

**Treading Water:
Flood Hazard Management and Adapting to
Climate Change in BC's Lower Mainland**

**by
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Abstract

Increases in coastal flooding from climate change related sea level rise and increased rainfall will stress local government's resources. While local governments are planning for expected climate change effects through the use of adaptation and flood management tools, a number of barriers limit long-term adaptation planning. This study examines which flood management tools are currently used in four municipalities in the Lower Mainland: the City of Vancouver, Delta, Richmond and Surrey. The study then presents an analysis of potential policy options to address the barriers to further implementation of flood management and adaptation tools. A recommendation of this research includes greater regional and provincial involvement in flood management to support adaptation in the Lower Mainland.

Keywords: Climate change policy; adaptation; coastal flooding; flood management; Lower Mainland

Dedication

I would like to dedicate this work to my family, and my colleagues and friends in the MPP program; I could not have done this without you.

To my dad Edward, thank you for introducing me to the wonders of nature and for inspiring me to dedicate my career to its protection. To my mum Eva and her partner Debbie: thank you for your unconditional belief in me and the world that I want to be part of. Thanks to my sisters Solange and Zoubi who are the best stress release!

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List of Acronyms

APEG BC	Association of Professional Engineers and Geoscientists of British Columbia
CALP	Collaborative for Advanced Landscape Planning
FBC	Fraser Basin Council
FCL	Flood Construction Level
FRFCP	Fraser River Flood Control Program
IPCC	International Panel on Climate Change
JPC	Joint Program Committee
LGA	<i>Local Government Act</i>
MFLNRO	Ministry of Forest, Lands and Natural Resource Operations
MTI	Ministry of Transportation and Infrastructure
OCP	Official Community Plan
RAC	Regional Adaptation Collaborative
SEF	Sustainable Environment Fund
SLR	Sea Level Rise

Glossary

Climate-related flooding	Climate-related flooding refers to the various forms of flooding resulting from the impacts of climate change, including increased rainfall, increased frequency and intensity of storms, storm surges, coastal erosion, landslides, floods and sea level rise.
Dike	A dike is an embankment, wall, fill, piling, pump, gate, floodbox, pipe, sluice, culvert, canal, ditch, drain, or any other thing that is constructed, assembled or installed to prevent the flooding of land. Alternate spelling: “dyke.”
Floodbox	A flood box is a culvert or set of culverts that provides hydraulic connectivity through dikes that separate internal drainage areas and the receiving waters.
Flood Construction Level	Flood Construction Levels (FCLs) are designated elevations above the natural boundary used to keep living spaces and areas used for the storage of goods damageable by floodwaters above flood levels.
Floodplain	A floodplain is a lowland area susceptible to flooding from an adjoining watercourse, ocean, lake or other body of water.
Floodplain map	A floodplain map delineates the area that can be expected to flood, on average, once every 200 years. Floodplain maps show the location of the normal channel of a watercourse, surrounding features or development, ground elevation contours, flood levels and floodplain limits.

Executive Summary

Coastal communities in BC's Lower Mainland are vulnerable to the threats of climate change. As global temperatures continue to rise, local climate impacts are expected to include increased rainfall, increased frequency and intensity of storms, storm surges, coastal erosion, landslides, floods and sea level rise. In particular, the threat of climate-related flooding is very real for the municipalities of Vancouver, Delta, Richmond and Surrey. Even with mitigation, adaptation is the only way to address climate change. While local policy indicates motivation for climate adaptation, concrete actions remain limited.

Adaptation is effective at a variety of levels, but in particular, local governments are well situated to implement adaptation policies. While municipalities have the jurisdiction to manage flooding, institutional barriers prevent the full use of available management tools and policies. The barriers that local governments face are similar to barriers to adaptation reported in climate change literature.

The goal of an effective policy option should be to reduce the barriers to addressing flood hazard management. Given this goal, the research question this study addresses is: *why are municipalities not using the tools available for managing flood hazards, and how can the barriers be overcome?*

The study attempts to answer this question through a three-part qualitative methodology of a literature review, a case study analysis, and participant interviews.

A review of the climate change literature defines adaptation concepts such as adaptive management, adaptive capacity and the benefits of adaptation. This literature review also identifies institutional barriers societies face in implementing adaptation. These barriers include access to climate information, resources and capacity, myopia, leadership and policy landscape, and liability. The literature review contextualizes potential barriers that local municipalities in the study area may experience.

The case study analysis examines the use of current adaptation and flood management tools and policy in Vancouver, Delta, Richmond and Surrey. These municipalities were chosen due to their coastal location, and their vulnerability to sea

and freshwater flood risk. The local government in each municipality has also acknowledged the risks of climate change, and has begun to consider adaptation action throughout municipal operations. However, the case study findings show that tools such as floodplain bylaws, floodplain maps, zoning bylaws, and dike upgrades are underutilized in these municipalities. Instead, other actions to support adaptation are being undertaken, including various adaptation strategies and participation in research studies that examine risk and create local inundation scenarios.

Interviews were conducted with six local government representatives from the four municipalities in this study. Participants were asked questions pertaining to current adaptation and flood management policy within their municipality and the impediments to further action. Participants were also asked to comment on potential policy options and criteria to assess the suitability of each policy option. Barriers to further strategies to plan for climate-related flooding identified through the interviews include: lack of resources, lack of agency coordination, and lack of long-term planning.

The findings of this study include:

- Barriers experienced by local governments to adapt to climate-related flooding include lack of dedicated resources, lack of agency coordination, lack of information, and increased liability.
- Scale is an important context for understanding and undertaking appropriate actions for adaptation. The scale at which adaptation occurs is different from the scale at which adaptation policy is supported. While adaptation actions are likely best implemented at the local level, such implementation will be impossible without added support from higher levels of government.
- Policies to address adaptation and flooding simultaneously are limited. While adaptation actions seem to be occurring to some extent in municipalities, the actions that specifically connect climate adaptation and flooding are limited.

To address these findings, policy options to reduce barriers for local governments are assessed using three criteria: effectiveness, municipal acceptability, and flexibility. The analysis develops four municipal and regional policy options: the status quo, a regional flood protection strategy, a regional adaptation strategy, and a

flood protection levy, and two provincial-level policy options—an adaptation fund and a floodplain mapping program.

The final recommendation of this research is for a staged policy approach. This includes a regional flood management strategy to address the immediate flood risks, followed by a regional adaptation strategy to address the long-term implications of climate change. Further, the roles and responsibilities of the provincial government with respect to flood management should be reconsidered. Municipalities are encouraged to seek greater collaboration with the provincial government to ensure that long-term implications of climate change can be addressed.

1. Introduction

The Lower Mainland is at risk for flooding from salt and freshwater sources due to its coastal location within the Fraser River floodplain. Climate change increases flood risk which will continue to threaten local populations, housing, infrastructure, economic centres, transportation modes, and coastal ecosystems. Prospering in spite of these impacts will require coastal communities to adapt to climate change.

Flooding is believed to be the most widespread and serious threat of climate change on human settlements (Scott & Gupta, 2001). The Fraser River delta is particularly vulnerable to sea level rise (SLR) (Thomson, Bornhold, & Mazzotti, 2008), and the cities of Richmond, Surrey, Delta and areas of the City of Vancouver are at risk from high consequences of flooding, either from rising sea levels or river flooding (Ausenco Sandwell, 2011a).

The climate impacts to the region are numerous. Warming has already caused precipitation to increase by 2% to 4% per decade in southern BC (Rodenhuis et al., 2009), and Thomson et al. (2008) predict that by 2050, precipitation in many coastal BC areas will rise by 10% to 25%. Along the BC coast, climate hazards include: increased frequency and intensity of storms, storm surges, coastal erosion, landslides, and floods (Walker & Sydneysmith, 2008). BC rivers, including the Fraser, have experienced earlier snowmelt and higher water volumes in the spring due to climate change (Shrestha, Schnorbus, Werner, & Berland, 2012). By the 2050s, winter and spring flows are projected to increase by 56% to 85% and 37% to 56% respectively in the Lower Fraser region (Shrestha, Schnorbus, Werner, & Berland, 2012). Sea levels are expected to rise by up to 88 centimetres along parts of the BC coast and considerably more over time (Rodenhuis et al., 2009). Sea level rise may be the single most important climatic factor which contributes to increasing coastal flood risk (Kundzewicz, 2002).

Because the portion of the Fraser contiguous with Metro Vancouver is tidally dominated, rising sea levels will have an impact on the total flood risk in the region. In

BC, a 1 metre rise in sea levels would inundate more than 4600 hectares of farmland and more than 15,000 hectares of industrial and residential urban areas in the lower mainland of BC (Yin, 2008). A report by the National Round Table on the Environment and the Economy (2011) predicts SLR will cause between \$2.1 billion and \$7.6 billion in damages by 2050 for BC (primarily Metro Vancouver). Further, Vancouver is ranked 15th out of 136 large global port cities in terms of the value of assets exposed to SLR, and the Canadian city the most at risk from sea level rise, storm surges and river floods (Nicholls et al., 2008).

1.1. Policy Problem and Study Goals

Following a series of legislative changes in 2003-2004, the BC provincial government transferred responsibility for flood hazard management to municipal governments. Municipalities now have authority to manage land use in flood hazard areas through the use of a number of tools that were previously provincial responsibility. The key changes include the downloading of responsibility for the approval of subdivisions and floodplain bylaws in flood hazard areas. Since this transfer of responsibility, the provincial government continues to outline and update a number of tools and guidelines to help municipalities better manage flood hazards. However, existing municipal government policy does not reflect the full implementation of these tools.

The policy problem this study addresses is that municipalities are not adequately preparing for the flood risks associated with climate change. While municipalities have the jurisdiction to manage flooding, there are barriers that prevent the full use of available management tools and policies. This policy problem is timely given the scientific evidence for the increased risk of flooding due to climate change.

This study examines what is hindering the implementation of flood management tools, and how barriers can be addressed to ensure communities are adapting to climate change. Given a strong demand for practical tools and resources that support adaptation planning from local government staff and elected officials in BC (Fraser Basin Council

and the BC Ministry of Environment, 2012), the use of flood management tools should support adaptive actions.

The objectives of this study are to highlight the challenges that local governments may face while addressing flood hazard management, and to devise a set of policy alternatives and a final recommendation. These policy options can inform municipal, regional, and provincial policy on the management of flood hazards in the Lower Mainland. The goal of these policy options is to reduce the impediments to addressing flood hazard management. Given this goal, the research question this study addresses is: *why are municipalities not using the tools available for managing flood hazards, and how can these barriers be overcome?*

Climate adaptation planning can occur at the federal, provincial, regional or municipal government level. Each level of government has a variety of tools which are appropriate to address their specific constitutional responsibilities. While it is beyond the scope of this paper to examine the appropriate division of powers with respect to both flood management and climate adaptation planning, the rationale for leadership roles is discussed briefly in Section 3.3.

1.2. Study Outline

The following chapter discusses the main concepts of adaptation to situate this research in the broader climate change literature. Chapter 3 outlines the context for flooding in the Lower Mainland, including the causes of flooding, the implications of climate change, and the present institutional context for flood hazard management in BC. Chapter 4 describes the method of data collection for this study, which includes a literature review, a case study analysis and participant interviews. Chapter 5 presents the demographic and geographical characteristics of each municipality chosen for this study: the City of Vancouver, Delta, Richmond and Surrey. Chapter 6 analyses the research findings from the case study analysis. The 7th chapter details the literature and interview findings to highlight barriers to adaptation. Chapter 8 introduces six policy options, including municipal, regional and provincial level policy options. Chapter 9 presents a set of criteria for evaluating the policy options, while Chapter 10 provides the

results of the policy analysis. A final two-stage recommendation is provided in Chapter 11 and Chapter 12 includes the study limitations, future research opportunities, and conclusion.

2. Adaptation Concepts in the Climate Change Literature

The United Nations Framework Convention on Climate Change identifies two responses to climate change: mitigation and adaptation. Mitigation reduces greenhouse-gas emissions and enhances carbon sinks, while adaptation involves adjusting to the physical impacts of climate change. Mitigation was the primary response to climate change until adaptation themes were included in the 4th Assessment report of the International Panel on Climate Change (IPCC) (Adger et al., 2007). Due to the large concentration of greenhouse gas emissions in the atmosphere, it is now understood that global mitigation efforts will not be sufficient to address the growing threat of climate change (Barker et al., 2007). The IPCC states that “no mitigation effort, no matter how rigorous and relentless will be sufficient for us to avoid climate impacts from affecting the global community over the next several decades” (Klein et al., 2007, p.748).

2.1. Adaptation Defined

Adaptation is complementary to mitigation because the immediate physical impacts of climate change are addressed. Adaptation is an “[a]djustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2001). Adaptive actions reduce vulnerability to the physical impacts of climate change (Smit & Pilifosova, 2001), and could include a wide variety of actions such as water conservation, flood resilient infrastructure, energy retrofits, or urban agriculture. Adaptation is an effective measure against climate change because the benefits are both immediately effective (by reducing vulnerability to climate change) and will increase over time (due to the avoided damage of climate change) (Klein et al., 2007). Pursuing adaptation involves both the recognition of current impacts of climate change and building a system’s resilience for future

impacts. Even in the absence of large-scale climatic change, adaptive strategies could still be worthwhile (Watts, 1997 as cited in Burrell, Davar, & Hughes, 2007).

The impacts of climate change will not be homogeneous. The impacts to coastal regions will be different than the impacts at high elevations or in the interior of BC. Adaptation to climate change requires knowledge and understanding of local risks to better prepare for the future. Adaptive actions then will be most beneficial at the local level (Klein, Schipper, & Dessai, 2005) where the impacts can be more readily addressed.

2.1.1. *The Economics of Adaptation*

The economic benefits of adapting to climate change are well outlined. It has been argued that adaptation actions are a cost effective way of responding to many climate change impacts to avoid greater social, economic and environmental costs in the future (National Roundtable on the Economy and the Environment, 2011). According to Stern, “[t]he benefits of strong and early action far outweigh the economic costs of not acting” (2006a, p.vi). For example, the economic value at risk from climate change is estimated at between 1% and 12% of GDP by 2030 for various global locations, but between 40% and 68% of these losses could be averted through adaptation measures (Economics of Climate Adaptation Working Group, 2009).

The costs of climate change are high. In Florida, the annual cost of inaction is projected to total \$92 billion by 2050 and \$345 billion by 2100 (Stanton & Ackerman, 2007). In Canada, climate change is expected to impose costs rising from an average value of \$5 billion per year in 2020 to an average value of between \$21 billion and \$43 billion per year by 2050 (National Round Table on the Environment and the Economy, 2011).

Investing in adaptation now can reduce the increased damage costs in the future. For example, the cost to build new infrastructure that is adapted to climate change will only add 0% to 5% to current construction costs which is significantly cheaper than restoring infrastructure post damage, retrofitting, or rebuilding (Feltmate & Thistlethwaite, 2012). It is recognized that increased investment in a community's ability

to overcome natural disasters will safeguard existing economic progress, and increase the economy's climate-related resilience (Federation of Canadian Municipalities, 2012).

Investing in adaptation can also create no-regret scenarios, where the benefits incurred from adaptation will be realized without the impacts of climate change. This is especially true for flood protection, because floods occur independently of climate change.

However, investing in adaptation will require policy makers to make trade-offs between present and future benefits to society. This is because the costs of investing in adaptation today can be significant. The annual global adaptation cost to protect against coastal flooding due to SLR is estimated to be \$22 billion, spent over a period of 30 to 40 years (Nicholls, 2007). Locally, the cost of upgrading existing infrastructure to meet the rise in sea level predicted by 2100 in Metro Vancouver is projected to be \$9.5 billion over the next 90 to 100 years (Delcan, 2012).

Adaptation is efficient only if the cost of making the effort is less than the resulting benefits (Mendelsohn, 2000). The gross benefit of adaptation is the difference between the climate damages with and without adaptation (Agrawala & Frankhauser, 2008). Adaptation will also have costs in and of itself and these costs need to be deducted from the gross benefits to arrive at the net benefit of adaptation (Stern, 2006b). Efficient adaptation occurs when adaptations maximize net benefits (or when the benefits of adaptation are greater than its costs) (Mendelsohn, 2012). However, not every adaptation action is efficient. For example, the construction of a \$6 billion dollar sea wall to protect land with value of \$1 billion is inefficient. Therefore, some adaptation actions may actually make society worse off, and policy makers should ensure that this does not occur (Mendelsohn, 2012).

