simpson Diversity Index Score.

A score of 0.5, however, is too low to provide a rich mix of housing. Although this measure may be useful to consider in the future, more needs to be understood about the measure and the appropriate score in order for it to be practically implemented.

The most common method for determining housing mix is to address the issue by setting housing mix targets in a manner similar to *Comprehensive Housing Strategy*. The City of Pickering, for example, has established criteria that a new neighbourhood provides for a diversity of housing types and densities (low, medium, high) such that no single residential density comprises more than 65 percent of the total. However, using this method requires an understanding of what "low", "medium" and "high" density housing refers to. The official plan of each municipality within Halton Region defines those three terms differently and within each municipality there may be a different definition depending on what area of the city or town is being referred to. Table 4 describes the definitions of "low", "medium", and "high" density by municipalities within Halton.

Table 4: Definitions of Density by Municipality and Type. Source: City of Burlington (2008), Town of Halton Hills (2008), Town of Milton (2001), Town of Oakville (2006).

Municipality	Density Type	Density Range (net hectare) [12]
Burlington	Low	Maximum 25 upha Maximum 35 upha - Orchard community Maximum 30 upha - Alton community
	Medium	26 to 50 upha
	High	51 to 185 upha
Halton Hills	Low	Maximum 20 upha
	Medium	21 to 50 upha
	High	51 to 100 upha
Milton	Low Density	Maximum 20 upha
	Medium Density I	Maximum 35 upha
	Medium Density II	Maximum 70 upha
	High Density	70 to 125 upha
Oakville	Low Density I	6 to 17 upha
	Low Density II	20 to 29 upha
	Medium Density I	25 to 35 upha
	Medium Density II	31 to 50 upha
	High Density I	51 to 100 upha
	High Density II	101 to 185 upha

12 The Local Municipalities' Official Plans use different definitions to define net density.

In addition to these ranges, each municipality defines what types of housing should occur in the range. So, low density typically refers to single and semi-detached dwellings, medium density typically refers to townhouses and row houses and high density typically refers to apartments.

The housing mix will be determined, in part, by the density targets in a given area. For example, by averaging the highest density ranges in Table 5, we get approximately 25 units per net hectare for low density, 55 units for medium density and 149 units for high density[12]. Applying the *Comprehensive Housing Strategy* targets of 50 percent, 30 percent and 20 percent for the three densities will give an overall density of 37 units per net hectare, which can support good bus service (as defined in Table 1). Assuming an average household size of 2.7 and a mix of one retail service job for every 10 person, 37 units per net hectare achieves 62 people and jobs per gross hectare. This exceeds the *Growth Plan* targets and comes close to achieving the density target for transitional zones. However, this housing mix will not achieve the density ranges necessary for activity nodes, transit nodes and activity corridors. These areas will require a greater amount of medium and high density housing in order to achieve their overall densities.

[12] Because the municipalities define net density differently, the average calculations are an approximation only.

Finally, the Health Department has observed that subdivision applications often come in at the lower end of the density range, which compromises the ability of a municipality to achieve a built environment that supports efficient public transit. This experience, along with the fact that the density ranges within the municipalities are varying, suggests municipalities should closely monitor the average density of new housing to ensure that the density targets have been achieved.

Given the important role that housing diversity plays in creating complete communities that support transit, reduce emissions of air pollutants and greenhouses gases, and provide for people at different life stages and incomes, it is important to create an adequate range and mix of housing . The housing mix should be aligned with the density targets of activity nodes, transit nodes, and activity corridors. It is important to monitor the average density of new housing for each housing type yearly to ensure that the overall density targets have been achieved.

b. Proximity to Diverse Uses

Having a variety of diverse establishments within a five to 10 minute walk or 400 m to 800 m of one's place of residence or place of work allows individuals to accomplish major trip purposes, such shopping trips, by walking. This is particularly important given that non-work trips account for between 70 percent and 83 percent of all trips taken (Pulleyblank-Patrick et al., 2006). A study conducted by King County (2005) found that the land uses most strongly correlated with the percentage of household walking trips were educational facilities, commercial office buildings, restaurants, and neighbourhood-scale retail establishments. Civic uses and grocery stores were also correlated with walking. Krizek (2003) cited research that found the most desirable uses

for residents included a drug store, food market, post office, specialty food store, and bank.

King County (2005) also found that the number of attractions by use was an important diversity variable for understanding walking trips. This research found that the number of attractions within a five to 10 minute walk or 400 m to 800 m of one's home had more impact on the decision to walk than the size or quality of an attraction. The study demonstrated that big-box stores, despite their size, had weaker correlations with walking than did the smaller retail establishments.

A recent study by McCormack et al. (2008) found that an increased mix of destinations in a neighbourhood encourages otherwise sedentary individuals to walk for transport, while encouraging higher levels of transport-related physical activity among already active individuals. Each additional type of destination in the neighbourhood was associated with approximately ten minutes more of transport-related walking per two-week period per person. The authors concluded that increasing the diversity of destinations should be considered highly important in the development of new neighbourhoods and for retrofitting existing neighbourhoods.

A study conducted by Handy (1996) found that residents with a supermarket within close proximity were more likely to walk than those that had a grocery store farther away. Distance to grocery stores is particularly important to low-income families that may not be able to afford their own vehicles. Research over the past few decades has documented the shortage of retail and service establishments in low-income urban communities, which results in reliance on options such as convenience stores. Convenience stores often supply goods at higher prices and offer fewer healthy options (Clifton, 2004). Low-income households often have limited flexibility and personal control over their schedules and expend time connecting with existing transport opportunities, arranging for new ones, or compensating for the uncertainty in their transportation (Clifton, 2004). Increasing retail and services, including supermarkets, in areas local to low-income households would be one policy measure that would alleviate some of the economic pressure and stresses experienced by low-income families (Clifton, 2004).

Within Halton municipalities, the support for creating diverse uses within walking distance can be found within the official and secondary plans through provisions that establish neighbourhood activity nodes within a five-minute walk of all residents. This is now common practice in Halton municipalities and is supported by provincial policy. However, it appears that specifying the number or types of diverse uses that should be available to residents within walking distance is not a common practice among municipalities. This is, in part, because the municipality has little control over the actual businesses that will locate within an activity node. That said, there is value in specifying that the overall mix of a community should include retail and services to meet people's daily needs.

The research findings suggest that the diversity of choices within a neighbourhood is an important component of a community's overall mix and can encourage walking and reduce automobile travel. The research also indicates that it is the number of diverse uses that plays an important role in encouraging active transportation. Currently, no research studies have defined the actual number of uses that need to exist in a community in order to encourage walking. However, LEED-ND, a certification program that is used to promote environmental neighbourhood design, specifies that residents should be within 400 m of six diverse uses. LEED-ND further goes on to specify the types of diverse uses.

The San Francisco Department of Public Health (SFDPH, 2007) developed the *Healthy Development Measurement Tool*, which is intended to determine the health impacts of land-use development applications. The SFDPH uses a "Neighbourhood Completeness Indicator" to measure the proximity of residents to daily goods and services within their neighbourhoods using 800 m as the radius. Included in the Neighbourhood Completeness Indicator are 11 key public and 12 key retail services that are considered necessary for meeting the daily needs of residents. The *Measurement Tool* assesses the proportion of residents that have access to eight out of 11 common public services within 800 m of residents, including childcare, community gardens, hospital and health clinic, library, post office, schools, public spaces and public art. The *Measurement Tool* assesses the proportion of residents that have access to nine out of 12 common retail services within 800 m such as beauty salon/barber shop, dry cleaner, eating establishments, gym/fitness centre, hardware store, laundromat, pharmacy, and entertainment. Finally, the *Measurement Tool* highlights the important role that retail food markets (supermarket, grocery store, and produce store) and a bank or credit union play in the health of a community and assesses the proportion of residents within 800 m of these important retail services as a separate measure in the index.

Given the important role that proximity to diverse land uses plays in creating complete communities that encourage active transportation and reduce emissions of air pollutants and greenhouses gases, it is important to ensure that residents have access to a variety of services and retail opportunities. The literature and best practices review suggest that in walkable communities, residents live within 400 m of six diverse land uses and within 800 m of 17 diverse land uses. Because of the important role that access to retail food markets plays in creating complete communities and ensuring access to healthy foods, the best practices literature suggests that food is accessible, from a proximity perspective, when residents live within 800 m of a planned or existing retail food market such as a supermarket, grocery store, or produce store.

c. Proximity to Schools

Because elementary school children are typically assigned to the school closest to their homes, the presence of nearby educational facilities appears to reduce household VKT by reducing the distance that children need to travel. King County (2005) found that the number of educational facilities in a community consistently proved to be associated

with household walking trips. This makes sense given that if a number of educational facilities exist in a given area, it is more likely that children will be able to walk or cycle to them. Larger but fewer schools will result in a greater number of children being bussed or driven to school because of the distances children must travel. This has implications for air quality, the climate, physical activity and injury prevention.

Research indicates that distance affects parents' decisions about their children's travel to school (McMillan, 2005). The physical distance between home and school limits the transportation options available to a household and was a strong determinant in a parent's decision about how children travel to school. There has been an increasing trend away from neighbourhood schools, which has, in part, resulted in increasing numbers of children being driven to school (Schlossberg, Greene, Phillips, Johnson and Parker, 2006). In their study of trips to school, Schlossberg et al. (2006) found that those children who live within 1500 m to school were the most likely to walk, followed by those living between 1500 m and 2500 m. They found that fewer than four percent of children who lived over 2500 m from school walked to school.

It is also important for schools to be within close proximity to residents because of the important role schools can play in being the hub of the neighbourhood. The school as hub can provide space for preschool, after school care, and a place for teens on evenings and weekends. The school can act as a base for parents to learn skills such as language training for new Canadians. The school can also serve as the locale for community events and celebrations. Halton's Our Kids Network uses a "school as hub" approach to provide services and programs to ensure that all children thrive and reach their full potential.

Currently, the distances that determine eligibility for home to school bus transportation by the Halton District School Board are:

- Grades JK to 5 – distance of more than 1600 m
- Grade 6 to 8 – distance of more than 3200 m
- Grades 9 to 12 – distance of more than 4800 m

The average time it takes to walk 500 m is approximately seven minutes for adults. It would take an adult approximately 20 minutes to walk 1600 m, 40 minutes to walk 3200 m and 60 minutes to walk 4800 m. It is realistic to think that children will walk slower than adults so these walking times would increase for children and youth. A 40 to 60 minute walk in the morning for children and youth would be outside the range of what is considered a comfortable walking distance. This seems to be reflected in the number of children being driven to school in the morning.

The proximity of elementary schools to residents differs from the proximity that is practical for secondary schools to residents because of the fewer number of students attending secondary school overall and the larger enrolment at each individual school. For example, the Halton District School Board has 77 elementary schools serving 34,591 students and 16 secondary schools serving 16,456 students. As a result, it is not practical to treat the placement of secondary schools the same as the placement of

elementary schools. In addition, youth attending secondary school would have greater capacity to use public transit if available. Therefore, residential proximity and school proximity to convenient public transit is also an important factor when considering the placement of secondary schools.

Given the important role that schools play in creating complete communities that support active modes of transportation and provide a neighbourhood hub it is important to ensure that residents have access to schools within their neighbourhoods. The literature and best practices review suggests: the land set aside for elementary schools should be located within 1500 m of residents to maximize the numbers of students walking; and, the land set aside for secondary schools should be within 3000 m of residents and should be located on local transit routes. Lands declared surplus by the school boards in Halton have public value and consideration should be given to purchasing these lands for public use.

d. Proximity to Transit

Public transit is an important part of a walkable community because it allows people to visit destinations outside of their immediate neighbourhood including shopping, entertainment, schools and employment without the necessity of a car. Public transit is particularly important if we are encouraging people to move away from using a car more often in favour of active transportation. For people walking to transit, short distances are crucial. The LUTAQH study found that for every 400 m increase in distance from a transit stop to home, the odds of taking a transit trip to work decreased by 16 percent. It found that a 400 m increase in the distance of transit from one's workplace reduced the likelihood of taking transit to work by 32 percent (King County ORTP, 2005).

The extent to which the number of vehicles on the road and the number of VKT is reduced depends, in part, on the efficiency of alternative modes of transportation such as public transit. An efficient public transportation network includes local transit systems, intra-regional transit systems, and inter-regional transit systems. Such a transportation network would allow residents of Halton to access amenities and services in their own local community as well as those in neighbouring communities. Inter-regional transit is particularly important in Halton because only 36 percent of the people in Halton Region work within their own communities. Individuals must be able to access transit near their home location, and must also be able to conveniently access their destination via transit. Ensuring that an intra-regional and inter-regional transit system is efficiently and effectively connected to a local transit system is important.

The extent to which the number of vehicles on the road is reduced also depends on the speed with which a transit system is introduced into a community. The Town of Oakville has adopted a "transit-first" policy for the NOESP to ensure that transit opportunities will be promoted through community design by encouraging development to proceed in a manner that will be supportive of the early provision of service. The "transit-first"

principle is based on the idea that if transit is not offered when someone moves into an area and they must drive to access their day-to-day amenities, it may be difficult to change their travelling behaviour at a later date. Offering convenient and reliable transit service early in development may make it easier to convince residents to use this service.

All of the Region's local municipalities have policies in their official plans that support transit. Currently, Halton Hills is the only municipality that does not have regular local transit servicing the community. However, Halton Hills does offer a dial-up transit service. Halton is also served by GO Transit. GO Transit is an inter-regional transit system that allows residents to access downtown Toronto and other areas via the Toronto hub. Ensuring access to this inter-regional transit system via local transit is an important component in the creation of an efficient transit system. Milton, for example, has established an 8-minute travel time to the GO Station using express local transit to make local transit to the GO Station a viable choice. At this time, GO Transit offers an intra-regional transit connection between Oakville and Milton. However, there is no other intra-regional transit system that connects north and south that would allow residents to visit the various municipalities in Halton.

Seniors in Halton experience difficulties in accessing day-to-day amenities without convenient public transit. The 2007 *Quality of Life for Seniors in Halton* by the Elderly Services Advisory Committee (ESAC) found that up to 30 percent of seniors 65 and older do not drive and approximately 12 percent need help getting to appointments or running errands. In ESAC's 2001 survey of seniors, 36 percent of seniors said that theyfound it difficult to go where they wanted to go and of those who indicated difficulty getting around, 36 percent said it was because there was no public transportation. The 2001 survey also asked seniors what improvements in transportation they would recommend. Seniors responded that regular bus service around the region (58 percent), regular bus service on weekends (42 percent), and regular bus service to larger centres (42 percent) would help seniors in the community. Seniors comments indicated that they were very concerned about the physical accessibility of transportation (ESAC, 2001).

Given the important role that transit plays in creating complete communities, in reducing emissions of air pollutants and greenhouses gases, and in ensuring all members of the community have access to necessary services and opportunities, it is important to create transit-supportive communities. The literature and best practices review suggests communities designed so that residents are within 400 m of an existing or planned transit stop support transit service and use. In addition, when developing new communities, adopt a "transit-first" principle.

e. Proximity to Open Space, Parks and Recreation

Having access to natural areas such as open space and parks has direct effects on physical and mental health. Providing shade, trees and vegetation helps to mitigate the negative impacts associated with climate change by reducing the "urban heat island

effect" that occurs when pavement, concrete, and buildings in urban areas absorb and radiate heat. The presence of green surroundings in urban settings is associated with fewer crime reports (SFDPH, 2006). More generally, living in proximity to green space is associated with better self-rated health, and higher scores on general health questionnaires (SFDPH, 2006). Sallis and Glanz, (2006) referenced a national U.S. survey that found 90 percent supported local government funds for parks and recreation and it was suggested that people support spending for these facilities because they believe open space improves their quality of life.

In addition to the important role that public parks play in encouraging physical activity and quality of life, it is important for the community to have access to recreation facilities such as playgrounds, pools, arenas, and sports fields. Children, in particular, need places where they can be physically active on a regular basis. The most important places for children's activity are outdoors and in the neighbourhood and include both public parks and commercial facilities (Sallis and Glanz, 2006). How accessible facilities are depends on how close they are to children's homes or schools, how costly they are, and how easily they can be reached (Sallis and Glanz, 2006). A study by Frank, Kerr, Chapman, and Sallis (2007) confirms the importance of parks and nearby recreation facilities for youth and suggests it is important to have a choice of destinations near their homes.

Parks and recreational facilities are important places for people to engage in recreational physical activity. However, parks and recreational facilities also act as destinations and can therefore contribute to greater levels of active transportation by providing another diverse use for people to access. There is an important role in the community for both small neighbourhood parks and larger community parks as they provide different recreational opportunities and encourage physical activity in different ways.

Large parks allow for a greater range of uses within the park, which can encourage greater levels of recreational physical activity. Smaller parks, on the other hand, can be used as meeting places and can accommodate a smaller range of needs but in closer proximity to residents' homes. Smaller parks have the potential to address children's and youth's unstructured play needs through the provision of small playgrounds and play areas. Smaller parks in greater quantity, therefore, have greater potential to be accessed using active transportation (Frank et al., 2005). In addition, smaller parks can help create pedestrian-friendly environments by enhancing the streetscape and providing connections between different pedestrian and cyclist routes (Frank et al., 2005). Because the uses within parks vary greatly, residents should have a range of park options that allow a diversity of uses.

Halton municipalities have official plan policies that support residents' access to a wide range of park and open space opportunities. All four municipalities have park hierarchies that outline the different types and sizes of parks. Although each municipality approaches the park hierarchy differently, general themes have emerged:

Town/City Wide Community Parks
These parks support the entire city or town and have the highest intensity of recreational use and level of facility development. They include parkland, irrigated sports fields and other major public facilities. Suggested sizes in Halton for these parks start at a low of 11 hectares to a high of 50 hectares in size.

Community or District Parks
These parks serve one or more planning areas and provide major sports facilities as well as other passive recreational opportunities. They can be located adjacent to a secondary school or community facility and would be a minimum of six hectares in size.

Neighbourhood Parks
These parks provide a variety of outdoor recreational experiences and can serve one or more neighbourhoods within a five to 10 minute walk or 400 m to 800 m range. They would include sports fields and children's play areas and can be connected to elementary schools to encourage the sharing of indoor and outdoor facilities. Suggested sizes for these parks start at a low of 1.5 hectares to a high of 4.25 hectares.

Village Squares/Parkettes
These are more passive park areas that would include opportunities for children to play. These parks would be located in sub-neighbourhoods and would be within a 200 m to 400 m radius of residents. Suggested sizes for these parks start at a low of 0.2 hectares to a high of 0.6 hectares.

Urban Squares
These squares are intended to provide flexible outdoor spaces for socializing and civic events and would be located in urban core areas.

In addition to the park classification, each municipality has stipulated a target for the amount of parks and open space for the population. The American National Recreation and Parks Association set a national standard of 10 acres of open space per 1000 people (approximately four hectares). This amount would include neighbourhood and community parks as well as more generic open space. Table 5 outlines the different standards set by Halton's municipalities.

Table 5: Open Space and Parkland Requirements by Municipality. Source: City of Burlington (2008), Halton Hills (2008), Town of Milton (2001), Town of Oakville (2006).

Municipality	Open Space and Parkland
Burlington	2.5 hectares per 1000 population
Halton Hills	3.7 hectares per 1000 population total 1.2 hectares local parks – Parkettes and Neighbourhood Parks 2.5 hectares non-local parks – Community Parks and Town Wide Parks
Milton	4 hectares per 1000 population 1 hectare Town Wide Community Park 2 hectares District Parks and Urban squares

	1 hectare Neighbourhood Parks and Village Parks
Oakville	2.2 hectares per 1000 population

It is important to caution that large open spaces can work against walkable communities by lowering density and reducing the ability to create compact urban forms. Large parks such as Central Park in New York City and High Park in Toronto are effective because they have high densities surrounding them, while maintaining several entrances to access and enter the park. Given the nature of community and town/city wide parks it is important to ensure that the surrounding neighbourhoods achieve densities that can support public transit. In addition, it is important for the community to have access to recreation facilities such as pools and arenas. Ideally these could be co-located with schools and other community uses such as libraries. Community recreation facilities should be located on public transit routes and in close proximity to shops, schools, and other community infrastructure to ensure maximum accessibility.

Given the important role that parks play in supporting physical activity, residents should have access to a full range of parks described in the parkland hierarchy. Physical activity is supported when residents live within 400 m of a village square/parkette and within 800 m of a neighbourhood park, and when community parks, town/city wide parks and recreational facilities are located on local transit routes.

It is important to note, that there are environmental benefits to ensuring that we preserve a healthy natural environment. However, these benefits are beyond the scope of this paper. This paper is only focused on the amount of open space needed to support physical activity and positive mental health and well-being. Ensuring biodiversity within the natural system is an equally important goal and may require much greater amounts of green space to be preserved.

f. Implementation Issues

An important implementation issue that is directly related to the ability of a community to support mixed-use is the amount of time between when residents move into a community and when amenities and services are available to residents. Creating complete communities requires that people live in areas that have a mix of housing, a mix of retail, schools, parks and recreational facilities. However, experience suggests that it is difficult to create complete communities all at once. It is not uncommon for all of the low density housing to be built first, followed by the medium density and then followed by the high density. This has implications for who will be able to live in the community and it has implications for the amount of retail and other services that are available. If only low density housing is built at the beginning of a project, it is unlikely that there will be sufficient levels of population to support a variety of retail options, schools, recreational facilities, or public transit. The ability to support alternative modes of transportation depends, in part, on the speed with which a community is built.

In order to deal with this issue, Oakville, for example, has stipulated in its Official Plan that although they will not require the achievement of the housing mix on a yearly basis, they shall monitor the housing mix to ensure compliance with the policies. LEED-ND also includes provisions for ensuring that the community develops so that amenities and services are available to residents quickly. Specifically, LEED-ND states that "the phasing of residential and non-residential development should occur at the same time and the non-residential component consists of additional neighbourhood amenities provided in mixed-use focal nodes or corridors".

In addition, the ability of the Region and Local Municipalities to ensure proximity to many of the diverse uses suggested above remains, in some cases, limited. Municipalities, for example, can designate land for school use but cannot dictate that a school will actually be built there. The Ministry of Education has certain requirements in terms of school size and if the population of school-aged children does not support a school, the school boards will not locate schools in the area set aside. This can, in part, be dealt with by ensuring that residential densities are high enough to support schools in neighbourhoods. However, the issue of school size and the Ministry of Education's direction to move towards larger schools poses a challenge for ensuring that elementary schools are located within walking distance of residents.

In addition to schools, most services and amenities may not realistically be located in every community. Community libraries, for example, need a certain number of people in order to be viable as do grocery stores, theatres and most retail businesses. It is unlikely, therefore, that each activity node would be able to accommodate all of the daily needs of each person. Looking for opportunities to co-locate certain services and amenities may help deal with this issue. For example, many municipalities combine recreation centres with libraries. There could also be a possibility of combining a community library with a school library. In addition, the provision of efficient public transit ensures that people are able to access amenities and services without the need of a car.

Finally, the ability of the Local Municipalities to provide efficient public transit relies on financing. Currently, Halton region does not have an intra-regional transit system and not all municipalities have the financial capacity to provide local public transit. The financial implications associated with transit service are an important implementation issue.

5. Design

"Density" and "mixed-use" are built environment elements that are focused on making walking and cycling possible options by ensuring that there are places to walk. The "design" aspect of the built environment, however, focuses on creating environments that actually encourage walking and cycling by establishing direct and varied routes that are safe and aesthetically appealing. Design encompasses those aspects of the built environment that influence how a person perceives a place (Frank and Engelke, 2005). Design has the potential to increase the desirability of walking and cycling as an option by enhancing the quality of the pedestrian and cyclist experience.

Walking and bicycling almost always occurs on publicly provided streets and trails so it is important to consider how this infrastructure supports active transportation. Communities that are built with the idea that the movement of cars is the priority have negative impacts on transit, bicycling and walking because these communities are typically built with wider streets, large parking lots, increased traffic volumes and higher traffic speeds (Frank, Kavage and Litman, 2006). On the other hand, communities that have sidewalks, on-street parking, buildings set close to the sidewalk and attractive features such as art, trees and benches appear to improve the perception of an area's safety and walkability (Frank et al., 2006). Focusing efforts on ensuring the design of the community supports active transportation has the potential to increase pedestrians' positive perception of their environment.

Generally, research has shown that street design can increase walking, cycling and public transit use and reduce potential conflicts with vehicles that are related to traffic volume and speeds. The LUTAQH study examined subjective measures of the built environment such as ease of street crossing, sidewalk continuity, street connectivity, and topography. This study found that an increase in the quality of the pedestrian environment can result in a 10 percent reduction in VKT in the neighbourhood (King County, 2005). This decrease can be attributed, in part, to the differences in average travel speed found on different street layouts. Areas with increased street connectivity have closer-spaced intersections which results in lower motor vehicle speed profiles, while suburban environments with large arterials and widely spaced intersections have higher motor vehicle speed profiles (Frank and Engelke, 2005). This has implications not only for VKT but also for injuries and fatalities related to motorized traffic for pedestrians and bicyclists.

Community design is believed to be an important determinant of active transportation because the travel speeds at which pedestrians and cyclists travel are considerably lower than for automobiles. This slower rate of travel allows pedestrians and cyclists to perceive a lot more detail in their surroundings. Motorists can only process a fraction of the details that a pedestrian or cyclist is able to process because of the speed at which they are moving (Frank and Engelke, 2005) and the attention required to operate a motor vehicle. This is the difference between "pedestrian-scale" and "automobile-scale". Therefore, an important consideration in creating positive pedestrian and cyclist

environments is to ensure that there are lots of interesting design details that can capture an individual's interest.

Neighbourhood streets have the potential to serve two physical activity purposes. They can be destinations for recreational physical activity, such as walking or jogging, and they can be routes to support getting to other destinations (Lee & Moudon, 2004). In terms of transportation related physical activity, Saelens et al. (2003) reviewed a number of studies and found that facilities that support walking, such as sidewalks that are well connected, were related to higher numbers of people walking to commercial centres even when other factors, such as density and land-use mix, were constant. It is therefore important to ensure that neighbourhoods are designed to support alternative modes of transportation by providing connectivity, appropriate facilities and a quality urban environment.

a. Street Design

Streets serve many purposes. They are part of a transportation network that moves pedestrians, cyclists, transit and motorists from an origin to a destination. Streets are also places in themselves where social activity occurs. These two, sometimes opposing purposes, make street design a challenge because it requires balancing the needs of many different users. Balancing travel time, safety and community character along with the needs of pedestrians, cyclists, transit, motorists, emergency service providers, and local business people is complicated. However, efforts to create streets as places, as well as links to destinations, are particularly important in an urban setting and for walkability. Road design can help determine speed and helps to determine the context of a particular place in much the same way as the adjacent land uses and buildings do (Institute of Transportation Engineers, 2006). Conventional road design that emphasizes vehicular capacity and automobile access may have the negative effect of making the roadways and adjacent uses less attractive to pedestrians due to safety and aesthetic reasons.

