


CITY OF
PRINCE GEORGE

# Adapting to Climate Change in Prince George:
## An overview of adaptation priorities

**October 19 2009**

**By: Ian Picketts**
**Dave Dyer**
**John Curry**

# Acknowledgements

This report was made possible by the efforts of many people and organizations.

Ian Picketts would like to recognize the Pacific Institute for Climate Solutions (PICS) for funding his research in 2008 and 2009 with two PICS Graduate Fellowships. The Canadian Institute of Planners also provided a graduate fellowship in 2008.

From the University of Northern British Columbia (UNBC), Ian Picketts' graduate committee members Eric Rapaport, Stephen Déry and Theresa Healy assisted with their insight on this project and support. Research assistant Robin Chang also helped with supporting research and revisions.

Several City of Prince George staff provided valuable assistance. Dan Milburn has been instrumental throughout this project. Mark Fercho provided valuable insight and assistance during the process, and Grant Bain helped start the partnership. Dan Adamson, Frank Blues, Glenn Stanker, Jeff Rowland, Marco Fornari, Nelson Wight and Greg Anderson provided helpful reviews of the impact sections. The City provided funding toward this work as well.

The Pacific Climate Impacts Consortium (PCIC) provided extensive assistance throughout this process. Arelia Werner and Trevor Murdock created the climate change information and worked with Ian Picketts to put it into report form. Arelia and Trevor also assisted in planning the two major workshops, and Arelia presented climate change information at both of them. Support has been provided to PCIC during the preparation of the analysis that informed this work by its two funding partners, BC Ministry of Environment and BC Hydro.

A special thanks goes to the Fraser Basin Council for their assistance in planning and executing the two major workshops. Elizabeth Henry and Joan Chess acted as facilitators at both workshops and played an integral role in organizing them, and Joan provided helpful feedback for this document. The Smart Growth on the Ground (SGOG) group provided a forum to discuss climate change adaptation with the public in Prince George, and also incorporated climate change adaptation into their research. Shana Johnstone and Amanda Mitchell were very accommodating and helpful, as was the rest of the SGOG team.

Many partners participated in the Planning Institute of British Columbia adaptation workshop by acting as facilitators and providing funding including the Planning Institute of BC, the BC Ministry of the Environment, UNBC, BC Hydro and Environment Canada.

## About the Authors

**Ian Picketts,** B.Sc (Eng) is a doctoral student at the University of Northern British Columbia (UNBC) in the Natural Resources and Environmental Studies program. Ian is studying environmental planning, focusing on community adaptation to climate change. A large portion of this research involves coordinating with the case study community of Prince George to create a climate change adaptation strategy that can be incorporated into the City's planning processes and operations. Ian has received research fellowships from the Pacific Institute for Climate Solutions and the Canadian Institute of Planners. He has a degree in Environmental Engineering from Queen's University and several years of related work experience. Before returning to school, Ian worked for the Pembina Institute (an environmental NGO based out of Alberta) focusing on encouraging responsible energy development and use. Ian has used his environmental experience to teach a second and a third year course while studying at UNBC.

**Dave Dyer**, P.Eng. is the Chief Engineer of Development Services for the City of Prince George. Dave has 28 years experience in the planning, design, and development of municipal infrastructure for urban, rural and First Nation communities in Northern British Columbia. He has been with the City of Prince George since 1995. Dave's current responsibilities as Chief Engineer include long range infrastructure planning, coordinating capital City works and private development projects, maintaining infrastructure standards, subdivision approval, watershed drainage planning, flood hazard management and developing a climate change adaptation strategy for the City.

**John Curry**, PhD MCIP, is an Associate Professor in the School of Environmental Planning at the University of Northern British Columbia, and past Chair of the program. John is professional planner who practiced in Prince Edward Island and Ontario before being part of a team launching the environmental planning program at the University of Northern British Columbia in Prince George BC. His teaching and research interests include professional planning practice, planning theory, sustainable communities, climate change, First Nations planning and economic development, and small business and entrepreneurship.

# Executive Summary

Climate affects people and the places where they live. Seasons, temperatures, precipitation types and amounts, and extreme weather conditions all contribute to the identity of a region or city. A key factor in many aspects of community planning is adapting to the local climate, and designing and maintaining the infrastructure needed to serve those that live there. If the climate of an area is expected to change, a community will need to proactively consider the impact on land use decisions and how infrastructure systems are managed.

The Intergovernmental Panel on Climate Change projects that Canada will continue to experience warming trends and changes in precipitation over the next hundred years, even if societies drastically reduce their carbon emissions. This means that communities must plan to adapt to the impacts of a changing climate, as well as mitigate their contribution to climate change. Proactive adaptation means planning to account for both the positive and negative effects of climate change, rather than simply reacting to the changes as they occur. Whenever possible, climate change adaptation should occur in such a way that it is complementary with mitigation actions.

In the 2008 Prince George Quality of Life Survey, 54% of survey respondents indicated that they were extremely or definitely concerned about the issue of climate change. Over 80% of respondents indicated that they and their family were likely to be affected by climate change, and 88% of people thought that Prince George, as a City, would be affected. This shows that Prince George citizens are aware of climate change and are concerned about its impacts on the community.

North-central British Columbia is highly susceptible to climate change. Analysis of climate information in Prince George shows an average warming trend of 1.3 $^{o}$C over the past 100 years. Minimum temperatures have increased at a faster rate of 2.2 $^{o}$C while maximum temperatures only increased at 0.4 $^{o}$C over the 100 year period. This means that Prince George has become ‘less cold’, and that more precipitation has been falling as rain rather than snow. The rise in minimum winter temperatures has had a huge impact on the region with the recent mountain pine beetle epidemic. Sectors in BC that are already being impacted by climate change include forestry, water resources, tourism and health.

Annual temperatures in the Prince George region are projected to increase by 1.4° C to 2.1 ° C over the next 50 years, and precipitation is projected to increase by 3% to 9% over this time period. A greater increase in temperature and precipitation is predicted to occur in winter months, and even more precipitation will fall as rain. These projected changes in precipitation and temperature imply complex adjustments to stream flow in the area. Changes in temperature of this magnitude will likely have a serious impact as they are above the historical range in variability for this region and hence will create conditions that Prince George has not experienced before in its history. More instances of floods and extreme weather are predicted.

The purpose of this document is to outline the climate change adaptation priorities for the City of Prince George. The City has partnered with the University of Northern British Columbia (UNBC) to determine the priorities for adaptation in Prince George, and to begin to recommend actions and next steps towards implementation. Many activities have occurred

in the City in collaboration with other organizations such as the Pacific Climate Impacts Consortium (PCIC), the Fraser Basin Council and Smart Growth on the Ground (SGOG). This report summarizes and draws upon results from the following documents and events:

- the "Climate Change in Prince George: Summary of Past Trends and Future Projections" report;
- the "Planning for Climate Change" workshop at the 2008 Planning Institute of British Columbia annual conference;
- the "Adapting to Climate Change in Prince George" workshop for City of Prince George staff in 2008;
- feedback from the SGOG downtown revitalization process in 2008 and 2009; and
- the 2008 Prince George Quality of Life (QOL) survey.

The climate information from the report "Climate Change in Prince George: Summary of Past Trends and Future Projections" was used to inform the two workshops and the exercise at the SGOG event. This allowed participants to consider past climate information and future projections as they discussed adaptation. The outcomes of the aforementioned exercises were analyzed along with the QOL survey to come up with a list of adaptation priorities for the City. Each of the events indicated the same general priorities for adaptation. The list of impacts that City representatives and local stakeholders feel pose the biggest threat to Prince George appears below in Table 1.

**Table 1: Priority impacts that will affect Prince George.**

| Level of Priority | Impact |
|---|---|
| **Top Priorities** | Forests |
| | Flooding |
| **High Priorities** | Transportation infrastructure |
| | Severe weather / emergency response |
| | Water supply |
| **Medium Priorities** | Slope stability |
| | Stormwater |
| | Buildings and utilities |
| **Other Priorities** | Health |
| | Agriculture |
| | New residents and businesses |

The order in which the impacts should be addressed by Prince George is not the same as the order shown in the priority impacts table. This is because for some impacts (such as flooding and forests) Prince George has already started to identify and implement adaptation actions. For other impacts (such as stormwater) the City has only begun to consider climate change adaptation in its planning and operations. Impacts in the 'Other Priorities' category were ranked lower because they tend to be more positive and socially oriented, and the risk analysis framework used in this research focuses on negative physical impacts. These priorities should be further considered, especially because there are potential positive

implications associated with some of these changes that can be exploited to the City's benefit (such as longer growing seasons for agriculture).

An overview of what is currently taking place in the City concerning priority impacts is as follows:

- **Forests**: the City has initiated wildfire hazard mitigation work on both municipal lands and within its Community Forest Agreement, and has a wildfire management strategy in place that accounts for changing ecosystems.
- **Flooding**: the City has retained a team of consultants who have finalized a flood risk evaluation, in consideration of flood protection measures, that takes climate change into account.
- **Transportation infrastructure**: Prince George is implicitly adapting to transportation impacts, but has not explicitly stated climate change in its plans.
- **Severe weather / emergency response:** City and provincial emergency response plans are in place, but the plans do not currently consider climate change.
- **Water supply:** The City has initiated a water smart program to protect water quality and quantity that can be built upon in a climate change adaptation strategy.
- **Slope stability:** Although there are strict regulations regarding development on slopes, climate change has not yet been a consideration when investigating slope stability and erosion.
- **Storm water:** Hydrological analyses for storm sewer infrastructure and overland flow and storm detention ponds are now requested to consider larger storm events.
- **Buildings and Utilities:** There are currently no codes and practices to account for the impacts of climate change on buildings and utilities.

Strategies to address these priorities should be incorporated into the upcoming Integrated Community Sustainability Plan (now called Smart Plan for Communities) and the Official Community Plan (OCP) review process for the City. Some of the impacts can be addressed in the Annual Provisional Financial Plan and/or the Asset Management and Performance Measures document. Committees or groups should be established to assess the impact priorities in more detail, identify adaptation strategies and communicate with the public. In many cases these tasks can be incorporated into the mandates of groups that will be created as part of the ICSP (Smart Plan) and OCP processes, or groups that are already in place.

The impacts identified are interrelated, and there is significant overlap in many of the solutions (e.g. many strategies will address more than one impact). As such, adaptation strategies should be created in an integrated fashion with maximum communication between the groups. To incorporate climate change adaptation into community plans effective communication of climate information, and a detailed understanding of the impacts in Prince George is required. Local topical experts, academics, community members, and representatives from other levels of government should participate in creating adaptation strategies.

This document can be utilized as a basis to establish and then implement effective long term strategies to adapt to climate change. Further research and collaboration needs to occur regarding all of the priorities identified. Prince George is well positioned to become a national leader in community climate change adaptation. The City can implement effective adaptation actions ensuring that its residents maintain a high quality of life in a changing world. In order to support this continued work the City should seek funding opportunities, grants, and (new and continued) partnerships.

# Table of Contents

# List of Tables



# List of Figures

# 1. Introduction to Report

This report is the culmination of nearly two years of work by the University of Northern British Columbia (UNBC) in partnership with the City of Prince George. Extensive assistance has been provided by many outside individuals and groups. In particular, the Pacific Climate Impacts Consortium (PCIC) and the Fraser Basin Council have both provided a large amount of support to this project.

This is not intended to be the final step in this research, but to be a report that educates readers on climate change and identifies priorities for adaptation in Prince George. Further action needs to be taken regarding all of the priorities identified, so that the City can implement effective adaptation measures to make it a better place to live in a changing world. Public engagement activities must be a part of the process so that the citizens of Prince George have a chance to comment on, contribute to, and evaluate this process. These initiatives should be implemented alongside extensive climate change mitigation action.

The adaptation strategy ideas identified in this document are not intended to be viewed as a list of appropriate solutions or expert opinion. They are examples of actions that have been successful in other regions and are included to demonstrate possible solutions and creative ideas. An independent process of validation should precede the implementation of the strategies mentioned herein, or of others.

Some of the material contained in this report is adapted from other documents and articles prepared by the author as part of post-graduate studies at UNBC. These other documents are as follows:

> Picketts, I., Curry, J. and Rapaport, E. 2009. Raising Awareness of Climate Change Adaptation in Planning'. Plan Canada. 49(1): 41-44.
>
> Picketts, I.M., Werner, A.T. and Murdock,T.Q. 2009. Climate change in Prince George: summary of past trends and future projections. Pacific Climate Impacts Consortium, University of Victoria, Victoria BC.
>
> Picketts, I. 2008. Adapting to climate change workshop. Planning West. 50(3): 12-13.

The material in this document is intended to be incorporated into the upcoming Official Community Plan (OCP) review and Phase II of the Integrated Community Sustainability Plan (ICSP); which is now known as the Smart Plan for Communities (Smart Plan). The ICSP for Prince George has been named 'myPG'.

# 2. Climate Change Awareness

According to the Intergovernmental Panel on Climate Change (IPCC) (2007a), the average air temperature of earth's surface increased by 0.74°C over the twentieth century. This temperature rise has had a strong influence on the global hydrological cycle, resulting in significant increases in precipitation in some areas of the world, and extreme droughts in others. Increasing evidence shows that most of this temperature rise can be attributed to greenhouse gas emissions generated by human activities, and not to natural climatic oscillations. The activities that are primarily responsible for the increased levels of greenhouse gases are fossil fuel production and use, livestock rearing and deforestation (Davidson et al. 2003), all of which are very relevant to the economy of Prince George and British Columbia.

There are many sobering statistics from a huge variety of sources that provide very strong support for the notion that the climate is changing at an unprecedented and unnatural rate, and that this is affecting more than simply the surface temperature of the earth. Examples of these statistics include:

- eleven of the twelve warmest years on earth between 1850 and 2006 (since detailed records have been kept) occurred between 1995 and 2006 (IPCC 2007a);
- the loss of volume, and sometimes complete disappearance, of glaciers from around the world over the twentieth century (Dyurgerov and Meier, 2000);
- a substantial increase of great floods during the 20$^{th}$ century (Milly et al. 2002);
- an estimated nine-fold global increase in economic losses from natural disasters between the 1960s and the 1990s (Kovacs and Kunreuther 2001); and
- worldwide observed changes in biological functions such as earlier timing of spring events like plant leaf unfolding, bird egg-laying and animal migrations (IPCC 2007a).

## *2.1. Global Implications of Climate Change*

Although climate change is a global issue, its impacts are most readily observable at the local and regional scale (Smith & Smith 2009). Many of the experiences that the City of Prince George has undergone with regards to climate change are similar to those that communities around the world are experiencing. Impacts such as flooding and forest fires are affecting regions and countries across the globe, accumulating in serious short long term problems (McLamb 2009).

This section outlines some major climate change impacts at the global level. These impacts are closely interrelated, multifaceted, and complicated by many factors. This discussion is relevant to the City's adaptation strategy because it provides examples of problems that Prince George may directly encounter, or be affected by as other regions of the world encounter them. It is intended that this section provide a global perspective and context within which the City's climate change actions can be framed.

## Food Systems & Security

In 2008, the Food and Agricultural Organization (FAO) formally recognized the implications of climate change on food and agriculture production and supply. As a fundamental pillar in human survival, the threat of negative impacts on food security is applicable to everyone. Climate is described by the FAO (2008) as an integral factor in food performance that affects the quality, types and value of food that is grown. Extreme weather events, including drought and floods, can damage or destroy crops or infrastructure, and affect the transport and distribution of the food supply system (FAO 2008; United Nations 2008). Ironically, other emerging demands such as the market for biofuels (as a low-carbon fuel source) are also competing against the demands of food security. Crops (such as sugar, maize and palm oil) are affected by this competing demand, amidst rising oil prices that further compound problems (United Nations 2008; Laurence 2006)).

## Health

Another important factor in human survival affected by climate change is health. Global climate change can affect human health through a range of mediums at multiple levels. Climate change alters regional weather through extremes in temperature and precipitation (Patz et al. 2005). A report completed by the World Health Organization (WHO) explains that local factors (such as contamination pathways and transmission dynamics) affected by climate change can result in impacts such as air-pollution-related health problems, and various types of diseases (McMichael et al. 2003; Martens 1998). Indirect climate change impacts on health include increased cases of skin cancers and water-borne diseases. Direct impacts include storm related injuries or deaths. Another close relationship to health is water scarcity, which impairs human health and development (McMichael et al. 2003).

## Economy

According to the International Monetary Fund (2007), the economic impacts of climate change can be divided into two major categories:

1. **Market Category**: includes effects on climate-sensitive sectors such as agriculture, forestry, fisheries and tourism. It also includes damage to coastal areas from sea-level rise, changes in energy expenditures (for heating or cooling) and changes in water resources.
2. **Nonmarket Category**: includes effects on health (such as the spread of infectious diseases and increased water shortages and pollution), leisure activities (e.g. sports, recreation, and outdoor activities), ecosystems (e.g. the loss of biodiversity) and human settlements.

An additional socio-economic impact includes increasing conflicts over how fossil fuels should be managed, allotted and reduced (Newell & Paterson 1998). Also there is the "doubling" up of climate change and economic globalization vulnerabilities in certain regions of the globe. Research shows that poor residents in urban and rural areas are more vulnerable to shifts in markets and capital. These poorer residents also tend to live in geographical locations such as hillsides, floodplains, or dry arid areas that are susceptible to geophysical climate change impacts, which make them even more vulnerable (O'brien & Leichenko 2000).

### Ecosystems

Climate change is influencing all aspects of ecosystems. This includes everything from birth, death, and growth rates of populations, community structures, and the cycling of nutrients. Climate change is directly altering water availability which affects the distribution and abundance of plant and animal species (Smith & Smith 2009). Various changes to ecosystems have already been noted such as shifts in biodiversity richness toward the north and the salinization of lands next to estuaries due to sea level rise (Smith & Smith 2009; Currie 2001). While it is difficult to plan for the uncertainties of climate change and its impacts on humans, it is as hard if not harder to consider the uncertainties related to its impacts on the natural environment (Smith & Smith 2009). This is of paramount importance, as humans are completely reliant on the resources the natural environment provides.

## *2.2. Community Adaptation to Climate Change:*

Climate is a key factor in almost all components associated with community planning and operations, and affects most land use decisions. Canada will continue to experience warming trends and changes in precipitation over the next hundred years regardless of even the most severe mitigative actions (IPCC 2007b). Some of the sectors already affected by climate change in British Columbia (BC) communities include water resources, forestry, agriculture, transportation, tourism and health (Walker & Sydneysmith 2008). Planning issues that are affected by climate change and that must be accounted for in community decisions, as outlined in King County (2007), Parks (2007), BC Government (2006a), the BC Ministry of Water Land and Air Protection. (2004) and the Federation of BC Naturalists (2006) include:

- energy costs
- natural area preservation
- sea level rise
- severe weather events
- air quality
- inland flooding
- river flows
- storm water management
- erosion
- river ice and ice jams
- aquifers
- surface waters
- forest fires
- wildlife
- water shortages
- transportation costs
- permafrost degradation
- food supply
- agriculture
- hunting
- tourism
- human migration
- building infrastructure
- transportation infrastructure
- emergency response
- wastewater management
- forest species conservation
- human health
- energy transmission

The IPCC (2007b) defines adaptation as ‘the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.’ This means that adaptation is planning (either reactively or proactively) to account for the positive and negative effects of climate change. Mitigation is defined by the IPCC (2007c) as, ‘an anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks. This means

that mitigation consists of actions that reduce the amount of greenhouse gases into the atmosphere, or increase the earth's abilities to absorb these gases.

Climate change adaptation is by no means new, as climate is inherently variable and societies have been adapting to changes throughout all of modern history (Adger et al. 2006). While climate change adaptation has a long social history, communities will encounter climatic conditions and climate change rates that have yet to be experienced in modern human history (Füssel 2007). However, there have been huge advances in humans' abilities to respond. Modern society now has the knowledge to determine the causes of climate change and to predict the extent of changes. This gives communities the opportunity to plan for and implement more effective and proactive adaptation strategies (Hay and Mimura 2006).

Historically, more attention has been focused on mitigation than adaptation in the climate change world. One major reason is the fact that mitigation reduces all of the long term impacts of climate change whereas there are some impacts that are difficult or impossible to adapt to (such as rising sea levels on small island nations). Mitigation reduces the root causes of climate change problems, but adaptation depends on the accuracy of models and impact projections. Also, measuring and reducing greenhouse gas emissions is much more straightforward than adapting to uncertain changes in the environment (Füssel 2007).

Over the last number of years the attention has shifted in the climate change world towards adaptation as well as mitigation. Adaptation is now accepted as an unavoidable reality that communities must seriously consider and plan for. This is because anthropogenic greenhouse emissions, already in the atmosphere, are currently affecting the climate and will continue to do so for the foreseeable future, even if there is a successful global mitigation effort (Hergel and Zwiers, 2007). Climate change will impose large impacts on communities and natural systems for generations (IPCC 2007b).

Adaptation can be an effective response to climate change at a regional scale. Some supporting reasons for this, as summarized by Jacques (2006), include:

- smaller, local organizations can move quickly to influence local adaptation to specific problems whereas large organizations, which are needed for large scale mitigation, move very slowly:
- adaptation can be created for specific needs of an area. These needs may be obscured when looking at a larger picture; and
- small scale adaptation may occur 'from the bottom up' or with the input and participation of local stakeholders.

Table 2-1 provides a summary of the definitions of climate change mitigation and adaptation, and some of their key similarities and differences:

**Table 2-1 Definitions, differences and similarities between mitigation and adaptation. Adapted from Swart and Raes 2007.**

| | | Mitigation | | Adaptation | |
|---|---|---|---|---|---|
| Definition | | Anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases | | Adjustment in natural or human systems in response to actual or expected stimuli or their effects, which moderate harm or exploits beneficial opportunities | |
| **Differences** | **Issue** | **Dominant focus** | **Examples of exceptions** | **Dominant focus** | **Examples of exceptions** |
| | Cause / effect | Primarily addresses causes | Smart growth with low energy needs and low vulnerability | Primarily addresses consequences | Drought resistant bio-fuels can address both |
| | Spatial scale | Main objective avoiding global changes | Co-benefits for local air pollution, energy security, jobs | Main objective avoiding local damage | Forestry adaptation may have global consequences |
| | Sectors | Mainly energy, transport, building and industry | Mitigation options in water and land management | Mainly urban planning, water, agriculture and health | Renewable energy sources can be vulnerable |
| | Time scale | Long-term benefit from avoided climate change | Co-benefits for local air pollution, energy security, jobs | short-term benefit from reducing vulnerability to current climate | Preparing for long term impacts |
| | Benefic-iaries | Mainly benefits others (altruistic) | Co-benefits for local air pollution, energy security, jobs | Mainly benefits those who implement it (egoistic) | Smart growth, agriculture, water use |
| | Incentives | Usually incentives needed | No-regrets policy (e.g. energy efficiency) | Often incentives not needed | Anticipatory actions without immediate benefits may need incentives |
| Similarities | Goal | Aiming at reduction of climate change risks | | | |
| | Benefits | Having ancillary benefits that may be as important as climate-related benefits | | | |
| | Drivers | Driven by availability/penetration of new technology & societal ability to change | | | |

There are also many barriers that inhibit communities' abilities to implement small and regional scale adaptation measures. A common barrier is financial restraint due to smaller taxation opportunities at a local and regional level. Other barriers include reduced access to technological and managerial capacity, and trans-regional obstacles to cooperation (Jacques 2006). In Canada, very few communities have begun to consider climate change adaptation. This is also an inhibiting factor, as it is difficult to find nearby examples or models to work from.

The distinction and separation between adaptation and mitigation can be difficult. Both strategies have the same desired outcome, which is reducing the consequences of climate change (Swart & Raes 2007). Mitigation can be considered to be the most effective and reliable method of long term climate change adaptation (Füssel 2007). However it has become clear that climate change is more than simply an environmental problem. It

cannot be addressed by only setting environmental targets and timetables, as was done with the ozone depletions problem in the early 1990s (Munasinghe and Swart 2004).

Adaptation and mitigation measures do not have to be mutually exclusive. For example, Smart Growth Principles, such as mixed land use and limiting development on natural and sensitive areas, are perfectly consistent with climate change adaptation strategies (Ruth 2006). (For more information about Smart Growth please refer to Section 5.4 or Appendix E.) Recent interest in this topic has led to the addition of a new chapter in the IPCC Impacts, Adaptation and Vulnerability working group report entitled 'Inter-Relationships Between Adaptation and Mitigation", which outlines ways that they can be complementary (IPCC 2007b).

It is imperative that climate change adaptation measures are consistent and complimentary with mitigation efforts. Adaptation should not occur and the expense of mitigation, nor should mitigation occur at the expense of adaptation (Cohen and Waddell 2008). To reduce the risks of climate change societies must pursue a portfolio of both adaptation and mitigation actions. It is important to consider the inter-relationships between the two, and be aware of trade offs and synergies between adaptation and mitigation (IPCC 2007d). Due to constraints in the scope of this project, the coalescence of mitigation and adaptation measures will not be discussed in detail.

## Climate Change Modeling:

Consulting with the people who are affected by decisions is a cornerstone of government decision-making. To properly consult with people on decisions related to climate change, stakeholders must have the proper information available to them to understand climate projections, and their associated risks and uncertainties (New Zealand Ministry of the Environment 2008). Ensuring that stakeholders have proper information is the responsibility of local and regional governments. This includes ensuring that information is communicated and understood at a local level (New Zealand Ministry of the Environment 2008).

In order to effectively plan for climate change it is essential to produce detailed global climate change scenarios (Mitchell et al. 1999). These scenarios are undertaken in order to inform decision-making, when planners are faced with an uncertain future (IPCC 2007a). Coupled ocean-atmosphere global climate models (GCMs) are widely accepted as the most reliable mechanism to model future climates (Mitchell et al. 1999; IPCC 2001). They are representations of the climate based on its physical, chemical and biological properties, their interactions, and their feedback processes (Rodenhuis et al. 2009). These models have improved over the last decade, and it is now possible to create high spatial-resolution scenarios based upon the projections from them. Furthermore, probabilistic characterization of future socio-economic and climate impacts is becoming available to more accurately model emissions scenarios (IPCC 2007a).

Global Climate Models compute weather patterns from around the world several times per day projected over future time frames. These models are products from geo-spatial grids that overlay the globe and contain the data points for precipitation, temperature, and

other climate relative processes. Regional Climate Models (RCMs) are able to accurately represent factors like mountains, cloud radiation and land-atmosphere interactions (Kunkel and Liang 2005). Large advances have recently been made in GCM and RCM technologies, and higher-resolution scenarios have become available that allow impact studies to be performed at a community scale (IPCC 2007a).

The need for good models to help to inform adaptation decisions is what has led to the partnership with PCIC on this project. A summary of the modeling results from the 'Climate Change in Prince George: Past Trends and Future Projections' report is included as Section 3 of this report. The following information about PCIC is summarized from their website, which can be found at http://www.pacificclimate.org/ (PCIC 2009):

The Pacific Climate Impacts Consortium is dedicated to stimulating collaboration to produce practical climate information for education, policy, and decision-making in the Pacific Northwest. The Consortium informs adaptation in both operational activities and long term planning in order to reduce vulnerability to climate variability, climate change, and extreme weather events. PCIC bridges the gap between:

- scientific research and applications;
- researchers and users;
- geophysical sciences: meteorology, hydrology, geography;
- physical sciences, economics, social relevance; and
- climate centers in Pacific North America.

The Pacific Climate Impacts Consortium's vision is

> *"…to stimulate collaboration among government, academic and industry to reduce vulnerability to extreme weather events, climate variability and the threat of global change. The consortium for climate impacts will bridge the gap between climate research and climate applications and will make practical information available to government, industry, and the public".*

## Adaptive Capacity:

Adaptive capacity can be described as the ability of a community to develop and implement a comprehensive strategy towards climate change (BC Government 2006a). This may also be referred to as resiliency. The greater the adaptive capacity of a community, the larger the set of adaptation options that is available to it for implementation (Yohe and Tol 2002). A municipality's adaptive capacity is a function of many variables, as outlined in Crabbe and Robin (2006), including:

- the range of technological options available;
- the resources available;
- the structure of critical institutions;
- the human resources and leadership available;
- the access to risk spreading mechanisms;
- the ability of decision makers to manage and evaluate information;

- the credibility of the decision makers; and
- the public's perception of the risks that the community is facing.

BC has considerable adaptive capacity compared to most of the world (due to its strengths regarding most of the factors listed above) (Walker and Sydneysmith 2008). Prince George is taking a leadership role in climate change planning, and has extensive technological, human and monetary resources available. Within the City are many individuals and groups that have considerably expertise on adaptation, and who are committed to implementing adaptation actions. The citizens of this region have also been exposed to the effects of climate change with the recent flooding problems and pine beetle epidemic. Although these events cannot be attributed directly to anthropogenic climate change, studies have shown that there are clear linkages between changes in the climate and flooding and pest outbreak events (Milly et al. 2002; IPCC 2007a). The negative consequences of these recent events are the likely causes for the high degree of concern about climate change among Prince George residents (see Section 5.1).

It is important to note that groups at an economic and social disadvantage are particularly vulnerable to climate change impacts (IPCC 2007a). This is relevant for many First Nations communities within and near to the City, and also to the City's homeless and underserviced residents. This is also relevant to many other communities and groups in Northern BC. Therefore it is important that Prince George play a leadership role in addressing this issue. This adaptation work can serve as a model that other communities can work from as they create their own adaptation strategies.

## Community Adaptation Framework

There is a growing body of research aimed at helping communities to develop strategies to adapt to climate change. Some of this is closely related to strategic planning, which typically implements the concepts of Strengths, Weaknesses, Opportunities and Threats (SWOT) to identify and prioritize strategic actions. Threats and opportunities are external to the community or organization, and strengths and weaknesses are internal or within the organization. The SWOT model is typically easy to use, and it is applied often to planning scenarios. There are many different versions of strategic planning. To apply it to adaptation in communities one must focus on the ability of the municipality to deal with or respond to the issues (Bryson 1995).

The Adaptation and Impacts Research Division of Environment Canada, in collaboration with the University of British Columbia, have produced a guidebook entitled "Canadian Communities' Guidebook for Adaptation to Climate Change" (Bizikova et al. 2008). This guidebook is designed to assist municipalities as they incorporate climate change adaptation and mitigation into their short and long term plans and operations. It has been referenced extensively when developing the framework for this project. The objectives of the guidebook, outlined by Bizikova et al. (2008), are as follows:

- assist local decision makers in applying current scientific knowledge on climate change impacts to facilitate actions at the local scale;
- help communities to promote their sustainable development priorities in a way that accounts for climate change adaptation and mitigation needs;

- identify capacity needed to be able to carry out successful adaptation and mitigation actions; and
- create a network of local cases aiming for integrated responses to climate change to foster information and experience exchange that will be beneficial for practitioners, policy-makers and researchers.

Other important documents that exist on the subject of community adaptation frameworks that were carefully considered in this exercise include Parks (2005), the Australian Government (2007), King County (2007), the City of Chicago (2007) and the New Zealand Ministry of the Environment (2008). They were all reviewed while conducting this research. Some of these documents are discussed briefly in this document, and they are examined in more detail in Ian Picketts' academic research.

# 3. Climate Change in North-Central BC

The information in this section is an overview of key concepts from the report "Climate Change in Prince George: summary of past trends and future projections" (Picketts et al 2009). The full report can be accessed at the PCIC website (http://pacificclimate.org/) or by contacting the City.

*Disclaimer regarding this section: information has been obtained from a variety of sources and while efforts have been undertaken to assure its accuracy, it is provided without warranty as a service by the Pacific Climate Impacts Consortium. Any decision taken based on the information contained here is the sole responsibility of the person taking the decision.*

## *3.1. Overview*

The northern regions of Canada (including northern-central BC) are highly susceptible to climate change. Because of the expected changes to the climate and the potential for disruptions to systems that humans rely on, it is important that northern municipalities are provided with information that they can use to develop and implement effective climate change adaptation and mitigation measures. This section provides an overview of historical changes in the hydro-climatology of the Prince George region and projected changes in climate and related features for the future.

## *3.2. Baseline Climatology*

Climatology is the study of climate over a set period. Often, temperature and precipitation are investigated and planning is carried out on the basis of means and extremes of a given climatological period, such as 30 years. In climate science, future projections of climate change are frequently given as a difference from these average recent conditions. The report provides baseline climatology for the Prince George area over the 1961-1990 period. Annual mean temperature and precipitation climatology maps, created with data from the Precipitation-elevation Regressions on Independent Slopes Model (PRISM), are shown in Figure 3-1.

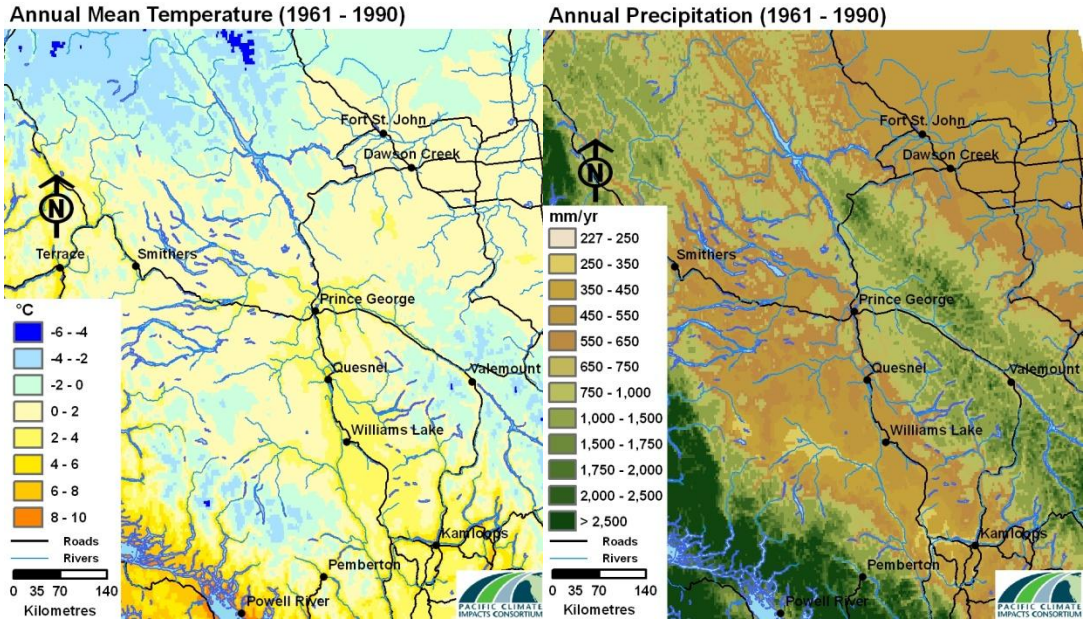


**Figure 3-1 Baseline climatology maps for the Prince George region for annual mean temperature and annual precipitation 1961-1990. Source: PRISM: Daly et al. 2004.**

## *3.3. Climate Variability*

Climate has a natural cycle of variability that brings different temperatures and precipitation amounts from those found on average. Climate variability refers to variations in the climate beyond individual weather events over time scales such as years or decades. It is caused by several different mechanisms that redistribute heat and influence the movement of the atmospheric and hydrological systems of the Earth.

The Prince George region is strongly influenced by changes to the sea surface temperature of the Pacific Ocean and related effects on atmospheric flow patterns. Two climate oscillations that affect Prince George are the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). ENSO influences climate variability on the scale of seasons to years, while the PDO occurs over 20 to 30 years.

## *3.4. Historical Trends*

Historical climate data gives an indication of how variables, such as temperature and precipitation, are being affected locally. Although current trends may not be extrapolated into the future, this analysis illustrates the changes that have taken place in the region and provides context for comparison of trends in this area relative to others. It is also important to note that the trends are influenced by modes of climate variability, such as ENSO and PDO.

Figure 3-2 shows that the long-term (1918-2006) mean annual temperature trend for Prince George warmed by 1.3°C per century. Night-time low temperature (minimum) increased at a faster rate of 2.2°C per century, and day-time high temperature (maximum) increased by only 0.4°C per century.

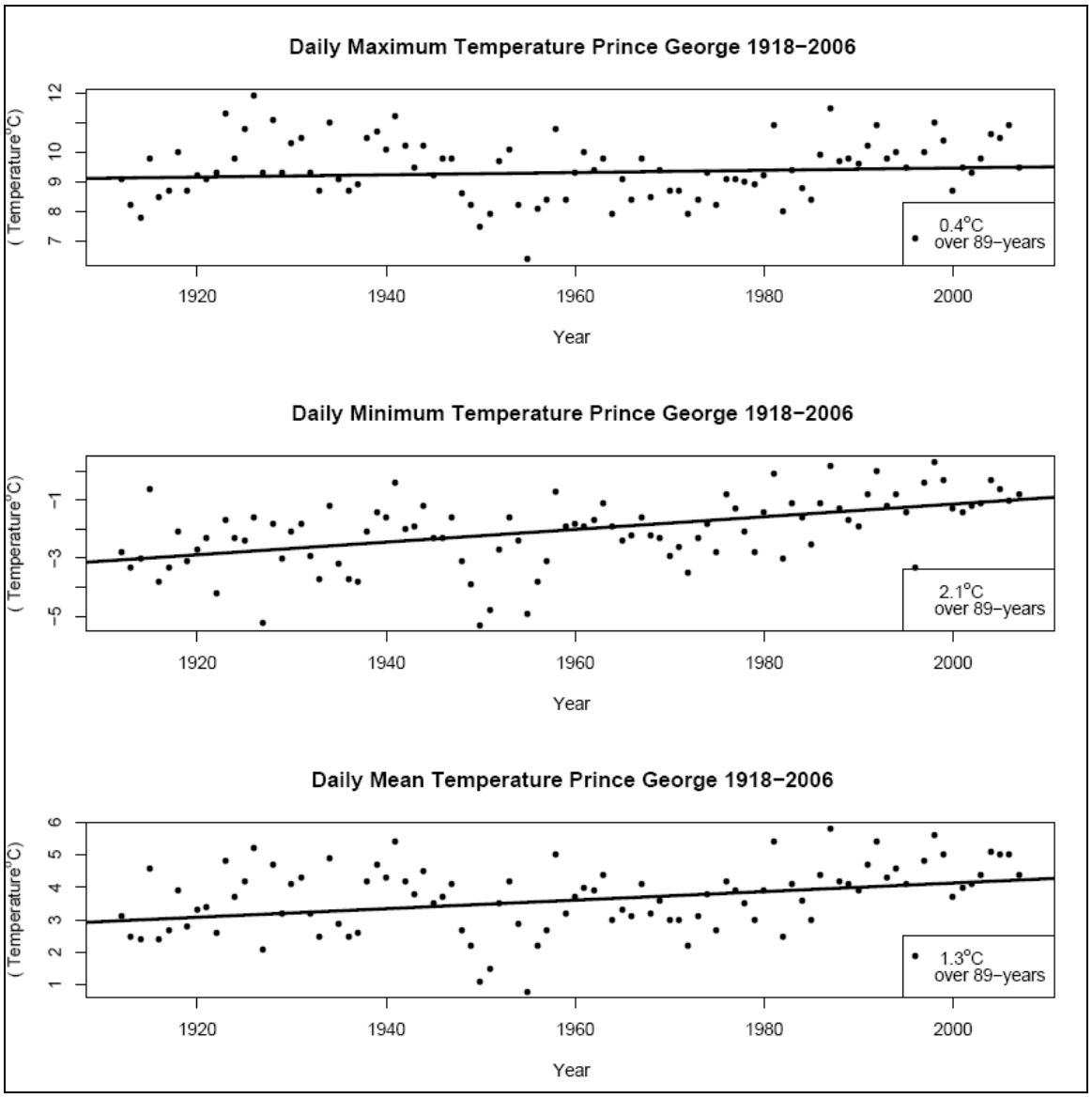


**Figure 3-2 Temperature trends from the Prince George airport station from 1918-2006. Source: A. Werner 2009.**

## *3.5. Streamflow*

Streamflow regimes can be classified into one of four categories: rainfall dominated (pluvial); a mixture of rainfall and snow-melt dominated (hybrid); snow-melt dominated (nival); and snow-melt and glacier-melt dominated (nival/glacial). Each category has defining characteristics that can be used to better understand streamflow response under a changing climate. Many stations were analyzed for streamflow in the Prince George region. These include stations that have been affected by human influences such as land-use changes or water extraction, and those that have not been affected by human influences. The streamflows were also analyzed for their responses to ENSO and PDO.

## 3.6. Future Projections of Climate Change and Uncertainty

Projections of future climate are provided from an ensemble of roughly 140 Global Climate Model (GCM) projections in the full report. These models are numerical representations of the climate system based on the physical, chemical and biological properties of its components, their interactions and their feedback processes. Higher resolution regional information is provided in maps from a Regional Climate Model (RCM). Because the RCM is at a higher resolution it represents elevation, physical and dynamical processes as well as land surface characteristics in more detail than the GCM. However, there are less runs of RCMs, and the projections shown are from only one model run with only one emission scenario.

The RCM projections shown in Figure 3.3 are on the warmer and wetter end of projections because they are run through a GCM which predicts warmer and wetter future conditions than most others. The range of 2050s climate change projected by the ensemble of GCMs is 1.6°C to 2.5°C and +3% to +10% for the region as a whole for annual average temperature and precipitation, respectively.

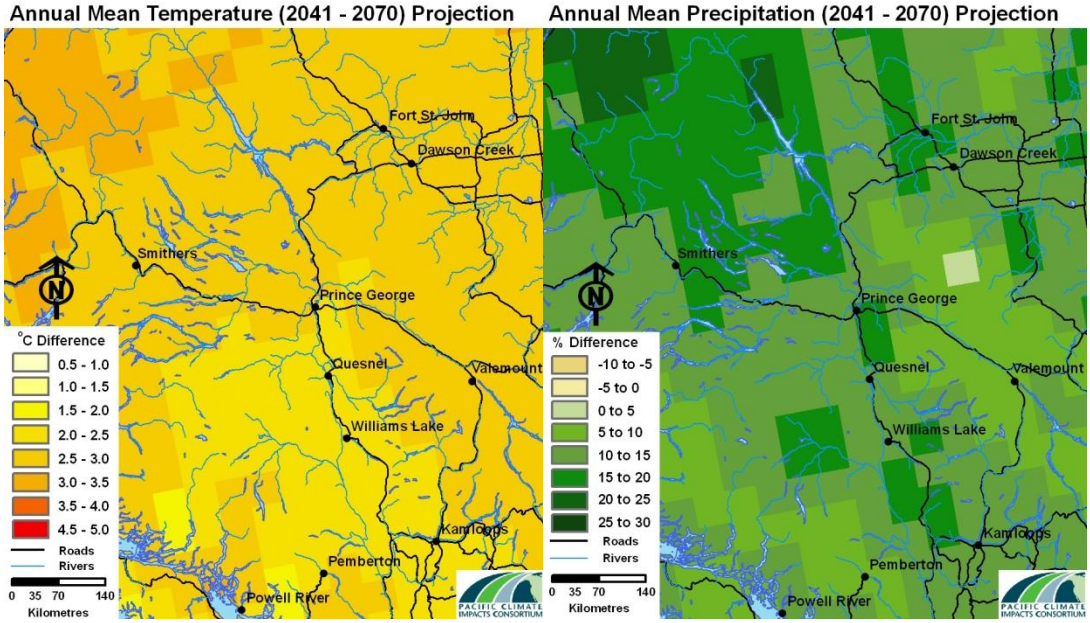


**Figure 3-3 Prince George region 2050s (2041-2070) projected annual mean temperature and precipitation anomalies from the 1961-1990 baseline. Source: Ouranos Consortium (CRCM4 forced with CGCM3 following the A2 emissions scenario).**

## 3.7. Vulnerabilities and Opportunities

Shifts in temperature and precipitation could change stressors on the municipal infrastructure in Prince George in ways that are likely to have significant cost implications. For example, increases in temperature could reduce the energy needed for heating. The cost of maintenance and renewal of roads and airport landing strips depends on temperature and precipitation. In particular, increased freezing and thawing cycles have already been attributed to the increased rate of deterioration of road surfaces (Dyer 2006).

