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Hazard change caused by climate change: workshop report

M. Heideman

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Hazard Change Caused by Climate Change

Workshop Report

SFU ACT

SFU CNHIR

Natural Resources Canada | Ressources naturelles Canada

Pacific Institute for Climate Solutions

February 22, 2016
Vancouver, British Columbia

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We are grateful for the generous contributions of time and materials from each of the agencies supporting the workshop, by the volunteers from the supporting agencies, the School of Regional and Community Planning, University of British Columbia, the Department of Earth Sciences, SFU, and particularly the workshop participants and the agencies who supported their participation.

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EXECUTIVE SUMMARY

On February 22, 2016, the Centre for Natural Hazard Research, in cooperation with Simon Fraser University's ACT (Adaptation to Climate Change Team) and Natural Resources Canada, hosted a one-day workshop to initiate and stimulate a national discussion about weather-caused and weather-triggered hazards that are changing in a warming world. The two main goals of the workshop were to:

1. improve knowledge and confidence of practitioners and policy makers when making land-use decisions or changes in professional practices that require a consideration of climate change; and
2. spark a national initiative to produce an understandable document that summarizes changes to hazards driven by changes in climate.

WORKSHOP FORMAT

Workshop delegates represented a cross-section of stakeholders and experts in natural hazards, risk management, policy and climate change, and included researchers, engineers, geologists, planners, officials from local, provincial, and federal government, and emergency managers.

Plenary presentations provided a framework for the workshop and stimulated discussions. The morning presentations provided an overview of the present understanding and implications of climate change, a summary of the impacts of sea-level rise in Canada, and some of the challenges and needs of those dealing with weather-related hazard management. The presentations provided perspectives of a municipality (the City of Vancouver), a developer, and professionals (engineers and geoscientists). Plenary presentations in the afternoon provided insight into current provincial and federal initiatives and programs related to climate change adaptation.

Two question-guided breakout sessions, one in the morning and one in the afternoon, allowed the workshop participants to share their thoughts and experience on the challenges and needs they face in their discipline or profession in understanding the intensity and frequency of climate-based and climate-influenced hazard events in a changing climate. The morning breakout session focused on identifying challenges in understanding and further aimed to assess whether there is a discrepancy between hazards that pose the largest threats and hazards that pose the biggest challenges in understanding. In the afternoon, the breakout session concentrated on identifying needs, in the form of information, tools, and governance and/or partnerships.

WORKSHOP OUTCOMES

During the morning breakout session, the workshop participants identified challenges in six categories: social, political, economic, environmental, scientific, and technical. Many of the identified challenges, however, are not problems of understanding climate-based or climate-influenced hazard intensity or recurrence, but rather challenges in managing changing hazards from the perspectives of specific disciplines. Overall, political challenges were identified as the highest priority, followed by technical, social, and scientific challenges, with communication issues as a recurring theme in several categories. More specifically:

- political challenges: lack of clear legislation and policies, incorporation of risk into planning and project management, and lack of provincial engagement;
- social challenges: lack of personal awareness and responsibility, cascading effects to other sectors and creating opportunities for change;
- technical challenges: availability and best use of data; and

- scientific challenges: uncertainties in climate modeling.

The workshop participants identified flooding as the largest threat and the biggest challenge in understanding for Canada, British Columbia, and southwest British Columbia. Depending on the participants' background (e.g. geologist vs. government official), the 'challenge in understanding' might not be a lack of understanding of flood hazards or flood science, but rather a lack of information or consistent policies, or interpretation of or access to data. Other main hazards that were identified as a threat or a challenge in understanding include: drought, wildfire, storms, and sea-level rise.

In the afternoon, the workshop participants identified needs for information, tools, and governance/ partnerships, specifically:

- Information needs:
  - improved information and communication to address social and scientific challenges;
  - more information about financial impacts, effectiveness of mitigation and adaptation methods, and regulation and policies.
- Tools:
  - political tools and policies, such as cost-benefit analysis, building codes, liability protection, and government support for new technologies;
  - technical or visualization tools;
  - communication tools, for example online platforms, online data storage, and narratives focusing on local and personal impacts of climate change and changing hazards.
- Governance/partnership:
  - capacity and resources at the federal and provincial level;
  - collaboration among governments and other stakeholders;
  - establishment of a IPCC sub-panel on hazards change.

