GRIDS Background Study: Hamilton's Vulnerability to Climate Change

Completed for the City of Hamilton
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Executive Summary

Hamilton's vulnerability to climate change must be a key consideration for future development in this thriving municipality. Health, water, infrastructure, and energy are all intricately linked in a vulnerable network. As a transforming industrial hub on the Niagara-Toronto corridor, the region is poised for tremendous growth over the next 30 years. Growth patterns, geography and ageing infrastructure are all factors that influence Hamilton's vulnerability to climate change.

City managers amd staff interviewed for this report flagged many of the same key vulnerabilities highlighted by the literature. However, it was clear that in-depth consideration of the related impacts and response to these scenarios has not been developed in detail.

Hamilton has a tremendous opportunity to begin to proactively manage it's vulnerability to climate change by looking at land use and infrastructure during the GRIDS process. Some basic policies derived from local interviews and senior government research include:

- Protect existing greenspaces to buffer extreme air and water related impacts of weather.
- Establish a legislated urban growth boundary and support rejuvenation of the downtown and development of existing brownfields to foster a more efficient land use pattern and reduce sprawl.
- Plan to facilitate the use of alternative modes of transportation (i.e. non-vehicle).
- Increase the supply capacity to preserve drinking water quality and quantity.
- Adjust shoreline management practices.
- Design infrastructure to be resilient to changing climate.
- Design land use patters to facilitate decentralized energy supply (community energy and the use of renewable energy sources).
- Consider overall transportation management to increase ability to adapt to climate change impacts such as extreme weather events and changing freeze-thaw cycles.

All of these suggestions relate directly to Hamilton, and many are reflected in the Nine Directions developed by the Hamilton community and adopted by Council in September, 2003. Maintaining conformity to the Nine Directions will decrease Hamilton's vulnerability to climate change through the creation of a more compact urban form. Other opportunities to reduce vulnerability are more directly related to the master plan process as they relate to water, waste-water, transportation and storm water. The linkage between land use and transportation,, infrastructure, sustainable development, environment, health,, and climate change are known. For Hamilton, GRIDS and many other initiatives are striving for the same overarching sustainable development targets of VISION 2020, which will help Hamilton reduce GHG emission and adapt to climate change.

Specific next steps for Hamilton GRIDS process include:

- Foster sustainable development by considering the Nine Directions of GRIDS and the Triple Bottom Line Accounting when evaluating options
- Focus on the main contributors to GHG –land use patterns, transportation and energy management.
- Have water, wastewater and stormwater master plans investigate local implications of climate change.

Future work on the Climate Change action plan may include:

- Assess the state of additional determinants of Hamilton's ability to adapt to climate change (i.e. economic resources[1], technology, information /skills, institutions and community equity)
- Continue to partner with senior government officials to identify and address Hamilton's climate change vulnerability as new information becomes available
- Explore senior government pilot projects and seek funding through partnerships.
- During the development of the Climate Change Action Plan, consider adaptation and mitigation opportunities less directly related to GRIDS. These include extreme weather, health impacts, energy management including conservation, and renewable energy).
- Continuously monitor, track and evaluate infrastructure vulnerability including deterioration or damage to roofs, roads, buildings, transmissions towers, energy supply, water systems, and land stability (landslides).
- Developing an accurate and well-managed GHG inventory management system.
- Assess the performance of existing buildings – conservation is the key to energy management.
- Recognize the common high-level goals of various initiatives.
- Celebrate the excellent initiatives that are currently in progress in Hamilton.
- Continue to support projects to increase awareness about GHG (e.g. Federal One-Tonne Challenge Program).
- Form strategic partnerships and learn from other efforts.

Tools are available with additional resources being developed by senior government.. Now is the time to embrace the opportunity by acknowledging the cause and effect relationships of climate change, especially as GRIDS develops. Many other Canadian communities are already doing so.

[1] For example, "*Prepare appropriate financial contingency strategies for seasonal and economic fluctuations (e.g. winter control, climate change, social services, tax stabilization."* Roadmap to Sustainability – A White Paper, City of Hamilton, 2004

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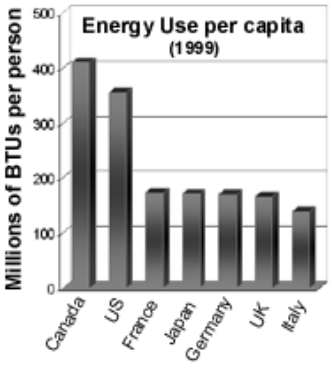
1 INTRODUCTION

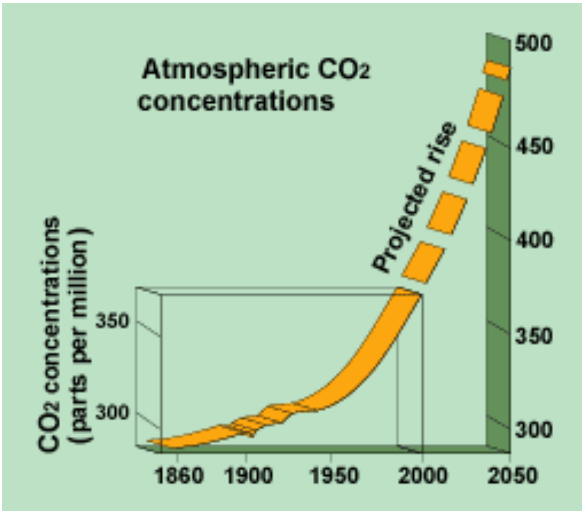
"Scientists now estimate that Ontario will warm an average of 2°C to 5°C within the next 75 to 100 years. Temperature increases will be greater in the winter than in the summer and that the frequency and severity of extreme weather events are likely to increase."



August, 2004 - adaptation.nrcan.gc.ca

Canadians are amongst the world's highest emitters of greenhouse gases at 23.2 tonnes per person in 2001 (Environment Canada). Thoughtful development to accommodate growth is necessary to address climate change adaptation, vulnerability and mitigation. Adaptation involves change to accommodate impacts, vulnerability indicates the flexibility to adjust, and mitigation entails addressing the problem – not just the symptoms – by reducing greenhouse gas (GHG) emissions.

Climate change is a universal reality that must be addressed by preparing for expected impacts, and acting responsibility now to mitigate future emissions. Over the last decade, commitment to the principles of sustainability by the City of Hamilton has resulted in many studies that highlight the need for responsible growth and development. One of the benefits this type of growth can deliver is a reduction in GHG emissions and proactive adaptation to climate change impacts.



Turner and Clague. http://adaptation.nrcan.gc.ca

Hamilton's position as a transforming major heavy industrial city on Lake Ontario, a central transport hub linking Toronto, Niagara and Western Ontario, and a geographic locale projected to undergo tremendous growth in the next 30 years, highlights the importance of leadership now to create a healthy, affordable and sustainable urban future. As brownfield reclamation and infilling of land within the existing urban boundary increases the population density, additional lands pushing the urban footprint into rural tracts of land must be developed thoughtfully. Infrastructure development impacts greenhouse gas emissions and our ability to adapt. Now is the time to make the connection between our growth decisions and our ability to deal with existing and future climate change.

This Vulnerability Study begins to identify existing and future impacts of climate change and opportunities for action relevant to the City's 30-year Growth-Related Integrated Development Strategy (GRIDS). This study will inform the GRIDS process, especially as it relates to land use patterns and infrastructure development. In future work, a working group representing the cross-section of departments, will be kept up-to-date regarding climate change impacts relative to their sector, with awareness of relevant impact, adaptive and operational issues related to climate change. For each department, key climate change issues, opportunities and threats will be highlighted. This will form part of the anticipated Climate Change Action Plan.

The purpose of this study is to:

- Identify Hamilton climate change vulnerability in terms of exposure/risks and adaptive capacity.
- Identity opportunities to reduce greenhouse gas (GHG) emissions through the planning process.
- Make recommendations for appropriate policy considerations for the Growth-Related Integrated Development Strategy (GRIDS) strategy that can help address Hamilton's vulnerability to climate change, with the goal of reducing emissions of GHG over time.

1.1 Scope of Work

A literature review, survey of best practices and existing reports, and stakeholder interviews begin to explore the nature of Hamilton's climate change vulnerability. A review of the existing GHG Inventory and literature review provided a profile of Hamilton's GHG emissions.

Analysis of existing information, reports and interviews with key City of Hamilton personnel allowed for the development of basic policy considerations for the GRIDS 30-year growth-management strategy.