These vulnerabilities and opportunities are discussed in more detail in the full PCIC report, and in the impact section (in Section 8) of this document.

## *3.8. Summary*

Long term trends reveal that Prince George has warmed by 1.3°C over the past century. Minimum temperatures have increased at a faster rate of 2.2°C while maximum temperatures only increased at 0.4°C over this time period. Precipitation trends over the last century depend largely on the period of analysis. Historic variability in precipitation was greater than that of temperature over the last century. Prince George is situated in a location of large precipitation gradients, significant historical temperature trends and is strongly influenced by patterns of climate variability, such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). ENSO affects the climate on a scale of one to several years and PDO on a scale of 20 to 30 years. During the ENSO warm phase (El Niño) winters in Prince George area are 1.5°C to 2.0°C warmer and there is 5% to 15% less precipitation than usual; during its cool phase (La Niña) winters are cooler and wetter than average. The PDO adds an additional influence of approximately 1.0°C over decadal time scales.

Annual temperatures in the region are projected to increase by an average of 1.6°C to 2.5°C by the middle of the 21$^{st}$ century. Precipitation is projected to increase by 3% to 10%, primarily in winter with possible decreases in summer. This means that Prince George will continue to become ‘less cold’ and that a greater percentage of precipitation will fall as rain rather than snow. Changes of this magnitude will likely have a serious impact as they are above the historical range in variability for this region and will create conditions that have not occurred before. These projected changes in precipitation and temperature imply complex changes to streamflow timing and amount that will depend on watershed location and type.

The full report on which this section is based (Picketts et al. 2009) includes additional information such as:

- historical baseline monthly and seasonal mean, minimum and maximum temperatures;
- historical influence of ENSO and PDO in the region;
- historical trend analysis on other time periods in addition to the long-term trends;
- analysis of streamflow trends and variability;
- future projections of monthly and seasonal mean, minimum and maximum temperatures; and
- future projections of growing degree days and tree species suitability.

# 4. Prince George, British Columbia

Prince George is a city in north-central BC with a population of approximately 77 000 (City of Prince George 2008a). The main industries in Prince George, in the order of the number of people employed, are health care and social assistance, retail trade, and manufacturing (BC Government 2009). The average income is approximately four percent above the provincial average, and most individuals and families in Prince George own their own homes rather than rent (B.C. Government 2007). Over the past 25 years, Prince George's population has become increasingly stable largely due to the investment in the forest industry. In addition, the urban infrastructure and services have improved within the city limits. Prince George continues to have a number of planning issues, particularly with its downtown and the location of heavy industry in the heart of the city (see Figure 4-1). Prior to the current Smart Growth on the Ground events (described in Section 5.4 and Appendix E) the City had undergone five downtown revitalization attempts (Llewellyn 1999).

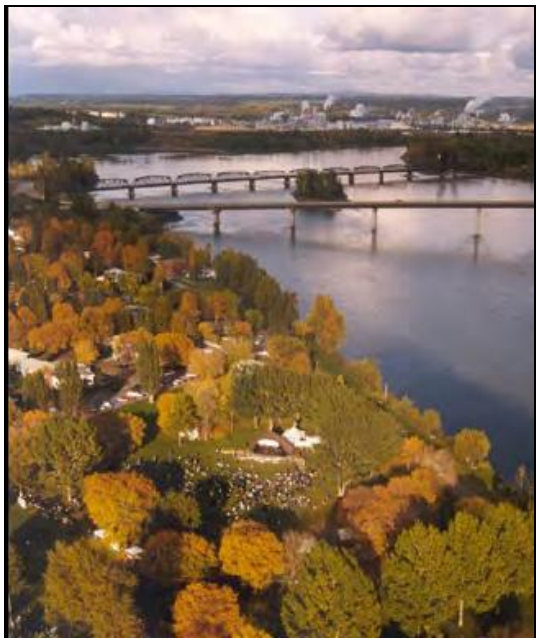

**Figure 4-1 Prince George looking over the Fraser River with pulp mills in background. Source: City of Prince George.**

The City of Prince George lies in the Fraser-Fort George Regional District and encompasses a total land area of 316 $km^2$, or 33 000 hectares (BC Government 2009). It is situated just east of the geographical centre of British Columbia: 786 km North of Vancouver and 739 km west of Edmonton, Alberta (BC Government 2007). The city is situated at 53°53 North Latitude, 122°40 West Longitude, and the elevation is 575m in the city centre. The population density is 229.1 persons per square kilometre. The average summer temperature (from 1971-2000) is Maximum 20.1 °C and Minimum 6.8°C, and the average winter temperature (from 1971-2000) is maximum -3.4°C and minimum

-11.8°C (City of Prince George 2008a).

Prince George is located within the Sub-Boreal Spruce (SBS) Biogeoclimatic Zone, which has a continental climate with extremes in hot and cold weather (B.C. Ministry of Forests 2004). The area experiences snow cover from roughly November to April and thunderstorms are frequent through the summer months, contributing to fire hazard and predominance of fire as the major disturbance factor in the zone. Lodgepole pine (Pinus contorta) and trembling aspen (Populus tremuloides) are common pioneer species, with hybrid white spruce (Picea engelmannii x glauca) and subalpine fir (Abies lasiocarpa) as the more common late-successional species (Timberline Forest Inventory Consultants 2006). Moose (Alces alces), marten (Martes americana), ermine (Mustela erminea), fisher (Martes pennanti), gray wolf (Canis lupus), snowshoe hare (Lepus americanus), and black bear (Ursus americanus) are the most common wildlife species in this zone. The forest canopy tends to be dominated by lodgepole pine, Douglas-fir (Pseudotsuga menziesii var. menziesii), and hybrid white spruce with trembling aspen and paper birch (Betula papyrifera) stands mixed in (BC Ministry of Forests, 2004).

Prince George is an ideal case study community to partner with on climate change adaptation research for a number of reasons. A few of the criteria that make the City an excellent candidate as a case study community include:

- **Commitment to climate change adaptation**: The City has shown a strong commitment to climate change action, and is already a Provincial leader in some areas related to climate change adaptation (such as forest fire management).
- **Upcoming OCP and ICSP (myPG) revisions:** Prince George is reviewing and updating its OCP and is in the process of creating an (entitled 'myPG') in 2009-2010. The City intends to incorporate climate change adaptation directly into both of these documents.
- **Site and Scale**: Prince George is a medium sized city that is situated near to the geographical centre of BC. The City is located in the Northern region of BC, far away from the Okanagan and greater Vancouver regions; which have been the focus of most climate change adaptation work in BC to date.
- **Vulnerability to climate change**: Prince George already is encountering major natural phenomena that can at least partially be attributed to climate change (such as the mountain pine beetle infestation and increased flooding). The City will be affected by many different impacts, and senior staff is aware of the need to start thinking about these impacts and incorporating adaptation strategies into its plans.
- **Collaboration with UNBC**: Prince George and UNBC have a long history of collaboration, particularly with respect to planning activities.

## *4.1. Official Community Plan*

The information in this section is summarized from the Prince George OCP (City of Prince George 2001). This document is available online at http://www.city.pg.bc.ca/city_services/ocp/ocp.pdf.

The Prince George OCP is Bylaw No. 7281, and was adopted on September 17, 2001. According to the OCP, the purpose of the plan is to 'establish a framework for directing

future growth and land use in the City of Prince George'. To guide the OCP, the Mayor and Council defined the priorities for development by establishing the mission statement: "to fulfill our destiny as B.C.'s 'Northern Capital' through: a) the development and enhancement of opportunities for employment, investment and reward; and b) the provision of an excellent quality of life" (City of Prince George 2001; p. 3).

To guide and support the mission statement, a series of strategies were developed to define the priorities for community development over the next few years. The strategies are:

- marketing the City of Prince George;
- encouraging growth and development within the City;
- improving infrastructure;
- planning effective transportation systems;
- implementing efficient corporate processes;
- rejuvenating the downtown;
- improving safety and security in the City; and
- growing civic pride.

The vision statement for the OCP is as follows:

> **"BC's 'Northern Capital', the City of Prince George will be a vibrant, active and diverse community that provides a strong focal point and identity for the north, with a thriving economy that offers full opportunities for housing, education, employment, recreation and the cultural life of residents."**

This statement was developed with the input of public stakeholders through surveys and open houses, and with the consultation of the public advisory committee (which was established as part of the OCP planning process).

The mission statement, the strategies designed to fulfill the mission statement, and the vision statement of the OCP do not have any direct reference to climate change, sustainability, or the environment. They contain indirect references to these issues through the mention of transportation (possible public transportation and bike networks), downtown revitalization (promoting a centralized downtown and discouraging urban sprawl and big box stores) and improving infrastructure (possibly by making it more efficient and resilient).

The 2001 Prince George OCP notes that some of the key issues repeatedly voiced by residents during public consultations included maintaining open space and connections with nature, and improving air quality. Section 1.3.3 states that quality of life for many residents is closely related to the quality of the physical environment and natural areas within the city. These statements, although not closely related to climate change, indicate that environmental issues were considered in the last OCP (and that this can be built upon in the next iteration).

There is no reference to climate change adaptation within the existing OCP for Prince George. However, there are explicit growth management strategies, agricultural

restrictions, protection of natural features, environmental quality guidelines, floodplain restrictions, restrictions on development of steep slopes and cut-banks, water supply protection measures, riparian protection measures, a section devoted to parklands and greenbelts, urban forestry recommendations, and utilities guidelines. These are all strategies that increase Prince George's resilience that can be built upon in the upcoming OCP review to incorporate climate change adaptation.

## *4.2. Integrated Community Sustainability Planning (Smart Plan) Initiative*

The following section is adapted from the Ministry of Community Services (recently renamed the Ministry of Community and Rural Development) Backgrounder Sheet on the Integrated Community Sustainability Planning Initiative, dated April 16 2007 (BC Ministry of Community Services 2007). (The document is available online at: http://www.cd.gov.bc.ca/LGD/intergov_relations/library/ICSP_Backgrounder.pdf)

Integrated Community Sustainability Planning is an initiative in BC that started from the Union of British Columbia Municipalities Gas Tax Agreement (GTA). This initiative began in 2005, and was designed to tie in with provincial interests to encourage the development of healthier and more sustainable communities, and also to address climate change. The Integrated Community Sustainability Plan (ICSP) initiative is designed to go beyond GTA support and to encourage partnerships to support community sustainability planning in the Province. In 2009 the ICSP initiative was renamed Smart Planning for Communities (Smart Plan).

An ICSP (Smart Plan) is a document that builds upon existing planning tools to encourage communities to self-analyze and to become more sustainable. It is designed to embrace certain tenants of sustainability. Some of the key tenants of integrated community sustainability planning are:

- long term thinking for sustainability and resilience;
- consideration of the environmental, social, cultural and economic needs of a community;
- integration of many different plans to encourage a coordinated approach with the input of various stakeholders (such as First Nations, neighbouring communities, NGOs, the private sector and different levels of government);
- extensive public engagement in the planning process;
- public education; and
- a focus on implementation with monitoring and evaluation to rate progress and continually improve plans.

The ICSP (Smart Plan) process is designed to involve three key phases:

I. Pre-planning phase: this phase is designed to educate the community and assess its planning capacity so that the community can have an accurate assessment of where it is and where it needs to go.

II. Core planning phase: this phase includes the development of a sustainability vision and a framework for the community so that targets

and actions can be set. This allows communities to identify unsustainable practices and actions to address them.

III. Implementation phase: this phase sees the plan into action and ensures that it remains a priority in the community. This may involve the adaptation of new decision making frameworks, the creation of checklists and indicators or a change in general governance.

## *4.3. The Prince George ICSP (myPG)*

The information in this section is summarized from the Prince George ICSP (myPG) website (City of Prince George 2009a). This is available online at http://icsp.princegeorge.ca/Pages/index.aspx.

In May 2007 the Prince George City Council supported the proposal to develop an ICSP (myPG). Phase I was completed and reported to council in October 2008. In February 2009 Council supported a cooperative agreement between UNBC and the City to develop phase II of the plan. At this point City staff researched other ICSPs (Smart Plans) from different BC communities, and developed a request for proposal that was tailored to the community. The City decided that phase II of the ICSP (myPG) be completed in concert with the OCP Review.

The consultant will become a partner with the City of Prince George and UNBC as they undertake this project. Phase II has been set to begin in the summer of 2009, and public engagement will begin in the fall. The consultants will interact extensively with Prince George residents as part of the process. The consultant also must incorporate a large amount of existing work and information into the next iteration of the OCP and the Prince George ICSP (myPG). Some of these initiatives include: Smart Growth on the Ground; Task Force for a Better Downtown; Communities that Care; Beyond Homelessness; Flood Risk Evaluation and Flood Control Solutions; Prince George Community Forest Advisory Committee; the Prince George Transit Business Plan; and this research.

Figure 4-2 outlines the broad range of topics and existing plans that the ICSP (myPG) incorporates, and the different strategies, bylaws, reports and systems that fall within its scope. Further discussion about how climate change adaptation fits into the ICSP (SmyPG) process is included in Section 4.4.

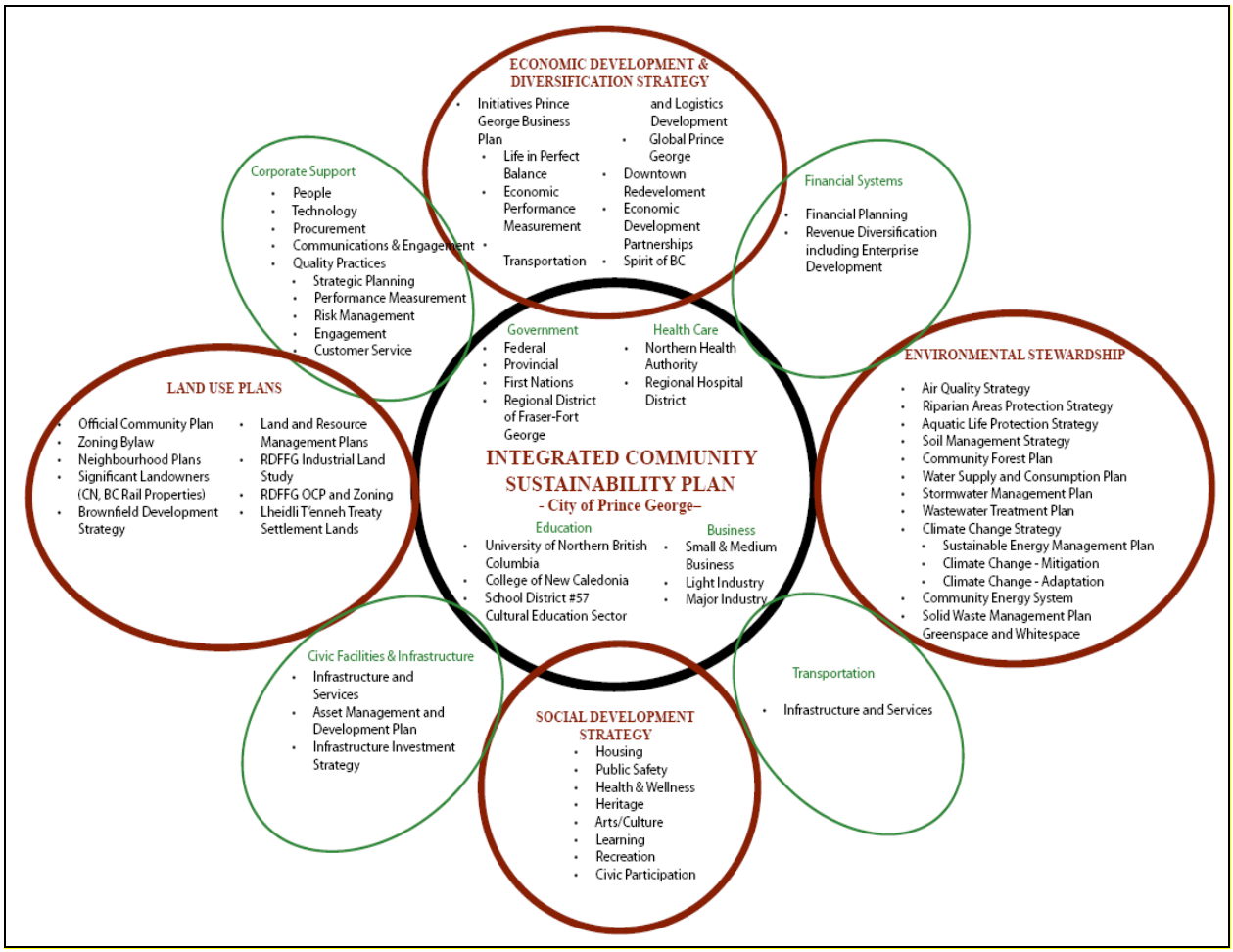


**Figure 4-2 Schematic of the Prince George ICSP (myPG). Source: City of Prince George 2009a.**

The development of the ICSP (myPG) in coordination with the OCP review in will occur in 2009 and 2010. The deadline for the completion of phase two of the ICSP (myPG) is March 2010, and the deadline for the OCP review is August 2010.

## *4.4. Climate Change adaptation in the OCP and ICSP (myPG)*

### Official Community Plan

An OCP that is developed with climate change adaptation will provide an umbrella for identifying actions to respond to change, and help to build a resilient community (Bizikova et al. 2008). As noted above, the purpose of the Prince George OCP is to establish a framework for directing future growth and land use in the City (City of Prince George 2001; p. 3). Incorporating climate change adaptation into the OCP will help to effectively fulfill both of these mandates. The requirement for OCPs to identify and consider landscape hazards, and the encouragement of smart growth principles, are examples of how climate change adaptation is beginning to be considered in OCPs (Bizikova et al. 2008).

The Develop With Care document, created by the BC Ministry of the Environment (2006) provides environmental guidelines for planning, implementing and reviewing developments. The community planning chapter includes a section on adaptation to climate change (Section 2.7.3) that advises communities to incorporate adaptation by assessing their vulnerability to future changes. Saanich BC has incorporated adaptation into its OCP at a cursory level. It has a climate change section (Section 4.1.1) that outlines the need for mitigation and adaptation. Also the first policy in the public infrastructure section (Section 4.2.10) prescribes that climate change impacts be considered in long term infrastructure projects (District of Saanich 2008). The City of Richmond and the District of Elkford are both in the process of finalizing OCP revisions which will extensively incorporate climate change adaptation (M. Daykin pers. comm. 2009; K. Gosal pers. comm.. 2009) The presence of adaptation in these documents indicates that it is beginning to be considered in OCPs in BC.

## Integrated Community Sustainability Plan (myPG)

As illustrated in Figure 4-2, climate change adaptation fits into the environmental stewardship bubble of the ICSP (myPG) along with climate change mitigation. The climate change adaptation plan will also have close links with other sectors identified in the diagram, such as civic utilities and infrastructure, transportation, and land use planning. Furthermore, a comprehensive climate change adaptation strategy should affect many aspects of social development, such as health and public safety. These will all have an effect on corporate support, financial systems, and economic development.

An ICSP (Smart Plan) is a big picture document that guides the development of all municipal planning, decision making and policies into one decision making framework that is geared toward sustainability (Baxter and Purcell 2007). This is ideally suited to climate change adaptation, as effectively planning for and responding to impacts often requires coordination and teamwork between many sectors (see Section 8 of this report). Whistler BC's ICSP (Smart Plan) was entitled 'Whistler 2020: Moving Toward a Sustainable Future', and it includes some references to climate change adaptation. The document includes several statements relating that Whistler needs to adapt to global impacts and take advantage of related opportunities; most of which are related to tourism and climate change (Resort Municipality of Whistler 2007).

# 5. Climate Change Adaptation in Prince George

Several workshops and other events have occurred in north-central BC that have raised awareness about climate change, and climate change adaptation, in the region. These have led to the creation of this adaptation strategy. The major adaptation related events that have occurred in Prince George, in chronological order, are as follows:

**A. "Adapting to Climate Change in Northern British Columbia" Workshop:**

In February 2003, approximately 40 key stakeholders from across BC met in Prince George for an "Adapting to Climate Change in Northern British Columbia" workshop. The purpose of the workshop was to discuss impacts that BC will experience as a result of climate change and possible strategies to address them. This workshop was put on by the Canadian Climate Impacts and Adaptation Research Network. The workshop brought together local and provincial government representatives from across BC, as well as academics and industry representatives. Prince George City staff and UNBC researchers attended the workshop.

**B. "Communities and Climate Change: Planning for Impacts and Adaptations" Workshop:**

A workshop occurred in Prince George on May 17, 2006 entitled, "Communities and Climate Change: Planning for Impacts and Adaptations". The workshop was hosted by the McGregor Model Forest Association, and was designed to enhance communication and coordination between climate change researchers, planners, community leaders, and the general public. Dave Dyer, the Chief Engineer of infrastructure for the City of Prince George, presented on communities and climate change impacts at the workshop.

One of the key outcomes of this workshop was the conceptualization of a Northern Climate Change Network that would promote information sharing about climate change adaptation in the North. The Network (initiated by the former McGregor Model Forest Association, which is now the Resources North Association) provides a website and a listserv, and has facilitated workshops and speaker events. It is looking to expand its services to help communities be better prepared for the potential impacts of climate change. For more information please visit http://www.resourcesnorth.org/rna/380/nccn.

**C. "Adaptation Partnership Between the City of Prince George and the University of Northern British Columbia:**

In the fall of 2007, Grant Bain (Manager of Long Range Planning), Dave Dyer (Chief Engineer of Infrastructure) and Ian Picketts (graduate student at UNBC) along with his graduate committee agreed to team up to continue to work on climate change adaptation in Prince George. In early 2008, Dan Milburn replaced Grant Bain as the manager of long term planning. This partnership has led to several reports and

workshops – which are described in the following sections. This partnership has also led to this adaptation document.

**D. "Climate Change Projection Information with the Pacific Climate Impacts Consortium:**

In early 2008, Ian Picketts advised the City of the climate change information available through PCIC. This organization is based out of the University of Victoria, and is a global leader in the production of past and future climate information. This partnership has led to the creation of the report: "Climate Change Impacts in Prince George: A Summary of Past Trends and Future Projections of climate in North-Central British Columbia". This document was published in September 2009. A summary of the information included in the report is included in Section 3. (The report can be accessed at PCIC's website: http://pacificclimate.org/, and hard copies are available at City hall). The partnership has also led to PCIC participating in and presenting at the Planning for Climate Change and Adapting to Climate Change in Prince George workshops.

**E. Prince George Quality of Life Survey:**

The City of Prince George has been conducting an annual public opinion survey since 1994. Each year the survey asks residents of Prince George many questions related to the City and their perceptions of their general quality of life with a specific focus. The 2008 survey was focused on sustainability, and included 12 questions about climate change and its impacts. The results from these questions have informed this adaptation document. More information about the survey is included in Section 5.1.

**F. Planning Institute of BC Workshop:**

In June 2008 a workshop was held in Prince George entitled "Planning for Climate Change". This workshop was put on by UNBC, with assistance from the City of Prince George, the Fraser Basin Council, PCIC, Environment Canada and others. The workshop occurred as part of Planning Institute of British Columbia's (PIBC) annual conference. The purpose of the workshop was to collaborate with Planners from across BC and Yukon to educate professionals on the subject of climate change adaptation, and also to discuss adaptation strategies for the case study community of Prince George. For more information on the workshop please refer to Section 5.2.

**G. Prince George City Adaptation Workshop:**

In November 2008 a stakeholder workshop was held in Prince George entitled "Adapting to Climate Change in Prince George". This workshop was put on by UNBC, with assistance from the City of Prince George, the Fraser Basin Council and PCIC. The workshop was designed to increase knowledge and awareness of climate change adaptation within the city, and to identify a prioritized approach for developing a climate change adaptation strategy for Prince George. For more information on the workshop please refer to Section 5.3.

**H. "Smart Growth on the Ground" Downtown Revitalization Plan:**
The City of Prince George has partnered with SGOG to create a sustainable downtown plan. For this process SGOG organized and facilitated information events in November 2008 and priority setting workshops in March 2009. Climate change adaptation was presented at the information and priority setting events, and has been incorporated into the design. The final charette design process took place in May 2009, and a concept document entitled "Smart Growth on the Ground: Downtown Prince George Concept Plan" was approved by council on September 14, 2009. Public feedback regarding climate change adaptation was also solicited at the information events. For more information about this process please refer to Section 5.4.

## *5.1. Prince George Quality of Life Survey*

The City of Prince George has conducted an annual public opinion survey since 1994. Since 1998 they have been doing this in partnership with UNBC's Institute for Social Research and Evaluation, headed by Dr. Alex Michalos. This is referred to as the Quality of Life (QOL) survey. Each year a sample of Prince George residents are asked many questions related to the City and their perceptions of their general quality of life. Every year the survey also has a specific focus. For example, in 2007 it was on items relevant to updating the City's OCP.

In 2008, the QOL survey focused on social, economic and environmental sustainability. As part of the environmental portion of the survey, a full section that included 12 questions was dedicated to climate change and its impacts. Approximately 660 people answered each of the questions in the climate change section. Please see Section 6.3 for an explanation of the research framework, and appendix A for the full results of this portion of the survey.

### Results

The section started with some general questions related to what climate change means to people, their level of concern, and their understanding of the issue. Participants were asked:

***How concerned are you personally about the issue of climate change?***

The results were as follows***:***

1. Extremely concerned ***15.3%***
2. Definitely concerned ***38.7%***
3. Somewhat concerned ***36.0%***
4. Not at all concerned ***10.0%***

When asked how well people felt that they understand the issue of climate change, 66.3% of respondents indicated that they have a good or excellent understanding of the issue, 31.0% indicated that they have a fair understanding and only 2.7% said that they had a poor understanding.

There were also questions about what concerns residents about climate change. These questions tie in very closely with this exercise, as the aspects of climate change that most concern citizens should correlate with high priorities for adaptation.

The overarching question was asked:

***What concerns you about climate change?***

Participants were instructed to indicate as many of the impacts that they thought were of concern. The results for this question are illustrated in Figure 5-1. If participants selected 'other' impacts they were asked to specify. The main 'other' concerns indicated were threats to wildlife (indicated by 1.5% of total respondents), food shortages (indicated by 1.5% of respondents) and nothing (indicated by 1.0% of respondents).

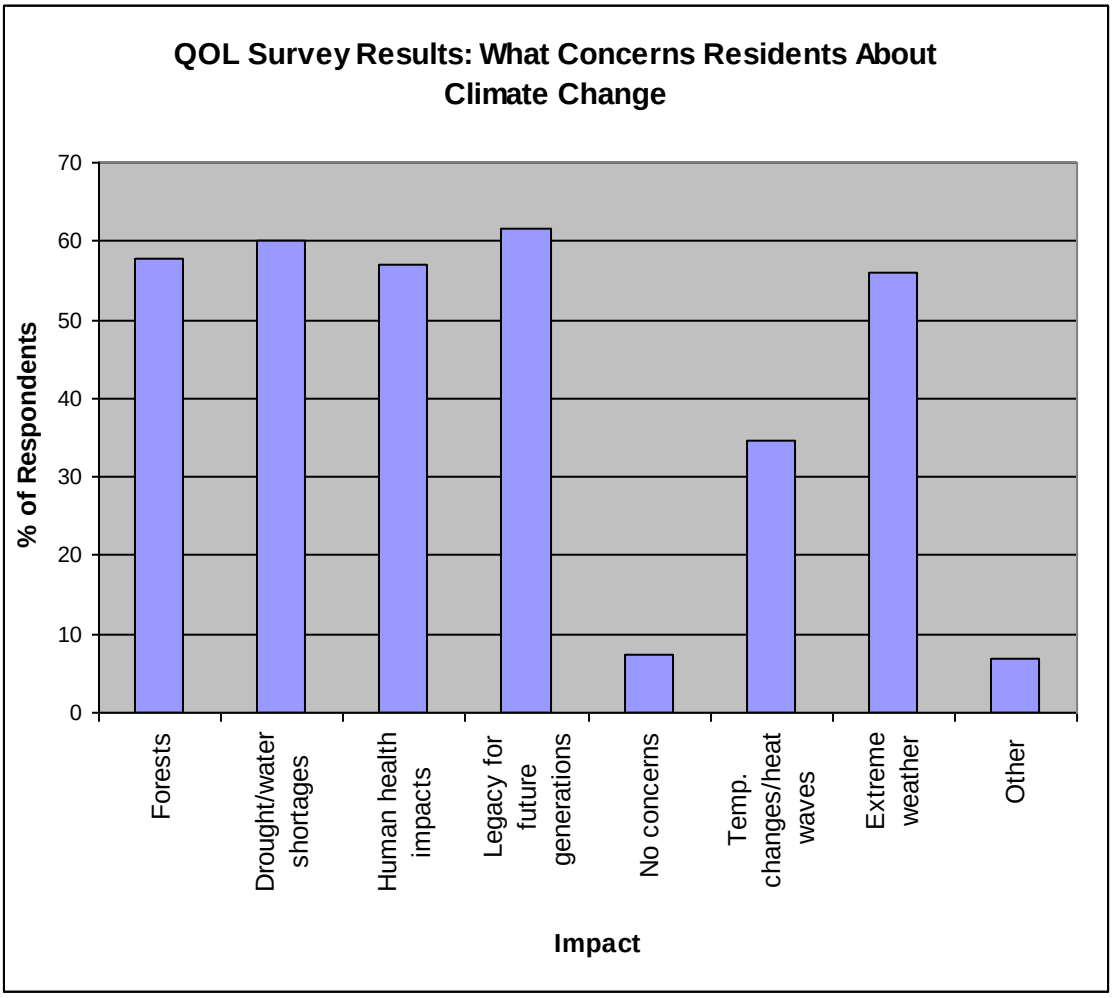


**Figure 5-1 Quality of life survey response to question: What concerns you most about climate change?**

Another question asked respondents:

***Do you feel that you and your family are likely to be affected by climate change?***

81.8 % of respondents answered yes to this question. Those who answered yes were asked the following:

***If yes, in what ways?***

Participants were instructed to indicate as many of the impacts that they thought were of concern. The results for this question are illustrated in Figure 5-2. If participants selected 'other' impacts they were asked to specify. The main 'other' concerns indicated were economic impacts (indicated by 2.2% of respondents), environmental impacts (indicated by 1.8% of total respondents) and impacts on wildlife (indicated by 1.3% of respondents).

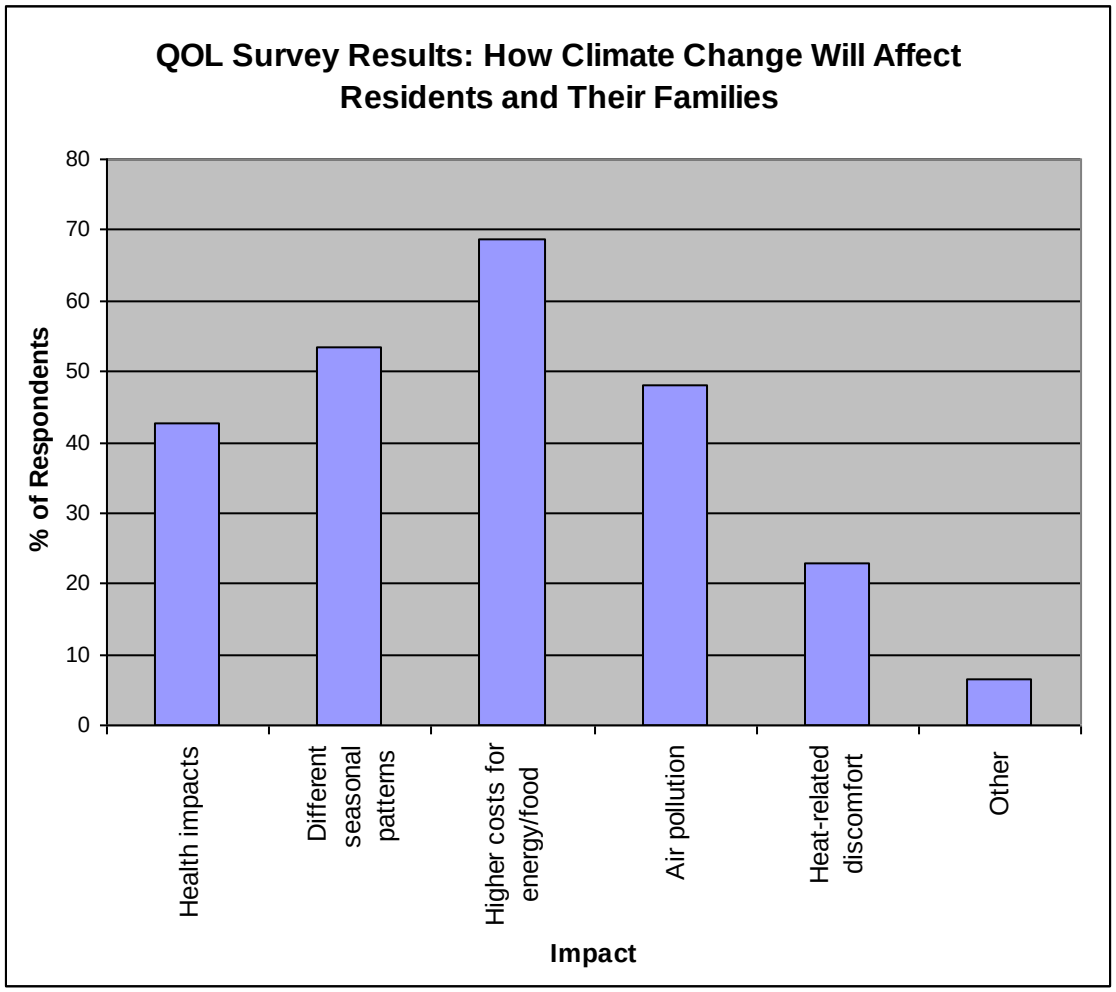


**Figure 5-2 Quality of life survey response to question: How will climate change affect you and your family?**

Another relevant question that was asked of the respondents was:

**Do you believe that Prince George as a whole is likely to be affected by climate change?**

88.3% of respondents answered yes to this question. Those who answered yes were asked the following:

***If yes, in what ways?***

Participants were instructed to indicate as many of the impacts that they thought were of concern. The results for this question are illustrated in Figure 5-3. If participants selected 'other' impacts they were asked to specify. The main 'other' concerns indicated were Environmental impacts/degradation (2.2% of respondents) and Cost to me (1.8% of respondents).

.

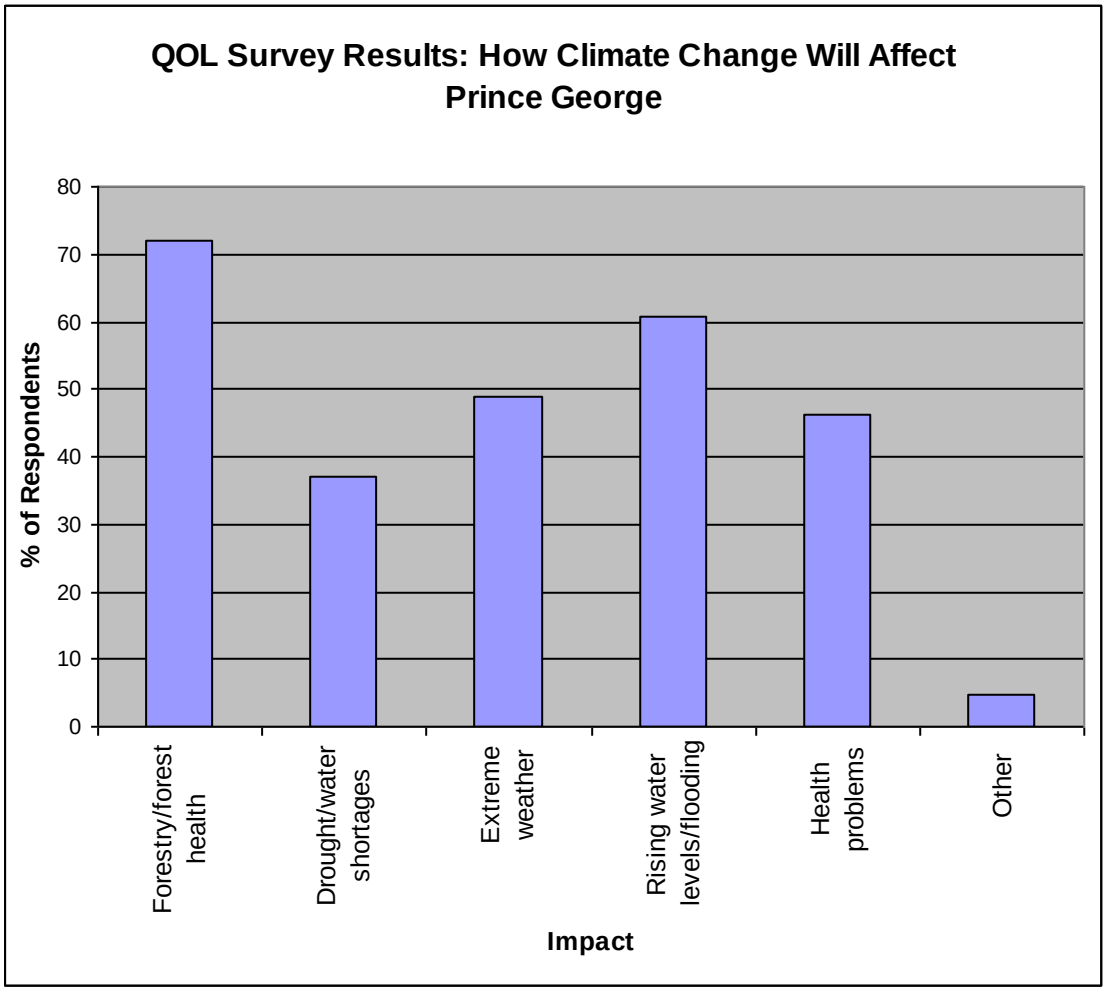


**Figure 5-3 Quality of life survey response to question: How will climate change affect Prince George as a whole?**

## *5.2. Planning Institute of BC Workshop*

In June 2008 the Planning Institute of BC (PIBC) held its annual conference in Prince George. The conference was entitled 'Planning for Change', and was focused on the role that planners have in addressing and responding to climate change. The University of Northern BC participated in the conference by working with the City of Prince George and other groups to organize a workshop focusing on adapting to climate change. The conference participants could elect to attend the full day workshop on the Thursday of the conference. Over 50 participants attended including planners from across BC and Yukon,

experts, and representatives from the City of Prince George. The workshop was entitled 'Adapting to Climate Change', and had two major objectives:

- to educate planners about climate change adaptation; and
- to generate innovative ideas for climate change adaptation strategies using Prince George as a case study.

*Additional information about the PIBC Workshop is included in Appendix B.*

**Workshop schedule:**
The workshop consisted of four sessions, which are described in Table 5-1 and visualized in Figure 5-4.

**Table 5-1 PIBC workshop agenda.**

| Time | Topic | Facilitators |
|---|---|---|
| 9:00am - 10:00 am | **Workshop Opening Session:** *Welcome, overview of workshop, background on climate change adaptation and definition of terms. Overview of past changes and future projections of temperature and precipitation in the PG region.* | Ian Picketts (UNBC) and Arelia Werner (PCIC) |
| 10:00am - 12:00pm | **Focus Group Sessions:** *Flooding & stormwater; Water quality and quantity; Infrastructure; Communication; and Implementation focus group sessions.* | City of PG reps and topic experts |
| **LUNCH** | | |
| 1:15pm – 2:30pm | **Integrated Sessions:** *Flooding & stormwater; Water quality and quantity; and Infrastructure integrated sessions* | City of PG reps and topic experts |
| 2:45pm - 4:00pm | **Workshop Plenary Session:** *Welcome to entire conference, review of key terms, climate information and workshop structure. Presentations from workshop focus groups and conclusions.* | Ian Picketts (UNBC), group reps & Stewart Cohen (Environment Canada) |

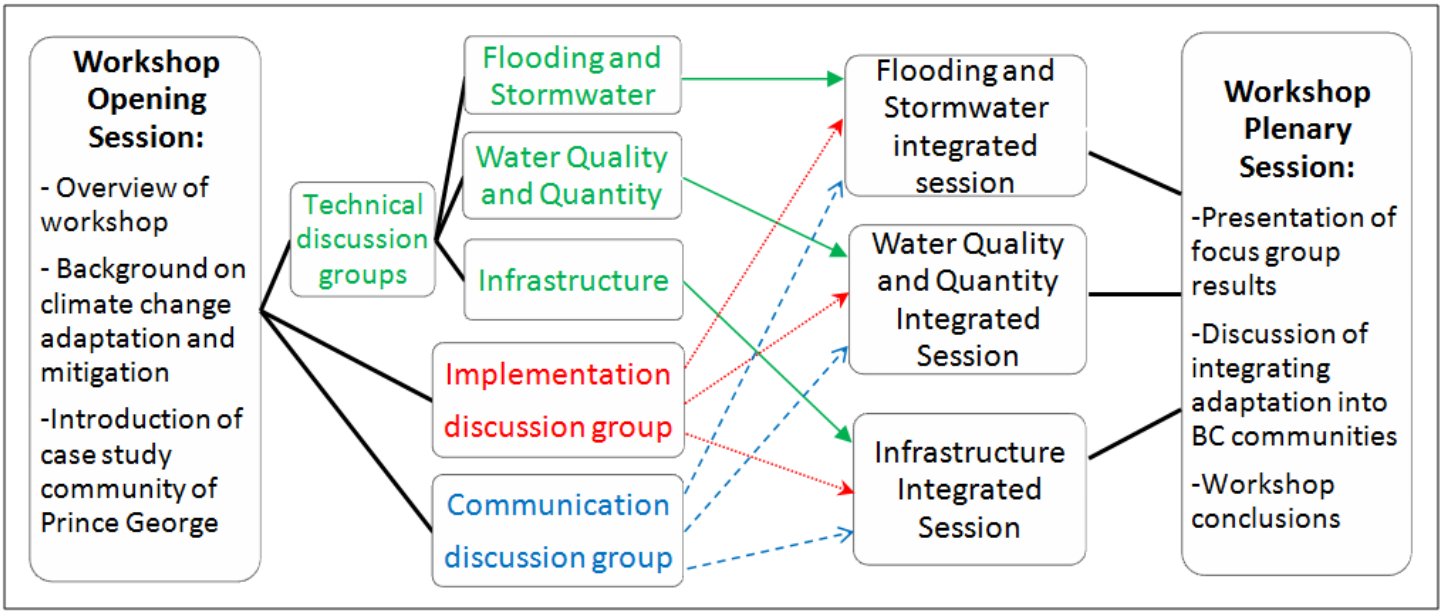


**Figure 5-4 Flowchart describing the four workshop sessions (opening session; focus groups; integrated sessions; and workshop plenary session).**

**Workshop sessions:**

1) **Opening Session:**

The workshop began with an opening session which provided an overview of the day's activities and key background information. Ian Picketts presented a background on climate change, definitions of key terms and facts about the case study community of Prince George. The clear definitions of, and differentiation between, climate change *adaptation* and *mitigation* were emphasized, and the focus on adaptation for the workshop was reinforced. As part of the opening presentation Arelia Werner from PCIC presented a detailed overview of past climate information and future projections for the region (see Section 3).