2.1.2. *Fostering Adaptation*

Climate change will impact the services, livelihoods, and infrastructure on which societies rely. Adapting to climate change will not be without financial or opportunity costs to individuals and governments. The choice to invest in adaptation will involve trade-offs between present and future benefits. For example, investing in adaptation for

future benefit will inevitably mean forgoing income or other resources that could be spent addressing more immediate public policy concerns. If the right policy frameworks are in place, the costs of addressing climate change will be manageable (Stern, 2006a). Governments can plan for adaptation by engaging in two processes: adaptive management and adaptive capacity.

2.1.3. Adaptive Management

Adaptive management is an iterative decision making process to manage uncertainty. The main premise of adaptive management is that management responses can change when more is learned about a system and uncertainty is reduced (Allen et al., 2011; McFadden et al., 2011; Holling, 1978). Adaptive management embodies flexibility because change is expected and seen as an opportunity to learn more about the system itself. Management processes can be adapted to more appropriately address the changing characteristics of the system.

Adaptive management is different from traditional management styles because it identifies uncertainties and establishes methodologies to test hypotheses concerning those uncertainties (Resilience Alliance, 2013). An adaptive management approach requires that decisions are made as part of an ongoing science-based process which involves planning, enacting, monitoring and evaluating strategies applied, and incorporating new knowledge into management approaches as it becomes available (WMO/GWP, 2009). Adaptive management can even allow for the reversal of decisions (WMO/GWP, 2009).

Adaptive management can be especially useful for climate adaptation planning and management (Arvai et al., 2006; Tompkins & Adger, 2004; Peterson et al., 1997; WMO/GWP, 2009). This is because climate change is a complex problem with uncertain impacts. Adaptive management can ensure that knowledge and policy are continually updated and challenged to respond to climate uncertainty (Peterson et al., 1997). The knowledge gained can then help inform the judgments of policy makers who must address the complexities and uncertainties of climate change (Arvai et al., 2006). Also, adaptive management can help increase resiliency to the threats of long-term climate change (Tompkins & Adger, 2004). This is because adaptive management can produce

policies that address key uncertainties, test alternative policies, provide opportunities for learning, and monitor policy outcomes (Peterson et al., 1997).

The BC Ministry of Forest, Lands and Natural Resource Operations (MFLNRO) is exploring how adaptive management can be used in the BC forestry sector.¹ The six steps² involved in applying adaptive management can also be applied to managing the uncertainty of climate change.

2.1.4. Adaptive Capacity

Ultimately, a region's ability to adapt to climate change is also dependent on its adaptive capacity (Juhola, Haanpää, & Peltonen, 2012). Adaptive capacity is the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change (Smit & Pilifosova, 2001; Adger, Brooks, Bentham, Agnew & Eriksen, 2004). Particularly, a system with adaptive capacity will take advantage of the changes that have occurred (Klein et al., 2007). Like adaptation itself, the actions that address and improve a system's adaptive capacity are often seen at local scales (Smit & Wandel, 2006; Kelly & Adger, 2000). Actions that can build adaptive capacity include communicating climate change information, building awareness of potential impacts, protecting property or land, maintaining economic growth, or exploiting new opportunities (Adger, et al., 2005). Clearly, these actions outline the important role of public policy in building adaptive capacity and facilitating adaptation to climate change through government action intended protect people, infrastructure, and land from the impacts of climate change.

2.1.5. Summary

Systems can better adapt to climate change by using the concepts of adaptive management and adaptive capacity. Thus local managers can use these tools to ensure that the risks of climate change are addressed so communities remain prepared and

¹ More information is available at the MFLNRO website:
<http://www.for.gov.bc.ca/hfp/amhome/index.htm>

² Assess the problem, design solutions, implement the actions, monitor results, evaluate outcomes and adjust as necessary (Nyberg, 1999).

protected as much as possible. However, while the benefits of adaptation are clear, local governments must balance the trade-offs between addressing adaptation and addressing other pressing social, environmental and economic goals. As the following research shows, local governments face a number of barriers to addressing adaptation.

3. Flooding Context and Management in BC

The sections below describe the causes of flooding and the implications of climate change for the Lower Mainland. These sections also discuss tools for management and the present institutional context for flood hazard management in BC.

3.1. Flooding in the Lower Mainland

The Fraser River is the longest river in BC. With headwaters in the Rocky Mountains, the river flows over 1,300 kilometres into the Strait of Georgia and the Pacific Ocean. The Lower Fraser River is vulnerable to floods every year, and parts of the Metro Vancouver area lie within this floodplain.

3.1.1. *History of Flooding*

Historically, the Fraser floodplain has experienced two major river floods. The largest flood occurred in the spring of 1894 when river levels rose due to a rapid snowmelt in the headwaters of the Fraser. This early flood is considered the "design flood", on which current flood protection and management is based. While the flood was significant, little damage was incurred because there was limited settlement at the time. However, a second flood in 1948 caused significantly more damage. By this time the population in the area had increased since the last flood, and the flood led to an evacuation of 16,000 people, damage or complete destruction of 2300 homes, 1500 residents left homeless, and recovery costs of about \$150 million (current values) (Fraser Basin Council, 2004a).

Since 1948, the Lower Fraser River has been spared from repeat events of similar magnitude. However, it has been predicted that there is a one-in-three chance that a flood of similar magnitude will occur within the next 50 years (Fraser Basin Council, 2004a). The threat of climate change (discussed in the Introduction and

Appendix A) can exacerbate this risk. A major flood in the Lower Mainland would result in severe social, economic and environmental impacts. These include risk of injury and loss of life, billions of dollars in damage to private and public property, temporary loss of infrastructure and community services, disruption of business and trade, degradation of water quality and harmful impacts on fish and wildlife habitat (Fraser Basin Council, 2004a).

3.1.2. Causes of Flooding

The Fraser Basin Council (2004b) has identified four primary causes of floods throughout the Fraser Basin. These include local, spring, winter, and tsunami, the latter two being a hazard only in coastal areas.

- **Local flood risks:** This type of flood risk occurs from heavy rainfall. Floods can occur when smaller streams and rivers overflow or when local drainage systems (such as storm sewers) exceed capacity.
- **Spring flood risks:** Spring snowmelt³ causes high water levels in the Fraser, and is the most significant flood concern on the Fraser River.
- **Winter flood risks:** This type of flooding occurs in coastal regions. The largest flood risk for Lower Fraser River municipalities on the coast is from winter storm surge from the Georgia Strait.
- **Tsunami flood risk:** This flood risk includes tsunami waves following an earthquake (Fraser Basin Council, 2004b).

The Lower Fraser floodplain is susceptible to all four of these flood risks. Climate change can have an impact on local, spring and winter flood risk though rising sea levels, increases in the frequency of extreme weather events, and increases in precipitation and snowmelt. The impacts of climate change in BC are discussed further in Appendix A.

³ Also called a freshet.

3.2. Climate Change Adaptation Policy in BC

The Climate Action Plan is the primary climate change policy vehicle for the BC government. The Plan outlines initiatives to move B.C. closer to its climate change goals, and includes a Climate Change Adaptation Strategy. The Strategy envisions that BC will be prepared and resilient to the impacts of climate change. This will be achieved through building knowledge and tools for decision makers to prepare for a changing climate, making adaptation part the BC government's business, and assessing risk in order to prioritize actions in key sectors (BC Ministry of Environment, 2010). However, beyond these three themes for adaptation, the Strategy lacks concrete and measurable plans to address adaptation at a provincial level in BC.

On a municipal level, other climate policy includes the *Local Government (Green Communities) Statutes Amendment Act* (Bill 27) which was passed in 2008. The Act requires that Official Community Plans (OCPs) and Regional Growth Strategies address climate mitigation by reporting greenhouse gas reduction targets, policies, and actions. In addition to these new requirements, Bill 27 offers municipalities greater authority to require, reward, and enforce different elements of sustainable development within their community (Rutherford, 2009). However, while local governments are faced with significant responsibilities to plan for climate change mitigation, there is currently no mandate to plan for adaptation.

3.3. Optimal Level of Government Responsibility

The devolution of governmental powers is a constant reality of modern democracies. Downloading can occur when the senior government either mandates that another level of government provide some service but does not provide matching compensation for doing so, or the senior government simply discontinues the service altogether which leaves local governments to fill the service gap (Graham, Philips, & Maslove, 1998).

Driving this downloading of responsibilities is the hope that local governments will be more responsive to the local preferences and cost conditions of their constituents and will be better placed to provide local services to meet these needs (Oates, 1999).

The theory of fiscal federalism explores the roles of different levels of government. Specifically, fiscal federalism provides a framework for assigning appropriate roles and responsibilities for each level of government and the tools to carry out these roles (Musgrave, 1959; Oates, 1972). An important component of this theory is how revenues are shared between the central government and lower levels of government. This theory states that central governments should take responsibility for macroeconomic concerns (such as income distribution) partly because lower levels of governments are financially constrained to address these issues (Oates, 1999). Ultimately, the provision of public services should be offered at the lowest level of government that encompasses the relevant benefits and costs (Oates, 1999).

Since 1986, the provinces have faced cuts to federal funds and, as a result, they have tended to push the burden downwards to the municipalities (Dewing, Young & Tolley, 2006). During the downloading process, senior governments have “often shifted burdens to local governments without careful consideration whether this was the correct course” (Gold & Wallin 1999, p. 73). The costs for adaptation and mitigation are being felt in Canadian municipal governments through the local property tax base (Rickett, Shapero, & Iorio, 2006). However, it is argued that local climate mitigation and adaptation projects (such as those pursued by the Federation of Canadian Municipalities Partners for Climate Protection⁴) have positive effects that spill over local boundaries, and thus the presence of these spillover effects indicates the need for cost-sharing with higher levels of government. For example, it is “abundantly clear that the municipal role in addressing climate change is critical, and there [is] widespread agreement that Canadian municipalities are acting largely without the help, partnership or funding of higher levels of government” (Rickett, Shapero, & Iorio, 2006, p. 29). Furthermore, it is understood that “[w]ithout strong multi-level government partnerships and financial

⁴ The Partners for Climate Protection program is a network of Canadian municipal governments that have committed to reducing greenhouse gases and acting on climate change.

support for both climate change mitigation and adaptation, Canadian municipalities will face increasing budgets, degraded environments and a less hospitable future” (Rickett, Shapero, & Iorio, 2006, p. 29).

3.4. Flood Hazard Management in BC

Prior to 2003, the responsibility for flood hazard management rested with the provincial government. The changes in policy were largely due to the termination of the Floodplain Development Control Program.⁵ The BC government passed Bill 56 (the *Flood Hazard Statutes Amendment Act*) in 2003, which amended the *Local Government Act (LGA)* to give responsibility for managing flood hazards to local governments. Amendments were made to the *Land Title Act* (Bill 56), *LGA* Section 910 (Bills 56 and 54), *Dyke Maintenance Act* (Bill 56), *Drainage, Ditch & Dyke Act* (Bill 56) and the *Ombudsman Act* (Bill 56). The provincial Acts set the regulatory framework for flood protection in BC, while a number of guidelines help local governments to fulfill their responsibilities under these Acts. Today, much of the responsibility for land use management in flood hazard areas lies with municipal governments through the *LGA* and other policy levers such as OCPs, bylaws, development permits, building permits, zoning restrictions, and other types of policies and documents. In particular, Sections 910, 919.1 and 920 of the *LGA* pertain to local government’s management of flood hazards. Today the MFLNRO manages the Integrated Flood Hazard Management Program. The Program provides policies, guidelines, and information that help local governments, diking authorities, provincial ministries and others manage land use in flood hazard areas and flood protection systems, maintain dike safety and prepare for, respond to, and recover from flood emergencies (BCFLNRO, 2013). The legislation regarding flood management is discussed further in Appendix B.

⁵ The provincial government managed development in designated floodplain areas from 1975 to 2003 through the Floodplain Development Control Program. This program required that a Ministry of Transportation and Infrastructure (MTI) Subdivision Approval Officer was required to refer all subdivision plans for lands subject to flood hazards to MFLNRO, who would assist local governments with the preparation of floodplain bylaws. Today, the MTI no longer refers subdivision applications to MFLNRO, although the MFLNRO still provides guidance in the form of the Flood Hazard Area Land Use Management Guidelines.

Since the legislative changes, an organization called the Fraser Basin Council has joined the provincial and local governments in flood hazard management. The Fraser Basin Council will continue to facilitate the development of flood hazard management tools to help with planning, dikes operation and maintenance, and emergency preparedness and response.

3.4.1. Flood Protection and Emergency Funding in BC

The federal and provincial governments have partnered to fund infrastructure projects that provide flood protection to communities across BC. The funding arrangements are through the Provincial Flood Protection Program of Emergency Management BC and the Federal Building Canada Plan, Disaster Mitigation Category of Infrastructure Canada. Costs are equally shared between federal, provincial and local governments who each contribute one-third to the fund. The Flood Protection Program funds infrastructure projects on an application basis, and applications for funding have been accepted from local governments (municipalities and regional districts) and diking authorities (including diking districts) (BC Ministry of Public Safety and Solicitor General Emergency Management BC, 2012). However, the program has been criticized for oversubscription (Loski, 2012). At the time of writing, applications were closed and it was not clear when the application process would reopen. Financial assistance from the provincial government is also available for emergency response to natural disasters.⁶

⁶ The BC Provincial Emergency Program leads BC's response to emergencies such as floods, earthquakes, fires, landslides, and severe storms. Under the *Emergency Program Act* and the Compensation and Disaster Financial Assistance Regulation, municipalities can receive financial assistance for eligible emergency response costs incurred during a disastrous event, and assistance for some post-disaster recovery costs expended to repair or restore public works and facilities that are essential to their operation (BC Ministry of Public Safety and Solicitor General, 2008). Therefore, these funds could be accessed to support the physical impacts of climate change, but do not consider the long term implications of climate change. Emergency funding is therefore largely a reactive, rather than proactive response to climate change, and it is unlikely that these funds will be substantial enough for the impacts in the future.

3.4.2. Recent Climate Change Guidelines

In 2011, the Flood Safety section of the MFLNRO published draft technical guidelines for the design of sea dikes and coastal land use, which included climate change considerations. These guidelines were prepared as part of the Regional Adaptation Collaborative (RAC) Climate Change Program supported by Natural Resources Canada.⁷ These guidelines include three components: *Sea Dike Guidelines*, *Guidelines for Management of Coastal Flood Hazard Land Use*, and a draft *Policy Discussion Paper*.

The *Sea Dike Guidelines* (Ausenco Sandwell, 2011c) document guides the design of sea dikes to protect low lying lands exposed to coastal flood hazards arising from climate change. The new guidelines significantly raise the recommended heights of dikes, sea walls, and flood construction levels of buildings in comparison to existing levels as a response to the worsening threats and improved understanding of SLR.

The *Guidelines for Management of Coastal Flood Hazard Land Use* (Ausenco Sandwell, 2011b) can help local governments develop and implement land-use management plans and make subdivision approval decisions for lands exposed to coastal flooding hazards and SLR. It also provides a list of land use management tools.

⁷ This program is a three year, \$30 million, cost-shared federal program to help communities prepare for and adapt to local impacts of climate change across the country (Natural Resources Canada, 2011). The BC RAC entitled *Preparing for Climate Change: Securing B.C.'s Water Future*, includes collaborative projects across the province to help decision makers address climate impacts on water allocation and use, forest and watershed management, flood protection and floodplain management and community planning (Fraser Basin Council, 2013). The Fraser Basin Council and BC Ministry of Environment - Climate Action Secretariat have worked together in managing the BC RAC, with \$3.3 million in funding from Natural Resources Canada and another \$3.3 million in funding and in-kind contributions from provincial ministries, local governments, First Nations, non-governmental organizations, the private sector and academia (Fraser Basin Council, 2013). The initiative ran from September 2009 through March 2012 and includes key outputs such as *the Delta-RAC Sea Level Rise Adaptation Visioning Study*, *Coastal Floodplain Mapping Guidelines*, *Guidelines for Sea Dike Design and Coastal Flood Construction Levels*, *Adaptation Guidelines for Flood Hazards and Risk Assessments* and *Participatory Flood Management Planning in Delta*.