WORKSHOP CONCLUSIONS AND NEXT STEPS

In conclusion, the workshop produced many useful insights:

1. Floods were (overwhelmingly) considered the biggest threat and challenge in understanding for BC and Canada. Drought, wildfire, storms and sea level rise (SLR) represented the next hazards of concern in BC and Canada;
2. The participants identified a clear need for better governance and leadership. Increased capacity and resources at the federal and provincial government levels were deemed essential to the participants to be able to manage and provide leadership (in terms of consistent and clear legislation and policies);
3. The workshop participants identified a need for better (scientific and technical) data, as well as the need to provide better communication and education of data;
4. Various tools were suggested to improve the understanding of changing hazards in a changing climate, for example improved or standardized methods for cost-benefit analysis that could guide decision-making, or visualization tools to improve communication and education.

The workshop further facilitated new, and strengthened existing, connections among participants. However, the workshop did not fully achieve the two main goals, which can be attributed to the difficulties inherent in assuring coordination between the intent of the workshop, framing of the breakout sessions questions, and the needs and responses of the invited multidisciplinary audience. Nevertheless, the results, and the feedback

from participants, revealed substantial demand and need for continued and more focused dialogue, collaboration, and cooperation, and as such it is important that the momentum the workshop created be maintained.

The workshop participants, as well as the organizers, agreed that the momentum of the workshop needs to be maintained. Follow-up (annual) workshops were suggested by many participants. To meet the needs of the various disciplines, separate workshops could be organized that focus on the technical or practical aspects of changing hazards in a changing climate. The results of such workshops should then of course be communicated across all disciplines. Another way to maintain the momentum of the workshop could be the establishment of online working groups or a forum. These working groups or forum can be used to disseminate (scientific or technical) results or foster communication and collaboration.

This report provides a summary of the plenary presentations and the discussions and results of the breakout sessions.

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INTRODUCTION

It has been common practice in risk management to use frequency-magnitude curves for predicting recurrence intervals of hazardous natural processes. These probabilistic frequency-magnitude plots are based on past events in the historical and geological record that occurred under past, relatively consistent, climatic conditions. It is evident that current climatic conditions are rapidly changing and are likely to continue to do so for at least the next 200 years. As a consequence, current risk management can no longer rely on the use of probabilistic frequency-magnitude curves; in fact, their use is becoming obsolete and potentially misleading. So, how then can we determine current and future hazard potential and manage our hazard risk?

Since the 1960s, global communities have witnessed an unprecedented increase in disasters, from fewer than 50 recorded events per year before 1963 to as many as 527 recorded events in 2000 (EM-DAT, 2015). In particular, hydro-meteorological disasters such as flooding and storm-related events have increased rapidly, accompanied by a steep rise in disaster management costs. Some of this increase is due to population growth and concentration in urban areas that has exacerbated the potential for complex infrastructure failures and other impacts during extreme weather events. However, given the extraordinary increases in Canadian insured losses incurred by the insurance industry between 2003 and 2013, it is clear that climate change is now a significant factor that is likely to become worse as warming progresses.

Anthropologically induced climate change is a widely recognized phenomenon and is now thought to be the main driver of recent increases in the occurrence and intensity of hydro-meteorological hazards around the world (e.g. IPCC, 2013; Melilo et al., 2014; Warren and Lemmen, 2014). Weather-related events, such as floods, landslides, and wildfire, among other hazards, are affected by changes in temperature and/or precipitation and are projected to significantly increase in many regions, leading for example to prolonged periods of drought, more frequent and severe wildfires, or intensified rain storms. Also, hurricanes and tornados appear to have become stronger and more frequent over an extended part of the year. In addition, global sea level rise, habitat/ecosystem changes, and human migration are key issues attributed to changes in climate (e.g. IPCC, 2014; James et al., 2014; David Suzuki Foundation, 2014). To make matters worse, rising global population and increasing wealth (more assets, buildings, and infrastructure), plus unsustainable development practices have left large populations more exposed to these weather- and climate-related hazards, with increases in costs of disaster recovery, response, and mitigation.