The primary measure of road user safety in Ontario is the number of fatalities for every 10,000 licensed drivers on our roads. In 2005, Ontario had a vehicle-related fatality rate of 0.87 per 10,000 licensed drivers (Ministry of Transportation, 2005). In addition, unintentional injury ranks fourth among the leading causes of death and it is estimated that these injuries cost nearly $3 billion in direct health care costs and indirect social and economic costs due to loss of productivity. In 2003-2004, about 11 percent of injury-related hospitalizations and seven percent injury-related deaths in Ontario were due to vehicle collisions (Canadian Institute for Health Information, 2006). This indicator suggests that there are significant human health and economic costs associated with motor vehicle collisions, in terms of lives lost, pain and suffering, and the impact on Ontario's healthcare system.

Safety is also an important issue for vulnerable users such as pedestrians and cyclists. In the United States, studies show that pedestrians are 20 times more likely to be killed on a per-mile-travelled basis than are motorists (Dumbaugh, 2008). In the United

States, adults aged eighty and older are roughly seven times more likely to be killed in a traffic collision than are individuals aged 25 to 70 and pedestrians older than 65 are twice as likely to be killed as are members of the population as a whole (Dumbaugh, 2008). This finding is particularly important as the number of older adults is expected to rise with our changing demographic.

A study by Garder (2004) developed a model to predict the number pedestrian collisions by road and then compared the model results to the actual reported number of collisions. The study found that higher vehicle speeds were associated with higher rates of pedestrian crashes. Low speed roadways, defined as those roads that have operating speeds under 32 km/h (20 mph) reported roughly half the number of crashes as predicted by the models. Moderate speed roadways that have operating speeds of 32–40 km/h (20-25 mph) reported three times as many crashes as predicted, and high speed roadways over 40 km/h (25 mph) reported five times as many crashes as predicted. The author found that, in general, low-speed, "main-street"-type designs reported the lowest rates of vehicle-pedestrian collisions, while areas with wide travel lanes and higher operating speeds reported the highest rates. A further study from Dumbaugh (2008) found that street networks that have multiple lanes of higher speed, through-traffic are the conditions in which older adults are most likely to be involved in a crash.

The design of our roads typically follows a road classification system. A road classification system is a policy designed to help manage street systems as a network by designating how individual street segments should prioritize moving vehicles along them versus how they should provide vehicle access to properties adjoining them (Hess & Milroy, 2006). Five broad road categories are commonly used for roads in Canada: freeways, expressways, arterials, collectors, and local streets. Halton Region's Official Plan outlines the following function of major transportation facilities:

Table 6: Function of Major Transportation Facilities. Source: Modified from Halton Region, 2006.

Facility Type	Function
Provincial Freeways	• Serve mainly inter-regional travel demands • Accommodate truck traffic • Accommodate rapid transit services and high occupancy-vehicle lanes • Carry high volumes of traffic • Connect urban areas or Nodes in different regions
Provincial Highways	• Serve mainly inter-regional travel demands • Accommodate truck traffic • Accommodate rapid transit services and high occupancy vehicle lanes • Carry high volumes of traffic • Connect urban areas or Nodes in different regions
Major Arterials	• Serve mainly inter-regional and regional travel demands • Accommodate truck traffic

	• Accommodate rapid transit services and high occupancy vehicle lanes • Connect urban areas or Nodes in different municipalities • Carry high volumes of traffic • Distribute traffic to and from Provincial Freeways and Highways
Multi-Purpose Arterials	• Serve a mix of functions of Major Arterials and Minor Arterials • Typically connects Major Arterials through urban areas or Nodes
Minor Arterials	• Serve mainly local travel demands • Accommodate local truck traffic • Accommodate local transit services • Connect urban areas or Nodes within the same municipalities • Carry moderate to high volumes of traffic • Distribute traffic to and from Major and Multi-Purpose Arterials

Freeways themselves are of limited utility for pedestrians and cyclists as those uses are not permitted on these roads. However, the overpasses over these freeways can prove to be important barriers for pedestrian and cycling activity (MO-55-07). In the case of Halton's municipalities, major expressways such as the Queen Elizabeth Way (QEW), and the 401 cut through communities creating connectivity barriers.

The classification of arterials, collectors, and local roads is typically based on the road's role in moving people from an origin to a destination or its role in providing access to a larger street network (Hess and Milroy, 2006). Movement and access are seen as inversely related. This means that as movement increases, access decreases and vice versa because many access points on a street result in an increased number of intersections. This results in a greater frequency of lights and stop signs, which leads to slower speeds. Arterial roads are typically intended to move moderate to high levels of traffic to and from urban areas. Access to these arterials is limited. Local roads, on the other hand, are intended to provide high levels of access. These roads provide access to residential homes, which means there are a number of access points along the street. However, these roads do not provide high levels of movement. Collector roads bridge the two types of roads by connecting local streets to arterials. These roads also often provide access to local business opportunities.

Hess and Milroy (2006) note that the road classification system that is used to identify and select the preferred road alternative ignores the types of street users and the activities that take place on the streets found in cities and towns because of its focus on vehicles. The Institute of Transportation Engineers (2006) in the United States also suggests that the conventional road design process emphasizes vehicular capacity and automobile access but does not consider the surrounding context. It is suggested that this can be a source of conflict with the community because the design may not be

compatible with its surroundings or may fail to address community concerns or interests.

Two alternative models for designing roads have been suggested in the literature that can accommodate both the importance of a road as a link and as a place. The Institute of Transportation Engineers (2006) in the United States has developed a handbook entitled "*Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities"*. It was developed to provide guidance and information on the design of major urban thoroughfares such as arterials and collectors and introduces a new classification system that uses both functional class (such as arterial, collector and local) and thoroughfare type (such as boulevard, avenue and street) to describe the role of a thoroughfare in the circulation network and its design character. The document further describes features of thoroughfare types and context zones that result in compatibility.

A European research project name Arterial Streets Towards Sustainability (ARTISTS) (Svensson, 2005) examined the road classification system as it relates to arterial roads and developed a new model that would help ensure arterials meet the needs of current users of the street system without compromising the ability of future users to meet their own needs. The researchers found that the conventional road classification system is not ideal for promoting sustainability because it disallows the combination of circulation and access implied by an arterial road. They also make it clear that the intent is not to convert all streets to pedestrian streets or local streets. To do so would be to create a non-functioning city or town. However, more attention needs to be placed on the road's function as an urban place and how this role interacts with its ability to act as a link.

The researchers for ARTISTS suggest a new classification system to identify a range of street types that reflects the different functions of different kinds of streets in the overall street system. The classification relies on both measures of the importance of the road based on its role as a link and its role in providing a sense of place.

Link status

Link status refers to the role a street section plays as a link in the network. A road's designation will be determined by its role in the network structure, for example, local access street, district distributor, city arterial. In a people oriented perspective it is important to not only regard link in terms of motorised traffic but in terms of cyclists and pedestrians as well.

Place status

Place status refers to the role a street section plays as an urban place in the whole urban area. There is no direct equivalent to place status in conventional street classifications or road hierarchies. Whereas the link status of a route will tend to stay constant over the length of a particular street, place status will vary along a street, and could be different in principle for each locale. Street sections can be defined by changes in place status along a given street, as well as by changes in link status.

According to ARTISTS, there is a balance or trade-off to be struck between the impacts on the immediate locality of the street and the wider urban area. The researchers suggest that the trade-off of the street space in a particular location will be affected not only by the immediate demands placed on that location, but its strategic significance relative to the wider city context.

Using this system, streets can be classified by their place status and by the conventional road classification system based on their role in a larger movement network. This is important because it begins to take into account the role that a road plays in the pedestrian realm. Roads that serve as major links but are also important local places should have lower speeds (and therefore enhanced safety) in order to accommodate pedestrians.

Halton Region is responsible for planning, maintaining and operating Major Arterials. An example of a Major Arterial is Guelph Line north of the QEW. The local municipalities are responsible for Multi-Purpose and Minor Arterials as well as collector and local streets.

The Regional Road network is planned through the Halton Transportation Master Plan, which is a transportation strategy that considers all modes of travel to meet the needs of residents and businesses to the year 2021. When Halton Region proposes changes to a section of a Regional Road, a Class Environmental Assessment Study (EA) as per the Municipal Class Environmental Assessment process (2000, as amended 2007) is undertaken. The expectation is that the EA process should provide a solution that is suitable for a healthy, sustainable environment. A “sense of place” is an important element when developing and examining the design concepts, which occurs in Phase 3 of the EA process. After the preferred solution has been identified, consideration is further given to the overall feel of a community so that the design developed creates the overall experience that the community is trying to achieve.

When considering the road network in Halton Region, it is important to ensure that the road’s sense of place features are considered equally with its role as a link between origins and destinations at the stage in the process where solutions are being identified and selected. This is particularly important for roads that serve as major arterials but are also important destinations for pedestrians and cyclists. It is also important to note that one road may be a rural road in one section, an arterial in another section and a main street in another section. Major Regional arterials, for example, often have these multiple roles.

Given the important role that road design plays in creating a desirable walking and cycling environment, the research and best practice literature suggest it is important to consider “sense of place” when identifying and selecting preferred road solutions.

b. Pedestrian Connectivity

Pedestrian connectivity refers to the directness or availability of alternative walking routes from one point to another within a neighbourhood. A highly connected street network allows people many possible routes between destinations (Handy et al., 2002). When streets are not connected and the route to get someplace is very indirect, it is less conducive to walking because the distances that must be travelled will be much greater. Well connected walking and cycling networks are crucial to encouraging active transportation (Frank et al., 2006).

Cul-de-sac networks and greater roadway widths make walking and cycling more difficult. Cul-de-sacs reduce the number of intersections, which reduces the number of direct routes that pedestrians can take. Wider roadways make it difficult for pedestrians, especially children and seniors, to cross. On the other hand, a connected road system designed in a more grid-like fashion, allows more direct travel between destinations, offers more route options, and makes active transportation more feasible (Frank et al., 2006). The LUTAQH study found that the odds of someone reporting that they walked for non-work purposes rose by 14 percent for each 25 percent increase in the level of street connectivity where they lived (King County, 2005). Studies suggest that intersection density needs to reach around 50 intersections per square kilometre before pedestrian travel becomes more commonplace (Frank et al., 2006).

A qualitative study by Ahlport et al. (2008) looked at the barriers and facilitators to walking and bicycling to schools. The participants of this study cited lack of adequate sidewalks as a barrier for allowing children to walk to school. Both parents and children perceived the lack of continuous sidewalks as a problem because it required children to cross over streets continually in order to stay on sidewalks. Schlossberg et al. (2006) also found that intersection density, a common measure of connectivity, was a strong predictor of whether or not children walked to and from school. Highly connected areas had more children walking.

Sidewalk and path availability and block size are the two main elements of connectivity that are most directly related to pedestrian activity. The presence and design of sidewalks and paths is one measure for pedestrian connectivity. Block size is also a measure of connectivity as it reflects the distance that a pedestrian must travel before reaching an intersection.

Requiring, as a general rule, sidewalks on both sides of residential streets with a minimum width of 1.5 metres seems to be common practice among municipalities. In addition, some municipalities outline specific requirements for commercial areas. The Regional Municipality of Niagara requires sidewalks in commercial areas to be a minimum of 3.5 metres wide with a 1.5 metre walkway and a 2.0 metre wide boulevard. The NOESP specifies that sidewalks in the commercial areas be 4.0 metres wide to accommodate pedestrian traffic and street furniture. The City of Burlington establishes guidelines for sidewalk widths in the downtown to be 4.0 to 5.0 metres whereever possible.

Block size guidelines differ depending on the municipality. The City of Pickering, for example, requires a pedestrian linkage when the block size exceeds 550 metres, which is more than a five-minute walk. This is too far to ensure connectivity. Both the Regional Municipality of Niagara and the NOESP, on the other hand, have established 250-metre blocks as the norm. All three municipalities have established grid-designed street layouts for all future development.

It is important to consider how to address connectivity in existing neighbourhoods that have not been developed on a grid pattern. It is highly impractical, and in some cases impossible, to attempt to change the street pattern of neighbourhoods already built. However, creating connectivity in already existing neighbourhoods is important in ensuring that current residents of Halton have the same active transportation and public transit opportunities as future residents. For these neighbourhoods, it will be important to look for opportunities to create pedestrian linkages through communities by developing pathways through residential housing connecting to arterial and collector roads.

Given the important role that walking plays in reducing emissions of air pollutants and greenhouses gases, and fostering good health directly, it is important to create pedestrian connectivity that has the potential to create a desirable walking environment. The research and best practices literature suggests that active modes of transportation are supported when:

- **Residents have access to continuous sidewalks or equivalent provisions for walking along both sides of all streets; new sidewalks in residential areas are at least 1.5 metres wide; and footpaths are at least 1.5 metres wide**
- **Commercial areas have continuous sidewalks or equivalent provisions for walking along both sides of all streets, and new sidewalks in commercial areas are at least 4.0 metres wide;**
- **Streets are designed on the basis of medium to short block lengths with a maximum block perimeter that does not exceed 250 metres. Where block perimeter exceeds 250 metres, a through block pedestrian linkage is provided.**
- **Neighbourhoods have a linked open space system that interconnects allowing pedestrian, bicycle and other recreational activities continuously throughout the community.**
- **Neighbourhoods built on a cul-de-sac street pattern system are connected to arterial and collector roads by looking for direct pathways that link residents to these areas.**

In order to support the inclusion of these elements in the development of Halton's communities, it would be helpful to incorporate a *walking and cycling review* for pedestrian connectivity and safety for planning applications.

c. Bicycling Connectivity

Bicycles allow an individual to cover a larger geographic area than can be covered by walking. Studies have shown that higher levels of bicycle infrastructure, such as bicycle lanes and paths, along with grid street patterns are associated with higher rates of bicycle commuting (Nelson & Allen, 1997; Dill & Carr, 2003; Moudon et al., 2005). Cities with higher levels of bicycle commuting have 70 percent more bikeways per roadway mile and six times more bike lanes per arterial mile than cities with low levels of bicycle commuting (Pulleyblank-Patrick et al, 2006). Just as with sidewalks, bicycle lanes and paths need to connect popular origins with destinations if the lanes and paths are going to be used for commuter or utilitarian purposes.

Cycling rates in Europe far exceed cycling rates in North America, despite equally high levels of car ownership. Europe has high and growing levels of cycling in virtually all segments of society regardless of age or sex (Pucher and Buehler, 2008). In countries with low rates of cycling and high rates of car use, traffic safety concerns have been identified as a major constraint on cycling (Garrard, Rose, Lo, 2007). To increase the number of cyclists, it is necessary to deal with both actual and perceived safety. Surveys tell us that the perceived traffic danger of cycling is an important deterrent particularly for women, individuals who currently don't cycle, and those who are beginner or infrequent cyclists (Pucher and Buehler, 2008; Garrard et al., 2007).

Cyclists have a variety of infrastructure needs related to the different types of facilities necessary for the travel portion of the bicycle trip and end of trip facilities. End of trip facilities include infrastructure such as close, secure parking that protects the bicycle from weather and theft and change rooms with showers and lockers. In addition, different cycling facilities are needed depending on whether the cyclist is a recreational or commuter cyclist and depending on whether the cyclist is experienced or a novice. Beginner cyclists or infrequent cyclists often prefer to be separated from the road because they perceive this to be safer. This is especially the case for parents' perception of safety for their children. On the other hand, experienced cyclists often prefer to be part of the road structure as this permits them to go faster, for example, by not having to cross driveways. Therefore, it is important when considering the infrastructure needs for cyclists to keep in mind the different types of cyclists.

Bicycle facilities along traffic routes, especially facilities that are off-road or adjacent to the road, are perceived by cyclists to diminish risk (Parken, Wardman, Page, 2006). An examination of bicycle-friendly environments in the Netherlands, Denmark and Germany found that the higher level of safety in these countries is the most important reason for higher levels of cycling especially among women, children and the elderly (Garrard et al., 2007). Cycling is over five times as safe in the Netherlands as in the U.S. (Pucher and Buehler, 2008). The provision of separate cycling facilities is considered a critical policy that has resulted in making cycling safe and attractive because they are designed to feel safe, comfortable and convenient for every user and for all levels of cycling ability.

There are three types of facilities for bicycles that address the issue of safety by providing space and direction for the cyclists:

- On-road bicycle routes – these are routes that are designated for bicycles but the routes themselves are shared with vehicular traffic. These routes can include wide curb lanes (WCL) that provide space in the lane nearest to the curb so that the lane may be shared with vehicles and cyclists.
- On-road bicycle lanes – these are lanes designed specifically for bicycles and are either marked lanes delineated from the adjacent motor vehicle lane or lanes that are entirely separated from traffic.
- Off-Road Paths – these are paths that are typically multi-use and shared with other activities such as walking or in-line skating. These paths are most common in parks and other greenspace.

There is a long-standing debate within the bicycling community about which cycling treatment is the most appropriate. Parents prefer their children to cycle on separated bike lanes. However, these lanes are often designed in a manner similar to a sidewalk. Driveways often cross the lane and intersection crossings are problematic because of the potential for increased vehicle/bicycle conflict. Cyclists must stop or slow far more often than on the road, this being particularly disadvantageous for the commuter cyclist. In Europe, where separated bicycle lanes are more common, such problems are avoided because these lanes are typically part of the road infrastructure (and not the sidewalk infrastructure), while still being separated from the road by some physical barrier.

Many beginner cyclists report feeling safer when they ride on bicycle lanes. These lanes are typically delineated on the road by a stripe. However, it has been suggested that bicycle lanes make it difficult for cyclists to handle turning manoeuvres at intersections, especially left hand turns. This is because the design of the bicycle lane typically leads the cyclist to the edge of the curb lane, making it difficult to enter traffic to make a left turn. This is an important issue because intersection-related collisions account for 50 to 70 percent of bicycle-motor vehicle crashes (FHWA, 1999). There are several suggested treatment options to assist in making the intersection safer including grade separation, coloured bicycle crossings, and advanced stop lines or bike boxes (FHWA, 1999).

Bicycle lanes that are separated from motor vehicle traffic by road markings also tend to accumulate debris that is knocked there by the tires of motor vehicles. Such debris can be dangerous (sand and gravel can cause loss of traction; glass shards can cause tire punctures; large objects can cause loss of control or damage the bicycle) and often causes the cyclist to have to move into the adjacent car lane. The solution is a commitment to frequent sweeping by the responsible municipality.

Many experienced cyclists prefer wide curb lanes as they encourage cyclists to operate more like motor vehicles leading to more correct manoeuvring at intersections. However, because wide curb lanes have no markings, vehicles may not be clear that they should be keeping to the left in the lanes, especially at intersections and when

motor vehicle traffic has slowed or stopped due to congestion. This has the potential to prevent the cyclist from being able to pass on the right, making the ride less efficient by negating the ability to keep moving while cars are stuck in traffic jams. Signs that remind drivers to stay to the left or bicycle symbols painted on the right side of the lane at regular intervals may be effective to increase safety. Wide curb lanes also require more frequent sweeping and, like bicycle lanes, must not have their right margins marred by steel gratings, potholes, or other obstacles that would cause a cyclist to have to move to the left.

The U.S. Federal Highway Administration (FHWA) concluded in its 1999 study of both bike lanes and wide curb lanes that both wide curb lanes and bike lanes work reasonably well. However, they also concluded that bike lanes are more likely to increase the amount of bicycling than wide curb lanes due to the perception of greater safety.

Providing a highly connected bicycle network that includes both off-road and on-road bicycling facilities has the potential to accommodate the greatest number of beginner and experienced cyclists (Dekoster, Schollaert, 1999). The bicycle networks in the Netherlands, Denmark and Germany are focused on enabling bicyclists to take the most direct possible route from origin to destination, which results in a wide range of facilities that create a complete, integrated system.

It is important to emphasize that bicycles are formally recognized as vehicles by the Province of Ontario, as outlined in the Highway Traffic Act, R.S.O., 1990. Bicycles, therefore, are legally entitled to share all classes of roadways, including arterial roads, collectors and local streets, with the exception of freeways. This means that “every road is a cycling road.” All roadways in a community should be ideally designed, updated and maintained in a way that provides a safe environment for bicycle use. No matter how extensive the off-road bikeway or trail facilities, some cyclists, especially commuters, will choose to ride on the road. They have that right, and accordingly, should feel safe and comfortable in doing so.

The local municipalities each have policies and design guidelines intended to develop integrated, connected bicycling systems that have a mix of designs including multi-use pathways, and on-road treatments. These policies and guidelines apply to roads under municipal jurisdiction. To provide connections between municipalities, leadership is taken by Halton Region as regional roads typically connect the municipalities. The Halton Region Transportation Master Plan currently specifies that all new urban arterial and collector roadways, as well as urban arterial and collector roadways that are to be rebuilt, should be reconfigured to have a minimum 4.2 m wide outside lane. A delineated cycling lane in an urban traffic setting should be an option for those roadways that are likely to have high cycling traffic, provided it is a prudent/beneficial measure to cyclists and conforms to industry design standards. However, this seems inadequate given the speeds travelled on regional roads, the volume of traffic, and the type of traffic, which is more likely to include trucks and tractor-trailer units. It is unlikely

that a 4.2 m wide lane, or even a delineated cycling lane, would encourage greater numbers of beginner or infrequent cyclists.

Standard design templates for bicycle facilities should be applied, wherever possible, to promote consistency across the region. However, it is apparent that such templates cannot be applied across the board to achieve standard or desired bicyclist movements because of the issues related to retrofitting existing roads that may not have the necessary rights-of-way. Without flexibility, achieving an integrated connected network through Halton would be difficult. Instead, each road should be considered individually to determine the most appropriate treatment, just as is done with roads for motor vehicles. When the treatment options are being planned all users from beginner to expert, from infrequent to daily users, from slow to fast riders, should be considered. In addition, the maintenance of the bicycle facilities needs to be addressed to ensure that obstacles such as potholes, storm water grates, bumps and debris are eliminated from bicycle routes.

Given the important role that cycling plays in reducing emissions of air pollutants and greenhouses gases, and fostering good health directly, it is important to create bicycle connectivity that has the potential to create a desirable cycling environment. The literature and best practices review suggests that the number of beginner or infrequent cyclists increases when:

- **Neighbourhoods and communities accommodate a cycling network that includes bike lanes and off-road cycling or multi-use trails**
- **Roads with speeds over 60 km/h have separated lanes that are part of the road, not sidewalk, infrastructure**
- **Roads with speeds between 50-60 km/h have marked bicycle lanes**
- **Roads with speeds under 40 km/h are shared**
- **Priority is given to cyclists in intersections**
- **Overly frequent stops or places where reduced cycling speeds are necessary are reduced**
- **Residents have access to trip end facilities such as secure long-term bicycle parking (e.g., lockers), secure short-term bicycle parking (e.g., bicycle racks), and showers in commercial buildings**
- **All streets, roadways, and designated bike routes are maintained to be free of deterrents to bicycling (such as potholes, debris, and overgrown landscaping)**

In order to support the inclusion of these elements in the development of Halton's communities, it would be helpful to incorporate a *walking and cycling review* for cycling connectivity and safety for planning applications.

d. Pedestrian and Cycling Environment

Subjectively measured variables, such as the perception of enjoyable scenery, are found to influence physical activity (Lee & Moudon, 2004). Amenities and aesthetic features are shown to increase the use of local parks, and the perception of

environmental aesthetics and convenience are associated with increased level of walking for exercise (Lee & Moudon, 2004). The pedestrian and cycling environment refers to the qualities that contribute to the attractiveness and the appeal of an area such as:

- building design,
- size of windows,
- location of the entrance doors,
- landscaping,
- lighting,
- benches,
- bicycle storage,
- showers.

The appeal of an area is subjective and different people will have different feelings about what makes something attractive. However, a review of the cited research from a visual preference survey in the U.S. found there is an almost universal *negative* reaction to the visual appearance of commercial strip sprawl and an almost universal *positive* reaction to traditional town-like communities of the past (Urban Land Institute, 2005).

The scale of the street is an important aesthetic factor that influences the appeal of an area. This refers to the space along a street as bounded by buildings or other features and can include ratios of building heights and street widths or the setbacks of buildings (Handy et al., 2002). Scale can often be described by terms such as “pedestrian-scale” or “automobile-scale”. The rate of travel speed determines the amount of the built environment that the brain is capable of processing. Motorists can process only a fraction of the detail that exists in the built environment compared with a pedestrian or a cyclist (Frank & Engelke, 2005). The pedestrian and the cyclist are more sensitive to urban design features of the built environment than the motorist. Walking and cycling travel is much slower than automobile travel, which allows the traveller to notice differences in landscape. A visually rich pedestrian environment has streets that change abruptly, are irregular and complex as these factors maintain the pedestrian’s interest (Frank & Engelke, 2001).

An important component of providing this variety is ensuring that buildings are located close to the sidewalk with windows and entrances accessible from the sidewalk. Pedestrians should be able to access a building directly from the sidewalk without having to walk around to the other side of the building. In addition, windows facing the sidewalk that are free of visual barriers are important as they provide not only interest but “eyes on the street”. There has been a recent move by retailers to locate buildings close to the sidewalk and have windows facing the sidewalk, as is required in the design guidelines of the municipalities. However, the windows along the sidewalk are then covered and the pedestrian must access the building by walking around to the other side and through the parking lot. This is less convenient for the pedestrian and potentially decreases aesthetics and pedestrian safety.

Availability and location of parking is also an important component of the pedestrian and cycling environment. Parking can enhance or detract from the appeal of an area through both the design and the placement of parking areas. Pedestrians and cyclists are usually given low priority in parking lots and may be left to navigate between parked cars and across wide driveways. In addition, conventional surface parking lots also contribute to the urban heat island effect, which raises local air temperature, elevates smog, and in turn, increases energy demand for summer cooling (Aniello, Morgan, Busbey & Newland, 1995). Traditional parking lot surfaces prevent rainwater and snowmelt from being absorbed into the soil to replenish groundwater (Toronto City Planning, 2007). One way to minimize the urban heat island effect is to plant healthy trees and vegetation. Trees provide shade for pedestrians, are visually appealing and can increase the aesthetic appeal of a pedestrian street.