The *Policy Discussion Paper* (Ausenco Sandwell, 2011a) intends to help bridge the gap between the science and practical application of measures to address climate change factors in BC coastal areas.

While not yet adopted as official provincial policy, the guidelines recommend provisions for a SLR of 0.5 metres by the year 2050, 1.0 metre by 2100, and 2.0 metres by the year 2200.⁸ However, presently these guidelines remain in draft form. The guidelines are not mandatory and there is no obligation for local governments to comply.

3.5. Flood Management

Flood management can be defined as any activity that prevents floods, reduces the probability of a flood, or lessens the damages from unavoidable floods (Burrell, Davar, & Hughes, 2007). Local governments have a number of tools at their disposal for flood management and protection, as outlined in the *LGA and Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use; Guidelines for Management of Coastal Flood Hazard Land Use*. These methods can be roughly divided into structural or nonstructural categories.

3.5.1. Structural Protection Methods

Structural measures include: dams, dikes, channel improvements, river diversion, floodwalls and seawalls (Environment Canada, 2012b), and can also include pump stations and floodboxes (APEGBC, 2012). Although many of these structural measures are beneficial, they also serve to encourage further encroachment upon river floodplains, which raises the potential for flood damage and leads to requests for greater levels of protection (Environment Canada, 2012b). Communities generally prefer to use structural measures such as dikes to keep risks at bay, as opposed to limiting development in hazardous areas (Burdby et al., 2000). However, relying on structural measures

⁸ These projections are based on the latest global SLR projections (McMullen & Jabbour, 2009; Allison et al., 2009).

becomes increasingly risky as SLR continues and climate change increases the variability of weather patterns and extreme conditions become more difficult to predict.

3.5.2. Non-structural Protection Methods

Over time, the regulation of floodplain development has evolved to include experience of floods and the restriction of proposed development on floodplains. Nonstructural approaches can reduce the need for expensive flood control measures and the demand for disaster assistance from flood damage (Environment Canada, 2012b). Non-structural measures include avoiding development in flood-prone areas by means of land use planning and zoning, restrictive covenants on land titles, enforcement of flood construction levels (FCLs⁹) and minimum building elevations, and floodproofing (APEGBC, 2012). It can also include acquiring property in the floodplain or relocating structures, altering upstream land management practices and establishing and maintaining flood forecasting and warning systems (Environment Canada, 2012b). Local governments can also use a number of planning tools to specifically manage and plan adaptation; thus the use of these tools may be effective to manage both existing flood risk and the increasing flood risk from climate change. These tools include OCPs, Development Area Permits, zoning, floodplain bylaws, and subdivision bylaws¹⁰ which are discussed below.

Official Community Plans (OCPs)

OCPs are authorized under the *LGA* (1996) and are a local government bylaw that provides objectives and policies to guide local decision-making and land use planning and management. OCPs can be useful to support action on climate change by mainstreaming adaptation across OCP policies and objectives, framing climate adaptation objectives, and support for stand-alone municipal policies and plans (Carlson, 2012). Section 877 of the *LGA* stipulates that OCPs must address restrictions on the use

⁹ Flood construction levels (FCLs) are the minimum allowable elevation for habitable space above sea level and are determined by engineering assessments. FCLs vary across regions.

¹⁰ It is important to mention that other flood management tools could include protection for street stormwater management, drainage, hydrological models, soil removal and deposition and protection of green space. However, these tools are not considered in this study.

of land that is subject to hazardous conditions, of which floods are included. However, it has been argued that these statements are not enough to acknowledge and address risk at a community-wide scale (Shoubridge, 2012).

Although communities are not officially mandated to prepare OCPs, in practice, it is rare that a BC municipality does not have one. The City of Vancouver is the exception because it is regulated by the Vancouver Charter (which is a provincial statute governing how the city operates). Vancouver has considerably more power over issues such as taxation and building codes than the other municipalities in this study which are under the *LGA* (City of Vancouver, 2012a).

Zoning

With zoning or land-use bylaws, local governments can regulate development by establishing land uses and specific requirements for buildings. Zoning can be used to delineate certain areas that may be at greater risk from climate impacts, and provide development requirements within such zones (Carlson, 2012).

Development Area Permits

Development permit areas (DPAs) refer to a set of development regulations that address a specific area as specified by the Official Community Plan. DPAs are more flexible than zoning tools as they can specify guidelines for site-specific results and solutions. Municipalities can create DPAs or update existing DPAs to account for different levels of risk associated with climate change. However, DPAs are most useful in developing or redeveloped areas, and thus may not be as useful for existing developed areas (Carlson, 2012). While a provincial DPA guide exists,¹¹ the actions described in this guide are primarily mitigation actions, and do not address adaptation.

Floodplain Bylaws

Floodplain bylaws can help reduce the risk of flooding for new development or redevelopment by designating land as floodplain. Within the floodplain area, local

¹¹ From the BC Ministry of Community, Sport and Cultural Development, available at http://www.cscd.gov.bc.ca/lgd/library/dpa_guide/dpa_guide.pdf

government can specify flood levels and setbacks for buildings. In particular, floodplain bylaws can be useful for local governments who want to consider the impacts that climate change may have on new development areas (Carlson, 2012).

Subdivision and Servicing Bylaws

Subdivision and servicing bylaws set out the infrastructure requirements for subdivisions, buildings and other structures in the case of new developments and redevelopment. These bylaws can have different requirements for different geographic areas within a local government's jurisdiction and can require certain components of infrastructure (such as green infrastructure), which can reduce the impacts of climate change (Carson, 2012). Current BC provincial policy encourages the use of floodplain bylaws according to Section 910 of the *LGA*.

Floodplain Maps

A floodplain map shows an area that is expected to flood. In BC, these maps show the area that is expected to flood, on average, once every 200 years (BC Ministry of Environment, 2013). Floodplain maps show the location of the normal watercourse, surrounding features and developments, ground elevation contours, flood levels and the extent of the high water marks for the 200-year flood (BC Ministry of Environment, 2013).

Coastal floodplain maps identify coastal flood hazards and provide the technical basis for land use planning and developing floodplain bylaws (Kerr Wood Leidal, 2011). Floodplain maps help decision makers plan how and where communities grow. The provincial *Coastal Floodplain Mapping Guidelines and Specifications* document recommends standards for topographic mapping and identifies engineering requirements for establishing building elevations in coastal areas. In light of SLR, coastal floodplain maps can be a useful tool to help local governments identify vulnerable areas, which will influence land use planning and decisions (Kerr Wood Leidal, 2011).

3.6. Summary

A mix of both structural and non-structural measures is likely to be the best way to manage flood risk. While structural methods are necessary to protect existing developments, particularly those in urban areas, an effective flood protection system is one that combines both structural and non-structural methods (Kundzewicz, 2002). The structural solution is seen as only a temporary and partial solution; long term solutions consist of keeping development and other land uses out of the floodplain areas (Environment Canada, 2012b). Moreover, relying on structural approaches becomes increasingly risky as climate change increases the variability of weather patterns and extreme conditions become more difficult to predict. Therefore, an over-reliance on the use of structural (relative to non-structural) measures may misdirect communities in the long term (Eriksen et al., 2011). This is because non-structural methods are generally less expensive and may have other benefits that are compatible with sustainable development planning over the long term, such as protecting natural flood barriers such as wetlands, dunes and streams. Avoiding further development in flood risk areas will reduce damage costs in the future. However, BC communities lack a comprehensive framework for managing natural hazard risk (including floods) in an ongoing way, as no assessment of policies exists (Shoubridge, 2012).

While the above tools may address the risks of flood hazards from climate change in the Lower Mainland, the analysis in the following chapter shows there is limited uptake of available tools in the Lower Mainland. A range of pressures limit the use of these tools, and options to address these pressures should be evaluated with the specific geographical, social and economic characteristics of each region. The objectives of this study are to inform policy by highlighting the challenges that local governments in the Lower Mainland may face when addressing flood hazard management in the context of climate change. The next chapter will outline the methodology used to collect data to meet the study objectives.

4. Methodology

This study examines the existing institutional barriers that are preventing municipalities from using available flood and adaptation tools, and investigates how these barriers can be overcome so municipalities can better address the risks of climate-related flooding.

The methodology for this study involves qualitative research methods using three components:

1. a cross-case analysis of existing adaptation tools and policies;
2. a literature review of institutional barriers to adaptation and flood management;
3. and qualitative semi-structured interviews with key local government participants and local experts.

4.1. Literature Review

This study reviews the scientific literature addressing the barriers to adaptation. The information was gathered through online searches of academic journal databases, including Academic Search Premiere, JSTOR, Canadian Public Policy Collection, Science Direct, and Google Scholar, as well as websites of governmental and non-governmental organizations, and publicly available adaptation plans and policies. The findings from this literature review guided the development of key topics areas to be explored in the semi-structured interviews.

4.2. Case Study Analysis

The case study analysis examines four municipalities in the Lower Mainland: the City of Vancouver, Delta, Richmond and Surrey. A rationale for why these case studies

were chosen is included in section 4.2.1. A case study analysis was used as a method to answer the research question because case studies often attempt to answer how or why questions (Yin, 2003). The case study analysis also allows for comparisons of the components of each municipality's adaptation and flood hazard management plans and policies.

The first stage of data collection for the case study analysis began by identifying tools from the provincial government document: *Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use; Guidelines for Management of Coastal Flood Hazard Land Use*.¹² This document includes tools that the provincial government recommends municipalities use to manage flood hazards. However, this document does not outline all the tools that municipalities are now expected to use. In particular, the responsibility for subdivision approval, the creation of floodplain maps, and dike upgrades are omitted. These three tools are also included in the analysis. The ten tools are described in Table 1.

¹² This document supersedes the related sections of the existing *Flood Hazard Area Land Use Management Guidelines* (2004) available at http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/guidelines-2011.pdf

Table 1. Flood Management Policy Tools

Tool	Description
Official Community Plans (OCPs)	OCPs must contain general land use policy statements and maps showing restrictions on the use of land subject to hazardous conditions, including floods (LGA: Section 877).
Development Permit Areas (DPAs)	OCPs may identify DPAs and create Development Permit Guidelines for Protection of Development from Hazardous Conditions, including flooding and some aspects of climate change (LGA : Sections 919 and 920).
Floodplain Bylaws	These bylaws designate an area as a floodplain, specify the minimum elevation to which development must be constructed, and establish setback requirements. Related enforcement provisions must consider Provincial Guidelines (LGA: Section 910).
Zoning Bylaws	Zoning bylaw provisions can give preference for low-risk land use in floodplains (LGA: Section 903).
Restrictive Covenants	Restrictive covenant agreements are signed between a property owner and a government agency that is registered on the title of a given property. The agreement usually specifies some restriction of activities or land-use that is applied to a portion of the subject property.
Subdivision Regulation	This tool includes the regulation of subdivisions to protect development in areas subject to hazards.
Public Education	This tool provides public education about the hazards and ways that individuals can address them by providing known site and hazard risk information to help individuals decide for themselves whether to proceed with a purchase of land or development.
Early Warning and Emergency Preparedness Programs	These tools include the preparation of emergency plans for flooding and other disasters, and how to undertake post-disaster planning.
Floodplain Maps	Floodplain maps identify areas susceptible to flooding and show lands designated as floodplains.
Dike Upgrades	This tool involves dike upgrading to reflect consideration for SLR.

A scan of existing policy was conducted to record which tools from Table 1 are being used in each municipality. A variety of documents were consulted to check existing policy. Publically available documents such as OCPs, meeting transcripts, reports to Council, media reports and other government documents including

management plans or other reports were consulted to create this Table. Generally, documents before the years 2003-2004 were not consulted (as this was when the legislation changed to shift responsibility for flood management to municipalities). These findings were confirmed by interviews. The use of each tool was recorded for each municipality in the study. Chapter 6 reports the adaptation actions and flood management tools being used in each municipality.

The second stage of data collection included further research of existing policies and plans in the study area. Any policies or plans that referenced flooding, specifically in the context of climate change or climate adaptation, were recorded. This data was collected in a similar fashion to that described above.

4.2.1. Rationale for Case Selection

A municipal-level study was chosen because local governments are responsible for flood hazard management and climate adaptation and mitigation planning. Local governments are required to uphold the public good for the long term and make well-informed decisions that will benefit their citizens. For example, local institutions have three critical roles in climate adaptation, namely: 1) structuring responses anticipating to local impacts; 2) mediating between individual and collective responses to vulnerability; and 3) governing the delivery of resources to facilitate adaptation (Agrawal, 2008). Local governments have an important role to play in climate change adaptation because ultimately, climate change will affect the services and infrastructure for which municipalities are responsible (Cote, 2004; Boston, 2007; Carlson, 2012). These services can include the built environment, building and maintenance of drainage and piped water infrastructure, provision of services, public transport and disaster response (Gagnon-Lebrun & Agrawala, 2007). Moreover, local governments have the tools (building codes, emergency response etc.) to address the short-term impacts of climate change.

The municipalities were chosen for analysis based on the following criteria:

1. Location in a floodplain or coastal area;
2. Vulnerability to flood hazards, either from river or sea;

3. Recognized climate adaptation plans or such intention (which may or may not specifically address flooding and/or SLR).

The consequences of flooding in the study area are estimated in Table 2.

Table 2. Flood Risk in the Lower Mainland

Area of Interest	Preliminary Estimate of Area Value	Estimated Consequences of Flooding
Fraser River delta – Richmond, Surrey and Delta coastal areas	High	High
Vancouver harbour	High	High close to shoreline

Table 2 adapted from Ausenco Sandwell (2011a).

Finally, these four municipalities were chosen because they each incorporate climate adaptation into local planning.

There are three distinctive differences between the City of Vancouver and the other municipalities in this study. First, Vancouver is primarily urban so the impacts of flooding differ from other areas, which may primarily experience flooding of agricultural lands. Second, Vancouver is regulated by the Vancouver Charter which grants the city different powers from other municipalities. Despite this, Vancouver was included in the analysis because it is organized and operated as a municipal entity similar to Delta, Richmond and Surrey. And third, Vancouver does not rely on dikes as a primary form of flood protection unlike the other municipalities in this study.¹³

4.3. Interviews

Information about current municipal adaptation plans and potential institutional barriers was collected in participant interviews. The aim of the interviews was to give context to the findings of the literature review and case studies, and garner comments on the perceived applicability of the policy options.

¹³ Vancouver relies on FCLs and building setbacks rather than dikes.

Interview participants were municipal government employees. Six interviews were conducted by email or in-person. In order to maintain full confidentiality, participants are referred to only as: “interview participant.” Information gathered in the interviews is generalized across the study area.

A semi-structured interview format was employed, which allowed for more free-flowing dialogue between interviewer and interviewee. In particular, participants were asked to outline which flood management tools were employed in their municipality, and to comment on the potential barriers their departments faced with respect to managing climate-related flooding and how these barriers could be minimized. Questions were asked pertaining to criteria and measures to evaluate potential policy options and feedback was sought on the policy options themselves. This process provided access to opinions that were not available in the existing literature and which were specific to each municipality in the study area. Appendix C contains a copy of the interview guide used, as well as further information pertaining to contact with participants.

Thematic analysis was used to organize the interview findings. Thematic analysis is a method for identifying, analyzing, and reporting patterns within data and is a foundational method for qualitative analysis (Braun & Clarke, 2006). In order to conduct this analysis, the interviews were transcribed and the participants’ statements were categorized into key themes. According to Braun and Clarke (2006), “[a] theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set” (p. 88). Because the municipalities in this study area do not necessarily experience similar risks from flooding, thematic analysis allowed for the findings to be organized into common themes to accurately answer the research question.

5. Study Area

This chapter describes the relevant geographical and demographic information of each municipality in this study. While each municipality is at risk from flooding, the vulnerabilities of each municipality are unique.

5.1.1. *City of Vancouver*

Population: 603,502 (Statistics Canada, 2012).