A full scale GHG emissions reduction strategy and scientific risk assessment and measurement of adaptive capacity is not the intent of this initial study, given the need to complete the study within the GRIDS timeframe (Fall, 2004), and the Federal research currently being conducted by Health Canada, Natural Resources Canada and related agencies (e.g. Canada Country Study Update, 2006).

This study will serve as a starting point for a Hamilton Climate Change Action Plan (a separate project).

1.2 Methodology

Context

This study is part of a larger commitment to sustainability and climate change issues that Hamilton has supported for many years under VISION 2020 and the Federation of

Canadian Municipalities Partners for Climate Protection (PCP) program. The VISION 2020 target is to reduce GHG emissions in the corporation by 20% over 1990 levels. To do this Hamilton has achieved the first two milestones required in the PCP program:

1) Prepare an emissions analysis for the base year and current year. Complete.
2) Establish an emissions reduction target. Complete.
3) Develop a local action plan to meet target. In Progress.
4) Implement the local action plan. Future.
5) Monitor emissions to determine if target is being met. Future.

The next task is development of a local action plan to meet the GHG reduction targets. Hamilton will incorporate mitigative measures to reduce GHG entering the atmosphere, and also consider adaptive measures to accommodate existing and projected climate change impacts.

A brief summary of Hamilton's climate change path is included in the table below. More details are included in Appendix E.

Date	Milestones Related to Hamilton's Climate Change Direction
1995	Commit to Canadian Declaration on Climate Change & the Urban Environment
1996	Commit to reduce corporate & community wide emissions relative to 1990 levels by 20% and 6% respectively Joined the Federation of Canadian Municipalities 20% Club and committed to completing an emissions analysis, reduction target, develop a local action plan (LAP), implement the LAP, and monitor emissions
1997	Canada agrees in principle to Kyoto Protocol targets.
1999	Corporate analysis of GHG Emissions completed (1994 used as base year due to limited data) SMOG advisory plan adopted.
2002	Countil adopts Federation of Canadian Municipalities resolution encouraging the Federal government to ratify the Kyoto Accord.
2003	Canada ratifies Kyoto Accord and rolls out national climate change initiative.
2003	Renewed VISION 2020 adopted (includes climate change)
2004	Climate Change Vulnerability Background Study completed for GRIDS growth strategy.

2 INTRODUCTION TO THE GROWTH-RELATED INTEGRATED DEVELOPMENT STRATEGY (GRIDS)

The September 2003 Study Design for Hamilton's GRIDS was adopted by Council. It highlighted the five-step implementation process. Deliverable dates are included in brackets:

1) Complete and summarize background studies (Summer 2004);
2) Formulate evaluation system and criteria (Spring 2004);
3) Identify long list of development options (Fall 2004);
4) Preliminary and detailed evaluation of development options to select preferred option (Short List – Winter 2005, Preferred Option – Summer 2005);
5) Documentation (Ongoing)

This background study: Hamilton's Vulnerability to Climate Change is one of the studies required to complete deliverable #1 in the summer of 2004. Please refer to Appendix A for a list of additional studies related to GRIDS[2].

Building a Strong Foundation[3] is a bold initiative coordinated by the City of Hamilton to implement VISION 2020 by integrating it directly into some of the City's primary decision-making processes: the Growth-Related Integrated Development Strategy (GRIDS), the Master Plans for Transportation, Water and Wastewater, Stormwater, the new Official Plan and the Social Development Strategy. In 2003, Hamilton's City Council adopted nine Directions as guiding sustainability principles of the City's GRIDS Strategy. These Directions to Guide Development, identified through the "Building a Strong Foundation" consultation process are as follows:

1) Encourage a compatible mix of uses of neighbourhoods that provide opportunities to live, work and play.
2) Concentrate new development within existing built-up areas and within a firm urban boundary.
3) Protect rural areas for a viable rural economy, agricultural resources, environmentally sensitive recreation and enjoyment of the rural landscape.
4) Design neighbourhoods to improve access to community life.
5) Retain and attract jobs in Hamilton's strength areas and in targeted new sectors.
6) Expand transportation options that encourage travel by foot, bike and transit and enhance efficient inter-regional transportation connections.
7) Maximize the use of existing buildings, infrastructure and vacant or abandoned land.
8) Protect ecological systems and improve air, land and water quality.
9) Maintain and create attractive public and private spaces and respect the unique character of existing buildings, neighbourhoods and settlements.

2.1 The Link Between GRIDS and Climate Change

GRIDS will determine the broad land use pattern and infrastructure required to accommodate new people and jobs in Hamilton in a way that supports VISION 2020. It will guide planning and infrastructure decisions for the next 30 years. Since planning and infrastructure decisions have the potential to affect GHG emissions and the ability of Hamilton to adapt to climate change, it is prudent to look at issues that should be considered in the GRIDS process.

[2] http://www.vision2020.hamilton.ca/forms/foundation-building/list-of-studies.asp
[3] www.vision2020.hamilton.ca

Hamilton Interview Results

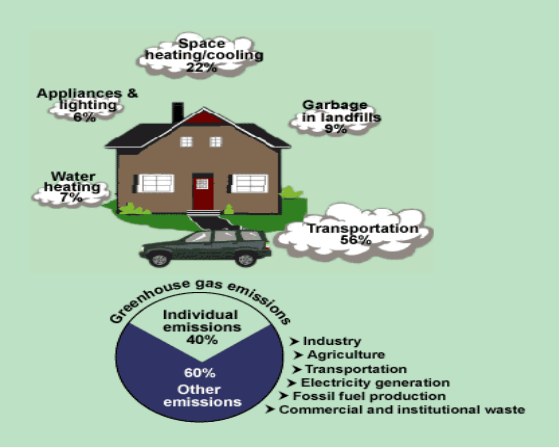
Senior city staff were interviewed to determine what they considered to be key vulnerabilities to be considered with development of the GRIDS plan. The interviews are summarized in Appendix C. The concerns highlighted by various stakeholders aligned with expected results. Clearly when speaking with the staff, consideration of Climate Change issue is still at a fledging state and there was an expressed need for more awareness and education. The key issues included:

- Transportation[4];
- Extreme weather;
- Health impacts;
- Urban Sprawl; and
- Energy management

Specifically relevant to GRIDS is the creation of sustainable infrastructure, which should be affordable to the community in the short-term and in the future. It should also encourage conservation of resources and the responsible management of natural systems as an integral part of the development strategy. A holistic cost analysis of infrastructure projects is necessary to support beneficial urban development, maximize existing infrastructure, and optimize new development[5]. Sustainable infrastructure planning includes the following services:

- Transportation
- Water
- Wastewater
- Stormwater
- Energy Supply

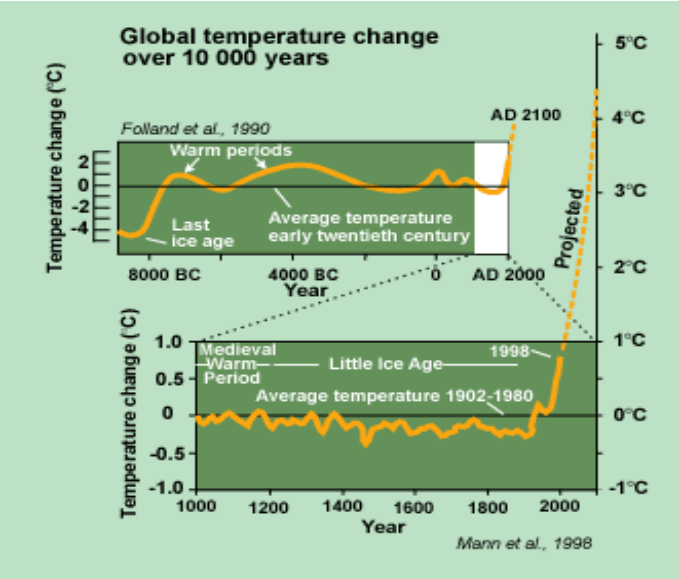
Clearly, as per the figure below, transportation is by far the greatest generator of greenhouse gas. Transport is also directly dependent upon the infrastructure surrounding a location. This includes shopping, commuting to work, recreational centres and schools.



DOE, 1998 (Revised by Torrie Smith Associates)
http://adaptation.nrcan.gc.ca/posters/articles/on_09_en.asp?Region=on&Language=en

[4] City of Hamilton - Transportation Master Plan Phase Two. Funding and Financing of Transportation Infrastructure Policy Paper, Transportation Energy Use and Greenhouse Gas Emissions Policy Paper.
[5] ICLEA

2.2 Why Climate Change is Important and Relevant to Communities



http://adaptation.nrcan.gc.ca/posters/articles/on_09_en.asp?Region=on&Language=en

The climate change issue has graduated from a debatable topic to a scenario that must be considered and anticipated. Although there are extremes to every scenario, a practical and realistic attempt must be made to quantity potential threats. In reality, Natural Resources Canada's 10,000 year timeline highlights the gradual global temperature trends showing that climate change is accelerating.