National governments recognize the need to respond to changing hazards and a changing climate, and they have recently (re-)committed to address these issues by signing several agreements (e.g. the Paris Agreement (COP21), the new UN Sustainable Development Goals, and the Sendai Framework for Disaster Risk Reduction). Additionally, advances in science and technology have provided opportunities to adapt to a changing climate, and have informed mitigation strategies, programs, and policies. Current responses, however, are not adequate for reducing atmospheric carbon dioxide levels, and as a consequence global temperatures and sea level are expected to rise above projected levels in the future (i.e. 2050 or 2100). Furthermore, higher temperatures will lead to increases in the moisture content of the atmosphere, which will exacerbate the intensity and occurrence of hydro-meteorological hazards.

Initiatives at the global, national, provincial, and local government levels provide communities with tools to deal with changing hazards and climate change, but actual actions and implementation of solutions are often complicated or constrained by jurisdictional or political factors, lack of government guidelines, lack of knowledge,

lack of collaboration or cooperation, resources, motives, inconsistent or unclear communication of scientific facts and predictions, or denial that climate is changing or that any change will have impacts on communities all over the globe. While rising concern and attention to limiting global warming to less than 2°C by the end of the century are much needed and warranted, adaptation strategies must be developed and coordinated with emissions mitigation efforts, informed by our improving understanding of how natural hazards might shift and affect society as a result of climate change. An improved understanding of natural hazards will enable society to better mitigate the risks they pose, and decrease exposure and vulnerability. Such understanding of changing natural hazards is an essential component of understanding and managing risk, and its consequences for new and existing development in a growing global society. We know that risk from natural hazards is changing due to climate change in combination with rapid population growth and development pressures, but quantifying the increased risk is a significant challenge. The intent of the workshop was to address this climate change challenge, to improve the knowledge and confidence of practitioners and policy makers when making land-use decisions or changes in professional practices, resulting from population growth and development pressures, which require a consideration of climate change.

PURPOSE OF WORKSHOP

The workshop was held on February 22, 2016, at the Joseph and Rosalie Segal Room at the Harbour Centre Campus of Simon Fraser University. The purpose of this workshop was to stimulate a national discussion about weather-caused and weather-triggered hazards that are changing in a warming world.

Participants included a cross-section of stakeholders and experts in the disciplines of natural hazards, risk management, policy, and climate change. Delegates from federal, provincial, and local governments, consulting and engineering companies, academia, private industries, and other organizations heard and discussed presentations and participated in two breakout sessions to discuss the implications of climate change for Canada.

Participants in the workshop:

- examined current and likely future changes in the frequency and intensity of hydro-meteorological hazards due to climate change;
- considered non-stationarity of hazards;
- prioritized the needs of professionals for information about future changes in the frequency and intensity of hazards controlled or affected by climate;
- examined the potential for national support for a program that documents changes in hazards and risk, and identify champions for such a program;
- examined implementation of climate knowledge for hazard and risk assessments; and
- explored best practices for professionals.

GOALS OF THE WORKSHOP

The Centre for Natural Hazard Research and its partners SFU ACT (Adaptation to Climate Change Team) and Natural Resources Canada hoped to capture and then highlight challenges faced by academics, practitioners, and policy makers with interests or involvement in hazard/risk management in a warming world. In particular, conversations were stimulated about how practitioners can make informed decisions based on expected changes in the frequency and magnitude of certain natural hazards.

The workshop had two main goals:

1. to improve knowledge and confidence of practitioners and policy makers when making land-use decisions or changes in professional practices that require a consideration of climate change; and
2. to spark a national initiative to produce an understandable document that summarizes changes to hazards driven by changes in climate.

WORKSHOP FORMAT AND PROCEEDINGS

Presentations at the workshop set the stage for, and framed, discussions. The morning presentations provided overviews of the challenges and needs of those managing weather-related hazards. Following the morning presentations, two breakout sessions focused on identifying challenges and needs in understanding and using knowledge about non-stationary hazards. A plenary session in the afternoon captured discussion highlights and priority setting.