Land area: 114km²

Vancouver is located between the Burrard Inlet to the north the Fraser River to the south, and is thus surrounded by water on three sides. The most relevant climate change impacts for Vancouver include flooding due to SLR, overland flooding due to increased frequency and intensity of precipitation, damage from increased frequency and intensity of wind and rainstorms, and health impacts from heat waves (The Sustainability Group, 2012).

5.1.2. *Delta*

Population: 99,863 (Statistics Canada, 2012).

Land area: 180 km²

Delta is located on a floodplain, also surrounded on three sides by water. Much of Delta lies between 0 and 2m above sea level and is protected by over 60km of dikes (Burch et al., 2010). Floodboxes, ditches, and more than 30 pump stations regulate water levels and protect the community from flooding (City of Delta, 2013a).

Currently, the largest flooding threats in Delta are from winter storms and high river flows from melting snow. Land use in Delta is primarily agricultural, and the tidal

flats are ecologically rich. Two important structures are located in Delta: Vancouver Port Authority's causeway leading to the Delta Port shipping terminal and BC Ferries Corporation's Tsawwassen Terminal. Delta is particularly vulnerable to the impacts of SLR, as 53% of Delta's total land area could be vulnerable to inundation (Barron et al., 2012). Facilities threatened by SLR include nine schools, 12 culturally and historically significant features, and 8663 buildings, totalling \$5.85 billion dollars in land and building values (2008 land value) (Barron et al., 2012). Other key concerns include a loss of fish and bird habitat on Roberts Bank tidal flats, possibility of compromised irrigation systems, and a deteriorated water supply from saltwater intrusion (Natural Resources Canada, 2010).

5.1.3. Richmond

Population: 190,473 (Statistics Canada, 2012).

Land area: 129.27 km²

The city of Richmond is situated on a series of low-lying islands at the mouth of the Fraser River and the Strait of Georgia, so flood protection is very important in Richmond. Most of the population lives on Lulu Island where flood protection includes 600 km of drainage mains, 39 pump stations, and 320 km of ditches/canals/sloughs (City of Richmond, 2012a). Flooding in Richmond can be triggered by a river event, caused by snow melting and warm spring temperatures, and flooding from weather events such as heavy rainfall or SLR (City of Richmond, 2010).

Richmond's vulnerabilities to climate change include: human health and safety, agricultural viability, water resources, energy servicing, infrastructure management, emergency planning and natural ecosystems (Carlile, 2010).

5.1.4. Surrey

Population: 468,251 (Statistics Canada, 2012).

Land area: 316.41 km²

Surrey's lowland areas are influenced by ocean and river tides in the Fraser River, the Serpentine and Nicomekl rivers and a network of tributaries spread throughout the city (Rowett, 2009). Mostly, the city has located urban development outside this floodplain, while lower density populations exist in the floodplain itself (Rowett, 2009). Flooding in Surrey can occur from rainfall, snowmelt, high tides, or a combination of events (City of Surrey, 2012). Over 8500 hectares of Surrey is currently within a floodplain area, and there are approximately 170 flood boxes, 100 km of dikes, 30 drainage pump stations, 10 spillways, and two sea dams (Baron, 2011). Many private and senior governmental agencies own and operate infrastructure within the floodplain such as Highways (Highway 15, Highway 10, Highway 99, South Fraser Perimeter Road), Agricultural Land Commission, port facilities, railway facilities and tracks, energy providers, treatment plants and transmission lines (Baron, 2011).

6. Case Study Findings

The case study analysis examines relevant flood and adaptation policies in the Lower Mainland. A scan of existing flood management and climate adaptation tools and policies was conducted for each of the four municipalities. Table 3 below represents the results of this scan.

Table 3. Case Study Results

Tool	Vancouver	Delta	Richmond	Surrey
Official Community Plans	NA	✓	✓	✓
Development Permit Areas	✗	✗	✓	✗
Floodplain Bylaw	✗	✗	✓	✗
Zoning Bylaw	✓	✗	✗	✗
Restrictive Covenant	✓	✗	✓	✓
Subdivision Regulation	✓	✗	✗	✗
Public Education	✓	✓	✗	✓
Recent Floodplain Map	✗	✗	✗	✗
Dike Upgrade	NA	✗	✗	✗

Table 3 shows that over half of the tools are underutilized¹⁴ in the municipalities in this study. These tools include development permit areas, floodplain bylaws, zoning bylaws, subdivision regulations, recent floodplain maps, and dike upgrades. The barriers

¹⁴ A tool is considered underutilized if it is used in one or none of the municipalities surveyed.

to their adoption were discussed with interview participants and are explained in section 7.2.

The implementation of tools is inconsistent in the study area, and no tool is used consistently across all four municipalities. This finding is not surprising. The impacts of climate change will not be evenly distributed, and thus solutions should be tailored to the specific impacts in each region. For example, the landscape of Vancouver is largely urban and the flood management tools employed will be much different than the tools that other less urban municipalities will employ.

It is also important to note that the results of the case study analysis may not be representative of the level of commitment to flood management in the municipalities in this study. Specifically, the tools recommended by the provincial government may no longer be appropriate to manage the growing risk of flood hazards in the Lower Mainland. While the tools may be useful for general flood management, they may not be relevant for the specific risks they are designed to address. The extent to which these tools are still relevant is beyond the scope of this research. Further analysis is needed to determine which tools are most useful to address the growing risk of climate-related flooding, and which level of government should be responsible for employing flood management tools.

Similarly, the current division of powers is such that the 24 local authorities in the Greater Vancouver area (of which Vancouver, Delta, Surrey and Richmond are included) manage the issues of climate change and flooding independently. However, an independent approach likely does not ensure the most efficient use of resources for the region. The provincial government should reconsider the roles of individual municipalities in the Lower Mainland with respect to climate-related flooding.

It is clear that not all the available flood management tools are being used in each municipality. However, municipalities are demonstrating leadership by addressing flood risk through a number of other actions that may better address climate-related flooding. These actions are discussed in the following sections.

6.1.1. City of Vancouver

The City of Vancouver is well known for its climate initiatives, which include Canada's first Adaptation Strategy and the city's push to be the greenest city in the world by 2020. Unlike other municipalities, the city does not use dikes for flood protection, but instead relies on flood construction levels and building setbacks. The actions listed below represent specific steps taken by the city to address climate-related flooding.

The Adaptation Strategy

Vancouver is the first Canadian municipality to create a Climate Change Adaptation Strategy. The Strategy is the result of the five-step ICLEI¹⁵ planning framework. The priority actions identified in the Strategy specifically relating to flooding and SLR are to develop new flood-proofing policies and conduct a Coastal Risk Assessment study to develop a city-wide SLR adaptation response which will address new infrastructure needs, erosion protection considerations, land use regulation changes and plans for amenities such as beaches and the seawall (The Sustainability Group, 2012). A supporting action of these plans is to continue coordinating with other regional municipalities and other levels of government to ensure a regional approach to coastal flood management.

The Greenest City Initiative

Vancouver is in an international bid to be the Greenest City in the world.¹⁶ This bid is supported by the Greenest City 2020 Action Plan, which is divided into 10 smaller plans addressing three overarching areas of focus: carbon, waste, and ecosystems (City of Vancouver, 2012b). While this initiative is too broad to directly address climate-related flooding, the Adaptation Strategy discussed above resulted from Goal 2 of this plan.

¹⁵ ICLEI (International Council for Local Environmental Initiatives) is an international association of local governments and national and regional local government organizations that have made a commitment to sustainable development. The five milestones include: 1. a baseline emissions inventory and forecast; 2. emissions reduction target; 3. local Climate Action Plan; 4. implementation of policies from Plan; 5. monitoring of results. For more information, visit <http://www.iclei.org/action-center/getting-started/iclei2019s-five-milestones-for-climate-protection>

¹⁶ The complete Plan can be found at: <http://vancouver.ca/files/cov/Greenest-city-action-plan.pdf>

Flood-Proofing Policy Review

Vancouver's Flood-Proofing Policies are currently under review to reflect anticipated sea level changes communicated in the *Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use* document (City of Vancouver, 2007). While the policies are being reviewed, the city has encouraged an interim Construction Level Strategy which recommends that developers increase the level of all construction in the coastal floodplain by 1m above existing FCLs (which are currently 3.5m within 300m of the natural boundary and 3.0m when beyond 300m) (City of Vancouver, 2007).

6.1.2. Delta

Delta has been a leader in the Lower Mainland, participating in a number of innovative actions to further examine climate-related flooding. These actions are described below.

BC Agricultural Climate Action Initiative

Delta is halfway through a planning exercise with the BC Agricultural Climate Action Initiative who will produce an adaptation plan for agricultural producers in Delta. This plan will include solutions to mitigate the impacts of flooding on the farming community (personal communication, January 2013).

Official Community Plan (OCP)

Delta's OCP makes many statements related to climate change and flooding, though they are addressed separately. While section 2.1 discusses climate change specifically, flooding is not mentioned. The section that discusses dikes and flood-proofing does mention SLR, but no definitive actions are proposed.

Climate Change Initiative

In 2007, Delta's Council endorsed the Corporate Climate Change Initiative which is composed of nine action plans to reduce Delta's vulnerability to climate change and

the city's contribution to greenhouse gases (City of Delta, 2013b). This initiative includes a Flood Management Plan, the goal of which is to identify ways to reduce the risks associated with climate-induced flooding from SLR, spring freshet events, or extreme precipitation events (City of Delta, 2007). The progress report (from December 2010) states that improvements have been made to the flood infrastructure system to reflect SLR projections (City of Delta, 2011).

Flood Management Strategy Work Plan

The goals of Delta's Flood Management Strategy Work Plan are: to provide a framework for action that is consistent with the guiding principles for flood protection; to maintain and enhance the degree of flood protection provided to the community; and to consider and plan for changing environmental factors. One of the guiding principles of this work plan is to consider the future impacts of climate change (Radnidge, 2008).

Research Initiatives

The Delta Regional Adaptation Collaborative (RAC)¹⁷ is a partnership between the University of British Columbia's Collaborative for Advanced Landscape Planning (CALP) and the Corporation of Delta which works to identify, model, visualize, and evaluate potential flood impacts and adaptation options for the Corporation of Delta. CALP has produced a set of 2D and 3D visualizations based on local hydrological modelling for SLR and storm surge dike breaches, as well as visualizations and indicators for future scenarios. The visual materials are being used with staff and a citizens' working group to measure and assess the policy implications and social acceptability of the various adaptation strategies (Barron et al., 2012).

Delta also participated as a case study in Natural Resources Canada's Municipal Case Study series: Climate Change and the Planning Process (Natural Resources Canada, 2010).

¹⁷ The RAC is a federal program sponsored by Natural Resources Canada (see section 3.4.2).

ICLEI

Delta is also participating in the ICLEI pilot program that, once completed, will result in a formal Climate Change Adaptation Plan. Delta is currently completing Milestone 2.

6.1.3. Richmond

Richmond has a number of flood management initiatives, including a floodplain bylaw limiting new development on floodplain areas. However, specific policies addressing climate adaptation in relation to flooding are limited.

2008-2031 Flood Protection Strategy

The Flood Protection Strategy was created to respond to the 2003-2004 legislative changes, and in particular to address climate change as it relates to flood protection. However, standards for SLR have not been established (Erceg & Gonzalez, 2008).

Floodplain Designation and Protection Bylaw (No. 8204)

Richmond is the only municipality in this study with an official floodplain bylaw. The bylaw prevents development from encroaching onto dikes and requires that all new finished floor areas susceptible to flood damage be above the FCL. However, the bylaw does not discuss adaptation or vulnerability to increased flooding and exemptions allows some development in the floodplain (Bylaw 8204, 2008).

Official Community Plan (OCP)

Richmond's OCP was updated in November 2012 to include climate change considerations. Section 2.4 of the OCP discusses climate adaptation and includes an objective for "sustainability staff to lead the integration of climate change adaptation considerations into key policies, plans, programs and services, including land-use and development decision-making, city infrastructure design and management; *floodplain management*, emergency preparedness, natural ecosystem health, agricultural viability,

social development planning and economic development” (emphasis added) (City of Richmond, 2012b). The City of Richmond City Centre Area Plan (a local area plan contained in the OCP) includes a direction to explore adaptation strategies that would strengthen community resiliency to climate change (City of Richmond, 2009).

Lulu Island Dyke Master Plan

In 2011, Council approved the Dike Master Plan. Richmond is currently undertaking Phase 1, which is primarily focused on identifying a long term flood protection improvement plan for the Steveston and southern West Dike area. The Dike Master Plan is intended to be a comprehensive guide to upgrade flood protection infrastructure to adequately protect Richmond from both ocean storm surges and Fraser River freshet events and to adapt to SLR from climate change (Irving, 2012). While the plan is currently limited to the Steveson area, the intention is to extend the plan to the whole region in the future (personal communication, January 2013).

The Climate Change Strategic Program

This program includes climate change adaptation targets, which require all city managers to undertake climate change awareness education and to prepare a Strategic Adaptation Plan by 2013 (Carlile, 2010). However, Richmond is currently not a member of ICLEI so it is not clear if the Adaptation Plan will be a result of this process as has been the case in the other municipalities in this study.

City of Richmond Waterfront Strategy

The Waterfront Strategy is a Parks department strategy adopted in 2009.¹⁸ While there are references to climate change in Strategic Direction No.5 (Responding to Climate Change and Natural Hazards) it is not clear if the stated intentions represent meaningful action that will be taken in the near future.

¹⁸ Available at: http://www.richmond.ca/__shared/assets/Waterfront_Strategy29243.pdf

6.1.4. Surrey

As is demonstrated by the policies listed below, adaptation to climate-related flooding is a relatively new concept in Surrey.

Official Community Plan (OCP)

Surrey's OCP presents various floodplain policies, though none of them are specific to climate-related flooding. However, the OCP is in the process of being rewritten so there may be more attention to this issue in the near future.

Climate Change Floodplain Review

The Climate Change Floodplain review is in process, and aims to examine the projected SLR impacts on the Sepentine, Nicomekl and Campbell River systems discharging to the Semiahmoo Bay/Boundary Bay area (Baron, 2011). However, additional studies will be required to clarify climate-related impacts such as the effect of a dyke breach scenario, critical timing of water levels on various components of the drainage system, and subsidence implications (personal communication, January 2013).

2009 Crescent Beach Climate Change Adaptation Strategy

This strategy looks at SLR, local subsidence and redevelopment practices in the Crescent Beach area which lies within the Boundary Bay floodplain (Lalonde, 2009). Prior to adopting this strategy, flood control within Crescent Beach consisted of a dyke system protecting the area from ocean surges and storms.

Sustainability Charter

The Sustainability Charter is Surrey's framework for implementing a 50-year vision of sustainability. One of the commitments to addressing climate change is the creation of an adaptation strategy, and one of the six cross-departmental working groups in the strategy will be flood and drainage. The city is currently designing this strategy by identifying critical infrastructure, vulnerable areas, mitigation options and costs (personal communication, January 2013).

Council Floodplain Policy

This policy involves a moratorium on new development in floodplain areas throughout Surrey. However, this policy is not an official floodplain bylaw and thus is not subject to the same liability or enforcement concerns of a floodplain bylaw.

6.1.5. Summary of Case Study Findings

Each municipality acknowledges the increased threat of flooding from climate change. While some tools are underutilized, municipalities are taking other actions which may better address climate-related flooding. These actions include the intention or implementation of adaptation plans or strategies, flooding strategies that consider climate adaptation, and participation in research studies that examine risk and local inundation scenarios. The City of Vancouver leads the movement towards adaptation planning in Canada. The other municipalities in this study are in the process of creating similar adaptation plans. It is worth noting that the creation of adaptation plans has occurred independently of provincial oversight.

In general, there are few examples of policies that specifically address the threats from climate-related flooding. Climate adaptation and the links with flooding are very generalized in Surrey and Richmond, and the extent to which it is being addressed tends to be limited to catch phrases in OCPs and sustainability initiatives. However, Vancouver and Delta seem to be addressing the links between climate change and flooding more comprehensively through actions such as the Adaptation Strategy and interim FCLs (Vancouver) and flood visualization research (Delta).