The Adaptive Capacity Workshop (Nov 2003) hosted by the Climate Change Impacts and Adaptation Directorate (Natural Resources Canada) and the Climate Change and Health Office (Health Canada) highlighted the need for communities to:

- **monitor / mitigate emissions, and**
- **adapt to climate change.**

Adaptation reduces vulnerability to climate change, and includes anticipatory actions taken prior to impacts occurring, and reactive steps taken to address real existing impacts. Adaptation can be planned or spontaneous. Whereas natural systems adapt reactively and spontaneously, managed human systems require more anticipatory and planned adaptation strategies. **Since many impacts of climate change are projected, the ability to link actions with future consequences is necessary.** Synergy among all stakeholders is necessary to facilitate this process.

The process of adaptation involves:

- Answering the questions:
  - What are the vulnerabilities? What is being adapted to?
  - What or who must adapt?
  - How will adaptation happen?
- Review practicality and feasibility of presented options

- Understanding the sensitivity and adaptive capacity of the region, knowledge regarding options, and collaboration between all parties.

3 ADAPTIVE CAPACITY

The Intergovernmental Panel on Climate Change (IPCC) defines adaptive capacity as "the ability of a system to adjust to climate change (including climate vulnerability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences". Therefore adaptive capacity is a measure of the ability to adapt to change. A high adaptive capacity enables a system to cope with or even benefit from changes in climate. On the other hand, a system with low adaptive capacity would be more vulnerable to any climate changes.

Adaptive capacity includes both natural ecosystems and human systems. While natural systems are driven by the Darwinian evolution and survival instincts, a wide range of motivations drives humans, including health, wealth, progress and happiness. Therefore the possibility and probability of a specific adaptation method may vary greatly.

Vulnerability depends upon a system's exposure to climate change, sensitivity to those impacts, and adaptive capacity. As adaptive capacity increases, vulnerability decreases. Quantifying vulnerability can be achieved by allocating a factor for exposure, sensitivity and adaptive capacity.

Vulnerability = Exposure x Adaptive Capacity

To determine the vulnerability of a community such as Hamilton, influencing factors must be reviewed, and action taken to enhance adaptive capacity. Improving adaptive capacity is a policy objective that reduces future vulnerability to climate change and improves resilience to present-day stresses. This also allows for the consideration of extreme scenarios such as drought, hot/cold temperatures and severe rain events.

Commonly identified determinants of adaptive capacity are listed below[6]:

Determinant	Explanation
Economic Resources	▪ Greater economic resources increase adaptive capacity ▪ Lack of financial resources limits adaptation options
Technology	▪ Lack of technology limits range of potential adaptation options ▪ Less technologically advanced regions are less likely to develop and /or implement technological adaptations
Information and Skills	▪ Lack of informed, skilled and trained personnel reduces adaptive capacity ▪ Greater access to information increases likelihood of timely and appropriate adaptation

[6] Smit et al, 2001

Infrastructure	▪ Greater variety of infrastructure can enhance adaptive capacity, since it provides more options ▪ Characteristics and location of infrastructure also affect adaptive capacity
Institutions	▪ Well-developed social institutions help to reduce impacts of climate-related risks, and therefore increase adaptive capacity ▪ Policies and regulations have constraints or enhance adaptive capacity
Equity	▪ Equitable distribution of resources increases adaptive capacity ▪ Both availability of, and entitlement to, resources is important

Factors that influence adaptation decision making include:

- Drivers – population and development pressures, funds or regulations from other levels of government, internal concerns, etc.
- Enabling factors – staff / management / political interest, previous experience, etc.
- Barriers – costs, attitudes, hidden agendas, control, acceptance, etc.
- Obstacles – attitudes, communication problems, media, accurate information, etc.
- Conflict resolution – education, incentives, scientific evidence / information, comfortable governance / management structure, etc.

4 DETERMINING VULNERABILITY

A proposed framework[7] for measuring vulnerability is:

1. Determine the system of concern
2. List all possible adaptation options
3. Determine a feasibility factor (FF) for each adaptation option
4. Determine an likelihood or efficacy factor (EF) for each adaptation option
5. Multiply FF by EF to get calculate potential coping capacity (PCC)
6. The overall lead coping capacity (CCL) is the highest PCC
7. An index of robustness (R) is then determined by comparing all options. A high R value indicated a high adaptive capacity.

Hence giving numerical values to each of these parameters is a subjective process, which makes quantifying vulnerability an interesting process.

[7] Yohe and Tol, 2002

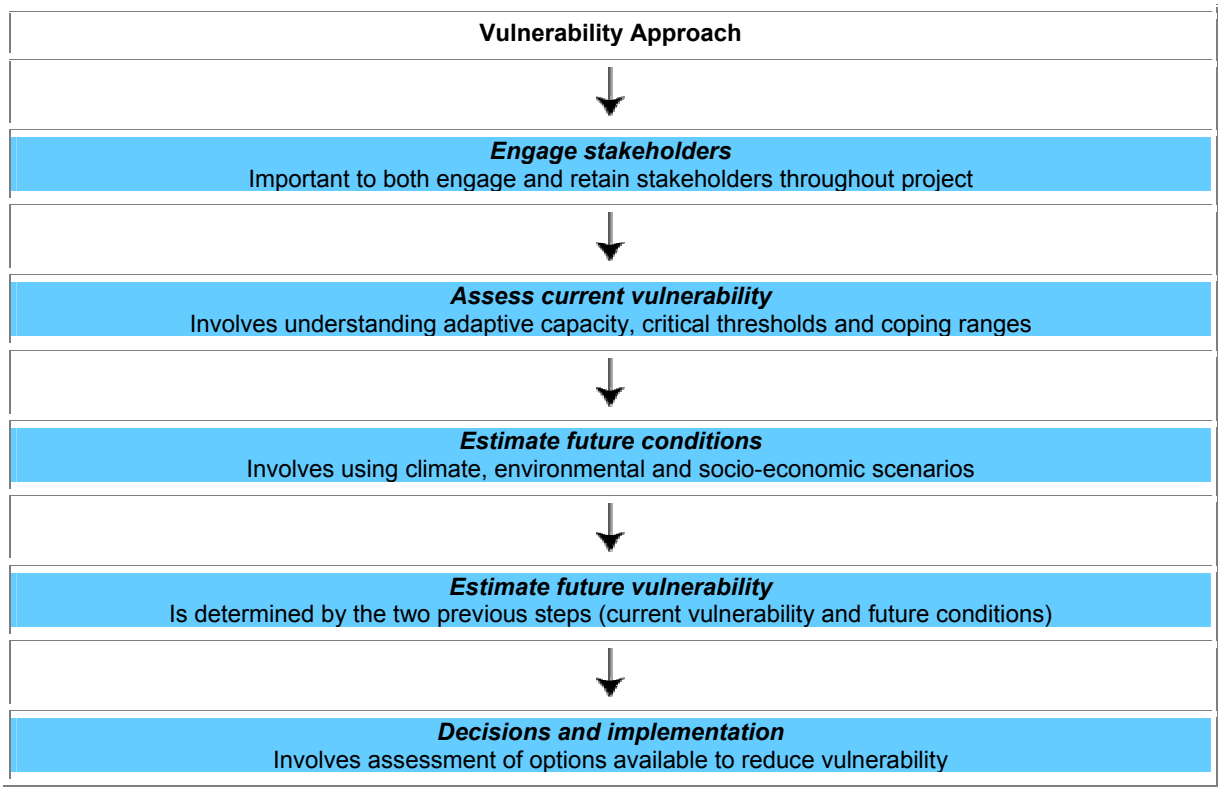
To illustrate this example, options to reduce poor air quality due to transportation emissions are compared. For clarification, refer to items 1-7 above. Assuming a range of 1-10 with a high rating indicating high feasibility and efficacy for that scenario.

Option	Feasibility Factor	Efficacy Factor	Potential Coping Capacity	Coping Capacity Lead	Robustness
Car Pooling	8	8	64	64	High
Wear Face Masks	6	3	18	64	Medium
Ban high emission vehicles	9	1	9	64	Low

Clearly, car pooling is a more feasible option to address vulnerability in the short term. Perhaps a long term evaluation could yield different results.

An Analytical Framework to assess the vulnerability of communities, was developed by C-CIARN (Canadian Climate Impacts and Adaptations Research Network), is extracted from the report "Climate Change Impacts and Adaptation: a Canadian Perspective"[8].