Availability of street parking can be pedestrian-friendly as it provides a buffer between the pedestrian and moving traffic. When street parking is considered, special attention needs to be given to how the parking interacts with bicycle movement, as opening car doors are a hazard to the cyclist. In addition, placement of larger parking areas should be minimized and located in behind buildings. The buildings themselves should be situated close to the sidewalk and the entrances should be from the sidewalk along the road. It is important when considering parking to ensure that pedestrian movement is given priority.

An often forgotten element of creating pedestrian-friendly spaces is the provision of appropriately sheltered public transit stops. Public transit stops should be designed for maximum appeal and be covered so as to provide shelter to passengers who may be waiting in rainy or snowy conditions. Provision for sitting should be provided and the transit stop should be directly connected to the sidewalk but should be placed in a way that does not impede pedestrian traffic.

A final important design element is ensuring everyone, including people with wheelchairs and other mobility devices, have the same access to all that our communities provide as people without these devices. The *Ontarians with Disabilities Act, 2001* sets out requirements for accessibility standards that are intended to create communities that allow everyone to fully participate in community life. The Ministry of Municipal Affairs and Housing has developed a toolkit for municipalities to assist them in creating universally accessible communities. This toolkit identifies universal design options including:

- ensuring that the slope of curb cuts and entrance ramps are gradual and non-slip surface
- ensuring that traffic signals are long enough for slow-moving persons to cross safely and that push buttons or sensor controls for traffic signals are low enough for wheelchair height
- the use of audible traffic signals to assist people with limited vision
- ensuring walkways are clear of obstructions

A barrier-free municipality is one that successfully strives to prevent and remove all obstacles in order to promote equal opportunity and participation by residents and visitors with disabilities.

Municipalities address the issues related to aesthetics by developing urban design guidelines. These guidelines outline all of the issues related to the design of a community including the public art that will be provided, the provision of street trees, the location and design of buildings and the location of parking. The City of Toronto, for example, has produced "Design Guidelines for 'Greening' Surface Parking Lots" and includes policies related to improving the public realm, enhancing pedestrian safety and comfort, increasing shade, and promoting the use of sustainable materials.

Burlington, Halton Hills, Oakville and Milton have all developed Urban Design Guidelines. It is beyond the scope of this paper to cover the level of detail in each of those guideline documents. It is also important that each municipality be able to define and maintain the character of each community. However, there are specific elements that should be considered in developing guidelines that are supported by the research and that could be included in a walkability review.

Given the important role that walking and cycling plays in reducing emissions of air pollutants and greenhouses gases, and in fostering good health directly, it is important to create environments that are inviting to pedestrians and cyclists. The literature and best practices review suggests walking and cycling can be encouraged when:

- **Building frontages that positively address the street, with active uses at ground and first floors**
- **All ground level non-residential interior spaces that face a public space have transparent glass on the ground level façade**
- **Length of blank walls (without doors or windows) along sidewalks are reduced**
- **Commercial buildings are designed and built so that each building has a front façade and at least one entrance that faces a publicly accessible area such as a street, square or plaza**
- **On-street parking is provided on selected streets**
- **All off-street parking facilities are located at the side or rear of buildings, leaving building frontages and streetscapes free of parking facilities**
- **Each transit stop provides at least one bench and where appropriate is sufficiently sheltered**
- **Sidewalks are connected directly to transit shelters**
- **Transit shelters are placed in such a way that they do not impede pedestrian traffic**
- **Street trees are planted between the vehicle travel way and sidewalk**
- **Universal design options are addressed**

In order to support the inclusion of these elements in the development of Halton's communities, it would be helpful to incorporate a *walking and cycling review* for pedestrian and cycling supportive environments for planning applications.

e. Implementation Issues

The implementation issues related to design occur most predominantly in the already existing urban areas. Most new communities are currently being built to support greater pedestrian and cycling connectivity through the development of grid street networks. However, older communities were not built with this level of connectivity in mind. Therefore, achieving these connections may be difficult.

As outlined in the Bicycle Connectivity section, some existing roads may be difficult to retro-fit to include bicycle lanes. This highlights the need for ensuring flexibility and to treat each road individually. An additional challenge with ensuring bicycle connectivity is that many motor vehicles simply do not expect to encounter cyclists on the road. As cycling increases, this will change eventually and lead to reduced motor vehicle collisions, as has been the case in Europe. However, in the transition years, various strategies will need to be undertaken to remind drivers that they may encounter cyclists at any time. Although beyond the scope of this paper, those strategies could include using media, ensuring road-side signage and symbols painted on the road, and enforcement of traffic laws. The Health Department could play a supporting role in increasing community awareness and support.

A final implementation issue is the provision of parking and the community support for alternative measures related to both parking and the provision of pedestrian and cycling facilities. It is not uncommon for both residents and the business community to express concern over lack of parking or complain about measures taken to increase pedestrian, cycling and public transit use at the expense of motor vehicle speeds. However, if we are going to ensure that we see a modal shift in the population and have more people walking, cycling and taking public transit, we will need to take bold steps in ensuring that these options are viable choices. After the infrastructure and facilities are in place, additional measures can be introduced that would act as deterrents to driving. These deterrents could include increased parking costs and increased licensing costs. However, until we have walkable and transit-supportive communities, introducing deterrents would only serve to penalize a population that has no other choice.

6. Suggested Directions for Consideration in the Sustainable Halton and Official Plan Review Processes

There are important opportunities for reducing air pollutants and greenhouse gases that contribute to poor air quality and climate change, and for achieving greater levels of physical activity in Halton by focusing on the land-use planning process. Communities that support physical activity and transit have the potential to increase the number of people who choose alternative modes of transportation. Research has demonstrated that *density, diversity (mixed use)* and *design* elements of the land-use planning process are correlated with physical activity and transit use. Each element plays an important role in encouraging walkable and transit-supportive communities and should be considered together to create an overall framework.

This paper provides the parameters for walkable and transit-supportive communities based on the health and planning research and best practice literature. The paper supports the Provincial *Growth Plan* that encourages the development of complete communities that are well-designed, offer transportation choices, accommodate people at different life stages and have a mix of housing, jobs and amenities to meet daily needs. Given the important role that walking and cycling plays in reducing emissions of air pollutants and greenhouses gases, and in fostering good health directly, it is important to create walkable and transit-supportive communities. On the basis of our review of the health and planning literature and best practices, the Health Department recommends consideration of the following parameters**,** in order to support the development of walkable and transit-friendly communities**,** during the Sustainable Halton and Regional Official Plan Review processes:

1. To create transit-supportive densities:
    - Locate neighbourhoods and employment areas within a 400 m to 800 m radius around activity nodes, transit nodes, or activity corridors
    - Activity Nodes, transit nodes and the 400 m radius around them have a minimum of 200 residents and jobs per gross hectare
    - Activity corridors have a minimum of 80 residents and jobs per gross hectare
    - Transitional zones within 800 m of activity nodes and transit nodes in greenfield communities have a minimum 75 residents and jobs per gross hectare
    - Stable communities and employment areas achieve a minimum 50 residents and jobs per gross hectare whenever possible

2. To provide appropriate housing for people at all stages of life and income, align the housing mix with the density targets for activity nodes, transit nodes and activity corridors. It is important to monitor the average density of new housing for each housing type yearly to ensure that the overall density targets have been achieved.

3. Residents live within 400 m of six diverse uses and within 800 m of 17 diverse uses. Because of the important role that access to retail food markets plays in creating complete communities and ensuring access to healthy foods, the best practice

literature suggests that residents live within 800 m of a planned or existing retail food market such as a supermarket, grocery store, or produce store.

4. Locate the land set aside for elementary schools within 1500 m of residents to maximize the numbers of students walking; and, locate the land set aside for secondary schools within 3000 m of residents and on local transit routes. Lands declared surplus by the school boards in Halton have public value and consideration should be given to purchasing these lands for public use.

5. Design communities so that residents are within 400 m of an existing or planned transit stop. In addition, when developing new communities adopt a "transit-first" principle.

6. Residents have access to a full range of parks described in the parkland hierarchy. Ideally residents will live within 400 m of a village square/parkette and within 800 m of a neighbourhood park. In addition, locate community parks, town/city wide parks and recreational facilities on local transit routes.

7. Consider "sense of place" when identifying and selecting preferred road alternatives.

8. Incorporate a *walking and cycling review* for pedestrian connectivity and safety at each stage in the planning process, which would include:
    - Residents have access to continuous sidewalks or equivalent provisions for walking along both sides of all streets. New sidewalks in residential areas should be at least 1.5 metres wide. Equivalent provisions for walking include footpaths
    - Commercial areas have continuous sidewalks or equivalent provisions for walking along both sides of all streets. New sidewalks in commercial areas should be at least 4.0 metres wide
    - Design streets on the basis of medium to short block lengths with a recommended maximum block perimeter that does not exceed 250 metres Where block perimeter exceeds 250 metres, a block pedestrian linkage is provided
    - Neighbourhoods have a linked open space system that interconnects allowing pedestrian, bicycle and other recreational activities continuously throughout the community
    - Neighbourhoods built on a cul-de-sac street pattern system are connected to arterial and collector roads by looking for direct pathways that link residents to these areas

9. Incorporate a *walking and cycling review* for cycling connectivity and safety, at each stage in the planning process, which would include:
    - Neighbourhoods and communities accommodate a cycling network that includes bike lanes and off-road cycling or multi-use trails
    - Roads with speeds over 60 km/h have separated lanes that are part of the road, not sidewalk, infrastructure

- Roads with speeds between 50-60 km/h have marked bicycle lanes
- Roads with speeds under 40 km/h are shared
- Priority for cyclists in intersections
- Reduce overly frequent stops or places where reduced cycling speeds are necessary
- Residents have access to trip end facilities such as secure long-term bicycle parking such as lockers, secure short-term bike bicycle parking such as bicycle racks and showers in commercial buildings
- All streets, roadways, and designated bike routes are maintained to be free of deterrents to bicycling (such as potholes, debris, and overgrown landscaping)

10. Incorporate a *walking and cycling review* to consider the appeal of the pedestrian and cycling environment at each stage in the planning process, which would include:
    - Building frontages that positively address the street, with active uses at ground and first floors
    - All ground level non-residential interior spaces that face a public space have transparent glass on the ground level façade
    - Consideration of the length of blank walls (without doors or windows) along sidewalks
    - Commercial buildings designed and built so that each building has a front façade and at least one entrance that faces a publicly accessible area such as a street, square or plaza
    - On street parking provided on selected streets
    - All off-street parking facilities located at the side or rear of buildings, leaving building frontages and streetscapes free of parking facilities
    - Each transit stop with at least one bench and, where appropriate, sufficiently sheltered
    - Sidewalks connect directly to transit shelters
    - Place transit shelters in such a way as to not impede pedestrian traffic
    - Street trees occur between the vehicle travel way and sidewalk
    - Universal design options are addressed

References

Ahlport, K.N., Linnan, L., Vaughn, A., Evenson, K.R., Ward, D.S., (2008). Barriers to and facilitators of walking and bicycling to school: formative results from the non-motorized travel study. *Health Education & Behaviour,* 35(2), 221-244.

American National Recreation and Parks Association (1990). *Open Space Guidelines and Standards*. Prepared by R.A. Lancaster. Accessed on July 29, 2008 from http://www.nrpa.org/content/default.aspx?documentId=3405

Aniello, C., Morgan, K., Busbey, A. & Newland, L., (1995). Mapping micro-urban heat islands using LANDSTAT ™ and a GIS. *Computers and Geosciences,* 21(8), 965-967.

Besser, L. M., & Dannenberg, A. L. (2005). Walking to public transit: Steps to help meet physical activity recommendations. *American Journal of Preventive Medicine, 29*(4), 273-280.

City of Burlington (2008). *City of Burlington Official Plan.* Accessed on July 14, 2008 from http://cms.burlington.ca/Page846.aspx

Government of Canada (Canada), (2002). *Climate Change Plan in Canada.*

Government of Canada (Canada), (2007). *From Impacts to Adaptation: Canada on a Changing Climate 2007*.

California Air Resources Board (CARB) & California Environmental Protection Agency (CalEPA). (1997). *The Land Use –Air Quality Linkage: How land Use and Transportation Affect Air Quality.* 1997 Edition.

Canadian Institute for Health Information (2006). *Ontario Trauma Registry 2005 Injury Hospitalizations Highlights Report.* The Institute, Ottawa.

City of Toronto (2007). *Design Guidelines for 'Greening' Surface Parking Lots (draft).* Accessed on August 13, 2008 from www.toronto.ca/planning/urbdesign/greening_parking_lots.htm

Clifton, K. J. (2004). Mobility strategies and food shopping for low-income families: A case study. *Journal of Planning Education and Research, 23*(4), 402-413.

Cervero, R., & Duncan, M., (2006). Which Reduces Vehicle Travel More: Jobs-Housing Balance or Retail-Housing Mixing? *Journal of the American Planning Association,* 72(4), 475-490.

Cervero et al., (2004). *Transit Oriented Development in the United States: Experiences, Challenges and Prospects.* TCRP Report 102, Transportation Research Board.

Crosignani, P. et al. (2004). Childhood leukemia and road traffic: A population-based case-control study. International Journal of Cancer. Vol. 108:596-599.

Dekoster, J., & Schollaert, U., (1999). *Cycling: the way ahead for towns and cities*. European Communities.

Dill, J., & Carr, T., (2003). Bicycling commuting facilities in major U.S. cities: if you build them, commuters will use them – another look. *TRB Annual Meeting CD-ROM.*

Dumbaugh, E., (2008). Designing Communities to Enhance the Safety and Mobility of Older Adults: A Universal Approach. *Journal of Planning Literature,* 23(1), 17-36.

Environmental Commissioner of Ontario (2008). *Getting to K(NO)W: Annual Report, 2007-2008*. Accessed on November 24, 2008 from http://www.eco.on.ca/eng/index.php/pubs/eco-publications/2007-08-AR.php

ESAC (2001). *Halton Seniors Survey Results: Housing, Transportation and Support Services*. Accessed on December 4, 2008 from http://www.halton.ca/scs/seniors/esac/pdf/research.pdf

ESAC (2007). *Quality of Life for Seniors in Halton*. Accessed on December 4, 2008 from http://www.halton.ca/scs/seniors/ESAC/pdf/ESACQualityLife.pdf

Ewing, R., Bartholomew, K., Winkelman, S., Walters, J., Chen, D., (2008). *Growing Cooler- The Evidence on Urban Development and Climate Change*. Urban Land Institute: Washington, D.C.

Frank, L.D., & Pivo, G., (1995). Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking. *Transportation Research Record 1466*. 44-52.

Frank, L. D., & Engelke, P. O. (2001). The built environment and human activity patterns: Exploring the impacts of urban form on public health. *Journal of Planning Literature, 16*(2), 202-218.

Frank, L. D., & Engelke, P. (2005). Multiple impacts of the built environment on public health: Walkable places and the exposure to air pollution. *International Regional Science Review, 28*(2), 193-216.

Frank, L. D., Engelke, P., & Schmid, T. (2003). *Health and community design: The impacts of the built environment on physical activity.* Island Press.

Frank, L.D., Kavage, S., & Litman, T., (2006). *Promoting public health through Smart Growth. Building healthier communities through transportation and land use policies and practices.* Prepared for SmartGrowthBC.

Frank, L.D., Kerr, J., Chapman, J., Sallis, J., (2007). Urban Form Relationships with walking trip frequency and distance among youth. *Health Promotion,* 21(4).

Federal Highway Administration (FHWA), (1999). *A Comparative Analysis of Bicycle Lanes Versus Wide Curb Lanes: Final Report*. Accessed on August 4, 2008 from www.fhwa.dot.gov/tfhrc/safety/pubs/99034/intro.htm

Friedman, M. S. et al. (2001). "Impact of changes in transportation and commuting behaviours during the 1996 Summer Olympic Games in Atlanta on air quality and childhood asthma", Journal of the American Medical Association. Vol. 285: 897-905.

Garder, P.E., (2004). The impact of speed and other variables on pedestrian safety in Maine. *Accident Analysis & Prevention,* 36, 533-542.

Gerrard, J., Rose, G., Lo, S.K., (2007). Promoting transportation cycling for women: the role of bicycle infrastructure. *Preventive Medicine,* 26, 55-59.

Go for Green/ Environics. (1998). *1998 national survey on active transportation, summary report*. Ottawa, ON.

Halton Region (2006). *Sustainable Halton: Overview*. Accessed on August 5th, 2008 from http://www.halton.ca/ppw/planning/SustainableHalton/default.htm

Halton Region (2006a). *Halton Region Official Plan [2006].* Accessed on July 2, 2008 from http://www.halton.ca/ppw/planning/OP/default.htm

Halton Region (2006b). *A Comprehensive Housing Strategy for Halton Region: 2006-1015+*. Accessed on November 20, 2008 from http://www.halton.ca/SCS/Housing/housingStrategy/pdf/CHSFinal2006.pdf

Halton Region (2007). *Explaining Density*. Prepared by Hemson Consulting Limited. Oakville, ON.

Halton Region (2008). *2007 Annual Housing Report*. Oakville, ON.

Halton Region (2008b). *Regional Road System and Data.* Accessed on September 26, 2008 from http://www.halton.ca/ppw/roads/SystemData/default.htm

Halton Region Health Department (2007). *Air Quality, Human Health & the Built Environment: Protecting Air Quality through the Land Use Planning Process*. Oakville, ON.

Handy, S.L., (1996). Understanding the link between urban form and nonwork travel behaviour. *Journal of Planning Education and Research,* 15, 183-198.

Handy, S. L., Boarnet, M. G., Ewing, R., & Killingsworth, R. E. (2002). How the built environment affects physical activity: Views from urban planning. *American Journal of Preventive Medicine, 23*(2 Suppl), 64-73.

Hansen, J. et al. (1998). "Increased risk of lung cancer among different types of professional drivers in Denmark", Occupational and Environmental Medicine. Vol. 55: 115-118.

Hess, P.M., & Milroy, B.M., (2006). *Making Toronto's Streets*. Toronto, ON.

Hoek, G. et al. (2002). "Association between mortality and indicators of traffic-related air pollution in the Netherlands: a cohort study". Lancet. Vol. 360: 1203-1209.

Holtzclaw, J., Clear, R., Dittmar, H., Goldstein, D., & Haas, P, (2002). Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles and San Francisco. *Transportation Planning and Technology*, 25(1), 1-27

Humpel, N., Owen, N., & Leslie, E. (2002). Environmental factors associated with adults' participation in physical activity: A review. *American Journal of Preventive Medicine, 22*(3), 188-199.

Institute of Transportation Engineers (2006). *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities: Fact Sheets 1 – 8.* Accessed on September 17, 2008 from http://www.ite.org/css/

International Panel on Climate Change (IPCC), (2002). *Technical Summary, Climate Change 2001: Impacts, Adaptation, and Vulnerability.*

International Panel on Climate Change (IPCC), (2007). *Technical Summary, Climate Change 2007: Impacts, Adaptation, and Vulnerability.*

International Panel on Climate Change (IPCC), (2007): Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contributions of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D., Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and L.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

King County (2005). *LUTAQH. A Study of Land Use, Transportation, Air Quality and Health in King County, WA.* Prepared by Frank, L.D., Sallis, J., Saelens, B., Bachman, D., & Washbrook, K.,

Accessed on June 18, 2008 from
www.metrokc.gov/healthscape/publications/LUTAQH_final_report.pdf

Krewski, D. et al. (2000). *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality*. Health Effects Institute. July 2000.

Krizek, K.J., (2003). Operationalizing Neighbourhood Accessibility for Land Use-Travel Behaviour Research and Regional Modeling. *Journal of Planning Education and Research,* 22, 270-287.

Lee, C., & Moudon, A. V. (2004). Physical activity and environment research in the health field: Implications for urban and transportation planning practice and research. *Journal of Planning Literature, 19*(2), 147-181.

Levine, J., Inam, A., & Torng, G. (2005). A choice-based rationale for land use and transportation alternatives: Evidence from Boston and Atlanta. *Journal of Planning Education and Research, 24*(3), 317-330.

Lin, S. et al. (2002). "Childhood asthma hospitalization and residential exposure to state route traffic", Environmental Research. Vol. 88: 73-81.

Lund, H. (2003). Testing the claims of new urbanism: Local access, pedestrian travel, and neighboring behaviors. *Journal of the American Planning Association, 69*(4), 414-429.

Mcmillan, T. E. (2005). Urban form and a Child's trip to school: The current literature and a framework for future research. *Journal of Planning Literature, 19*(4), 440-456.

Metrolinx (2008). *Green Paper #7: Transit: Development of a Regional Transportation Plan for the Greater Toronto and Hamilton Area.* Accessed on June 18, 2008 from http://metrolinx-consult.limehouse.com/portal/green_papers/reviewgreenpaper7

McCormack, G.R., Giles-Corti, B., Bulsara, M., (2008). The relationship between destination proximity, destination mix, and physical activity behaviours. *Preventive Medicine,* 46, 33-40.

Ministry of Municipal Affairs and Housing (2008). *Planning for Barrier-Free Municipalities.* Accessed on December 19, 2008 from http://www.mah.gov.on.ca/Page1290.aspx

Ministry of Transportation, (2005). *Ontario Road Safety Annual Report 2005.*. Accessed on September 22, 2008 from http://www.mto.gov.on.ca/english/safety/orsar/orsar05/chp1_05.shtml

Moudon, A.,V., Lee, C., Cheadle, A.D., Collier, C.W., Johnson, D., Schmid, T.L., & Weater, R.D., (2005). Cycling and the built environment, a U.S. perspective. *Transportation Research Part D,* 10, 245-261.

Nelson, A.C., & Allen, D., (1997). If you build them, commuters will use them. Association between bicycle facilities and bicycle commuting. *Tranportation Research Record 1578*, 79-83.

Newman, P.W.G., & Kenworthy, J.R., (1989). Gasoline Consumption and Cities. *Journal of the American Planning Association,* 55(1), 24-37.

Ontario Medical Association (OMA). (2005). *The Illness Costs of Air Pollution in Ontario*. June 2005.

OMA (2008). *Local Premature Smog Deaths in Ontario*. Accessed on January 14, 2009 from http://www.oma.org/media/news/pr080606b.asp

Ong, P., & Blumenberg, E., (1998). Job Access, Commute and Travel Burden among Welfare Recipients. *Urban Studies,* 35(1), 77-93.

Ontario Ministry of Municipal Affairs and Housing (2005). *Provincial Policy Statement.* Toronto, ON.

Ontario Ministry of Public Infrastructure Renewal (2006). *Places to Grow. Better Choices. Better Future. Proposed Growth Plan for the Greater Golden Horseshoe.* Toronto, ON.

Parkin, J., Wardman, M., Page, M., (2006). Models of perceived cycling risk and route acceptability. *Accident Analysis and Prevention*, 39, 364-371.

Pollution Probe (Probe) and York Centre for Applied Sustainability (2004). *Moving Together: Towards a Healthier and More Sustainable Future.* (Conference Proceedings) Edited by Michael Keating and Quentin Chiotti, October 2004.

Public Health Agency of Canada. (2003). *Physical activity for health: The evidence.* Accessed on November 16, 2006 from http://www.phac-aspc.gc.ca/pau-uap/fitness/evidence.html

Pucher, J, Buehler, R., (2008). Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany. *Transport Reviews,* 28(4), 495-528.

Pulleyblank-Patrick, S., Raimi, M., Ewing, R., Franck, L. D., Chapman, J., & Kreutzer, R. (2006). *Understanding the relationship between public health and the built environment: A report prepared for the LEED-ND core committee.*

Region of Waterloo Public Health (2005). *Urban Form, Physical Activity and Health* from http://www.region.waterloo.on.ca/web/region.nsf/vwSiteMap/D82004FE6AE3B57585256F48006C2264?OpenDocument

Saelens, B. E., Sallis, J. F., & Frank, L. D. (2003). Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine : A.Publication of the Society of Behavioral Medicine, 25*(2), 80-91.

Sallis, J.F., Cervero, R.B., Ascher, WI, Henderson, K.A., Kraft, M.K., & Kerr, J., (2006). An ecological approach to creating active living communities. *Annual Review of Public Health* 27, 297-322.

Sallis, J.F., Glanz, K. (2006). The Role of Built Environments in Physical Activity, Eating, and Obesity in Childhood. *The Future of Children,* 16(1), 89-108.

Samet, J.M., Dominici, F. et al. (2000). *Fine Particulate Air Pollution and Mortality in 20 U.S. Cities, 1987-1994*, New England Journal of Medicine. Vol 343, No.24, December 2000.

San Francisco Department of Public Health (SFDPH), (2007). *The Healthy Development Measurement Tool: A Health Impact Assessment Method to Support Healthy Cities and Neighbourhoods*. Accessed on March 13, 2007 from www.sfdph.org/phes/enchia

Schlossberg, M., Greene, J., Phillips, P.P., Johnson, B., & Parker, B., (2006). School trips: effects of urban form and distance on travel mode. *Journal of the American Planning Association,* 72(3), 337-346.

Smargiassi, A. et al. (2005). *Traffic Intensity, dwelling value and hospital admissions for respiratory disease among the elderly in Montreal (Canada): a case-control study*. (Pre-published copy).

Statistics Canada. (2006). *2006 Census: Family Portrait.* from http://www12.statcan.ca/english/census06/analysis/famhouse/tables.cfm

Stieb, Dave. (2005). Interview re: AQBAT with Dave Stieb. Epidemiologist, Health Canada. July 27, 2005.

Sustainable Urban Development Association (2008). *Housing Alternatives Acceptability Study (HAAS). Accessed on October 18, 2008 from www.suda.ca*

Svensson, Ä (2005). *Arterial Streets for People: Guidance for Planners and Decision Makers when Reconstructing Arterial Streets*. European Commission Fifth Framework Program.

Toronto City Planning (2007). *Design Guidelines for 'Greening' Surface Parking Lots*. Accessed on August 16, 2008 from http://www.toronto.ca/planning/urbdesign/pdf/greening_parking_lots_dg_update_nov07_1-3.pdf

Toronto Public Health (2004). *Air Pollution Burden of Illness in Toronto: 2004 Summary*. Prepared for the Environmental Protection Office by Monica Campbell, David Pengelly and Monica Bienefeld. Toronto: July 2004.