2) **Focus Groups Sessions:**

During the second phase of the workshop, the participants broke off into five separate focus groups. A Forests group was planned, but cancelled prior to the workshop due to lack of participant interest. A brief description of the focus groups is as follows:

**Flooding and stormwater**: Flooding events are expected to become more frequent with climate change, and existing flood protection works may no longer be adequate to accommodate for more severe and frequent river flooding events. This group focused on coming up with creative ideas to deliver planning solutions to the impacts that increased flooding will have on communities, and also on managing stormwater better to account for changes brought upon by climate change. The group discussed what information is needed to inform these solutions (i.e. precipitation projections, spring snowmelt projections, river flow rates).

**Water quality and quantity**: Climate change will alter the hydrological cycle, and is expected to increase strains on water resources. Communities must manage their supplies carefully to ensure that they have a sustainable supply of clean water for the future. This group focused on coming up with strategies to deliver planning solutions for the impacts of climate change on both water quality and quantity. The group discussed what information is needed to inform these solutions (i.e. precipitation projections, temperature projections, streamflow projections).

**Building and stormwater infrastructure:** Climate change affects the way that transportation and building infrastructure is planned, built and maintained. This group focused on coming up with creative ideas on how to plan building and transportation infrastructure in a way that appropriately considers and accounts for climate change. The group discussed what information is needed to inform these planning solutions (i,e, winter and summer precipitation projections, temperature projections, freezing degree days, freeze-thaw cycle projections).

**Implementation:** This group focused on discussing the challenges of getting adaptation measures incorporated into the appropriate community plans (i.e. OCPs, ICSPs (Smart Plans), Corporate Plans, management structures, functional Plans, etc.). People in this group discussed strategies for, and potential challenges to, implementation. This group then split up to join different integrated sessions during the next part of the workshop.

**Communication:** This group focused on raising awareness about climate change at all levels including government, industry and the public. The objective was to foster support for adaptation plans; and to gain this support stakeholders must understand this incredibly complex and uncertain issue. Adaptation needs to become a much higher priority for officials of all levels of government, local staff, elected officials and the public. People in this group spent the focus group session discussing communication strategies. The group then split up to join different integrated sessions during the next part of the workshop.

**3) Integrated Sessions:**

In the afternoon the focus groups reassembled in integrated sessions to focus on climate change solutions. The five focus groups merged into three integrated sessions by dissolving the implementation and communication groups, and having some participants from these groups join each of the others. The facilitators of the communication and implementation groups also joined the implementation sessions, Participants and facilitators in the technical focus groups remained in the same sessions so that the discussions could continue to evolve. The three integrated sessions were as follows:

1. Flooding and stormwater integrated session
2. Water quality and quantity integrated session
3. Infrastructure integrated session

These groups continued to build on the morning focus group discussions, but reoriented their discussions to talk about the issues at a broader scale. Groups were encouraged to

explore how strategies can be applied in communities and how they can be effectively communicated to the public and implemented.

**4) Final plenary session**

The entire PIBC conference attended the final plenary session. Ian Picketts provided an overview of the workshop for the plenary and background information about climate change adaptation, and Prince George. Arelia Werner spoke briefly to overview past climate information and future projections for the region. A representative from each of the integrated sessions and the implementation and communication focus groups briefly presented their findings from the day to the entire conference. These presentations provided the plenary with an overview of the key climate change adaptation concepts and strategies that were discussed throughout the day.

Doctor Stewart Cohen concluded the workshop by talking about the importance of climate change in planning. Stewart spoke elegantly about how planning can no longer rely on the past as a proxy for the future, and how the profession will have to plan for uncertainty. He stressed that communities will have to become more resilient, and that planners must take the lead in advocating for this resiliency. He concluded his talk by articulating that the planning community already has within it the capacity and creativity to deal with this new and unprecedented challenge.

## Results

The workshop was an effective mechanism to raise awareness of climate change amongst the planning community. It presented an excellent opportunity for dialogue about this new facet of planning. Many participants indicated that they had a more solid understanding of adaptation as a response to climate change after the workshop. The final plenary provided a forum to share information about climate change adaptation with over 200 planners attending the PIBC conference.

A summary of the key results from the integrated sessions as reported by Picketts (2008) in the Planning West Magazine article entitled, ‘Adapting to Climate Change Workshop’ is as follows:

**Flooding and Stormwater**: this group concluded that a detailed flood risk assessment needs to be conducted as soon as Prince George is not in an emergency situation. In the short term, the floodplain bylaw must be amended to reflect recent happenings. All levels of government need to communicate more clearly to address flooding issues. All natural stormwater retention areas (such as wetlands and ravines) should be utilized to the greatest extent possible. Increased streamflow and precipitation data (particularly seasonal data) and projections are crucial to inform adaptation plans.

**Water Quality and Quantity**: this group concluded that all (municipal, residential, agricultural and industrial) water use should be metered and charged at an increasing block rate (e.g. higher rates for excessive use). Surface water, stormwater, and greywater should be utilized wherever possible to reduce strains on freshwater sources. The City should encourage development near existing wells to protect aquifers and reduce costs.

To conserve water quality, development should occur in a manner that is sensitive to important groundwater recharge zones. Streamflow and precipitation projections are required to adequately plan for this. The public must be educated to overcome the misconception that there is an infinite supply of clean water in Prince George.

**Infrastructure:** this group concluded that reducing the overall footprint of the City Prince George will reduce the amount of infrastructure needed (particularly roads). Costs savings associated with this can be reallocated to building structures that can better withstand more extreme events and freeze-thaw cycles. This strategy also has important climate change mitigation co-benefits. Provincial building codes must account for long term climate change. To inform these decisions, a detailed analysis must be performed on future freeze-thaw scenarios, and building and paving materials in the north. The public must develop a greater awareness about the costs of city infrastructure, and the benefits of compact cities.

These results will be used to help the final impact groups as they discuss climate change adaptation on their topics. They are incorporated into the impact section (Section 8) of this document.

### Discussion

After talking to the facilitators it was also clear that some of the drawbacks of the workshop could be minimized by working with a smaller participant group - such as a community - on a more familiar case study topic. Decisions also require input from local decision makers who are familiar with the community and the surrounding natural environment. Therefore, the key outcome of this workshop was the envisioning of the City Adaptation Workshop with Prince George staff. This workshop built upon the research that had gone into the PIBC Workshop, and many of the same techniques, topics and formats were used. The results of and feedback from the PIBC Workshop were used to guide the City Adaptation Workshop.

The City Adaptation Workshop was specifically designed to generate prioritized results for the City, from the staff and stakeholders from the region who deal with planning and operations. An overview of the City adaptation workshop follows in Section 5.3.

## *5.3. Prince George City Adaptation Workshop*

In November 2008 a stakeholder workshop was held in Prince George entitled “Adapting to Climate Change in Prince George”. The purpose of this workshop was to engage Prince George city staff and key stakeholders in adapting to climate change. The workshop two principle objectives were;

1. to increase the knowledge and awareness of climate change impacts and climate change adaptation priorities within the City of Prince George; and
2. to identify a prioritized approach for developing a climate change adaptation strategy for the City.

Representatives with expertise on virtually all of the facets of planning and operations within the City attended the workshop. (For a list of workshop participants please refer to

appendix C.) The workshop agenda is shown in Table 5-2, and the sessions are briefly described afterward.

*Additional information about the City Adaptation Workshop is included in Appendix C.*

**Table 5-2 City Adaptation Workshop agenda.**

| Time | Topic | Facilitators |
|---|---|---|
| 10:00am - 10:15 am | **Introduction to Workshop:** *Welcome, overview of workshop, definition of terms, summary of climate change work occurring in PG* | UNBC |
| 10:15am - 11:15:am | **Understanding Changes in PG's Climate*:*** *Overview of the past changes, and future temperature and precipitation projections in the PG region.* | PCIC |
| 11:15am – 12:15pm | **Identifying the Impacts of Climate Change in PG:** *Linking the climate projections with actual impacts on city infrastructure, operations and planning.* | UNBC, Fraser Basin Council |
| **LUNCH & Discussion** | | |
| 1:00pm – 2:30pm | **Visioning an Adaptation Strategy for PG:** *Determining the priorities for an adaptation strategy, and the best approach for developing this strategy. Identifying the future vision for the City of PG, and how we must plan to adapt to climate change so that we can attain this vision. Wrap up, final thoughts and Future directions.* | City of PG, UNBC, Fraser Basin Council |

**1) Workshop introduction:**

Ian Picketts opened the workshop with a brief introductory presentation to welcome the participants and outline the workshop's purpose. To set the context for the workshop some key terms were clearly identified and differentiated between, such as mitigation and adaptation. The objectives were explained, and it was expressed that the participants were the experts; as they are the people who are witnessing and planning for changes. Therefore they have the best local knowledge to identify and prioritize the different impacts that are, and will be, facing the city.

**2) Understanding the past and projected changes in Prince George's climate*:***

The introduction was followed by a 40 minute presentation by Arelia Werner from PCIC on past trends and future projections of climate in the region. This presentation served as an opportunity to communicate the concepts of historic climate trends, climate variability, climate change, global and regional climate models, and future climate projections. It also helped attendees to begin to grasp what the major trends in the region are and what types of changes to Prince George's climate are expected. The information that was presented is summarized in Section 3 of this document. After the presentation there was a 20 minute question and answer period.

**3) Identifying the impacts of climate change in Prince George:**

Over the next hour the plenary split into four groups for discussions on the impacts of Climate Change in Prince George. The four groups were selected so that each had representation from different areas of expertise such as current planning, long term planning, operations and utilities. Each focus group produced a list of priority impacts that the City is currently addressing or will have to eventually address, using the information that had just been presented to guide the discussion. Based on the feedback generated in this section a master list of impacts was created.

**4) Visioning an adaptation strategy for Prince George:**

This session began with a brief report back from the facilitators to finalize the master list of impacts. The visioning exercise was designed to determine the priorities for an adaptation strategy, and the best approach for developing this strategy. Participants prioritised the master list of impacts, decided which City sectors would be involved in addressing these issues, and selected which documents the adaptation plans should be incorporated into. There was also an opportunity for participants to offer their ideas on ways to address the impacts.

These ambitious outcomes were achieved by providing each participant with a spreadsheet or 'matrix' to fill out. Participants were instructed to evaluate the risk of each impact, name the sectors in the City that would be most seriously affected by it, determine in what plans the issue should be addressed, and provide ideas for adapting to the impact. This matrix was modeled from an adaptation guide created by the City of Chicago (2008).

## Results

**Results from: Identifying the impacts of climate change in Prince George:**

The priorities that were identified in the master list of impacts are as follows:

1. Increased forest fires
2. Increased flooding
3. Extreme weather events – emergency response
4. Increased freeze / thaw impacting transportation
5. Threats to water quality & quantity
6. Stresses on transportation infrastructure (other than freeze-thaw)
7. Extreme weather events limiting transportation capabilities
8. Stresses on storm-water infrastructure
9. Stresses on utilities infrastructure
10. Warmer temperatures leading to increased agricultural capacity
11. Warmer temperatures leading to more residents and business opportunities
12. Erosion & landslides

**Results from**: **Visioning an adaptation strategy for Prince George:**

The participants took the Master List of impacts and filled out the matrix based on them. They completed sections on the risk of impacts, priorities for city services to address

impacts and implementation tools. Participants had the option to offer ideas for solutions in the final section. A total of 26 people filled out the matrix.

Participants were requested to rank each of the impacts in terms of its risk. This was accomplished by having the participants rank the likelihood and timing of the impact, and the consequence of not acting on the impact, on a scale of one to five (see appendix C for more details). The following three figures represent the average (or mean) workshop stakeholders' perceptions of the risks of climate change impacts in Prince George:

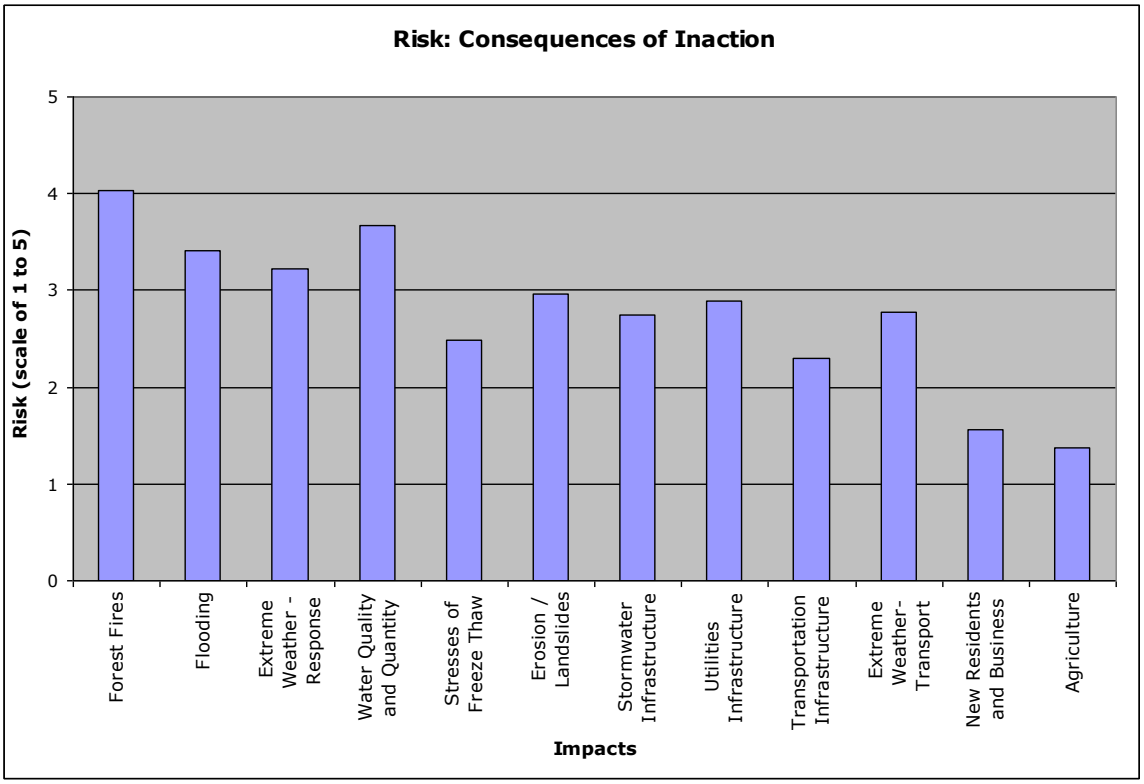


**Figure 5-5 Workshop results for mean risk (consequences of inaction) ratings for climate change impacts.**

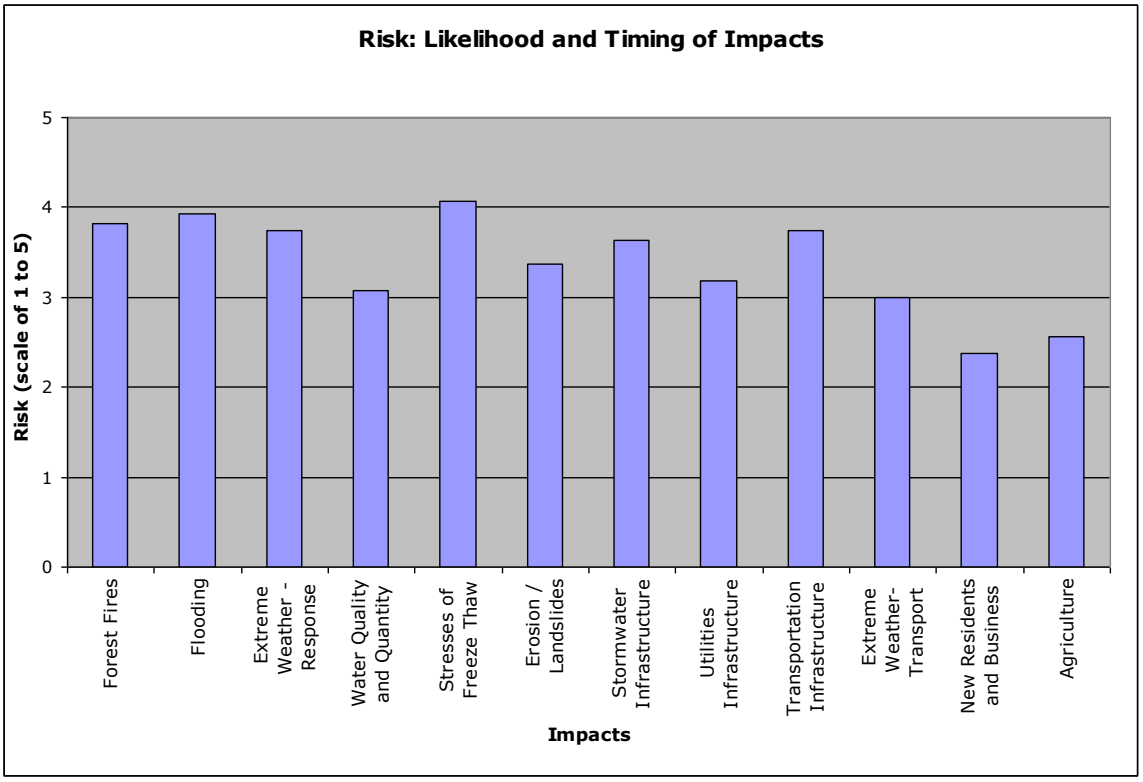


**Figure 5-6 Workshop results for mean risk (likelihood and timing of impacts) ratings for climate change impacts.**

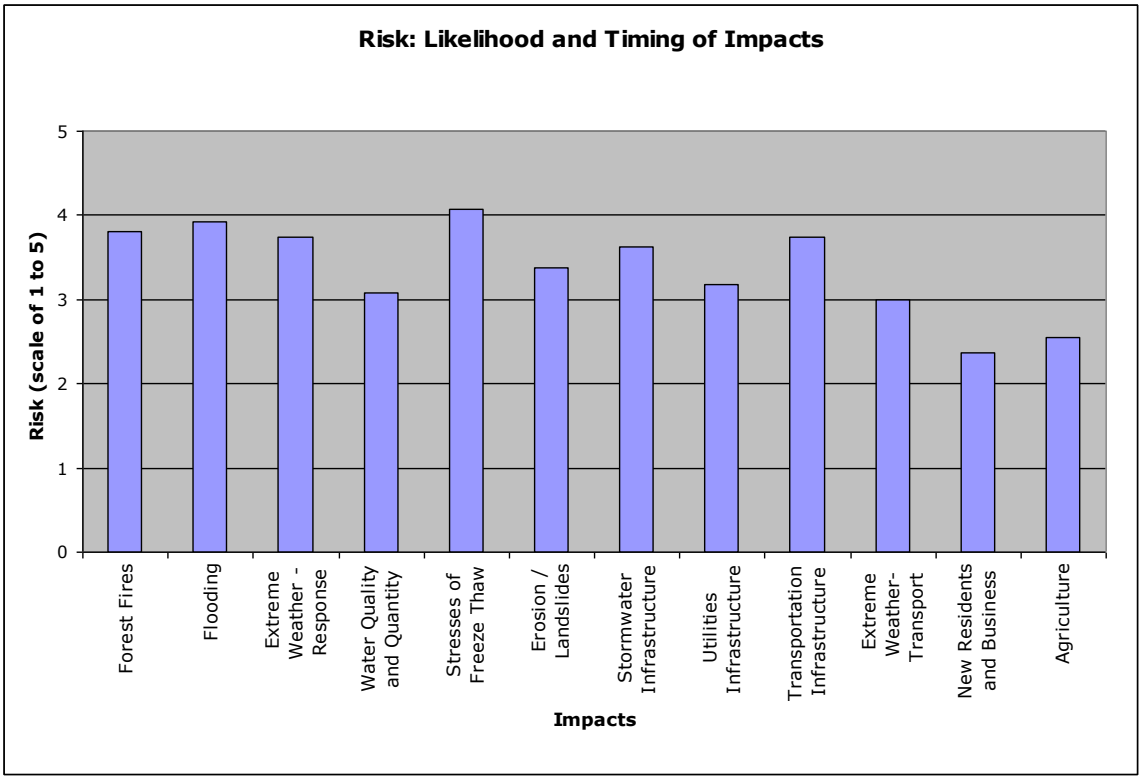


**Figure 5-7 Workshop results for risk (consequences of inaction times likelihood and timing of impacts) ratings for climate change impacts.**

## Sectors most seriously affected by impacts:

Table 5-3 shows the top 3 City sectors that stakeholders identified should be involved in addressing each impact. (Note that many sectors tied. In the event of a tie both sectors are included in one cell of the table, and separated with an '&'.)

**Table 5-3 Top sectors identified for addressing impacts in City Adaptation Workshop.**

| IMPACTS | PRIORITIZED CITY SERVICES TO ADDRESS | | |
|---|---|---|---|
| | 1st priority | 2nd Priority | 3rd Priority |
| **Increased forest fires** | Police, Fire and Rescue Services | Real Estate and Bylaw Services | Municipal Emergency & Response |
| **Increased flooding** | Municipal Emergency and Response | Police, Fire, and Rescue Services | Long Range Planning |
| **Extreme weather events-emergency response** | Municipal Emergency and Response | Police, Fire, and Rescue Services | Risk and Benefits |
| **Threats to water quality and quantity** | Utilities | Environmental Services | Long Range Planning |
| **Increased freeze/thaw impacting transportation** | Transportation | Financial Services | Fleet and Supply Services |
| **Erosion/landslides** | Long Range Planning | Real Estate and Bylaw Services & Environmental Services | - |
| **Stormwater infrastructure** | Utilities | Financial Services | Transportation & Risk and Benefits |
| **Utilities infrastructure** | Utilities | Municipal Emergency and Response | Police, Fire, and Rescue Services & Financial Services & Long Range Planning |
| **Transportation infrastructure** | Transportation | Financial Services | Corp. Serv: Fleet and Supply Services |
| **Extreme weather events-transportation & people** | Transportation | Municipal Emergency and Response | Police, Fire, and Rescue Services |
| **Warmer temperatures-new residents and businesses** | Long Range Planning | Solid Waste Services & Social Policy | - |
| **Warmer temperatures-agriculture** | Long Range Planning | Environmental Services | Parks and Trails |

**Implementation tools to address impacts:**
Table 5-4 shows the top implementation tool that stakeholders identified should address each impact:

**Table 5-4 Top implementation tool in which City should address impacts identified in City Adaptation Workshop.**

| IMPACTS | TOP IMPLEMENTATION TOOL |
|---|---|
| **Increased forest fires** | ICSP (myPG) |
| **Increased flooding** | ICSP (myPG) |
| **Extreme weather events-emergency response** | Annual Provisional Financial Plan |
| **Threats to water quality and quantity** | ICSP (myPG) |
| **Stresses of freeze thaw** | Asset Mngt. Performance Measures |
| **Erosion/landslides** | OCP |
| **Stresses on stormwater infrastructure** | Asset Mngt. Performance Measures |
| **Stresses on utility infrastructure** | Asset Mngt. Performance Measures |
| **Stresses on transportation infrastructure** | Annual Provisional Financial Plan |
| **Extreme weather events-transportation & people** | ICSP (myPG) |
| **Warmer temperatures-new residents and businesses** | OCP |
| **Warmer temperatures-agriculture** | OCP |

**Results from addressing impacts comments:**
Participants provided excellent feedback in the comment section on the back of the matrix. More comments were provided for the impacts at the beginning of the list, as many people ran out of time (although half of the participants were asked to comment on the impacts at the end of the list first). The comments are incorporated into the Section 8 of this report, which focuses on the individual impacts, and should be examined further by groups addressing these impacts. Please refer to Appendix D for a complete list of the comments provided by the participants.

## *5.4. Smart Growth on the Ground Feedback*

Smart Growth on the Ground (SGOG) is an integrated program administered by Smart Growth BC that has worked with various communities across the Province (Maple Ridge, Squamish, Greater Oliver and most recently Prince George). The program guides communities to develop more sustainable neighbourhood plans that incorporate the principles of Smart Growth (SGOG 2009). As part of an inclusive process, SGOG facilitated practical research in working towards a design charrette to create a concept plan for Prince George's downtown (SGOG 2009).

Ian Picketts took advantage of the timing and the nature of the SGOG process to work with the team to incorporate climate change adaptation as a component of the project. During the first SGOG learning event (which took place in November 2008) Ian gave a presentation on climate change adaption that included an overview of climate trends and projections. Smart Growth was able to assist the climate change adaptation research effort by allowing for two detailed questions to be included in the evaluation for the two learning events. In consultation with UNBC researchers and experts at the City, the following questions were included in the final evaluation sheet:

- **9. What are the climate change impacts that you think will affect Prince George the most, and that the City should address in a climate change adaptation strategy?** Please check up to 5, and feel free to add you own impacts.

☐ Forests (such as increased pest outbreaks)
☐ Severe weather events (storms, etc.)
☐ Slope stability (landslides, erosion etc)
☐ Road conditions (freeze-thaw creating potholes, etc.)
☐ Storm-water capacity (overflow, etc)
☐ Agricultural changes (ie longer growing season)
☐ Water quality problems
☐ Need for more emergency services
☐ Forest fire risks
☐ Health issues
☐ Affects to buildings
☐ Water shortages
☐ Increased river flooding
☐ Other: _____
☐ Other:_____
☐ Other: _____

- **10. Please explain what worries you most about projected changes in the climate (ie warmer temperatures, more precipitation). What you think the city should do to adapt to future changes?**

Response was quite good, and a total of 74 members of the public answered the adaptation questions. One potential source of error is that people who filled out the evaluation on the second night did not hear Ian Picketts' presentation on climate projections and impacts. A cursory analysis of the results of the respondents on each night shows that there was not a significant change in the answers between the two nights (See appendix E).

*Additional information about the SGOG process and the feedback questions is included in appendix E.*

## Results

### Results from Question 9:

Figure 5-8 shows the results for the adaptation priorities (question nine) from all of the evaluation forms. Only 12 people wrote down 'other' impacts for question nine, and none were indicated by more than one respondent. Therefore none of these impacts are included in this analysis.

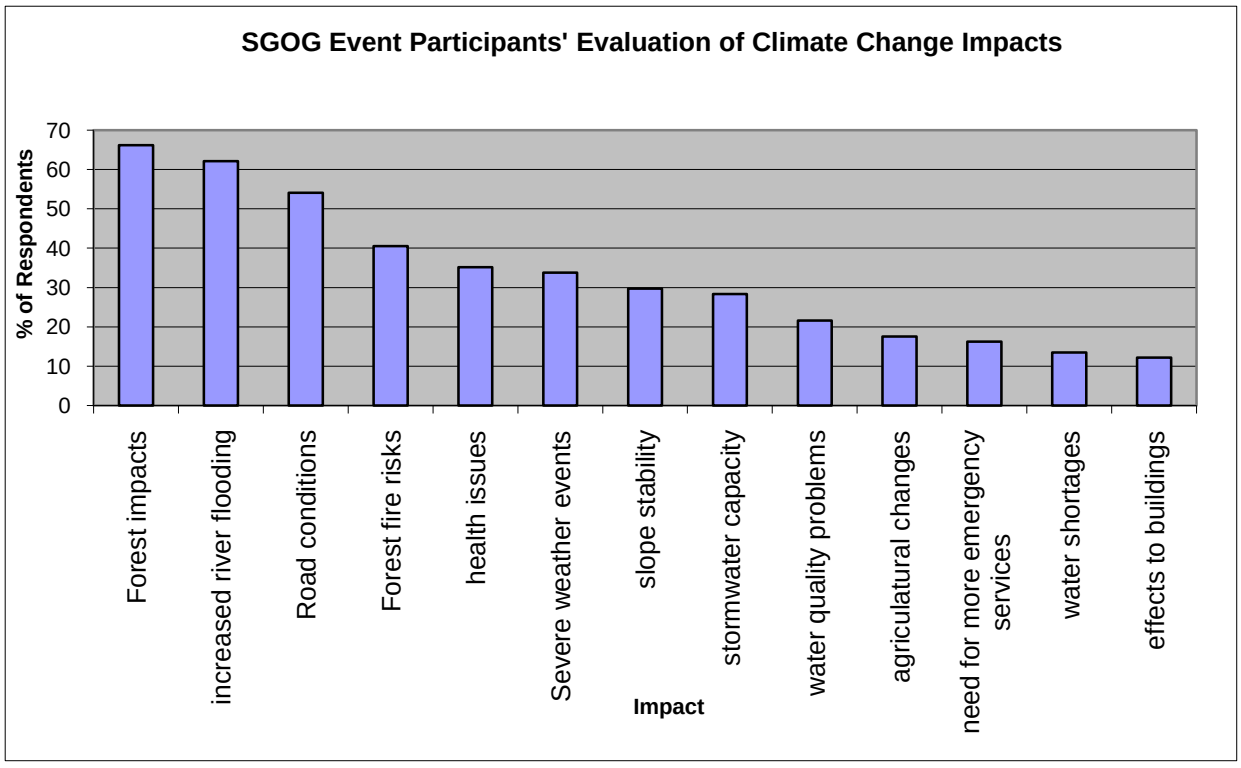


**Figure 5-8 Smart Growth on the Ground participants' indications of adaptation priorities.**

**Results from Question 10:**
A total of 50 people wrote a response to the open-ended question 10. The question was, **"**Please explain what worries you most about projected changes in the climate (i.e. warmer temperatures, more precipitation). What you think the city should do to adapt to future changes?"

There was considerable variation in the responses to this question. People related ideas about a wide range of topics from government bureaucracy to local agriculture to recycling. The results were analyzed by categorizing the responses. Even after an effort to broadly categorize the answers there were still nearly as many categories as topics. A large number of the responses were focused on climate change mitigation rather than adaptation, and many responses were focused on broader downtown issues. The greatest number of adaptation-related responses were: floods (four responses); transportation (four responses); forest issues (three responses); climate refugees (two responses); agriculture (three responses); biodiversity (two responses); and extreme weather (two responses). Three respondents indicated that they were not worried about the affects of climate change and that it should not be a priority for the City. Due to the wide variation in the nature, length and tone of the responses they were not analyzed in detail to inform the final climate change adaptation priorities or discussion.

For a complete list of the responses to question 10 please refer to Appendix F.

# 6. Analytical Framework of Research and Analysis

The purpose of this partnership between the City and UNBC is to identify an adaptation strategy for Prince George. This has led to a number of different partnerships, workshops and activities. There have also been other independent initiatives that the City has taken on focused on climate change adaptation, as well as strategies to address individual impacts. Below is a brief summary of the key activities that are integrated into this document:

- The 'Climate Change in Prince George: summary of past trends and future projections' report by Picketts et al. (2009) informs adaptation actions by providing important information about past climate changes and future climate projections.
- The PIBC workshop was designed educate planners and begin to outline a climate change adaptation strategy for Prince George. After the workshop, it was apparent that more research needed to be conducted directly with City stakeholders to inform a more specific strategy.
- The City Adaptation Workshop was an outcome of the PIBC workshop. This event was specifically tailored to inform the adaptation strategy with City staff.
- The work with SGOG provided an opportunity to begin to consider climate change adaptation in the downtown area, and to gather feedback from local residents about adaptation priorities.
- The City of Prince George 2008 QOL Survey has provided valuable community feedback about climate change impacts and concerns.

Different research methods have different strengths. Therefore it is reasonable to conclude that combining different research methods will produce more comprehensive information than each individual method would in isolation (Morgan 2006). The activities listed above represent multiple sources of evidence for the adaptation priority exercise. It is valuable to incorporate the results of multiple relevant exercises to add validity to the research, given the inevitable strengths and shortcomings that are associated with single method studies (Jick 1979).

Although the City Adaptation Workshop, SGOG events and QOL survey were conducted using different methodologies, they all involved stakeholders selecting and/or ranking climate change impact priorities. Therefore the results of each of these can be compared and considered in the determination of the selection of the impact priorities for Prince George. This usage of multiple research methods can be referred to as triangulation, which is broadly defined as "the combination of methodologies in the study of a single phenomenon" (Denizen 1978: 291). Triangulation can be described as a mechanism to provide a more in-depth and balanced overview of a situation, and a way to cross check data from multiple sources (Alrichter et al. 1996; O'donoghue and Punch 2003). 'It is an important method for contrasting and comparing different accounts of the same situation.' (Alrighter et al. 1996; p. 115) The term 'triangulation' has many different

meanings in academia, so it is often more prudent to use terms such as convergence or confirmation when referring to this concept (Morgan 2006).

In a broader sense this research utilizes the case study approach (with Prince George as the case study), which is justified on both practical and methodological grounds. The deciding factor that determines whether or not research is a case study is if one is examining a bounded system, or specific phenomenon (Smith 1978). Case studies are considered the most appropriate method for asking how or why questions about complex social phenomena, and for understanding the role of process and context in affecting change (Yin 1984). There are many drawbacks to a case study approach: the research provides very little basis for scientific generalization; and it is not easily transferable to other situations and settings (Yin 1989). However, due to the large number of variables that affect a communities' ability to implement climate change adaptation, the multiple sources of information used, the multitude and complexity of the variables, and the objective to produce a holistic description of climate change adaptation measures, the case study approach is deemed to be the most appropriate.

A brief overview of the methodologies and analytical frameworks of the research methods used to identify the impact priorities are described below. These will be outlined in more detail in academic papers discussing this research.

## *6.1. Quality of Life survey*

The questions in the 2008 Prince George QOL survey were designed to inform the upcoming ICSP (myPG) for Prince George. They were formed by a working group of representatives from the City. A total of 657 people responded to the questionnaire. The respondents were selected at random, and 54% were female, 46% were employed full time and the mean age was 54 (Nordin 2008). The outputs of the survey discussed in this report are a quantitative assessment of the publics' views on climate change. This means that the results represent the views of the residents of the City as a whole (A. Michalos pers. comm. 2009). The return rate for the survey gives error margins of plus or minus four percentage points, 19 times out of 20. So, for example if 79% of respondents said yes to a question, then it can be said that the figure represents between 75% and 83% of the population of Prince George (Nordin 2008).

No information was provided to the respondents about climate change, or climate change models to educate the participants and provide them with information to inform their solutions. Stakeholders did not have the opportunity to create the impacts that they were to evaluate, however there was a space for them to indicate 'other' impacts. Participants were given five impacts to select from a list that was generated by the City of Prince George in 2007. Respondents were permitted to indicate as many impacts as they thought were appropriate.

The results used for analysis from the QOL survey are the percentage of respondents who indicated each of the impacts for the 'How will climate change affect Prince George?" question. This is the most relevant impact question for the City that was included in the survey. This survey represents a good overview of the public's concerns regarding

climate change impacts. The only significant drawback is the relatively small number of impacts that the participants had to select from. Comparing these results with the SGOG survey will help to fill in some of these gaps.

## 6.2. City Adaptation Workshop

The City Adaptation workshop was a qualitative research exercise that utilized focus groups to generate impact priorities. Focus groups are a method of data collection that capitalizes on communication between research participants to generate data. This is a very useful tool to analyze what people think about a subject, as well as how people think and why they think that way (Kitzinger 1994). The focus group method allows people to work together to explore and clarify their views and opinions in greater depth than they could in an interview setting. When there are good dynamics within a focus group, they have the potential to take the research in new directions (Kitzinger 1995). Interactions between the participants can enhance the data, the consistency of views can be quickly assessed, and the group nature of the exercise tends to be an enjoyable process (Patton 2002). Furthermore, focus groups are appropriate if the research is in an exploratory stage. These groups provide an effective tool early in the research process to refine frameworks (Hoggart et al 2002). For these reasons focus groups were deemed to be the most appropriate method to gather feedback from local experts in the workshop.

The participants were selected based on their knowledge of certain aspects of City planning and operations, or expertise on climate change. The workshop was split into four focus groups in such a way that each group had representation from different sectors such as current planning, long range planning, operations and utilities. Approximately eight people were in each group, which is an ideal size for this type of research (Patton 2002). Participants were exposed to information about climate change adaption in the workshop introduction, and about climate change modeling in Arelia Werner's presentation on past climate changes and future projections to the workshop. Participants were also provided with a draft of the report "Climate Change in Prince George: summary of past trends and future projections" (Picketts et al. 2009) for their reference two weeks before the workshop.

The facilitators of the focus groups were Elizabeth Henry and Joan Chess from the Fraser Basin Council, and Robin Chang and Ian Picketts from UNBC. All of the facilitators participated in the organization and conceptualization of the workshop, and met several times before the workshop to ensure consistency with information gathering from the focus groups. In each group, the facilitator started the discussion by asking for different impacts that the City would face. Leading and open ended questions were used by facilitators to continue the discussions if necessary. Prompt questions such as "What are the worst impacts possible?" and "What is most likely to happen?" were used when necessary. Careful planning and proper facilitation is crucial to allow groups to effectively share their ideas and perceptions, and to encourage conversations to flow among the participants (Krueger and King 1997)

The City Adaptation workshop continued on from the focus group sessions with a matrix evaluation that was developed based upon the concept of risk analysis. The two

determinants for Risk that were evaluated by the workshop participants were 'likelihood and timing' and 'consequences of inaction'. These risk sections were adapted from the City of Chicago Adaptation guide (2008). Chicago is a global leader in community climate change adaptation. Chicago used the likelihood and consequence framework to evaluate risk in such a way as to measure the probability of a predicted impact occurring and the probable severity of the consequence associated with that impact. This is illustrated in Figure 6-1 below:

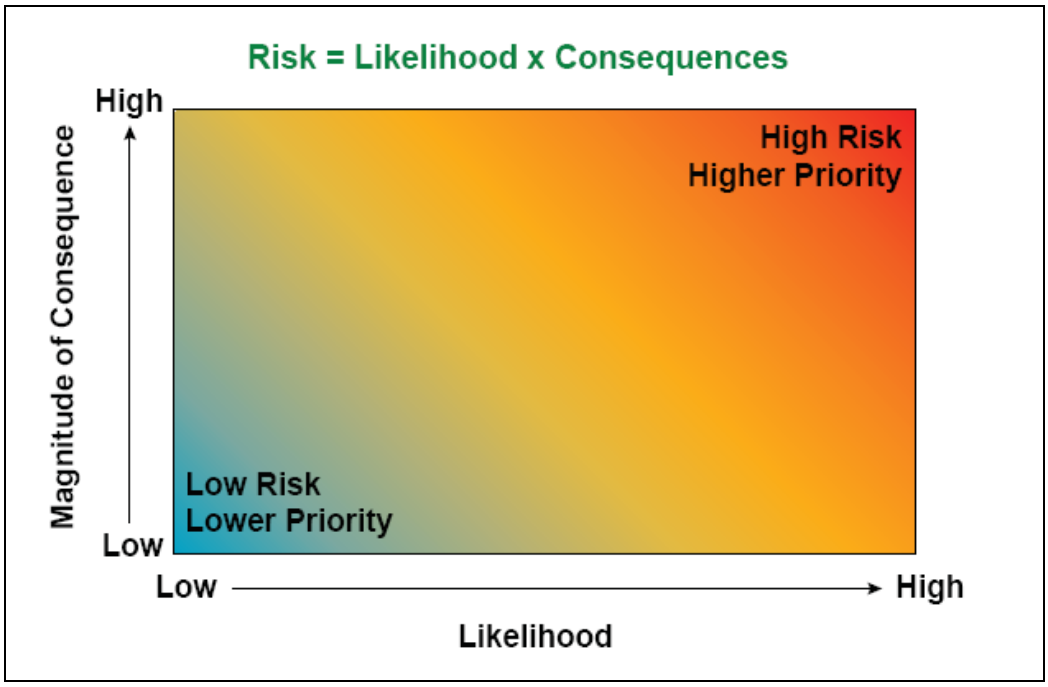


**Figure 6-1 Climate change impact risk calculation methodology. Source: City of Chicago 2008.**

Prior to implementation, the discussion on risk evaluation in the chapter 'Assessing key vulnerabilities and the risk from climate change' in the IPCC (2007e) report, 'Climate Change 2007: Impacts, Adaptation and Vulnerability assessing key vulnerabilities and the risk from Climate Change' was used to verify the risk framework. The framework was also compared to another risk framework developed by the Allen Consulting Group (2005) to identifiy adaptation priorities for the Government of Australia. This is discussed in detail in Appendix G.

One key shortcoming of the study's risk framework is that it does not properly account for positive impacts that may occur as a result of climate change. The magnitude of consequences risk scale does not properly evaluate potential positive benefits such as increased agricultural capacity or economic opportunities. It also does not properly account for less certain impacts such as negative health affects. Therefore it is important to reconsider these potential positive impacts independently in separate studies, or as a continuation of this work.

## *6.3. Smart Growth on the Ground Event*

Two questions included in the evaluation form of the SGOG workshops in November 2008 was an effective way to capitalize on an opportunity to gather public feedback about climate change impacts and adaptation. This is a qualitative study, as the sample population is limited to the participants of the SGOG event. Therefore the results from this type of research cannot be used to generalize with confidence to the general population (Patton 2002). A more detailed research framework of the SGOG evaluation is included in appendix H.