This report provides a summary of the presentations and discussions that emerged from the workshop. It includes summaries of the plenary presentations; breakout sessions, discussions, and evaluations; recommendations for future initiatives related to changing natural hazards; and references. The appendices, which are published as a separate document, include detailed responses to the questions in the breakout sessions, breakout session summaries, comments left on the 'mural', evaluation feedback, background information regarding weather-related hazards, and the participant list.

Results and discussions in this report are presented without attribution to specific persons. Comments are only identified only by discipline in order to assess possible differences among the stakeholders.

PLENARY PRESENTATIONS

INTRODUCTION

JOHN CLAGUE, EARTH SCIENCES, SFU

In an increasingly urbanized world, there are more people and wealth (i.e. assets, buildings, and infrastructure) exposed to natural hazards. The population of the Greater Vancouver area has grown to about 2,356,000 people in 2011, and is projected to increase to about 3,443,000 by 2041 (Metro Vancouver, 2015). This growth raises the question of society's vulnerability to hydro-meteorological hazards, especially when the occurrence and intensity of hazardous events are changing due to changes in climate.

> *"Plan for the future because that's where you are going to spend the rest of your life"* – Mark Twain

Climate is changing throughout British Columbia; annual temperatures and average precipitation have increased across the province in the period 1900-2013. Storm surges are also becoming an issue, as currently more than 296,000 people live just above mean sea level on the Fraser Delta (Metro Vancouver, 2015).

So, how do we plan for these changes? How does a changing climate affect the communities of south-coastal British Columbia, and Canada in general? What risks does climate change pose? How does climate change affect the occurrence and intensity of natural hazards at a local scale? While most of the workshop participants would agree there are risks related to climate change, many Canadians do not. An effective response to the challenges posed by climate change requires a commitment from Canadians that action is required.

PRESENT UNDERSTANDING OF CLIMATE CHANGE

The first presentation of the morning plenary session, by Deborah Harford, provided a brief overview of current understanding and implications of climate change, including the latest international agreements dealing with climate change and Canadian initiatives.

The second presentation, by Thomas James, provided information on, and projections of, sea-level rise. He also discussed guidance provided by the British Columbia Government for improving sea dikes in anticipation of sea-level rise through this century.

CLIMATE CHANGE AND WEATHER HAZARDS, AN OVERVIEW

DEBORAH HARFORD, ACT (ADAPTATION TO CLIMATE CHANGE TEAM), SFU

In 2015, three international agreements addressing issues associated with climate change were signed or ratified: the Paris Agreement (COP21), the UN Sustainable Development Goals, and the Sendai Framework for Disaster Risk Reduction). The agreements signal global recognition of, and concern about, the impacts and consequences of climate change.

Notwithstanding global initiatives to reduce future greenhouse gas (GHG) emissions, atmospheric modeling indicates that rising temperatures and subsequent impacts on society and ecosystems are now, to some degree, inevitable due to the longevity of CO_2 and other GHGs in the atmosphere. Any "commitment to climate change" requires that we plan to adapt to its effects while working to reduce emissions as quickly as possible.

Rising temperatures will lead to an increase in atmospheric moisture and a reduction in the temperature differential between the Arctic and the equator. These changes will affect global weather patterns and cause more extreme weather events. In Canada, observed effects include an increase in temperatures, especially in the Arctic, and growing numbers of weather disasters, particularly flooding. Projected impacts include an increase in the severity of extreme weather events; sea-level rise; loss of ice, snow, and permafrost; shifts in species, habitat, and human populations; and new or exacerbated health risks.

With 80% of the Canadian population currently living in urban areas, and an enormous municipal infrastructure deficit already a challenge, climate change poses ongoing risks to our infrastructure and the safety and health of the population. Half of all insurance payouts in Canada are currently for water damage (Insurance Bureau of Canada, 2014). The combined effects of climate change, aging infrastructure, increasing property values, and increases in population will require an increase in spending on disaster mitigation.