Steps in the vulnerability approach. Note that research need not follow a linear progression; instead, the process should be iterative, with some steps being undertaken simultaneously.



[8] www.adaptation.nrcan.gc.ca/perspective_e.as

> The primary goal of the vulnerability approach is to promote research that contributes to adaptation decision-making by providing a framework in which priorities can be established in spite of the uncertainties concerning future climate change.

The interactions between human and natural systems must be established in a specific region in order to determine potential vulnerability to climate changes in the present and in the future. For detailed information, The Canadian Institute for Climate Change[9] lists climate change severity data for each of winter/summer discomfort, psychological, hazard and outdoor mobility. As this data accumulates, specific trends and relationships can be validated.

The field of vulnerability and adaptive capacity assessment is moving ahead quickly due in large part to the commitment of the Federal government through research and funding. An on-line tool developed by the Oak Ridge National Laboratory[10] is aimed at determining vulnerability and response assessment (VARA) by using the following five step process:

Step #	Description
1	Consider what is distinctive about your city that may affect its vulnerability to climate change impacts, such as its location, its size, and its resources available
2	Estimate possible effects of climate change in your city, such as warming, changes in precipitation patterns, changes in sea level and/or changes in severe weather event frequency or behavior
3	Estimate impacts of these changes on your city, reflecting its distinctive circumstances
4	Identify coping capacities and potentials for increasing your city's resilience to possible impacts of climate change
5	Identify possible strategies for action to increase your city's resilience, including steps to take to explore the strategies

This model is suggested for use in the creation of Hamilton's Climate change Action Plan in the future.

4.1 Hamilton and Climate Change Vulnerability

Hamilton in particular is poised for significant growth over the next 30 years, and has a critical responsibility to consider climate change impacts and mitigation due to:

- The recent amalgamation of six municipalities (Hamilton, Stoney Creek, Glanbrook, Dundas, Ancaster, Flamborough) has increased overall land size to over 1,100 square km under a single tier governance system.
- Infrastructure is aging and decisions are now required on locating and designing new infrastructure.

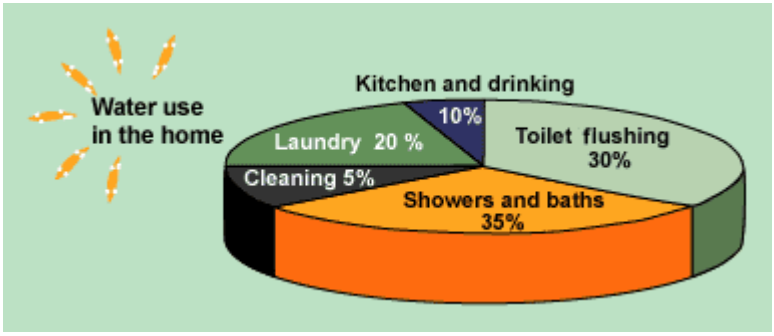
[9] http://www.cics.uvic.ca/severity/maps/select.cgi
[10] www.public.ornl.gov/vara/vara_fivesteps.cfm

- Hamilton has a geographic and economic position as one of the top ten port cities in Canada at 12 million metric tonnes, 700 vessels in 2002 (http://www.hamiltonport.ca/commercial.asp)
- There is a current trend towards higher vehicle emissions due to commuting: Hamilton has a low population/employment ratio and could become a bedroom community for Toronto and other communities.
- The environmentally sensitive Niagara Escarpment UN biosphere reserve runs through the urban area.
- There is a need to accommodate growth. There are opportunities to create compact growth given the need for downtown core rejuvenation and the significant brownfield lands potentially available for re-development.
- There are urban growth pressures on prime agricultural farmland

In fact, the GRIDS Project Status Update[11] of June 4, 2004 highlights that:

- The population of Hamilton is expected to be 622,000 in 2031 - compared with the current 2001 population of 503,000 (www.hamilton.ca);
- The number of households in Hamilton will increase by approximately 81,000 between 2001-2031;
- A minimum of 825 ha. (700 acres) of additional employment lands are required to accommodate projected employment growth; and
- Approximately 40,000 new dwelling units can be accommodated within the existing urban area.

Increasing population is analogous with increased demands on infrastructure and resources. The water–use diagram below breaks down consumption patterns into different sectors. The key point is that the increased population predicted for Hamilton will impact all services, including such things as water supply and water treatment. Water quality and supply will also be affected by climate change.



Environment Canada.

4.2 Specifics of Vulnerability

The following key climate change impacts and adaptation issues were flagged at the C-CIARN Ontario Workshop on November 28-29, 2002. A preliminary rating of low/

[11] Report #CMO4017

medium or high priority was delegated to each category. However, it should be noted that each further review is required in each area for vulnerabilities specific to Hamilton, Ontario.

4.2.1 Ecosystem Health

Threats From:	Priority
Extreme weather events	High
Ice changes	Medium
Lower Lake Levels	High
Loss of Wetlands	High
Cumulative Impacts	High
Threats To:	
Biodiversity	High
Land Resources	Medium
Management Ability	High
Water Quality and quantity	High
Air Quality	High
Other	

4.2.2 Infrastructure

Threats	Priority
Runoff and landslide impacts (flooding)	High
Water intake / control infrastructure (water quantity)	Med
Deterioration of infrastructure (buildings, roads, etc.)	High
Damage to infrastructure (roofs, roads, transmission towers, etc.)	High
Reduced security of energy supply	High
Design Specifications / margin of safety of building codes	Med

4.2.3 Human Health

Threats	Priority
Vector borne diseases	High
Extreme weather – extreme heat or cold	High
Deteriorating air quality	High
Deteriorating water quality	High
Secondary impacts (e.g. indoor moulds, weather related transportation accidents and fatalities)	High
Collective / Cumulative impacts	Med

4.2.4 Water Resources

Threats From:	Priority
Increased capacity demands on sewage /water control system	High
Pressures on source of water resources	Med
Change in pattern of supply (municipal management implications)	Med
Social and economic impacts (e.g. tourism, recreation)	High

Degraded water quality	Med

Additional categories were selected from the Canadian Climate Impacts and Adaptation Research Network (C-CIARN) website and issues prioritized. Although there is some overlap, it is important to note the spectrum of impact scenarios.

4.2.5 Health

Health Concerns	Examples of Health Vulnerability	Priority
Temperature-related morbidity and mortality	• Cold and heat related illnesses • Respiratory and cardiovascular illnesses • Increased occupational health risks	High
Health effects of extreme weather events	• Damaged public health infrastructure • Injuries and illnesses • Social and mental health stress due to disasters • Occupational health hazards • Population displacement	High
Air pollution-related health effects	• Changed exposure to outdoor and indoor air pollutants and allergens • Asthma and other respiratory diseases • Heart attacks, strokes & other cardiovascular diseases • Cancer	High
Health effects of water and food-borne contamination	• Diarrheas and intoxication caused by chemical & biological contaminants	Low
Vector-borne and zoonotic diseases	• Changed patterns of diseases caused by bacteria, viruses and other pathogens carried by mosquitos, ticks and other vectors	High
Health effects of exposure to ultraviolet rays	• Skin damage and skin cancer • Cataracts • Disturbed immune function	High
Population vulnerabilities in rural and urban communities	• Seniors • Children • Chronically ill people • Low income and homeless people • Northern residents • Disabled people • People living off the land	High
Socio-economic impacts on community health & well-being	• Loss of income and productivity • Social disruption • Diminished quality of life • Increased costs to health care • Health effects of mitigation technologies	Med

4.2.6 Water Resources

Impact	Priority
Low water levels may result in:	
• Extension &/or relocation of municipal & industrial water intakes.	Med
• Water supply, odour and taste problems with increased weed and algae concentrations.	Med
• Increased incidence of flooding and erosion.	Med

• Increased beach size. • Exposure of toxic sediments. • Increased frequency of boats running aground. • Increased frequency and intensity of precipitation affects water quality.	Low High Low Med

4.2.7 Transportation and Navigation

Impact	Priority
Lower water levels will affect the navigability of rivers and lake, forcing ships to carry lighter loads	Med
Reduction in ice cover could increase the length of the commercial shipping season. However, increases in extreme Fall and Winter storms could create hazardous conditions for shipping	Med
Reduction in sea-ice cover could make other ports, such as Churchill, more economically viable	Low

4.2.8 Hydro Power and Energy

Impact	Priority
Extreme meteorological events (ice storms, tornadoes, etc.) which may become more frequent due to climate change, affect power infrastructure	High
Changing stream flow regimes and take levels could adversely affect electrical production	High
Accurate forecasts of power demand under extreme climate scenarios would be difficult	High

Additional categories that relate to Hamilton and climate change and GRIDS less directly are included in Appendix B. These categories include:

- Coastal Zones - Great Lakes Region
    - Changing water level impacts
    - Changing weather conditions
    - Changing lake and ice conditions
    - Changing human use
- Agricultural
- Fisheries
- Forest
- Landscape Hazards

4.2.9 Suggested Adaptations for Communities

The following adaptation options from C-CIARN also highlight the general vagueness of climate change vulnerability and adaptation strategies at this time.. However, as detailed information is collected, more precise action can determined. Recognition of the issue initiates the process.