Town of Halton Hills (2008). *Town of Halton Hills Official Plan (Consolidated May 2008).* Accessed on July 16, 2008 from http://www.haltonhills.ca/planning/pdf/official-plan/Official-Plan-Halton-Hills-2008-05.pdf

Town of Milton (2001). *Town of Milton Official Plan (Consolidated January 2001)*. Accessed on July 15, 2008 from http://www.milton.ca/plandev/officialplan.pdf

Town of Oakville (2006). *Town of Oakville Official Plan 2006 Consolidation*. Accessed on July 15, 2008 from http://www.oakville.ca/Media_Files/Offical_Plan_2006_consolidation.pdf

U.S. Green Building Council (2007). *LEED for Neighbourhood Development.* Accessed on May 12, 2008 from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=148

Urban Land Institute (2005). *Higher Density Development: Myth and Fact*. Accessed on August 6, 2008 from www.uli.org/Content/ContentGroups/PolicyPapers/MF**Higher**010.pdf

U.S. Environmental Protection Agency (US EPA). (2004). *Air Quality Criteria for Particulate Matter.* October 2004.

Van Vliet et al. (1997). *Motor Vehicles Exhaust and Chronic Respiratory Symptoms in Children Living Near Freeways.* Environmental Research. Vol.74(2), p.122-132.

World Health Organization (WHO) Europe. (2004). *Health Aspects of Air Pollution (2004).* Results from the WHO project 'Systematic Review of Health Aspects of Air Pollution in Europe'.

For more information, contact

Halton Region

Dial 311 or 905-825-6000

Toll free 1-866-4HALTON (1-866-442-5866)

TTY 905-827-9833

www.halton.ca

HE-09026

Protecting Health: Air Quality and Land Use Compatibility

Dr. Bob Nosal
Medical Officer of Health
Halton Region Health Department

February 2009

Reference:
Halton Region Health Department, *Protecting Health: Air Quality and Land Use Compatibility*. Oakville, Ontario: 2009

Authors:
Peter Steer, Environmental Health Senior Policy Analyst, Health Department
Kim Perrotta, Senior Health and Environment Advisor, Health Department

Reviewers:
This report has benefited greatly by the expertise, policy direction and editorial advice offered by the following reviewers in Halton Region Health Department:

- Gena Ali, Environmental Health Senior Policy Analyst
- Dr. Monir Taha, Associate Medical Officer of Health
- Dr. Bob Nosal, Medical Officer of Health
- Pat Hewitt, Manager, Public Health Administration

Table of Contents

Executive Summary

This discussion paper is intended to provide suggested directions for consideration (and possible inclusion) in the Sustainable Halton and Halton Region Official Plan Review processes. It is recognized that future public and agency consultation on this paper will take place through these processes and that some of the suggested directions fall under local municipal purview.

Introduction

There is a significant burden of illness associated with poor air quality that is commonly experienced in southern Ontario. The Ontario Medical Association estimates that in 2005 air pollution contributed to approximately 190 premature deaths, 540 hospital admissions, 2,010 emergency room visits, and one million minor illness days in Halton Region.

Air quality can vary significantly across a community and differences in air quality can have a substantial impact on human health. For example, studies conducted along high volume traffic corridors consistently report associations between proximity to traffic and at least one of the following adverse health effects: asthma and other respiratory diseases, diminished lung function, adverse birth outcomes, childhood cancer, and increased mortality risks.

It is also well understood that certain populations of people are more sensitive to the negative health impacts associated with air pollution. While poor air quality can affect all people, it is the young, the elderly, and those with existing health problems who are more likely to become ill, be hospitalized, or to die prematurely in response to poor air quality, rather than healthy adults.

Keeping sensitive populations separated from industrial facilities and high-volume traffic corridors can help reduce the negative health impacts associated with poor air quality.

Approaches to Incompatible Land Use

Many jurisdictions provide guidance on avoiding conflicts between sensitive land uses and various other land uses such as industrial facilities, transportation routes, and agricultural operations. The jurisdictions reviewed are: California (state-, air quality management district-, and city-level); Australia (state-level); England (national- and borough-level); British Columbia (provincial level); and Ontario.

Incompatible land use guidance documents prepared at the national or state/provincial level vary from the general (concepts and principles) to the specific (minimum separation distances) without actually placing legal requirements on local governments. Generic recommended separation distances

are generally consistent across jurisdictions, are not intended to address pre-existing land use conflicts, and are not intended to deal with upset conditions (for example, spills).

Some jurisdictions measure the separation distance from property line to property line while others measure from the sensitive receptor to the activity boundary, which is not necessarily the property boundary.

Most jurisdictions acknowledge that generic separation distances are a starting point only and that the best information on keeping incompatible land uses apart comes from site-specific assessments. In Ontario, the generic separation distance is referred to as the zone of influence, within which air quality impacts are expected to occur. If air studies exist that show trivial impacts, a separation distance less than the zone of influence may be used but only up to a minimum separation distance that is not to be exceeded (dependent upon class of industrial facility).

For the jurisdictions reviewed, guidance on completing site-specific assessments is widely available but some questions arise: Should background air concentrations be included when assessing the impact of a new facility? Should air emissions from other nearby facilities be included in the assessment (i.e., cumulative air emissions)? How big a difference between baseline air quality and post-development air quality is acceptable? If cumulative air impacts from several planned developments are unacceptable, how is it decided which developments are approved and which are not?

Planning and Air Quality in Halton Region

Official Plans for Halton Region and the local municipalities all include policies that refer to provincial land use guidelines. Language in the municipalities' Official Plans reflects the different stages of development and local circumstances. While noise, odour, dust and vibration are addressed in all of them, it is less clear if the requirements apply to gaseous pollutants arising from both point and area sources.

Concerns with the Ministry of the Environment (MOE) Guideline D-6 (*Compatibility Between Industrial Facilities and Sensitive Land Uses*), expressed by local planners, include difficulty meeting requirements for infill, urban redevelopment, and transition-to-mixed-use situations. Current incompatible land use guidelines work better for greenfield development, and municipalities facing build-out will find it challenging to protect sensitive receptors during infill, urban redevelopment or transition to mixed use.

When land use planning conflicts are brought to the Ontario Municipal Board for resolution, inconsistencies of interpretation arise. From a review of some recent decisions of the OMB, it appears that greater consistency in application of land

use guidelines could result if clear and explicit policies were included in Regional and Local Official Plans.

Suggested Directions for Consideration in the Sustainable Halton and Regional Official Plan Review Processes

On the basis of our review of the health literature and best practices, the Halton Region Health Department recommends that the following parameters be considered during the Sustainable Halton and Regional Official Plan Review processes, in order to protect human health, particularly sensitive receptors, from incompatible land uses:

 # 1

Recognizing maturing urban areas, particularly zones of transition and intensification, and Section 38 of the Halton Region Official Plan, Halton Region encourage the MOE to update Guidelines D-1 and D-6 to reflect the changing nature of municipalities and the requirements of the *Places to Grow Plan*. The update should include the additional experience of environmental officers and public health inspectors gained since 1995, applicable research on separation distances for incompatible land uses, more specific industrial activity classification criteria, and a clear definition of sensitive land use.

 # 2a

Halton Region develop a made-in-Halton Incompatible Land Use Guideline (as part of the Healthy Communities Guidelines) that will:

- be developed by the Health Department, in consultation with Regional and Local partners;
- be largely based on the Ministry of the Environment D-Series Guidelines;
- be supplemented with best practices from other jurisdictions, and health research on incompatible land uses;
- incorporate the Minimum Distance Separation (MDS) Formulae for agriculture;
- address both greenfields development and infill, urban re-development, and areas of transition to mixed uses;
- identify when an air study will be requested, the parameters to be included in an air study, and how the results of such a study would be interpreted;
- be updated periodically to reflect advances in understanding of human health impacts related to land uses.

 # 2b Update policies in Halton Region's current Official Plan to explicitly reference the MOE Guidelines D-1 and D-6 to be used until such time as a made-in-Halton Incompatible Land Use Guideline is developed, and to explicitly reference that MOE Guideline D-6 be used to keep rail yards and

sensitive land uses separated until such time as a made-in-Halton Incompatible Land Use guideline is available.

 # 3

Sensitive land uses not be located closer than 150 m to highways anticipated to have greater than 100,000 vehicles per day based on ultimate planned capacity. When applying this guidance, future road widening should be taken into consideration.

 # 4

Sensitive land uses not be located closer than 30 m to roads with greater than 30,000 vehicles/day annual average daily traffic (AADT) based on ultimate planned capacity. Exceptions to this guidance are condominiums and mixed-use buildings, which could locate closer than 30 m provided appropriate controls are incorporated into the building design to protect indoor air quality for the occupants. When applying this guidance, future road widening should be taken into consideration.

 # 5

Air studies for quarry applications should include:

- a modelled frequency and duration analysis, which includes $PM_{2.5}$ (to understand how frequently and how long air levels can be expected to approach the maximum air levels); and
- background air concentrations of $PM_{2.5}$ in the modelling analysis (to enable the assessment of additional emissions from the quarry and a comparison to the Canada Wide Standard which is an ambient air standard)

 # 6

For non-livestock operations, where the MDS Formulae do not apply, MOE Guideline D-6 should be used to protect agricultural operations from encroachment by sensitive land uses until such time as a made-in-Halton Incompatible Land Use Guideline is available.

 # 7

The Halton Region Official Plan should require site-specific air studies when proposed new development would potentially result in separation distances (between industrial facilities and sensitive land uses) that are less than those recommended in MOE Guideline D-6 until such time as a made-in-Halton Incompatible Land Use Guideline is available.

Glossary of Terms

Organizations and Agencies

CARB	California Air Resources Board
MMAH	Ministry of Municipal Affairs and Housing
MNR	Ministry of Natural Resources
MOE	Ministry of the Environment
MPIR	Ministry of Public Infrastructure and Renewal
OMA	Ontario Medical Association
OMB	Ontario Municipal Board
SCAQMD	South Coast Air Quality Management District (California)
SMAQMD	Sacramento Metropolitan Air Quality Management District (California)

Other Terms and Acronyms

AADT	Annual Average Daily Traffic
Area source	sources that release pollutants to the air other than from stacks or vents; these are typically, though not always, small releases from evaporative processes, leaks in plant equipment such as valves, pump seals, flanges, or sampling connections
BATEA	Best Available Technology Economically Achievable
HAP	hazardous air pollutant
HRA	Health Risk Assessment
Line source	air pollution emitted from a linear “source” or geometry, for example, a roadway
MDS	Minimum Distance Separation
OP	Official Plan
Point source	a single, identifiable source of air pollutant emissions (for example, from a stack) which may be either elevated or at ground-level
PM_{10}	particulate matter smaller than 10 microns (inhalable particulate—coarse particles which usually do not travel further than the upper airways)
$PM_{2.5}$	particulate matter smaller than 2.5 microns (respirable particulate—fine particles which can travel deep into the lungs)
PPS	Provincial Policy Statement (Ontario)
PPS23	Planning Policy Statement 23: Planning and Pollution Control (UK)
Relative risk	the risk of developing a disease relative to exposure: relative risk is the ratio of the probability of the event occurring in the exposed group versus a non-exposed group
Veh/d	vehicles per day

1. Introduction

This discussion paper is intended to provide suggested directions for consideration (and possible inclusion) in the Sustainable Halton and Halton Region Official Plan Review processes. It is recognized that future public and agency consultation on this paper will take place through these processes and that some of the suggested directions fall under local municipal purview. This paper builds on earlier reports prepared by Halton Region Health Department including the policy paper, *Air Quality, Human Health & the Built Environment: Protecting Air Quality Through the Land Use Planning Process* (February 2007) and Council Reports MO-35-07 re: "Health Department's Proposed Air Quality Program" and MO-04-08 re: "Air Quality Program – Update".

This paper focuses on the policies and practices needed to protect Halton residents from localized air pollution that can be associated with certain types of activities or land uses. Halton Region is facing considerable growth over the next couple of decades—growth that will be accommodated through intensification of the existing built up area and focused in urban growth centres, intensification corridors, major transit station areas, and brownfields and greyfields (Ontario Ministry of Public Infrastructure and Renewal, 2006). Across Halton Region, municipalities are in different phases of maturity, approaching build-out in some areas while having greenfields available for development in other areas. This diversity will create different pressures across the Region and pose challenges for managing growth while protecting human health.

1.1 Halton Region Context

Local governments play a critical role in air quality management through transportation and land use planning; bylaws; public education to promote awareness and behaviour change; and corporate emission reduction measures (Institute for Risk Research, 2007).

In 2007, the Halton Region Health Department produced a policy paper, *Air Quality, Human Health, and the Built Environment: Protecting Air Quality Through the Land Use Planning Process*, which identified actions that could be taken by the Health Department to address air quality issues associated with land use planning and development processes. Subsequent reports outlined the Health Department's program for addressing air quality issues associated with the land use planning processes in Halton Region. The program was endorsed by Council in 2007 when it approved Report MO-35-07 entitled *Health Department's Proposed Air Quality Program* and was reaffirmed in 2008 when Council approved Report MO-04-08 entitled *Air Quality Program – Update*.

Report MO-04-08 identified the need to develop a discussion paper to inform guidelines and/or policies to protect the public's health from poor air quality that can result when sensitive land uses and emission sources encroach on one another.

The objective of this discussion paper is to review how leading jurisdictions address incompatible land use problems arising from growth and development. The jurisdictions reviewed are: California (state-, air quality management district-, and city-level); Australia (state-level); England (national- and borough-level); British Columbia (provincial level); and Ontario. In Ontario, the Ministry of Natural Resources (MNR), the Ministry of Agriculture, Food and Rural Affairs (OMAFRA), and the Ministry of the Environment (MOE) all provide land use compatibility guidance which is reviewed with two exceptions. The discussion of the MOE's D-Series Guidelines is restricted to D-1 *Land Use Compatibility* and D-6 *Compatibility Between Industrial Facilities and Sensitive Land Uses*. The D-Series Guidelines also include D-2 *Compatibility Between Sewage Treatment and Sensitive Land Use* and D-4 *Land Use On or Near Landfills and Dumps*, which are not reviewed at this time.

The review does not address existing incompatible land uses, rather it focuses on how to prevent or minimize future, localized, air quality problems (noise, odour, dust, and gaseous pollutants) caused by the encroachment of sensitive land uses and emission sources on one another.

This discussion paper addresses the following actions in the 2007-2010 Strategic Plan:

> 2007: "Define, in conjunction with the development of Healthy Communities principles, a framework of policies leading to improved air quality, to be implemented through the Sustainable Halton Plan and the resulting Official Plan." (Theme 2, Goal 1, Action a)
>
> 2008: "Investigate policy tools with other partners that support the development of complete communities." (Theme 1, Goal 1, Action 1e)
>
> 2009: "Update Healthy Community policies in the Official Plan, specifically…Air Quality Guidelines – Land Use Compatibility." (Theme 1, Goal 1, Action 1g)

1.2 Incompatible Land Use, Air Quality, and Human Health

Definitions

Much has been written about incompatible land uses from planning, environmental, and human health protection perspectives, yet it is difficult to find a specific definition of incompatible, or compatible, land use. Historically, zoning has sought to prevent one landowner from harming his or her neighbour by engaging in an incompatible use (Purdue University, 2002), yet the original intent of zoning has now been far exceeded and a rigid separation of land uses makes it difficult to meet demands for more compact, walkable neighbourhoods (National Association of Local Boards of Health, 2006). For this discussion paper, incompatible/compatible land uses will refer to the relationships that exist between one land use and another, usually adjacent, land use with a focus on air quality problems.

Likewise, it is difficult to find a specific definition of sensitive land use. Many jurisdictions refer to sensitive land uses but define them by example using language such as "…may include one or a combination of…" or "…include, but are not limited to…" The jurisdictions examined for this discussion paper do not address the issue of exposure duration and in some instances this may lead to an overly restrictive definition of 'sensitive'. For example, the Ontario Ministry of the Environment Procedure D-1-3 *Land Use Compatibility: Definitions*, includes camping grounds as a sensitive land use. Common to most examples of sensitive land uses are residential uses, hospitals, schools, child care facilities, and nursing homes.

Air Quality and Human Health

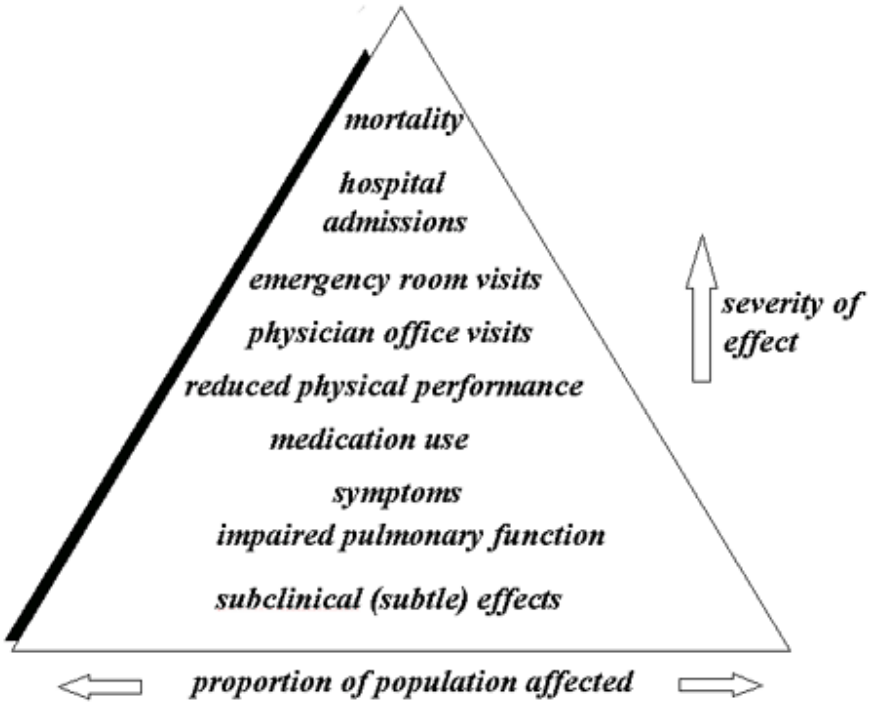
Smog and other air pollutants are caused by the burning of fossil fuels to drive our cars and trucks, and heat and cool our homes, offices, and commercial buildings. Industrial and manufacturing activities also emit smog-forming pollutants. As well, hundreds of other air pollutants, known as air toxics or hazardous air pollutants, can impact human health in some circumstances. Hazardous air pollutants can be emitted from a broad range of activities including mining, smelting, manufacturing, electricity generation, waste disposal, vehicles, and wood burning (Halton Region, 2007; Pollution Probe, 2002).

Human health impacts from air pollution are well documented and include effects related to short-term and long-term exposures. Effects related to short-term exposures include increases in non-traumatic deaths and hospital admissions for respiratory and cardiovascular conditions, increases in asthma symptoms and respiratory infections, and reductions in lung capacity. Long-term exposures are associated with reductions in

lung function in children and adults, reductions in life expectancy, increases in chronic heart diseases, and increases in respiratory diseases including asthma and chronic obstructive pulmonary disease and lung cancer (Institute for Risk Research, 2007; Boothe and Shendell, 2008; Gauderman et al., 2005).

These adverse health effects have been depicted as a pyramid (Figure 1) showing a smaller proportion of the population affected by more serious health outcomes (the top of the pyramid) and a larger proportion of the population (the bottom of the pyramid) impacted by subtler health conditions.

Figure 1. Pyramid of Health Effects from Air Pollution (From: http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/effe/health_effects-effets_sante-eng.php#4, accessed December 3, 2008).



It is also well understood that certain populations of people are more sensitive to the negative health impacts associated with air pollution. While poor air quality can affect all people, it is the young, the elderly, and those with existing health problems who are more likely to become ill, be hospitalized, or to die prematurely in response to poor air quality, rather than healthy adults (World Health Organization, 2004).

Air Pollution's Impacts in Ontario and Halton Region

For 2005, the Ontario Medical Association (OMA) estimates that the five common air pollutants (ground-level ozone, fine particulate matter, sulphur dioxide, nitrogen dioxide, and carbon monoxide) contributed to about 5,800 premature deaths, almost 17,000 hospital admissions, 60,000 emergency room visits and 29 million minor illness days in Ontario. These health impacts cost Ontario almost $8 billion (Ontario Medical Association, 2005a).

The OMA estimates that in 2005 air pollution contributed to approximately 190 premature deaths, 540 hospital admissions, 2,010 emergency room visits, and one million minor illness days in Halton Region. It is estimated that these health impacts resulted in almost $17 million in health care costs and almost $13 million in lost productivity costs (Ontario Medical Association, 2005b).

Incompatible Land Use and Air Quality

Air quality problems in southern Ontario are not only due to poor regional air quality but also to the impacts from localized pollutant emissions from point, area, and line sources (e.g., industrial facilities, quarries, traffic corridors). A growing body of research has demonstrated that air quality can vary significantly across a community and that differences in air quality can have a substantial impact on human health.

Point and Area Sources

The Ministry of the Environment has responsibility for regulating emissions associated with industrial facilities. Facilities with stacks that release emissions above ground level are generally referred to as point sources of emissions, while those that emit air pollutants at ground level are usually referred to as area sources. Many industrial facilities include both types of emissions. In both types of situations, the highest concentration of air pollutants will be in the area immediately surrounding the facility.

For example, Figures 2 and 3 show, respectively, modelled concentrations of nitrogen oxide from a wastewater treatment plant with incineration (a point source with emissions from a stack) and fine particulate matter from a quarry (an area source with ground level emissions). Both examples show higher air levels closest to the source and concentrations declining with distance away from the source.

Figure 2. An Example of Scenario-Specific Modeled Nitrogen Oxide Concentrations Near a Wastewater Treatment Plant (Toronto Public Health, 2005).

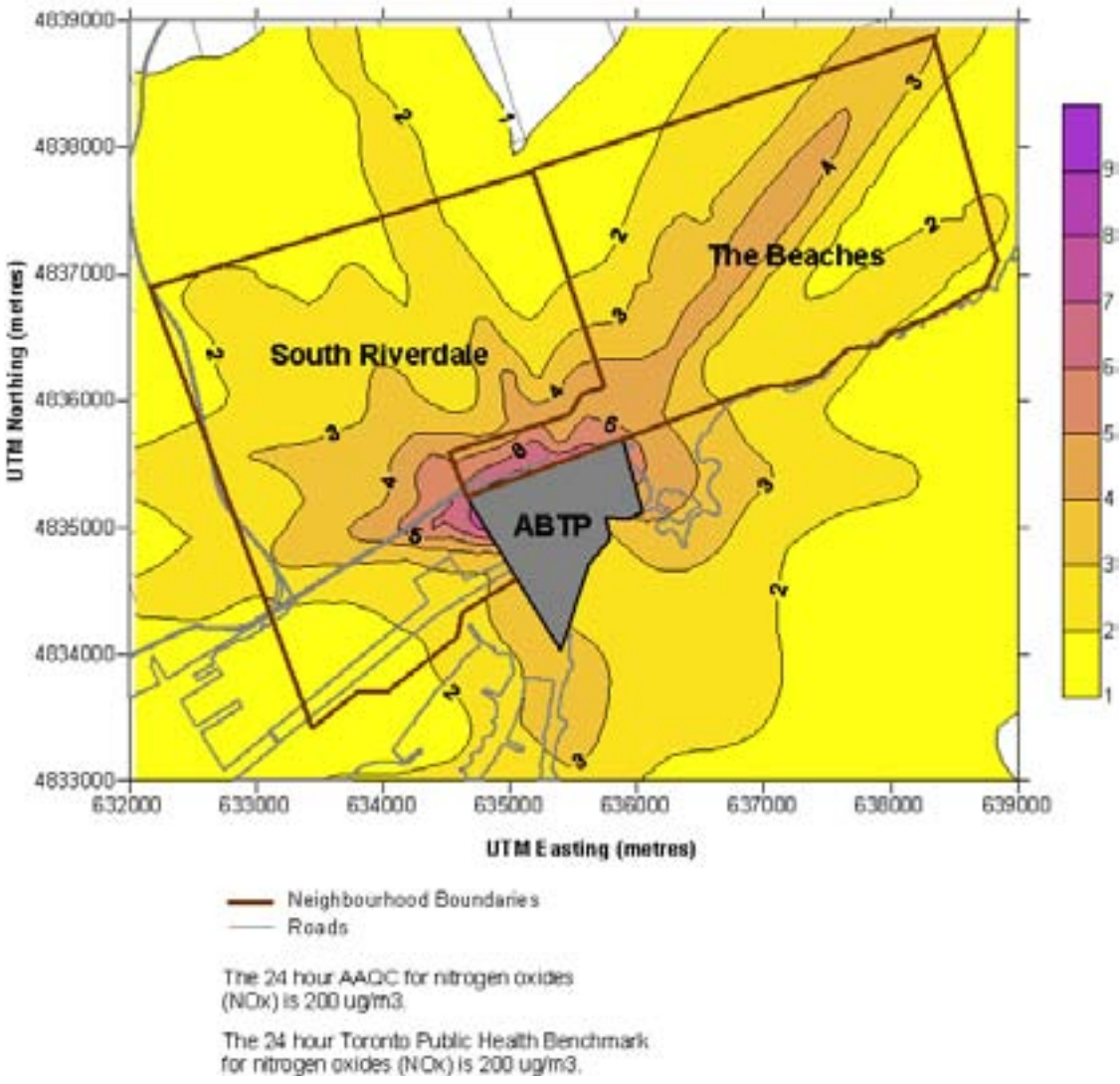
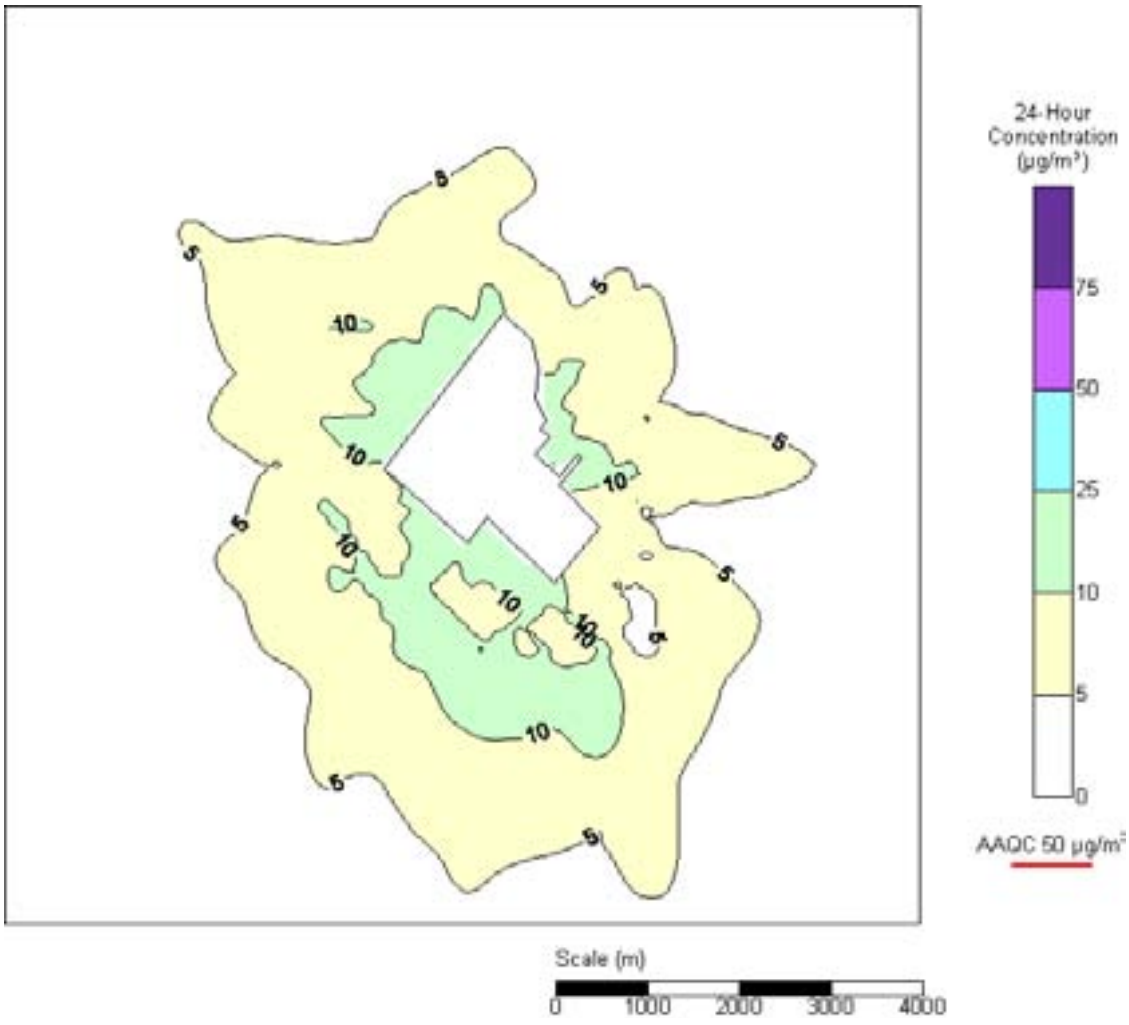


Figure 3. Predicted Maximum 24 Hr PM_{10} Concentration for a Proposed Future Quarry Expansion (Golder Associates, 2004).