Half of all insurance payouts in Canada are currently for water damage (IBC, 2014).

The federal government has recognized these issues through recent initiatives on climate change and adaptation, including allocations of money for green infrastructure projects. Other government levels and sectors are also taking action; for example, the new BC Climate Leadership Plan is being developed, and climate change adaptation plans have been released by several major Canadian cities. There is a clear economic incentive to act given recognition that that spending money on climate change adaptation now will reduce future spending and damages by significant amounts.

While government leadership and policies are essential to drive effective climate change adaptation, the private sector and professionals are integral to policy development and must be consulted to ensure that adaptation strategies are appropriate and feasible.

Audience question 1: We have a huge legacy of development without consideration of relevant available data in this country, largely due to government inaction. For example, the 2013 flood in Calgary was predictable, although it was significantly smaller than the flood of record. The city's vulnerability to floods was well known, but was ignored by all levels of government. We need to be cautious in asserting that data collection and historical records are irrelevant.

Answer: There's certainly a lot of development on floodplains and, as municipalities are only able to generate income from property taxes, there is little incentive for them not to allow construction on floodplains, particularly when they are 'bailed out' by the federal and provincial government in emergencies. Municipalities also must expend public monies to upgrade infrastructure and pay for the recovery. Advocating for tax reform is important to deal with this problem, but we also have to take into account the fact that the required data and conditions are changing.

Audience question 2: People do not necessarily make better decisions based on having the best available information. We can't bombard ignorance with more facts and expect a different result. We often forget that behavioural change and changes in some public perceptions (i.e., 40% of the Canadian public do not believe in human-induced climate change) should be the focus, receiving at least as much attention as science itself. Behaviour and perception are just as important at this time.

Answer: I agree. This is a changing and evolving system. Our last federal government had a cold war on climate change. You could not even say 'climate change'. We now have a Minister of Environment and Climate Change, and that alone sends a message to Canadians. That kind of leadership will help to influence behaviour change.

SEA-LEVEL RISE

THOMAS JAMES, NATURAL RESOURCES CANADA

Rising sea levels will lead to shorter return periods of coastal floods, meaning that a one-in-50 year extreme event at Halifax will occur about every three years by 2050 for a high-emissions scenario. This predicted change in the frequency of extreme water level events does not, however, take into account possible increases in storminess and associated storm surges that might further increase the magnitude or frequency of extreme water levels.

The 5th assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC, 2013) concludes that average global sea level will rise more than 25 cm, and perhaps as much as 1 m, by 2100. The projected rise in relative sea level across Canada, however, differs substantially, in large part because of differing amounts of ongoing crustal uplift and subsidence. In general, populated coastal areas of southern Canada are likely to experience sea-level rise of up to a few tens of centimetres by 2050. At Vancouver, the most extreme emissions scenario might result in nearly 1 m of sea-level rise by 2100 (James et al., 2014, 2015). However, some regions in the Arctic and Hudson Bay are experiencing crustal uplift from unloading due to melting of the late Pleistocene Laurentide ice sheet, and thus will experience a continuing fall in relative sea level.

The Provincial Government provides climate change guidelines for the construction of sea dike and flood construction levels, taking into account future sea-level rise, maximum high tide, storm surge, estimated wave effects, and a freeboard. The province's recommendation planning levels for sea-level change provide a margin of safety to account for uncertainty in forecasts. Climate change science is rapidly evolving and guidelines and regulations must be reconsidered and updated as required as new information becomes available. For example, Barnard et al. (2015) conclude that if projections for increasing frequencies of extreme El Niño and La Niña events are confirmed, coastal erosion and flooding events around the Pacific will increase, independent of sea-level rise.

At Vancouver, the most extreme emissions scenario might result in nearly 1 m of sea-level rise by 2100.

<u>Audience question 1:</u> In all the calculations being done, is the projection that the total volume of water on earth remains the same? Is it just relocation of water, or is the volume of water on earth increasing or decreasing?
<u>Answer:</u> The assumption is that the total volume [of water on earth] remains the same, but the surface level of the ocean changes as water warms and expands. Also, there are changes in storage, as melting glaciers contribute water to the oceans.