Adaptations for Water Resources:

- Increase supply capacity, to preserve drinking water quality and quantity.

- Adjust shoreline management practices
- Use flexible structures (such as floating wharves)
- Implement public awareness and education campaign about water management.

Adaptations for Hydro Power and Energy:
- Encourage energy conservation and efficiency
- Develop coping mechanisms for changing water flows
- Design infrastructure to be resilient to current and changing climate
- Renewable Energy
- Decentralized Power

5 HOW GRIDS INFLUENCES THESE VULNERABILITIES.

The challenge when considering climate change impacts and associated vulnerabilities is the fact that such a gradual and macro-scale process is difficult to measure and more difficult to motivate others to prepare for it. As well, with so many parameters interconnected, separating one entity and drawing a causal relationship is complicated. However, it is clear that Hamilton's GRIDS includes land use and infrastructure issues that are directly related the vulnerabilities listed above.

Sprawling land use patterns are known to create climate change impacts. The City of Hamilton managers interviewed for this study recognized this. Clearly sprawling communities encourage greenhouse gas emissions through dependence on automotive transportation and energy expended to provide services including water supply and removal, gas supply, waste pickup and recycling over long distances.

5.1 Recognizing the Links Between Action and Consequences of Vulnerabilities

5.1.1 Urban Sprawl

Recognizing the link between urban sprawl and climate change vulnerability is the first step towards addressing the vulnerabilities of climate change through GRIDS. The high cost of urban sprawl is a burden on the taxpayer. At one time, cities were diverse and populated. Ironically, tremendous growth in North American cities has reduced the density and diversity of these metropolises. This runs completely counter to any sustainable development commitment.

The Suzuki document[12] lists the cost of sprawl as:

[12] www.davidsuzuki.org. Understanding Sprawl: A Citizen's Guide

Climate change – Clearly transportation contributes to GHG emissions. However, it should be highlighted that climate change also has a deleterious effect on each of the issues listed below– by increasing Hamilton's risk exposure and therefore vulnerability.

Low-density means high cost over time – extension of services is subsidized by existing taxpayers.

Household costs of sprawl – Transportation is a major expense with the average annual vehicle ownership in Canada costing $6,262.43 (or $17.16 per day) plus 12.15 cents per kilometre. This amounts to 13% of family expenditure, exceeding food consumption at 11%. Time is also an invaluable that is spend driving to destinations. Currently about 25% of Hamilton's employed population out-commutes to other cities. At this rate, the number of people commuting will increase to over 50% if no changes are made.

Consuming precious land – Prime agricultural land has been used for development. This has encouraged urban sprawl by providing a lower-cost alternative for the market. The major problem is commuting between work and home. In addition to having negative social and economic impacts for the City, commuting is one of the main GHG contributors.

Public health – vehicles emit pollution, including greenhouse gases that have detrimental health effects. Acid rain, fine particulate matter, and smog cause detrimental cardio-vascular, respiratory and environmental effects. Vehicle accidents causing death and injury are another clear impact. Finally, obesity and related diseases and disabilities increase with car dependence.

Energy – There is a life-cycle cost of energy that is largely ignored. For example, each barrel of oil produced creates 125 kilograms of GHG during production.

Water - Asphalt and concrete change the water patterns, and prevent water from percolating into the ground. This collected water is then treated at the wastewater treatment plant.

Wildlife – Habitat destruction occurs as urban sprawl encroaches on wetlands and woodlands.

5.1.2 Infrastructure

Threats to infrastructure such as flooding, runoff and landslides after extreme weather events will place capacity demands on Hamilton's combined sewer management system, potentially resulting in sewage release to the harbour basin. Clearly as larger sections of land are developed and paved over, and as precipitation patterns change, collected water that would normal percolate into the water table will add to the system capacity stress Similarly, deterioration of buildings, roads, roofs, and transmission tower infrastructure

could also result, creating the need for more stringent design standards to increase system integrity.

Low water levels may result in:

- Extension &/or relocation of municipal & industrial water intakes.
- Water supply, odour and taste problems with increased weed and algae concentrations.
- Increased incidence of flooding and erosion.
- Increased beach size.
- Exposure of toxic sediments.
- Increased frequency of boats running aground.
- Increased frequency and intensity of precipitation affects water quality.

Interviews with staff indicate that overall transportation management affects Hamilton's ability to respond to climate change impacts, such as extreme weather events and freeze/thaw cycle changes.

5.1.3 Transportation Master Plan

Part of the GRIDS project involves developing a new Transportation Master Plan (TMP) for the City. Transportation is the largest generator of GHG. Therefore, this plan is critical to Hamilton's future emission levels. In the August 2004 TMP Draft Report: Transportation Use and Greenhouse Gas Emissions Policy Paper, the document states that:

- The City Government sets local policies and zoning laws that, along with real estate markets, determine the shape of land use which in turn influences the GHG's emitted for travel.
- The City can set local policies that affect car use and influence personal decisions of how to travel, for example parking supply and pricing.
- The City can influence the effectiveness of the alternatives to car use such as transit, walking and biking. The City already provides transit service and has been moving toward improving options for non-motorized travel such as bike lanes, trails and pedestrian safety.
- The City works with other local governments and agencies in the region to coordinate transportation services and policies.

This document acknowledges the critical link between public policy and transportation patterns and offers recommended policies such as (1) the recognition of the importance of energy conservation in transportation and ensuring that the City of Hamilton plays a role in helping to achieve Canada's commitment to reducing GHG emissions; (2) Ensuring Hamilton residents and businesses are able to respond to a potential future wherein the availability and price of fossil fuels makes travel by car financially difficult; (3) reducing

the amount of fossil fuels used by transportation in Hamilton by improving vehicle efficiency and reducing motorized travel, starting with municipal fleets and activities.[13]

5.1.4 Energy

Energy is critical to the GRIDS program since it is a vital element of our everyday supply. When the power stops, the systems that we rely on are not functional. Hence power generation, transmission, distribution and the maintenance of these systems must be considered carefully. Many communities are now installing wires below the ground in corridors shared with telecommunication and other services.

The interview with Bob Desnoyers stressed the need for the City to re-think energy as a critical residential service. The concept of a service corridor incorporating all of the major piped and wired infrastructure would be an excellent option, especially when access for servicing, upgrading or modifications are necessary.

Development of a master infrastructure strategy including energy as one component was suggested as an excellent project relevant to GRIDS.

Energy is another leading contributor to GHG, and conservation has the added benefit of saving the consumer money. Renewable energies, in particular are poised to be deployed in large numbers as energy costs rise and social and environmental benefits, as per the Triple Bottom Line model are prioritized.

Renewable energy also presents a tremendous manufacturing and employment opportunity for Hamilton: steel for wind towers, installation expertise, and incorporation into new construction or upgrades

One opportunity is presented at the City of Hamilton swimming pools. Currently, the majority use electric water heaters. If solar panels were installed on the building roofs, the majority of heating requirements would be met, and the costs of fuel eliminated.

As well, current waste gases from Hamilton's industrial east end could be collected to power a cogeneration plant. Energy generated would feed back into the grid and provide a local supply, thereby increasing energy security. Similarly, waste heat could be recovered from the exhaust and used to residential district heating or industrial process needs.

The Hamilton Community Energy project located in downtown Hamilton is an excellent example of a project that is a win-win situation. This project provides hot water heating to various building in the Hamilton core including City Hall and Copps Colisseum. Recently, Victoria Homes joined the "Coalition of Hamilton's District Heating Willing".

[13] City of Hamilton. Development of Policy Papers for Phase Two of the Transportation Master Plan for the City of Hamilton, SUMMARY OF PROPOSED RECOMMENDED POLICIES, September, 2004, p.6.

Renewable energy successes are found throughout the globe such as Germany and Japan that are situated at higher latitudes than Hamilton. These countries are now enjoying healthy economic benefits due to expertise in this area.

Hamilton's closing of the SWARU plant has benefited the North American air-shed, but actually created an increase in the City's GHG emissions[14]. This has also bolstered the importance of the waste management strategy which is aggressively striving for a 65% waste diversion strategy.