In qualitative research, the sample selection has a profound effect on the ultimate quality of the research (Coyne 1997). It is difficult to accurately assess this sample group due to the limited amount of information describing the participants. The respondents were almost entirely from Prince George, and they had 'self selected' by electing to participate in this event, and to answer the questions. Therefore it can be assumed that these people are generally more concerned about climate change and its impacts than the general public.

In order to get good answers that can be analyzed, good questions have to be asked. Questions must be clear, well worded and carefully thought through if they are to provide adequate data (Payne 1951). Extensive work was put into the questions that were posed on the evaluations and they were reviewed by many people. Information about climate change adaptation and future climate projections was provided via Ian Picketts' presentation to the respondents on the first night of the event. As described in Section 5.4, and Appendix H, the presentation did not lead to a significant change in peoples' responses between the two nights.

Although these results give a good overview of the publics' attitudes about climate change adaptation, this exercise has some shortcomings - from a research perspective - with regards to the participant selection. Because of these shortcomings, less weight will be attributed to the final priorities based on this work. The results from this sample will be used to add validity to the other results, or to bring up inconsistencies for discussion. The results from this study are useful to help to fill in gaps that are present due to the small number of impacts respondents in the QOL survey had to select from.

# 7. Climate Change Impact Categories

The results of each exercise are shown below in an appropriate form for comparison:

**Quality of Life survey results:**

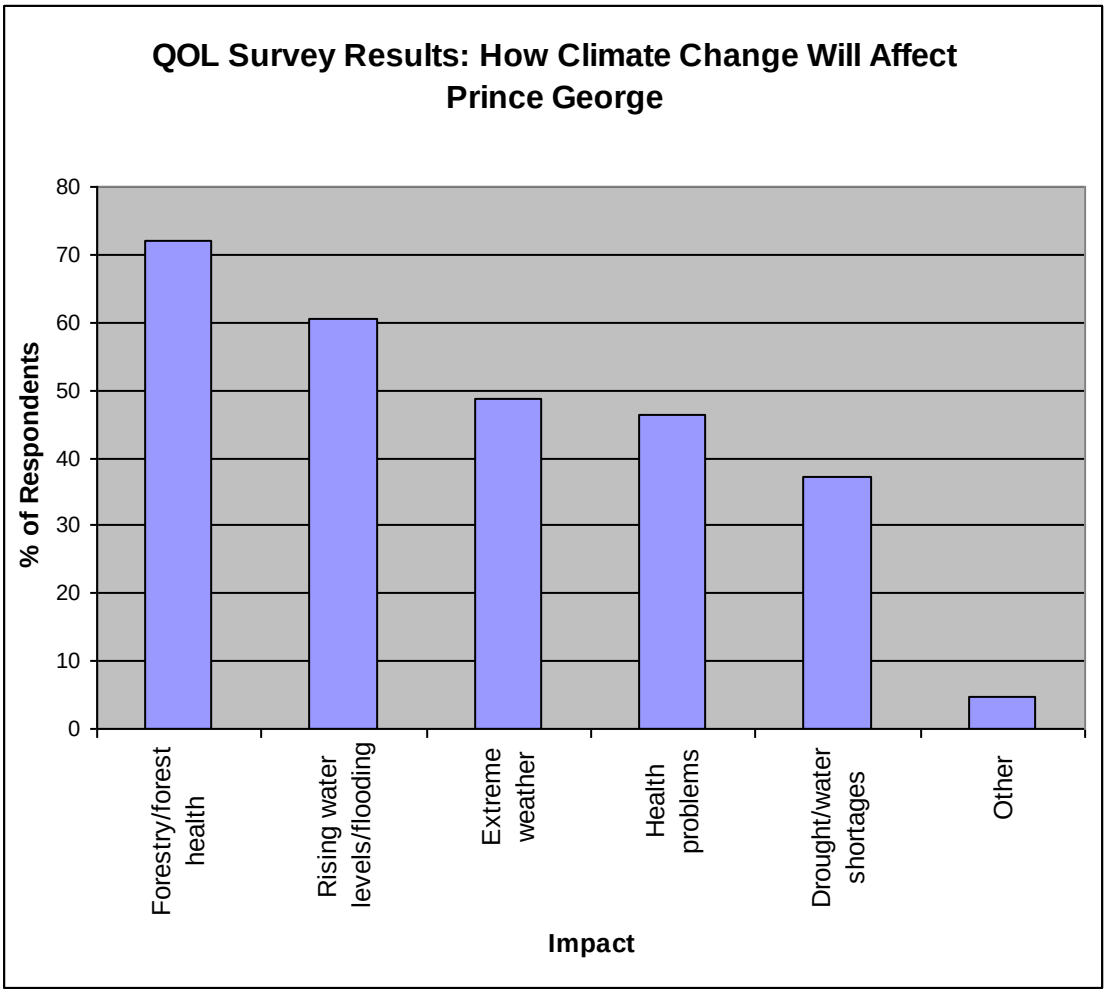


**Figure 7-1 Results from the quality of life survey to question: How will climate change affect Prince George?**

None of regular responses to the 'other' impacts were specific enough to be considered as an independent impact (the two frequent ones were 'environmental impacts' and 'cost'), Therefore they are not included in this analysis.

**Smart Growth on the Ground learning event evaluation:**

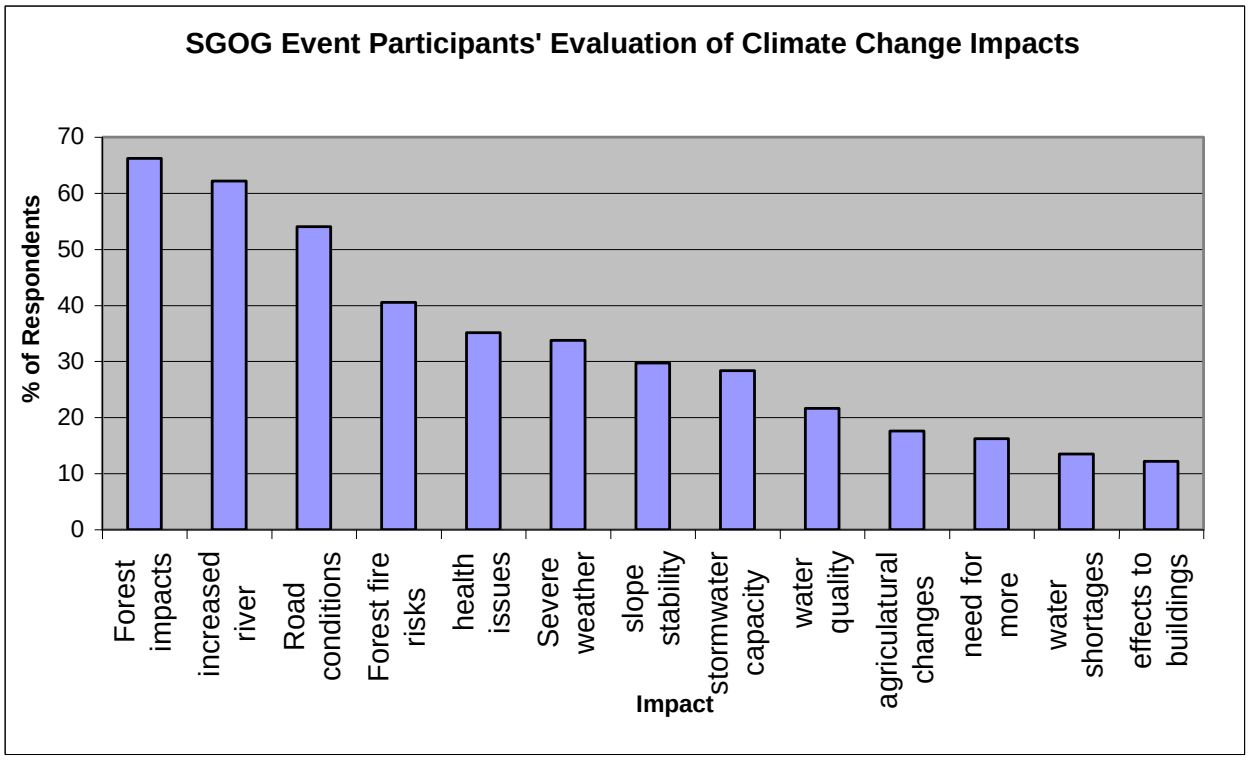


**Figure 7-2 Results from the Smart Growth on the Ground evaluation.**

No 'other' impact was mentioned more than once, and all of the frequent responses in question 10 were either focused on mitigation or referring to impacts that were included in question 9. Therefore they are not included in this analysis.

**City Adaptation Workshop results:**

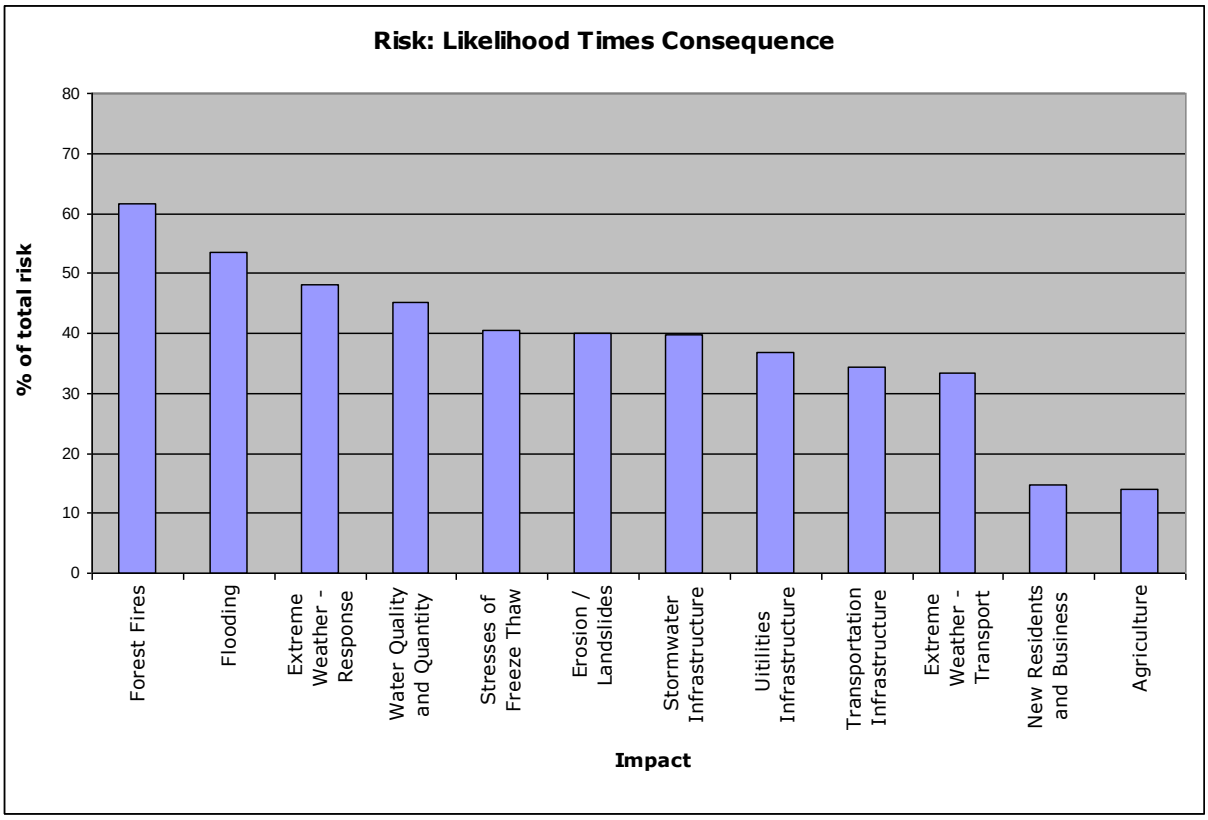


**Figure 7-3 Results from the City Adaptation Workshop.**

The results from the City Adaptation Workshop are the average percentage of the risk scores (that participants ranked the impacts out of), out of the total possible score. These are the rankings of on the two types of risk (likelihood of occurrence and the consequences of an occurrence) multiplied together and converted into a percentage value by divided by the total possible risk (five times five or 25). Since none of regular responses to the 'other' impacts were specific enough to be considered as an independent impact they are not included in this analysis.

## *7.1. Determining a List of Prioritized Impacts*

Combining qualitative and quantitative methods together in a project is a particularly effective way to strengthen research, as qualitative and quantitative methods have very different attributes. Therefore this combination maximizes the ability to bring different strengths together into a single research project (Morgan 2006). The purpose of conducting research from multiple studies is in the hopes of arriving at the same results. If this occurs than it shows that the findings are more legitimate, as they are not a function of a single methodology (Morgan 2006).

There are some formidable challenges to combining qualitative and quantitative research, and attempts to do so are often thwarted. This is because of the different paradigms

associated with each, and the different set of assumptions that the two types of researchers have about the world (Casebeer and Verhoef 1997). Therefore researchers tend to favour one type of method and discount the other. However, there have been books written and studies completed about successful integration of the two types of research (particularly in the health sciences field), that can be used as a model for this exercise (Casebeer and Verhoef 1997; Jick 1979; Morgan 2006; O'donoghue and Punch).

It is not possible to directly compare the different results because they involve different methods, stakeholders, and background information. For example the PIBC and City Adaptation workshops both featured a detailed climate information presentation based on the PCIC work, the SGOG workshop had a brief overview of climate information, and the respondents to the quality of life survey were not provided with any information on climate change. Different response options were also presented to stakeholders in different exercises: the City Adaptation Workshop participants listed and prioritized their own impacts; the SGOG questions respondents indicated up to five impacts from a list of 13; and the QOL survey respondents indicated as many impacts as they saw fit to out of a list of five.

This research follows a method of triangulation outlined by Morgan (2006) called the complementary method. This method starts with an examination of the primary research and then uses a secondary (and tertiary if applicable) study for discussion and comparison. The primary study is the City Adaptation Workshop, the secondary study is the QOL survey and the tertiary study is the SGOG evaluation. Therefore the qualitative City Adaptation Workshop is examined first, and then the quantitative QOL survey helps to verify or guide the research, and finally the qualitative SGOG results provides another source of verification. Ideally researchers can conduct the qualitative research first and then use the results for the quantitative assessment (Morgan 2006). If this was the case, then the participants in the QOL survey would have been asked which of the impacts of climate change that were identified in the City Adaptation workshop that they thought would affect Prince George, and the SGOG respondents would have been presented with the same list to choose from. However, due to the restraints on the research given the timing of the different events, this was not possible.

## *7.2. Prioritized Impacts – Summary of Results*

A summary of the results from the three prioritization exercises is included in Table 7-1:

**Table 7-1 Summary of impact prioritization exercise results.**

| SGOG Evaluation | | City Adaptation workshop | | QOL Survey | |
|---|---|---|---|---|---|
| # of participants: n = 74 | | # of evaluators: n= 26 | | # of respondents: n = 571 | |
| **Impact** | **% that selected impact** | **Impact** | **% of total possible risk rating** | **Impact** | **% that selected impact** |
| Forests | **66.2** | Increased forest fires | **61.6** | Forestry/forest health | **71.9** |
| Increased river flooding | **62.2** | Increased flooding | **53.5** | Rising water levels/flooding | **60.6** |
| Road conditions | **54.1** | Extreme weather events-emergency response | **48.2** | Extreme weather | **48.8** |
| Forest fire risks | **40.5** | Threats to water quality and quantity | **45.1** | Health problems | **46.3** |
| Health issues | **35.1** | Stresses of freeze thaw | **40.4** | Drought/water shortages | **37.1** |
| Severe weather events | **33.8** | Erosion/landslides | **39.9** | | |
| Slope stability | **29.7** | Stormwater infrastructure | **39.8** | | |
| Stormwater capacity | **28.4** | Utilities infrastructure | **36.8** | | |
| Water quality problems | **21.6** | Transportation infrastructure | **34.4** | | |
| Agricultural changes | **17.6** | Extreme weather events-transportation & people | **33.3** | | |
| Need for more emergency services | **16.2** | Warmer temperatures-new residents and businesses | **14.7** | | |
| Water shortages | **13.5** | Warmer temperatures-agriculture | **14.0** | | |
| Affects to buildings | **12.2** | | | | |

### Finalization of Impact Categories

To put the priorities into one list, the impacts had to be generalized into appropriate categories first. The sectors identified in the BC chapter of the Natural Resources Canada Impacts and Adaptations report by Walker and Sydneysmith (2008) were used a reference. If the impact(s) identified or created in the exercises clearly fell within a sector, then the sector name was used as the impact. If it was apparent that the impact should be more specific than at the level provided in the chapter, or if it was not discussed, than it was simply left as was outlined in the City Adaptation Workshop.

## *7.3. Climate Change Impact Priorities*

To identify the final priorities, the results from the City Adaptation exercise were considered, and then referenced against the QOL results. Finally, the SGOG research was analyzed to identify any discrepancies and address any gaps that were present in the QOL results. Based on this analysis the final adaptation priorities are as follows:

**Table 7-2: Prince George adaptation priorities.**

| Level of Priority | | Impact |
|---|---|---|
| **Top Priorities** | 1 | Forests |
| | 2 | Flooding |
| **High Priorities** | 3 | Transportation infrastructure |
| | 4 | Severe weather / emergency response |
| | 5 | Water supply |
| **Medium Priorities** | 6 | Slope stability |
| | 7 | Stormwater |
| | 8 | Buildings and Utilities |
| **Other Priorities** | 9 | Health |
| | 10 | Agriculture |
| | 11 | New Residents and Businesses |

### Top Priorities

These impacts were clearly identified as the top priorities in all of the assessment exercises:

1. **Forests – forest health and fires:**
   City Adaptation Workshop: Increased forest fires: 61.6 risk rating
   QOL Survey: Forestry / forest health: 71.9% selected
   SGOG evaluation: Forests: 66.2% selected
   Forest fire risks: 40.5% selected

**Discussion**: All three exercises had a forestry related impact as the top priority for adaptation, or concern about climate change. The SGOG evaluation had forestry divided into two impacts, which were the 1st and 4th highest priorities for the exercise. Therefore forestry is clearly the first priority for adaptation among the stakeholders in all three exercises. The more general term 'forests' is used because it addresses fires and other important issues that are closely related to it (such as the mountain pine beetle).

## 2. Flooding:

| | |
|---|---|
| City Adaptation Workshop: | Increased flooding: 53.5 risk rating |
| QOL Survey: | Rising water levels/flooding: 60.6% selected |
| SGOG evaluation: | Increased river flooding: 62.2% selected |

**Discussion**: the results of all three exercises indicated that river flooding was the second highest priority for adaptation, or concern about climate change. Therefore flooding is a top priority for adaptation based on the exercises. River flooding should not be confused with localized flooding caused by storm events. Stormwater runoff is an impact that is considered separately.

## High Priorities

These next priorities were all ranked highly in the exercises but not as consistently as the top priorities. The author has provided rationale for the order in the discussion section, however depending on the criteria they could be considered to be in other orders.

## 3. Transportation infrastructure:

| | |
|---|---|
| City Adaptation Workshop: | Stresses of freeze- thaw: 40.4 risk rating<br>Stresses on transportation infrastructure: 34.4 risk rating<br>Extreme weather -transportation & people 33.3 risk rating |
| QOL Survey: | Not identified as an impact |
| SGOG evaluation: | Road conditions: 54.1% selected |

**Discussion**: Transportation was clearly a very high concern among the participants of the City Adaptation Workshop exercise. There were three related impact categories identified in the top list of impacts, which shows that it is an important priority. This also shows that transportation is closely linked with emergency response. This option was not included in the QOL survey, however transportation was ranked 3rd in the responses from the SGOG evaluation, with over 50% of respondents indicating that road conditions were an impact of concern.

### 4. Severe weather / emergency response:

| | |
|---|---|
| City Adaptation Workshop: | Extreme weather - emergency response: 48.2 risk rating |
| | Extreme weather -transportation & people 33.3 risk rating |
| QOL Survey: | Extreme weather: 48.8% selected |
| SGOG evaluation: | Severe weather events: 33.8% selected |

**Discussion**: Emergency response and severe weather events are included as one impact, as the increased need for emergency response is generally considered to be in response to these events (as illustrated in the City Adaptation Workshop results). Extreme weather / emergency response was the 3rd highest impact ranked by the City Adaptation workshop respondents, the 4th highest impact chosen by the QOL respondents and the 6th highest impact chosen by the SGOG respondents.

### 5. Water supply:

| | |
|---|---|
| City Adaptation Workshop: | Threats to water quality and quantity: 45.1 risk rating |
| QOL Survey: | Drought / water shortage: 37.1% selected |
| SGOG evaluation: | Water quality problems: 21.6% selected |
| | Water shortages: 13.5% selected |

**Discussion**: the quantity and quality of water is closely interrelated, and is therefore considered jointly as 'water supply'. 'Threats to water quality and quantity' was the 4th highest rated impact in the City Adaptation Workshop, with a score of 45.1. A significant number of people (37.8%) indicated in the QOL survey that water shortages were a concern, however it was the impact that the least number of people selected. 21.6% of SGOG respondents thought that water quality was a priority and 13.5% thought that water shortages were of high concern.

## Medium Priorities

These impacts can be considered moderate priorities for the City of Prince George, and should be considered along with the top and high priorities.

### 6. Slope stability:

| | |
|---|---|
| City Adaptation Workshop: | Erosion / landslides: 39.9 risk rating |
| QOL Survey: | Not identified as an impact |
| SGOG evaluation: | Slope stability: 29.7% selected |

**Discussion**: Slope stability ranked considerably in both the City Adaptation Workshop and SGOG evaluation, and should be considered a moderate priority.

### 7. Stormwater:

City Adaptation Workshop: Stresses on stormwater infrastructure: 39.8 risk rating
QOL Survey: Not identified as an impact
SGOG evaluation: stormwater capacity: 28.4% selected

**Discussion**: Stormwater is a significant issue that should be considered in a Prince George adaptation strategy. Increased stormwater runoff can cause severe erosion, landslides, and localized flooding events.

### 8. Buildings and utilities:

City Adaptation Workshop: Stresses on utility infrastructure: 36.8 risk rating
QOL Survey: Not identified as an impact
SGOG evaluation: Affects to buildings: 12.2% selected

**Discussion**: Stresses on utilities infrastructure ranked considerably in the City Adaptation Workshop. However, buildings were not identified as an impact in this workshop. It also ranked the lowest in the SGOG evaluation, so should not be considered to be a very high priority. Buildings were included in this impacts because utilities is closely interrelated to both stormwater and water quality and quantity, therefore many concerns will be addressed in other higher priority categories.

## Other priorities

These impacts are important priorities for the City that should be addressed in a climate change adaptation strategy, however they were not deemed to be of a high priority based on this exercise. This is because there is no emergency or immediate high risks associate with these impacts. It should be noted that there are positive benefits associated with some of these impacts that can be exploited to the benefit of Prince George. The risk exercise in the City Adaptation Workshop was set up so that positive benefits and non-urgent issues would not score as high. These issues warrant further research and discussion in partnership with the City.

### 9. Health:

City Adaptation Workshop: Not included as impact
QOL Survey: Health problems: 46.3% selected
SGOG evaluation: Water quality problems: 35.1% selected

**Discussion**: Health was not selected as a major impact in the City Adaptation workshop so it is not included as a high priority. This is largely due to the format of the workshop and the emphasis on physical impacts to climate change. It, it ranked 4$^{th}$ in the QOL survey and 5$^{th}$ in the SGOG evaluation. Therefore this can be considered to be a pressing priority that warrants further research.

## 10. Agriculture:

City Adaptation Workshop: Warmer temperatures-agriculture: 14.0 risk rating
QOL Survey: Not identified as an impact
SGOG evaluation: Agricultural changes: 17.6% selected

**Discussion**: Agriculture is an important issue that should be considered in an adaptation strategy. It did not rank particularly highly in the City Adaptation Workshop rating system because it does not pose any significant threat to human life or short term health. This is one impact that has many positive implications that should be capitalized upon.

## 11. New residents and businesses:

City Adaptation Workshop: Warmer temperatures – new businesses and people: 14.7 risk rating
QOL Survey: Not identified as an impact
SGOG evaluation: Not identified as an impact

**Discussion**: New residents and businesses did not rank particularly highly in the City Adaptation Workshop rating system because it does not pose any significant threat to human life or short term health. However this is another impact that has positive implications that could be capitalized upon if properly planned for.

# 8. Adaptation Actions

This chapter summarizes information about each of the impact categories, and recommends actions for Prince George.

## *8.1. Forests*

### Background

The IPCC (2007a) concludes that disturbances such as wildfire and insect outbreaks are increasing and are likely to intensify in a warmer future with drier soils and longer growing seasons. The mean and variance of annual burned area in Canada has increased significantly in recent years compared to the first half of the century (Podur et al. 2002). In 2003 large fires swept through the southern interior of B.C and severely affected many communities. This was the worst summer in recent years for B.C. forest fires, with over 2,500 fire starts and an all-time record number of wildland-urban interface fires. These interface fires destroyed 334 homes, forced the evacuation of 45 000 people, and resulted in a total estimated cost of $700 000 000 (Filman 2004). Warmer summer temperatures are expected to continue to extend the window of high fire ignition risk, and substantially increase the area that will be affected by forest fires in Canada over the next century (IPCC 2007a). Prince George, which is often referred to as a city within a forest, has the potential to be severely affected by the impacts to forests brought upon by climate change.

Climate change is expected to have significant effects on forest ecosystems in Canada in numerous other ways besides forest fires, impinging on productivity, regeneration ability, tree mortality and disturbance patterns (Singh and Wheaton 1991). Future conditions are projected to become more suitable for new species of plants and animals. This includes invasive species that can cause considerable damage to ecosystems (Williamson et al. 2007). One noteworthy example of a temperature related affect to forests in BC is the wide-scale mountain pine beetle infestation. This infestation is expected to kill more than 75% of the merchantable lodgepole pine volume in the province within the next decade (BC Ministry of Forests 2008). The large increase in fuel load in the forests from the recent mountain pine beetle (Dendroctonus ponderosae) outbreak has greatly increased the potential for forest fires to cause great damage in the province (Filman 2004). A report prepared for the City of Prince George by Needoba and Blackwell (2009) note that wildfire hazards decrease after the needles drop from dead trees, but increase significantly years later when the affected trees fall over.

The amount of timber that can be harvested in the area around Prince George (e.g. the allowable annual cut) has been increased by over 25% in recent years. This has been done in an effort to harvest pine beetle affected wood. The increase in logging activity exacerbates the effects the beetle infestation is having on the hydrologic cycle by removing trees (both living and dead) from the environment (BC Government ND). Research has shown that beetle infestation results in more water reaching the forest floor, changes in timing of snowmelts and less water being lost through transpiration. These

changes all lead to greater flood risks in a catchment, and also decrease slope stability and affect water quality (BC Ministry of the Environment 2008). (Work is ongoing at the University of Washington to explore the combined impacts of mountain pine beetle and forest harvesting on flooding.)

**Figure 8-1 Prince George home surrounded by beetle affected forests. Source: City of Prince George.**

A major initiative has been undertaken to assess Vanderhoof, BC's vulnerability with regards to forestry and climate change. This study was conducted by the Canadian Model Forest Network, the McGregor Model Forest and the Canadian Forest Service, in collaboration with the Municipality of Vanderhoof, and it was completed in 2008. Since Vanderhoof is very close to Prince George geographically and shares a close relationship with its forests, the case study is very relevant. A report on the exercise by Williamson et al. (2008) outlines the interrelated nature of the affects of climate change on forestry:

> *'… climate change affects disturbance regimes in forests surrounding communities and may affect several disturbance factors (e.g., fire, insects, drought, windstorms) at the same time. Moreover, these disturbance factors are interrelated. For example, 20th-century climate change contributed to the unprecedented MPB outbreak in Vanderhoof and the surrounding area. The resulting tree mortality is having immediate implications for susceptibility to wildfires. Once the dead needles drop, fire susceptibility is expected to decrease. However, if climate change results in warmer and drier conditions in the future, wildfire activity is projected to once again increase. Thus, local disturbance-related impacts are interrelated, complex, and dynamic.'*

The focus of the report is on assessing the vulnerability of forest based communities to the impacts of climate change, using Vanderhoof as the case study.

Figure 8-2 from Williamson et al. (2008) provides an overview of the pathways that forest based communities are impacted by climate change. The image illustrates that many social factors (such as jobs and cultural traditions), economic factors (such as

property assets and timber values) interrelate with environmental factors to impact communities.

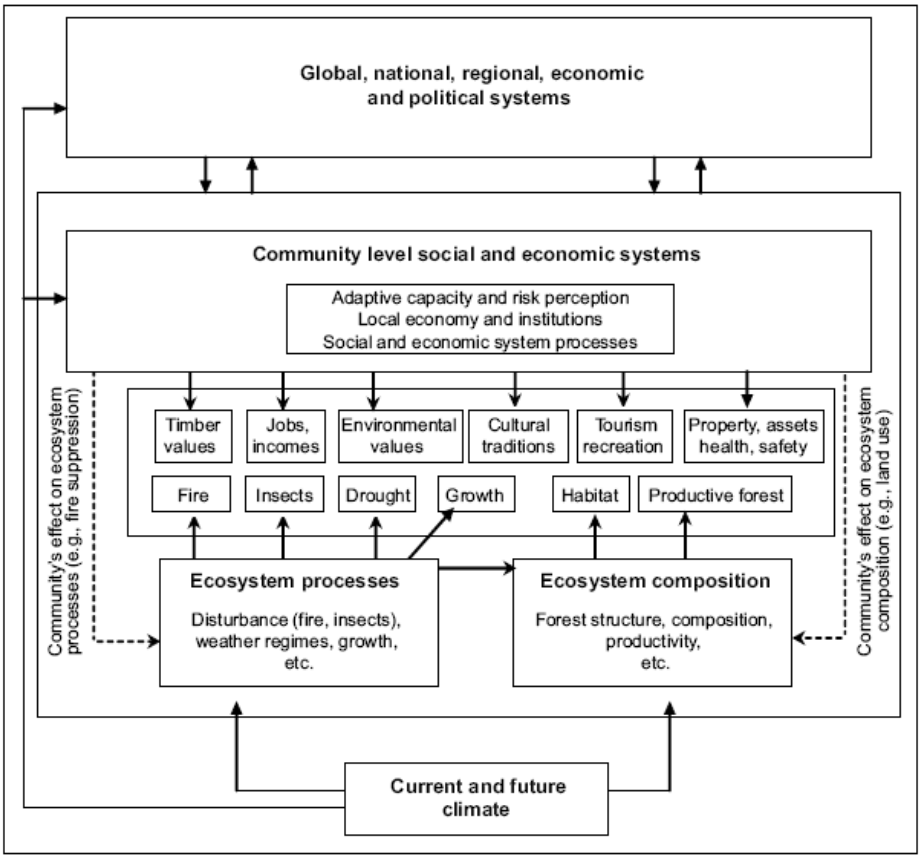


**Figure 8-2 Pathways for forest based community impacts to climate change. Source: Williamson et al. 2007.**

An article by Natural Resources Canada (2008) recently provided forestry related predictions for Vanderhoof over the next 50 years. The overview outlined the following impacts:

1. Continued forest cover and increased forest productivity to 2050
2. A more variable timber supply in the next 10–15 due to changes in forest policies;
3. A smaller forest industry once beetle-affected wood is salvaged;
4. Higher harvest costs due to shorter winters (which is the most cost-effective harvesting season);
5. Greater susceptibility to forest fires; and
6. Increased forest disturbances from more frequent and intense weather events

Perhaps most importantly (as is illustrated by the predictions for Vanderhoof study and Figure 8-2), the changes in forests in BC will affect many communities at a social and economic level. Many areas in Northern BC have a long history that is inextricably linked to their forests. This discussion is beyond the scope of this report, however it is extremely important and needs to be considered in Prince George.

Most of BC's forests are on Crown land, and it is the Provincial Government's responsibility to set policies and develop management objectives for this land (Walker and Sydneysmith 2008). Therefore, effective adaptation to forest changes should be done in close collaboration with the provincial government. However it is also true that licensees have an important role in establishing management objectives (D. Adamson pers. comm. 2009).

## Prince George Overview

The City of Prince George is well aware of its close link to forests and forestry, and of the importance of forest health and fire protection. Most of the recent actions associated with adapting to forest changes have been focused on addressing the mountain pine beetle epidemic by capturing as much value as possible from the dead pine trees and reducing the spread of the beetle (D. Adamson pers. comm. 2009). There are many initiatives that have been taken to respond to forest changes which are easy to build upon in an adaptation strategy.

Prince George initiated a plan to prepare for local fire events after the 2003 fires, in response to the perceived threat to local residents and infrastructure. A Wildlife/Urban Interface Wildfire Management Strategy was prepared by Diamond Head Consulting Ltd. (2006) to produce comprehensive strategies to reduce the long-term wildfire hazard for the city. The City also has a firesmart program that offers information to people so that they can better protect their home from fires (City of Prince George 2008b). More information from the City is available at: http://www.city.pg.bc.ca/city_services/fire/

Recently, City Council received a report and presentation by Needoba and Blackwell (2009) from B.A. Blackwell & Associates highlighting the outstanding wildfire hazard areas to the north and west of the municipal boundary. Given experience from other wildfires (e.g. Kelowna in 2003), and the increased probability of more drought conditions from climate change, there are concerns that wildfires could be a significant hazard to property and life in the city. A major concern is spot-fires, which are started kilometres ahead of a fire front caused by ember showers pushed ahead by winds (Needoba and Blackwell 2009). Council has approved City staff to begin consultations with the Regional District, the Province, the Leidl T'enneh and other stakeholders towards a strategy to address this wildfire hazard (D. Adamson pers. comm. 2009).

Prince George received a probationary Community Forest Agreement from the British Columbia Ministry of Forests in 2006. This enables the City to manage portions of the crown land within the city limits with the primary goals of minimizing the wildfire hazard to the city (as outlined in the Wildfire Management Strategy) and mountain pine beetle impacts. The Community Forest allows for the City to manage crown and municipal lands in concert, and to address local forest issues while upholding the City's strategic long term planning objectives, as outlined in the OCP (Timberline Forest Inventory Consultants 2006; Prince George Community Forest ND). The community forest agreement grants harvesting rights to identified parcels of Crown land within the city limits of Prince George, which was a total of 5543 ha in 2006 (Figure 8-3) and the

allowable annual cut is 12 000$m^3$ per year (Timberline Forest Inventory Consultants 2006). The Province recently enacted the Forest Amendment Act (Bill 13-2009) which, among other provisions, eliminates the probationary phase of community forests. Therefore the Prince George Community Forest licence has been automatically converted to a minimum 25 year license (D. Adamson pers. comm. 2009).

In 2007 (the first year of the community forest operation), salvage harvesting was conducted along the Cranbrook Hill Greenway trail, and extensive tree removal operations were conducted at the Otway Nordic Ski Centre - in partnership with the managing organizations of those areas. Over the past year the Forests for the World area has been the priority for logging and thinning operations for the purpose of wildfire reduction (Prince George Community Forest ND) and is expected to be completed in the fall of 2009. The community forest website is available at http://www.communityforest.princegeorge.ca/.

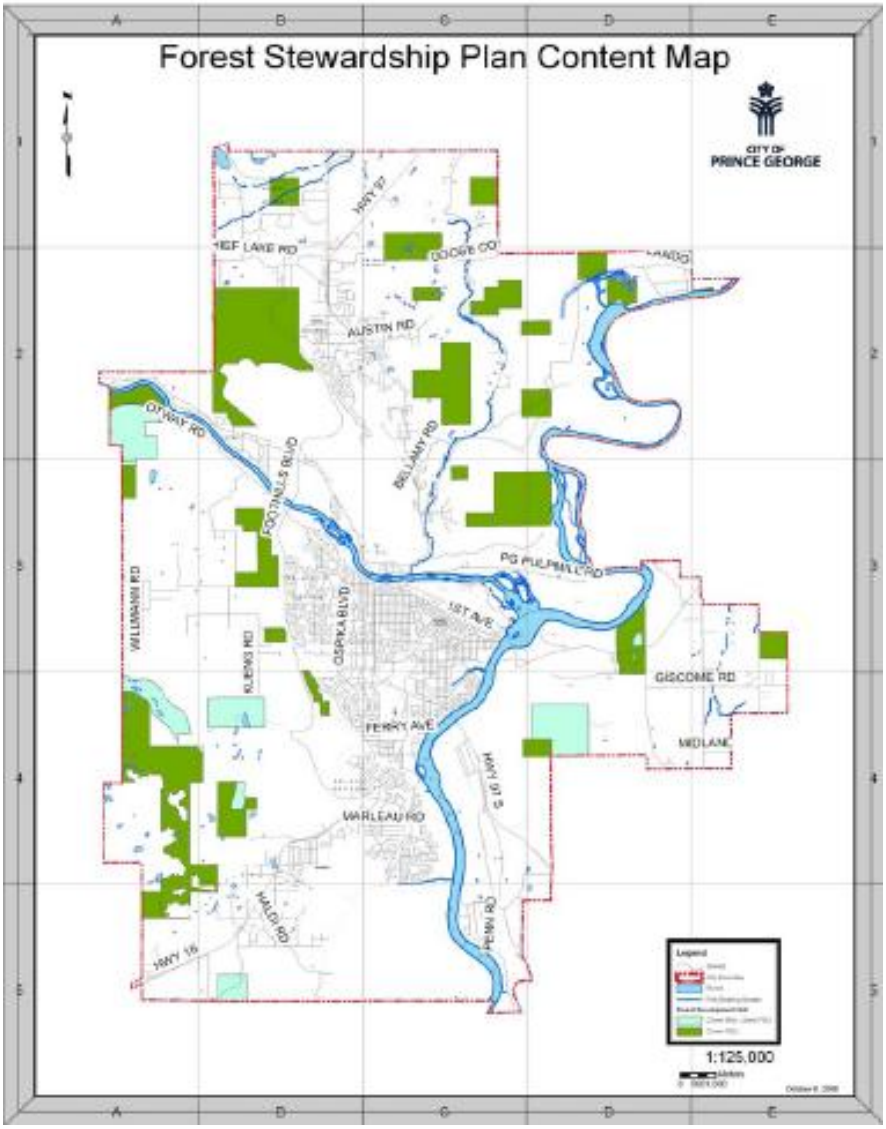


**Figure 8-3 Map of Prince George community forest lands in 2006. Source: Timberline Forestry Inventory Consultants 2006.**

The Prince George Community Forest was never intended to be a self-sustaining economically viable licence, since it requires extensive outside grant funding to cover the considerable operational costs of wildfire hazard reduction fuel treatments. The City is currently assessing options to expand the licence in order to achieve an economically sustainable operation, while addressing wildfire hazards and managing for other forest objectives. Based on the experiences of other community forests, an allowable annual cut of at least 60,000 $m^3$/yr is needed for interior forests to be economically sustainable (D. Adamson pers. comm 2009).

The City of Prince George also acquires grant funding from the Province's job creation program, from Natural Resources Canada and Service Canada (now through the BC

Ministry of Housing and Social Development) for crews to assist with thinning and brush removal along the Cranbrook Hill Greenway and other land parcels. The main funding for current operations comes from the Provincially funded Union of BC Municipalities Operation Fuel Treatment Program, which provides up to 75% of the costs of fuel treatments for mountain pine beetle affected areas. Council has dedicated over $800,000 of city funds over the years to make up the 25% matching funds required for this grant program (D. Adamson pers. comm. 2009).

## Workshop Results

Results from City Adaptation Workshop:
**Implementation tool where impacts should be addressed:** ICSP (myPG)
**Prioritized City services to address impact:**
**1st priority:** Police, Fire and Rescue Services
**2nd priority:** Real Estate and Bylaw Services
**3rd priority:** Municipal Emergency & Response

## Ideas for Adaptation Strategies

**Vulnerability assessment framework:**
Recent research with the community of Vanderhoof resulted in an assessment framework for communities. An overview of the framework is shown in Figure 8-4. This conceptual model can be applied to Prince George to assess various aspects of vulnerability related to forestry and climate change (from social, environmental and economic perspectives).

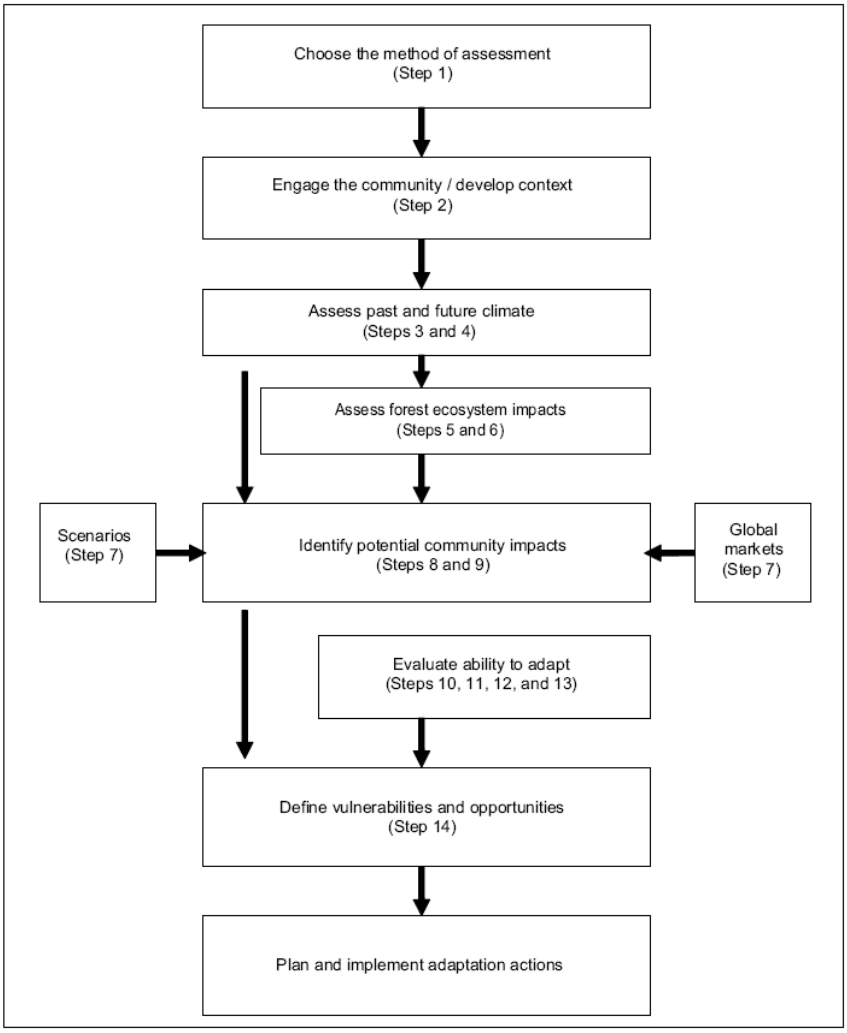


**Figure 8-4 Conceptual model for vulnerability assessment of forest-based communities. Source: Williamson et al. 2007.**

## Recommended Actions

The City of Prince George is engaged in a number of proactive forest programs. There are more initiatives that should be taken to create new plans, and to explicitly incorporate climate change into existing plans. The following actions are proposed:

- Communicate with the group conducting the phase II of the ICSP (myPG) to ensure that adapting forest management to climate change is incorporated into the plan.
- Communicate the principles of climate change, impacts and adaptation to the City staff managing the Prince George Community Forest and to the Community Forest Advisory committee. Ensure that climate change adaptation is incorporated into Community Forest plans, that future climate projections are utilized as part of the Community Forest planning process, and that climate change adaptation is outlined as a management objective in public documents (such as the Community Forest website). This work should be referenced and incorporated into the ICSP (myPG).