Line Sources

Line sources are linear features associated with air pollution. Probably the best example is roadways and, over the last couple of decades, numerous health studies have been directed at traffic corridors. These studies, discussed in more detail later in this report, consistently report associations between proximity to traffic and at least one of the following negative health effects: asthma and other respiratory diseases, diminished lung function, adverse birth outcomes, childhood cancer, and increased mortality risks (Boothe and Shendell, 2008).

These findings are also supported by air studies showing that vehicle-related pollutants can be concentrated along traffic corridors. For example, Figures 4 and 5 below show, respectively, modelled particulate concentrations along a road where trucks queue near a border crossing (higher concentrations in the left of figure, declining in the downwind direction towards the right of the figure), and the influence of a highway (across the top of the figure) and a secondary road (down the middle of the figure) on modelled $PM_{2.5}$ (warmer colours indicate higher concentrations).

Figure 4. An Example of Modeled Particulate Concentrations Along a Road With Truck Queuing (Ontario Ministry of the Environment, 2005).

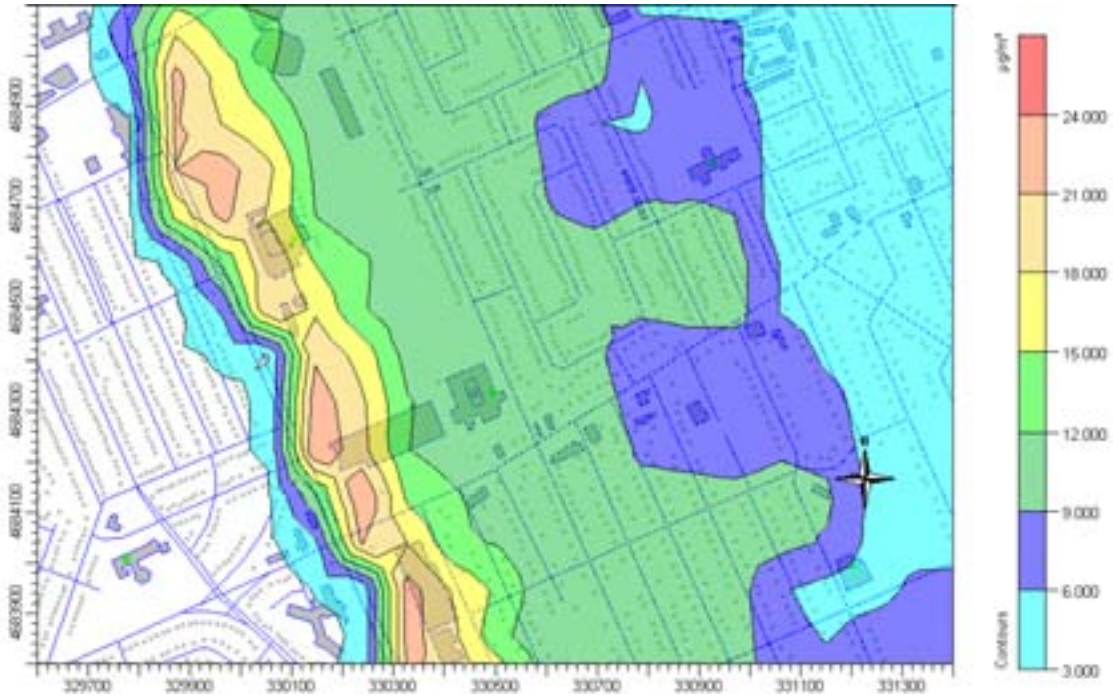
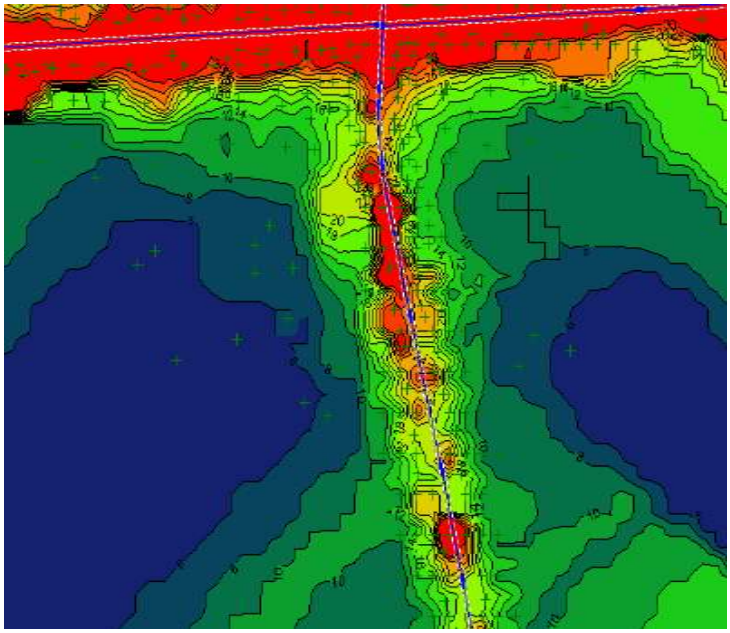


Figure 5. An Example of Modeled $PM_{2.5}$ Concentrations Showing the Influence of a Highway and a Secondary Road (University of Waterloo, undated).



Limitations of Air Standards and Permitting Programs

While pollution control regulations and programs are developed to control emissions and limit ground-level concentrations, most suffer from several shortcomings. For example, it is only recently (at least in Ontario) that air standards have been set based solely on health endpoints (O.Reg. 419). In the past, air standards reflected socio-economic and technical considerations as well as health effects, and for some pollutants, such as nitrogen oxides and fine particulate matter, this is still the practice. In these instances, permitting programs that are based on these air standards do not ensure protection for human health, particularly for the more sensitive members of the population.

In Ontario, the Ministry of the Environment has responsibility for permitting industrial facilities and issues Certificates of Approval based on the emissions from a single facility and, sometimes, on a single source within a facility. This approach does not take into consideration background concentrations (air pollution due to emission sources beyond a community's border) or cumulative impacts (air pollution from other sources from the same facility or from other, nearby, facilities). Consequently, while the Certificate of Approval process ensures that individual point or area sources do not exceed air standards, it does not ensure that air levels within a community stay below air standards.

Finally, air permitting programs are based on the assumption that operating procedures and controls adequately protect against upset conditions; they do not necessarily consider fugitive emissions from doors, diesel exhaust from trucks, or exposures that can occur in the event of the failure of an engineering control system. These shortcomings in regulatory control have been mitigated to some extent by recommending separation distances to keep industrial facilities and sensitive land uses apart.

Growth in Halton Region

In Halton Region, emissions of air pollutants are likely to increase as the Region's population is forecast to grow by 340,000 (from about 440,000 in 2006 to 780,000 by 2031) while employment is projected to grow by 140,000 (from about 250,000 in 2006 to 390,000 by 2031) (Ontario Ministry of Public Infrastructure and Renewal, 2006).

As this growth occurs, the age structure of the Region will also change. The percentage of those under 19 is projected to decline slightly while the percentage of those over 65 is projected to increase substantially. By 2031, it is estimated that there will be about 180,000 residents in Halton under the age of 19 (up from about 122,000 in 2006) and about 131,000 over the age of 65 (up from about 54,000 in 2006) (Hemson Consulting Ltd., 2007). This means that there will be a greater number of people in Halton Region who will be vulnerable to the negative health impacts associated with poor air quality.

One way to minimize the negative health impacts associated with poor air quality is to keep industrial facilities from encroaching on sensitive land uses, and vice versa.

1.3 Structure of Discussion Paper

Section 2 of this discussion paper provides an overview of how other jurisdictions approach the incompatible land use issue. Section 3 provides an overview of existing provincial guidelines addressing incompatible land uses. Section 4 looks at planning and air quality governance—how the province, the region and the local municipalities interact during development planning—and summarizes how incompatible land use guidelines are used both at the provincial and municipal levels. Section 5 explores some of the incompatible land use issues that need to be resolved and suggests recommendations for consultation.

2. Approaches to Incompatible Land Use in Other Jurisdictions

Many jurisdictions provide guidance on avoiding conflicts between sensitive land uses and various other land uses such as industrial facilities, transportation routes, and agricultural operations. The summary that follows is intended to be illustrative rather than comprehensive.

2.1 California

State-level

In 2005, the California Air Resources Board (CARB) released the *Air Quality and Land Use Handbook: A Community Health Perspective* (California Environmental Protection Agency, 2005). The guidance document is neither regulatory nor binding on local agencies but, rather, is intended to "…highlight the potential health impacts associated with proximity to air pollution sources so planners explicitly consider this issue in planning processes."

Sensitive land uses include schools and schoolyards, parks and playgrounds, daycare centres, nursing homes, hospitals and residential communities. The guidance document relies on relevant research to recommend minimum separation distances between new sensitive land uses and eight specific source categories of air pollution. The source types, recommended separation distances and the rationale for the distance recommendation are summarized in Table 1, below.

Table 1. California's Recommended Separation Distances Between Sensitive Land Uses and Eight Source Categories of Air Pollution.

Source	Separation Distance	Rationale
High traffic freeways and roads	500 feet (~150 m) for freeways, urban roads with 100,000 vehicles/day, or rural roads with 50,000 vehicles/day	Traffic studies show health risk within 1,000 feet and strongest at 300 feet. CA freeway studies show 70% drop in particulate levels at 500 feet.
Distribution centres	1,000 feet (~300 m) for more than 100 trucks/day, more than 40 trucks/day with operating transport refrigeration units (TRU) or where TRUs exceed 300 hrs/wk	Emissions and modelling analyses suggest 80% drop in pollutant concentrations at 1,000 feet.
Rail yards	1,000 feet (~300 m) for major service and maintenance rail yard; within 1 mile (~1,600 m) consider siting limitations and	Roseville Rail Yard Study showed highest impact within 1,000 feet associated with service and maintenance

	mitigation	activities. Next highest impact between half and one mile of yard dependent on wind direction and speed.
Ports	Avoid sensitive land uses immediately downwind and consult local air districts	Studies underway. Advisory is based on health impact of diesel particulate emissions.
Refineries	Avoid sensitive land uses immediately downwind and consult local air districts	Risk assessments from CA refineries show air toxics risks under 10 chances of cancer per million. Advisory based on known emissions from refineries particularly during non-routine releases.
Chrome plating facilities	1,000 feet (~300 m)	Studies show localized risk from hexavalent chromium diminishing significantly at 300 feet. Due to data limitations and the potency of hexavalent chromium, 1,000 feet is recommended as a precautionary measure.
Dry cleaners (using perchloroethylene)	300 feet (~90 m); 500 feet (~150 m) if two or more machines; Consult local air district for three or more machines; Do not site sensitive land uses in the same building as perc dry cleaning facilities	Studies show individual cancer risk reduced by up to 75% with a 300 foot separation distance from a one-machine operation. For two or more machines, 500 feet can reduce risk by over 85%.
Large gas dispensing facilities	50 feet (~15 m) for typical facility; 300 feet (~90 m) for facilities with greater than 3.6 million gallons/yr (~13.6 million litres/yr)	Based on Gasoline Service Station Industry-wide Risk Assessment Guidelines. Large facilities under rural air dispersion conditions can pose a larger risk at a greater distance.

The recommended separation distances are based on ranges of relative cancer risk—an estimate of the increased chances of getting cancer due to facility emissions over a 70-year lifetime. The relative cancer risks estimated by CARB do not take into account the regional cancer risk from air pollution (i.e., background), which in the South Coast Air Basin (Los Angeles area) is 1,000 in one million.

Minimum separation distances are problematic in cases where there is an elevated health risk over a large geographical area, for example, downwind of ports and rail yards. In these cases, CARB recommends avoiding locating sensitive land uses within the highest risk zones.

The guidance also acknowledges that local agencies must balance considerations beyond air quality, such as housing and transportation needs, economic development priorities, and other quality of life issues.

Air Quality Management Districts

There are a number of air quality management districts in California and these provide guidance to cities and counties within their jurisdiction. Guidance documents vary from the general (concepts and principles) to the specific (minimum separation distances). Local agencies may codify minimum separation distances in regulations.

For example, the Sacramento Metropolitan Air Quality Management District released, in 2004, the *Guide to Air Quality Assessment in Sacramento County*. The guide (Sacramento Metropolitan Air Quality Management District, 2004) explicitly acknowledges the linkage between land use and air quality, and land use conflicts and exposure of sensitive receptors. However, the guidance does not specify mitigation requirements, such as minimum separation distances, but instead states that early consultation between project proponents and Lead Agency staff can "avoid or minimize localized impacts to sensitive receptors."

Three years later, in 2007, that same agency released *Recommended Protocol for Evaluating the Location of Sensitive Land Uses Adjacent to Major Roadways*. In contrast to the agency's earlier guide, this protocol (Sacramento Metropolitan Air Quality Management District, 2007) provides a detailed process to evaluate the potential cancer risk posed by a project to determine if a site specific health risk assessment (HRA) is warranted. If a site specific HRA is indicated, the protocol provides guidance on how it should be performed.

The South Coast Air Quality Management District (SCAQMD) takes yet another approach. In *Guidance Document for Addressing Air Quality Issues in General Plans and Local Planning*, the SCAQMD provides some detail regarding air quality and land use, referring extensively to the CARB Air Quality and Land Use Handbook, particularly for the influence of major roadways on air quality (South Coast Air Quality Management District, 2005). However, no specific recommendations are made and the guidance provided is more good planning principles and accepted methods for reducing emissions of criteria and toxic air contaminants. The document takes pains to point out that air quality management districts can do no more: "Local governments have the flexibility to address air quality issues through ordinances, local circulation systems, transportation services, and land use. No other level of government has that authority, including the AQMD."

Absent legal authority, it is not surprising that advice from the state and air quality management districts in California ranges from the broad and generic to the specific and detailed without actually placing requirements on local governments.

Local Government

An example of a local government that has codified separation distances in regulation is the city of Alameda, California. The Municipal Code provides general guidance regarding compatible land use and allows for the issuance of Use Permits with conditions that may require, for example, open spaces, buffer strips, walls, fences and landscaping, or limits on hours of operation or time of day for the conduct of some activities. The Code is more specific for hazardous materials processing uses, requiring a buffer zone of at least 2,000 feet between the operational area of a facility and the nearest residence and a buffer zone of at least 5,000 feet between a facility and any immobile population. Immobile populations include "schools, hospitals, convalescent homes, prisons, facilities for the mentally ill, day care centers, homeless shelters, and other similar uses." These minimum distance requirements may be relaxed if the developer can demonstrate, by risk assessment, that a smaller buffer zone provides adequate protection in the event of an accident (City of Alameda, 2007).

2.2 British Columbia

In 2006, British Columbia's Ministry of the Environment released *Develop With Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia* (British Columbia Ministry of the Environment, 2006). The document is intended to provide province-wide guidelines for maintaining environmental values during the development of:

- urban and rural lands;
- greenfields (land not previously built upon); and
- brownfields and greyfields (land that has been previously developed).

The guidelines do not apply to developments related to forestry, mining, or commercial agriculture within the Agricultural Land Reserve. Separate sections provide guidance for Community Planning; Site Development and Management; and Environmentally Valuable Resources.

The Community Planning section provides high-level guidance on good planning principles including the use of buffers to separate incompatible land uses. The only specific recommendations for separating sensitive land uses are provided in Section 2.7 *Guidelines for Air Quality and Climate Change* and refer to major transportation routes. The guidance suggests "…a minimum 150 m setback from busy roads for buildings such as schools, hospitals, long-term care facilities, and residences." A busy road is defined as a road with more than 15,000 vehicles/day. The guidance also recommends additional setbacks for buildings along major

truck routes. Neither “additional setback” nor “major truck routes” are defined.

The sections on Site Development and Management and Environmentally Valuable Resources also advocate the use of buffers, but it is only for environmentally valuable resources that specific separation distances are recommended. Environmentally valuable resources include “…all features, sites, and species whose presence enhances the natural biodiversity of the area…” and tables of recommended separation distances are provided for Biodiversity Conservation, Riparian Areas, and Songbirds. For some species, a breeding season ‘quiet’ buffer is added to the separation distance: for example, the target buffer distance for Great Blue Heron nests is 300 m in undeveloped areas, 200 m in rural areas, and 60 m in urban areas. An additional 200 m is required during the breeding season.

2.3 England

National Guidance

In England, the government initiated planning system reform in 2002 and subsequently issued a number of planning policy statements to provide guidance to Local Authorities. Land use planning and environmental quality are addressed in *Planning Policy Statement 23: Planning and Pollution Control* (PPS23) and an annex to PPS23 – *Annex 1: Pollution Control, Air and Water Quality* (Annex 1).

PPS23 advises that “any consideration of the quality of land, air or water and potential impacts arising from development, possibly leading to impacts on health, is capable of being a material planning consideration, in so far as it arises or may arise from or may affect any land use” (Office of the Deputy Prime Minister, 2004a). The policy statement acknowledges that development can bring environmental benefits from, for example, mixed uses, travel reductions, improvements in transport infrastructure and remediation of past contamination. However, PPS23 advises that development plan documents should consider, among other things:

- the possible impact of potentially polluting development on land use including effects on health, the natural environment or general amenity;
- the need to separate potentially polluting and other land uses in order to reduce conflicts;
- the cumulative impacts on air quality of a number of smaller developments, particularly in areas where air quality is already, or is likely to be, poor.

PPS23’s Annex 1 (Office of the Deputy Prime Minister, 2004b) provides the background on pollution control legislation, its interactions with the

planning system and how these interactions are dealt with in planning. Local Planning Authorities are required to prepare Local Development Documents (LDD) which apply national government policies to local areas. LDDs should include considerations of sensitive land uses—developments such as housing, schools and hospitals in proximity to sources of pollution such as roads and certain industrial processes.

Annex 1 also suggests that planning authorities consult with pollution control agencies when development will be sited within a radius of 500 m of a large industrial installation or 250 m of smaller industrial installations. Consultation is also recommended for specific circumstances, for example, if the development will:

- occur in areas of high background levels of air pollution;
- occur in areas which cater to those more vulnerable to pollution (e.g., the elderly, children or those with respiratory illnesses);
- attract people and traffic on a regular basis (e.g., shopping centres, entertainment complexes, offices).

Neither PPS23 nor Annex 1 provide recommended separation distances to keep sources of pollution away from sensitive land uses and vice versa.

Local Implementation

The Royal Borough of Kensington and Chelsea provides an example of how national guidance is implemented at the local level. National policies are reflected in the Royal Borough's *Unitary Development Plan* (UDP) which is the borough's principal policy document shaping decisions related to land use. To supplement the policies of the UDP, the Royal Borough has produced *Supplementary Planning Guidance-05 Air Quality* (Royal Borough of Kensington and Chelsea, 2003), hereafter referred to as SPG-05. While SPG-05 has several objectives, three are of particular interest:

- to emphasize the importance of air quality as a material planning consideration;
- to identify those circumstances where an air quality assessment would be required to accompany a development proposal; and
- to provide technical guidance relating to the provision of an air quality assessment.

Air Quality Assessments are normally required from developers for applications where the impact on air quality is likely to be significant (Royal Borough of Kensington and Chelsea, 2003). The Association of London Government has published a Technical Guidance Note with the following criteria to help assess significance:

- proposals that will result in an increase in vehicle trip generation in the local area, which result in increases in traffic volumes (Annual

Average Daily Traffic) of five per cent or more on individual road links with more than 10,000 vehicles per day;
- proposals which may result in increased congestion and lower vehicle speeds than are present on the existing local road network;
- proposals which significantly alter the composition of traffic such that adverse air quality impacts may arise;
- proposals for new developments with 300 parking spaces or more or an increase in existing parking provision of 300 spaces or more;
- proposals for coach and lorry parks;
- any development likely to have an adverse impact on air quality, particularly in sensitive areas (for example where predicted air pollution levels already exceed air quality objective levels by 10% or more); or
- proposals that have the potential to result in significant emissions of pollutants from industrial activities.

The Royal Borough will also normally require Air Quality Assessments where a proposal will require an application under the Pollution Prevention and Control regime. (This appears to be similar to Ontario's Certificate of Approval process.) Activities and installations covered include virtually all heavy industry.

Annex 2 in SPG-05 provides technical guidance for undertaking air quality assessments and two of the general principles are noteworthy:
- "An air quality impact assessment should clearly indicate the likely change in pollutant concentrations (relevant to the air quality objectives) arising from the proposed development. The factor of greatest importance will, generally, be the difference in air quality as a result of the proposed development."
- "For all developments, it is vital that air quality assessments take fully into account the cumulative air quality impacts of committed developments (i.e. proposals that have been granted planning permission at the time the assessment is undertaken)…"

While the guidance is helpful in determining when air quality assessments would normally be requested by the local authority and what an air quality assessment should include, it does not explain how an air quality assessment would be used in the planning process. For example, how big a difference between baseline air quality and post-development air quality is acceptable; if cumulative air impacts from several planned developments are unacceptable, how is it decided which developments are approved and which are not? Neither does SPG-05 provide explicit separation distances to keep industrial land uses and sensitive land uses from encroaching on each other.

2.4 Australia

Most states in Australia use separation distances to control potentially incompatible land uses during the development process. Two slightly different approaches from Western Australia and South Australia are compared. For both states, extensive tables of recommended separation distances are available though they are not reproduced here.

Western Australia

The Government of Western Australia has produced a Guidance Statement (Western Australia Environmental Protection Authority, 2005) to assist with implementation of its statutory *State Industrial Buffer Policy*. This policy is intended to provide a consistent Statewide approach to protect industrial and sensitive land uses from encroaching on each other. The Guidance Statement recognizes that "sound site-specific technical analysis is generally found to provide the most appropriate guide to the separation distance that should be maintained between an industry or industrial estate and sensitive land use." However, site-specific studies are not necessary all the time and so generic separation distances are recommended based on experience of the Department of Environment and other regulatory agencies.

The guidance document points out that the recommended separation distances do not take into account:

- cumulative impacts;
- non-typical emissions (e.g., upset conditions);
- the protection of natural resources or significant elements of the natural environment; or
- potential health impacts from emissions.

The recommended separation distances are not intended to be absolute, rather, they provide a starting point for assessing whether site-specific studies are required. There is no mention of existing or required pollution control technology and the distances provided are from property line to property line (i.e., not from sensitive use to industry).

South Australia

In South Australia, the primary role of separation distance guidelines is to serve as an aid to the assessment of development proposals (South Australia Environment Protection Authority, 2007). The guidelines are designed to be:

- simple for all parties;
- transparent;

- quick and cheap (expert air quality or noise advice should not be required);
- more conservative than separation distances predicted by air pollution or noise modelling, for a high percentage of proposals.

Comparison of Western and South Australia

The principle of keeping industrial and sensitive land uses from encroaching upon one another is the same as for Western Australia; however, there are some key differences between Western Australia and South Australia.

First, in South Australia, separation distance is measured from the boundary of the sensitive receptor to the activity boundary which is not necessarily the property boundary. In Western Australia, the measurement is from property line to property line.

Second, the separation distances in South Australia are based on the assumption that pollution control equipment that is the Best Available Technology Economically Achievable (BATEA) is implemented. This can result in shorter separation distances than in Western Australia where there appears to be no such assumption.

Third, in South Australia, factors that account for surface roughness and topography are applied to modify the recommended separation distances. As a result, a separation distance may be more or less than that recommended in the guidance document.

A final difference occurs in the factors considered for the recommended separation distance. In Western Australia any or all of five factors may influence the recommended buffer distance: gaseous, noise, dust, odour, or risk. In South Australia, the recommended distances are based almost entirely on “air” although in a few instances, a distance based on noise is given (and that distance is always higher than an air-based separation distance).