DEALING WITH WEATHER-RELATED HAZARD EVENTS

The next three morning plenary presentations were made by speakers who deal with changes in the occurrence and intensity of natural hazards due to climate change on a daily basis. The first presentation provided an overview of the adaptation strategies of the City of Vancouver. The second presentation highlighted the challenges and needs developers face in adapting to climate change. And the third presentation outlined how the Association of Professional Engineers and Geoscientists of British Columbia is incorporating climate resilience in the design of public infrastructure through the development of professional guidelines.

MUNICIPAL ISSUES IN HAZARD RISK MANAGEMENT IN A CHANGING CLIMATE

TAMSIN MILLS, CITY OF VANCOUVER

At the municipal level, there is a heightened focus on climate change, from emergency management to proactive planning and engineering. Promoting resilience with regard to climate change requires collaboration and cooperation across disciplines such as engineering, planning, and emergency management.

The City of Vancouver ('the City') adopted a climate change adaptation strategy in 2012, for which risks and vulnerability for the city were identified based on available science. The City prioritized risks and impacts and initiated adaptation planning. The Risk-based Land Use Guide (Struik et al., 2015) served as a helpful tool for assisting planners to 1) identify hazards (shocks and stresses), 2) identify what could be harmed, 3) assess potential losses and identify a community's acceptable risk level, 4) identify planning options to reduce risk, and 5) monitor the situation and preserve future options. The City has incorporated climate change into these steps by considering hazard, risk, and vulnerabilities both today and in the future. Climate change introduces more uncertainty into planning, which requires a consideration of scenarios and adaptive management.

Challenges: Climate change predictions add uncertainties to planning efforts, determining acceptable risk, and communicating risk and uncertainty.
Needs: Flexible, adaptive management.

The City performed a flood mapping exercise, including five different scenarios. That exercise showed that planning based on current information does not yield an accurate picture of potential future impacts, due to changes in infrastructure, people, economy/assets, and the environment. Flood hazard mapping is traditionally based on a specific return-period flood (e.g. 1-in-100 year flood). However, determining the acceptable risk for a community (that is, defining and adopting a specific flood return period for new developments) is a difficult process, as risk concepts are difficult to communicate, particularly in light of uncertain future conditions.

To move forward and adapt to climate change, solutions must be flexible, adaptable, and robust instead of optimal or based on a single scenario. Uncertain hazard conditions and predictions due to climate change pose difficulties for decision-makers, who have to justify spending decisions based on a business case, and may result in 'decision paralysis'. Regardless of the uncertainties associated with climate change and changing natural hazards, there is enough knowledge and opportunities to engage the public, stakeholders, and governments; to implement no-regret actions; to refine engineering design (e.g. changes to building codes), to preserve future options (e.g. amend land use plans), and to monitor and review.

Audience question 1: I appreciated the discussion on co-benefits for health. We need to look at integration to move our health system forward. I am Interested in the notion of climate 'extremes'. Our trajectory is not optimistic, but it could be worse. How are possible climate-related extremes considered in planning? The city does not have the infrastructure to get to SLR [Sea Level Rise] 2.5.
Answer: We use PCIC [Pacific Climate Impact Consortium] data to inform, but it is a challenge for estimating sea-level rise. Another challenge is the planning timeframe; we do not look past 2100. It is very difficult to get people to think past 2100.

Audience question 2: NRCan in its 2014 national climate change impact and adaptation assessment specified 29 adaptation measures, but only 11 have been implemented. Why are we still in this position, and how do we move forward faster?
Answer: We need to include economic risk in communications to decision makers, just as we do for other business cases. Municipalities are dealing with huge demands on resources, and uncertainty and a poorly developed business case make it difficult to compete with other business/investment cases.