- Communicate the principles of climate change, impacts and adaptation to the City staff involved in the Prince George Firesmart Program. Ensure that future climate projections are utilized as a part of the operations planning process, and reference this in the ICSP (myPG).
- Seek long term external funding so that the City can support continued work on wildfire hazard reduction. This is crucial as continued treatments will be required in high risk areas for decades to mitigate the risk of wildfires. Incorporate climate change adaptation into wildfire hazard reduction plans, and reference this in the ICSP (myPG).
- Support further forest adaptation actions in the City. These actions should include input from many stakeholders including City workers representing police fire and rescue services, real estate and bylaw services, and municipal emergency and response city sectors. They should also include input from local First Nations, academic experts, community members, and members of other levels of government.
- Support the multi-stakeholder approach to provide a collaborative landscape level fuel treatment strategy for the City, as outlined by Adamson (2009).
- Work with the Provincial Government to help to set policies and develop management objectives regarding climate change adaptation and forests. Discuss key linkages and partnerships with other levels of government.
- Discuss information needs and further modeling requirements to inform adaptation strategies.
- Consider long term social and economic programs related to adapting to changes in forests and forestry (such as economic diversification). This may involve the use of the vulnerability assessment framework outlined by Williamson et al (2008). Long term external funding will likely be required for these programs.
- Consider and incorporate climate change information from the 'Climate Change in Prince George' report, as well as the results from the City Adaptation and PIBC workshops, into future strategies.
- Consider all climate change mitigation co-benefits and trade-offs as a part of the plan.

## *8.2. Flooding*

### Background

The frequency of great floods increased dramatically during the 20$^{th}$ century, and models suggest that this trend will continue (Milly et al. 2002). By examining the great floods from rivers around the world through a pooled study, the IPCC (2007a) found that there has been a strong increase in 100-year flooding events in the last 15 years, and an intermittent increase over the last 35 years. Kleinen and Petschel-Held (2007) found that up to 20% of the world's population live in river basin areas that will be affected by an increase in flood events caused by global warming. This includes a large number of people in Canada who depend on flood management systems to minimize flood risks.

The economic, social, and environmental costs of climate change over the next few decades can be very difficult to assess, and this is particularly true regarding flooding and

related events. Communities may make deliberate adaptations to account for a changing climate using projections, and the changes may not prove to be optimal. Alternatively, communities may not take any actions, and accept that they will have to deal with the costs (and possibly liability) of the affects associated with increased flooding (Arnell 1998). Decision makers must have access to the appropriate tools to assess the options available to their communities. They should have the opportunity to evaluate uncertainties with climate information, reliable projections, and relevant economic and hydrological data (Kulkarni et al. 2004).

Urban areas are at a higher risk of flooding because buildings, roads, infrastructure and other impervious areas produce less controlled run-off as rainfall is prevented from infiltrating into the soil. Urbanization typically makes surfaces less pervious through impermeable covers (i.e. pavement), or through the disturbance of the natural soil structure (i.e. compaction of earth). This affects the local water balance because it increases storm flow rates and decreases baseflow components (e.g. natural water storage areas that discharge at a slower rate). This problem is exacerbated by traditional stormwater management strategies that are designed to remove runoff from the site as quickly as possible (Holman-Dodds et al. 2003). *For more information please refer to Stormwater infrastructure (Section 8.7).*

Prince George is potentially affected by flooding from two major rivers: the Fraser and the Nechako. Winter and summer flooding events on the Nechako River over the past year have had a major impact on the City. The Fraser River is at a high risk of springtime flooding, and the Nechako River is more susceptible to experiencing ice jam flooding (NHC 2009). Milly et al. (2002) studied the effects on river discharge under future climate scenarios that would arise if atmospheric $CO_2$ was allowed to quadruple. The Fraser River was one of the most impacted rivers in the study, and it was projected that it could experience a 100 year flood event every two to five years under these atmospheric conditions. The flow regime of the Nechako River is partially regulated by the Kenney Dam. The Dam has been reducing flows since it was built in the early 1950s, but the effects of climate change on the dam and the flow of the River are not well understood (NHC 2009).

Over the past 18 months, the City has experienced flood conditions three times. This includes freshet flooding events in the spring of 2007 and 2008, and also the ice jam flood on the Nechako River in the winter of 2008. The ice jam flooding event pushed waters above the 200 year flood plain, made national headlines and caused significant damages (see Figure 8-5). Although it is impossible to attribute events like this directly to anthropogenic warming, flooding events have increased in the last 30 years, and are predicted to continue to increase in the future (Milly et al. 2002; IPCC 2007a).

**Figure 8-5 Prince George during the January 2008 flooding event. Source: City of Prince George.**

## Prince George Overview

Flooding protection and response has been a high priority for the City of Prince George over the two years. During the highly publicized ice jam flooding events in the early winter of 2007-2008, the City combated the floodwaters using several response tactics to mitigate the flood hazard in the short term. (This can be considered reactive adaptation.) Some of the response tactics included constructing over 4000m of temporary dikes, pumping water out of the affected areas, discharging warm water on the melt the ice and open a channel and using an amphibious ice excavator (called an 'amphibex') to dig a channel through the ice (City of Prince George 2009b). More information on the City's response efforts is available at http://www.city.pg.bc.ca/city_services/emergency/icejam/response/.

To investigate long term solutions for flood protection in Prince George, the City retained Northwest Hydraulic Consultants Ltd (NHC) - along with subconsultants: McElhanney Consulting Services Ltd; Environmental Dynamics Inc; M. Miles and Associates Ltd; and Kevin Brown Communications Ltd - to assess the flood risk of the city and to suggest viable solutions to mitigate risks. According to the City of Prince George (2009c) the main goals of the assessment were to:

- prepare a comprehensive flood risk evaluation incorporating a threat and consequence analysis, and developing and prioritizing flood relief options;
- following a public consultation process, select suitable flood control solutions and develop conceptual level designs, including cost estimates and approval requirements; and
- update the existing floodplain maps prepared in 1997.

Three reports were prepared by NHC:

- Risk Anaylsis – Progress Report 1, June 2008;
- Flood Risk Evaluation and Flood Control Solutions – Phase 1, May 2009 ("NHC Phase 1");
- Flood Risk Evaluation and Flood Control Solutions – Phase 2, September 2009 ("NHC Phase 2").

The reports are available online through the City's website at: http://www.city.pg.bc.ca/pages/news/2009/floodStudy/0%20full.pdf. The report analyzes and evaluates the spring flooding risks in the Fraser River and the ice-related flooding risk in the Nechako, as well as the many factors that affect river flow in the region (such as the Kenney Dam). As part of the report a large background study was done to determine historical flood threats and to look at how the rivers have changed over time.

The NHC Phase 1 report identifies seven areas of high risk along the Nechako, and seven along the Fraser. The high risk areas are shown in Figure 8-6. The report identifies and discusses several potential flood control options, which are listed below. The potential flood control options were evaluated for their efficacy in each of the 14 high risk areas. Factors such as cost and environmental impact were considered in this evaluation. The final report provides recommendations for solutions for each of the areas, and cost estimates for each action. To address each area as the report recommends is predicted to cost the City approximately $ 35 million (NHC 2009).

The potential flood control options and a brief description of their predicted effectiveness in Prince George, as outlined by NHC (2009), are as follows:

1. **Extract gravel from the river bottom**
   This method was concluded to be ineffective in alleviating flood risks in both the Nechako and Fraser Rivers.
2. **Enlarge existing side channels**
   This was viewed as a potentially viable solution for flood relief during ice-related flooding events, for example, the Cottonwood Island side channel.
3. **Build dikes**
   Riverside dikes were concluded to be expensive to build and maintain, and ecologically harmful. However, dikes that are set back from the river were slated as a potentially viable solution if they took into account groundwater seepage and internal drainage. Set back dikes can be constructed along new and existing roads
4. **Change land use**
   Changing the land use in flood prone areas was shown to be a cost effective solution in some situations, as it has been in the past in Prince George. This would usually involve purchasing properties and removing the buildings.
5. **Local, small scale flood-proofing**
   Flood proofing individual buildings was deemed to be a potential solution for single-family developments.
6. **Business as usual with reliance on emergency response**

Business as usual was not considered in depth due to the degree of damage and public dissatisfaction associated with previous flooding events.

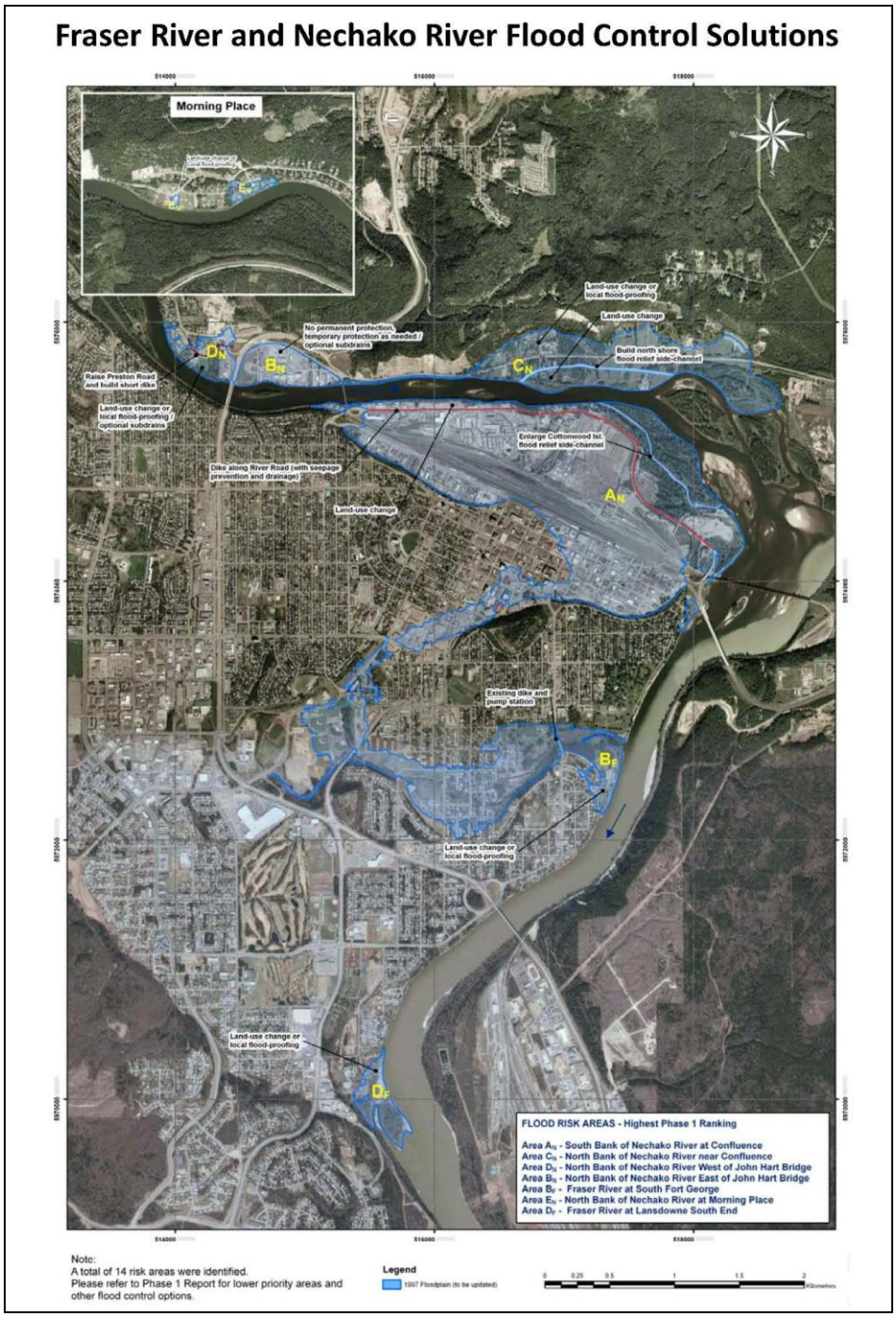


**Figure 8-6 High priority flood risk areas with recommended solutions. Source: NHC 2009.**

Public consultations were held after the NHC Phase 1 report was received by City Council to present the report findings and to gather public feedback about the results. Results of the public consultations were documented and assisted NHC in prioritizing projects for the flood risk areas. These priorities were presented in the NHC Phase 2

report, which was presented to City Council in October 2009. . Flood hazard planning projects and proposed flood protection works will be included in the preparation of the City's Capital Expenditure Plan for consideration by City Council.

The NHC Phase 1 report discusses climate change and states that, based on river flow records, the affects of climate on river flow currently do not appear to be significant. It references the analysis generated by PCIC from the Future Impacts report by Rodenhuis et al. (2007) and the draft of the local Prince George focused report by Picketts et al. (2009) to predict future hydrological conditions for the 2050s. The NHC Phase 1 report states that studies suggest that climate change will reduce spring peak flows at Prince George, while the effects of the mountain pine beetle will increase them. For winter flows, the climate studies suggest there will be an increase but by how much is unknown. The NHC Phase 1 notes that increased flows on the Nechako may result in more frequent flow conditions conducive to ice-related flooding, but that this could be offset by warmer winter temperatures that would reduce frazil ice generation – a key component for ice jamming.

The NHC Phase 1 report calls for a freeboard allowance of 1.0 m to account for the potential impacts of climate change and the impacts of the pine beetle on river hydrology. The freeboard allowance is a safety factor used in preparing flood plain mapping. The practice in British Columbia is to use a 0.6metre freeboard above the 1:200 year peak flow. The report states that more hydrographic analysis and modeling are required to more accurately assess the impacts of climate change and the mountain pine beetle (NHC 2009).

*Other flooding initiatives in Prince George:*

**Emergency Response Bylaw:**
Prince George has an emergency bylaw that 'provides for the establishment, administration and operation of an Emergency Response and Recovery Plan for the City. In the case of major emergency such as a flood or an earthquake, services might be interrupted without notice. Should this happen, the municipal emergency plan will be ready' (City of Prince George 2009b). *For more information on this bylaw please refer to the emergency response Section.*

**Flood Plain Bylaw:**
In 2007, Prince George adopted its Flood Plain Regulation Bylaw No. 7855; the purpose of which is to designate flood plain land and to regulate the development of these flood prone areas. The bylaw designates what areas are considered to be in a flood plain and the flood levels for the land within the flood plain. Various setbacks from different bodies of water or structures (such as dikes, or bluffs) are prescribed. There are restrictions on what can be built within the setback (City of Prince George 2007a).

As a result of the work done by NHC, new flood plain mapping will be completed in early 2010 and Bylaw 7855 will be updated.

## Workshop Results

PIBC Workshop Outputs:
A detailed flood risk assessment needs to be conducted as soon as the city is not in an emergency situation. In the short term, the floodplain bylaw must be amended to reflect recent happenings. All levels of government need to communicate more clearly to address these issues.

Results from City Adaptation Workshop:
**Implementation tool:** ICSP (myPG)
**Prioritized City services to address impact:**
**1st priority:** Municipal Emergency & Response
**2nd priority:** Police, Fire and Rescue Services
**3rd priority:** Long Range Planning

## Ideas for Adaptation Strategies

The strategies for mitigating flood risk in Prince George mentioned in Section 8.2 are discussed in detail in Section 6 of the NHC report (2009). Please refer to this report for more information about the strategies, and an analysis of their predicted efficacy in key areas in the City. Some creative examples of other flood risk (and other relevant) strategies to adapt to climate change are included below.

**Improve flood response:** refer to emergency response section

**Buying land and rezoning:**
Buying up properties in flood prone area is a common and often cost effective solution to mitigate flooding hazards. This has been done before in Prince George; in 1972 housing was removed from the Island Cache area (near Cottonwood Island) after a flooding event (NHC 2009). In the United States a buyout program was introduced as a floodplain management tool after the Great Midwest Flood of 1993. The Federal Emergency Management Agency and other organizations purchased between 17,000 and 20,000 properties across 36 states as part of this program. By law, all purchased land must revert to natural floodplain or recreational land (Conrad et al. 1998).

**Flood-proofing existing buildings:**
The US Federal Emergency Management Agency (FEMA) has been warning citizens about the increased risks of disasters (such as flooding) as a result of climate change for decades. It provides resources to show how buildings can be retrofitted to be more resistant from floods in many ways. These and other techniques are discussed in detail on the Federal Emergency Management Agency (FEMA) homepage at http://www.fema.gov/. Some of the mechanisms to floodproof buildings as, outlined by FEMA (2009), include:

- elevating buildings: on walls, piers, piles, or fill;
- wet flood-proof buildings: by allowing floodwater to inundate selected portions of building that are not vulnerable to water damage; and
- dry flood-proof buildings: by ensuring that floodwater does not enter.

There are also many Canadian guides for flood-proofing buildings. A couple of examples of these include a guide for flood-proofing historic settlement areas by the Arlington Group Planning and Architecture (2009) and a handbook for reducing basement flooding by Sandink (2009). Flood-proofing buildings is not new; the BC Ministry of the Environment (1981) printed a comprehensive manual on the subject nearly 30 years ago which includes many cost effective and aesthetic techniques to minimize flood risks on new residential buildings,

## Recommended Actions

The detailed flood risk evaluation is an excellent step in adapting Prince George to the impacts of increased flooding. This document should be built upon, and complemented with alternative flood risk mitigation strategies. Many of the alternative strategies are related to other impacts included in this report. The following actions are proposed:

- Communicate with the group conducting phase II of the ICSP (myPG) to ensure that adaptation to increased flooding from climate change is included in the plan.
- Continue to work with the flooding experts (NHC et al.) as they finalize the flood evaluation and envision a flood risk mitigation strategy for Prince George. Ensure that this process considers climate change to the greatest extent possible, that it uses and considers the best available climate information and models, and that resiliency is built into the plan.
- Communicate with City staff from the municipal emergency and response, police fire and rescue services and long range planning sectors to ensure that they are engaged in adapting to increased flooding as a result of climate change.
- Communicate climate change and flooding information to local stakeholders.
- Encourage alternative mechanisms to adapt to and mitigate flood risks. (Some of these are mentioned in the NHC report, but many of them are not. Most of these strategies are closely related to other priorities identified in this document.) There are many opportunities for co-benefits and interrelations with regards to this topic. Ideas for alternative flood control and response mechanisms include:
    - Improve infrastructure to better facilitate emergency response (e.g. construct roads so that emergency vehicles can access areas during floods).
    - Design transportation infrastructure to be resilient to increased flooding and to help minimize potential flooding damages wherever possible.
    - Design building infrastructure to be resilient to increased flooding and to help minimize potential flooding damages wherever possible.
    - Encourage responsible forestry practices to minimize the negative effects of climate change and mountain pine beetle on flooding and the hydrological cycle.
    - Design stormwater infrastructure to retain run-off as much as possible to mitigate flooding risks.
    - Maximize permeability throughout the City to decrease run-off back to rivers and mitigate flooding risks.
    - Encourage appropriate land use in flood prone areas throughout the City.

- Consider and incorporate climate change information from the 'Climate Change in Prince George' report, as well as the results from the City Adaptation and PIBC workshops, into flooding adaptation strategies.
- Consider all climate change mitigation co-benefits and trade-offs as a part of the plan.

## *8.3. Transportation Infrastructure*

### Background

Transportation infrastructure can be described as structures and facilities designed to move people and freight. These include roads, bridges, railways, airport runways, shipping terminals and canals (Natural Resources Canada 2007). Climate change will impact transportation infrastructure in many ways, including how it is located, designed, constructed and maintained (National Research Council 2008). The affects of climate change will be compounded by aging infrastructure, poorly designed communities, air pollution and an aging population. Most of Canada's infrastructure was constructed between the 1950s and the 1970s, and is in need of maintenance, rehabilitation or replacement (Mirza and Haider 2008). A greater awareness and consideration of climate change adaptation is required for planning transportation infrastructure (especially bridges), because of their extremely long lives. These large projects are long term fixed investments, often with life spans of over a century (Riley 2000; Swain 2007). Proactive adaptation in developed areas is extremely important for avoiding costly retrofits to infrastructure in the future (IPCC 2007a).

A recent report from the US Natural Resource Council (2008) entitled 'Potential Impacts of Climate Change on US Transportation' included two key findings. The first is that flooding is potentially the greatest impact of climate change on North America's transportations systems (see Section 8.2). The other key finding from the report is:

> *"Climate change will affect transportation primarily through increases in several types of weather and climate extremes, such as very hot days; intense precipitation events; intense hurricanes; drought; and rising sea levels, coupled with storm surges and land subsidence. The impacts will vary by mode of transportation and region of the country, but they will be widespread and costly in both human and economic terms and will require significant changes in the planning, design, construction, operation, and maintenance of transportation systems."*

Some of these impacts are relevant to Prince George; however many of them are not, including hurricanes and rising sea levels. Extreme heat will also not affect this area as much as the hotter areas in North America. For example Galbraith et al. (2005) did tests that showed that a minimum temperature of 45°C was required for one hour to deform pavement. This illustrates that Prince George is faced with different challenges related to infrastructure than warmer, more southern regions.

In northern regions, cold temperatures in winter are a much greater challenge with respect to infrastructure than summer heat (Natural Resources Canada 2007). A particular concern in Prince George is the affects of freeze thaw cycles on roads. Temperature cycles cause volume changes within road materials, which lead to cracks that fill up with water. This water will freeze (thus expanding) and then thaw, leaving voids that turn into larger cracks and potholes. When the road materials are broken down, particularly the surfacing materials, more moisture is let into the road structure (Galbraith et al. 2005). While southern parts of Canada may experience less freeze thaw cycles with climate change as temperatures remain above freezing, northern regions (such as Prince George) are expected to experience more of these cycles and experience greater road and runway deterioration (Natural Resources Canada 2007).

Climate change will have an impact on transportation infrastructure in Prince George, particularly roads. There are 630 km of roadways and 155 km of sidewalks in the City to maintain (Amec 2006). Some of the potential effects of climate change on roads, as outlined by Dyer (2006), include:

- more frequent freezing and thawing will result in more ice on roads and cause safety issues:
- more frequent freezing and thawing will result in more rapid road surface and road structure deterioration;
- temperature changes will result in an increase in maintenance costs to deal with them (more salt, pre-wetting, anti-icing etc.);
- greater amounts of salt will increase the toxicity in runoff; and
- more snow disposal sites may potentially be required if snowfall increases.

The life-spans of roads in Northern Climates are considerably lower than those in more temperate areas. A road built in Victoria is typically expected to last for 25 years. In Prince George, a typical arterial road is expected to last between 10 and 15 years (primarily because of the weather conditions), even though the City buys a high quality asphalt product (G. Stanker pers comm. 2008). There are other factors that affect road material selection such as the fluctuating costs of asphalt, correlating with the changing costs of petroleum (IPCC 2007b).

In Canada, provincial and local governments spend a total of approximately $1.3 billion dollars on snow and ice control of roads. This includes many activities including salting, sanding, snowplowing and the construction of snow fences (Natural Resources Canada 2007). Large storm events can make up a large proportion of total seasonal costs as well as hinder the effectiveness of emergency response (refer to next section).

## Prince George Overview

Currently there are several initiatives ongoing that implicitly address climate change related impacts on transportation in Prince George.

Prince George has a well developed snow and ice control program that includes various types of equipment to clear roads and sidewalks in a priority sequence (City of Prince George 2008c). The City uses best management practices for snow removal and ice

control, many of which have been developed locally (F. Blues pers. comm. 2009). The City also communicates with northern municipalities from around the world about winter maintenance and other issues through its involvement in the Winter Cities Association. This Association was founded to improve design and enhance live-ability in winter seasons in northern communities (Winter Cities Institute ND).

Snow and ice control within the City includes pre-wetting and anti-icing programs that involve the application of liquids (such as magnesium or calcium chloride). Pre-wetting is the application of liquid salt to either winter abrasive or salt, before it is applied to a road surface. Pre-wetting the abrasives will help them to stick to, and penetrate into, an icy road surface. Pre-wetting road salt will help it to react faster and embed itself into the ice. Anti-icing is the application of liquid salt on to the road surface before a snow event, to improve traction and prevent snow and ice build up (City of Prince George 2007b). An example of a provincially recognized practice followed in Prince George is the application of low fines 'high fracture' abrasive on roads. This involves applying coarse crushed gravel (with no fine material less than 1mm in diameter) on roads, which remains on the road surface for longer and has other important air quality and aquatic environment co-benefits (F. Blues pers. comm. 2009). These programs will help the City if they are faced with worsening road conditions as a result of changing winter weather.

The City has a Salt Management Plan to minimize the application of salts on roads. This plan was created in response to a study by Environment Canada (2004) which concluded that road salt is harmful to the environment. The plan is in compliance with Environment Canada's voluntary code of practice for road salt management (Amec 2006). The City's plan is available online through the City's website at http://www.city.pg.bc.ca/city_services/transportation/salt_management_plan.pdf. This plan will help the City to use salt more effectively with changing winter weather.

With regards to flooding, access was restricted to and on River Road (on the South side of the Nechako River) during the ice jam flooding in 2007/2008 as floodwaters covered the road between 0.3 and 1.2 metres. The roadway has since been raised up permanently to permit vehicle access during flooding events, and to help to contain flood waters. This action was taken upon the recommendation of the NHC Risk Analysis – Progress Report 1, June 2008. This is an example of adapting to transportation infrastructure, emergency response and flooding impacts concurrently.

Information about transportation in Prince George is available at the City's website at http://www.city.pg.bc.ca/city_services/transportation/.

## Workshop Results

PIBC Workshop Outputs:

This group concluded that reducing the overall footprint of the City of Prince George will reduce the amount of road infrastructure needed. Cost savings associated with this can be reallocated to building structures that can better withstand more extreme events and freeze-thaw cycles. This strategy also has important climate change mitigation co-benefits. To inform these decisions, a detailed analysis must be performed on future

freeze-thaw scenarios, and paving materials in the north. The public must develop a greater awareness about the costs of city infrastructure, and the benefits of compact cities.

Results from City Adaptation Workshop**:**
**Implementation tool:** In the workshop equal numbers of participants indicated: the Annual Provisional Financial Plan, Asset Mngt. Performance Measures and the ICSP (myPG)
**Prioritized City services to address impact:**
**1st priority:** Transportation
**2nd priority:** Financial Services
**3rd priority:** Fleet and Supply Services; Municipal Emergency and Response

## Ideas for Adaptation Strategies

**Design roads for more freeze thaw cycles:**
Although it is not discussed in detail in this report, there have been numerous studies about which road materials are more resilient to the effects of freeze-thaw and changing temperatures. To put into context the amount of research there is on this subject, there is an international scientific journal specifically devoted to the study of road materials and pavement design called Road Materials and Pavement Design (its website is: http://www.ijrmpd.com/.)

**Build fewer roads:**
One key climate change adaptation for infrastructure is to design transportation networks so that there are fewer roads (and perhaps roads built to a reduced width where feasible). This equates to lower costs, which can be redirected to designing more climate resilient transportation infrastructure. New networks should be designed that are beyond the current systems in Canada, which have fostered an individual reliance on personal transportation (Natural Resources Canada 2007). Reducing roads will help to rectify these problems and provide important climate change mitigation co-benefits related to transportation (Ruth 2005). This strategy will also help to save the City of Prince George money, provide benefits for public transit, and address the significant infrastructure deficit that exists in Canada (Mirza and Haider 2003).

**Design infrastructure for changing climates:**
An example of an infrastructure project in Canada that incorporated climate change adaptation into its design is the Confederation Bridge. This 13 km bridge links Prince Edward Island to Canada's mainland at New Brunswick. The bridge's design specifications were made to withstand potential climate change impacts over its long life, such as a one-metre rise in sea level (Lee 2000).

**Maintain roads differently:**
In response to observed changes in winter weather, particularly during the 2004-2005 winter, Ottawa City Council undertook an investigation to study how winter maintenance operations need to be adapted to climate change (OGRA 2006). According to projections, central Canada will likely experience higher temperatures, more variability, and increased freeze/thaw cycles. This region will also experience more frequent and severe freezing

rain conditions, which is associated with the highest damage costs per event (Cheng 2007). The City allocated funds to improve their winter maintenance activities. Some of their purchases include deicing equipment with specialized GPS equipment to improve efficiency, and ice grinding machines. The City also has enhanced weather forecasting services to help estimate conditions in different areas of the city (OGRA 2006).

### Recommended Actions

There are a number of initiatives that are occurring in Prince George and in BC that can be built upon to adapt the City's transportation infrastructure to climate change. It should also occur in tandem with climate change mitigation activities to ensure that co-benefits are exploited. The following actions are proposed:

- Engage with City workers involved with Annual Provisional Financial Plan, Asset Management Performance Measures and the ICSP (myPG) process to ensure that adapting transportation infrastructure to climate change is incorporated into these documents. (Local experts may dictate one or two of these documents that should include this impact.)
- Create a transportation task force to develop an adaptation strategy for the City. This may involve the creation of a new group, or the incorporation of this mandate into an existing group. This group should include City staff representing transportation, financial services, fleet and supply services, and municipal emergency and response. It should also include input from academic experts, community members, representatives from other communities in BC that have undergone this type of work, and members of other levels of government. The group should outline the actions already in place, existing resources, key linkages and partnerships with other levels of government and key vulnerabilities of Prince George to climate change with respect to infrastructure.
- Engage with local community and road design experts to assess the best strategies for road construction in Prince George.
- Engage with climate change modeling experts (such as PCIC) to obtain state of the art freeze-thaw predictions to help to inform these strategies.
- Collaborate with the Provincial government to incorporate climate change adaptation strategies into the transportation infrastructure within and around Prince George that is under Provincial jurisdiction.
- Consider and incorporate climate change information from the 'Climate Change in Prince George' report, as well as the results from the City Adaptation and PIBC workshops, into future strategies.
- Consider all climate change mitigation co-benefits and trade-offs as a part of the plan.

## *8.4. Severe Weather / Emergency Response*

### Background

Communities are built to 'normal' conditions, or to the range of weather that lies within a locations' expected range of climate. Extreme weather events are by their nature unusual, and are thus generally unexpected (Environment Canada 2002). Climate change is expected to bring about an increase in the magnitude and frequency of extreme events, as

well as a change in the regions in which these events occur (IPCC 2007e). Studies from the IPCC (2007f) show significant positive trends in the occurrence of extreme weather events in recent decades.

According to Walker and Sydneysmith (2007: p. 339), 'extreme weather and weather related events directly affect British Columbians more than any other climate risks.' There are many types of extreme weather that may affect residents in British Columbia. Some of these, as outlined by Hamlet (2003); Sandford (2006); Walker and Sydneysmith (2007); Parks (2007); and McBean (2002) include:

- forest fires
- storm surges
- landslides
- snowstorms
- hail
- floods
- heavy rains
- ice jams
- freezing rain
- mudslides
- snowslides
- rain on snow events
- high winds
- lightning strikes
- traffic accidents

One mechanism to gage the number and severity of extreme weather events is insurance losses. According to Kovacs et al. (2001), there has been an estimated nine fold increase in economic losses from natural disasters from the 1960s up to $ 430 billion (US) in the 1990s. Similar research has shown that the losses from extreme weather events have been trending upward, even when accounting for inflation and the significant increases in the values of what is exposed to risk (due to more development in at risk areas) (IPCC 2007g). There has been a dramatic increase in the impact of extreme weather events in BC. Between 2003 and 2005 the average costs of climate-related disasters in BC were $ 86 million per year. This is a dramatic increase from the period from 1999 to 2002, in which the average costs to the Province were approximately $ 10 million per year (Whyte, 2006).

Some general land use adaptations to extreme weather events, outlined by Parks (2007), include:

- better municipal policies and bylaws to improve land use location decisions;
- protection and/or relocation of existing land uses;
- best practices for stormwater management;
- structural adaptations to infrastructure; and
- better emergency management response.

It is clear from the above mentioned lists of extreme impacts that may affect BC residents and general land use adaptations that emergency response has significant correlations with other climate change impacts in this report. As previously mentioned, forest fires and flooding events are increasing, and are projected to continue to increase in the future (Sections 8.1 and 8.2). Many impacts are also directly related to transportation infrastructure as extreme events affect transportation, and functioning transportation networks are crucial to adequately respond to these events. (This relationship is reflected in the City Adaptation Workshop priority 'extreme weather events – transportation and people'.)

It is important to examine the vulnerability of citizens in a community to extreme weather emergencies. Types of people who may be vulnerable include elderly persons, disabled persons, people who live further away from neighbours, people who live close to hazardous areas (such as a river) and people who rely on shallow wells for water. These people will be at the highest risk in an extreme weather event (Halifax Regional Municipality 2006).

## Prince George Overview

Currently there are several initiatives ongoing related to emergency response in Prince George.

Bylaw No. 7920 is intended to develop and implement emergency response plans in a way that is consistent with the Emergency Response Program Act. It 'provides for the establishment, administration and operation of an emergency response and recovery plan for the City. In the case of major emergency such as a flood or an earthquake, services might be interrupted without notice. Should this happen, the municipal emergency plan will be ready.' (City of Prince George 2009d). The bylaw names an emergency policy committee, an emergency planning committee, delegates authority and names a coordinator. The bylaw was passed unanimously by City Council on December 4, 2006, and was adopted on December, 18 2006 (City of Prince George 2006). The Emergency Response Program Act discusses local and provincial emergency plans, dictates when a state of emergency or a local emergency can be declared, and includes information about costs and liabilities (Government of BC 1996).

The Province of BC has adopted an emergency response system entitled the BC Emergency Response Management System (BCERMS). Its mandate is to provide support to local government emergency planning and response in the event that an emergency or a disaster exceeds the capacity for local resources to handle it. The organization has over 120 people on staff, and has an office in Prince George (Provincial Emergency Program 2005). For more information about the Provincial Emergency Program refer to http://www.pep.bc.ca/index.html.

The Government of Canada is trying to establish a National Strategy action plan for critical infrastructure. A report by Public Safety Canada (2008) states that an integrated plan for critical infrastructure should fall within the following categories: Energy and utilities; Communications and information technology; finance; health care; food; water; transportation; safety; government; and manufacturing.

The City has reviewed the ice jam flood response in a process facilitated by Jim Lamorte. This has been done to examine and evaluate the efficacy of this recent emergency response effort, and to make recommendations based on it. The report that has been prepared has not yet been presented to council (J. Rowland pers. Comm. 2009).

The City has put into place a number of actions related to emergency response in Prince George related to forest fires, flooding and transportation (see Sections 8.1, 8.2 and 8.3).

## Workshop Results

Results from City Adaptation Workshop**:**
**Implementation tool:** Annual Provisional Financial Plan
**Prioritized City services to address impact:**
**1st priority:** Municipal Emergency & Response
**2nd priority:** Police, Fire and Rescue Services
**3rd priority:** Risk and Benefits

## Ideas for Adaptation Strategies

**Measure capacity to adapt to extreme events as a result of climate change:**
In Atlantic Canada two communities endeavoured to increase their awareness of, and ability to respond to, climate change impacts by testing their response to emergency events. This was done by running a full scale storm surge simulation exercise in each community. According to Robichaud (2007) the exercises were designed to help the communities:

- determine the biophysical, physical and social impacts of extreme events;
- develop and share best practice responses to actual emergencies; and
- test existing emergency response plans.

The exercise report gives an overview of climate change and emergency response, summarizes the events, and gives more than 30 recommendations for improvement. It is available online at http://adaptation.Natural Resources Canada .gc.ca/projdb/pdf/158d_e.pdf (Robichaud 2007).

**Integrating climate change into broader emergency response frameworks**:
The additional risks of climate change should be considered in emergency response frameworks. The following excerpt from a report created for the Australian Government by the Allen Consulting group (2005) is an example of this type of recommendation:

> *Adaptation options for urban systems and emergency services would include ensuring that the current study of emergency management priorities and responses being carried out at the Council of Australian Governments' direction systematically includes the additional risks posed by climate change. Action in this area should build on existing programs and responsibilities. Deliberations under the Australian Government's Disaster Mitigation Australia Package should also be informed by climate change risks.*

**Public education to minimize risk of injury and damage**:
The Halifax Regional Municipality (2006: p. 14) outlines adaptation options for residents to minimize their risks from severe weather as a result of climate change. They recommend following severe weather-related options for people to minimize their risks of personal injury and property damage:

- don't build in high-risk locations such as low areas prone to flooding and coastal areas vulnerable to storm surge and erosion;
- remove dead, damaged or dying trees and replant with new trees;

- ensure the timely professional removal of any tree limbs from overhead power and telephone lines;
- where possible, bury electrical and telephone cables underground on the property when building a new home;
- organize community re-forestation activities to minimize erosion, flash floods and landslides; and
- recognize the value of water catchment areas, such as swales, wetlands, streams and ponds on your property - they handle stormwater flows.

### Recommended Actions

There are many actions that can be taken to reduce Prince George's vulnerability to extreme weather. The following actions are proposed:

- Engage with City workers involved with Annual Provisional Financial Planning to ensure that adapting emergency response to climate change is included in this document.
- Create an emergency response task force in Prince George to incorporate climate change adaptation into the emergency response strategy for the City. This may involve the creation of a new group, or the incorporation of this mandate into an existing group. The task force group should include City staff representing municipal emergency and response, police, fire and rescue services, and risk and benefits. It should also include input from academic experts, community members, representatives from other communities that have undergone this type of work and members of other levels of government. The group should outline the actions already in place, existing resources, key linkages and partnerships with other levels of government and key vulnerabilities of Prince George to climate change with respect to emergency response.
- Discuss information needs and modelling requests to inform the strategy.
- Review the examination of the ice jam flood (facilitated by Jim Lamorte) to examine and evaluate the efficacy of recent emergency response efforts, and to determine key strengths and weaknesses.
- Consider and incorporate climate change information from the `Climate Change in Prince George` report, as well as the results from the City Adaptation workshop, into future strategies.
- Consider all climate change mitigation co-benefits and trade-offs as a part of the plan.

## *8.5. Water Supply*

### Background

The IPCC (2007a) projects that water resources in North America will be constrained by climate change. Demand from economic development, agricultural activities and population growth will further limit surface and groundwater availability in many areas within the province. Many regions in the interior of BC have already felt the effects of water scarcity and have been forced to take action in response to the issue (Cohen and Neale 2006). Water shortages are frequently cited as the number one impact associated

with climate change that Canadians are concerned about (Swain 2007; Federation of BC Naturalists 2007).

The quantity of water supply will be altered by many different climate change effects. Rising temperatures are expected to diminish snowpacks and increase evaporation. This will affect the seasonal availability of water, and may result in more frequent periods of water scarcity (IPCC 2007a). Also, although precipitation in Canada is projected to increase, studies reveal that a widespread increase in extreme precipitation events will occur. This means that (although there will be more rain) there will be an increase in periods of drought (Christensen et al., 2007). Groundwater will also be influenced severely with climate change; reflecting changes in the demand and availability in other sources, recharge rates and surface water interactions (Rivera et al. 2004).

Along with quantity, the quality of water supply is going to be affected by climate change. Communities that rely on surface water may have shallower intakes, which are more vulnerable to contamination. Also, the concentrations of nutrients or contaminants are relatively higher in smaller amounts of water. This means that effluent dilution in water courses will be a less effective mechanism to deal with pollutants (Federation of BC Naturalists 2007).

Little is known about water in BC, and climate model projections related to precipitation and water supplies are much less certain than temperature projections. Water controlling factors - such as water vapour feedback and water use in conjunction with photosynthesizing plants - are extremely difficult to model and have only recently begun to be accounted for in global climate models (Varis et al. 2004). Basin scale hydrology models, climate models and river trends are essential for understanding the effects of climate change on BC's water. As of 2003, there were less than 10% of the World Meteorologist Organization's recommended climate stations present in BC (Kulkarni et al. 2004). To adequately plan to adapt to the changes that will be occurring with regards to water in Prince George and BC, good information is essential.

Currently, 83% of British Columbia irrigation water is supplied from surface sources, but almost all new irrigation developments are from groundwater (Swain 2007). The City of Prince George relies on groundwater for all of its water supply. Over 80% of the City's water wells tap into aquifers that are charged by the Nechako River. The maximum future pumping rate from these wells is projected to be approximately 1% of the low water flow of the Nechako River (Golder Associates 2003). This means that Prince George is not facing immediate water shortages. However, this abundant supply is vulnerable to contamination as it does not have a protective layer of low permeability on top of it to prevent contaminants from entering the aquifer. Also, there are many potential sources of contamination located near to this valuable groundwater source. Reduction in water demand will slow the movement of contaminants into and through the aquifer, and thus make it easier to treat, and easier to avoid potential contamination (City of Prince George 2005).

## Prince George Overview

The City of Prince George (2005) initiated a Water Conservation Plan that provided an overview of the City's water system and identified activities to conserve water. The overall goal of the Prince George Water Conservation plan is to reduce residential water consumption by 20% and overall water consumption by 15% in next 10 years, using 2004 as the baseline year. It is predicted that this will save the City $15,000 per year in capital cost deferral and reduce operational costs by $139,000 annually (City of Prince George 2005). In this past year, water metering has become a mandatory requirement for new homes in the City (M. Fornari pers. comm. 2009). Unmetered residential customers are charged a flat fee of $16.06 per dwelling. The Plan also highlighted that Citizen's were not very knowledgeable of their water resources. In a recent a survey less than 20% of residents were aware that their water came from underground reservoirs (City of Prince George 2005).

Agricultural land reserves account for 23% of the area of Prince George, and 73% of land within the City is zoned to allow for agriculture (City of Prince George 2001). In Prince George, most agricultural water use is not metered and from private sources, so it is hard to evaluate and improve the efficiency of water use. Also, farming in Prince George is currently not very lucrative. So there may be pushback against restricting or charging for agricultural water usage (M. Fornari pers. comm. 2008).