The inclusion of adaptation into flood management considerations (or vice-versa) is very recent. Therefore, it is probably too early to measure the effectiveness of each municipality's progress. Likely the connections between flood management and climate adaptation will only increase as the impacts of climate change continue.

7. Findings and Analysis: Barriers to Adaptation

This chapter presents the results from the literature review and interviews. The climate adaptation literature defines barriers that may prevent decision makers from implementing adaptation policies. The findings from the case studies discussed in the previous chapter and the interviews discussed following are consistent with the literature, showing that local governments in the Lower Mainland experience similar barriers to climate change related flood management.

7.1. Literature Review Findings: Barriers to Adaptation

Although many studies have focused on identifying impacts and vulnerabilities or evaluating adaptation options, very few studies specifically address the institutional barriers governments face to generating adaptation policy. The literature review examines the impediments to adaptation practice in general. Flood hazard management ultimately relies on known adaptation strategies to effectively plan for climate impacts. The literature outlines a number of barriers that make the implementation of adaptation policy difficult. These barriers include: a) lack of access to climate information, b) myopia, c) resources and capacity, d) leadership and policy landscape and e) liability.¹⁹ This discussion helps outline criteria for the analysis of policy options in order to address successful adaptation to the increase in flood risk due to climate change.

¹⁹ An alternative response considers cognitive processes as a limitation to adaptation. Adaptation can be a social phenomenon, where “limits are endogenous and emerge from ‘inside’ society” (Adger et al., 2009, p.338). Using this assumption, the limits to adaptation are mutable, subjective and socially constructed (Adger et al. 2009). While the literature outlines a number of cogitative responses that may hamper adaptation efforts, this study will only focus on the institutional barriers identified in the literature.

a) Lack of Access to Climate Information

A lack of information can prevent local government from taking action on climate change. A lack of access to information outlining the vulnerabilities of municipalities to climate impacts has been identified as a barrier to climate adaptation (Measham, Preston, Smith, Brooke, Gorddard, Withycombe, & Morrison, 2011). In particular, misunderstood information, misinterpretation of the information, or a lack of content or frequency of information can be a significant disruption to the work of those involved in adaptation processes (Moser & Ekstrom, 2010). A New Zealand case study found that the most critical issue regarding barriers to adaptation in local government was the need for clear information from reputable and trustworthy sources (Lawrence & Quade, 2011).

Access to climate information is important because a significant amount of uncertainty exists regarding the impacts of climate change. For example, while scientific models show that climate change is already occurring, at this point in time, society does not know when or how severe future impacts will be (Quiggin, 2008). There is a concern that in the uncertainty about climate change, 'business as usual' policies will lead to inaction (Quiggin, 2008). Governments may be weary of spending money on adaptation projects while the specific impacts of climate change remain uncertain.

Information can close knowledge gaps that decision-makers have by converting uncertainty into knowledge about local risks. If societies do not perceive risk, there will be little action taken to pursue adaptation (O'Brien et al. 2006; Adger et al., 2009). With more abundant or more precise information, decision makers will be better positioned to support adaptive actions in the short term.

Governments must address the trade-offs that occur with a lack of information. While delays preparing for the impacts of climate change may result in terrible flood losses in the medium term, over or unnecessary preparation is costly (Hanak & Lund, 2012). Addressing the trade-offs between present costs and future benefits is further discussed with the concept of myopia.

b) Myopia

The projected impacts of climate change imply that the global community should respond now to avoid future damage. However, humans tend to be myopic, in that they

favour the short-term over the long-term, or discount potential future benefits of current actions (Stoll-Kleemann et al., 2001). A dilemma arises when policy makers must consider the future impacts of climate change. This can complicate the policy-making process, as decision makers must continually address the trade-offs between present costs and future benefits. If policy makers suggest an allocation of resources to address the threats of climate change, other pressing short-term societal problems may be neglected.

Climate policy-making relies on a number of models to predict impacts that climate change will have in the future. Any prediction far into the future elicits more uncertainty. For example, “the plausible range of damages associated with a ‘business as usual’ policy range from zero (or perhaps small net benefits) to catastrophic damage including the extinction of most animal and plant species and threats to the viability of our current civilization” (Quiggin, 2008, p. 205). Given the wide range of potential impacts, diverting current resources to alleviate an unknown level of risk remains a serious public policy dilemma.

c) Lack of Resources and Capacity

An availability of resources is important at almost every stage of adaptation (Tribbia & Moser, 2008). Resources can be financial, but can also include informational resources, technology, staff expertise, and time. According to recent research, “inadequate resources” is often the first response practitioners give when asked why they have not yet begun adaptation planning (Tribbia & Moser, 2008).

In a UK study examining the local capacity for strategic response to climate risks, 74% of respondents cited insufficient staff resources to analyze and assess relevant information, just under 60% mentioned insufficient staff time to even begin getting informed about climate change by gathering relevant information, and 46% referred to a lack of technical assistance from regional or state agencies (Few, Brown, & Tompkins, 2007). Similar results are reported by Burch (2010) who found that few municipal employees have the time or inclination to address adaptation-related tasks.

A local study in Surrey, BC found that cost was a key barrier to both mitigation and adaptation planning to address the climate impacts from flooding (Rowett, 2009). As

the impacts of climate change can damage public and private infrastructure, the upfront cost to either protect or repair infrastructure could be a significant burden for local governments.

d) Leadership and Policy Landscape

A study on the needs of coastal managers revealed that a lack of high-level leadership and governance can undermine the capacity and willingness to make adaptation decisions (Tribbia & Moser, 2008). This may be especially true when there is no mandate, law, employee responsibility and job description, or public demand for adaptation planning (Tribbia & Moser, 2008). Furthermore, the time horizons of coastal planning are generally too short for the consideration of the long-term impacts of climate change (Few, Brown, & Tompkins, 2007).

Another constraint to local institutions in adapting to climate change is the local planning context. As Measham et al. (2011) comment, the policy framework through which local governments operate is by reference to higher levels of government; often municipal authorities have no constitutional standing of their own. This is certainly the case in the Lower Mainland. One local study found that respondents were frustrated with the inconsistencies between municipal, regional, provincial, and federal approaches to climate change (Burch, 2010).

One of the most frequently cited barriers to climate change adaptation in the Lower Mainland is the absence of strong leadership, both technical and political (Burch, 2010). In Burch's study, interviewees suspected that political support for climate action was simply a politically savvy response to the public mood, and that political statements in support of climate action were not backed by the decisions needed to take significant action.

e) Liability

Legal liability is an important concern for local governments. In the context of climate change, liability is most likely to arise in the form of negligence or nuisance claims against local governments. For example, a local government can be found to be negligent if it can be proved that reasonable care towards its residents has not been exercised. However, a key consideration for courts is whether or not the harm in

question was reasonably foreseeable. Local governments may find it difficult to defend negligence or nuisance claims made against them if they did not take the “foreseeable” climate impacts into account. Therefore, municipalities could potentially be liable if development is approved in an area that is at risk from natural hazards that may be exacerbated by climate change (such as flooding) (Carlson, 2012).

A class-action lawsuit example from Stratford, Ontario clearly illustrates this scenario. After a large flood occurred in 2002, the city paid \$7.7 million to more than 800 home-owners, as well as approximately \$1.3 million in emergency compensation immediately after the flood (City of Stratford, 2013). A similar situation occurred in Thunder Bay, Ontario where a class-action lawsuit against the municipality was launched alleging negligence in the design and maintenance of the city water, storm, and sewer systems and failure to account for recent climate change in their planning. Lawyers are seeking damages totalling \$300 million on behalf of local residents (“Thunder Bay,” 2012). A local example that resulted in death occurred in the District of North Vancouver in 2005. One woman was killed, another seriously injured, and 100 others were forced to flee their homes after a landslide (“1 dead as mudslide destroys,” 2005). A subsequent report found that the slide was both predictable and preventable, and a lawsuit against the District was settled in 2009 (“North Vancouver District settles,” 2009).

7.1.1. Summary of concepts

The concepts explored through the literature review demonstrate that a number of barriers to adaptation exist. As detailed above, lack of access to climate information, myopia, lack of resources, leadership, and liability are all constraints to adaptation planning. As the results from the participant interviews demonstrate in the following section, the barriers to further implementation of such policies are similar to the barriers outlined above. These barriers may be evidence for why policies that simultaneously address flooding and adaptation are limited.

7.2. Interview Findings

Below is a thematic analysis of the information gleaned from interviews. Participants shared information related to barriers to implementing existing flood management tools in light of climate adaptation.

7.2.1. *Participation with Flood Management Tools*

A number of barriers complicate the implementation of the available flood management tools. As chapter 6 highlighted, a number of tools are not fully implemented across the study area. Interview participants were asked why these particular actions were not taken. Their responses are discussed below.

Dike Upgrades

Most municipalities in this study have not yet upgraded dikes to be consistent with provincial standards for SLR. Vancouver does not have dikes, but is considered an exception due to the interim Construction Level Strategy. According to interview participants, municipal governments have not yet adhered to provincial standards due to barriers such as cost, lack of support, lack of specificity, and liability.

For example, most interview participants mentioned that cost was the most significant barrier. The *Cost of Adaptation – Sea Dikes and Alternative Strategies* report (Delcan, 2012) estimates the cost of upgrading existing infrastructure to meet the rise in sea level predicted by 2100 in Metro Vancouver to be \$9.5 billion over the next 90 to 100 years. This cost estimate includes design, project management, land acquisition, environmental mitigation, impacts on utilities and pump stations and earthquake-resistant construction methods. The provincial inspector of dikes has confirmed there is no new funding tied to the new standards (Hoekstra, 2011). One interview participant mentioned: “the crux of the issue is that we don’t have the money. There is no way that a municipality or all the municipalities together could find the \$9 billion dollars that is estimated.” Another participant commented that: “No local government has funding to do this kind of work especially given the other conflicting needs at this time.”

Specifically, participants mentioned that solutions should be designed for potential future expansion because it is not cost effective to invest in something in the present that will only need to be redesigned in the future. Solutions should be flexible so future changes will be less challenging. This could involve allowances for dike upgrades over time to better reflect local risk and consequences of flooding.

Some respondents commented that the provincial recommendations are simply too broad. The recommendations were criticized for neglecting potential urban design and zoning challenges that municipalities would face by adhering to the recommendations. For example, the recommendations make reference to building dikes higher to protect communities from SLR, but this is irrelevant for communities such as Vancouver which does not rely on dikes as a primary means of flood protection. Two participants commented that the guidelines should be more flexible to allow municipalities to incorporate solutions that are more appropriate given each municipality's own planning context and risks.

Most participants stressed the importance of local solutions. This is especially relevant regarding global climate models that make generalized predictions that may not be relevant on smaller scales where impacts may differ considerably. Not all municipalities have faith in the heights that the provincial government has suggested because the science may not be specific enough to justify undertaking the upgrades in the present. One participant mentioned that it is still too early to expect widespread compliance with the recommended policies, as they were only recently released (early 2011).

There was also general agreement that increased financial support should come from the provincial or federal governments. However, the details of this support varied among participants.

Floodplain Maps

Since the changes in legislation, the provincial government no longer provides flood hazard maps.²⁰ While the maps identified areas prone to flooding and areas recognized as floodplains by both the federal and provincial governments, the maps are now largely out-of-date (APEGBC, 2012). In fact, most of the Lower Mainland remains unmapped and existing maps are generally 20 to 30 years out of date (Peters, 2012). However, the provincial government still maintains guidelines²¹ on creating flood hazard maps.

The municipalities in this study do not have official floodplain maps and interview participants did not unanimously support the suggestion of further floodplain maps. Participants cited cost and liability as primary reasons why they are not maintained. However, some participants mentioned that flood mapping may be useful to meet information gaps at the municipal level, provided that financial support was available from another level of government.

Floodplain Bylaws, Zoning Bylaws and Subdivision Regulations

There is limited use of floodplain bylaws, zoning bylaws and subdivision regulations in these municipalities. Interview respondents identified impediments to the implementation of these tools to address flood and climate-related flood risks.

For example, liability is an important factor in relation to these tools. Since the transfer of responsibility for flood management in 2003-2004, local governments are responsible for designating lands as floodplains. Yet the primary financial assistance for local governments to repair, rebuild or replace flood-damaged structures is from the provincial government, (as specified in the *Compensation and Disaster Financial Assistance Regulation of the Emergency Program Act*). However, Section 15 of this Act

²⁰ The Floodplain Mapping Program lasted from 1987 to 1994, and was jointly created by federal and provincial governments with the goal of minimizing flood damage in BC (BC Ministry of Water, Land and Air Protection, 2004).

²¹ The *Coastal Floodplain Mapping-Guidelines and Specifications* is produced by MFLNRO and is available at:
http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/coastal_floodplain_mapping-2011.pdf

stipulates that no assistance will be given unless the structure can be said to have been properly protected from risk of flood, based on provincial guidelines of minimum requirements for land use in flood hazard areas (*Flood Hazard Area Land Use Management Guidelines*) (BC Emergency Program Act, 2006). Provincial emergency assistance will not pay for damage to properties that have been issued variances. So municipalities are liable for flood damages to such properties. Liability is, therefore, a significant concern for a number of municipalities that may be considering implementing floodplain bylaws. The liability concern is thus relevant for both floodplain maps and floodplain bylaws, both of which clearly designate lands as being at risk of flooding. One participant assumed that the provincial government is aware of the liability concerns within floodplain areas. However, it is not clear if such awareness on the part of the provincial government is a deliberate sidestepping of this issue.

Important to note, however, is that while municipalities may not be officially designating lands as floodplains based on bylaw or official floodplain maps, this does not mean that municipalities are not adhering unofficially to flood standards. Most municipalities still maintain the FCLs which they advise residents to use.

7.2.2. *Participation with Climate-related Flood Policy*

Generally, interview participants conveyed that effective measures are being taken to address climate-related flooding. Even though municipalities in this study are not exclusively implementing the available tools, municipalities are responding to climate-related flooding through other measures. Alternative measures include: adaptation strategies and plans that link the current and expected impacts of climate change to flood management in local jurisdictions; flooding strategies that consider climate adaptation; and participation in academic research to examine risk and local inundation scenarios. All participants gave a high or medium-high rating when asked to report the level of individual municipal participation with strategies that address climate-related flooding. This participation can be further outlined by the intention to create adaptation strategies. However, two participants mentioned “opportunity windows” in regards to future climate adaptation and flooding strategies. That is, some strategies may only be adopted if the opportunity arises and if the benefits can be seen across departmental mandates. Therefore, some adaptation policies may be seen as

opportunistic rather than as guided by underlying intentions to increase adaptability and resilience over the long term.

While interview participants shared reasons why the recommended flood management tools are not implemented, participants also mentioned barriers that relate to further strategies for climate-related flooding. These general barriers, which are discussed below, include: lack of funds, lack of agency coordination and lack of long-term planning.

Lack of Funds

Municipalities lack funds to conduct the localized research necessary to develop comprehensive strategies. Examples include the cost of conducting studies on local SLR risk and vulnerability, rainfall estimates, where dikes should be placed, etc. The individual studies need to be conducted before any new policy mechanisms are established or any infrastructure upgrades or new infrastructure built. For example, one participant asked, “how do we make a policy change without the data to support it?” (personal communication, January 2013). Such studies generally include engineering support to outline options for what is physically feasible and desirable for a certain location.

Municipalities are wary of unnecessary spending, especially as this would require raising current taxes, a move that is not politically favoured. Further complicating this is uncertainty about the reliability and accuracy of current SLR and other climate-related predictions. Some interviewees expressed concern about investing in infrastructure upgrades or other adaptation projects when different SLR models are not consistent. Another concern was the risk of implementing strategies when the probable effectiveness of that strategy is unknown. One participant commented that it can be difficult to justify investing in flood protection if it is not clear how effective the strategy will be until the benefits can be proved through further research. For example, one participant commented, “intuitively you know that there is a benefit but until you document it, it’s very hard to address that.”