Site-specific Assessments

For some activities, although there may be a recommended separation distance, a site-specific assessment is required if the activity exceeds a certain threshold. For example, in Western Australia for metal smelting, refining, melting, casting, fusing, roasting or processing works of less than 100 tonnes per year, the separation distance is 100-200 metres; for works of between 100 and 1,000 tonnes per year the separation distance is 300-500 metres; and for works over 1,000 tonnes per year, the separation

distance is determined on a case-by-case basis and depends upon the process being used.

Sewage treatment works provide an example from South Australia: separation distances of 100, 200, or 300 metres are recommended for works serving different sized populations up to 15,000 people. For sewage treatment works serving more than 15,000 people, an individual assessment is required.

Examples From Western and South Australia

For some activities that may be relevant to Halton Region, a few Australian examples of recommended separation distances are provided in Table 2, below. The uppercase letter in brackets following the separation distance indicates the factor(s) considered: G – gaseous; N – noise; D – dust; O – odour; R – risk; A – air.

Table 2. Examples of Separation Distances from Two Australian States

Activity	Western Australia	South Australia
Asphalt Preparation	1,000 m (N,D,O)	1,000 m [1] (A)
Chemical Storage – Bulk	500-1,000 m (G,R)	500 m (A)
Electric Power Generation	3,000-5,000 m (G,N,D)	--
Vehicle Production >2,000 units/yr	--	500 m (A)
Galvanizing	500 m (G,N,D,O)	300 m (A)
Crematoria	200-300 m (G,N,R)	150 m (A)

1 Example of applying the surface roughness and terrain factors: if the proposed plant is on a slight slope within a broad valley and has heavy timber between it and the sensitive receptor, applying the surface roughness factor and the terrain factor would yield an upslope separation distance of 770 m and a downslope separation distance of 1,232 m.

3. Ontario's Approach to Land Use Compatibility

The Provincial Policy Statement (PPS) provides high-level guidance to regional and local governments on planning for growth. It states that:

> Healthy, liveable, and safe communities are sustained by…avoiding development and land use patterns which may cause environmental or public health and safety concerns – Policy 1.1.1(c); and
>
> Land use patterns within settlement areas shall be based on densities and a mix of land uses which…minimize negative impacts to air quality and climate change… – Policy 1.1.3.2(a)3 (Ontario Ministry of Municipal Affairs and Housing, 2005)

Section 4.0 of the PPS addresses implementation and interpretation and requires decisions affecting planning matters to be consistent with the Provincial Policy Statement. Furthermore, the policies of the PPS represent minimum standards and planning authorities and decision-makers may go beyond these minimum standards provided there is no conflict with any policy of the PPS (Section 4.6).

In Ontario, land use compatibility guidance is provided by the Ministry of the Environment, the Ministry of Agriculture, Food and Rural Affairs and the Ministry of Natural Resources. It is worth reviewing the Ontario guidance in some detail to inform the discussion on how land use compatibility guidance is used and where there might be room for improvement.

3.1 Ministry of the Environment

In 1995, the Ontario Ministry of the Environment (MOE) released a revised series of guidelines and procedures related to land use compatibility. The two guidelines which are the subject of this discussion paper—Guideline D-1 *Land Use Compatibility* and Guideline D-6 *Compatibility Between Industrial Facilities and Sensitive Land Uses*—were accompanied by a number of Procedures to aid with implementation. The Guidelines, intended to apply only when a change in land use is proposed, recommend separation distances and other control measures to prevent or minimize adverse effects from the encroachment of incompatible land uses.

Both guidelines apply:

- for the formulation and review of land use policies, guidelines or programs;
- for the review of municipal general plans and proposals (e.g., official plans, official plan amendments, secondary plans); and
- for the review of site-specific development plans including redevelopment and infill proposals.

Both guidelines quite clearly state that they are intended to be supplemental to (i.e., do not replace) legislated controls and that “Nothing in th[ese] guideline[s] is intended to alter or modify the definition of ‘adverse effect’ in the *Environmental Protection Act*.” The availability of the guidelines acknowledges that regulatory requirements, such as Certificates of Approval (Air) as required by the Environmental Protection Act, are not necessarily sufficient for the prevention of adverse effects.

3.1.1 Guideline D-1 *Land Use Compatibility*

Scope

The objective of Guideline D-1 is to minimize or prevent the exposure of any person, property, plant or animal life to adverse effects associated with the operation of specified facilities.

Section 2.4 of Guideline D-1 states “Depending upon the particular facility, adverse effects may be related to, but not limited to, one or more of the following:

(a) noise and vibration;
(b) visual impact (only for landfills under O. Regulation 347);
(c) odours and other air emissions;
(d) litter, dust and other particulates; and
(e) other contaminants.”

Section 4.0 of the implementation guidance (Procedure D-1-1 *Implementation*) addresses mitigation and the effectiveness of buffers for separating incompatible land uses. Specifically, the guidance points out that buffers that may work for the control of noise may not be adequate for “dust, odours, or gaseous air contaminants” and that privacy fences or narrow strips of plantings have little or no effect with regard to the reduction of noise or air pollution.

Clearly, Guideline D-1 is intended to apply not only to noise, odours, and dust, but also to air pollutants.

Exemptions and Exclusions

Guideline D-1 is not intended to apply in a number of situations, the first of which being where incompatible land uses already exist and there is no new land use proposal for which approval is being sought.

Second, the Guideline does not normally affect a change in land use, an expansion, or a new development provided the facility or sensitive land use is in compliance with existing zoning and the official plan designation. The Guideline goes on to the state that exceptions to this include plans of subdivision and condominium and/or severance in which case the MOE may require studies and mitigation measures to prevent or minimize adverse effects. This is now out of date since the memorandum of understanding of 1996 (discussed later) relieves provincial review agencies from responsibilities associated with planning applications for subdivisions and condominiums.

Third, emergency situations such as process upsets or spills are not subject to D-1 as they are dealt with through other practices.

Finally, Guideline D-1 does not normally apply to lands owned or purchased by undertakings under federal jurisdiction. So, for example, a residential development encroaching upon federally owned lands would be subject to the MOE Guidelines but activities undertaken on the federally owned lands would not. However, generally, undertakings of the federal government comply not only with federal requirements, but also with provincial and municipal requirements in the jurisdiction of the undertaking.

Examples of Compatibility

Procedure D-1-1 provides a table of simplified examples of "compatibility ratings" for different types of facilities and sensitive land uses. The examples provided are for Class I, Class II, and Class III Industrial Facilities (the subject of Guideline D-6, see below) and the "compatibility ratings" are, respectively, "not recommended", "poor", and "incompatible". This oversimplification raises more questions than it answers since the table does not address separation distances or other control measures to mitigate impacts.

Interestingly, the table also includes transportation corridors and suggests a "compatibility rating" of "possible with conditions". Transportation corridors are not mentioned anywhere else in Guideline D-1 or Guideline D-6. It is unclear if vehicle transportation corridors are included in the definition of *Facilities* which mentions, by example, airports and railways. Both airports and railways fall under federal jurisdiction; however, freeways do not. The only clue that freeways are included as transportation corridors appears in Procedure D-1-2 *Land Use Compatibility: Specific Applications*, which refers the reader to a document by another agency: *Guidelines on Noise and New Residential Development Adjacent to Freeways* (Ministry of Housing, April 1979).

Traffic Corridors

The table in Procedure D-1-1 suggests that transportation corridors are compatible with sensitive land uses "with use of buffers (e.g. noise)." However, the same document acknowledges that what works to control noise may not be adequate for dust, odour or gaseous contaminants.

Since 1995, when the D-Guidelines were last updated, a substantial body of research has developed demonstrating serious health impacts due to air pollution near highways. Depending upon traffic density and distance from roadways, health impacts include cardiovascular disease, asthma,

decreases in pediatric lung function, and cancer (Brugge et al., 2007). Some evidence also exists for adverse birth outcomes, for example preterm birth and low birth weight (Wilhelm and Ritz, 2003; Brauer et al., 2008), although the case for these health effects is less well developed (Brugge et al., 2007). Clearly, a short-coming of the D-Guidelines is their failure to address vehicle traffic corridors and proximity of sensitive land uses.

3.1.2 Guideline D-6 *Compatibility Between Industrial Facilities and Sensitive Land Uses*

Scope

Guideline D-6 is a direct application of Guideline D-1 and specifically addresses potential conflicts between industrial land uses and sensitive land uses. The guideline uses the concept of influence area and is applicable when a new sensitive land use is proposed near an existing facility and/or when a new facility is proposed near an existing sensitive land use.

Potential Area of Influence and Minimum Separation Distance

The potential influence area is the area where adverse effects are generally expected to occur and it is within this area that sensitive and industrial land uses must not encroach. However, if studies exist showing the impact from an industrial facility to be trivial, then sensitive and industrial land uses may be located within a facility's potential area of influence up to, but no closer than, a minimum separation distance. The distance is normally measured from property line to property line although other measurement points are allowed including measurement from the emitting source to the sensitive receptor. This is a reasonable approach for instances where a sensitive land use is adjacent to an industrial land use (the property line to property line distance would be zero) provided there is sufficient space for a separation distance buffer on either or both lots (though, preferably, the emitting source should provide the buffer).

Infill, Urban Re-development and/or Transition to Mixed Use

For areas of infilling, urban re-development, and/or transition to mixed use, the guideline recognizes that the recommended minimum separation distances may not be achievable. In these instances, to assess whether or not to allow a separation distance less than that recommended, the guideline requires the following:

- detailed mapping showing the area subject to the proposed development and all industrial facilities and any other sources of adverse effects;

- mapping of all vacant properties currently zoned and/or designated for industrial use including excerpts from the official plan and/or zoning by-law to indicate the full range of permitted uses;
- assessment of the types and levels of contaminant discharges being generated by current industrial facilities, including those associated with transportation facilities which serve the industries;
- identification of mitigative measures based upon technical assessments;
- an indication of how the mitigative measures will be implemented;
- where mitigative measures will be applied off-site to an existing industrial facility, the proponent must demonstrate the industrial facility has no objection to the proposed use or to the addition of the necessary mitigative measures; and
- proponents should demonstrate to the approving authority that no objections to the proposed use have been raised by area residents, industries, etc.

Application

Section 1.2.2 states "The guideline applies to all types of proposed, committed and/or existing industrial land uses which have the potential to produce point source and/or fugitive air emissions such as noise, vibration, odour, dust and others, either through normal operations, procedures, maintenance or storage activities, and/or from associated traffic/transportation." Point source emissions come from stacks and vents and are relatively easy to measure while fugitive emissions are generally associated with leaks from pipes and valves, doorways, truck bays, etc. and are much more difficult to measure or model and consequently can be grossly underestimated (Chambers, et al., 2008).

Procedure D-6-1 *Appendix A: Industrial Categorization Criteria* also makes it clear that point sources must be considered as well as fugitive emissions and this has been confirmed by the Ministry of the Environment: "…the intent of looking at the air quality issue when assessing industrial/sensitive land use interface is to have ALL sources of air emissions identified, fully described and have appropriate mitigation measures and separation distances suggested." (emphasis in original email from MOE staff to Halton Region staff, dated November 19, 2007).

Exemptions

Guideline D-6 names the following facilities to which the guideline does not apply:

- Sewage treatment facilities
- Waste management facilities that require a Waste Certificate of Approval (from the Ministry of the Environment)

- Agricultural operations
- Airports
- Railways (but it does apply to railway yards and other ancillary rail facilities)
- Pits and quarries (except in the absence of site-specific studies)

Classification of Industrial Facilities and Separation Distances

Industrial facilities to which the guideline does apply are classified, by scale of operation, into three categories. The criteria for categorizing industrial facilities are derived from experience of the Ministry of the Environment and the investigation of complaints related to industrial facilities.

A *Class I Industrial Facility* is a "place of business for a small scale, self contained plant or building which produces/stores a product which is contained in a package and has low probability of fugitive emissions. Outputs are infrequent, and could be point source or fugitive emissions for any of the following: noise, odour, dust and/or vibration. There are daytime operations only, with infrequent movement of products and/or heavy trucks and no outside storage." Examples include beverage bottling, furniture repair and refinishing, auto parts supply, and laundry and linen supply.

For Class I Industrial Facilities, the potential influence area is 70 m and a minimum separation distance of 20 m is recommended.

A *Class II Industrial Facility* is a "place of business for medium scale processing and manufacturing with outdoor storage of wastes or materials (i.e. it has an open process) and/or there are periodic outputs of minor annoyance. There are occasional outputs of either point source or fugitive emissions for any of the following: noise, odour, dust and/or vibration, and low probability of fugitive emissions. Shift operations are permitted and there is frequent movement of products and/or heavy trucks during daytime hours." Examples include magazine printing, paint spray booths, dry cleaning services, and feed packing plants.

For Class II Industrial Facilities, the potential influence area is 300 m and a minimum separation distance of 70 m is recommended.

A *Class III Industrial Facility* is a "place of business for large scale manufacturing or processing, characterized by: large physical size, outside storage of raw and finished products, large production volumes and continuous movement of products and employees during daily shift operations. It has frequent outputs of major annoyance and there is high probability of fugitive emissions." Examples include organic chemicals

manufacturing, breweries, metal manufacturing, and the manufacturing of such things as paints and varnish, resins and coatings, and soaps and detergents.

For Class III Industrial Facilities, the potential influence area is 1,000 m and a minimum separation distance of 300 m is recommended.

Sensitive Land Uses

Both Guideline D-6 and Procedure D-1-3 *Definitions* provide guidance on sensitive land use. Sensitive land uses occur where routine or normal activities, occurring at reasonably expected times, would experience one or more adverse effects from contaminant discharges from a nearby facility.

Residential land use, i.e., “residences or facilities where people sleep”, is considered sensitive 24 hours/day and may include (but is not limited to) single- and multi-unit dwellings, nursing homes, hospitals, trailer parks, and campgrounds.

Also considered potentially sensitive, but not for 24 hours/day, are facilities such as schools, churches, community centres, day care centres, some outdoor recreational facilities (e.g., picnic areas), and some agricultural operations.

Section 6.0 of the PPS defines sensitive land uses as “…buildings, amenity areas, or outdoor spaces where routine or normal activities occurring at reasonably expected times would experience one or more adverse effects from contaminant discharges generated by a nearby major facility. Sensitive land uses may be a part of the natural or built environment. Examples may include, but are not limited to: residences, day care centres, and educational and health facilities.” (Ontario Ministry of Municipal Affairs and Housing, 2005, p.35)

The definition of sensitive land use is reasonably consistent between Guideline D-6 and the PPS; however, there are a couple of differences. First, Guideline D-6 refers to “…a nearby facility” whereas the PPS refers to “…a nearby **major** facility” (emphasis added)—the word ‘major’ being subject to interpretation. Second, Guideline D-6 classifies residential use as sensitive 24 hours/day, whereas the PPS does not. On the surface, D-6 appears to be more protective but, perhaps, unnecessarily so. For example, classifying campgrounds—closed for much of the year and, generally, not occupied by the same individuals for extended periods—as sensitive 24 hours/day may need re-thinking.

Discussion of MOE Guidelines

The MOE Guidelines provide comprehensive assistance for evaluating land use planning decisions. The separation distance concept is widely used, the generic recommended separation distances are not inconsistent with those from other jurisdictions, and both new development and infill, urban re-development, and transition to mixed use are addressed.

There are, however, a number of areas for improvement. They are mentioned here briefly and discussed in more detail in Section 5.

First, and perhaps most important from a human health perspective, traffic corridors are not addressed. This is understandable given the date that the MOE Guidelines were last updated and the relatively recent literature on health impacts of vehicle emissions. Fortunately, there exists a substantial body of sound research from which to recommend a minimum separation distance to protect sensitive land uses from emissions from high-traffic corridors.

Second, Guideline D-6 recommends an area of influence but allows for a closer minimum separation distance provided studies exist showing a "trivial impact" at the closer distance. Trivial impact is defined as "Present or predictable contaminant discharges which are or are likely to be so minor that there would not be an 'adverse effect'." There is no guidance on what should be included in a study to justify use of the minimum separation distance (rather than a distance based on the potential area of influence). For example, should background air concentrations be included when assessing the impact of a new facility? Should air emissions from other nearby facilities be included in the assessment (i.e., cumulative air emissions)? Having completed a study, how should the results be interpreted? This is crucial since it is the demonstration of trivial impact which justifies the use of a minimum separation distance.

Third, while the Guidelines state that they are supplemental to legislated controls, these controls are only implemented long after land use planning decisions are made. For example, the requirement, under the *Environmental Protection Act*, for a Certificate of Approval (Air) is not triggered at the land use planning stage but some time before the facility begins operating. It is only at this later stage that an Emissions Summary and Dispersion Modelling (ESDM) Report is prepared and an assessment of facility emissions against provincial standards and guidelines can be made.

3.2 Ministry of Agriculture, Food and Rural Affairs

Scope

Beginning in 1970, minimum separation distances were recommended to keep livestock or poultry barns separate from neighbouring houses, residential zones, lot lines and roads. This early guidance used fixed separation distances and focused on keeping agricultural operations away from sensitive land uses.

The guidance was updated twice in the 1970s to introduce a two-way approach to separating livestock and poultry barns (i.e., to protect these facilities from encroaching sensitive land uses and vice versa) and to incorporate a sliding distance scale that takes into account the size and type of a farm. The most recent guidance (Ontario Ministry of Agriculture, Food, and Rural Affairs, 2006) updates the separation distance formulae slightly, but the principles upon which the guidance is based remain unchanged.

The Minimum Distance Separation I formula (MDS I) was developed to determine the minimum separation distances between proposed new development and existing livestock facilities and/or permanent manure storage. The Minimum Distance Separation II formula (MDS II) was developed to determine the minimum separation distances between proposed new, enlarged or remodeled livestock facilities and/or permanent manure storages and other existing or approved development.

Limitations

Application of the Minimum Distance Separation guidance is limited in a number of ways:

- "The objective…is to minimize nuisance complaints due to odour and thereby reduce potential land use conflicts. MDS does not account for other nuisance issues such as noise and dust." (p.2)
- the MDS is not intended to address odour issues related to the land application of manure
- the MDS applies only to livestock facilities defined as "One or more barns or permanent structures with *livestock occupied portions*, intended for keeping or housing of *livestock*. A *livestock facility* also includes all *manure* or *material storages* and *anaerobic digesters*." (p.6)
- the MDS does not apply to abattoirs, apiaries, assembly yards, fairgrounds, feed storages, field shade shelters, greenhouses, kennels, livestock facilities less than 10 m^2 in floor area, machinery sheds, mushroom farms, pastures, slaughter houses, stockyards or temporary field nutrient storage sites.

A guidance document and CD to aid MDS calculations are available from OMAFRA.

Discussion of OMAFRA MDS Formulae

The OMAFRA MDS guidance is up to date and reasonably comprehensive. The guidance does not rely on generic, fixed recommended separation distances but uses the MDS formulae to develop situation-specific separation distances that should properly protect incompatible land uses.

The limitations present some concerns: the guidance only applies to livestock operations, noise and dust are not considered, and some exclusions seem unjustified. For example, mushroom farms are excluded yet these operations can be the source of significant odours. However, in instances where the MDS formulae do not apply, it should be possible to use the MOE guidelines to ensure suitable separation distances.

3.3 Ministry of Natural Resources

Scope

Aggregate extraction activities in the province are governed by myriad legislation at both the provincial and federal levels. At the federal level, the *Fisheries Act*, the *Migratory Birds Convention Act* and the *Species at Risk Act* work to protect fish and wildlife habitat and at the provincial level, 15 acts influence extraction of aggregate from pits and quarries (http://www.mnr.gov.on.ca/en/Business/Aggregates/1ColumnSubPage/STEL02_167084.html, accessed May 1, 2008).

To provide more concise, user friendly and understandable minimum requirements for the delivery of the *Aggregate Resources Act*, MNR has produced guidance documents for 15 categories of aggregate activity. The reason for 15 categories is to reflect the types of applications that can be applied for: for example, a licence or a permit, for a pit or a quarry, removing more or less than 20,000 tonnes of aggregate annually, from above or below the water table.

Requirements for aggregate operations are explained in four sections: Site Plan Standards; Report Standards; Prescribed Conditions (which “pertain to the individual category and cannot be varied or rescinded by either the Minister or the Ontario Municipal Board”); and Notification and Consultation Standards.

In the Introduction to the Guidance documents, MNR states:

“In searching and/or preparing reports to accompany an application, reference should be made to the following documents and agencies:

a) Provincial Policy Statement and Associated Training Manuals;
b) Zoning by-law(s);
c) Official Plan(s);
d) *Environmental Protection Act*;
e) *Ontario Water Resources Act*;
f) *Conservation Authorities Act*;
g) Niagara Escarpment Commission;
h) Guide to Completion of the Compliance Assessment Report for licences and aggregate permits;
i) Flow chart for the Notification and Consultation Standards for licences, aggregate permits, wayside permits, Category 13 and the annual compliance reporting;
j) MOEE Guidelines including:
   – MOEE Guideline NPC-205, Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban);
   – MOEE Guideline NPC-232, Sound Level Limits for Stationary Sources in Class 3 Areas (Rural);
   – MOEE Guideline NPC-233, Information to be Submitted for Approval of Stationary Sources of Sound;
   – MOEE Guideline NPC-119, Blasting.

   The above list serves only as a guide and should not be interpreted as all-Inclusive
k) Provincial and Federal references to endangered species;
l) Federal Fisheries Act and Associated Guidelines;
m) Environmental Assessment Act and Exemptions.”

(Note: MOEE refers to the Ministry of Environment and Energy, now the Ministry of the Environment.)

Further guidance is provided in Section 2.0 which requires technical reports accompanying an application to include an assessment of whether natural environment features (e.g., significant wetlands, habitat of endangered or threatened species, significant woodlands, areas of natural or scientific interest) occur on or within 120 m of the site. If so, an impact assessment must be completed and will include proposed preventative, mitigative or remedial measures. A cultural heritage resource survey must also be completed and mitigation proposed if archaeological or other heritage resources are identified. If the extraction is below the water table, a hydrogeological study must be included.

Separation Distances

Separation distances are used to protect sensitive receptors from noise and dust. Sensitive receptors include “…residences or facilities where people sleep (nursing homes, hospitals, trailer parks, camping grounds,

etc.); schools; day-care centres." Table 3 (below) summarizes the requirements for pits and quarries.

Table 3. Noise Assessment and Dust Mitigation Requirements for Pits and Quarries.

	Pit	Quarry
Licence	Noise assessment report required if sensitive receptor within 150 m. Dust mitigation required for internal haul roads and processing areas. Processing equipment must use dust suppressing or collection devices if sensitive receptor within 300 m.	Noise assessment report required if sensitive receptor within 500 m. Dust mitigation required for internal haul roads and processing areas. Processing equipment must use dust suppressing or collection devices if sensitive receptor within 300 m.
Permit	Noise assessment report required if sensitive receptor within 2000 m. Dust mitigation required if sensitive receptor within 2000 m of permitted boundary; for internal haul roads; and processing areas if sensitive receptor within 500 m of site.	Same as for pit.

Absent site specific studies, MOE's Guideline D-6 requires pits and quarries to be considered Class III Industrial Facilities and the recommended separation distance is 1,000 m.

Discussion of MNR Guidance

The technical reports required by MNR are comprehensive although, from an air quality perspective, only noise and dust are assessed for appropriate separation distances and air studies assessing particulate matter levels off-site are not required.

It is commonly understood that there is no level of exposure to coarse (PM_{10}) or fine ($PM_{2.5}$) particulate matter that is without negative health impacts. Requiring air studies for quarry applications would allow a more complete assessment of separation distances that are protective of human health. This is discussed in more detail in Section 5.

4. Planning and Air Quality in Halton Region

"The planning system controls land use and development and is one of the main levers to reduce the environmental impacts of urban areas." (Royal Commission on Environmental Pollution, 2007)

While land use and development processes are governed by the Regional Official Plan, the planning system in Halton must be consistent with two memoranda of understanding, one between the Region and the Province and one amongst the Region, Local Municipalities, School Boards, Regional Police Services and Conservation Authorities.

Memoranda of Understanding

The *Memorandum of Understanding Between The Province of Ontario and The Regional Municipality of Halton Regarding Municipal Plan Review*, signed in 1996, sets out the framework within which the Region and the Province agree to certain roles and responsibilities for municipal plan review. Specifically, it is through this Memorandum that provincial review ministries are no longer involved in the following planning applications:

- Subdivisions;
- Condominiums;
- Consents;
- Validations of Title;
- Partlot Control Bylaws;
- Minor Variances;
- Site Plans;
- Zoning Bylaws and Amendments; and
- Site Specific Local Official Plan Amendments.

With the provincial government no longer involved in planning applications, it became necessary for regional and local municipalities to agree amongst themselves on the roles and responsibilities for doing this work.

The *Memorandum of Understanding Amongst the Regional Municipality of Halton, the City of Burlington, the Town of Oakville, the Town of Milton, the Town of Halton Hills, the Halton Regional Police Services Board, the Halton District School Board, the Halton Catholic District School Board, the Halton Region Conservation Authority, the Credit Valley Conservation Authority, and the Grand River Conservation Authority Regarding the Implementation of An Integrated Halton Area Planning System*, signed in 1999, sets out the framework for the redistribution and administration of certain planning approval authorities and responsibilities.

Part 3 of this Memorandum sets out the policy matters for which the Region is responsible (in cooperation with other Halton Planning Partners). The policy matters of specific interest to this discussion paper are listed in section 5.3 and include:

- protection of Provincial land use policy interests;
- the Halton Region Official Plan;
- housing planning;
- transportation planning and transit services;
- regional environmental planning;
- rural planning;
- mineral aggregate; and
- agricultural planning.

Halton Region Official Plan

The *Halton Region Official Plan 2006* is based on the two planning concepts of land stewardship and healthy communities and outlines a long-term vision for Halton's physical form and community character (Halton Region, 2006). The Plan sets forth goals and objectives, describes an urban structure to accommodate growth, states the policies to be followed, and outlines the means for implementing those policies.

Incompatible land uses are addressed by a number of policies in the Regional Official Plan (ROP). For example, encroachment on agricultural operations is addressed by Policy 101(2)d which requires local municipalities to apply provincially developed Minimum Distance Separation formulae in their zoning bylaws, and Policy 110(1) addresses aggregate operations by requiring local municipalities to adopt zoning bylaws to permit the operation of legally existing pits and quarries in accordance with The *Aggregate Resources Act* and protect them from new land uses incompatible with such operations.