## Workshop Results

PIBC Workshop Outputs:
All (municipal, residential, agricultural and industrial) water use should be metered and charged at an increasing block rate (e.g. higher rates for excessive use). Surface water, stormwater, and greywater should be utilized wherever possible to reduce strains on freshwater sources. The City should encourage development near existing wells to protect aquifers and reduce costs. To conserve water quality, development should occur in a manner that is sensitive to important groundwater recharge zones. Streamflow and precipitation projections are required to adequately plan for this. The public must be educated to overcome the misconception that there is an infinite supply of clean water in Prince George.

Results from City Adaptation Workshop**:**
**Implementation tool:** ICSP (myPG)
**Prioritized City services to address impact:**
**1st priority:** Utilities
**2nd priority:** Environmental Services
**3rd priority:** Long Range Planning

## Ideas for Adaptation Strategies

**Limit agricultural water contamination:**
Although agriculture production is currently minimal in Prince George, with Climate change, North-Central BC may become a much more agriculturally productive region in the future (see Section 8.10). A resource management workshop was held in 1998 at UNBC that focused on water pollution and agriculture. As summarized by Tingle (ND)

the two priority topics for North-Central BC agriculture that were identified at the workshop were:

- spring run-off (brown water problem); and
- cattle access in riparian areas.

These are two appropriate issues to start to focus on for limiting agricultural water contamination. Solution strategies include: Restricting cattle from riparian areas at certain times of year; Fencing riparian areas; and monitoring water sources used by agriculture to minimize contamination of water supplies (Tingle ND).

**Minimize residential indoor and outdoor water use:**

Cohen and Neale (2006) worked extensively with the City of Kelowna to study climate change adaptation through residential water use and water management. The report has come up with many strategies for Kelowna to limit use, as an adaptation mechanism to climate change and to the general scarcity of water in the region. In partnership with the City, Cohen and Neale (2006) studied many demand side management (DSM) methods to reduce per capita consumption of water. The major strategies considered were: public education; water meter installation and billing at a constant unit charge (CUC); water meter installation and billing at an increasing block rate (IBR) (e.g. where charges increase after a threshold amount has been reached); xeriscaping properties to require less water; and implementing bylaws to require high efficiency fixtures and appliances. An overview of these methods, and their predicted indoor and outdoor water use savings, are shown in Table 8-1.

**Table 8-1 Demand side management strategies and their corresponding indoor and outdoor water savings. Source: Cohen and Neale 2006.**

| DSM Option | Water Savings | |
|---|---|---|
| | Indoor | Outdoor |
| **DSM Option 1: PUBLIC EDUCATION**<br>Sustained public awareness program as described by Hrasko (2003a) including a part-time staff person and printed brochures etc. | 10% | 10% |
| **DSM Option 2: METERING WITH CUC**<br>Water meter installation and volume-based billing. Water rate is a constant unit charge (CUC), or the same charge for each additional unit of water consumed. | 20% | 20% |
| **DSM Option 3: METERING WITH IBR**<br>Water meter installation and billing with an increasing block rate structure (IBR). Volume-based water charges increase when water use exceeds pre-defined thresholds. | 32% | 32% |
| **DSM Option 4: XERISCAPING**<br>Xeriscaping bylaws are implemented, similar to the landscape ordinances used in several US jurisdictions, requiring all new and renovated landscaping to conform to xeriscaping principles. | 0% | 50% |
| **DSM Option 5: HIGH EFFICIENCY FIXTURES & APPLIANCES**<br>Bylaws are implemented requiring water efficient appliances and fixtures to be installed in all new and renovated dwellings. | 40% | 0% |
| **DSM Option 6: COMBINED METERING WITH IBR, XERISCAPING AND HIGH EFFICIENCY APPLIANCES & FIXTURES**<br>Options 3-5 are implemented. Water savings for Xeriscaping and High Efficiency Fixtures & Appliances are reduced by the percentage water savings for Metering with IBR to account for voluntary adoption of these mechanisms under the metering program. | 59% | 66% |

**Watershed scale source protection plans:**
One example of a source water protection plan is the Ontario Government's Bill 43: the Clean Water Act. This bill, which was passed in 2006, provides a legislative basis for planning for source water protection. It integrates the public, municipalities, conservation authorities, industry, community groups and farmers to participate in developing source protection plans at the watershed scale (Ontario Ministry of the Environment 2007). Source protection plans involve the development of many approaches, including a water budget, source water planning, and professional training for water managers (Cataraqui Region Conservation Authority 2008).

### Recommended Actions

Prince George has an excellent start at a strategy to preserve water quality and quantity with its Water Conservation Strategy. In the future, Prince George's abundant supply of clean water may become a major attraction for the City. The following actions are proposed:

- Communicate with the group conducting the ICSP (myPG) to ensure that conserving water quality and quantity as an adaptation to climate change is included in the plan.
- Create a water task force to create an adaptation strategy for the City. This may involve the creation of a new group, or the incorporation of this mandate into an existing group. This group should include City workers representing utilities, environmental services and long range planning sectors. It should also include input from academic experts, community members, representatives from other communities in BC that have undergone this type of work (such as Kelowna), and members of other levels of government. The group should outline the actions already in place, existing resources, key linkages and partnerships with other levels of government and key vulnerabilities of Prince George to climate change with respect to water.
- Collaborate with communities and other levels of government in BC and Canada that have undergone water conservation strategies to build upon Prince George's strategy.
- Discuss information needs and modelling requests to gain a better understanding of the affects of climate change on water supply.
- Consider and incorporate climate change information from the 'Climate Change in Prince George' report, as well as the results from the City Adaptation and PIBC workshops (e.g. utilizing grey-water and developing near existing wells), into the strategy.
- Consider all climate change mitigation co-benefits and trade-offs as a part of the plan.

## *8.6. Slope Stability*

### Background

Climate has an influence on slope stability through its interconnectedness with such things as groundwater and sub-surface pore pressure (Dehn et al. 2000). Increases in the magnitude and frequency of precipitation events and long term precipitation trends will

affect these properties, and the number of rainfall triggered landslides (Buma and Dehn 1998). Studies have found that the correlation between climate change and increasing slope instability is present, but not very large (Dehn et al. 2000; Buma and Dehn 1998).

The BC Ministry of Energy, Mines and Petroleum Resources (2006) states that some slopes are naturally stable whereas others are prone to landslides. Factors such as the underlying bedrock and soil, the geometry and configuration of the slope and groundwater conditions contribute to a slope's stability. Other mechanisms may also cause landslides including:

- gradual changes such as weathering;
- natural external mechanisms such as stream erosion, intense rainfall; and
- human activities such as road building or loading slopes.

Many different types of human activities can cause, or increase the risk of, landslides. Activities such as undercutting slopes, loading slopes or causing vibrations can lead to slides. Activities related to water such as irrigation, sewage disposal or redirecting surface flow also can increase the risk of landslides. Forestry and the removal of vegetation will also decrease slope stability in an area (BC Ministry of Energy, Mines and Petroleum Resources 2006).

Mountain pine beetle is a local climate related impact that is closely related to slope stability in BC. In the Mountain Pine Beetle Action Plan, the BC Government (2006b) includes identification and monitoring of unstable terrain impacted by the beetle as one of its five year objectives.

## Prince George Overview

There are currently no activities occurring in Prince George regarding slope stability and climate change.

The Prince George OCP makes many references to slope stability and the conservation of steep slopes. Many of the natural areas that are identified for conservations are steep slopes areas (including the area west of Foothills Boulevard, which constitutes the west boundary of urban development). Significant slopes over 20% are considered sensitive natural areas and generally excluded from development. The protection of steep slopes and cutbanks is identified as an environmental quality guideline in the OCP, and slopes are identified in the Long Range Land Use map. They are intended to remain in their natural state (City of Prince George 2001).

The Prince George community forest has taken slope stability into consideration with respect to tree removal. During recent pine beetle infected tree removal operations in the City, infected trees were not cut down if they were located on unstable slopes (City of Prince George 2007c).

## Workshop Results

Results from City Adaptation Workshop**:**
**Implementation tool:** OCP
**Prioritized City services to address impact:**

**1st priority:** Long Range Planning
**2nd priorities:** Real Estate and Bylaw Services & Environmental Services

## Ideas for Adaptation Strategies

**Integrated management of at risk areas:**
One interesting example of the integrated management of a high risk area is outlined in Bourqe and Simonet (2008). The study focuses on the management of a coastal zone in Quebec. Detailed analysis has been done by governments and professionals to model the past and future impacts of climate change on bank erosion in the St. Lawrence area. Local decision makers have been educated on these technologies, and can use this information to review planning and zoning policies as part of committees. As a result of this work, regulations to limit development in zones vulnerable to coastal erosion and flooding have been established. This is an excellent example of adapting to changes in slope stability, and also the effective communication of climate information to local stakeholders. Local stakeholders are provided with the appropriate information, and can use it to make informed collaborative decisions.

**Public education:**
The township of Langley has posted a list of best management practices that residents can follow to reduce the potential of slope failures on their properties and in town (Township of Langley 2007). The list provides the following recommendations for residents:

1. Avoid construction of any structures, paths/trails, or landscaping at or near the top of slopes or along slopes.
2. Do not remove vegetation from anywhere along slopes.
3. Regularly inspect structures for damage and pools for leakage.
4. Discharge rain run-off away from slopes to rock pits, splash pads, or storm sewer systems.
5. Locate septic fields away from the top of slopes.
6. Do not dispose of yard waste or place fill (soil) on top of, or along slopes.
7. Remove human-made obstructions from creeks at the bottom of slopes.
8. Maintain clear bridges and culvert crossings.
9. Obtain geotechnical advice from certified professionals for slope concerns or planned works.
10. Obtain applicable permits from local, provincial, and federal agencies for any planned works.

## Recommended Actions

The City of Prince George should continue to expand on its work regarding slope stability and incorporate climate change adaptation explicitly into its plans. The following actions are proposed:

- Communicate with the group conducting the next iteration of the OCP to ensure that adaptation to decreased slope stability as a result of climate change is included as a part of the plan.
- Create a slope stability task force to create an adaptation strategy for the City. This may involve the creation of a new group, or the incorporation of this

mandate into an existing group. This task force should include City representatives from long range planning, real estate and bylaw services and environmental services sectors. It should also include input from academic experts, community members, representatives from other communities in BC that have undergone this type of work, and members of other levels of government. The group should outline the actions already in place, existing resources, key linkages and partnerships with other levels of government and key vulnerabilities of Prince George to climate change with respect to slope stability.

- Communicate with the Prince George Community Forest and the BC Government to ensure that work done to address the pine beetle epidemic continues to consider slope stability and climate change.
- Consider and incorporate climate change information from the `Climate Change in Prince George' report, as well as the results from the City Adaptation Workshop, into the strategy.
- Consider all climate change mitigation co-benefits and trade-offs as a part of the plan.

## *8.7. Storm Water*

### Background

Communities must adjust their stormwater management practices to proactively adapt to changes such as higher peak flows during periods of heavy rain, different spring freshets, and an increased percentage of precipitation falling as rain rather than snow (Federation of British Columbia Naturalists 2006; Picketts et al. 2009). Technically speaking, best management practices can be applied to better replicate the natural water balance when developing storm water management plans. Strategies, such as subsurface recharge and the use of parks and undeveloped areas to safely accommodate excess water from storms, can increase a communities' resilience to flooding and save communities money (Prince George's County 1999). These techniques may also lead to improved water quality and reduced stream erosion. Unfortunately this does not often happen, and buildings and infrastructure are often constructed in a manner that actually obstructs natural drainage channels (Huq et al. 2007).

Table 8-2 outlines the major types of stormwater infrastructure, the functions of this infrastructure, and the potential effect of climate change on them.

**Table 8-2 Major types and functions of stormwater infrastructure. Adapted from Watt et al. 2003.**

| Type of infrastructure | Examples | Function of infrastructure | Potential effect of climate change |
|---|---|---|---|
| transmission structures | gutters, ditches, pipes | transport stormwater | need for bigger structures to accommodate larger rainfall events |
| quantity control structures | roof tops, ponds, infiltration devices | store water during peak flows | need for increased capacity for larger rainfall events |
| quality control structures | filters, wetlands | store and clean stormwater | less sensitive to climate impacts |
| sewer overflow abatement structures | combined sewage overflow structures | dispose of sewage & stormwater together during high precipitation | more maintenance and shorter service lives |

The sensitivity of urban stormwater infrastructure to climate change is a function of the types of infrastructure that are in place. Types of stormwater management systems in Canada range from combined sewers that dispose of stormwater directly from urban areas into downstream receiving waters, to entirely separated systems such as extension ponds, infiltration basins, porous pavement and sand filters (Watt et al. 2003).

Prince George stormwater is not combined with sanitary sewers. Stormwater is conveyed by means of swales, ditches and natural ravines in rural, sub-urban and some older, outlying urban areas of the City, and by storm sewers in the City core and in subdivisions developed over the last 35 years. Within the last 5 to 10 years, more development has been encouraged to utilize sub-surface groundwater recharge systems where soils permit and more detention ponds have been constructed to accommodate peak flows and provide some treatment to reduce the discharge of sediments, hydrocarbons and other contaminants into natural receiving waters. In many cases, well-designed sub-surface recharge and storm detention facilities have reduced the capital cost of upgrading larger diameter storm piping downstream to accommodate increased stormwater flow due to development.

Urban areas are at a higher risk of localized stormwater related flooding events because buildings, roads, infrastructure and other impervious areas produce less controlled run-off, as rainfall is prevented from infiltrating into the soil. Urbanization typically makes surfaces less pervious through impermeable covers (i.e. pavement), or through the disturbance of the natural soil structure (i.e. compaction of earth). This affects the local water balance because it increases storm flow rates and decreases baseflow components (e.g. natural water storage areas that discharge at a slower rate). This problem is exacerbated by traditional stormwater management strategies that are designed to remove runoff from the site as quickly as possible (Holman-Dodds et al. 2003).

Climate change has the potential to impact stormwater in Prince George in a number of ways. In addition to increased precipitation, increased freeze-thaw cycles will deteriote structures more quickly, and temperature changes will result in more rain on snow events

(Dyer 2006). These changes will result in increased maintenance costs, and a greater incidence of inlet structures and catchbasins being blocked due to ice. Sanitary sewer manholes are also vulnerable to inflows from snowmelt and rainfall, especially in areas where they are located in ditches rather than on roads.

## Prince George Overview

There are currently no programs or policy requirements in place that are related to climate change and stormwater in Prince George. There are, however, some areas where climate change is now considered in the design of stormwater infrastructure. The City's Development Services Department now requires that, instead of a 1 in 5 year return period, a 1 in 10 year return period be used to design storm sewers designed for upgrades and for new subdivisions. This is a direct result of the uncertainty climate change may have on conventional design criteria for storm water discharge used by the City of Prince George. More frequent, severe storms may not be captured in the rainfall intensity parameters that have been developed from Environment Canada records, therefore, to allow for this uncertainty, Prince George has elected to require storm sewer systems to be designed to accommodate greater discharge.

The City's Subdivision and Development Servicing Bylaw No. 7652 (2004) prescribes the standards for infrastructure works and services on new land developments. This document dictates that type of storm sewer service that is required at a new development for various types of land zones. In section 7.5.6 of the bylaw it states that on-site stormwater systems may be required in some instances. This bylaw is currently being updated allowing the opportunity to revise infrastructure standards that are more resilient to climate change.

The preparation of watershed drainage plans throughout the City of Prince George were included as a objective in the City's last update of the Official Community Plan, 2001. There are three such plans to be completed for very large areas of the City over the next three years. Climate change impacts will be considered in these plans, including the opportunity to develop policy and best management practices that will direct the development of neighbourhoods to be more resilient to climate change.

## Workshop Results

PIBCWorkshop Outputs:
All natural stormwater retention areas (such as wetlands and ravines) should be utilized to the greatest extent possible. Increased streamflow and precipitation data and projections are crucial to inform these adaptations.

Results from City Adaptation Workshop**:**
**Implementation tool:** Asset Mngt. Performance Measures
**Prioritized City services to address impact:**
**1st priority:** Utilities
**2nd priority:** Financial Services
**3rd priorities:** Transportation & Risk and Benefits

## Ideas for Adaptation Strategies

**On site stormwater retention:**
UniverCity is a model sustainable community that neighbours Simon Fraser University in Burnaby BC. One of the most innovative designs within the community is the stormwater management system; which is designed to maintain pre-development stormwater run-off quality and quantity. This means that it must return as close to 100 percent of stormwater to the ground as possible and not adversely affect the quality of the water (UniverCity 2009). The system does not use drainage pipes and storm sewers, but utilizes a network of watercourses and bioswales and two detention ponds. Each parcel of land must include an on-site stormwater management system that is capable of capturing the run-off from 35mm per day. It must include storage, and infiltration gallery, as well as permeable paving and specific landscaping when it is developed (UniverCity 2008). For more information about UniverCity and its stormwater management system see http://www.univercity.ca/home.42.html.

**Increase stormwater infrastructure capacity:**
One mechanism to adapt to increased precipitation as a result of climate change is by upgrading infrastructure to handle greater loads. To account for climate change, Grand Prairie, Alberta has redesigned its stormwater infrastructure to accommodate a one in 100 year flooding event, whereas formerly it was designed to accommodate a one in five year flood (Parks 2005).

## Actions

There are many initiatives that Prince George can undertake to improve stormwater and provide important flooding and emergency response co-benefits. The following actions are proposed:

- Communicate with City members involved in Asset Management Performance Measures Planning group to ensure that adaptating stormwater to climate change is incorporated into this document.
- Create a stormwater task force to create an adaptation strategy for the City. This may involve the creation of a new group, or the incorporation of this mandate into an existing group. The task force should include City representatives from utilities, financial services, transportation and risk and benefits. It should also include input from academic experts, community members, representatives from other communities in BC that have undergone this type of work, and members of other levels of government. The group should outline the actions already in place, existing resources, key linkages and partnerships with other levels of government and key vulnerabilities of Prince George to climate change with respect to stormwater.
- Communicate with the group conducting the next iteration of the OCP and the ICSP (myPG) to ensure that adaptation to the impacts of stormwater from climate change is included as a part of the plans.
- Collaborate closely with the parties involved in the flood risk assessment to integrate strategies that concurrently address flooding and stormwater.
- Explore information needs and modeling requests that can help to properly inform the stormwater strategy.

- Consider and incorporate climate change information from the 'Climate Change in Prince George' report, as well as the results from the City Adaptation and PIBC workshops, into the strategy.
- Consider climate change adaptation in the preparation of watershed drainage plans.
- Consider all climate change mitigation co-benefits and trade-offs as a part of the stormwater adaptation strategy.

## *8.8. Stresses on Building and Utilities Infrastructure*

### Background

There are many challenges associated with designing building and utilities infrastructure to future climates. These include the uncertainty of projections, and the high costs associated with changing 'business as usual` practices. Municipalities have inherited a legacy of aging infrastructure that is not well suited to current development, and they do not have the ability to finance long term infrastructure projects (Crabbe and Robin 2006). There are other specific challenges related to infrastructure adaptation such as the long life spans of some infrastructure (Swain 2007). Also climate change is just one of several factors stressing infrastructure; it is compounded by demographics, economic development and other environmental pressures (Crabbe and Robin 2006).

"Infrastructure design must change. Engineers need new and updated climatic design values, revised codes and standards, and new methodologies to incorporate potential climate changes into engineering procedures" (Infrastructure Canada 2006: p. 21). Design standards currently do not consider climate change as they guide engineers (and other professionals) to design and retrofit infrastructure. A group called the Public Infrastructure Engineering Vulnerability Committee was recently formed to conduct a national assessment of engineering vulnerability of public infrastructure to climate change in Canada. The group is a partnership between Engineers Canada and Natural Resources Canada, and includes many members such as Natural Resources Canada, Environment Canada, Infrastructure Canada and the Canadian Standards Association (Kertland and Cheema 2008).

Climate change can and will affect the functions and operations of utilities infrastructure, including raw storage facilities, stormwater collections systems, trans-basin diversion structures, potable water treatment facilities, wastewater treatment facilities, transmission lines, and local distribution systems (Water Research Foundation 2009). Water infrastructure will have to be adapted to the larger and more frequent precipitation events that are expected with climate change. Sources of drinking water are of particular concern with climate change, as there is a greater potential for contamination (Crabbe and Robin 2006). Many of these impacts are discussed in the water supply section.

A vast array of climate change related factors must be considered in building design. Some of these potential factors, as outlined by Riley (2000), include:

- the effects of wind increases;
- the impacts of higher temperatures on building materials and structural stability;

- the effects of heavier rainfall on building materials and structural stability;
- the effects of increased precipitation loading on rooftops;
- indoor air quality issues (particularly in summer) due to hotter dryer temperatures;
- changes to water tables affecting building foundations;
- the capacity of buildings to cope with increased instances of flooding;
- the increasing risk of fungal attack on timber structures; and
- the impacts of increased thermal structure movements.

Further study is needed to determine the correlation between climate change impacts, building materials, maintenance schedules, and the lifespan of infrastructure. Walker and Sydneysmith (2008) note that the key impacts related to utilities and services associated with climate change in BC include: supply demand mismatches in urban centres: increasing demands of water and sewage infrastructure; increasing loads on stormwater systems; and potential impacts to infrastructure expansions for oil and gas projects in BC.

## Prince George Overview

There are currently no projects regarding building and utilities infrastructure and adaptation to Climate Change in Prince George. Presently the building bylaw in Prince George references the BC building code. Additional standards must first be prepared by the Province, and can then be adopted by the City. From a climate change mitigation perspective, the City is considering offering incentives for sustainable building practices, and many Provincial buildings (such as the hospital addition and a new building at the College of New Caledonia) are being built to Leadership in Energy and Environmental Design (LEED) standards (N. Wight pers. comm. 2009).

The City has incorporated an ingenious design to accommodate fluctuating ground water levels in the recently constructed downtown gaming parkade. It has been constructed with several catch-basins in its floor so that, in the event of high ground water levels, water may enter the structure. If water levels rise, the parkade can be closed until the water levels drop and the water drains out. If the structure was impermeable, then the rising water levels would exert large amounts of stress on the foundation, and could potentially damage the building (G. Anderson pers. comm. 2009). To mitigate flooding The City is increasing its scrutiny to lot grading in the subdivision and building permit review processes (N. Wight pers. comm. 2009).

## Workshop Results

PIBCWorkshop Outputs:

This group concluded that reducing the overall footprint of the City Prince George will reduce the amount of infrastructure needed. Costs savings associated with this can be reallocated to building infrastructure that can better withstand more extreme events and freeze-thaw cycles. This strategy also has important climate change mitigation co-benefits. Provincial building codes must account for long term climate change. To inform these decisions, a detailed analysis must be performed on future freeze-thaw scenarios, and building materials in the north.

Results from City Adaptation workshop**:**
**Impact selected:** Affects to utilities infrastructure
**Implementation tool:** Asset Management Performance Measures
**Prioritized City services to address impact:**
**1st priority**: Utilities
**2nd priority:** Municipal Emergency and Response
**3rd priorities:** Police, Fire, and Rescue Services & Financial Services & Long Range Planning

## Ideas for Adaptation Strategies

**Review of water supply infrastructure:**
After reviewing scenario information, the Portland Water Bureau concluded that its water supply sources were vulnerable to climate change. Surface water supplies were predicted to become less stable, especially with potential increased demand in summers. The City is examining its groundwater supplies, and considering expanding its source-water infrastructure development. It is examining many options and emphasizing flexibility in its infrastructure planning to account for unexpected changes (Water Research Foundation 2009).

**Assess new built developments**:
Riley (2000) proposes a process called a 'climatic impact assessment', that all future developments should undergo before being constructed. The assessment involves looking at many climate change criteria (listed in the background section) and evaluating what the potential risk of climate change is to human life, cost, and other factors. The climate impacts assessment is designed to enable the developer (or owner) to consider and minimize the impacts of climate change for a new project (Riley 2009).

## Recommended Actions

There are a number of initiatives that will help to adapt building and utility infrastructure to Climate Change in Prince George. In the future building and utility impacts may be addressed separately. The following actions are proposed:

- Engage with City workers involved with Asset Management Performance Measures to ensure that adapting building and utility infrastructure to the impacts of climate change is incorporated into this document.
- Create a building and utilities impacts task force (or potentially two task forces) in Prince George to create an adaptation strategy for the City. This may involve the creation of a new group, or the incorporation of this mandate into an existing group. The task force should include City staff representing utilities, municipal emergency, police fire and rescue services, long term planning and financial services. It should also include input from academic experts, community members, and members of other levels of government. They should outline the actions already in place, existing resources, key linkages and partnerships with other levels of government and key vulnerabilities of Prince George to climate change with respect to building and utilities infrastructure.
- Explore information needs and request for climate models that can help inform adaptation strategies.

- Collaborate with different levels of government to discuss the implementation of new standards for infrastructure that consider climate change (such as design values and engineering codes).
- Educate private property owners about future risks. (i.e. create a best practices manual, provide incentives and think of other creative ways to promote resilient design).
- Implement performance covenants and phased development agreements to encourage developers/builders to address adaptation strategies.
- Consider and incorporate climate change information from the 'Climate Change in Prince George' report, as well as the results from the City Adaptation and PIBC Workshops, into the strategy.
- Consider all climate change mitigation co-benefits and trade-offs as a part of the plan.

## *8.9. Health*

### Background

Although it is very difficult to assess the affects of climate change on health, it is projected to have predominantly negative influences, particularly in poorer regions of the world. (IPCC 2007g). It is important to note that wealthy areas can also be affected by climate change. A striking example of this was the massive heat wave that spread across Europe in 2003 and killed over ten-thousand people (Kovats and Haines 2005).

Recently Ostry et al. (2008) created a report for the Pacific Institute for Climate Solutions on climate change and health in BC. This document provided insight on climate change, extreme weather, and health effects within the Province. Eight areas of particular concern were outlined for the Province. Many of these factors are very relevant to Prince George, particularly those regarding mountain pine beetle. The areas of concern are (Ostry et al. 2008: p. 15):

1. Direct or indirect climate change-related de-stabilization of communities will have the most immediate and severe impact on the health of British Columbians.
2. It will be important to investigate the impacts of climate change in vulnerable communities, such as those currently affected by, and in the future path, of the mountain pine beetle infestation.
3. Communities that rely upon glacier and snowfields for their water supply are likely to face adverse health effects related to water quality as well as quantity.
4. If climate change produces more frequent and more severe fires and floods in the province, both acute and chronic illnesses in relation to these hazards will increase.
5. If fires increase and if industrial and residential pollution remains the same or increases, interactions with increased temperatures may lead to increases in respiratory and cardiovascular disease.
6. The frequency of heat events are likely to increase in BC and will be significant for vulnerable populations in the interior.
7. The prevalence of vector-borne illnesses already established in the province will likely increase as temperatures and precipitation increase in BC.

8. Some, as of yet unknown, number and type of illnesses with vectors from warmer and wetter climes may be introduced and establish themselves in BC as the climate changes.

Health interrelates with many of the other impacts identified in this document, particularly water supply and emergency response,

### Prince George Overview

There are currently no activities explicitly related to health and climate change ongoing with the City of Prince George.

### Workshop Results

Health was not included as an impact in the City Adaptation Workshop.

### Recommended Actions

There are many direct and indirect measures that Prince George can take to consider climate change adaptation and health. The following actions are proposed:

- Collaborate with health related organizations in the City to address health impacts with respect to climate change. This may involve the formation a health and climate change committee or task force dedicated to this, or the incorporation of climate change adaptation into the mandate of an existing health related group.
- Minimize health impacts from water, emergency response and other impacts by effectively adapting to them.
- Incorporate health impacts and climate change into the upcoming ISCP revision. (Note that health is including in the social development strategy of the ICSP (myPG) in Figure 4-2.)
- Consider and incorporate climate change information from the 'Climate Change in Prince George' Report into the strategy.

## *8.10. Agriculture*

### Background

Changes in agriculture as a result of climate change are expected to vary widely throughout the world and across Canada. Many climate related factors will affect agriculture including changes in growing degree days (an indicator of temperatures during a growing season), maximum and minimum temperatures, average temperatures, frost free days, frost timing, biological activity and range of diseases. These will have an effect on both the types of crops planted, and their productivity (IPCC 2007g). Longer growing seasons are projected to increase the range of crops suitable for agricultural production in BC. In the northern interior region of the Province, forage crops (such as grasses and cereals) are projected to benefit from longer growing season, and species like corn may begin to become viable (Walker and Syndeysmith 2008).

Some facts related to agriculture in Northern BC, as outlined by Tingle (2003), are as follows:

- The second biggest agricultural commodity in BC is beef (the first is salmon).
- Fifty-seven percent of the provincial beef herd is located from the caribou region northward.
- The Cariboo and Highway 16 regions produce more forage than any other area of the province, including the Peace River.
- Only about a quarter of the land designated for agriculture in crops is currently being used in Northern BC.
- Crops grown in the Fraser Fort George Regional District in 2002 include potatoes, carrots, beets, broccoli, rutabagas, cabbage, brussels sprouts, peas, beans, raspberries, strawberries, and crab apples.

The agricultural land reserve (ALR) is an institutional tool to help manage and maintain the small amount of land in BC that is suitable for agriculture. It can be very helpful in managing the province's agricultural lands under the effects of climate change (Walker and Sydneysmith 2008). 6970 hectares of land are in the ALR in Prince George, which is about 23% of the land area in the City. In 2001 there were 55 farms in Prince George, as compared to 63 in 1996 (BC Ministry of Agriculture, Food and Fisheries 2001).

Local agriculture provides other big picture adaptations to climate change. These include lessening a communities' reliance on unpredictable fossil fuel costs (and potentially availability) for transportation of food. Also a supply of food that is available locally increases a regions' resilience to extreme weather events that may affect transportation networks (Ruth 2006). There are also important climate change mitigation benefits associated with local agriculture associated with the transportation of food. Local growers should be supported to exploit these important benefits. Within Prince George, local stakeholders have expressed concern that there is a general lack of support for agricultural amongst governments (Connell et al. 2007).

## Prince George Overview

There are currently no activities related to agricultural and climate change ongoing with the City of Prince George.

The local farmer's market has been incredibly successful in Prince George, with an estimated annual economic impact of $794 000 (Connell et al. 2006). This has encouraged local food growth and consumption, along with providing many other benefits to the community.

## Workshop Results

Results from City Adaptation Workshop**:**
**Implementation tool:** OCP
**Prioritized city services to address impact:**
**1st priority:** Long Range Planning
**2nd priority:** Environmental Services
**3rd priority:** Parks and Trails

### Recommended Actions

There are many direct and indirect measures that Prince George can take to consider climate change adaptation and agriculture. The following actions are proposed:

- Collaborate with agricultural related organizations in the City to address agricultural impacts with respect to climate change. This may involve an agriculture and climate change committee or task force dedicated to this, or the incorporation of climate change adaptation into an existing committee or group. The group should include City representatives from long range planning, environmental services and parks and trails sectors. It should also include input from local stakeholders, academic experts and different levels of government. The group outline the actions already in place, existing resources, key linkages and partnerships with other levels of government and key vulnerabilities and opportunities of Prince George to climate change with respect to agriculture.
- Incorporate climate change adaptation and agriculture into the upcoming iteration of the OCP.
- Minimize agricultural impacts on water, and conserve water quality and quantity to ensure that there is an adequate supply of clean water for future agriculture.
- Encourage local agriculture as an adaptation to climate change with important mitigation co-benefits.
- Consider and incorporate climate change information from the 'Climate Change in Prince George' report, as well as the results from the City Adaptation Workshop, into the strategy.

## *8.11. New Residents and Businesses*

### Background

Human migration is an expected response to climate change, as people are faced with impacts that they are unable or unwilling to adapt to. It has been shown that climate has been a factor in migration throughout human history, and it is expected that rapid climate change will result in the same responses (McLeman and Smit 2006). This could occur as in-migration (movement within a region or country) or as immigration. One example of in-migration that occurred in North America is the dustbowl in the United States. Drought and dust storms made for bad agricultural conditions in the mid-west. This, along with accompanying unfavourable economic and political conditions, led to approximately 300,000 people leaving the Southwest region, many of whom relocated to California (Gregory 1989). In BC impacts such as water shortages, extreme events and sea level rise may lead to the displacement of people and settlements. Prince George may become a much more appealing area to live as other regions in BC suffer more severe climate impacts, which will result in more residents and businesses in the community.

Climate change may present business opportunities beyond the migration of people and increased agriculture. One major business related climate change impact is tourism. Tourism is very important component of both coastal and mountainous regions around the world (World Tourism Organization 2003). After forestry, tourism is BC's second largest economic sector, providing approximately 7% of total provincial employment

(Walker and Sydneysmith 2008). Climate change has affected tourism in BC already, and projected future changes will continue to affect it more. Examples of this include the effects of tourism on droughts and forest fires in the Okanagan, rising snowlines in winter mountain recreation areas in Southern BC, and rising sea level in coastal communities (Walker and Sydneysmith 2008). Winter destinations are particularly vulnerable to climate change, and many popular areas may not be suitable to host the activities that have historical attracted tourists. Tourism represents a potential business opportunity that the City can plan for.

## Prince George Overview

There are currently no activities related to new residents and businesses and climate change ongoing with the City of Prince George.

## Workshop Results

Results from City Adaptation workshop**:**
**Implementation tool:** OCP
**Prioritized City services to address impact:**
**1st priority:** Long Range Planning
**2nd priorities:** Solid Waste Services & Social Policy

## Recommended Actions

There are many direct and indirect measures that Prince George can take to adapt to the potential for new residents and businesses. The following actions are proposed:

- Collaborate with business related organizations in the City to consider long term opportunities with respect to climate change. This may entail a tourism and migration and climate change committee or task force dedicated to this, or the incorporation of this mandate into an existing group. The group should include City representatives from long range planning, solid waste services and social policy. It should also include input from local stakeholders, academic experts and different levels of government.
- Consider business and tourism and climate change in the upcoming iteration of the OCP.
- Consider and incorporate climate change information from the 'Climate Change in Prince George' Report, as well as the results from the City Adaptation Workshop, into the strategy.

# 9. Next Steps

This report should be presented to council along with the 'Climate Change in Prince George' report created by UNBC and PCIC (Picketts et al. 2009). The University of Northern BC and the City should continue to work in partnership to examine the priorities outlined in this report in more detail, and create viable adaptation strategies for Prince George. For this to happen many steps are required. A list the future tasks that need to be undertaken is as follows:

- report results back to the participants of the City adaptation workshop;
- communicate with experts within and outside of the City of Prince George to consider and evaluate adaptation options for the City regarding the impacts;
- undertake further background research on adaptation options for various impacts;
- if necessary, obtain more climatic information or projections from PCIC, or other group(s) that specialize in this work;
- analyze the results from the PIBC workshop further and, where appropriate, incorporate ideas into adaptation strategies;
- analyze ideas from the participants from the City Adaptation workshop further and, where appropriate, incorporate ideas into adaptation strategies;
- communicate this report to the consultants undertaking the ICSP (myPG) and the next iteration of the OCP, so that this work is incorporated in those documents;
- collaborate with the OCP and ICSP (myPG) consulting team to determine the most effective way to include the adaptation priorities in this report into these plans;
- communicate with City officials responsible for the annual provisional financial plan and the asset management performance measures to discuss how the appropriate adaptation measures can be incorporated into these documents;
- communicate with representatives of the appropriate city sectors about how adaptation measures can be incorporated into the planning and operations of these sectors;
- communicate the results of this report as well as the climate change information to City staff, community members and mayor and council to educate people about climate change and garner support for adaptation work;
- review the SGOG design brief to build upon the adaptation mechanisms are in place through this process; and
- re-consider and re-evaluate the Health, Agriculture and New businesses and people impacts to take social factors into greater consideration as well as potential positive impacts.

# 10. Closure

Adapting to climate change is a high priority for the residents of Prince George. This was clearly illustrated in the results from the recent QOL survey. It is also a priority for the City as is shown by the creative adaptation strategies that are currently in place. City staff's facilitation of focus groups in the PIBC Workshop, participation in the City Adaptation Workshop, and leadership in the Smart Growth on the Ground process has engaged stakeholders and generated information about climate change impacts and adaptations. It is extremely encouraging that there is so much expertise and enthusiasm regarding proactive adaptation to climate change within the City.

This region will face many challenges, but the community has an extremely high adaptive capacity, and has already taken many proactive measures to begin to consider climate change in its planning and operations. Many other regions in the world will be far more affected by climate change, and do not have the capacity to plan for the changes that they will face. This is a new area of study and there are few examples of communities implementing adaptation measures from which to build on. However there is a substantial amount of literature available about climate change impacts, and guides and workbook to build upon to create a strategy.

This research is extremely well timed. The upcoming creation of phase II of the ICSP (myPG) and the OCP revision represent ideal opportunities to explicitly plan to adapt to Climate Change in Prince George. The outputs of this report should be referenced and built upon as the City makes recommendations about how to adapt to the various impacts. Prince George is positioned to become a provincial and national leader in the field of community climate change adaptation. Action on these priorities will bring positive attention on the City, and help to showcase its many attributes. With effective adaptation, Prince George can become one of the most desirable cities to live Canada, and continue to offer residents an outstanding quality of life despite changes in the climate.

Within this document are recommended actions for each of the 11 priority impacts identified. These recommended next steps are included in the '*Recommended actions*' section for each of the impacts, which are discussed in detail from Sections 8.1 -8.11. These recommended actions constitute the main conclusions of this document. These should be discussed and evaluated by community stakeholders, and form the basis of a climate change adaptation strategy for Prince George.

The order of the list of impact priorities is not necessarily the same as the order that actions should be addressed in Prince George. There is already positive work being done to address many of these impacts. The City should examine the impacts, the work that is occurring in the City related to the impact, the consequences of inaction and the likelihood of occurrence of the impact and the range of responses available to it in order to decide what actions to take first.

Although it was not discussed in detail in this report, it is imperative that communities minimize their contribution to climate change by mitigating their greenhouse gas emissions. Climate change adaptation should be viewed as a short term solution to climate change, and adaptation actions should be undertaken alongside serious mitigation efforts. When planning adaptation strategies, stakeholders should consider the climate change mitigation implications associated with them. Whenever possible, adaptation actions should also improve mitigation efforts, and vice versa.

## Works Cited

Adamson, D. 2009. Staff Report to Council: Community Mountain Pine Beetle Removal and Wildfire Protection Update and Recommended Action. Presented to Mayor and Council of Prince George: 5 June 2009.

Adger, W.N., Paavola J., Huq, S. and Mace, M.J. 2006. Fairness in adaptation to climate change. MIT Press, Cambridge

Allen Consulting Group. 2005. Climate Change Risk and Vulnerability. Prepared for the Australian Greenhouse Office, Department of the Environment and Heritage. Availablie from http://www.climatechange.gov.au/impacts/publications/pubs/risk-vulnerability.pdf [accessed 23 February 2009].

Altrichter, H., Posch, P. and Somekh, B. 1996. Teachers investigate their work; An introduction to the methods of action research. London: Routledge

Amec. 2006. City of Prince George Salt Management Plan 2006-2007. Prepared for the City of Prince George. Available from http://www.city.pg.bc.ca/city_services/transportation/salt_management_plan.pdf [accessed 4 June 2009].

Arlington Group Planning and Architecture. 2001. Floodproofing Options for

Arnell, N. 1998. Climate change and water resources in Britain. Climate Change. 39:83-110.

Australian Government. 2007. Climate Change Adaptation Actions for Local Government. Australian Greenhouse Office: Department of Environment and Water Resources.

Baxter, K. and Purcell, M. 2007. Community Sustainability Planning. Municipal World. November 2007: 35-38.

Bizikova L., Neale, T. and Burton, I. 2008. Canadian communities' guidebook for adaptation to climate change, First Edition. Environment Canada and University of British Columbia, Vancouver.

Bourque, A. and Simonet, G. 2008. Quebec; in From Impacts to Adaptation: Canada in a Changing Climate 2007. Edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, On, p. 171-226.

Bryson, J. 1995. Strategic Planning for Public and Nonprofit Organizations. Jossie Bass Publishers: San Francisco, CA.

Buma, J. and Dehn, M. 1998. A method for predicting the impact of climate change on slope stability. Environmental Geology. 35: 190-196.

BC Government 2009. Community Facts: Prince George City. Available from http://www.bcstats.gov.bc.ca/data/dd/facsheet/cf163.pdf [accessed 12 January 2009]

BC Government. 2007. B.C. Statistics: Community Facts - Prince George. Available from www.bcstats.gov.bc.ca [accessed 10 October 2007].

BC Government. 2006a. Canadian Climate Impacts and Adaptation Research Network. Adapting to Climate Change; an Introduction for Canadian Municipalities. Victoria, BC.

BC Government 2006b. Mountain Pine Beetle Action Plan 2006-2011: Sustainable Forest, Sustainable Communities. Available from http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/actionplan/2006/Beetle_Action_Plan.pdf [accessed 1 February 2009].

BC Government. 1996. Emergency Program Act. Available from http://www.bclaws.ca/Recon/document/freeside/--%20E%20--/Emergency%20Program%20Act%20%20RSBC%201996%20%20c.%20111/00_96111_01.xml#!--%20#id=info%20--# [accessed 28 May 2009].

BC Ministry of Agriculture, Food and Fisheries. 2001. City of Prince George Agriculture in Brief. Available from http://www.agf.gov.bc.ca/resmgmt/sf/agbriefs/Pr_George.pdf [accessed 26 March 2008].

BC Ministry of Community Services. 2007. The Integrated Community Sustainability (ICSP) Initiative. BC Government. Available from http://www.cd.gov.bc.ca/LGD/intergov_relations/library/ICSP_Backgrounder.pdf [accessed 12 May 2009].

BC Ministry of the Environment. 2008. Mountain Pine Beetle Infestation: Hydrological Impacts. Prepared by EDI Environmental Dynamics Ltd. Available from http://www.llbc.leg.bc.ca/public/PubDocs/bcdocs/445817/finishDownloadDocument.pdf [accessed 12 November 2008].

BC Ministry of the Environment. 2006. Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Available from http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare2006/develop_with_care_intro.html [accessed 7 July 2009].

BC Ministry of the Environment. 1981. Floodproofing New Residential Buildings in British Columbia. Queen's Printer for British Columbia, Victoria.

BC Ministry of Forests, 2008. 2006-2011 Mountain Pine Beetle Action Plan: Progress Report. Kamloops, BC.

BC Ministry of Forests, 2004. The Ecology of the Sub-Boreal Spruce Zone. Vancouver, BC.

BC Ministry of Water Land and Air Protection. 2004. Weather, Climate and the Future: BC's Plan. Ministry of Water, Land and Air Protection. December 2004.

Casebeer, A. and Verhoef, M. 1997. Combining qualitative and quantitative research methods: considering the possibilities for enhancing the study of chronic diseases. Chronic diseases in Canada 18(3): 130 – 136

Cataraqui Region Conservation Authority. 2008. Resource Management: Drinking Water Source Protection. Available from http://www.cataraquiregion.on.ca/management/sourcewaterprotection.htm [accessed 1 June 2008].