Lack of Agency Coordination/ Lack of Leadership

Some interview participants highlighted the failure to coordinating climate adaptation policy through multiple departments. The participants commented that climate adaptation requires the cooperation of a number of departments to represent the range of expected impacts. Thus climate change cannot be managed in silos but must consider interdepartmental and sometimes inter-jurisdictional collaboration to address the complexities of the anticipated impacts. For example, Delta and Surrey are home to vulnerable infrastructure such as YVR airport, ports and highway infrastructure. This infrastructure is not under municipal jurisdiction and remains the responsibility of provincial and federal governments. Thus, participants stressed other government agencies should be involved in designing solutions that address the risk to these regions rather than leaving the responsibility with individual local governments of limited abilities and resources.

Lack of Long-Term Planning

Some participants mentioned that, while municipalities may be clear on the necessary solutions to enhancing local resilience to flooding, there is a lack of incentives which would motivate stakeholders to commit to adaptation, consistently and over time. Some municipalities are constrained by a lack of long-term vision, possibly explaining their reluctance to invest in solutions to address both current and future problems.

7.2.3. *Call for Provincial or Federal Support*

Many interview respondents advocated for stronger support from higher levels of government. This was especially so in relation to financial, technical, and policy support to help municipalities better prepare for the increased risk of flooding due to climate change. This was also highlighted by the fact that floods affect the operation of multiple government departments, but management remains with local governments specifically. For example, one respondent commented, “you can’t expect municipalities to go this alone, it’s just too big.”

7.2.4. Call for Regional Support

A number of interview respondents also called for a regional approach to flood management. For example, all municipalities have a responsibility to protect human life and public and private infrastructure from the risk posed by future climate-related flooding. As all municipalities will need to conduct further research to determine what specific changes are needed, where they are needed, and when they will take place, a coordinated effort to address the wide-ranging effects would be beneficial. For example, installing structures such as dikes can have unintended consequences downstream by creating sediment backup in other areas. The effectiveness of the dike itself can be reduced if an extensive dike project is constrained by regional boundaries. Therefore, greater benefits can come from sharing projects that span across boundaries to ensure full protection for the entire area.²²

7.3. Discussion of Themes

The results from the literature review, case studies and interviews suggest a number of useful themes for understanding flood management and adaptation to climate change in the Lower Mainland. These themes are summarized below.

Barriers exist for local governments to adapt to climate-related flooding.

Successful policies will focus on removing these barriers so local governments can better manage flood hazards. The most important barriers experienced by local governments are lack of resources, lack of agency coordination, lack of information and increased liability. The barriers that municipalities face could also largely be attributed to the change in provincial legislation that transferred this responsibility to local governments. Therefore, addressing these barriers ultimately means that the governance structures in which municipalities are operating should also be examined. While this is beyond the scope of this analysis, the findings of this report indicate the importance of a renewed role from the provincial government.

²² A number of other concerns were mentioned during the interviews, which will not be considered in the analysis of policy options. These concerns are described in Appendix D.

Scale is an important context for understanding and undertaking appropriate actions for adaptation, as the scale at which adaptation actions occur is different from the scale at which adaptation policy should be supported.

There appears to be a disconnect between the assumptions of the provincial government about what adaptation should look like in theory, and how flood management occurs in practice in local communities. It is clear that adaptation should occur at the local level because local governments are responsible for much of the infrastructure and services that are vulnerable from climate change. Similarly, too much oversight from the provincial government will result in generalized information that is not specific enough to address the localized impacts of climate change. This represents a tension between the scale at which adaptation occurs, and the scale at which the policy to support adaptation occurs. While adaptation actions are probably best taken at the local level, these actions will be impossible without added support from higher levels of government. Adaptation to flood threats will require significant collaboration and support across different a variety of departments and levels of government.

Policies to address adaptation and flooding simultaneously are few but increasing.

While adaptation actions seem to be occurring to some extent in municipalities, the actions that specifically connect climate adaptation and flooding are limited. Adaptation is a relatively recent phenomenon in the scientific literature and it may take some time for this information to trickle down to municipal planning and policy. However, there remains a strong sentiment amongst interview participants that the study area has a high level of participation with adaptation and flooding.

The following chapter presents a number of policy options that address these themes and that could be applied to flood management and climate adaptation in the Lower Mainland.

8. Management Options

This paper argues that municipalities in the Lower Mainland face barriers that may be preventing the full use of flood management tools, thus potentially increasing their vulnerability to climate change. Potential policy options should consider reducing these barriers to ensure that municipalities are prepared for flood risk from climate change.

Even though the provincial guidelines for sea dikes were recently updated to include considerations for climate change, the other tools recommended by the provincial government are not specific to climate change. These tools do not encourage the shift that is needed to properly address the threat of climate-related flooding in BC. Therefore, policies addressing this issue should favour options that give municipalities more support to manage flooding to ensure adaptation options are relevant for their existing budget, expertise, and local level of risk.

Choosing the most appropriate policy option is challenging. This is especially because adaptation approaches to increasing flood risk are still emerging. However, reducing the barriers that municipalities face to addressing floods in general may be a useful first step to addressing adaptation in particular. As all municipalities face different risks and have different geographical, social, and economic contexts, a one-size-fits-all approach will not be appropriate. Therefore, strategies that support adaptive management at the local level will be most useful in the long-term. In the short-term, it is necessary to address, at the provincial level, concerns regarding lack of funding and lack of information.

The policy options described below represent changes that could be made at municipal, regional and provincial levels of government. This is because the scale at which to manage adaptation to climate change and flooding depends on which tools are implemented. While adaptation itself is a local process, the policy with which to support adaptation may not exist at the local government level. For example, some policies

require further funding or regional oversight to better manage the risk from climate-related flooding. Therefore, these options should be considered in tandem and it is possible that the best strategy will require municipal, regional and provincial collaboration to most adequately ensure that adaptation planning is occurring in anticipation of the threats of climate-related flooding in the Lower Mainland.

The policy options considered include: the status quo, a regional flood protection strategy, a regional adaptation strategy, a flood protection levy, and further provincial support through an adaptation fund or a floodplain mapping program. These options were chosen because they either reflect general feedback from interview respondents or specifically address one or more components of the policy problem. For example, the regional flood protection strategy was chosen because there is wide support for this option and because of its potentially high level of effectiveness in addressing interagency coordination and the stresses that individual municipalities face. Similarly, the adaptation strategy was chosen because it offers the opportunity to initiate adaptation on a regional level and allows for the mobilization of resources throughout the region. The flood protection levy was chosen specifically for its function to relieve financial stress on municipalities by placing a portion of the expense of flood management directly on the public. The options that call for provincial support are included in the analysis because it is clear that municipalities would benefit from some form of external support. The options considered for analysis are discussed below.

8.1. Status Quo

The status quo option represents the current policy context in which each municipality independently addresses flood hazard management and climate adaptation. Policy responses are disaggregated and decisions for flooding and adaptation are made at the individual council level. The status quo may be appealing for some local governments due to a variety of resource constraints or other limiting factors. However, land use decisions made today will have consequences later this century when the anticipated impacts of climate change will become more prominent.

8.2. Regional Flood Protection Strategy

Regional policies that ensure municipalities can better manage climate-related flood hazards should ensure that they have the resources they need. The inconsistencies between municipalities in the Lower Mainland in the use of policies addressing climate-related flooding provide evidence for a policy that considers regional management of this issue. For example, it is clear that local governments lack resources such as funding and internal technical capacity to address this issue. While some municipalities such as Delta and Vancouver have examined SLR implications through flood inundation scenarios, this information is not available on a regional basis to determine the full extent of the impacts. Climate change will not discriminate between locations and its effects will be felt across jurisdictions. It follows that there is little incentive for one municipality to invest in significant flood management if the municipality bordering it does not.

This option advocates for flood management to be coordinated and administered at the regional level where combined policy efforts may be more effective than unilateral ones. A regional plan could set guidelines and standards for the whole region. A regional approach could also alleviate some of the pressure on staff members to address this issue independently and thus increase efficiency. An important component of this option could be to create regional vulnerability maps that would help prioritize actions in areas that are most at risk.

A regional strategy could also include a broader set of jurisdictions and interests such as highways, agricultural lands, utilities, industry and other specific jurisdictions (e.g. Port Metro Vancouver or YVR), specifically those entities over which local governments do not have jurisdiction. This option would speak to the need for multi-level and cross-jurisdictional responses to address SLR.

The provincial government or another body such as the Fraser Basin Council (FBC) could lead this initiative to ensure that municipalities are not left alone to make decisions regarding large infrastructure upgrades or investments. The FBC initiated the Joint Program Committee (JPC) for Integrated Flood Hazard Management, which is a multi-party, consensus-based committee that brings together 36 federal, provincial, and

local government agencies and organizations to address flood risks. While the FBC itself has no mandate or authority to oversee flood protection works or emergency services, it plays a role in supporting government authorities through the coordination, facilitation and secretariat of the JPC. The plan for a regional strategy was outlined in the *Cost of Adaptation-Sea Dikes and Alternative Strategies* report and some initial steps to prepare a regional strategy are already in place or have been partially completed.

The regional strategy could be modeled after the Fraser River Flood Control Program (FRFCP) (1968-1995). This program took a long-term approach, established a management board for decision-making, and employed a technical board to develop standards and prioritize work. Diking authorities managed individual projects but a larger governance structure was in place. Therefore, the FRFCP could be a useful model for local governments to follow if considering implementation of a regional strategy.

8.3. Regional Adaptation Strategy

This policy option advocates for the creation of an adaptation committee at a regional level. This committee could involve municipal leaders who would add political force to a process that usually relies on planners. While in theory this policy is similar to a regional flood protection strategy, this option would consider a wider range of climate threats. Therefore, this option would create more flexibility than a regional flood protection strategy. The organization of this committee could be modeled after the successful Southeast Florida Regional Climate Change Compact.²³

This option could be supported by existing mandates from Metro Vancouver; specifically by the Regional Growth Strategy which recognizes that many of the major natural hazards that the region experiences (such as floods) are exacerbated by climate change (Metro Vancouver, 2011). As part of Strategy 3.4 in Regional Growth Strategy, the region will encourage land use and transportation infrastructure that improves its

²³ The Southeast Florida Regional Climate Change Compact was created to manage mitigation and adaptation activities across county lines. The Compact is designed to allow local governments to set the agenda for adaptation while providing an efficient means for state and federal agencies to engage with technical assistance and support. More information is available at the Compact website: <http://southeastfloridaclimatecompact.org/>

ability to withstand climate change impacts (which include SLR) and natural hazard risks (which include flooding) (Metro Vancouver, 2011).

A regional strategy would be an effective way to manage the risks of climate change across the Lower Mainland. Because adaptation typically works on the scale of an impacted system, the greatest opportunities for success occur at the local level (Klein et al., 2007). This option could be cost effective for individual municipalities not only because of streamlining efforts through collaboration, but also because there could be a stronger call for funding from higher levels of government if municipalities in the Lower Mainland cooperate.

8.4. Flood Protection Levy

Given that lack of finances is the largest barrier that municipalities face to addressing the risk from climate-related flooding, the creation of a funding mechanism is an obvious solution to support municipalities. This policy option would allow municipalities to conduct site-specific studies and infrastructure construction or upgrades to better address SLR and other climate induced flooding.

This funding would come from levies on existing property taxes in municipalities in the Lower Mainland. This tax could be administered in a similar way to the existing Drainage Parcel Tax in Surrey which is added to existing sewer and drainage utility taxes. Currently, all monies collected from the drainage parcel tax are used to maintain and upgrade the city's drainage system which includes rivers, creeks, ditches, dikes, drainage pump stations, storm-water pipe systems and detention ponds. Drainage works required by new development are funded separately by Development Cost Charges levied against new lots or buildings (Ham, 2002). Currently, this tax is a flat rate of \$140 for all Surrey property owners.²⁴ A similar tax could be applied to residents in local municipalities to help offset the cost of expensive flood protection infrastructure or other activities.

²⁴ Except for agricultural lands, where the tax is \$90 to reflect the \$50 charge they pay to private diking districts.

8.5. Provincial Support

A number of the barriers municipalities face could be attributed specifically to the change in legislation that assigned flood responsibility to local governments. Therefore, before any policy option is undertaken at the municipal level, the governance structures under which floods are managed should be re-examined. In this regard, strategies that call for further support at the provincial level should be considered in combination with other municipal and regional level policies. Without this oversight and support from the provincial government, municipalities will continue to struggle with the management of these important issues.

Without the creation of new legislation, this study proposes two non-legislative governance-structure proposals that could be considered at the provincial level to alleviate some of the problems that municipalities face. These options are a provincially-sponsored adaptation fund and a flood mapping program. While support for these options from interview participants was mixed, it is clear that further support in some form from higher levels of government is desired.

8.5.1. *Adaptation Fund*

Currently, there is no funding specifically reserved for adaptation projects at the regional or municipal level.²⁵ Municipalities in the Lower Mainland would benefit from an adaptation fund to help offset the cost of flood management. Such a fund could be offered through the existing Sustainable Environment Fund (SEF) administered by the provincial Ministry of the Environment. The SEF is intended to support the government costs associated with program delivery to protect and enhance the environment (Sustainable Environment Fund Act, 1996). This fund totals \$50 million dollars²⁶ and estimates of SEF spending for the 2013/2014 fiscal year are approximately \$19 million

²⁵ The federally funded Regional Adaptation Collaborative (RAC) Climate Change Program ended in 2012. The Green Municipal Fund is another federally funded program, geared towards municipal environmental projects. While mitigation projects are considered for funding, there are no specific considerations for, or mentions of, adaptation projects.

²⁶ \$50 million was transferred to the fund from the Lottery Fund special account on April 1, 1990 (Sustainable Environment Fund Act, 1996).

(BC Ministry of Finance, 2013). An adaptation fund could allocate a portion of the SEF budget to coastal adaptation projects to support the financial and information gaps experienced by local governments.

Because the SEF is already established, this option would be relatively easy to implement and would not require any additional funds. For example, the Minister of Environment is legally and politically responsible for the performance of the SEF. Based on the definition of the fund it is well within the mandate of the minister to use a portion of the SEF revenue for climate change programs. Among other internal departmental activities, the revenues from this fund could include transfers to local governments (BC Ministry of Finance, 2013).

However, the reallocation of funds would not be without its own trade-offs. These trade-offs require further investigation to determine if the benefits of funding adaptation projects are greater than the loss of funding to other environmental projects within the SEF mandate.

8.5.2. *Floodplain Mapping Program*

A lack of information was cited as an important barrier to municipalities. As floodplain maps remain largely outdated in BC (see section 7.2.1), flood maps could be a useful way to ensure municipalities have access to the localized climate risks they face. However, because municipalities cited cost as a barrier to creating such maps, support for such mapping needs would come from a higher level of government. Thus the provincial government, in exchange for downloading flood responsibilities, could initiate a new floodplain mapping program. The resulting maps would identify the extent of the flood risk and perhaps predict trends resulting from climate change. The need for updated floodplain mapping and other technical flood hazard information was a recurring theme in a BC survey conducted by the Fraser Basin Council (Fraser Basin Council, 2008).

A flood mapping program would help to bridge some information gaps by providing municipalities with better information about the boundaries of floodplains and the expected reach of future floods. Flood maps would be a useful tool for outlining the

flood risks to the whole region, allowing municipalities to better prepare for the risks of flooding.

The importance of floodplain mapping was highlighted at a recent workshop hosted by the BC Real Estate Foundation.²⁷

²⁷ The BC Real Estate Foundation recently (March, 2013) held a workshop entitled “Planning to Avoid Disaster-Floodplain Maps Stakeholder Workshop”. The purpose of the workshop was for stakeholders to explore concrete steps to update existing floodplain maps in BC. More information available at : <http://www.bcrea.bc.ca/docs/government-relations/bcreafloodplainmapworkshoppromo.pdf?sfvrsn=2>

9. Criteria for Evaluation of Management Options

The primary goal of policies designed to improve adaptation to climate change is to reduce the barriers faced by local governments. Considering this, policy options should be assessed with a number of objectives:

- ensuring the costs of policies remain within the means of local governments;
- increasing support for local governments through interagency coordination;
- providing local governments with the specific and localized information needed to make informed choices;
- ensuring the policy considers liability;
- ensuring the policy is acceptable to municipal decisions makers;
- maintaining flexibility by instilling the principles of adaptive management.