Other policies in the ROP explicitly address noise and vibration issues arising from incompatible land uses. Policy 143(9) requires noise studies if proposed development is within 300 m of a railway right-of-way or 1,000 m of a railway yard and vibration studies if the development is within 75 m of a railway right-of-way or railway yard. The policy also requires implementation of approved recommendations including "…the restriction of new residential and other sensitive uses."

Policy 143(12) "Require[s] the proponent of land uses sensitive to noise and vibration, such as residential, outdoor recreation, hospitals and schools, in proximity to industrial and some utility facility sources of noise and vibration including railway corridors and railway yards to complete a noise and vibration study and undertake necessary mitigation actions, in

accordance with Ministry of the Environment and any other applicable guidelines."

Without explicitly naming them, Policy 143(12) appears to include, among others, Ministry of the Environment (MOE) Guidelines D-1 (*Land Use Compatibility*) and D-6 (*Compatibility Between Industrial Facilities and Sensitive Land Uses*) in the Official Plan. This interpretation seems to be supported by Policy 147(1) which "Require[s] all development to have regard to policies and guidelines of the Ministry of the Environment regarding land use compatibility."

Local Official Plans

Local Official Plans also address the incompatible land use issue. Local municipalities are at different stages of Official Plan review and some of the policies that currently appear to apply are briefly reviewed.

City of Burlington

Burlington has recently completed an Official Plan review and the policies that seem most applicable to this discussion paper are 2.7.3 n) and 2.7.3 o).

Policy 2.7.3 n) requires transportation or industrial facilities and sensitive land uses to be kept from encroaching upon each other. Separation distances and/or other means are recommended and "Provincial guidelines *shall* be referred to for direction in land use planning decisions" (emphasis in original).

Policy 2.7.3 o) allows (but does not require) the municipality to request a risk assessment from proponents of residential development or other sensitive land uses "within proximity to any existing or potential sources of man-made hazard."

Numerous other policies address incompatible land use issues. For example: air quality studies may be requested (Policy 2.12.2 g (ix)) in support of an application for a new or expanded aggregate operation; noise studies required near roadways (Policy 3.3.2 r, s, and t); noise and vibration studies required near railway lines and railway yards (Policy 3.7.2 d); risk and compatibility assessments for certain sensitive institutional uses in employment areas (Policy 4.3 d); and protection of farm operations using MDS formulae (Policy 13.3 b).

Incompatible land uses appear to be assessed with respect to noise, odour, dust or vibration and there may be situations for which a more detailed air quality study would better inform planning decisions.

Assessing gaseous air pollutants, for example, would be consistent with MOE Guideline D-6 which is, presumably, captured in Policy 2.7.3 n (above).

Town of Halton Hills

Halton Hills also has recently completed an Official Plan review and incompatible land use issues are addressed through policies such as; C11 Agricultural Operations, C14 Land Use Compatibility; and C15 Noise and Vibration.

C11 requires use of the Minimum Distance Separation formulae to keep agricultural and non-agricultural operations from encroaching on each other; C14 requires incompatible land uses to be "separated or otherwise buffered" from each other—an assessment of the proposal to be in accordance with guidelines prepared by the MOE; and C15 requires noise impact studies near industries and certain roadways, and noise and vibration studies near railway lines and rail yards.

In addition, there is guidance on requirements for day nurseries, gas stations, protection of aggregate resources, and on what constitutes compatible land uses in commercial and employment land areas.

Similar to Burlington's Official Plan, the MOE Guidelines are referred to although noise, odour, dust or vibration seem to be the dominant concern. In some instances, studies assessing air pollution could help inform development decisions.

Town of Milton

The Town of Milton's Official Plan is about 10 years old, having been updated shortly after the province updated its D-Series Guidelines. Similar to Burlington and Halton Hills, there are numerous policies addressing incompatible land uses.

Policies 2.3.3.16 to 2.2.3.23 require noise and/or vibration studies near railway lines (but rail yards are not mentioned) and noise studies for certain developments affected by excessive road noise levels. Noise sensitive uses are discouraged along provincial freeways and truck routes must have regard for the need to protect residential neighbourhoods from truck noise, pollution and hazards.

Policy 2.4.3.5 a) and b) protect agricultural land and Policy 4.1.1.15 requires new uses and lots within the Rural, Agricultural, Niagara Escarpment Plan and Parkway Belt Corridor Areas to have regard to the Minimum Distance Separation Formulae.

Policies of 4.7.3 address protection of aggregate resources and prohibit residential development within 500 m of lands designated Mineral Resource Extraction Area.

Although not as current as Burlington or Halton Hills, Milton's Official Plan addresses many aspects of incompatible land use. Areas for improvement could include specifically addressing rail yards and more explicit language in some policies. For example, "shall" do something is a clearer requirement than "having regard" for something.

Town of Oakville

The Town of Oakville's Official Plan also addresses incompatible land uses throughout and references the MOE Guidelines for appropriate guidance. For example, General Policy 10.4 allows the Town to enact by-laws to regulate land uses that may produce "inappropriate airborne emissions containing particulate or odours…" and may have an adverse effect on adjacent uses in accordance with MOE guidelines.

General Policy 10.8 addresses traffic noise and rail noise and vibration, again referring to MOE policies and guidelines and recommending minimum distances for determining noise sensitive areas.

Land Use Policies provide more specific guidance. For example, Land Use Policy 1.5 f) prohibits residential development in areas where "pollution from noise, air or water exceed Provincially recommended limits" unless mitigation measures can be incorporated into the proposed development.

New non-agricultural uses in the Agricultural designation must comply with the MDS (Land Use Policy 6.2 c) and all applications for amendment to permit a pit or quarry shall include (among other things) an Environmental Impact Statement which addresses (again, among other things) the potential effects of air pollution on nearby land uses (Land Use Policy 8.6 j).

Language in municipalities' official plans reflects the different stages of development and local circumstances. While noise, odour, dust and vibration are addressed, it is less clear that requirements for gaseous pollutants arising from both point and area sources are sufficient. It may be beneficial to include consistent language regarding incompatible land uses in the Regional and local official plans, addressing, for example, requirements for air quality studies to better determine separation distances protective of human health.

4.1 Guideline Use in Ontario, Halton Region and Local Municipalities

Although other land use guidelines (agricultural and aggregate) for Ontario have been briefly reviewed, the focus of this section is the use of Guideline D-6 to keep industrial facilities and sensitive land uses apart. This section is based on discussions with OMAFRA, MOE, and regional and local planners and on a review of some decisions of the Ontario Municipal Board in which MOE Guidelines are referenced.

In agricultural situations, the Minimum Distance Separation formulae have been found to be very helpful, particularly the use of variable separation distances, and, if the MDS is met, there should be few odour complaints (OMAFRA, personal communication), at least related to livestock operations.

For aggregates, Guideline D-6 only applies to quarries in the absence of site specific studies and regional experience is that air quality studies are always requested as part of an application for a quarry. However, there are no guidelines or terms of reference for what should be included in an air quality study and guidance of this sort would provide clear and consistent direction during the aggregate development process.

The provincial government is no longer involved in planning applications, although expertise in Guideline D-6 has not been lost and assistance with interpretation is available. From a provincial perspective, municipalities can ensure the use of Guideline D-6 by incorporating policy guidance into their official plans and by the use of zoning bylaws (Ministry of the Environment, personal communication).

While there are differences in language in local municipalities' official plans, the intent seems to be to follow provincial guidelines, particularly to address sources of noise and vibration near sensitive land uses. Some official plans go further and require incompatible land use assessments, using for guidance the MOE guidelines.

Uncertainties arise from some vagueness in Guideline D-6 in which sensitive uses are defined by example and it is unclear whether or not, for example, places of worship or outdoor recreation areas are sensitive uses. Uncertainties also arise with the classification of industrial facilities which, even though criteria are provided, may be open to interpretation.

Other concerns with the MOE guidelines, expressed by local planners, include difficulty applying them in infill, urban redevelopment, and transition-to-mixed-use situations. D-6 works better for greenfield development, and municipalities facing build-out will find it challenging to protect sensitive receptors during infill, urban redevelopment or transition

to mixed use. Recent examples include proposals for day care centres and private schools in transition areas. How can sensitive receptors be protected while the character of an area changes (often very slowly) over time?

Decisions of the Ontario Municipal Board

Decisions of the Ontario Municipal Board (OMB) seem to reflect municipal concerns with Guideline D-6 and suggest the importance of clear authority and consistency of interpretation. In a decision with respect to permitting the occupation of a place of worship in an existing industrial building across the road from Class III industries (File PL040574; Decision/Order No: 1192), the OMB accepted that "…the Guidelines have legislative authority stemming from section 2 of the *Planning Act* and section 14 of the *Environmental Protection Act*." (Ontario Municipal Board, 2006). (See Appendix 2 for the referenced sections.)

However, in another decision with respect to a proposed residential development near a railway right-of-way (File PL030635; Decision/Order No: 1815), the OMB found that "…the Ministry of Environment Land Use Compatibility Guidelines are guidelines only, and are neither law, nor regulation, nor policy and should not be considered or treated as such, *unless elements of the guidelines are incorporated into the applicable planning policies of a municipality*." (Ontario Municipal Board, 2004: emphasis added).

In a recent case (File PL080018) involving a severed parcel of land, the involved Township argued against a proposed land use citing the Township's Official Plan which requires the Township to have regard to the MOE Guidelines. The OMB found, however, that the MOE Guidelines conflicted with separation distances in the Township's Official Plan and that the Official Plan policies must govern (Ontario Municipal Board, 2008).

These decisions point to the importance of including specific land use guidance in an official plan to provide clear authority for addressing the encroachment of industrial land use on sensitive land use, and *vice versa*.

Including specific land use guidance in the official plan could also lead to more consistent application of separation distances. For example, in a decision with respect to a Class I industry (File PL000598; Decision/Order No: 1948), the OMB found for a 20 m setback (Ontario Municipal Board, 2006) but Guideline D-6 requires a 70 m separation distance (the area of influence) for Class I industries. If site specific studies are available to demonstrate that an impact is trivial at less than 70 m, then the minimum

separation distance would be 20 m. In the OMB's decision it was not apparent that such studies were provided.

In Decision/Order No: 1192 (referred to above), the OMB accepted the area of influence concept, i.e., a separation distance should not automatically 'default' to the minimum suggested in Guideline D-6: "The Board further accepts the testimony that for Class III industries the 'area of influence' is 1000 metres as defined by section 4.1 of D-6 and that the Minimum separation Distance for the same class is 300 metres as defined by section 4.3 of D-6." (Ontario Municipal Board, 2006).

In yet another decision (File PL020779; Decision/Order No: 1948), the OMB's recommendation allows for the separation distance to be measured from the sensitive use to the industrial facility (which is consistent with Section 4.4 of Guideline D-6): "The Board finds that the area zoned for the workshop and sawmill operation should be moved to the east side of the property, where it would have much less impact on the appellant's property and would provide for the separation distance to be located on the proponent's lands rather than on the appellant's." (Ontario Municipal Board, 2004).

Municipal experience interpreting and implementing Guideline D-6 and decisions of the Ontario Municipal Board suggest that it would be useful to develop consistent criteria for interpreting and applying Guideline D-6 in land use planning.

5.0 Discussion and Suggested Directions for Consideration in the Sustainable Halton and Regional Official Plan Review Processes

From the review of jurisdictional approaches to incompatible land use, an understanding of existing official plan policies and implementation challenges, and an appreciation of some of the recent decisions from the Ontario Municipal Board, it is apparent that there are several areas for improvement for separating industrial and sensitive land uses. Potential improvements and recommendations for consideration in the Sustainable Halton and Official Plan Review processes are provided below under five headings: Industrial Facilities; Traffic Corridors; Quarries; Agriculture; and Air Studies.

5.1 Industrial Facilities

The MOE D-1 and D-6 Guidelines have been discussed extensively and it is clear from policies in Halton Region's Official Plan that they are intended to apply during the planning and development process. The guidelines are broadly consistent with the separation distance approach used by other jurisdictions reviewed in this paper and provide useful generic separation distances to help keep industry and sensitive land uses apart. However, there are areas for improvement.

The guidelines are out of date and there is a certain amount of subjectivity involved when classifying industrial activities based on the MOE criteria and when determining what is a sensitive land use. Updating the guideline would bring to bear additional experience gained since 1995 and any applicable research on the use of separation distances to protect human health from incompatible land uses. Updating and clarifying the classification criteria and the definition of sensitive land use would lead to more transparent and consistent application of the guideline. Finally, updating the MOE land use compatibility guideline would assist in the implementation of the Provincial Policy Statement and Growth Plan (Ontario Professional Planners Institute, 2007).

Suggested Direction # 1 for Consideration in the Sustainable Halton and Regional Official Plan Review Processes:

Recognizing maturing urban areas, particularly zones of transition and intensification, and Section 38 of the Halton Region Official Plan, Halton Region encourage the MOE to update Guidelines D-1 and D-6 to reflect the changing nature of municipalities and the requirements of the Places to Grow Plan. The update should include the additional experience of environmental officers and public health inspectors gained since 1995; applicable research on separation distances for incompatible land uses; more specific industrial activity classification criteria; and a clear definition of sensitive land use.

Current difficulties with clear and consistent application of the guidelines, as evidenced by the discussion of decisions by the Ontario Municipal Board, need also to be addressed. For example, allowing measurement from sensitive land use to industrial activity in some circumstances (consistent with what is currently allowed by Guideline D-6) and requiring extensive impact analyses when incompatible land uses propose either to locate within the potential area of influence recommended by Guideline D-6, or, for infilling, urban redevelopment and/or transition to mixed uses, to locate within the recommended minimum separation distance.

Suggested Direction # 2a for Consideration in the Sustainable Halton and Regional Official Plan Review Processes:

For the protection of human health and sensitive receptors, Halton Region develop a made-in-Halton Incompatible Land Use Guideline (as part of the Healthy Communities Guidelines) that will:

- **be developed by the Health Department, in consultation with Regional and Local partners;**
- **be largely based on the Ministry of the Environment D-Series Guidelines;**
- **be supplemented with best practices from other jurisdictions, and health research on incompatible land uses;**
- **incorporate the Minimum Distance Separation Formulae for agriculture;**
- **address both greenfields development and infill, urban re-development, and areas of transition to mixed uses;**
- **identify when an air study will be requested, the parameters to be included in an air study, and how the results of such a study would be interpreted;**
- **be updated periodically to reflect advances in understanding of human health impacts related to land uses.**

Suggested Direction # 2b for Consideration in the Sustainable Halton and Regional Official Plan Review Processes:

Update policies in Halton Region's current Official Plan to explicitly reference the MOE Guidelines D-1 and D-6 to be used until such time as a made-in-Halton Incompatible Land Use Guideline is developed, and to explicitly reference that MOE Guideline D-6 be used to keep rail yards and sensitive land uses separated until a made-in-Halton Incompatible Land Use Guideline is available.

A specific land use of particular interest to Halton Region is railway yards. California has recommended a separation distance of 1,000 feet (about 300 m) from major service and maintenance rail yards and suggests considering siting limitations and mitigation measures within one mile (1,600 m). This guidance is broadly consistent with MOE D-6 in which rail yards would be a Class III industrial facility and subject to a potential area of influence of 1,000 m and a minimum separation distance of 300 m, provided studies supporting the shorter separation distance are available.

Finally, there are important concerns related to planning, air quality and human health which are not addressed by Guideline D-6. The influence of vehicle emissions from high-traffic corridors and the impact of cumulative air emissions both need to be considered. The California Air Resources Board addresses traffic corridors but not cumulative air emissions and

most of the guidance documents reviewed from other jurisdictions state that, while the recommended separation distances do not take into account the impact of cumulative air emissions, these impacts should be considered from both existing and new projects when making siting decisions (e.g., Sacramento Metropolitan Air Quality Management District, 2005; Office of the Deputy Prime Minister, 2004a; South Australia Environment Protection Authority, 2007).

Traffic corridors are discussed below in Section 5.2 and criteria for requesting detailed air studies, including an assessment of cumulative air impacts, are discussed in Section 5.5.

5.2 Traffic Corridors

Major traffic corridors are a category not addressed in the MOE D-series guidelines or by either of the Australian states examined. California suggests a separation distance from freeways and high traffic roads (urban roads >100,000 vehicles per day; rural roads >50,000 vehicles per day) of 500 feet (i.e., about 150 m) (California Environmental Protection Agency, 2005). British Columbia recommends a minimum setback of 150 m from busy roads (>15,000 vehicles per day) and suggests additional setbacks for sensitive uses along major truck routes, but a specific recommendation is not provided (British Columbia Ministry of the Environment, 2006).

Traffic corridor studies suggest that those who spend large amounts of time in close proximity to major roadways may be at increased risk for a range of adverse health impacts. For example:

- A study of children in grades 3-5 in San Francisco found that children living within 75 m of a freeway/highway (between 90,000 and 210,000 veh/d) are at markedly increased risk of current asthma (physician diagnosed asthma at some time in the past plus an “asthma-episode” or “wheezing” in the past 12 months). There was no clear association between current asthma or bronchitis and living within 75 m of a principal artery (~28,500 veh/d) (Kim, et al., 2008). Study results were adjusted for the following socio-economic status factors: race/ethnicity; household income; and education of the parent who completed the questionnaire.

- A study of more than 70,000 subjects in the greater Vancouver area found increased risk for low full-term birth weight and small for gestational age birth for mothers living within 50 m of an expressway or highway compared to mothers living more than 50 m from an expressway or highway (average >21,000 veh/d). No increased risk was observed for those living 150 m from a highway

or 50 m from a major road (average 15,000-18,000 veh/d) (Brauer, et al., 2008). Study results were adjusted for the following socio-economic status factors: ethnicity; neighbourhood income; and maternal education.

- A study examining the effect of motor vehicle emissions on respiratory hospitalization in southeast Toronto found that exposure to $PM_{2.5}$ had a significant effect on admission rates for a subset of respiratory diseases (asthma, bronchitis, chronic obstructive pulmonary disease, pneumonia, upper respiratory tract infection) (Buckeridge, et al., 2002). Study results were adjusted for the following socio-economic status factors: educational attainment and family structure.

- A study of respiratory symptoms in U.S. veterans found, after adjusting for cigarette smoking, occupational dust exposure and age, that subjects living within 50 m of a major roadway (>10,000 veh/d) had approximately 30% excess risk of reporting persistent wheeze compared to subjects 400 m or more away and had an elevated risk of chronic phlegm (Garshick, et al., 2003).

- A study in Hamilton of subjects living within 50 m of a major road or 100 m of a highway found, after adjusting for diagnoses of chronic respiratory and pulmonary diseases and diabetes, that subjects residing within traffic pollution buffers had elevated mortality rates regardless of whether they had been diagnosed with chronic pulmonary disease (excluding asthma) (Finkelstein, et al., 2004). Study results were adjusted for the following socio-economic status factors: household income.

- A recent review of epidemiologic evidence of cardiac and pulmonary health risks near freeways summarized pollutant gradient studies that show ultra-fine particles, black carbon, carbon monoxide, and oxides of nitrogen elevated near highways (>30,000 vehicles/day) and suggest that people living within about 30 m of highways are likely to receive much higher exposure to traffic-related air pollutants compared to residents living more than 200 m (+/- 50 m) from highways (Brugge, et al., 2007).

- In a review of the traffic corridor literature between 1999 and 2006, of 29 studies reviewed, 25 reported statistically significant associations between residential proximity to traffic and one or more of the following adverse health effects: increased prevalence and severity of symptoms of asthma and other respiratory diseases; diminished lung function; adverse birth outcomes; childhood cancer; and increased mortality risks. The majority of

studies using distance to residence as the exposure metric found adverse health effects for distances up to about 200 m but not for greater distances (Boothe and Shendell, 2008).

QEW and 400-Series Highways

The evidence suggests that it is important to use separation distances to keep sensitive uses from encroaching on high-traffic corridors. The difficulty is in selecting a separation distance that is appropriately protective of human health yet does not 'sterilize' land required to meet mixed use, higher density development targets as Halton absorbs the growth projected to 2031.

Preserving land along major traffic corridors (>100,000 vehicles/day) for employment lands may be one solution—sensitive land uses would then be 'buffered' by the employment lands (depending, of course, on what type of activities occupy the employment lands).

Suggested Direction # 3 for Consideration in the Sustainable Halton and Regional Official Plan Review Processes:

For the protection of human health and sensitive receptors, sensitive land uses not be located closer than 150 m to highways anticipated to have greater than 100,000 vehicles per day based on ultimate planned capacity. When applying this guidance, future road widening should be taken into consideration.

At present, this recommendation would only apply to the QEW and 400-series highways because no other roads in Halton Region approach this volume.

Neither the California Air Resources Board nor the review by Brugge mention explicitly where the measurement is made from; however, Brugge summarizes pollution gradient measurements between 2 m and 400 m which suggests that the measurement point should be from the edge of the roadway (as opposed to the centerline, for example) to the sensitive land use. Allowing a measurement other than property line to property line is consistent with guidance in Guideline D-6.

As Halton Region grows, it is reasonable to assume that sensitive land uses are more likely to encroach on high-traffic roadways than the other way around, and that the sensitive land use should be prepared to provide the buffer required for an appropriate separation distance.

Developments where future road widening may occur will have to be given careful consideration. For example, it may be necessary to provide a

larger separation distance for sensitive land uses in areas where highway widening is anticipated for the future.

Secondary Roads

Separation distances for sensitive land uses along secondary/regional roads present some challenges. While it is clear that health impacts can be associated with these roads, there is less clarity about the separation distances needed for varying volumes of traffic.

The approach by British Columbia, requiring 150 m from roadways of greater than 15,000 vehicles/day, could prevent the Region from achieving walkable and transit-supportive communities. While there is information to suggest that particulate pollution drops dramatically within as little as 30 m from roadways, other pollutants are also a concern. With shorter separation distances, factors such as wind speed and direction or socio-economic status (for example, is cooling provided by air conditioning or open windows?) become more important.

These studies suggest that a separation distance of 30 m should be maintained between residential developments built at ground level to protect sensitive receptors. It is possible, however, that mixed land uses could be allowed within 30 m if design and engineering controls could be used to protect occupants from localized air quality impacts (for example, air intakes on the roof, rather than lower, and high efficiency particle filters, Morawska, et al., 1999).

Suggested Direction # 4 for Consideration in the Sustainable Halton and Regional Official Plan Review Processes:

For the protection of human health and sensitive receptors, sensitive land uses not be located closer than 30 m to roads with greater than 30,000 vehicles/day annual average daily traffic (AADT) based on ultimate planned capacity. Exceptions to this guidance are condominiums and mixed-use buildings, which could locate closer than 30 m provided appropriate controls are incorporated into the building design to protect indoor air quality for the occupants. When applying this guidance, future road widening should be taken into consideration.

To get a sense of what this might mean for Halton Region, see Appendix 3: Road Classifications and Traffic Volumes in Halton Region.

5.3 Quarries

Quarries are not addressed in the California guidance but are covered in the two Australian states, which recommend separation distances of 500 m based on air (South Australia) or 1,000 m (Western Australia) to 3,000 m (South Australia) based on noise if blasting is involved. In Ontario, land use concerns for quarries are addressed by the Ministry of Natural Resources. MOE Guideline D-6 only mentions quarries in the absence of site specific studies.

In the Regional Official Plan, Policy 110(1) requires local municipalities to adopt zoning bylaws to permit the operation of legally existing pits and quarries in accordance with The *Aggregate Resources Act* and protect them from new land uses incompatible with such operations.

Quarries can be contentious and it is Halton Region experience that air quality studies are always requested as part of an application for a quarry. Although criteria for determining when to request an air study and what should be included are discussed below (Section 5.5), it is appropriate here to focus specifically on particulate matter.

Human health impacts from exposure to particulate matter (PM_{10}: particulate matter, including coarse particulate, less than 10 microns, and $PM_{2.5:}$ fine particulate matter less than 2.5 microns) are well documented (see Appendix 1) and from a health protection perspective it is important to know not just the maximum air levels, but also how frequently high levels of particulate matter occur and how long they last.

Suggested Direction # 5 for Consideration in the Sustainable Halton and Regional Official Plan Review Processes:

For the protection of human health and sensitive receptors, air studies for quarry applications should include:

- **a modelled frequency and duration analysis, which includes $PM_{2.5}$ (to understand how frequently and how long air levels can be expected to approach the maximum air levels); and**
- **background air concentrations of $PM_{2.5}$ in the modelling analysis (to enable the assessment of additional emissions from the quarry and a comparison to the Canada Wide Standard which is an ambient air standard)**

5.4 Agriculture

From the jurisdictional review conducted for this discussion paper, Ontario appears to have one of the best procedures for addressing separation distances for agricultural operations. California acknowledges that

agricultural operations are often the source of odour complaints, but makes no specific recommendations about separation distances. The two Australian states reviewed recommend generic separation distances based on the type and size of the activity. The Minimum Distance Separation Formulae used in Ontario take into account a number of factors before calculating a site-specific, and therefore variable, separation distance.

Regional and local official plans require use of the MDS formulae to protect agricultural operations from encroachment by sensitive land uses. However, the MDS formulae only apply to livestock operations and some of the excluded activities (see Section 3.2 above) may be cause for concern.

Suggested Direction # 6 for Consideration in the Sustainable Halton and Regional Official Plan Review Processes:

For the protection of human health and sensitive receptors, for non-livestock operations, where the MDS formulae do not apply, MOE Guideline D-6 should be used to protect agricultural operations from encroachment by sensitive land uses until such time as a made-in-Halton Incompatible Land Use Guideline is available.

5.5 Air Studies

In most jurisdictions, the recommended separation distances are a starting point only and "A sound site-specific technical analysis is generally found to provide the most appropriate guide to the separation distance that should be maintained between an industry or industrial estate and sensitive land use." (Western Australia Environmental Protection Authority, 2005). Jurisdictions recognize that site-specific technical analysis is expensive and time-consuming and that generic separation distances may be adequate if they are conservative. When generic separation distances are inadequate for the protection of sensitive receptors, site-specific studies must be undertaken.

Amendment No. 33 to The Regional Plan (2006) amends Part V, Implementation, Planning and Development Approval to include a new policy 187(10) which, among other things, adds 'Air Quality' to the list of other information and/or reports that the region may request to support a complete application for a Regional Official Plan Amendment, Plan of Subdivision, or Consent application (Policy 187(10)).