Christensen et al. 2007. Regional Climate Projections. In: S. Solomon et al. (editors), Climate Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge United Kingdom and New York, NY, USA.

City of Chicago 2008. Chicago Area Climate Change Quick Guide: Adapting to the Physical Impacts of Climate Change. Parzen, J. Chicago Il.

City of Prince George. 2009a. ICSP Prince George. Available from http://icsp.princegeorge.ca/Pages/index.aspx [accessed 1 March 2009].

City of Prince George. 2009b. Emergency Services. Available from http://www.city.pg.bc.ca/city_services/emergency/icejam/response/ [accessed 12 January 2009].

City of Prince George. 2009c. Flood Risk Evaluation and Flood Control Solutions. Available from http://www.city.pg.bc.ca/city_services/emergency/icejam/misc/longterm.php [accessed 2 June 2009].

City of Prince George. 2009d. Emergency Preparedness. Available from http://www.city.pg.bc.ca/city_services/emergency/ [accessed 2 June 2009].

City of Prince Geoge. 2008a. Community Website. Available from http://www.city.pg.bc.ca/ [accessed 31 October 2007].

City of Prince George. 2008b. Fire / Rescue Services. Available from http://www.city.pg.bc.ca/city_services/fire/ [accessed 2 July 2009].

City of Prince George. 2008c. City of Prince George: Transportation Division – snow operations. Available from http://www.city.pg.bc.ca/city_services/transportation/snowoperations/ [accessed 17 July 2009]..

City of Prince George. 2007a. Bylaw No. 7855. Available from http://www.city.pg.bc.ca/city_services/cpd/newzoning/bylaw7855.pdf [accessed 14 May 2009].

City of Prince George. 2007b. Winter Lights Community Profile. Available from http://www.city.pg.bc.ca/rec_culture/winterlights/winterlights_profile_bk.pdf [accessed 17 July 2009].

City of Prince George. 2007c. Urban Forest Management: Mountain Pine Beetle. Available from http://www.city.pg.bc.ca/rec_culture/parks/urbanforestry/management/ [accessed 2 July 2009].

City of Prince George. 2006. Bylaw No. 7920. Available from http://www.city.pg.bc.ca/cityhall/bylaws/bylaw7920.pdf [accessed 14 May 2009].

City of Prince George. 2005. City of Prince George Water Conservation Plan. Prepared by Utilities Division. Available from http://www.city.pg.bc.ca/city_services/utilities/waterconservation/water_conservation_plan.pdf [accessed 23 February 2008].

City of Prince George. 2004. Bylaw No. 7652. Available from http://www.city.pg.bc.ca/city_services/cpd/sds/bylaw7652.pdf [accessed 2 June 2009].

City of Prince George. 2001. Official Community Plan. Available from http://www.city.pg.bc.ca/city_services/ocp/ocp.pdf [accessed12 October 2007].

Cohen, S. and Neale, T. 2006. Participatory integrated assessment of water management and climate change in the Okanagan Basin, British Columbia. Vancouver: Environment Canada and University of British Columbia.

Cohen, S. and Waddell, M. 2008. Climate Change in the 21st Century. McGill-Queens University Press, Montreal.

Connell, D., Borsato, R. and Gareau, L. 2007. Farmers, farmers markets and land use planning: case studies in Prince George and Quesnel. Prince George BC: School of Environmental Planning, University of Northern British Columbia.

Connell, D., Taggart, T., Hillman, K. and Humphrey, A. 2006. Community and economic impact assessment: Prince George farmer's market. Prince George BC: School of Environmental Planning, University of Northern British Columbia.

Conrad, D., McNitt, B. and Stout, M.1998. Higher Ground: A report on voluntary property buyouts in the Nation's floodplains. National Wildlife Federation. Available from http://www.nwf.org/hurricanes/pdfs/NWFHigherGround.pdf [accessed 12 June 2009].

Coyne, I. T. 1997. Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries. Journal of Advanced Nursing. 26: p. 623-630.

Crabbe, P. and Robin, M. 2006. Institutional adaptation of water resource infrastructures to climate change in Eastern Ontario. Climate Change. 78: 103-133.

Currie, D. 2001. Projected effects of climate change on patterns of vertebrate and tree species richness in the conterminous United States. Ecosystems. 4:216-225

Daly, C., Neilson, R.P. and Phillips, D.L. 2004. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. Journal of Applied Meteorology. 33: 140-158.

Davidson, D. Williamson, T. and Parkins, J. 2003. Understanding Climate Change Risk and Vulnerability in Northern Forest-Based Communities. Available from http://cjfr.nrc.ca [accessed 12 November 2007].

Dehn, M., Burger, G., Buma, J. and Gasaretto, P. Impact on climate change on slope stability using expanded downscaling. Engineering Geology 55: 193-204.

Diamond Head Consulting Ltd. 2005. City of Prince George Urban Wildland/Urban Interface Wildfire Management Strategy. Prepared for the City of Prince George. . Available from http://www.city.pg.bc.ca/rec_culture/parks/urbanforestry/wildfire/management_plan.pdf [accessed 8 November 2007].

District of Saanich. 2008. Saanich Official Community Plan 2008: Appendix A to bylaw 8940. Available from http://www.gov.saanich.bc.ca/business/development/plan/pdfs/ocp%20files/ocp_adopted_jul808.pdf [Accessed 6 July 2009].

Dubois, Bernatchez, Bouchard, Daigneault, Cayer, Dugas. 2006. Evaluation du risqué d'erosion du littoral de la Cote-Nord du Saint-Laurent pour la periode de 1996-2003. Presented at the regional conference of the elected representatives of the Cote-Nord; April 1996.

Dyer, D. 2006. Communities and Climate Change. Presented at the Communities and Climate Change Conference; Prince George. May 17, 2006

Dyurgerov, M. and Meiere, M. 2000. Twentieth century change: evidence from small glaciers. Proceeding of the National Academy of Sciences. 15-97(4): 1406-1411.

Environment Canada. 2004. Code of Practice for the Environmental Management of Road Salts.

FAO. 2008. Food and Agricultural Organization of the United Nations. Climate Change and Food Security: A Framework Document. Rome.

Federation of BC Naturalists. 2006. Community Planning Tools and Approaches for Protecting Freshwater Shorelines in the Thompson – Nicola - Shuswap Region of the BC Interior in Response to Climate Change.

FEMA. 2009. Federal Emergency Management Agency: Disaster Information Page. Available from http://www.fema.gov/hazard/index.shtm [accessed 15 June 2009].

Filman, G. 2004. British Columbia Firestorm 2003; Provincial Review. Government of British Columbia, Victoria, B.C. Available from http://www.llbc.leg.bc.ca/public/PubDocs/bcdocs/367694/Firestorm_Report.pdf [accessed 11 November 2007].

Flannigan, M. and de Groot, B. 2009. Forest Fires and Climate Change in the Circumboreal Forest. ALANIS/iLEAPS Workshop.

Fleming, S.W. 2005. Comparative analysis of glacial and nival streamflow regimes with implications for lotic habitat quantity and fish species richness. River Research and Applications, 21: 363-379.

Fowler, F. 1995. Improving Survey Questions: Design and Evaluations. Sage Publications, CA.

Füssel, H.M. 2007. Adapting planning for climate change; concepts, assessment approaches, and key lessons. Integrated Research System for Sustainability Science. 2:265-275

Galbraith, R. M., Price, D. J. and Shackman, L. 2005. Scottish Road Network Climate Change Study. Prepared for the Scottish Government. Available from http://www.scotland.gov.uk/Publications/2005/07/08131510/15117 [accessed 22 June 2009].

Golder Associates. 2003. Application for Environmental Certificate and Draft Comprehensive Study Report - City of Prince George Hart Water Supply Improvements; Fishtrap Island Collector Well Project, Prince George BC.

Gregory, J. N. 1989. American Exodus: The Dust Bowl Migration and Okie Culture in California. Oxford University Press, New York.

Halifax Regional Municipality. 2006. HRM Climate SMART Community Action Guide to Climate Change and Emergency Preparedness. Available from http://adaptation.nrcan.gc.ca/projdb/pdf/185b_e.pdf [accessed 12 October 2008].

Hay, J. and Mimura, N. 2006 Supporting climate change vulnerability and adaptation assessments in the Asia-Pacific region: an example of sustainability science. Sustainability Science 1:23–35.

Hegerl G.C.and Zwiers F.W.. 2007. Understanding and attributing climate change. In: IPCC (ed) Climate change 2007: the physical science basis, chapter 9. Cambridge University Press, Cambridge

Hoggart, K., Lees, L. and Davies, A. 2002. Researching Human Geography. New York, NY: Oxford University Press Inc.

Holman-Dodds, J., Bradley, A. and Potter, K. 2003. Evaluation of hydrologic benefits of infiltration based urban storm water management. Journal of the American Water Resources Association. February: 205-215.

Huq, S., Kovats, S., Reid, H. and Satterthwaite, D. 2007. Editorial: Reducing risks to cities from disasters and climate change. Environment and Urbanization. 19(1) 3-15.

Infrastructure Canada 2006. Adapting Infrastructure to Climate Change In Canada's Cities and Communities: A literature Review. Available from: http://www.infc.gc.ca/altformats/pdf/rs-rr-2006-12_02-eng.pdf [accessed 21 June 2009]

International Monetary Fund. 2007. World Economic Outlook: Globalization and Inequality. World Economic and Financial Surveys.

IPCC. 2007a. Assessment of observed changes and responses in natural and managed systems. Climate Change 2007: Impacts, Adaptation and Vulnerability. Rosenzweig, C., Casassa, G., Karoly, D.J, Imeson, A. Liu, C., Menzel, A., Rawlins, S., Root, T.L., Seguin, B. and Tryjanowski, P. Cambridge University Press, Cambridge, UK. 79-131.

IPCC. 2007b. Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth AssessmentReport of the Intergovernmental Panel on Climate Change, Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden P.J. and C.E.Hanson. Cambridge University Press, Cambridge, UK.

IPCC. 2007c. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. and Meyer, L.A. Cambridge University Press, Cambridge, UK.

IPCC. 2007d. Inter-relationships between adaptation and mitigation. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Klein, R.J.T., Huq, S., Denton, F., Downing, T.E., Richels, R.G., Robinson, J.B. and Toth, F.L. Cambridge University Press, Cambridge, UK. 745-777.

IPCC 2007e. Assessing key vulnerabilities and the risk from climate change. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Schneider, S.H., Semenov, S., Patwardhan, A., Burton, I., Magadza, C.H.D., Oppenheimer, M., Pittock, A.B Rahman, A., Smith, J.B., Suarez, A. and Yamin, F. Cambridge University Press, Cambridge, UK. 779-810

IPCC 2007f. Observations: Surface and atmospheric climate change. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Trenberth, K.E., Jones, P.D., Ambenje, P., Bojariu, R., Easterling, D., Klein Tank, A., Parker, D., Rahimzadeh, F., Renwick, J.A., Rusticucci, M., Soden, B. and Zhai, P. Cambridge University Press, Cambridge, UK. 235-336.

IPCC 2007g. Assessment of observed changes and responses in natural and managed systems. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Rosenzweig, C., Casassa, G.,. Karoly, D.J, Imeson, A., Liu, A. Menzel, C., Rawlins, S., Root, T.L., Seguin, B. and Tryjanowski, P. Cambridge University Press, Cambridge, UK. 79-131.

IPCC. 2001. Climate change 2001: the scientific basis. Houghton, J.T., Ding, Y., Griggs, D.J, Noguer, M., van der Linden, P.J. Dai, X., Maskell, K. and Johnson, C.A.. Cambridge University Press, Cambridge UK.

Jacques, P. 2006. Downscaling climate models and environmental policy: from global to regional politics. Journal of Environmental Planning and Management. 29(2) 301 – 307.

Jick, T. 1979. Mixing Qualitative and Quantitative Methods: Triangulation in Action. Qualitative Methodology. 24(4): 602-611.

Kertland, P. and Cheema, S. 2008. Engineering Assessment of the Vulnerability of Infrastructure to Climate Change. Presented at the Planning For Climate Change Conference, July 22, 2008.

Kharin, V.V., Zwiers, F.W., Zhang, X. and Hegerl, G.C. 2007. Changes in Temperature and Precipitation Extremes in the IPCC Ensemble of Global Coupled Model Simulations. Journal of Climate. 20(8): 1419-1444.

King County. 2007. King County 2007 Climate Plan. Available from http://www.metrokc.gov/exec/news/2007/pdf/climateplan.pdf [accessed 23 February 2008].

Kitzinger, J. 1995. Qualitative Research: Introducing focus groups. BMJ (British Medical Journal). 311: 299-302

Kitzinger J. 1994. The methodology of focus groups: the importance of interactions between research participants. Sociology of Health and Illness.16; 103-21.

Kleinen, J, & Petschel-Held, G. 2007. Integrated assessment of changes in flooding probabilities due to climate change. Climate Change. 81: 288-312

Kovacs, P. and Kunreuther, H. 2001. Managing Catastrophic Risk: Lessons from Canada. Institute for Catastrophic Loss Reduction, Research Paper Series No. 13.

Kovats, R. S. and Haines, A. 2005. Global climate change and health: recent findings and future steps. Canadian Medical Association Journal 172(4):501-502.

Krueger, R. And King, J. 1997. Involving Community Members in Focus Groups. The Focus Group Kit, Vol 4. Thousand Oaks, CA. Sage.

Kulkarni, T., Blais-Stevens, A. and Berardinucci, J. 2004. Community Vulnerability to Flooding and Climate Change. Proceedings from Joint CCIARN Landscape Hazards – Canadian Water Resources Association (British Columbia) Workshop 2003. Natural Resources Canada.

Kunkel, K.E. and Liang, X. 2005. GCM simulations of the climate in the central United States. Journal of Climate. 18(7): 1016-1031.

Laurence, W. 2006. The Value of Trees. New Scientist. April 15: 2547.

Lee, R. 2000. Climate Change and Environmental Assessment: Part 1: Review of Climate Change Considerations in Selected Past Environmental Assessments. Prepared by the Canadian Environmental Assessment Agency.

Llewellyn, J. 1999. Understanding a City's Form and Function: The development and Planning History of the City of Prince George. Master's Thesis: University of British Columbia. Submitted December 1999.

Martens, W. 1998. Health impacts of climate change and ozone depletion: an ecoepidemiologic modeling approach. Environmental Health Perspectives. Vol 106 (Supplement 1): 241-251.

McBean, G. 2002. Climate change and extreme weather: a basis for action. Natural Hazards. 31: 177-190.

Mclamb, E. 2009. Human Costs of Climate Change. Ecology Global Network. Available from http://ecology.com/ecology-today/2009/03/16/human-costs-of-climate-change-2/. [accessed 10 June 2009].

McMichael A.J., Cambell-Lendrum, D.H., Corvalan, C.F.,, Ebi K.L., Githeko A.K., Scheraga, J.D. and Woodword A,. 2003. Climate Change and Human Health: Risks and Responses. World Health Organization, Malta.

McLeman and Smit. 2006. Migration as an adaptation to climate change. Climate Change. 76: 31-53.

Milly P., Wetherald, R., Dunne, K. and Delworth, T. 2002. Increasing risk of great floods in a changing climate. Nature. 415.

Mirza, S. and Haider, M., 2003, The State of Infrastructure in Canada: Implications for Infrastructure Planning and Policy. Preprared for Infrastructure Canada. McGill University, Montreal, QC. Available from http://www.infc.gc.ca/altformats/pdf/rs-rr-2003-03-eng.pdf [accessed 3 May 2009].

Mitchell, J., Johns, T.C., Eagles, M.,. Ingram, W.J. and Davis, R.A. 1999. Towards the construction of climate change scenarios. Climate Change. 41:547-581.

Morgan, D.L. 2006. Practical Strategies for Combining Qualitative and Quantitative. Methods. In Emergent Methods in Social Research. Hesse-Biber, S. and Leavy, P. (eds.). Sage Publications, Ca.

Morse, J.M. 1991. Strategies for sampling in qualitative nursing research: a contemporary dialogue. Sage, Newbury Park, California. p. 127-145

Munasinghe, M. and Swart, R. 2004. Primer on Climate Change and Sustainable Development. Cambridge University Press, UK.

Natural Resources Canada. 2008. Forest communities: adapting to new climates. Available from http://canadaforests.Natural Resources Canada .gc.ca/articletopic/175?format=print [accessed 1 June 2009].

Natural Resources Canada. 2007. Climate Change Impacts and Adaptation: A Canadian Perspective: Impacts on Transportation Infrastructure. Available from http://adaptation.Natural Resources Canada .gc.ca/perspective/transport_3_e.php [accessed 3 June 2009].

National Research Council. 2008. Potential Impacts of Climate Change on US Transportation. Available from http://onlinepubs.trb.org/onlinepubs/sr/sr290.pdf. [accessed 1 June 2009].

Needoba, A. and Blackwell, B. 2009. City of Prince George Landscape Scale Fire Behaviour Modeling. BA Blackwell and Associates Ltd. Submitted to the City of Prince George.

New Zealand Ministry of the Environment. 2008. Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand. 2nd Edition. Mullan, B., Wratt, D., Dean, S., Hollis, M., Allan, S., Williams, T. and Kenny, G. Ministry for the Environment, Wellington.

Newell, R. and Paterson, M. 1998. A Climate for Business: Global Warming, the State and Capital. Review of International Political Economy, Vol 5(4): 679-703.

Nordin, W. 2008. Staff Report to Council: 2008 Quality of Life Survey. Presented to Mayor and Council of Prince George: 12 October 2008.

NHC 2009. Northwest Hydraulics Consultants: City of Prince George Flood Risk Evaluation and Flood Control Solutions. Prepared for the City of Prince George.

O' Brien, K.L.and Leichenko, R.M. 2000. Double exposure: assessing the impacts of climate change within the context of economic globalization. Global Environmental Change 10: 221-232.

O'Donoghue, T. and Punch, K. 2003. Qualitative Educational Research in Action: Doing and Reflecting. London: Routledge.

OGRA 2006. Ontario Good Roads Association: Winter Maintenance: Ottawa - Adapting to Climate Change. OGRA's Milestones. V6(3): September.

Ontario Ministry of the Environment. 2007. Ontario Clean Water Act. Available from http://www.ene.gov.on.ca/en/water/cleanwater/index.php [accessed 8 June 2008].

Ostry, A., Ogborn, M., Takaro, T., Bassil, K. and Allen, D. 2008. Climate Change and Health in British Columbia. Pacific Institute for Climate Solutions. Available from http://www.pics.uvic.ca/assets/pdf/Health.pdf. [accessed May 10 2009].

Parks, J. 2007. Climate Change Adaptations for Land Use Planners. Birch Hill GeoSolutions.

Patton, M.Q. 2002. Qualitative Evaluation and Research Methods: 3rd ed. Sage Publications, California.

Patz, J.A., Campbell-Lendrum, D., Holloway, T. and Foley, J.A. 2005. Impact of regional climate change on human health. Nature. Vol 438(17): 310-317.

Payne, S. 1951. The Art of Asking Questions. Princeton University, New Jersey.

Picketts, I.M., Werner, A.T. and Murdock,T.Q. 2009. Climate Change in Prince George: summary of past trends and future projections. Pacific Climate Impacts Consortium, University of Victoria, Victoria BC.

Picketts, I. 2008. Adapting to climate change workshop. Planning West. 50(3): 12-13.

Podur, J., Martell, D.L. and Knight, K. 2002. Statistical quality control analysis of forest fire activity in Canada. Canadian Journal of Forest Research. 32: 195-205.

Prince George Community Forest. ND. Prince George Community Forest Website. Available from http://www.communityforest.princegeorge.ca/ [accessed 12 November 2007].

Provincial Emergency Program. 2005. Emergency Management Structure in British Columbia. Available from http://www.llbc.leg.bc.ca/public/PubDocs/bcdocs/376342/Emergency_Management_in_BC.pdf [accessed 30 June 2009].

Public Safety Canada. 2008. Working Towards a National Strategy and Action Plan for Critical Infrastructure (draft). Available from http://www.publicsafety.gc.ca/prg/em/cip/_fl/nat-strat-critical-infrastructure-eng.pdf [accessed 3 June 2009

PCIC. 2009. Pacific Climate Impacts Consortium Homepage. Available from http://www.pacificclimate.org/. [accessed 8 October 2007].

Resort Municipality of Whistler. 2007. Whistler 2020: Moving Toward a Sustainable Future. Available from http://www.whistler2020.ca/whistler/site/genericPage.acds?context=1967831&instanceid=1967832 [accessed 21 June 2009]

Riley, M. 2000. Policy and practice; a process for assessing the impact of climate change on new developments. Journal of Environmental Planning and Management. 43(5): 711-720.

Rivera A., Allen D.A. and Maathuis H. 2004. Climate variability and change-Groundwater, Chapter 10: in Environment Canada, Threats to the Availability of Water in Canada, Report No. 3, National Water Research Institute, Burlington Ontario. pp. 89-95.

Robichaud, A. 2007. Operation White Tide: Evaluating the Capacity of Atlantic Coastal Communities to Adapt to Extreme Events. Prepared by Virtual Planning Inc. Available from http://adaptation.Natural Resources Canada .gc.ca/projdb/pdf/158d_e.pdf [accessed 12 January 2009].

Rodenhuis, D., Bennett, K., Werner, A., Murdock, T. and Bronaugh, D. 2009. Hydro-climatology and future climate impacts in British Columbia. Pacific Climate Impacts Consortium, University of Victoria, Victoria BC.

Ruth, M. 2006. Smart Growth and Climate Change. Edward Elgar Publishing Ltd. Cheltenham, UK.

Sandink. 2009. Handbook for Reducing Basement Flooding. Institute for Catastrophic Loss Reduction, Toronto.

Shatzman, L. and Strauss, A.L. 1973. Field Research: Strategies for a Natural Sociology. Prentice Hall, New Jersey.

Singh, T. and Wheaton, E.E. 1991. Boreal forest sensitivity to global warming: implications for forest management in western interior Canada. Forest Chron. 67: 342-348.

SGOG. 2009. Smart Growth on the Ground: SGOG Overview. Available at http://www.sgog.bc.ca [accessed 2 March 2009].

Smarth Growth BC. 2002. What is Smart Growth? Available from http://www.smartgrowth.bc.ca/AboutUs/tabid/56/Default.aspx [accessed 21 April 2009]

Smith, T.A. and Smith, R.L. 2009. Elements of Ecology, 7th Edition. Pearson.

Smith, L. M. 1978. An evolving logic of participant observation, educational ethnography and other case studies. Review of Research in Education. Chicago: Peacock.

Swain, H. 2007. Climate Change and Water Users in British Columbia. Pacific Climate Impacts Consortium. Available from http://pacificclimate.org/docs/publications/ClimateChangeWaterUsers.pdf [accessed 24 April 2008].

Swart, R. and Raes, F. 2007. Making integration of adaptation and mitigation work: mainstreaming into sustainable development policies. Climate Policy 7(4), 288–303.

Timberline Forest Inventory Consultants. 2006. Community Forest of Prince George: Management Plan. Prepared for the City of Prince George.

Tingle, J. 2003. Impacts of Climate Change on Agriculture in Northern BC, Adapting to Climate Change in Northern British Columbia Workshop, Prince George, BC, pgs. 48-51.

Tingle, J. ND. Protection of Water and Soil in Northern BC's Agricultural Industry. Available from http://www.city.pg.bc.ca/pages/wintercities/forum_1999/pres_tingle.html [accessed 23 September 2008]

Township of Langley. 2007. Water Resources and Environment. Available from http://www.tol.bc.ca/index.php?option=com_content&view=article&id=1107&Itemid=942 [accessed 1 July 2009].

United Nations. 2008. The State of Food Insecurity in the World. FAO of UN, Rome Italy.

UniverCity. 2009. UniverCity on Burnaby Mountain. Available from http://www.univercity.ca/home.42.html [accessed 21 March 2009].

UniverCity. 2008. UniverCity East Neighbourhood Plan Phase 3: Development Guidelines and Requirements. SFU Community Trust.

Varis, Olli, Kajander, Tommi, Lemmela, Risto. 2004. Climate and water: from climate models to water resources management and vice versa. Climate Change. 66: 321-344.

Walker, I.J. and Sydneysmith, R. 2008. British Columbia in From Impacts to Adaptation: Canada in a Changing Climate, edited by D.S. Lemmen F.J. Warren, K. Lacroix and E. Bush; Government of Canada, Ottawa ON. P. 329-386.

Water Research Foundation. 2009. Utility Infrastructure and Climate Change. Available from http://www.theclimatechangeclearinghouse.org/ResearchByTheFoundation/InfrastructureAndClimateChange/default.aspx [accessed 1 July 2009].

Watt, W. E.., Waters, D. and McLean, R. 2003. Climate Change and Urban Stormwater in Canada: Context and Case Studies. Toronto-Niagara region study on atmospheric change report and working paper series. Report 2003-1. Meteorological Service of Canada, Waterloo, On.

Whyte, J. 2006. Extreme Weather Impacts on Provincial Emergency Programme (PEP) and Public Safety: Canadian Water Resources Association Conference, Victoria, BC.

Williamson, T.B., Price, D.T., Beverly, J.L., Bothwell, P.M., Frenkel, B., Park, J. and Patriquin, M.N. 2008. Assessing potential biophysical and socioeconomic impacts of climate change on forest-based communities: a methodological case study. Natural Resources Canada.

Williamson, T.B., Price, D.T., Beverly, J.L., Bothwell, P.M., Parkins, J.R., Patriquin, M.N., Pearce, C.V., Stedman, R.C. and Volney, W.J.A. 2007. A framework for assessing vulnerability of forest-based communities to climate change. Natural Resources Canada.

World Tourism Organization. 2003. Climate Change and Tourism: Proceeding of the 1st international conference on climate change and tourism. Available from http://www.world-tourism.org/sustainable/climate/final-report.pdf [accessed 2 March 2009]

Winter Cities Institute. ND. Winter Cities: Ideas for sustainable and livable northern places. Available from http://www.wintercities.com/index.html [accessed 21 July 2009].

Yin, R.K. 1984. Case Study Research. Thousand Oaks, CA. Sage Publications

Yin, Robert. 1989. Case Study Research – Design and Methods, Revised Edition: Applied Social Research Methods Series. Volume 5. London. Sage Publications.

Yohe, G. and Tol, R. 2002. Indicators for social and economic coping capacity – moving toward a working definition of adaptive capacity. Global Environmental Change. 15: 25-40.

# Appendix A: Results from Climate Change Section of 2008 QOL Survey

**Section 2B – Climate Change**

B1. What does climate change mean to you? (*Circle all numbers that apply*.) ***Note: Many individuals chose more than one answer therefore numbers may add up to more than 100.***

| | | ***Percentage*** | ***Frequency*** |
|---|---|---|---|
| 1. | Global warming | ***47.7%*** | ***324*** |
| 2. | Change in temperature | ***35.3%*** | ***240*** |
| 3. | Change in, or unusual weather patterns | ***75.0%*** | ***509*** |
| 4. | Extreme weather/natural disasters | ***40.3%*** | ***274*** |
| 5. | Other *(Please specify)*: ***Please see Appendix 7.*** | ***9.9%*** | ***67*** |

B2. How concerned are you personally about the issue of climate change? (*Circle one number*.)

***N = 667, M = 2.41***

| | | |
|---|---|---|
| 1. | Extremely concerned | ***15.3%*** |
| 2. | Definitely concerned | ***38.7%*** |
| 3. | Somewhat concerned | ***36.0%*** |
| 4. | Not at all concerned | ***10.0%*** |

B3. What concerns you about climate change? (*Circle all numbers that apply*.) ***Note: Many individuals chose more than one answer therefore numbers may add up to more than 100.***

| | | ***Percentage*** | ***Frequency*** |
|---|---|---|---|
| 1. | Forests | ***57.7%*** | ***392*** |
| 2. | Drought/water shortages | ***60.1%*** | ***408*** |
| 3. | Human health impacts | ***57.1%*** | ***388*** |
| 4. | Legacy for future generations | ***61.6%*** | ***418*** |
| 5. | No concerns | ***7.5%*** | ***51*** |
| 6. | Temperature changes/heat waves | ***34.6%*** | ***235*** |
| 7. | Extreme weather/natural disasters | ***55.9%*** | ***380*** |
| 8. | Other (*Please specify)*: ***Please see Appendix 8.*** | ***6.9%*** | ***47*** |

B4. How well do you feel you understand the issue of climate change? (*Circle one number.*)

***N = 674, M = 2.75***

| | | |
|---|---|---|
| 1. | Poor | ***2.7%*** |
| 2. | Only fair | ***31.0%*** |
| 3. | Good | ***54.7%*** |
| 4. | Excellent | ***11.6%*** |

B5. Do you feel that you and your family are likely to be affected by climate change? (*Circle one number.*) ***N = 660***

| | | |
|---|---|---|
| 1. | Yes (*Please go to C6.*) | ***81.8%*** |
| 2. | No (*Please go to C7.*) | ***18.2%*** |

B6. If yes, in what ways? (*Circle all numbers that apply.*) ***Note: Many individuals chose more than one answer therefore numbers may add up to more than 100.***

| | | ***Percentage*** | ***Frequency*** |
|---|---|---|---|
| 1. | Health impacts | ***42.7%*** | ***290*** |
| 2. | Different seasonal patterns | ***53.4%*** | ***363*** |
| 3. | Higher costs for energy/food | ***68.8%*** | ***467*** |
| 4. | Air pollution | ***48.0%*** | ***326*** |
| 5. | Heat-related discomfort | ***22.9%*** | ***156*** |
| 6. | Other (*Please specify*):***Please see Appendix 9.*** | ***6.5%*** | ***44*** |

B7. Do you believe that Prince George as a whole is likely to be affected by climate change? (*Circle one number.*) ***N = 647***

| | | |
|---|---|---|
| 1. | Yes *(Please go to C8.)* | ***88.3%*** |
| *2.* | No *(Please go to C9.)* | ***11.7%*** |

B8. If yes, in what ways? (*Circle all numbers that apply.*) ***Note: Many individuals chose more than one answer therefore numbers may add up to more than 100.***

| | | ***Percentage*** | ***Frequency*** |
|---|---|---|---|
| 1. | Forestry/forest health | ***71.9%*** | ***489*** |
| 2. | Drought/water shortages | ***37.1%*** | ***252*** |
| 3. | Extreme weather | ***48.8%*** | ***332*** |
| 4. | Rising water levels/flooding | ***60.6%*** | ***412*** |
| 5. | Health problems | ***46.3%*** | ***315*** |
| 6. | Other (*Please specify*):***Please see Appendix 10.*** | ***4.7%*** | ***32*** |

B9. As far as you know, is there something you can personally do about climate change? ***N = 637***

| | | |
|---|---|---|
| 1. | Yes (*Please go to C10.*) | ***81.3%*** |
| *2.* | No *(Please go to Section 3.)* | ***18.7%*** |

B10. If yes, what can you do? (*Circle all numbers that apply*.) ***Note: Many individuals chose more than one answer therefore numbers may add up to more than 100.***

| | | ***Percentage*** | ***Frequency*** |
|---|---|---|---|
| 1. | Car pool/drive less/cycle | ***58.5%*** | ***398*** |
| 2. | Energy efficiency/use less energy | ***71.6%*** | ***487*** |
| 3. | Recycle/reduce waste | ***72.5%*** | ***493*** |
| 4. | Reduce emissions/cleaner fuel | ***48.7%*** | ***331*** |
| 5. | Use public transit | ***33.1%*** | ***225*** |
| 6. | Walk more | ***55.4%*** | ***377*** |
| 7. | Other (*Please specify)*: ***Please see Appendix 11.*** | ***9.7%*** | ***66*** |

B11. Which, if any, of those things have you done in the past year? (*Circle all numbers that apply*.) ***Note: Many individuals chose more than one answer therefore numbers may add up to more than 100.***

| | | ***Percentage*** | ***Frequency*** |
|---|---|---|---|
| 1. | Car pool/drive less/cycle | ***44.5%*** | ***302*** |
| 2. | Energy efficiency/use less energy | ***71.9%*** | ***488*** |
| 3. | Recycle/reduce waste | ***75.4%*** | ***512*** |
| 4. | Reduce emissions/cleaner fuel | ***23.7%*** | ***161*** |
| 5. | Use public transit | ***10.6%*** | ***72*** |
| 6. | Walk more | ***45.9%*** | ***312*** |
| 7. | Other (Please specify): Please see Appendix 12. | ***7.2%*** | ***49*** |

B12. If you have not done any of those things, why not? (*Circle all numbers that apply*.) ***Note: Many individuals chose more than one answer therefore numbers may add up to more than 100.***

| | | ***Percentage*** | ***Frequency*** |
|---|---|---|---|
| 1. | Apathy/laziness | ***5.1%*** | ***35*** |
| 2. | Do not drive much | ***4.9%*** | ***33*** |
| 3. | Don't have time | ***4.3%*** | ***29*** |
| 4. | Don't know | ***1.0%*** | ***7*** |
| 5. | Financial reasons | ***6.2%*** | ***42*** |
| 6. | Inconvenient | ***18.1%*** | ***123*** |
| 7. | No control over decisions | ***3.5%*** | ***24*** |
| 8. | No public transit available | ***13.7%*** | ***93*** |
| 9. | No need | ***3.1%*** | ***21*** |
| 10. | Not close/Too far away | ***10.5%*** | ***71*** |
| 11. | Other (P*lease specify)*: ***Please see Appendix 13*** | ***4.7%*** | ***32*** |

***Appendix 7.***

**B1. What does climate change mean to you? *(Circle all numbers that apply). N = 67 Top five answers given.***

| | *Freq* | *Percent* |
|---|---|---|
| **Natural occurrence** | **31** | **45.6** |
| **Change in wildlife** | **5** | **7.4** |
| **Change in general** | **5** | **7.4** |
| **Threat to water supply** | **5** | **7.4** |
| **Air pollution** | **4** | **5.9** |

***Appendix 8.***

**B3. What concerns you about climate change? *(Circle all numbers that apply). N = 47 Top six answers given.***

| | *Freq* | *Percent* |
|---|---|---|
| **Wildlife threatened** | **10** | **21.3** |
| **Food shortages** | **10** | **21.3** |
| **Nothing** | **7** | **14.9** |
| **Unpredictable weather patterns** | **5** | **10.6** |
| **Loss of biodiversity** | **5** | **10.6** |
| **Reduction in polar ice caps/glaciers melting** | **4** | **8.5** |

***Appendix 9.***

**B6. If yes, in what ways? (*Circle all numbers that apply). N = 44 Top four answers given.***

| | *Freq* | *Percent* |
|---|---|---|
| **Economic impacts** | **15** | **34.1** |
| **Environmental impacts** | **12** | **27.3** |
| **Impact on wildlife** | **9** | **20.5** |
| **Cold related discomfort** | **4** | **9.1** |

***Appendix 10.***

**B8. If yes, in what ways? (*Circle all numbers that apply). N = 32 Top two answers given.***

| | *Freq* | *Percent* |
|---|---|---|
| **Environmental impacts/degradation** | **15** | **46.9** |
| **Cost to me** | **12** | **37.5** |

***Appendix 11.***
**B10. If yes, what can you do? *(Circle all numbers that apply.) N = 66 Top six answers given.***

| | *Freq* | *Percent* |
|---|---|---|
| **Plant a garden-community & personal** | **28** | **42.2** |
| **Write letters, canvas, advocate** | **10** | **15.2** |
| **Buy local/Canadian products** | **9** | **13.6** |
| **Carpool/use public transit** | **7** | **10.6** |
| **Buy local produce** | **4** | **6.1** |
| **Use bicycle** | **4** | **6.1** |

***Appendix 12.***
**B11. Which, if any, of those things have you done in the past year? *(Circle all numbers that apply). N = 49 Top five answers given.***

| | *Freq* | *Percent* |
|---|---|---|
| **Conserved water** | **8** | **16.3** |
| **Used bicycle** | **7** | **14.3** |
| **Buy local/Canadian products** | **7** | **14.3** |
| **Bought smaller car/motorcycle/scooter** | **5** | **10.2** |
| **Planted garden** | **4** | **8.2** |

***Appendix 13.***
**B12. If you have not done any of those things, why not? *(Circle all numbers that apply). N = 32 Top three answers given.***

| | *Freq* | *Percent* |
|---|---|---|
| **Public transit lacking** | **11** | **34.4** |
| **Lack of curbside recycling/composting** | **74** | **21.9** |
| **Health issues/disability** | **4** | **12.4** |

# Appendix B: Additional Information about PIBC Workshop

## Materials Provided to Participants

Members of each group were given two visions of the city from which to work from as they discussed adaptation. These visions were designed to illustrate different scenarios for Prince George; one in which the city proactively planned and adapted to changes, and another business as usual scenario where the city ran into problems and was forced to reactively adapt and suffer the consequences of changes. A poster was also created for each group to help them to organize the findings of their discussions, and to help to keep them on track. The facilitators were instructed to use the posters as a guideline for discussion, but did not have to fill out the posters if the session headed in a different direction. Each poster had background information, strategy types and space for top priorities

## Focus Group Facilitators

A brief overview of the focus group facilitators is as follows:

**A. Technical: Flooding and Storm Water**

Facilitators:

**Stephen Déry,** PhD**:** is a professor at UNBC and the Canada Research Chair in northern hydrometeorology.

**Dave Dyer**, P.Eng: is the Chief engineer of infrastructure with the City of Prince George, and the principle City contact with the ice jam flooding response and flood study.

**B. Technical: Water Quality and Quantity**

Facilitators:

**Stewart Cohen** PhD: is a researcher with Environment Canada Impacts and Adaptations Research Division with extensive experience working in the Okanagan on water management issues.

**Marco Fornari**: is the manager of the utilities division of the City of Prince George, and a local expert on water issues.

**C. Technical: Infrastructure**

Faciliators:

**Eric Rapaport,** PhD, MCIP: is the acting chair of the planning program at UNBC and an expert on transportation and infrastructure planning.

**Glenn Stanker,** P.Eng: is the transportation manager for the City of Prince George.

**D. Implementation**

Facilitators:

**Elizabeth Henry:** is a program coordinator with the Fraser Basin Council specializing in sustainable transportation and climate change adaptation.
**Gerard LeBlanc,** MCIP**:** is a planner with Landworks Consultants with more 15 years of planning experience working with different groups to implement projects.
**Grant Bain,** MCIP**:** is the former head of long term planning with the City of Prince George and the current director of development services.

**E. Communication**

Facilitators:

**Joan Chess** MA, MCIP**:** is a Sustainability Facilitator for the Fraser Basin Council with extensive experience facilitating, communicating and organizing projects with and for planners.
**Brian Frenkel:** is a Councillor with the District of Vanderhoof, and a key contributor to the climate vulnerability assessment for forest based communities project with the community.

## Workshop Participant Signup

The conference attendees were provided with a description of the workshop in an information package, and could elect to sign up for it in their conference registration form. Response was excellent, and 77 attendees of the conference enlisted in the workshop. Through correspondence with the participants, planners were placed into focus groups before the event took place. Due to a lack of interest the forest fires focus group was cancelled. Participants were encouraged to arrive with an open mind and prepare for creative problem solving and learning opportunities. They were instructed to focus on the case study community of Prince George, but also encouraged to discuss how ideas can be applied to other communities in BC and Yukon.

Some of the people who signed up for the workshop did not end up attending due to the busy PIBC conference which had many other presentations scheduled that conflicted with the workshop. A couple of people (including PIBC president Hazel Christy) signed up, but last minute meetings precluded their participation. Attendance was still good, and the workshop involved over 50 participants; including planners from across BC and Yukon, experts, and representatives from the City of Prince George.

## Focus Group Selection

Initially 11 discussion groups were outlined for the workshop that are relevant to climate change adaptation in the region. It soon became apparent that having 11 discussion groups was not reasonable for a single day workshop with one principle organizer. Based on conversations with city workers, academics, and climate change adaptation specialists the list was narrowed to four technical focus groups appropriate to the issues Prince George is likely to face in the near future. These groups were:

A. Flooding and stormwater
B. Water quality and quantity
C. Infrastructure
D. Forest issues

Two non-technical groups were included to cover focal issues outside of the scope of specific impacts. These groups were:

E. Implementation
F. Communication

## Workshop Feedback:

At the end of the PIBC conference the participants were asked to fill out evaluation forms, which included a section on the workshop. Thirteen people filled out the section on the workshop, out of 33 people who filled out the entire evaluation. This is a very small number from a statistical standpoint; but the feedback is valid and warrants discussion. Participants were asked to rank seven questions from a scale of one to five about the workshop; five being high (or definitely), and one being low (or no). The questions that were asked were as follows:

1. Did you find the workshop relevant?
2. Did you find the workshop interesting?
3. Were the workshop objectives generally met?
4. Was there time for questions or comments?
5. Was the length of the workshop appropriate?
6. Was the information gathered summarized in adequate depth?
7. How would you rate the relevance of the topics discussed relative to your occupation?

Response to all of the questions was generally good, and the mean response to all questions was 3.7 out of five. Questions one and seven were both favourably responded to, indicating that the participants found the information being discussed relevant to their work and communities. Questions five and six garnered the poorest responses, indicating that there was a lot of information to discuss in a short time, and that there was not time to discuss topics in enough detail and depth.

At the end of the evaluation the participants were asked to list the events or sessions that most interested them. Three people indicated that the climate change workshop was very interesting to them. The only parts of the conference that received more votes were the Stephen Lewis presentation, a presentation about renewable energy in BC, and a talk about climate change and transportation. This indicates that some people got a great deal out of the workshop.

## Discussion

The feedback from the workshop revealed that the groups were successful in gathering general solutions to different impacts associated with climate change adaptation. These solutions were not directly applicable to an adaptation strategy for Prince George as they

were too broad and general. This is attributable to most participants' lack of familiarity with the City and the region.

Most of the groups left the posters relatively blank, as the facilitators were instructed to allowed ideas to organically grow and evolve within the group. For this reason, many groups did not get a chance to talk about the full breadth of issues. For example, the water group focused almost entirely on water use mitigation and did not have time to hone in on protection of water supplies. A couple of facilitators indicated that it was difficult to keep their groups on track. Often the participants had a hard time focusing solely on climate change adaptation. This is because of the newness of the topic and the desire of some participants to discuss mitigation.

Upon analysis of the results, it was clear that this type of workshop needed to be followed up by more activities if the goal is to envision a workable adaptation strategy. This is because long range planning issues and climate predictions are uncertain and complicated, and extremely case specific. Therefore, they require a process that allows for local input, revalidation and flexibility to help guide an adaptation strategy.