The effectiveness of any policy in addressing climate-related flooding should be evaluated using the first four objectives which involve reducing the barriers to management. As long as constraints such as cost, lack of support, lack of information, and liability concerns remain too high, action addressing climate-related flooding in the Lower Mainland will be restrained.

Similarly, given that the responsibility for flood management is a relatively new responsibility for municipalities, a successful policy should be one that has a high degree of acceptability from local decision makers. Any policy option to reduce the barriers that municipalities face must consider how the policy will be received by the municipality itself. For example, some policies are more likely to be accepted by Council than others.

Finally, adaptive management provides flexibility in resource management and is thus an important component of any policy addressing the uncertainties of climate change. Adaptive management was defined in Section 2.1.3. It can be useful for examining climate change and its impacts on floods and droughts because the scientific

knowledge surrounding these issues is still not well understood (WMO/GWP, 2009). This criterion is important for decisions regarding climate adaptation because it means there is still uncertainty regarding how severe the impacts from SLR and freshwater flooding will be in the study area.

From these objectives, the following criteria can be used to assess policy options: effectiveness, acceptability and flexibility. These criteria were developed based on knowledge gained from the existing literature and participant interviews. The criteria and measures used to assess the policy options are listed in Table 4.

Table 4. Criteria and Measures Matrix

Criteria	Definition	Qualitative Assessment	Index
Effectiveness	The extent to which the policy will reduce municipal barriers to managing climate-related floods	A policy's ability to increase support through coordination between government agencies	Low Adequate Medium-high High
		A policy's ability to reduce financial burden on local governments	
		A policy's ability to increase knowledge for local governments	
		If a policy will reduce liability for municipalities	
Municipal acceptability	Level of municipal government support for the policy	The probability of acceptance by Council	Low Moderate High
Flexibility	Amount of flexibility an option can provide-i.e. adaptive management concept demonstrating a flexibility to cope with future climate changes with potential to amend policy in the future	A policy's ability to be flexible	Low Moderate High

Other criteria considered, but not included in the analysis are implementation costs and administrative ease. Including these criteria would risk double counting with one of the effectiveness measures (reducing financial burden). A policy option that would be both expensive and difficult to implement would not reduce the financial burden to municipalities.

10. Evaluation of Management Options

Using the criteria above, each proposed policy is analyzed to determine the most appropriate recommendation for local governments' flood hazard management. However, a distinction must be made between the policies directed at a municipal and regional scale and those directed at a provincial scale. Ultimately, local governments are well placed to address adaptation in general, but they lack the necessary funding to carry out such actions. Thus higher levels of government can assist local governments by sharing knowledge and offering access to the expertise and funding that is necessary for local-level adaptation projects. To ensure that the policy options can be adequately analyzed those options that involve municipal or regional governance will be analyzed separately from those that involve the provincial government.

The section below analyzes how each criterion is scored against each policy option. The options are ranked against each other to determine the level of effectiveness, municipal acceptability and flexibility. The results are tallied to produce a final recommendation.

10.1. Status Quo

The status quo will not be particularly effective, as it does not address the barriers that municipalities currently face. The barriers of cost, lack of interagency coordination, lack of information and liability will remain if the status quo continues. The status quo is assumed to be highly acceptable to municipal governments as it represents the current state of affairs. This option is the least flexible, as it does not allow municipalities the opportunity to employ the concepts of adaptive management to cope with the future impacts of climate change. This is because the status quo does not provide the flexibility required for uncertainty and adaptation planning.

10.2. Regional Flood Protection Strategy

The regional flood protection strategy has a high degree of effectiveness because it satisfies the first four policy objectives. Specifically, this policy will increase agency coordination and support for municipalities. It consists of support from the provincial government or another regional body such as the Fraser Basin Council; both of whom have limited jurisdiction over flood management, but will be able to offer support by facilitating interagency or even intergovernmental collaboration. Interagency coordination will be useful for addressing the wide range of services and infrastructure that are at risk from flooding. Such amenities include YVR, highways, or utilities located within municipal boundaries but not municipal responsibility. A regional flood strategy would ensure that planning occurs collaboratively to provide more comprehensive strategies for addressing flooding across the region and across government jurisdictions. This option would also reduce financial burdens on local governments, because the cost of significant regional projects (such as region-wide guidelines) could be shared. Collaborating with other local governments could allow for significant knowledge transfer among different municipalities with regards to localized climate impacts. This option would not increase the liability risk for municipalities, as the responsibility for flood management would not change.

With regards to municipal acceptability, this policy is likely to have a moderate level of support. Most interview participants were supportive of this option, which received higher support than the regional adaptation plan. Support for this option from Vancouver can be seen through the Adaptation Strategy, which calls to continue to “coordinate with other municipalities through the Fraser Basin Council and with the province of BC to ensure a regional approach” (The Sustainability Group, 2012, p. 33). However, this option would also require a significant amount of buy-in from municipalities in the Lower Mainland. The extent to which all municipalities would participate is unknown. When compared to the status quo, this option would need more support from the provincial government. The downloading of responsibility for flooding to the municipal level has contributed to the barriers that local governments face to addressing this issue. Therefore, removing these barriers would involve some further level of provincial support.

This option would be moderately flexible, as it would allow for priorities for action to be shared at a regional level rather than independently. Adaptive management is important for decisions regarding climate change because uncertainty remains about the severity of impacts from SLR and freshwater flooding. A component of adaptive management is to prioritize information sharing to enable the development of baselines, especially for high-risk areas (WMO/GWP, 2009). Adaptive management will be easier to conduct at a regional level where information can be shared between participating municipalities. Therefore, this option would be more flexible than the status quo which would leave municipalities to address climate adaptation and flooding independently.

10.3. Regional Adaptation Strategy

This policy option would have a medium-high level of effectiveness. While this option would increase support for local governments at a regional scale, this strategy would not address interagency support to the same extent as the regional flood strategy. Collaboration is a way to coordinate responses to the wide-reaching impacts of climate change which require larger scale responses to be effective (Carlson, 2012). Undertaking adaptation at a regional level would offer cost savings and synergies, both with respect to assessing impacts and to implementing responses (Carlson, 2012), thus reducing the financial burden of adaptation on local governments. Knowledge would also be increased as best practices of management techniques and risk evaluation could be shared among participating municipalities. This option would not increase the liability risk for municipalities, as the responsibility for flood management would not change.

The municipal acceptability for this option may be mixed. Support for this option in Vancouver would likely be high, as evidenced by the emphasis on regional collaboration in the Vancouver Adaptation Strategy. However, it would require a greater amount of political support in other municipalities than it has at the moment.

This option is highly flexible in comparison to the status quo because it will address a wider range of climate change impacts than just flooding. Therefore, this option is moderately more flexible than the regional flood protection strategy because flooding would be addressed within a wider context of climate adaptation. This would allow for

the properties of adaptive management to be used to the fullest, as knowledge is created through the collaborative process. Increased knowledge could better equip decision makers who function within a context of uncertainty. This option would allow for synergies to exist between various departments and working groups that address the different levels of climate adaptation separately.

10.4. Flood Protection Levy

The flood protection levy would be significantly less effective than the options mentioned above. The levy would not increase agency or support for local governments in any way. The governance structure would remain as the status quo. However, this option would have a positive effect on municipal finances, as it would place a greater burden on the public (landowners) to take responsibility and relieve some of the pressure that local governments face with regards to funding for flooding protection and infrastructure. This option would not change the amount of municipal knowledge with regards to the risk of flooding, nor would it change the level of liability on the municipality.

This option would also likely not be received well by individual municipalities, because it would involve an increase in property taxes. The public, to whom municipal leaders are accountable, would likely resist this increase in taxes. This option includes significant trade-offs. The collection of levies would offer greater financial support to municipalities, but it would create significant equity issues for homeowners. The levy would have to be applied to all homes in the municipality, regardless of their location in a floodplain or in an area vulnerable to the impacts of SLR. Those residents with homes removed from this risk would be paying the levies to subsidize the risk that the vulnerable regions face.

With regards to flexibility, this option offers a moderate level of flexibility. The reason for this is that once collected, the levy could be used for a variety of purposes, so long as it is used to combat flood risk in municipalities. Therefore, as the risks from climate-related flooding become clearer, this option can easily be amended to better address the issue at hand.

10.4.1. Summary of Analysis for Regional Options

Applying the criteria to each policy option helps to highlight the trade-offs that policy makers face. The matrices in Table 5 below and Table 6 (on page 72) represent these trade-offs. The red colour signifies a low score against the criterion; the yellow signifies a medium score, while green signifies a high score. The policy option with the highest score is the policy with the most characteristics to address the policy problem of reducing barriers to municipalities in addressing climate-related flooding.

Table 5. Synthesis of Policy Evaluation: Municipal and Regional Options

Policy Options	Effectiveness	Municipal Acceptability	Flexibility
Status Quo	Does not increase agency, reduce financial burden, increase knowledge or change liability	High acceptability	Low; does not consider adaptive management
Regional Flood Strategy	Will increase agency, reduce financial burden, increase knowledge, and will not increase liability	Moderate; requires significant buy-in, though has general support from interview participants	Moderate; sharing of information
Regional Adaptation Strategy	Will minimally increase agency, reduce financial burden, increase knowledge, and will not increase liability	Moderate; mixed support from short vs. long term	High; addresses wider range of climate considerations
Flood Levy	Will not increase agency, will reduce financial burden, will not increase knowledge, will not increase liability	Low; will not be politically favourable	Moderate; options for use of levy

10.5. Provincial Level Policies

The last two policy options, the adaptation fund and the flood mapping program require change on a provincial level. These policy options would relieve financial pressure on municipalities but will require changes to the existing policy framework. Therefore, the impact that these policy options will have on municipalities will be different from the local policies analysed above.

While the transfer of flood management may have been logical at the time of legislation change ten years ago, the growing threat of climate change illustrates that this may no longer be the case. Changes at the provincial level would help to reduce barriers that municipalities face as a result of the legislative changes by reclaiming some responsibility for flood management either directly through the reestablishment of a flood mapping program, or indirectly through the adaptation fund.

For example, these options will increase interagency coordination and support because they would directly engage more than one level of government. Both options provide increased financial support for municipalities, which will help to address existing funding barriers. However, it is unlikely that the adaptation fund will be substantial enough to fund the major infrastructure projects that are needed to address climate-related flooding. For example, as was evidenced in the *Cost of Adaptation-Sea Dikes and Alternative Strategies* report (Delcan, 2012), the estimated cumulative costs of adapting flood protection to meet the SLR predicted by 2100 in Metro Vancouver are anticipated to be \$9.5 billion. While these costs would be spread out over 90 to 100 years, it is a significant investment for local governments who already face limited budgets to address existing social and economic priorities. Given that the existing SEF, through which the adaptation fund could be created, has expected expenditures of \$19 million in 2013/2014, the extent to which a new fund could help local governments meet the significant costs of adapting to climate change is unlikely. This is of course, unless the adaptation fund was substantial enough to fund large infrastructure projects over

time. Therefore, the flood mapping program is likely a better allocation of resources in the short-term as the information gains will be quite high.

The flood mapping program would be an effective method of information gathering for municipalities as it will help local governments identify areas with the greatest flood risk. However, a potential trade-off with this increased information is the risk of increased liability for local governments. In contrast, the adaptation fund would not address information barriers, but it would also not affect liability either. Thus, it is clear that there are significant trade-offs for each policy option. Defining current government objectives will be necessary to determine which trade-offs are too important to ignore.

With regards to municipal acceptability, it is expected that support for the adaptation fund will be high because it will offer funding for the projects that individual municipalities identify as their greatest need. Municipal support for the mapping program will probably be mixed because it could offer financial support for municipalities to fund their own flood hazard maps, but identifying certain areas as being at risk of future flooding may increase liability.

The flexibility criterion was not used in the analysis of the provincial level options because it is not a relevant criterion. This is because the provincial options are not designed to consider the impact of new information. The only impact that new information regarding the impacts of climate change would have on the policy options would be an adjustment in the level of funding for flood mapping or adaptation projects.

10.5.1. Summary of Analysis for Provincial Options

The matrix in Table 6 represents the trade-offs policy makers consider. As discussed in section 10.4.1 above, the policy option with the highest score is the policy with the most characteristics to address the policy problem of reducing barriers to municipalities in addressing climate-related flooding.

Table 6. Synthesis of Policy Evaluation: Provincial Options

Policy Options	Effectiveness	Municipal Acceptability	Flexibility
Adaptation fund	Will increase agency, will reduce financial burden, will not increase knowledge, will not increase liability	High; will reduce barriers to municipalities	NA
Mapping program	Will increase agency, will reduce financial burden, will increase knowledge, will increase liability	Mixed; will reduce barriers to municipalities but may not be acceptable to all municipalities due to potentially increased liability	NA

This research shows that there are many trade-offs that exist when analyzing potential policy options for reducing barriers to municipalities addressing flood hazards. Ultimately, choosing one policy option will not immediately address all relevant concerns. However, the analysis allows for the trade-offs to be considered when making a final recommendation.

11. Recommendation

The results of the analysis above demonstrate two important findings:

- 1) a regional flood management strategy ranks above the other options considering its effectiveness to address the existing barriers municipal governments face;
- 2) a staged approach including a suite of policy options is necessary to ensure that the immediate risks of flooding are addressed.

This research recommends a staged policy approach. It is recommended that municipalities in this study seriously consider collaborating to establish a regional flood strategy to address the immediate risks of climate-related flooding. Second, the lessons learned from the flood strategy can be used to support the development of a regional adaptation strategy that clearly embodies the principles of adaptive management to address the long-term implications of climate change. Consideration of the roles and responsibilities of the provincial government with respect to flood management should be included.

According to Carlson (2012), robust adaptation strategies typically include a range of adaptive measures or actions to be implemented. A suite of policy options, including both regional and provincial policies, may be most suitable to ensure that floods are managed in the most effective manner given the resources available.

The policy option of creating a regional flood management strategy scores the highest in the above analysis with both local and provincial options. The high score is primarily because this option has the greatest effectiveness. The regional flood strategy is the only option that satisfies all four effectiveness measures.

Given the uncertainties of the impacts of future climate change, it is important to be able to amend policies in the future to address new and unpredicted risks. While the adaptation strategy is more flexible than the flood management strategy, the ability of

the flood strategy to address all the barriers that municipalities face to flood hazard management is significant and satisfies the focus of this paper.

This option received greater support from interview participants in comparison to the regional adaptation strategy. Overall, the level of municipal support for this option is likely to be similar to the adaptation strategy because both options will require significant buy-in from municipalities across the region. The fact that a regional flood strategy received higher support from interview participants is evidence that this option will probably have higher support across the region. There is clear support for a regional flood strategy through the Fraser Basin Council which will make the implementation of this strategy relatively straightforward.

A regional flood strategy will also ensure that interdepartmental and intergovernmental management gaps are addressed. The services and amenities that lie within municipal boundaries but outside of municipal responsibility will also be protected. A regional strategy will provide a more comprehensive approach, encompassing the entire region. This is in comparison to the status quo, which will continue to manage flood hazards in silos.

Once a regional flood management strategy is implemented, the lessons learned can be used to support a regional adaptation strategy. A regional adaptation strategy will be more suitable for addressing the long-term flood risks that climate change poses for the Lower Mainland. The adaptation strategy will also allow greater opportunities to practice the values of adaptive management. It is clear that adaptation to these flood risks will need to occur within the 100-year time period outlined in the climate change literature to ensure adequate protection for the environmental, social and economic resources in the Lower Mainland.

While both regional options will inherently involve a mechanism to share costs for prioritized adaptation and flood actions across the Lower Mainland, it is likely that outstanding costs will still limit further adaptation.