Other energy options include:

Energy Source	Comment
Wind Power	Positive Power – a local renewable energy coop is planning to erect a local turbine
Ethanol and Bio-diesel	A bio-diesel plant will be constructed on Hamilton's waterfront using waste animal fats
Hydro-Electric Plant	A small hydro plant is being developed at Christie's Conservation Area
Solar Water Heating, Solar Photovoltaics, Solar Air Heating	The National Water Resources Institute has large installations of these renewable energies
Ground Source Heat Pumps	The Marine Discovery Centre has a ground source heat pump system
Methane Digester	Methane recovery from landfills and the wastewater sewage plant is being studied
Lake-Water Cooling	Toronto's Enwave Project has raised the profile of the City. Perhaps Hamilton could couple this technology and use the HCE district plant piping network to provide cool lake water in the summer
Emissions Trading Options	Purchase or sell credits, renewable energy credits, hedging

5.2 Tracking Hamilton's GHG Emissions

Determining Hamilton's baseline GHG emission levels and then monitoring over time will provide an important benchmark to identify any GRIDS related emissions trends.

The Corporate Analysis of Greenhouse Gas (GHG) Emissions for the Regional Municipality of Hamilton-Wentworth/City of Hamilton (1994 and 1998) was completed in 1999. Note that 1994 was used as the base year due to lack of 1990 data.

[14] Thomas A. Brown, "Glanbrook Landfill Green Power Strategy", 2004.

Results indicate that:

	1994	1998	2005
Emissions (Tonnes eCO_2)*	18,503	17,800	14,802
% Change from Base-year (1994)	---------	- 3.8 %	- 20 %

*eCO_2 represents equivalent CO_2. All GHG's are converted to units of eCO_2.

The existing municipal inventories completed for 1994 and 1998 were still awaiting police fleet data and facilities natural gas data. FCM will be consulted to determine if this information is required to maintain accurate GHG figures. Updating of the original inventories may also be necessary.

Clearly, this analysis was very general, and more precise numbers are necessary to increase accuracy, and also determine where GHG mitigation efforts should be targeted. At this time, the City of Hamilton is using the Cities for Climate Protection emissions calculation software tool developed by Torrie-Smith & Associates and administered through the PCP. Although renewal is free of charge, annual inventories have not been conducted. Therefore, upgrades will be required, and compatibility with current computer software reviewed. A new inventory for 2003 must also be completed.

5.3 Specific Climate Change Initiatives Currently Underway in Hamilton

Title	Relevance: Adaptation (A), Mitigation (M), Vulnerability (V)
Growth Plan	A, M, V
Anti-Idling Campaign	A, M, V
Hamilton Community Energy District Heating Plant	A, M, V
GHG Inventory	A, M, V
Waste Plan	A, M, V
SWARU Shutdown	A, M, V
Transportation Master Plan	A, M, V
Dofasco/Stelco GHG Emission Reductions	A, M, V
Upwind Downwind Conference and Community Network Initiative	A, M, V
Anti-idling Bylaw	M
Fleet Greening Policies	M, V
Regional Tree Planting Program	A, M, V
Building Energy Performance Review	A, M, V
Hamilton Hydro PowerWise Program	M, V

5.4 Monitoring Hamilton's Progress

5.4.1 Vision 2020 Indicator Ratings for 2003

The VISION indicator ratings for 2003 suggest that in the past, Hamilton has not satisfactorily addressed the key parameters that affect climate change issues. This highlights the importance of accelerating progress by proactively considering climate change issues in major planning projects such as GRIDS.

- Agricultural & Rural Economy: Urban Expansion – Hectares of Agricultural Land Lost due to Official Plan Amendments. **"Needs Improvement"**
- Natural Areas and Corridors: Cumulative Area of Significant Natural Areas Protected. **"Making Progress"**
- Reducing and Managing Waste: Residential Waste Generated. **"Making Progress"**
- Consuming Less Energy: Residential Electricity Consumption. **"Hard to Say"**
- Improving Air Quality:
    - Ground Level Ozone Exceedances. **"Needs Improvement"**
    - Average Sulphur Dioxide (SO_2) Concentration. **"Making Progress"**
    - Average Nitrogen Dioxide Trend. **"Needs Improvement"**
    - Average Inhalable Particulate Matter (PM10). **"Making Progress"**
    - Hospitalization Rate for Respiratory Illness. **"Hard to Say"**
- Changing our Mode of Transportation:
    - Transit Ridership per Capita. **"Needs Improvement"**
    - Number of Cars per Capita. **"Needs Improvement"**
- Land Use in Urban Area: Residential Permits - Downtown Core. **"Making Progress"**
- Personal Health and Well Being. **"Needs Improvement"**

As a community, Hamilton's transportation trend is dismal considering that transit ridership and transit funding is decreasing while personal use of cars is increasing. This runs counter to the desired trend of increased use and support of public transportation.

6 FUTURE RESEARCH NEEDS TO ASSIST COMMUNITIES IN ADDRESSING CLIMATE CHANGE

The C-CIARN workshop[15] identified the following research needs to assist with assessment of climate change vulnerabilities and adapt to climate change. This will require support from senior government.

Ecosystem Health	• Resolution of climate models at scale appropriate to municipal decision makers (regional and temporal) • Baseline data on biodiversity is required including cataloguing species as well as distribution, population size, risks, habitat, space and other parameters • Research to improve adaptive management approaches (holistic approach)

[15] C-CAIRN Workshop November 2003

	• Sufficient data to set targets is required. Catalogue existing targets and evaluate in terms of climate change
Human Health	• More effective surveillance, monitoring including GIS mapping of disease, vectors and vulnerable communities • Research into cumulative, synergistic, non-linear impacts (e.g. ecosystem fragmentation) • Research into communication strategies and market research
Infrastructure	• Data to revise design criteria with updated climatic design values • Cost/benefit analysis of increased redundancy for critical infrastructure • Evaluation and update of current community emergency preparedness • More information required on secondary issues • Evaluations of adaptation and mitigation measures and their sustainability
Water Resources	• Data on existing groundwater supplies and recharge capacity • Research into regulatory measures needed to balance groundwater supply versus demand exacerbated by a warming climate • Water resources and related issues of infrastructure design and capacity, human health and ecosystem health • Research into decision making process and the enabling of adaptive behaviour in communities • Inventory of hidden subsidies that lead to adverse adaptation

7 WHAT ARE OTHER COMMUNITIES DOING TODAY?

Many government-funding initiatives are now centred around climate change. In essence, the Kyoto Protocol is merely a catalyst to foster sustainable growth. Therefore, it is wise for Hamilton to look at similar programs in other cities within Canada, the US, and elsewhere.

The International Council for Environmental Initiatives (ICLEI) and the Federation of Canadian Municipalities' (FCM) 20% Club have merged to form "Partners for Climate Protection: For a Better Quality of Life." The (PCP) program will support Canadian local governments in reducing greenhouse gas and air pollution emissions through development and implementation of local climate action plans.

The municipalities involved represent 61 percent of the population of Canada. Participants in the PCP are also part of ICLEI's International CCP, which now represents eight percent of global carbon dioxide emissions. This includes 250 members in North America. Appendix E lists the IPCC adaptation and vulnerability chapter sections for North America. Review of this information is beyond the scope of this document.

The David Suzuki Foundation states that: "Municipalities across Canada are reducing greenhouse gas emissions through a wide range of projects. Local governments say they can achieve one quarter of Canada's Kyoto target while creating jobs and strengthening the health of our communities". The target areas are transportation, electricity, industry, buildings, landfills, awareness and alternative energy.

7.1 Canadian Community Success Stories

Canadian Community success stories[16] include:

Halifax: A city-wide composting program now prevents organic matter from reaching landfills. This has cut methane production by the equivalent of over half a million tons of carbon dioxide per year, compared to 1995.

Calgary: Achieving its target of six per cent below 1990 levels ahead of schedule and at 50 per cent projected costs, with substantial energy bill savings and employment created. Through the "Ride the Wind" initiative, the light rail system is powered by wind-generated electricity.

Edmonton: Target - to reduce emissions by six per cent below 1990 levels by 2010, and 20 per cent by 2020. Has already reduced emissions through one landfill waste-to-energy project by 174,949 tonnes.

Regina: Reduced emissions from internal operations nine per cent, or 10,000 tonnes annually, from 1988 levels. Energy retrofits will reduce emissions another four per cent and save $400,000 annually.

Sudbury: Will reduce emissions by 21,000-51,000 tonnes per year with a co-generation and district energy system. Retrofit programs aim to reduce energy consumption 30 per cent and save more than $800,000 annually.