# Appendix C: Additional Information about City Adaptation Workshop

## City Adaptation Workshop participants

**Table C-1 List of City Adaptation Workshop participants.**

| First Name | Last Name | Division | Supervisor / Contact |
|---|---|---|---|
| Dan | Adamson | Environment / Long Range Planning | Dan Milburn |
| Greg | Anderson | Civic Facilities | Tom Madden |
| Frank | Blues | Long Range Planning | Dan Milburn |
| Tara | Bogh | Initiatives Prince George | NA |
| Ray | Borgia | Risk/Benefits | Kathleen Soltis |
| Kristy | Brown | Utilities | Blake McIntosh |
| Robin | Chang | University of Northern BC | NA |
| Joan | Chess | Fraser Basin Council | NA |
| John | Curry | University of Northern BC | NA |
| Marija | Cvenkel | Current Planning & Development | Don Parent |
| Shirley | DuBois | Development Services Admin | Santa du Preez |
| Dave | Dyer | Long Range Planning | Dan Milburn |
| Mark | Fercho | Corporate Management | Derek Bates |
| David | Flanders | University of British Columbia | NA |
| Marco | Fornari | Utilities | Bill Gaal |
| Bill | Gaal | Operations | Bob Radloff |
| Elizabeth | Henry | Fraser Basin Council | NA |
| Pam | Hext | Current Planning | Grant Bain |
| Laurie | Kosec | Long Range Planning | Dan Milburn |
| Cindy | Kroeger | Human Resources | Kathleen Soltis |
| Dave | Leman | Northern Climate Change Network | NA |
| Blake | McIntosh | Utilities | Marco Fornari |
| Steven | Mercedes | Current Planning & Development | Don Parent |
| Jillian | Merrick | Fraser Basin Council | NA |
| Kerry | Pateman | University of Northern BC | NA |
| Daniel | Pearce | Transportation | Al Clark |
| Lauren | Phillips | Long Range Planning | Dan Adamson |
| Ian | Picketts | University of Northern BC | NA |
| Tanja | Puhlmann | Current Planning & Development | Don Parent |
| Ed | Shearer | Streets | Al Clark |
| Shona | Smith | Utilities | Marco Fornari |
| Deanna | Wasnik | Current Planning & Development | Pam Hext |
| Jocelyn | White | Environment / Long Range Planning | Dan Adamson |
| David | Yee | Utilities | Marco Fornari |

## Workshop Organization

Ian Picketts from UNBC organized the workshop with research assistant Robin Chang, along with Dave Dyer from the City of Prince George and Elizabeth Henry and Joan Chess from the Fraser Basin Council. The workshop utilized the climate information that was generated by PCIC. Once again, Arelia Werner was on hand to make an introductory presentation to the group, and to answer stakeholder questions throughout the day. As part of this event, meetings occurred between UNBC researchers, PCIC representatives and senior City staff that were unable to attend the workshop.

## Additional information about workshop introduction

To put the workshop into context for the audience, a brief overview was given of the partnership that has been forged between UNBC and City to address this issue in Prince George. It was made clear that Prince George must participate in both mitigation and adaptation activities, but that the group would be concentrating on adaptation for the day's activities (although trying to maximize any co-benefits). This is because the City (and most of the entire climate change world) is significantly behind on adaptation planning relative to mitigation planning.

The events that had occurred prior to the workshop were briefly recapped (such as the PIBC workshop and the climate change modeling work with PCIC). To finish off the introduction the point was reiterated that the participants were the *key stakeholders* that are needed to prioritize a future strategy. The session concluded with a brief go-around where everyone said their name and their role with the City, or with the institution that they were affiliated. This was helpful so that the participants could gain an understanding of the range of interests and experiences that had come together for the workshop.

## Additional information about understanding the past and projected changes in Prince George's climate

Arelia Werner's presentation was followed by a 20 minute question and answer period related to her talk. The discussion helped many people to gain a better grasp of the trends and projections. It also was very helpful to PCIC, as there was excellent feedback on what information was well communicated, and what could be made clearer

## Additional information about identifying the impacts of climate change in Prince George

The facilitators of these groups were Elizabeth Henry and Joan Chess from the Fraser Basin Council, and Robin Chang and Ian Picketts from UNBC.

In each group, the facilitator started the discussion by asking for different impacts that the City would face. All of the groups came up with a great number of different impacts related to many topics such as land use planning, maintenance, operations and social issues. Once individual groups had a long general list of impacts, they were asked to prioritize the top three issues that they thought would affect Prince George the most, as well as up to two other noteworthy issues that would have an impact. Prompt questions such as "What are the worst impacts possible?" and "What is most likely to happen?"

were prepared by the facilitators to aid in the prioritization process. These questions helped the group to identify and prioritize both positive and negative climate change impacts that would have the greatest affect on Prince George. These questions also helped the groups to quantify the magnitude of the impacts by linking them to the climate change information and projections. The facilitators had met several times beforehand so that they all were looking at getting the same type of information from the groups and the same degree of specificity of impacts.

The prioritization exercise was followed by a lunch break that provided an opportunity for attendees to rest, and to discuss the outcomes of the impacts visioning session. During this break the facilitators met to amalgamate the prioritized impacts from the breakout groups into a single master list. This was accomplished by cross referencing the lists, and including any key impact that was noted in two or more groups into the final list.

## Additional information about visioning an adaptation strategy for Prince George

To ameliorate the complexity of the matrix exercise, attendees were instructed to fill them out with two other workshop participants that they did not work with on a regular basis. This also allowed for further discussion on strategy development in these small groups. Prompt questions were prepared by the facilitators and 'roaming experts' wandered between the groups asking questions and clarifying the instructions. See Figures C-1 and C-2 for images of the front and reverse sides of the matrix.

The front side of the matrix had three main sections. The first part of the matrix consisted of two columns in which the participants were asked to rank each impact in terms of its risk. The first column instructed participants to rank the likelihood and timing of the impact on a scale of one to five. A one meant that the likelihood was 'very unlikely' (meaning that the impact would not affect Prince George), and a five meant that the impact was already occurring. The numbers two to four correlated with increasing likelihood in shorter time frames. In the second risk column participants ranked the consequence of inaction on a scale of one to five. A one meant that there would be little to no costs associated with inaction on the impact and a five meant that there would be major consequences in costs and human safety. The numbers two to four correlated with increasing costs and risks to health and life. This data is used to determine the highest priorities that need to be addressed in an adaptation strategy. These risk sections were adapted from the City of Chicago Adaptation guide (2008).

The second section of the matrix referred to the sectors of the city that would be most seriously affected by the impact. These sectors were identified by the City before the workshop. Participants were instructed to select up to five sectors that they thought that would be most affected by the impact. There was also space for the participants to select outside agencies if they felt that addressing the issue was beyond the responsibility or capacity of the City. This information is crucial for the adaptation strategy so that the City can begin to plan where the adaptation work for climate change will have to occur. Representatives from the sectors most mentioned should be a part of the committee or

group that addresses each impact. The list of sectors that the participants had to choose from and their groupings is included in Table C-2.

The third section of the matrix was dedicated to implementation. In this section participants were asked to indicate their single top priority of where they believed that the issue should be addressed. This is important so that the priorities indicated can be incorporated into the appropriate documents. The plans and other documents that the workshop participants selected from are as follows:

- Integrated Community Sustainability Plan;
- Official Community Plan;
- Annual Provisional Financial Plan;
- Standards Bylaw;
- Asset Management Performance Measures; and
- Other (please specify).

The final section of the matrix was located on the reverse side of the page (see Figure C-2). In this section participants were given the instructions:

> *Please provide any comments on how you think Prince George needs to address this impact. Please feel free to present specific ideas for adaptation, ways to make Prince George more resilient to the impact, specific groups or individuals that should help create an adaptation strategy for this impact, further information that you need to help to inform a strategy, or any other pertinent information that you think will be valuable in regards to the topic. (Please continue comments on another sheet if you run out of room. There will be an opportunity to provide further feedback in the near future.)*

**Prince George Climate Change Workshop Matrix**

| Affect on Prince George: | RISK | | Sectors most seriously affected (please check off only 5 sectors) | | | | | | | | | | | | | | | | | | | | | | | | | | IMPLEMENTATION | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Administrative Services | | | Corporate Services | | | | | Development services | | | | Operations | | | | Community Services | | | Outside Agencies, Organizations, Groups | | | | | Where should this issue be addressed? - please indicate top priority | | | | | |
| Impact: | RISK: likelihood and timing (scale of 1 - 5) See chart 1 | RISK: consequence of inaction (scale of 1-5) See chart 2 | Real Estate and Bylaw Services | Police, Fire and Rescue Services | Municipal emergency & Response | Financial Services | Human Resources | Risk and Benefits | Fleet and Supply Services | IT Services and GIS | Current Planning | Long Range Planning | Building Inspection | Environmental Services | Parks and Trails | Solid Waste Services | Utilities | Transportation | Civic Facilities | Community Services | Social Policy | Federal | Provincial | First Nations | Other Local Government | Other Organizations (please specify) | ICSP | OCP | Annual Provisional Financial Plan | Standards Bylaw | Asset Mngmnt - Performance Measures | Other (please specify) |
| 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

CITY OF PRINCE GEORGE

Name:_____

| Chart 1: Risk Scale - likelihood and timing | | |
|---|---|---|
| score | likelihood | |
| 5 | occuring now: | already happening |
| 4 | very likely: | likely to happen in next 10 yrs |
| 3 | likely: | may happen in next 20 yrs |
| 2 | unlikely: | may or may not happen |
| 1 | very unlikely: | will not effect us |

| Chart 2: Risk scale: consequence | | |
|---|---|---|
| score | consequence | costs |
| 5 | catastrophic: | major consequences to human life |
| 4 | major: | risk to health and life, very expensive (>$10million) |
| 3 | medium: | risk to health, expensive ($2-10 million) |
| 2 | low: | low risk to health, mid expense ($1-2 million) |
| 1 | minimal: | minimal costs |

**Figure C-0-1 Prince George City Adaptation Workshop matrix – front side.**

Please provide any comments on how you think Prince George needs to address this impact. Please feel free to present specific ideas for adaptation, ways to make Prince George more resilient to the impact, specific groups or individuals that should help create an adaptation strategy for this impact, further information that you need to help to inform a strategy, or any other pertinent information that you think will be valuable in regards to the topic. (Please continue comments on another sheet if you run out of room. There will be an opportunity to provide further feedback in the near future.)

| | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |

**Figure C-0-2 Prince George City Adaptation workshop matrix - reverse side.**

**Table C-2 List of City sectors included in the matrix.**

| | |
|---|---|
| **Administrative Services** | Real Estate and Bylaw Services |
| | Police, Fire and Rescue Services |
| | Municipal emergency & Response |
| **Corporate Services** | Financial Services |
| | Human Resources |
| | Risk and Benefits |
| | Fleet and Supply Services |
| | IT Services and GIS |
| **Development services** | Current Planning |
| | Long Range Planning |
| | Building Inspection |
| | Environmental Services |
| **Operations** | Parks and Trails |
| | Solid Waste Services |
| | Utilities |
| | Transportation |
| **Community Services** | Civic Facilities |
| | Community Services |
| | Social Policy |
| **Outside Agencies, Organizations, Groups** | Federal |
| | Provincial |
| | First Nations |
| | Other Local Government |
| | Other Organizations (participants were asked to specify) |

## Workshop conclusion

In the last 15 minutes of the workshop, the group came together for a final discussion. This was aimed at addressing any final questions or comments about the workshop, and discussing ideas of the future vision for the City of Prince George - and how it must plan to adapt to climate change so that it could attain that vision. The question was posed, "Where does Prince George need to be in 15 years so that it can plan for the changes in the climate that will occur over the next 50 years."

Many insightful observations and ideas were presented from the workshop participants. One major point that was articulated by several people is that climate change information has to be presented in a simple and digestible manner so that the public can understand it.

Another recurring theme in the discussion was that the public must be consulted in this process if an adaptation strategy is to be a success. One stakeholder presented the argument that the City needs to look at a planning horizon of about 10 years, so that people will feel that the plans will come to fruition in a timeline that they can see. Participant feedback was overwhelmingly positive and constructive, and people were excited about the work on the adaptation strategy.

## Results from small group exercise: Identifying the impacts of climate change in Prince George.

The results of the four discussion groups that focused on identifying and prioritizing the three major impacts of climate change, as well as up to two other noteworthy impacts, are illustrated in Table C-3. This list of impacts was the outcome of the 'Identifying the Impacts of Climate Change in PG' segment of the workshop.

**Table C-3 Impacts identified by focus groups in City Adaptation Workshop.**

| | | | |
|---|---|---|---|
| GROUP 1 | Top Impacts: | 1 | Water quality and quantity management |
| | | 2 | Infrastructure - freeze thaw and snow |
| | | 3 | Flooding – threats to public and private property |
| | Other Noteworthy Impacts: | 1 | Extreme weather events |
| | | 2 | Fire risk in the city |
| GROUP 2 | Top Impacts: | 1 | Increase in freeze thaw events-transportation: safety, infrastructure, economy |
| | | 2 | Forest fire increase: increase in temperature and droughts |
| | | 3 | Infrastructure changes due to increase in precipitation/temperature, changes in frost levels |
| | Other Noteworthy Impacts: | 1 | Earlier and more precipitation/flooding: could affect water supply |
| | | 2 | none identified |
| GROUP 3 | Top Impacts: | 1 | Flooding and implications |
| | | 2 | Land-use: must change as a response |
| | | 3 | Impacts to transportation and infrastructure |
| | Other Noteworthy Impacts: | 1 | Economics: Funding, Taxpayers, Cost-effectiveness |
| | | 2 | Policy: Public education/marketing, Partnerships, communication |
| GROUP 4 | Top Impacts: | 1 | Impacts to in natural resources (forest fires, hydrology, etc.) |
| | | 2 | Impacts to infrastructure caused by increased winter temperatures |
| | | 3 | Increase in flooding-frequency and magnitude |
| | Other Noteworthy Impacts: | 1 | Water supply and water quality |
| | | 2 | Warmer weather-agriculture growing season & attracting new residences and businesses |

## Master list of impacts:

The facilitators met over the lunch break to amalgamate the prioritized impacts from the breakout groups (Table C-3) into a single master list. This was accomplished by cross referencing the lists, and creating a new list of impacts that included the impacts that each of the groups put forward. To create a representative list of impacts that reflected the four groups, some of the wording of the impacts was changed, and a couple of impacts were added that were mentioned by several groups, although not listed by them. The master list was presented back to the entire group and put up for discussion; a comprehensive and representative list was necessary for the final part of the workshop to be effective. Participants were asked if they were satisfied with the list that was presented to them. There was a brief discussion about the list and some wording was changed. A couple of items were added that participants felt strongly about, if there was general support among the rest of the workshop participants. This discussion ended up taking several minutes longer than anticipated, but at the conclusion of the talk all of the participants indicated that they were satisfied with the list.

The priorities that were identified on the master list and the group(s) that identified them are as follows:

1. Increased forest fires (noted by groups 1 and 2)
2. Increased flooding (noted by groups 1, 2, 3 and 4)
3. Extreme weather events – emergency response (noted by group 1, indirectly referenced by group 4)
4. Increased freeze / thaw impacting transportation (noted by groups 1 and 2)
5. Threats to water quality & quantity (identified by groups 1 and 4)
6. Stresses on transportation infrastructure (other than freeze-thaw) (noted by groups 2, 3 and 4)
7. Extreme weather events limiting transportation capabilities (added in the group discussion because participants felt that the ‘extreme weather event’ priority did not focus on this problem)
8. Stresses on storm-water infrastructure (indirectly mentioned by all 4 groups, added by facilitators after group discussion)
9. Stresses on utilities infrastructure (indirectly mentioned by all 4 groups, added by facilitators)
10. Warmer temperatures leading to increased agricultural capacity (identified by group 4, noted in other groups and added by facilitators)
11. Warmer temperatures leading to more residents and business opportunities (identified by group 4, noted in other groups and added by facilitators following group discussion)
12. Erosion & landslides (added by facilitators after group discussion)

The following key impacts were listed by individual focus groups but not included or incorporated into the Master List:

- Land use - must change as a response.

*This was not included as it was considered to be more of a response to the impacts of climate change than a direct impact itself.*

- Economics - Funding, Taxpayers, Cost-effectiveness.

*This was not included as it was considered not to be a direct impact of climate change, but a result of other impacts.*

- Policy - Public education/marketing, Partnerships, communication.

*This was not included as it was considered to be more of a response to the impacts of climate change than a direct impact itself.*

- Impacts to natural resources (forest fires, hydrology, etc.).

*This was not included because it was covered by a number of the other impacts in the list (such as forest fires, water quality and quantity and flooding).*

# Appendix D: Comments Regarding Impacts from City Adaptation Workshop

**Instructions on matrix:** *Please provide any comments on how you think Prince George needs to address this impact. Please feel free to present specific ideas for adaptation, ways to make Prince George more resilient to the impact, specific groups or individuals that should help create an adaptation strategy for this impact, further information that you need to help to inform a strategy, or any other pertinent information that you think will be valuable in regards to the topic. (Please continue comments on another sheet if you run out of room. There will be an opportunity to provide further feedback in the near future.)*

**Responses** (in random order):

**Increased forest fires:**

A. mitigation: reducing fir hazard through fuel treatments. New developments should have to employ "Fire Safe" standards. Pre-planning and coordination between all relevant agencies.
B. Fire fuel control = $$. Promote it in Regional District and in outlying area.
C. Identify high risk areas (based on stand type/ age, fuel type, fire history, etc.). Fire smart homes, forest management (thinning, brush clearing) near residential areas.
D. Continue the community forest agreement & work closely with the crown & First Nations.
E. Limit distance to structures & forests-residential exterior sprinklers, non flammable building exterior finishes.
F. Huge priority-city also needs to provide help for FN communities.
G. Already in progress.
H. City is doing fire control now.
I. Urban forester to continue to reduce fuel load-planning. Plan for emergency response if a fire were to occur.
J. Enviro Sys continues to work on Community Forest Plan with Fire & Rescue involvement.
K. Stay the course on forest management.
L. City has addressed somewhat with identifying forest fire hazards & identifying dp areas.
M. Continue work on community forest fire reduction.
N. Continue implementation of fire interface plan.
O. Emergency plan prepared for most likely wildfire scenario.

**Increased flooding:**

A. Need further info regarding what river levels could be.
B. Build flood protection -plan for no more building in the flood plain.
C. Buy out at risk structures, monitor freezing river locations, open Fraser if it freezes first.
D. Develop plans to deal with emergency.

E. Land use/ development controls are needed to reduce risky uses in floodway.
F. Increase training, construct dyke along Nechako & subdrain with pump chambers.
G. Develop a response plan for each event.
H. Purchase the riverfront properties subject to flooding & limit infrastructure.
I. Internally utilize the ICSP to bring in any and all potential stakeholders and carry out their own risk assessment that addresses impact on property/assets, ability to provide secure cost of services, employer & public safety, job security, economic viability, etc. Implementation of corporate mission and goals and strategic plans.
J. Continue with mitigation plan-buy properties. PG is built on a floodplain…maybe move some businesses, create, side channels if possible with no environmental impact.
K. Review land use plan & flood plain levels.
L. Follow recommendation in flood mitigation strategy. Communicate to residents and work with affected industry/governments.
M. May require more info on possible flood level(s).
N. developing engineering to effectively divert flood waters from businesses & residents.

**Extreme weather events – emergency response**

A. Developing response plans for various weather event types, increase training.
B. Implement measures recommended in Flood Mitigation Plan.
C. Developing response plans for various weather events; increase training capacity.
D. Response plan.
E. Continue the emergency preparedness plan that is underway.
F. Get fire departments (pd & volunteer) to work together and with agencies like Search & Rescue, Ham Radio operators, PEP, etc.
G. Implement EOC.
H. Exercise emergency plan not in operation last year.
I. Emergency planning scenario for response measures.

**Increased freeze/ thaw impacting transportation**

A. Specialty approaches (new techniques) developed for dealing with pot holes.
B. Encourage residents to take more responsibilities, encourage bigger tire diameters & studs, and less snow clearing, Quebec snow tires.
C. Review use of chlorides (preset +salt) in management plan to frost practice.
D. Move away from original paving methods towards material that has higher rubber percentage.
E. Investigate structural option to reduce impact.
F. Research other road building/construction and watch for new technology. In meantime, consider other funding opportunities.
G. Look at different paving methods. $$. Long term planning.

**Threats to water quality& quantity**

A. Example: Water Shortages for residential properties on wells. Collect anecdotal data from well drillers/servicers, etc. and use this data to develop priority response plans.
B. Water conservation initiatives to reduce stresses on future supply. Ie. Demands from

non connected systems.
C. Regulations & education on land use practices. Eg. Pesticides etc
D. Water conservation, toilet replacement program, water monitoring, greywater recycling.
E. Water storage measures (sinter storage in residential areas), water metering.
F. Sentinal wells, upgrades to aging infrastructure, critical water main assessment.
G. Making compulsory "water meters" on all houses. Not just new buildings.
H. Sentinal wells, upgrades to aging infrastructure, critical water main assessment.

**Stresses on transportation infrastructure**
A. Decrease salt use, and increase gravel and sand use.
B. Development of resources-better planning.
C. ?Strategic Planning?
D. Already happening.
E. Review & use best practices.
F. Increased resources for transportation maintenance.

**Extreme Weather limiting transportation capabilities**
A. Look towards improving transportation networks and looking at new/alternate routes into the city.
B. Emergency planning scenario for response measures.
C. Long range planning-emergency preparedness.
D. Emergency plan for shut-down scenario.
E. Develop response plans for various weather events & increased training capacity.
F. Having a transport link cut would be a major issue-there needs to be a contingency plan.

**Stresses on stormwater infrastructure**
A. Upgrades to aging infrastructure, increase capacity.
B. Current/ Long range planning - determining areas that will need to upgraded immediately and in the long term.
C. Focus more effort on storm runoff reduction from properties through bylaw development practices.
D. Cheaper, greener infrastructure. Soft- managed floodplains, wetlands.
E. Upgrades to aging infrastructure, increase capacity of system.
F. Increased alternative stormwater management via bioswales, rooftop gardens, landscaping, road design, etc.
G. Upgrades to system.
H. Managing stormwater on site rather than pipes-stormwater recycling.
I. Review & use best practices, Consider implementing green subdivision bylaw.

**Stresses on Utilities infrastructure**
A. Increased wind? Prepare for damage to existing infrastructure. Opportunity for more wind power? Bylaws to support this?
B. Increase capacity.
C. Upgrades to aging infrastructure, increase capacity.

D. ? *(The respondent just indicated a question mark.)*
E. Green/ Soft infrastructure (instead of concrete/asphalt/ pipes) where possible. Eg. permeable systems, "country lanes," street trees, etc.
F. Upgrades to aging infrastructure, increase capacity of system.
G. Go underground (beautification) where feasible from an economic point of view.

**Warmer temperatures leading to increased agricultural capacity**
A. Not heavy intensive agriculture-turning marginal timber land to agriculture.
B. Biomass production; it wouldn't be displacing much food production in this regions-priority is for this kind of energy.
C. Work with provincial govt. & UNBC to develop new agriculture (also use heat from mills for greenhouse).
D. Review OCP & land use plan.

**Warmer temperatures leading to more residents and tourism**
A. With the OCP & Land use Plans consider a beautified, greener community with increased active transportation infrastructure.
B. Smart Planning.
C. Attracting population: many items housed under this that need to be addresses. Public health & economic development need to be central themes in making PG a more attractive & liveable city.
D. One stop show-reduce red tape for businesses locally & provincially.
E. With the OCP & Land use Plans consider a beautifies, greener community with increased active transportation infrastructure.
F. Focus on density/ infill. This also addresses many of the other issues related to risks to infrastrure because less infrast. = less to be damages by extreme events and less to maintain.

**Slope stability**
A. Best practices for land development guidelines.
B. Keep vegetated slops vegetated! Manage water flow so doesn't dump over top of slopes. Involve Geotech engineer in land-use & long term planning, Encourage carbon sequestration projects
C. Land use studies determining feasible areas to build considering topography & smart growth.
D. Building away from streams!

**Other impacts**
A. How to prepare: trust fund.
B. Stranded investment: Ultimately a tough decision to abandon and are w.r.t. costly improvements and focus $$ to areas that will incur a high cost/benefit. Approach federal government with writing-off assets or obtaining "liquidated damages."
C. City should be prepared for emergency response for many of these topics-be prepared to reduce climate change impacts, city should reduce $CO^2$ or offset & become carbon neutral (mitigation).
D. Increase and encourage walkability & connectiviey in community year round

(implement design principles from smart growth, for example). Involves public input to define what could be incorporated in place of ice oval ski hills, etc. (ie. Discounted prices for use of civic facilities such as Colesium). Create spaces that allow for year round use of recreational activities.

# Appendix E: Additional Information About the SGOG Events

## Information about SGOG

The information in this section is summarized from the Smart Growth on the Ground Website, which is available at http://www.sgog.bc.ca/ (Smart Growth on the Ground 2009).

Smart Growth on the Ground (SGOG) is an integrated program administered by Smart Growth BC that has worked with various communities across the Province (Maple Ridge, Squamish, Greater Oliver and most recently Prince George). As a partnership between the Design Centre for Sustainability at UBC, the Real Estate Institute of BC, and Smart Growth BC, the program guides communities to develop more sustainable neighbourhood plans that incorporate the eight Smart Growth Principles. These principles are:

1. Each community is complete
2. Options to the car are emphasized
3. Work in harmony with natural systems
4. Buildings and infrastructure are greener, smarter, and cheaper,
5. Housing meets the needs of the whole community
6. Jobs are close to home
7. The spirit of each community is honoured
8. Everyone has a voice

As part of an inclusive process, SGOG facilitates practical research towards a design charrette to create a concept design that communities can follow through with to implement results. The recent SGOG process with Prince George aligns with city efforts to create a sustainable vision for a downtown that incorporates many facets of sustainability. Ian Picketts took advantage of the timing and the nature of the SGOG process to work with the team to incorporate climate change adaptation as a component of the project.

## Steps in the SGOG process

The SGOG design process required a number of steps. The following list outlines of events SGOG has organized in partnership with the City of Prince George to facilitate the development, visioning and implementation for a sustainable downtown plan:

- On July 8, 2008, SGOG held an opening forum event in Prince George. This forum included presentations by the SGOG team regarding Smart Growth Principles and the SGOG process. As part of this event vision statements were created and important locations for the Prince George downtown area were identified.
- On November 26 and 27 2008, two events were organized by SGOG. The first night was a learning event that focused on climate change and housing. This event

included presentations about climate change from Dr. Stephen Sheppard and Dave Flanders from the University of BC (UBC), and about climate change adaptation by Ian Picketts. The presenters and sat on a panel in a discussion on climate change. The second night was a Priority-Setting Workshop that consisted of and in depth exercise where issue statements from the Opening Forum were categorized under the eight SGOG Principles. As part of the event evaluation for each night there were questions about climate change adaptation.

- On March 4 and 5, 2008, two workshops were held to present research related to the SGOG process and to answer questions to help establish future design targets for Prince George. The first night consisted of presentations on air quality, commercial energy use, renewable potential energy, residential energy use, storm water management, and street trees. The second night covered the topics of alternative transportation, heritage housing, local food and climate change adaptation (presented by Ian Picketts).
- The final SGOG event was the charrette, which ran from May 12-15, 2009. During these four days the charette team (including community members, local and academic experts, designers and facilitators) gathered to create a downtown design that reflected the SGOG principles, the priorities and targets that were established in previous events, and the related research that the city has been taking part in. The group was able to come up with a concept plan over the four days. The plan included climate change adaptation in it, and was received favourably by the public.

While the charrette event was a success, there is still a lot more work to complete to see the plan come to fruition. The last day of the charrette concluded with the formation of a new group whose task is to consider how to address social and cultural issues in the project and beyond. No final date of the project is currently available, however, updated information regarding the status of the SGOG project is Prince George can be found at http://www.sgog.bc.ca/content.asp?contentID=138 or by contacting Shana Johnstone at shana@smartgrowth.bc.ca or Amanda Mitchell at amanda@smartgrowth.bc.ca.

## Background information provided to respondents

People who filled it in evaluation on the second learning event did not hear Ian Picketts' climate change adaptation talk. This means that they would not have been as clear on the concept of climate change adaptation, nor did they have the opportunity to receive a brief overview of the climate change modeling data that offered some insight into future climates in the area. However, these respondents were also were less likely to be swayed by any of the examples that were offered during the talk, or any biases that Ian introduced during it. For comparison, Table E-1 shows which percentage of people who picked each impact on each evening:

**Table E-1 Percentage of Smart Growth on the Ground participants that selected the different impacts on November 26 and November 27.**

| | Forests | Severe weather events | Slope stability | Road conditions | Stormwater capacity | Agricultural changes | Water quality problems | Need for more emergency services | Forest fire risks | Health issues | Affects to buildings | Water shortages | Increased river flooding |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % of people who selected impact on Nov 26 | 67 | 35 | 35 | 52 | 35 | 22 | 24 | 15 | 39 | 35 | 13 | 13 | 59 |
| % of people who selected impact on Nov 27 | 64 | 32 | 21 | 57 | 18 | 11 | 18 | 18 | 43 | 36 | 11 | 14 | 68 |

A cursory analysis of the results of the respondents on each night shows that there was not a significant change in the percentage of people who selected most impacts between the first night and the second night. The only impacts that had a discrepancy of over 10% between the percentage of people who filled them in on the two nights were stormwater capacity (17% discrepancy), slope stability (14% discrepancy), and agricultural changes (11% discrepancy). Ian did not speak in any detail about any of these impacts, nor did he use these as examples in his presentation. This shows that the presentation did not have a large impact on peoples' responses. As mentioned above, only two people left the adaptation questions entirely blank on the first night, whereas 13 people left the questions blank on the second night. This is likely because there were people on the second night that had attended the first night, and were instructed to leave it blank.

# Appendix F: Comment Change Concerns Comments from SGOG Evaluations

**Question**: *Please explain what worries you most about projected changes in the climate (i.e. warmer temperatures, more precipitation). What you think the city should do to adapt to future changes?*
**Responses:**

**Table F-1 Responses to SGOG evaluation question 10.**

| Comment | Date of Comment | Categorization of comment |
|---|---|---|
| Stop using green space to build on so we CAN start to farm locally in town. Let's do what we can to keep our summers hot and winters cold. | 11/26/2008 | Agriculture |
| Ensure that any projects and programs are well researched and understood by council and do not jeopardize our sensitive airshed. | 11/27/2008 | air quality |
| Changes in habitat and biodiversity. I believe the city should incorporate planning around green spaces and wildlife protection. | 11/26/2008 | biodiversity |
| Loss of biodiversity; more mitigation; tree planting; support local agriculture. | 11/26/2008 | biodiversity & agriculture |
| Increased climate refugees - that our city is prepared to welcome and assist the. Public education, preparedness re: housing/services. | 11/26/2008 | Climate refugees |
| Climate refugees causing global instability - City can't do much except plan in case of expansion. Food shortages - maybe more local food? | 11/26/2008 | Climate refugees |
| Utilize UNBC for research into problems and resolutions. | 11/27/2008 | collaborate with UNBC |
| Transportation costs and food shortages combining to make food and shelter costs very expensive in the North. | 11/26/2008 | costs |
| Political will - focus on downtown. | 11/26/2008 | downtown/ planning |
| Promote and revitalize downtown PG into a sustainable hub. | 11/26/2008 | downtown/ planning |
| The city needs to keep abreast of the problems. It seems that the only movement happens after the fact. | 11/26/2008 | downtown/ planning |
| Need to change the mind-set of planners, developers and builders. Incentives to those who do build with climate challenges in mind. | 11/27/2008 | downtown/ planning |
| Change in participation. | 11/27/2008 | downtown/ planning |
| Policy changes re: sprawl development. | 11/26/2008 | downtown/ planning |
| Extreme weather! We need to be prepared. | 11/27/2008 | extreme weather |
| More frequent extreme weather events. Start developing infrastructure that is more resistant to effects (ex. Underground telephone optical). | 11/27/2008 | extreme weather |

| | | |
|---|---|---|
| Floods! | 11/26/2008 | floods |
| River levels being managed, taking preventative steps against flooding and ice jams would be key. | 11/27/2008 | floods |
| Flooding. Need to be proactive and have timely implementation of solutions. | 11/27/2008 | floods |
| Increased flooding. How will this impact downtown? I have concerns about the city not making appropriate adjustments in a timely manner due to bureaucracy, lack of funding to facilitate necessary changes. | 11/27/2008 | floods |
| Temperature. Lack of cold weather to kill off bugs (pine beetle, spruce beetle) and viruses (more people getting flu and colds). | 11/26/2008 | forests |
| State of our forests (fires, bugs). | 11/26/2008 | forests |
| I'm worried that we're leaving a sad future for people's kids (I've chosen not to have any of my own as a result). Adapt: invest in reducing forest fire hazard in wild land/urban interface zones. Use models to run different scenarios (emergencies, etc) then run mock scenarios with city, province, fire, health, etc. to identify biggest weaknesses. | 11/26/2008 | forests, emergency response |
| Future for children. | 11/26/2008 | general future |
| Prepare for anything. | 11/27/2008 | general preparedness |
| We need a broader vision of a liveable city with more force on liveablity in its various aspects treated holistically; water preservation and less wasted resources; protection of potential arable lands; more focus on alternative energy sources (local food production). | 11/26/2008 | general preparedness |
| The increased temperatures effecting the way we use heating and cooling. | 11/26/2008 | heating and cooling |
| What worries me most is that people are not clueing in fast enough to try to change their habits, perspectives, expectations. The city needs to lead in a much more progressive way to took at alternatives to the status quo = motorized travel, non-residential downtown, suburban sprawl. | 11/26/2008 | mitigation |
| What worries me? Regulations prevent good stuff from happening ex. Food marketing rules, food sales - so many disposable products. The city should ban drive through (cars idling), do more to promote walking ex. No sidewalk when walking along HWY 97 from Spruceland over to Parkhill Centre. Promote the building of smaller homes with schools and grocery, hardware etc. within walking distance. New housing development closer to the workplaces. | 11/26/2008 | mitigation |
| More mass transit. Local. | 11/26/2008 | mitigation |
| Use more solar and wind energy. | 11/26/2008 | mitigation |
| Develop co-gen (combined heat and power) from existing sources, for example methane from landfill. NO to biofired electricity generation: increases $CO_2$ neutral in the long term (120 years) and has HUGE impacts in the short (<40 years) term. | 11/27/2008 | mitigation |
| Follow Kyoto accord guidelines. | 11/27/2008 | mitigation |
| Consider renewable energy and energy efficiently as a suite of measures that can both help adapt and mitigate. | 11/26/2008 | mitigation cobenefits |
| That I will not be around to see grapes growing here. | 11/26/2008 | no category |

| | | |
|---|---|---|
| Climate change in the north is different than in Vancouver. | 11/27/2008 | no category |
| Too late to tackle this one. | 11/26/2008 | no category |
| Incredible amount of $$$ devoted to tackling climate change that could be put to better use (such as disease, poverty, etc). | 11/26/2008 | not worried |
| Nothing. Another Y2K scare that turned out to be nothing. | 11/27/2008 | not worried |
| I'm really not that worried, in PG warmer is better. | 11/26/2008 | not worried |
| Blue box. | 11/26/2008 | recycling |
| Use more sustainable resources - work more on cleaning up the city and re-establishing our community with relation to nature. | 11/26/2008 | social issues |
| I believe we need to achieve social sustainability prior to genuine collective action. We should focus on fostering community through green spaces, affordable housing, mixed use and green/public spaces. I am concerned about increased water levels, and loss of rural economics due to MPB. | 11/26/2008 | social issues |
| Use the floodplain as an asset. Work with the natural water systems - not against them!!! | 11/27/2008 | stormwater |
| More hcl3A in asphalt is needed for 0 degree barrier. | 11/26/2008 | transport |
| More ice - dangerous road conditions, more potholes. | 11/26/2008 | transport |
| Load surfacing improvements. | 11/27/2008 | transport |
| More problems with SAD etc and possible higher amounts of snowfall making walking/transportation without a car harder. | 11/27/2008 | transport |
| "Worries" implies we have no power over these climate changes. Encourage planting more trees everywhere, shrubs, vegetation as well, increase natural habitats. | 11/27/2008 | trees |
| Can't say that I have one big worry about climate change. Water shortages and agricultural changes are foremost though. | 11/27/2008 | water and agriculture |

# Appendix G: Verification of Risk Framework For City Adaptation Workshop

To verify the risk framework, it was compared to a chapter assessing key vulnerabilities and the risk from Climate Change by the IPCC (2007e).This paper discusses criteria for selecting key, or most important, vulnerabilities to climate change. There are seven criteria identified in the report from an extensive literature review that may be used to identify key vulnerabilities. These are:

i. magnitude of impacts,
ii. timing of impacts,
iii. persistence and reversibility of impacts,
iv. likelihood (estimates of uncertainty) of impacts and vulnerabilities, and confidence in those estimates,
v. potential for adaptation,
vi. distributional aspects of impacts and vulnerabilities,
vii. importance of the system(s) at risk.

A synapsis of the comparison is as follows:

**Likelihood and timing** in the City adaptation workshop refers closely to timing, and likelihood (as part of likelihood and confidence) in the IPCC framework. However it does not pertain to confidence as the workshop did not delve into the uncertainty of climate change models in detail.

**Consequences of inaction** in the City adaptation workshop refers closely to magnitude. It also pertains to importance for the vulnerable system, as more important systems will result in larger scores correlating to greater consequences to life and finances. The importance of vulnerable ecological systems was not covered in detail as the workshop was focused on municipal planning and operations

**Aspects of the IPCC (2007e) framework that were not covered in the City Adaptation workshop:** Distribution aspects was not relevant because we were focus on a specific geographical area and population group. Potential for adaptation was not considered due to the time constraints of the workshop, and the general feeling among the organizors that the City had the capacity to address most of the changes that would likely be discussed. It is noteworthy that there were no impacts discussed during the workshop that the participants did not feel that there were capable of adapting to as a City. This is likely due to the extremely high adaptive capacity of regions like Canada (Walker and Sydneysmith 2008). Persistance and reversibility was not discussed as there was not time to discuss subjects such as the intensification of cycles with climate change. This is not as relevant to a community adaptation strategy, as the irreversible and persistant effects of climate change (like extinction, loss of major ice sheets, loss of unique cultures and permanent drought conditions) do not closely pertain to City operations (IPCC 2007e)

Before implementation, the framework was compared to another risk framework developed by the Allen Consulting Group (2005) to identifiy adaptation priorities for the Government of Australia. This adaptation prioritization exercise involved the identification of vulnerable systems by evaluating their exposure ( human and natural costs of failures), sensitivity (degree to which a system is likely to be affected) and adaptive capacity (ability of system to change). The framework that was used in this exercise was very similar to the City Adaptation framework with the exception of adaptive capacity. This exclusion was largely due to the high adaptive capacity of this region as compared to Australia, which is already dealing with very severe impacts (IPCC 2007b). The workshop organizors felt that the framework used in the Chicago report (2008) was more straightforward, and that it would be better suited for the City Adaptation workshop, and Prince George.

# Appendix H: Research Framework of the SGOG Evaluation

"There is almost a limitless body of desirable and useful information that can be gathered only by asking people questions." (Fowler 1995 p. 1). Two questions in an evaluation of the SGOG workshops on November in 2008 was an effective way to capitalize on an opportunity to gather public feedback about climate change impacts and adaptation. Quantitative surveys typically depend on large numbers of people who are selected at random. The results from this type of research can then be used to generalize with confidence, to the general population (Patton 2000). This can not be considered a random survey of people, as it was limited to members of the public who elected to attend this particular event.

As a qualitative study, this exercise can be best described as a selective and purposeful sample. This type of sampling is often a function of the constraints that a researcher has on him and on the situation (Schatzman and Strauss 1973). Selective may be defined as 'having or exercising power of selection: able to discriminate: choosing or involving only certain things or people'. Patton (1990) defines fifteen different strategies for purposeful sampling that may be used in different circumstances. The types of purposeful sampling that most closely resemble this case are opportunistic sampling and convenience sampling. This is because the researcher takes advantage of a particular opportunity to query the public, and he has picked a group of people whom he could gather feedback from quickly and conveniently.

In order to receive good qualitative data, one must survey good informants. These people should be articulate, knowledgeable and willing to share knowledge with the studier. (Morse 1991). In qualitative research, the sample selection has a profound effect on the ultimate quality of the research (Coyne 1997). It is difficult to accurately assess this sample group due to the small amount of information available about them. The overwhelming majority of the respondents were from Prince George, as this is where the event was hosted. Therefore most respondents have local awareness to help to guide them. Participants also 'self selected' by electing to participate in this event, and to fill out the evaluation form and answer the questions. Therefore it can be assumed that people who are motivated to attend a downtown planning session with an environmental focus are generally more concerned about climate change and its impacts than the majority of other Prince George residents. It is assumable that they have a slightly higher level of concern and knowledge about this subject than the general population. Convenience sampling is likely the most common sampling technique, but it is the least desirable (Patton 2000).

In order to get good answers that can be analyzed, good questions have to be asked. Questions must be clear, well worded and carefully thought through if they are to provide adequate data (Payne 1951). Fowler (1995) outlines the five basic characteristics of questions and answers that are fundamental to a good measurement process:

1) The question must be consistently understood;
2) The question must be consistently administered to the respondents;
3) What constitutes an acceptable answer must be communicated consistently to all respondents;
4) All respondents should have access to the information needed to answer the question rapidly; and
5) Respondents must be willing to respond to the questions being asked.

Extensive effort was put into creating the questions that were included in the evaluations. City workers, academics, planning students and members of the public were asked to review the questions before they were printed to ensure that they were clear and understandable. The instructions were given to the respondents and people were on hand to answer any questions about the evaluation. Information about climate change adaptation and future climate projections was provided via Ian Picketts' presentation. Only 46 respondents (the ones who attended on the first night) were present for this presentation. An analysis of the results from the two nights did not show that there was a significant change in peoples' responses (refer to Table E-1). The only impacts that had a discrepancy were ones that were not spoken about in any detail in Ian Picketts' presentation. Stakeholders did not have the opportunity to create the impacts that they were to evaluate, however there was a space for them to indicate 'other' impacts, and they had an opportunity to name and discuss q other impacts in question 10.

Although these results give a good overview of the publics' attitudes about climate change adaptation, this exercise has some shortcomings with regards to the participant selection. Therefore this cannot be considered a random sample of Prince George citizens, or a group of experts or knowledgeable stakeholders. Because of these shortcomings, less weight will be attributed to the final priority order based on this work. The results from this sample will be used to add validity to the other results, or to bring up inconsistencies for discussion. The results from this study are useful to help to fill in the gaps that are present due to the small amount of impacts that the respondents to the QOL survey had to select from.