This research has shown that the downloading of flood management to municipalities has created barriers for municipalities to manage flood hazards. To address these barriers it is imperative that any action taken to address this issue also

considers challenging existing governance structures around flood management to ensure that the provincial and municipal responsibilities for flood management take into account the growing threat of climate change. Municipalities should seek greater collaboration with the provincial government to ensure a more sustainable solution for the long-term implications of climate change can be found. This will require the provincial government to offer support through funding mechanisms such as an adaptation strategy and/or through funding a floodplain mapping program. Long-term support from the provincial government could also consider a re-evaluation of the division of responsibilities to place more responsibility for flood management with provincial entities. In particular, the provincial government could assist municipalities by absorbing the liability risk from floodplain maps or floodplain bylaws. This could be achieved by amending Section 15 of the *Compensation and Disaster Financial Assistance Regulation of the Emergency Program Act* to ensure that assistance will be offered to offset the costs of replacing or repairing flood-damaged infrastructure that has not been properly protected from flood risk, or to properties that have been issued variances (see section 7.2.1). Alternatively, the onus for flood damages could be placed with property owners themselves. Flood risk could be disclosed at the time of purchase and property owners would be responsible for any and all flood-related damages. Future research may investigate whether the existing Canadian insurance industry can or should be amended to include protection for flooding, and if there is a possibility for flood insurance co-management between public and private entities.

While some general recommendations have been made with regards to two potential policies for the provincial government to consider, a more detailed analysis of how the province could amend policies to reclaim some level of responsibility for flood management is beyond the scope of this research.

12. Study Limitations, Future Research and Conclusion

Climate adaptation is a relatively new addition to local policy formulation and decision making. This is especially true for the linkages between climate change impacts and flood hazard management in the Lower Mainland. Therefore, it is likely that new policies are needed in the Lower Mainland to address the risk of climate-related flooding.

This study examines the barriers municipalities face to implement available flood management tools. This study concludes that a staged approach including short and long term objectives will be most useful for addressing the increased threats of climate-related flooding in the Lower Mainland. In the short term, a regional flood strategy is the most effective option to address the barriers to ensure flood hazards are managed more efficiently as flood risk increases due to climate change. A regional adaptation strategy will be an important component to ensure long-term adaptation occurs across the region. However, further support from the provincial government is necessary to ensure climate-related flooding is addressed in the long term.

The most important finding of this study is that while local governments are responsible for many of the components of flood hazard management and adaptation, barriers such as a lack of resources, lack of agency coordination, lack of information and potential increased liability will not be adequately addressed without further provincial or federal government support. Ultimately, this division of responsibility is important because it demonstrates an important finding of this research; that the scale at which adaptation occurs and the scale at which the policy to support adaptation actions are different.

A limitation of this research is that the feasibility of further involvement from the provincial government with respect to flood management is not assessed. Provincial or

federal government stakeholders were not consulted in this research. The sample size of the interview respondents is also small.

Finally, future research should address the issue of liability so that municipal planners can confidently employ the necessary tools to best manage climate-related flooding. This will involve a reassessment of the available flood management tools to ensure they are relevant to manage growing flood risk. The study of climate adaptation is a relatively new concept in the literature. The impacts of climate change remain uncertain and no climate model may be able to accurately predict the full damages of future climate change. Therefore, further study should be conducted on a regular basis to ensure that coastal communities in the Lower Mainland are adequately preparing for the increasing risk of climate-related flooding.

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Appendices

Appendix A

Climate Change Impacts in BC

Annual average temperatures are expected to increase 1°C to 4°C across the province (Rodenhuis et al., 2009). In BC, 2011 was the 9th warmest year on record since 1880, and nine out of ten of the warmest years occurred since 2000 (Rodenhuis et al., 2009). Thomson et al. (2008) predict that by 2050 precipitation in many coastal BC areas will rise by 10-25%. It is expected that these climatic changes will result in an increase in the frequency of floods in small and medium drainage basins that will be dominated by rainfall, and flood events will typically be more intense and of a larger magnitude (APEGBC, 2012). Moreover, the risk of a historically high flood will remain since an exceptionally large winter snow accumulation followed by a sudden spring heat wave could create extremely high runoff (APEGBC, 2012).

Sea level rise is another significant threat for the BC coast. Rising sea levels are due partly to an increase in the volume of water as it warms and expands and partly to the increased flow of freshwater from land where melting ice adds to the total volume of water in the oceans (Miller & Douglas, 2004). According to Goelzer et al. (2012), a global sea level rise of 1.1 metres by the year 3000 is unavoidable.

For the Fraser River delta, relative sea level is predicted to rise by around 50 cm with a range of 30 to 70 cm by the year 2100. More extreme estimates lead to a predicted relative sea level rise of 90 to 100 cm for Vancouver and 120 cm for the Fraser River delta. Storm surges can be of major importance in the Fraser River delta region, particularly Boundary Bay which is exposed to southeasterly storm winds. Major storm surges in low lying regions such as the Fraser River delta can add another 100 cm and typically occur in late fall to early winter and when there is the possibility of high spring tides. As global sea level continues to rise, there will be an increasing impact of storm surges on the low lying regions of British Columbia. The possibility of increased storm intensity and duration associated with global warming could also lead to higher wind, waves and swell in winter which would lead to greater land erosion and flooding during periods of high tide (Thomson et al., 2008).

While the IPCC is cited as the global expert panel on climate change research, the latest IPCC assessment report of the state of climate change was published in 2007. More recent evidence suggests that sea levels are rising much faster than reported by the IPCC and that the IPCC's predictions have been underestimated (McMullen & Jabbour, 2009; Allison et al., 2009). Satellites also show global average sea level rise to be exceeding IPCC predictions by some 80%, and these projections suggest that by 2100 global sea level is likely to rise at least twice as much as envisioned by the IPCC (Allison et al., 2009).

The BC government has acknowledged the gaps in science and have adjusted policy accordingly. Taking present trends of measured emissions and sea level rise to be greater than the IPCC projections, the provincial government predicts sea level rise will be a concern for the province by mid-century, with estimates of a rise of 0.5m by 2050 and 1m by 2100 (Ausenco Sandwell, 2011a).

Appendix B

Flood Management Context in BC

Prior to 2003, the responsibility for flood hazard management rested with the provincial government. The changes in policy were largely due to the end of the Floodplain Development Control Program²⁸. Legislation changes included amendments to the *Land Title Act*, *Local Government Act*, *Dyke Maintenance Act*, *Drainage, Ditch & Dyke Act* and the *Ombudsman Act*. In 2003, Bill 56 (the *Flood Hazard Statutes Amendment Act*) was passed by the BC Government. This Bill amended the *Local Government Act* to give powers to local governments to designate their own flood hazard areas through bylaw, FLCs and setbacks as long as they take provincial guidelines under consideration. The use of a covenant under Section 219 of the *Land Title Act* was also authorized which imposes obligations or restrictions on land use (Fraser Basin Council, 2008).

The provincial legislation that addresses flood management includes:

Environmental Management Act: Sections 5(f) and 138 (3) (e) allow the Minister of MFLNRO with broad flood management powers, including the authority to establish guidelines and regulations. For example, the Ministry has published the *Flood Hazard Area Land Use Management Guidelines* that must be considered by local governments when adopting floodplain bylaws under Section 910 of the *Local Government Act* (discussed below).

Land Title Act (Section 86; Subdivision Approvals). Section 86 of the *Land Title Act* contains provisions for the approving officer to refuse to approve a subdivision plan if the officer reasonably expects that the land could be subject to “flooding, erosion, land slip or avalanche.”

Community Charter (Section 56; Building Permits). Section 56 of the Community Charter contains provisions governing the ability of a building inspector to issue or refuse a building permit for land that is likely to be subject to flooding, mud flows, debris flows, debris torrents, erosion, land slip, rockfalls, subsidence or avalanche.

Drainage, Ditch and Dike Act. This Act addresses the administrative aspects of diking including construction, taxes, enforcement, expropriation, compensation, asset transfer etc. The construction and maintenance of many of the flood control works in BC are regulated by the *Dike Maintenance Act*. There are approximately 100 diking authorities throughout the province, which are charged with the responsibility of operating and maintaining these works. The majority of diking authorities are local governments designated under the Local Government Act or the Community Charter (APEGBC, 2012). The provincial government has a number of roles in regards to dikes, including setting the design standards, approving changes to existing or new dikes, and monitoring the management of the work by diking authorities. Though the Provincial Inspector of Dikes must approve all new flood protection projects, updates and repairs, local governments are responsible for the maintenance of these structures.

²⁸ The provincial government managed development in designated floodplain areas from 1975 to 2003 through the Floodplain Development Control Program. This program required that a Ministry of Transportation and Infrastructure (MTI) Subdivision Approval Officer was required to refer all subdivision plans for lands subject to flood hazards to MFLNRO, who would assist local governments with the preparation of floodplain bylaws. Today, the MTI no longer refers subdivision applications to MFLNRO, although the MFLNRO still provides guidance in the form of the Flood Hazard Area Land Use Management Guidelines.

Flood Hazard Area Land Use Management Guidelines. These Guidelines are published by the MFLNRO under the *Environmental Management Act* to assist local governments in developing and implementing management strategies for flood-prone areas. These guidelines are referenced under Section 910 of the *Local Government Act* and must be considered by local government in developing bylaws under that Section.

Local Government Act (Section 910; Floodplain Bylaws, Variances and Exemptions). Section 910 of the Act addresses construction requirements in relation to floodplains, and empowers local governments to create bylaws that designate a floodplain area and specifies corresponding flood levels and setbacks. When local governments develop floodplain bylaws, they must consider provincial guidelines and comply with provincial regulations.

Local Government Act (Section 919.1 and 920; Development Permits). Sections 919.9 and 920 of the Act state that OCPs can establish a Development Permit which specifies which areas of land are subject to hazards such as “flooding, mud flows, torrents of debris, erosion, land slip, rock falls, subsidence, tsunamis, avalanche or wildfire” should remain development-free.

BC Emergency Program Act. The Act gives local authorities the ability to declare local states of emergency to respond to flood disasters.

The above provincial Acts set the regulatory framework for flood protection in BC, while guidelines help local governments to fulfill their responsibilities under these Acts. Most of the responsibility for flood management lies with local governments through the *Local Government Act* and other policy levers such as Official Community Plans (OCPs), bylaws, development permits, building permits, zoning restrictions, and other types of policies and documents. In particular, Sections 910, 919.1 and 920 of the *Local Government Act* pertain to local government’s management of flood hazards.

Since the legislative changes, a BC organization called the Fraser Basin Council has joined in flood hazard management with the provincial and local governments. The Fraser Basin Council will continue to facilitate the development of flood hazard management tools to help with planning, dikes operation and maintenance, and emergency preparedness and response.

Appendix C

Interview Information and Interview Guide

The majority of interview contacts were recruited through public sources such as organizational websites or personal contacts. The snowball sampling technique was used to gain additional contacts through initial interviews.

These interviews were conducted through e-mail exchange, telephone or in-person methods, depending on each participant's own personal preference. Consent to participate in the interview was ascertained through e-mail in the case of an email interview, verbally in the case of a telephone interview, and written in the case of an in-person interview. Permission was not sought from the organizations that employ the research participants before the interviews were conducted and the participants were interviewed in their professional capacity. In the case of telephone and in-person interviews, the participants were asked for permission to be recorded. Before each interview began, each participant indicated if they required their name, professional designation, current field, or current employer to remain confidential.

Upon receiving confirmation from interested participants, each interested participant was emailed a brief description of the research, a draft interview schedule, and a consent form. Participants were given the option to discontinue their participation at any point in the research process.

Interview Guide:

The following interview guide was distributed to interview participants.

Interview Information

The purpose of this interview is to understand the institutional barriers that your municipality faces with regards to managing climate-related flood hazards. The information will be used to explore policy options to address these barriers and to inform my master's project entitled "Treading Water: Flood Hazard Management in BC's Lower Mainland."²⁹ The interview will take approximately 45 minutes to complete.

Interview Questions:

1. How would you measure the current level of participation with adaptation/planning strategies for flooding in this municipality? (E.g. high, med, low).
2. Can you provide examples of current strategies/tools that this municipality uses to manage climate-related flood hazards?
3. How recent are this municipality's floodplain maps?
4. Using the chart below, please indicate in the box provided whether or not the policy/strategy in question is currently employed in this municipality.

²⁹ The title of this thesis later changed to: "Treading Water: Flood Management and Adapting to Climate Change in BC's Lower Mainland"

Tool	Description	Use: Y or N
Official Community Plans (OCP)	OCPs must contain general land use policy statements and maps showing restrictions on the use of land that is subject to hazardous conditions.	
Development Permit Areas (DPA)	OCPs may identify DPAs and create Development Permit Guidelines for Protection of Development from Hazardous Conditions, including flooding and some aspects of climate change	
Floodplain Bylaws	Current BC Provincial Policy encourages the use of Floodplain Bylaws according to Section 910 of the Local Government Act.	
Zoning bylaws	Zoning bylaw provisions can be an added tool in protecting development and the environment from consequences of flooding, by giving preference in floodplains to low risk uses such as agriculture, forestry, day-use recreation or short term industrial uses as opposed to high risk uses such as urban residential of various densities	
Restrictive covenants	Restrictive covenant agreements are signed agreements usually between a property owner and a government agency that is registered on the title of a given property. The agreement usually specifies some restriction of activities or land-use that is applied to a portion of the subject property.	
Public education	Public education about the hazards and ways that individuals can address them; provide known site and hazard risk information to help individuals decide for themselves whether to proceed with a purchase of land or development	
Emergency preparedness	Prepare emergency plans for flooding and other disasters, undertake post disaster planning	
Risk Management	Includes: Identification, assessment, measurement of the likelihood and consequences of risks to property, buildings and people; Cost benefit analysis; Vulnerability assessment; Resilience assessment	
Subdivision Regulation	Includes: Regulation of subdivision to protect development in areas subject to coastal hazards; Regulation of subdivision where the natural environment would be adversely affected due to sea level rise	
Building Regulation	Regulation of building construction to address safety of land subject to coastal hazards (FCLs and setbacks)	

5. What do you think are the most effective strategies to use to plan for climate-related flooding in this municipality?

a. Are these methods being used in this municipality? If not, why?

6. What are some existing institutional barriers to the implementation of these strategies? (E.g. cost, political feasibility, limited resources). Please explain in detail.

a. What could be done to alleviate these barriers?

7. The goal of any policy option adopted to increase the ability of municipalities to address the risks of climate-related flooding should be to reduce the barriers to addressing flood hazard management.

Considering the above goal, the following criteria can be used to assess potential policy options. In the chart below, please indicate how important each criterion is to meeting the stated goal.

Criterion	Definition	Level of importance to reducing barriers (e.g. not important, important, very important)
Effectiveness	The extent to which the policy will reduce risk for the most amount of people at the least amount of institutional change.	
Equity	Geographical, social or technical (i.e. equity issues that may arise with new vs. existing development, or between high vs. low risk neighbourhoods etc.)	
Municipal acceptability	Level of municipal government support for the policy	
Flexibility	Amount of flexibility an option can provide- i.e. adaptive management concept; flexibility to cope with future climate changes and amend options in the future if necessary	
Reduce barriers to adaptation	Administrative ease: The ease with which a policy can be implemented at the local level	
	Implementation cost (government): (i.e. staff, new systems expertise)	
	Liability: the amount of liability placed upon municipalities as a result of the change in policy	

8. Can you think of other important criteria that are not included in the chart above?

9. What policy options could this municipality benefit from to help alleviate some of the barriers to addressing climate-related flooding? (Some examples could include: A regional plan for the Lower Mainland to address SLR and other climate-related flooding; an adaptation fund inspired by the GMF, new insurance plans to account for increased flooding risk)

10. Is there anything else you would like to add?

Appendix D

Other Participant Concerns

Some participants mentioned the distinction between existing and new development. While some of the flood management strategies mentioned above are particularly useful for limiting new development in floodplain areas, addressing existing development is particularly difficult. Residents may not want their waterfront access or views restricted by taller dikes, and raising new buildings to accommodate higher flood levels may detract from the overall design of a streetscape. A major challenge for local governments is that existing development on floodplains limits policy options for changing inappropriate land use (APEGBC, 2012).

Another equity concern is regarding accessibility. If houses are to be designed to be raised above water levels, they will likely require staircases, which are not accessible to all those who may have difficulty with stairs. Further, this raises questions of form and character where new development is interspersed with older development (City of Richmond, 2012b).

Municipalities also may be concerned about a loss of development opportunities. By restricting development in floodplain areas, municipalities will lose the investments that developers would make in that location. Developers will seek other locations, which will result in a loss of revenue for the municipality.