Site-specific air studies should be requested when a new development will result in a sensitive land use inside the potential area of influence of an industrial facility as defined in MOE Guideline D-6. This is consistent with

the current guideline but needs to be made explicit since some decisions of the Ontario Municipal Board seem to suggest that separation distances shorter than the potential area of influence are used even though there appear to be no supporting studies to justify the shorter distance.

When to request site-specific air studies for infill, urban redevelopment, and/or transition to mixed uses poses some challenges. Requesting air studies would be consistent with the current guideline which requires considerable analysis including what could be interpreted as cumulative air studies—the requirement for an assessment "…of the types and levels of contaminant discharges being generated by current industrial facilities…" (Ontario Ministry of the Environment, 1995e; Section 4.10.3). It is not clear why the guideline does not require an assessment of current industrial facilities for greenfield developments or how the requirements of Section 4.10.3 can be balanced with the goals of intensification.

Suggested Direction # 7 for Consideration in the Sustainable Halton and Regional Official Plan Review Processes:

For the protection of human health and sensitive receptors, the Halton Region Official Plan should require site-specific air studies when proposed new development would potentially result in separation distances (between industrial facilities and sensitive land uses) that are less than those recommended in MOE Guideline D-6 until such time as a made-in-Halton Incompatible Land Use Guideline is available.

The suggested directions proposed in this discussion paper are consistent with the vision and policies of the *Provincial Policy Statement* (PPS) and *Places to Grow, the Growth Plan for the Greater Golden Horseshoe* (the *Growth Plan*).

For example, Part IV of the PPS, Vision for Ontario's Land Use Planning System, speaks to efficient development patterns which, among other things, "…minimize the undesirable effects of development, including impacts on air, water and other resources." Two paragraphs later, the Vision goes on to state "It is equally important to protect the overall health and safety of the population." These concepts are captured in Policy 1.1.1c in Part V which states "Healthy, liveable and safe communities are sustained by avoiding development and land use patterns which may cause environmental or public health and safety concerns."

The *Growth Plan* provides policy direction on where and how to grow and provides six principles to guide decisions on how land is developed, resources are managed, and public dollars are invested. So although the focus is somewhat different from the PPS, it is important to note that the

Growth Plan “prevails where there is a conflict between [it] and the PPS. The only exception is where the conflict is between policies relating to the natural environment or human health. In that case, **the direction that provides more protection to the natural environment or human health prevails**.” (emphasis added).

It is also important to note that, provided there is no conflict, municipalities may have requirements that are more stringent than those of the Province.

Appendix 1: Health Impacts of Particulate Matter

It is commonly understood that there is no level of exposure to PM_{10} and $PM_{2.5}$ that is without negative health impacts.

Many health studies have demonstrated that short-term increases in air levels of PM_{10} and/or $PM_{2.5}$ are associated with an increase in a broad array of negative health impacts. For example:

- A 4% increase in heart attacks was demonstrated with a 10 µg/m^3 increase in air levels of $PM_{2.5}$ (Pope et al., 2006); and
- A 20% increase in the risk of having a more severe asthma attack was observed among children with a 10 µg/m^3 increase in daily air levels of $PM_{2.5}$ (Slaughter et al., Oct. 2003).

Several comprehensive studies have demonstrated that long-term exposure to PM_{10} and/or $PM_{2.5}$ can have a significant impact on public health. For example, a long-term study, which followed 1.2 million adults in the United States over a 16-year period, found that for every 10 µg/m^3 increase in air levels of $PM_{2.5}$ in a community:

- Deaths from all causes increased by 4%;
- Deaths from cardiopulmonary disease increased by 6%; and
- Deaths from lung cancer increased by 8% (Pope et al., 2002).

In 1999, the Canadian Federal Provincial Working Group on Air Quality Objectives and Guidelines concluded that there is clear and consistent evidence that:

- Hospital admissions increase when air levels of PM_{10} are equal to or greater than 25 µg/m^3 (24-hour); and
- Hospital admissions increase when air levels of $PM_{2.5}$ are equal to or greater than 15 µg/m^3 (24-hour) (Working Group on Air Quality Objectives and Guidelines, 1999).

Air levels of $PM_{2.5}$ present a significant public health concern in southern Ontario because they frequently exceed air levels that are known to produce significant health impacts. For example, in 2005, air levels of $PM_{2.5}$ at the Oakville and Burlington air monitoring stations:

- Exceeded 22 µg/m^3 10% of the time; and
- Exceeded the 24-hour Canada Wide Standard (CWS) of 30 µg/m^3, 10 and 11 times respectively.

Appendix 2: Section 2 of the *Planning Act* & Section 14 of the *Environmental Protection Act*

Section 2 of the Planning Act

2. The Minister, the council of a municipality, a local board, a planning board and the Municipal Board, in carrying out their responsibilities under this Act, shall have regard to, among other matters, matters of provincial interest such as,

(a) the protection of ecological systems, including natural areas, features and functions;

(b) the protection of the agricultural resources of the Province;

(c) the conservation and management of natural resources and the mineral resource base;

(d) the conservation of features of significant architectural, cultural, historical, archaeological or scientific interest;

(e) the supply, efficient use and conservation of energy and water;

(f) the adequate provision and efficient use of communication, transportation, sewage and water services and waste management systems;

(g) the minimization of waste;

(h) the orderly development of safe and healthy communities;

(h.1) the accessibility for persons with disabilities to all facilities, services and matters to which this Act applies;

(i) the adequate provision and distribution of educational, health, social, cultural and recreational facilities;

(j) the adequate provision of a full range of housing;

(k) the adequate provision of employment opportunities;

(l) the protection of the financial and economic well-being of the Province and its municipalities;

(m) the co-ordination of planning activities of public bodies;

(n) the resolution of planning conflicts involving public and private interests;

(o) the protection of public health and safety;

(p) the appropriate location of growth and development. 1994, c. 23, s. 5; 1996, c. 4, s. 2; 2001, c. 32, s. 31 (1).

Section 14 of the Environmental Protection Act

14. (1) Subject to subsection (2) but despite any other provision of this Act or the regulations, a person shall not discharge a contaminant or cause or permit the discharge of a contaminant into the natural environment, if the discharge causes or may cause an adverse effect. 2005, c. 12, s. 1 (5).

Appendix 3: Road Classifications & Traffic Volumes in Halton Region

Road Classifications

The following information is available, verbatim, from: http://www.halton.ca/ppw/roads/SystemData/default.htm (accessed 12/01/09).

Arterial Roads in Halton Region are divided into categories based on their function:

- **Provincial Highways and Freeways** serve high volume inter-regional travel demands, including truck traffic, high-order transit and HOV lanes. They connect urban areas or nodes in different regions.
- **Major Arterials** serve high volume inter-regional and regional travel demands, including truck traffic, high-order transit and HOV lanes. They connect urban areas or nodes in different municipalities and distribute traffic to and from Provincial Highways and Freeways.
- **Multi-Purpose Arterials** serve a combination of the functions of Major and Minor Arterials while connecting Major Arterials through urban areas or nodes.
- **Minor Arterials** serve moderate to high volume local traffic demands, including local truck traffic and local transit. They distribute traffic to and from Major and Multi-Purpose Arterials.

Traffic Volumes

Annual Average Daily Traffic is defined as the average 24 hour, two-way traffic for the period January 1st to December 31st (Provincial Highways Traffic Volumes 1988-2005, Ontario Ministry of Transportation, accessed 13/01/09) http://www.raqsb.mto.gov.on.ca/techpubs/TrafficVolumes.nsf/tvweb

For the QEW and Hwy 401 (ETR407 is not provincially owned and data are not available from the MTO publication) the lowest traffic volumes in 2005 were measured on Hwy 401 at the Hwy 25 interchange in Milton (95,800 vehicles/day). All other highway segments were over 100,000 vehicles per day, the highest count measured at QEW and Brant Street (175,400 vehicles/day).

For regional roads, Table 1 below shows locations of traffic counts over 30,000 vehicles/day (2007 data) and Table 2 below shows traffic counts between 20,000 and 30,000 vehicles/day. As Halton grows, the traffic counts at locations listed in Table 2 may exceed the 30,000 vehicle/day threshold.

Table 1. Annual Average Daily Traffic (AADT) Volume Greater Than 30,000 Vehicles per Day on Halton Region Arterial Roads – 2007 data (Provincial Highways and Freeways are not Included).

Location	Total Volume
Trafalgar Rd. north of QEW south of Leighland/Iroquois Shore	58,900
Trafalgar Rd. south of QEW north of Cross Ave.	53,050
Guelph Line south of Mainway north of Mountainside Dr.	50,678
Guelph Line south of train tracks north of N. Service Rd.	47,205
Dundas St. just east of Hwy 403	43,927
Brant St. just north of QEW	43,398
Dundas St. just west of Hwy 403	43,372
Winston Churchill Blvd north of train tracks south of Sheridan Garden Dr.	42,970
Trafalgar Rd. north of Leighland/Iroquois Shore south of White Oaks Blvd	42,370
Winston Churchill Blvd north of QEW south of Upper Middle/N. Sheridan Way	42,260
Guelph Line north of Mainway south of Palmer Dr.	42,046
Trafalgar Rd. south of Cross Ave north of Cornwall Rd	41,449
Dundas St. E. just east of Meadowridge Dr. (between Trafalgar and Ninth Line)	40,812
Dundas St. W. just west of Neyagawa Blvd	40,652
Appleby Line and N. Service Rd (just north of QEW)	39,981
Trafalgar Rd just south of Upper Middle Rd E.	39,437
Dundas St. E. just east of 6th Line	38,668
Guelph Line south of Upper Middle north of Palmer Dr.	37,434
Dundas St. E. just east of Trafalgar Rd	37,180
Dundas St. E. just west of Trafalgar Rd	37,136
Dundas St. W. just west of 6th Line	37,039
Ninth Line south of Upper Middle north of QEW	36,123
Appleby Line just south of Mainway	35,857
Dundas St. E. just west of Winston Churchill Blvd	35,606
Appleby Line just south of Upper Middle Rd	35,428
Winston Churchill Blvd just south of Dundas St. E.	35,024
Trafalgar Rd south of Upper Middle Rd (at Sheridan College)	34,711
Dundas St. halfway between Appleby Line and Walkers Line	34,229
Upper Middle Rd halfway between Dorval Dr. and Neyagawa Blvd	34,196
Upper Middle Rd just west of Ninth Line	33,796
Trafalgar Rd. just north of Upper Middle Rd	32,933
Trafalgar Rd. halfway between Upper Middle Rd and Dundas St.	32,780
Dundas St just east of Guelph Line	32,621
Bronte Rd (Hwy 25) just south of Hwy 401	32,352
Appleby Line north of Upper Middle Rd south of train tracks	32,306
Dundas St halfway between Bronte Rd and Tremaine Rd	31,096
Dundas St halfway between Bronte Rd and Third Line	30,977
Dundas St just west of Tremaine Road	30,226
Dundas St west of Walkers Line east of ETR407	30,116

Table 2. Annual Average Daily Traffic (AADT) Volume Greater Than 20,000 Vehicles per Day and Less Than 30,000 Vehicles per Day on Halton Region Arterial Roads – 2007 data (Provincial Highways and Freeways are not Included).

Location	Total Volume
Ford Drive at Kingsway Dr. (just south of QEW)	29,799
Dundas St halfway between Guelph Line and Cedarsprings Rd (Brant St.)	29,653
Guelph Line north of Upper Middle Rd south of ETR407	29,440
Brant St. and ETR407	28,984
Bronte Rd (Hwy 25) just north of Steeles Ave (Hwy 8)	28,550
Steeles Ave at Hwy 401	27,591
Trafalgar Rd just south of ETR407	27,354
Dorval Dr north of Speers Rd south of QEW (at train tracks)	27,083
Upper Middle Rd just east of Neyagawa Blvd (Oxford Ave)	26,978
Upper Middle Rd just west of Trafalgar Rd	26,672
Trafalgar Rd south of Britannia Rd (Hwy 6)	26,335
Dundas St between Cedarsprings Rd and Milborough Line (W. edge of Halton)	25,859
Upper Middle Rd halfway between Trafalgar Rd and Eighth Line	25,811
Upper Middle Rd halfway between Eighth Line and Ninth Line	25,792
Winston Churchill Blvd south of QEW	25,688
Trafalgar Rd north of ETR407 south of Lower Base Line Rd	25,552
Dorval Dr. north of QEW just south of N. Service Rd.	25,040
Upper Middle just east of 6th Line	24,916
Ford Dr. north of Royal Windsor Dr (at train tracks)	24,886
Trafalgar Rd just north of Hwy 401	24,846
Steeles Ave east of Bronte Rd (Hwy 25) west of Ontario St (Milton)	24,474
Upper Middle halfway between Dorval Dr and Nottinghill Gate	24,392
Upper Middle just east of Eighth Line	24,382
Trafalgar Rd north of Derry Rd (Hwy 7) south of Hwy 401	24,242
Bronte Rd (Hwy 25) just south of QEW	23,861
Ford Dr just south of Royal Windsor Dr.	23,632
Appleby Line just south of Dundas St	23,303
Bronte Rd (Hwy 25) just north of Hwy 401	22,920
Trafalgar Rd just south of Dundas St.	22,254
Upper Middle Rd just east of Ninth Line	22,245
Trafalgar Rd just north of Britannia Rd (Hwy 6)	21,102
Bronte Rd just south of Upper Middle Rd	21,072
Bronte Rd just north of Upper Middle Rd	20,947
Dorval Dr just south of Upper Middle Rd	20,812
Winston Churchill Blvd just south of Steeles Ave (Hwy 8)	20,471
Trafalgar Rd halfway between Dundas St and Burnamthorpe Rd	20,436
Steeles Ave just east of Ontario St. (Milton)	20,131

References

Boothe, V.L. and D.G. Shendell, 2008. Potential health effects associated with residential proximity to freeways and primary roads: Review of scientific literature, 1999-2006. *J. Environ. Health*, 70(8):33-41.

Brauer, M., Lencar, C., Tamburic, L., Koehoorn, M., Demers, P., and C. Karr, 2008. A cohort study of traffic-related air pollution impacts on birth outcomes. *Environ. Health Perspect.* 116(5):680-686. DOI:10.1289/ehp.10952.

British Columbia Ministry of the Environment, 2006. *Develop With Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia*. British Columbia Ministry of the Environment, March 2006. Available from: http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare2006/develop_with_care_intro.html

Brugge, D., Durant, J.L., and C. Rioux, 2007. Near-highway pollutants in motor vehicle exhaust: A review of epidemiologic evidence of cardiac and pulmonary health risks. *Environ. Health* 6(23). DOI:10.1186/1476-069X-6-23.

Buckeridge, D.L., Glazier, R., Harvey, B.J., Escobar, M. Amrhein, C. and J. Frank, 2002. Effect of motor vehicle emissions on respiratory health in an urban area. *Environ. Health Perspect.* 110(3):293-300.

California Environmental Protection Agency, 2005. *Air Quality and Land Use Handbook: A Community Health Perspective*. California Air Resources Board, California Environmental Protection Agency, April 2005. Available from: http://www.arb.ca.gov/ch/handbook.pdf

Chambers, A.K., Strosher, M., Wootton, T., Moncrieff, J., and P. McCready, 2008. Direct measurement of fugitive emissions of hydrocarbons from a refinery. *J. Air & Waste Manage. Assoc.* 58(8):1047-1056.

City of Alameda, 2007. Chapter XXX Development Regulations; 30-21 Variances, Use Permits: Procedure. City of Alameda California Municipal Code current as of October 16, 2007 and accessed February 12, 2008. Available from: http://www.ci.alameda.ca.us/code/_DATA/TITLE30/30_21_VARIANCES__USE_PERMITS__PROC/index.html

Finkelstein, M.M., Jerrett, M. and M.R. Sears, 2004. Traffic air pollution and mortality rate advancement periods. *Am. J. Epidemiology* 160(2):173-177.

Garshick, E., Laden, F., Hart, J.E. and A. Caron, 2003. Residence near a major road and respiratory symptoms in U.S. veterans. *Epidemiology* 14(6):728-736.

Gauderman, W.J., Avol, E., Lurmann, F., Kuenzli, N., Gilliland, F., Peters, J. and R. McConnell, 2005. Childhood asthma and exposure to traffic and nitrogen dioxide. *Epidemiology* 16(6):737-743.

Golder Associates, 2004. Air Quality Assessment Of Nelson Quarry Company Burlington Quarry Extension, Burlington, Ontario. Report submitted to Nelson Quarry Company, Golder Associates Ltd. August 2004.

Halton Region, 2006. *Halton Region Official Plan [2006]*. Regional Municipality of Halton, Office Consolidation, August 17, 2006.

Halton Region, 2007. *Air Quality, Human Health & the Built Environment*. Halton Region Health Department, Oakville, Ontario, May 2007. Available from: http://www.halton.ca/ppw/planning/SustainableHalton/Phase1.htm

Hemson Consulting Ltd., 2007. Effect of Demographic Change on Halton Region. Draft Final Background Report for the Sustainable Halton Planning Process. May 2007. Available from: http://www.halton.ca/ppw/Planning/SustainableHalton/Phase1.htm

Institute for Risk Research, 2007. *Air Pollution and Public Health: A Guidance Document for Risk Managers*. Institute for Risk Research, Waterloo, Ontario, Canada, May 2007.
Available from: http://www.irr-neram.ca/CQ5Vancouver/CQ5.html

Kim, J.J., Huen, K., Adams, S., Smorodinsky, S., Hoats, A., Malig, B., Lipsett, M. and B. Ostro, 2008. Residential traffic and children's respiratory health. *Environ. Health. Perspect.* 116(9):1274-1279.

Morawska, L., et al., 1999. A study of the horizontal and vertical profile of submicrometer particles in relation to a busy road. *Atmos. Environ.* 33:1261-1274.

National Association of Local Boards of Health, 2006. *Land Use Planning for Public Health: The Role of Local Boards of Health in Community Design and Development*. NALBOH, 2006. Available from: http://www.nalboh.org

NSCA, 2006. *Development Control: Planning for Air Quality*. Environment Protection UK, 2006. Available from: http://www.environmental-protection.org.uk/assets/library/documents/Development_Control_planning_for_air_quality.pdf

Office of the Deputy Prime Minister, 2004a. *Planning Policy Statement 23: Planning and Pollution Control*. Office of the Deputy Prime Minister, Her Majesty's Stationery Office, Government of the United Kingdom, 2004. Available from: http://www.communities.gov.uk/publications/planningandbuilding/planningpolicystatement23

Office of the Deputy Prime Minister, 2004b. *Planning Policy Statement 23: Planning and Pollution Control Annex 1: Pollution Control, Air and Water Quality*. Office of the Deputy Prime Minister, Her Majesty's Stationery Office, Government of the United Kingdom, 2004. Available from: http://www.communities.gov.uk/publications/planningandbuilding/pps23annex1

Ontario Medical Association, 2005a. *The Illness Costs of Air Pollution: 2005-2026 Health & Economic Damage Estimates*. Ontario Medical Association, June 2005. Available from: http://www.oma.org/Health/smog/index.asp

Ontario Medical Association, 2005b. *The Illness Costs of Air Pollution (ICAP) – Regional Data for 2005*. Available from: http://www.oma.org/Health/smog/index.asp

Ontario Ministry of Agriculture, Food, and Rural Affairs, 2006. *Minimum Distance Separation Formulae [MDS] Implementation Guidelines*. Ontario Ministry of Agriculture, Food and Rural Affairs, Publication 707, Queen's Printer for Ontario, 2006 Toronto, Canada.

Ontario Ministry of the Environment, 1995a. *Guideline D-1 Land Use Compatibility*. Ministry of the Environment, Government of Ontario, July 1995. Available from: http://www.ene.gov.on.ca/en/publications/forms/index.php#LandUse

Ontario Ministry of the Environment, 1995b. *Procedure D-1-1 Land Use Compatibility: Implementation*. Ministry of the Environment, Government of Ontario, July 1995. Available from: http://www.ene.gov.on.ca/en/publications/forms/index.php#LandUse

Ontario Ministry of the Environment, 1995c. *Procedure D-1-2 Land Use Compatibility: Specific Applications*. Ministry of the Environment,

Government of Ontario, July 1995. Available from: http://www.ene.gov.on.ca/en/publications/forms/index.php#LandUse

Ontario Ministry of the Environment, 1995d. *Procedure D-1-3 Land Use Compatibility: Definitions*. Ministry of the Environment, Government of Ontario, July 1995. Available from: http://www.ene.gov.on.ca/en/publications/forms/index.php#LandUse

Ontario Ministry of the Environment, 1995e. *Guideline D-6 Compatibility Between Industrial Facilities and Sensitive Land Uses*. Ministry of the Environment, Government of Ontario, July 1995. Available from: http://www.ene.gov.on.ca/en/publications/forms/index.php#LandUse

Ontario Ministry of the Environment, 1995f. *Procedure D-6-1 Appendix A: Industrial Categorization Criteria*. Ministry of the Environment, Government of Ontario, July 1995. Available from: http://www.ene.gov.on.ca/en/publications/forms/index.php#LandUse

Ontario Ministry of the Environment, 2005. *Modelling Traffic Influences on Particulate Concentration*. Queen's Printer for Ontario, December 2005, PIBs 5110e.

Ontario Ministry of Municipal Affairs and Housing, 2005. *Provincial Policy Statement 2005*. Ministry of Municipal Affairs and Housing, Government of Ontario, 2005. Available from: http://www.mah.gov.on.ca/Page1485.aspx

Ontario Ministry of Public Infrastructure and Renewal, 2006. *Growth Plan for the Greater Golden Horseshoe*. Ministry of Public Infrastructure and Renewal, Government of Ontario, 2006. Available from: http://www.placestogrow.ca/index.php?option=com_content&task=view&id=9&Itemid=14

Ontario Municipal Board, various years.
Available from:
http://www.omb.gov.on.ca/english/eDecisions/eDecisions.html

Ontario Professional Planners Institute, 2007. *Healthy Communities, Sustainable Communities: The 21st Century Planning Challenge*. OPPI, Fall 2007. Available from: http://www.ontarioplanners.on.ca

Purdue University, 2002. *The Law Behind Planning & Zoning in Indiana*. Purdue University Cooperative Extension Service, February 2002. Available from: http://www.ces.purdue.edu/extmedia/

Pollution Probe, 2002. *The Smog Primer*. Toronto, June 2002. Available from: http://www.pollutionprobe.org

Pope, C.A. III, Burnett, R.T., Thun, M.J., Calle, E.E., Krewski, D., Ito, K. and G.D. Thurston, 2002. Lung cancer, cardiopulmonary mortality and long-term exposure to particulate air pollution. *J. Am. Med. Assoc.* 287(9):1132- 1141.

Pope, C.A. III, Muhlestein, J.B., May H.T., Renlund, D.G., Anderson, J.L., and B.D. Horne, 2006. Ischemic heart disease events triggered by short-term exposure to fine particulate air pollution. *Circulation* 114:2443-2448.

Royal Borough of Kensington and Chelsea, 2003. *Supplementary Planning Guidance-05: Air Quality*. The Royal Borough of Kensington and Chelsea, September 2003. Available from: http://www.rbkc.gov.uk/Planning/UnitaryDevelopmentPlan/spg_airquality.pdf

Royal Commission on Environmental Pollution, 2007. 26th Report. *The Urban Environment*. The Royal Commission on Environmental Pollution, TSO, London.

Sacramento Metropolitan Air Quality Management District, 2007. *Recommended Protocol for Evaluating the Location of Sensitive Land Uses Adjacent to Major Roadways: Final Draft*. Sacramento Metropolitan Air Quality Management District, January 2007. Available from: http://www.airquality.org/ceqa/index.shtml#SensitiveLU

Sacramento Metropolitan Air Quality Management District, 2005. *Guidance Document for Addressing Air Quality Issues in General Plans and Local Planning*. South Coast Air Quality Management District, May 2005. Available from: http://www.aqmd.gov/prdas/aqguide/aqguide.html

Sacramento Metropolitan Air Quality Management District, 2004. *Guide to Air Quality Assessment in Sacramento County*. Sacramento Metropolitan Air Quality Management District, July 2004. Available from: http://www.airquality.org/ceqa/index.shtml#SensitiveLU

Slaughter, J.C., Lumley, T., Sheppard, L., Koenig, J., and G. Shapiro, 2003. Effects of ambient air pollution on symptom severity and medication use in children with asthma. *Annals of Allergies, Asthma and Immunology* 91(4):346-353.

South Australia Environment Protection Authority, 2007. *Guidelines for Separation Distances*. South Australia Environment Protection Authority, December 2007. Available from: http://www.epa.sa.gov.au/guidelines.html

Toronto Public Health, 2005. *Air Emissions From the Ashbridges Bay Treatment Plant*. Report prepared for Toronto Public Health by Earth Tech Canada Inc. and Golder Associates Ltd., April 2005, Appendix F Concentration Contours of Chemicals of Concern (24Hr).

University of Waterloo, undated. A Detailed Emission Factor Model (MicroFac) Combined with a Dispersion Model to Assess Human Exposure Effects of Traffic. PowerPoint presentation by R. Singh and J. Sloan, Waterloo Centre for Atmospheric Sciences, University of Waterloo.

Western Australia Environmental Protection Authority, 2005. *Separation Distances between Industrial and Sensitive Land Uses: Final Guidance No. 3*. Western Australia Environmental Protection Authority, June 2005. Available from: http://www.epa.wa.gov.au/template.asp?ID=14&area=EIA&Cat=Guidance+Statements

Wilhelm, M. and B. Ritz, 2003. Residential proximity to traffic and adverse birth outcomes in Los Angeles County, California, 1994-1996. *Environ. Health Perspect.* 111(2): 207-216. DOI:10.1289/ehp.5688.

Working Group on Air Quality Objectives and Guidelines, 1999. *National Ambient Air Quality Objectives for Particulate Matter: Addendum to The Science Assessment Document.* A report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines. December 1997, Revised April 1999. Minister, Public Works and Government Services, Canada.

World Health Organization, 2004. *Health Aspects of Air Pollution: Results from the WHO Project "Systematic Review of Health Aspects of Air Pollution in Europe"*. World Health Organization, Regional Office for Europe, June, 2004.

World Health Organization, 1996. *Our Cities, Our Future*. Price, C. and Tsouros, A. (ed.). WHO Healthy Cities Project Office, Copenhagen, 1996.