St. John's: Retrofits to municipal buildings are expected to deliver annual energy savings of $600,000, improve workplace lighting and comfort levels, and reduce maintenance costs.

Toronto: Reduced emissions by 67 per cent below 1990 levels, exceeding the city's goal threefold, generating thousands of jobs and reducing costs for many operations. Success was achieved through landfill waste-to-energy programs, energy efficiency building retrofits, streetlight changes, and more efficient vehicle fleets.

Profiles of leading companies listed included Hamilton's **Dofasco** (Steel Production), since Dofasco reduced emissions 22 per cent below 1990 levels by 1999, and 20 per cent per unit of production. The target is to further improve specific energy intensity by 10 per cent by 2010.

7.2 Resources Available

The Canadian Climate Impacts and Adaptation Research Network (C-CIARN) has links to existing studies that other municipalities have created and are now implementing.

[16] www.davidsuzuki.org

The Mission of C-CIARN

The National, Regional and Sectoral C-CIARN Coordinating Offices will build a network of researchers and stakeholders involved in climate change impacts and adaptation, facilitate research, and help to provide voice and visibility to the issue.

C-CIARN Objectives

- Establish a national coordination office of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN) and a set of C-CIARN Sectors and Regions.
- Provide coordination, facilitation and advice to researcher groups in each C-CIARN Region and Sector.
- Identify and promote research priorities that address impact and adaptation uncertainties of importance to stakeholders.
- Develop an integrated communications program to share relevant information among the research and stakeholder community and to help to increase the visibility and understanding of climate change impacts and adaptation issues among policy makers and the public.
- Assist in Canadian climate change impacts and adaptation assessments.

A comprehensive list of climate change resources can also be found in the VISION 2020 Annual Sustainability Indicators Report, http://www.vision2020.hamilton.ca/NewVision2020pdf/Indicators2003/climate-change.pdf

8 CONCLUSIONS AND RECOMMENDATIONS

Hamilton's vulnerability to climate change must be a key consideration for future development in this thriving municipality. Health, water, infrastructure, and energy are all intricately linked in a vulnerable network. As a transforming industrial hub on the Niagara-Toronto corridor, the region is poised for tremendous growth over the next 30 years. Growth patterns, geography and ageing infrastructure are all factors that influence Hamilton's vulnerability to climate change.

City managers and staff interviewed for this report flagged many of the same key vulnerabilities highlighted by the literature. However, it was clear that in-depth consideration of the related impacts and response to these scenarios has not been developed in detail.

Hamilton in particular is poised for significant growth over the next 30 years, and has a critical responsibility to consider climate change impacts and mitigation due to:

- The recent amalgamation of six municipalities (Hamilton, Stoney Creek, Glanbrook, Dundas, Ancaster, Flamborough) has increased overall land size to over 1,100 square km under a single tier governance system.
- Infrastructure is aging and decisions are now required on locating and designing new infrastructure.
- Hamilton has a geographic and economic position as one of the top ten port cities in Canada at 12 million metric tonnes, 700 vessels in 2002 (http://www.hamiltonport.ca/commercial.asp)
- There is a current trend towards higher vehicle emissions due to commuting: Hamilton has a low population/employment ratio and could become a bedroom community for Toronto and other communities.
- The environmentally sensitive Niagara Escarpment UN biosphere reserve runs through the urban area, complicating growth and infrastructure choices.
- There is a need to accommodate growth. There are opportunities to create compact growth given the need for downtown core rejuvenation and the significant brownfield lands potentially available for re-development.
- There are urban growth pressures on prime agricultural land

In fact, the GRIDS Project Status Update[17] of June 4, 2004 highlights that:

- The population of Hamilton is expected to be 622,000 in 2031 - compared with the current 2001 population of 503,000 (www.hamilton.ca);
- The number of households in Hamilton will increase by approximately 81,000 between 2001-2031;
- A minimum of 825 ha. (700 acres) of additional employment lands are required to accommodate projected employment growth; and

[17] Report #CMO4017

- Approximately 40,000 new dwelling units can be accommodated within the existing urban area.

Hamilton has a tremendous opportunity to begin to proactively manage it's vulnerability to climate change by looking at land use and infrastructure during the GRIDS process. Some basic policies derived from local interviews and senior government research include:

- Protect existing greenspace to buffer extreme air and water related impacts of weather.
- Establish a legislated urban growth boundary and support rejuvenation of the downtown and development of existing brownfields to foster a more efficient land use pattern and reduce sprawl.
- Plan to facilitate the use of alternative modes of transportation (i.e. non-vehicle).
- Increase the supply capacity to preserve drinking water quality and quantity.
- Adjust shoreline management practices.
- Design infrastructure to be resilient to changing climate.
- Design land use patters to facilitate decentralized energy supply (community energy and the use of renewable energy sources).
- Consider overall transportation management to increase ability to adapt to climate change impacts such as extreme weather events and changing freeze-thaw cycles.

All of these suggestions relate directly to Hamilton, and many are reflected in the Nine Directions developed by the Hamilton community and adopted by Council in September, 2003. Maintaining conformity to the Nine Directions will decrease Hamilton's vulnerability to climate change through the creation of a more compact urban form and changes to the transportation network. Other opportunities to reduce vulnerability are more directly related to the master plan process as they relate to water, waste-water, transportation and storm water.

The linkage between land use and transportation, infrastructure, sustainable development, environment, health,, and climate change are known. For Hamilton, GRIDS and many other initiatives are striving for the same overarching sustainable development targets of VISION 2020, which will help Hamilton reduce GHG emission and adapt to climate change.

Specific next steps for Hamilton GRIDS process include:

- Foster sustainable development by considering the Nine Directions of GRIDS and the Triple Bottom Line accounting when evaluating growth options.
- Focus on the main contributors to GHG and adaptability – land use patterns, transportation and energy management (conservation and renewable energy, waste diversion, vehicle miles traveled).
- Have water, wastewater and stormwater master plans investigate local implications of climate change.

Future work on the Climate Change action plan may include:

- Assess the state of additional determinants of Hamilton's ability to adapt to climate change (i.e. economic resources[18], technology, information /skills, institutions and community equity).
- Continue to partner with senior government officials to identify and address Hamilton's climate change vulnerability as new information becomes available
- Explore senior government pilot projects and seek funding through partnerships.
- During the development of the Climate Change Action Plan, consider adaptation and mitigation opportunities less directly related to GRIDS. These include extreme weather, health impacts, energy management including conservation, and renewable energy).
- Continuously monitor, track and evaluate infrastructure vulnerability including deterioration or damage to roofs, roads, buildings, transmissions towers, energy supply, water systems, and land stability (landslides).
- Develop an accurate and well-managed GHG inventory management system
- Assess the performance of existing buildings – conservation is the key to energy management.
- Recognize the common high-level goals of various initiatives.
- Applauding the excellent initiatives that are currently in progress in Hamilton
- Continue to support projects to increase awareness about GHG (e.g. Federal One-Tonne Challenge Program).
- Form strategic partnerships and learn from other efforts.

Tools are available with additional resources being developed by senior government. Now is the time to embrace the opportunity by acknowledging the cause and effect relationships of climate change, especially as GRIDS develops. Many other Canadian communities are already doing so.

- [18] For example, "*Prepare appropriate financial contingency strategies for seasonal and economic fluctuations (e.g. winter control, climate change, social services, tax stabilization."* Roadmap to Sustainability – A White Paper, City of Hamilton, 2004

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Appendix A
City of Hamilton Project - Interview Summary

John Mater, Director of Fleet & Facilities Public Works Department X-3982 ENERGY MANAGEMENT Two key initiatives for Fleet and Facilities: Green Fleet Transition Plan • report to Council late 2004 • increased use of hybrids • alternative fuels (i.e. biodiesel) • on-going fleet reduction by users • hybrid transit buses (Transit Fleet Division) Facilities Energy Management • development of feasibility study to review energy performance of 20 City buildings is on-going • potential to expand to all facilities • reduced fuel use and emissions	Aug 19/04 – 3 pm
Tim Boychuck, Assistant Deputy Fire Chief Hamilton Emergency Services – Fire • Extreme weather events • Amalgation of the new City of Hamilton creates a coverage area of 1,200 square km. Include a map of the city of Hamilton. • The blackout of 2003 re-enforced the need for individual power sources at each fire station to permit safe and secure operation. • During rural expansion, service (fire hydrant) access considerations must be included to service future development (not part of the new Binbrook supply line). • The need for good arterial roads is necessary for quick response. The Red Hill Creek Expressway should provide some of this access. • ULC Fire Underwriter's Survey rates Hamilton as the #1 for Urban Fire Protection in Canada. Rural coverage is not as ideal, due to recent amalgamation and large land coverage required. • Air quality also cited as an issue. Fire response will manage any incoming calls to the best of their ability. Although respiratory-related calls may be relatively simple to handle, the frequency should be monitored. • Erosion may be an issue if infrastructure failures result from sinkholes or other deteriorating conditions. • Hamilton has an aggressive sewer/stormwater overflow tank management plan. The catch with this is that enormous volumes of water are treated even though it is clean rain water – hence an added long-term expense.	Aug 13/04 – 9:15 am
Robert Hall, Community Health, rhall@hamilton.ca X-3571 Interview	Contacted. No response.
Marilyn Baxter, BARC, 905-527-7111 • BARC is still managing past mistakes to restore the ecosystem health. Once these are addressed, proactive climate change measures will be part of the focus. • Current issues include habitat restoration, phosphorous levels, and the Randle Reef containment project • Lake Ontario water levels are controlled by the St. Lawrence Seaway, therefore the impact of climate change to local water conditions should consider this.	Aug 20, 2004
Cathy Plosz, Natural Heritage, City of Hamilton, Eco-Systems, Ext. 1231 • Monitoring is important • Use current systems in place – Clean Air Hamilton and Vision 2020 Sustainability Indicators	Aug 18, 2004

Dr. Brian McCarry, Chair, Clean Air Hamilton, Professor McMaster University, mccarry@mcmaster.ca 905-525-9140 Ext. 24504	Ongoing Discussion
Helen Tanguay, Planner – Transportation Master Plan (TMP)	Refer to TMP
Bill Janssen, Ext. 1261 (for help is necessary)	Contact not made
Robert Desnoyers, President, Hamilton Community Energy 905-317-4722 • Utility service supply corridors should be integrated as part of a uniform channel – this includes water supply, wastewater return, electricity, telecom, district heating, and gas supply. This will reduce construction costs (no furnace for example), and increase diversity, security and reliability of supply. Opportunities include: • Distributed generation – HCE Downtown • Provincial RFP for Renewable Energy – Hamilton has potential small hydro, additional cogeneration district heating using heavy industry process gases (now flared), methane recovery, energy-from-waste, and WWT sludge digester gas. • With growth, development a sustainable mix of alternative power. • GHG will be impacted significantly through conservation and deployment of wind, solar, etc. • Development of a Community Energy Plan would be important part of a larger Utility Infrastructure Plan. • Look at other communities that are being innovative (e.g. Markham)	Aug 18, 2004
Bob Price, ICLEA Climate Change Specialist, Berkeley, CA, 510-540-8843, bprice@iclei.org • Still high uncertainty when determining vulnerabilities of specific regions • "VARA" vulnerability tool at http://public.ornl.gov/vara/. • International Panel on Climate Change (IPCC) website http://www.grida.no/climate/ipcc_tar/wg2/545.htm	Aug 20, 2004
Jim Harnum, Director of WWT and Public Works, Ext. 4483	Referral to Bill Pasel
Bill Pasel, Emergency Measures Coordinator, Ext. 5787 • Agricultural growing cycles • Overall transportation management • Freeze/thaw cycles – port shipping • Hot weather – increase electrical air conditioning load • Vector borne diseases	Aug 17, 2004
Connie Verhaeghy, Emergency Response Planner, Ext. 3531 • Severe heat - seniors and children impacted • Air quality – respiratory issues • Pest management (includes West Nile) • Flooding	Aug 17, 2004

Appendix B
Vision 2020 Background Studies related to GRIDS. www.vision2020.ca

Economics	• Economic Development Strategy Report • Residential Land Economics • Hamilton Airport Gateways Opportunities Study • Golden Horseshoe Biosciences Strategy
Population, Housing, Labour and Employment Forecasts	• HR Matters • Population, Housing and Employment Forecast
Social and Health	• Social Vision for the New City of Hamilton • GRIDS Context Paper Regarding Social and Health Consideration in the City of Hamilton
Land Use	• Industrial Business Park Review • Keys to the Home • Commercial Land Use Inventory • Institutional Land Use Inventory • Open Space Inventory • Assessment Data Verification • Commercial Marketing Analysis • Vacant Residential Land Use Inventory • Industrial Land Use Inventory • Intensification Opportunities • Setting Sail • Historic Land Use Inventory
Rural Issues	• Agricultural Economic Impact Study • Agricultural Land Evaluation and Area Review (LEAR)
Natural Heritage	• Ground Water Assessment • Natural Heritage System – GIS Project • Natural Watercourse Inventory and Condition (Quality) • Natural Watercourse Inventory and Condition (Quantity) • Public Health, Mortality and Hospital Admissions Attributable to Air Pollution in Hamilton, 2003 • Hamilton Vulnerability to Climate Change • Hamilton's Greenhouse Gas Emissions Inventory
Cultural Heritage	• Archeological Inventory • Cultural Heritage Landscape Survey • Heritage Building Inventory
Infrastructure	• Wastewater Collection Master Plan • Water Distribution Master Plan • Storm Water Master Plan • Transportation Master Plan
Financial	• Financial Feasibility Study • Sustainability Assessment (Triple Bottom Line Principles)

Appendix C
Additional Vulnerabilities

. Additional categories were selected from the Canadian Climate Impacts and Adaptation Research Network (C-CIARN) website and included in Appendix D. Where appropriate, issues were also prioritized.

Coastal Zones - Great Lakes Region

Changing Water Level Impacts (includes long-term fluctuations, erosion & flooding)	**Priority**
Wave climate, coastal circulation, sediment redistribution and other physical processes	Low
Shoreline ecosystems, particularly estuaries (e.g. increased loss, rate of migration or succession of coastal wetlands, periodic flushing during storm events)	Med
Ecosystem biodiversity (includes species life cycles, population sizes, migration patterns, species distribution, species diversity & productivity)	High
Low levels - Coastal communities & infrastructure (e.g. municipal water intakes may need to be relocated, exposure of timber frame wharves to dry rot during low water)	Med
High levels - Coastal landowners, communities & infrastructure (e.g. during extended periods of low lake levels development may encroach into low-lying flood prone areas)	Low
Low levels - Transportation & navigation (e.g. maintaining of navigational channels, shipping routes & ports)	Med
Low levels - Human activities such as tourism & recreation (e.g. maintaining of navigational channels, marina access & issues of reduced coastal access)	Med
Hydroelectric generation	Low
Shoreline development, real estate & legal issues (e.g. lower water will mean wider beaches & may affect property ownership or access)	Low
Changing Weather Conditions	
Precipitation patterns affect seasonal & long term lake water levels	Low
Precipitation patterns impact (runoff, drainage, slope stability, sediment redistribution and flooding)	Med
Wind and storm activity on wave climate, coastal circulation, sediment redistribution & other physical processes	Low
Storm activity – affects coastal communities, infrastructure, commercial shipping & recreational activities	Low
Changing Lake Ice Conditions (including extent, thickness and seaon)	
Evaporation rates & seasonal or long-term water levels	Low
Waves & currents	Low
Shoreline stability	Low
Coastal communities and infrastructure	Low
Commercial shipping, transportation & navigation (extended season, but perhaps more severe weather)	Med
Changing Human Use	
Lack of information related to erosion, flooding & water-levels	High
Lack of planning to consider coastal system response to climate change	High
Increased demand for use, access to, development & protection of coast	Med

Agricultural

Impact	**Priority**

Increase in heat units and growing season length available for corn, soybeans, spring seeded cereal crops and forages. This may increase yields and result in expansion of corn and soybean production into additional areas.	Low
Water deficits	Low

Fisheries

Impact	Priority
Changes in fish, fisheries and aquatic resource distribution, diversity and production	Low
Increased frequency and severity of natural climate events (drought, flood, storms, ocean upwelling, sediment transport, El Nino & La Nina events)	Low
Changes in fisheries productivity	Low
Altered economic, social and health conditions	Low

Forest

Impact	Priority
Natural disturbance	Low
Forest Practices	Low
Biotechnology	Low
Industry Competitiveness	Low
Forest-Based Communities	Low
Vegetation Shifting	Low
Growth and Yield	Low
Biodiversity	Med
Non-timber Forest Values	Low

Landscape Hazards

Impact	Priority
Landslides	High
Flooding	High
Permafrost	Med
Drought	Low
Peatlands	Low
Erosion	Low

Appendix E
Intergovernmental Panel on Climate Change's website on vulnerability and adaptation in North America (http://www.grida.no/climate/ipcc_tar/wg2/545.htm).

15. North America
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