Audience question3: I agree that engaging communities and citizens matters, but 44% of Canadians do not believe in human-induced climate change. It is already difficult to get citizens vote, so how do you engage people on an issue they do not really care about?
Answer: We are still trying to figure this out. We are meeting with staff for cities in the United States, working with public art, and thinking about accessibility to waterfront because these are matters that people care about; so this is a good starting point. Visualisations might help, but a lot of visualisation is scary and might turn people off. I recommend focusing on what people themselves can do to adapt.

Audience question 4: You showed a slide with sea-level rise projections after 2100. The IPCC always shows sea-level rise after 2100, but the problem will persist much longer. Is the City of Vancouver planning for SLR after 2100?
Answer: We find it very difficult to plan past 2100. I welcome ideas on how to get past the 2100 barrier.

Audience question 5: There are some pessimistic people in Vancouver. What do we need to plan for? Is it a consensus view? What do we do with the Hansen et al. paper (2015) [paleoclimate pessimists]?
Answer: We need a broader discussion because the City of Vancouver can't solve the problem of sea-level rise by itself. In terms of dealing with outliers, the City looks at the ranges provided and looks to the Province for guidelines. And we hope that the BC guidelines will be reviewed every five years.

Audience question 6: APEGBC has a Climate Change Advisory Group, which frequently engages engineers. The engineers want to do the right thing, but clients are often reluctant/unresponsive. They have found that until requirements are legislated, developers do only what they are legally required to do, rather than the 'good thing to do.' What is the role of City in engaging developers and engineers to do the good thing?
Answer: The City certainly wants to work with engineers and the design community to adopt guidelines that encourage efficiency and resilience. The City has changed some bylaws, and there are some active developers in the community that are innovative. Hopefully more innovation will coming from these changes.

DEVELOPERS' ISSUES IN HAZARD RISK MANAGEMENT IN A CHANGING CLIMATE

JONATHAN MEADS, CONCERT PROPERTIES LTD.

Property development and construction require a long-term vision and approach, as it often takes more than five years to acquire land, go through the OCP [Official Community Plan] amendment process, rezone, and apply for a development and a building permit. Within that period, government policies and bylaws may change, complicating the process.

Several problems in connection with sea-level rise arise when building in the Greater Vancouver area. First, local municipalities require different flood construction levels (FCLs) (e.g., FCL=4.5 m in North Vancouver versus FCL= 4.6 m in Vancouver), or have different requirements over the use of subterranean space. The inability to locate rooms, such as electrical/mechanical rooms or storage, below grade has implications for buildings. For example, elements of the streetscape are blocked off to provide this space; and the loss of leasable area increases costs and hence reduces affordability. In some instances, where municipalities have imposed minimum-use requirements, it is hard to develop buildings, especially retail at grade. Second, there is a policy disparity for

building at existing locations vs, building at new locations; additional buildings at existing sites do not always have to meet adjusted flood construction levels.

In addition to following local policies and bylaws, developers must make trade-offs between the aesthetics of a building (e.g. floor-to-ceiling windows) and adjustments to climate change (e.g. increased demand for air conditioning), which again come with greater development costs. The new Building Act (2015) allows the Provincial Government to set one standard for construction activities, but there is a need to consider how this standard should be enacted.

New technologies, such as energy-efficiency ratings, are available to developers and builders, but more education regarding the challenges and options of adapting to climate change is needed, both for developers and builders and for other stakeholders and the public.

Challenges: Long-term vision and approach of developers vs. shorter-term political cycles and policy changes; policy disparity between existing and new developments; trade-off between the affordability of adaptation measures and aesthetics of buildings.
Needs: More education for developers on the issue of climate change and adaptation options.

Audience question 1: There are soft soils in the development area, so there is a need to design for ground motion related to earthquakes. Will there be liquefaction or settlement and how does that impact potential inundation?
Answer: We build to LEED Gold standard and to seismic code. There will be an additional barrier to deal with liquefaction. (As Jonathan is not an engineer he is not comfortable to answer the part of the question related to the effects of soil or seismicity).

Audience question 2: Since the [building] requirements are so severe, is it difficult to do this [i.e. develop] and get a return [on investment] on Harbourside? Are there any issues along the present day shoreline that might preclude future projects?
Answer: The Harbourside development has thinner margins than other projects that Concert does. In this case the City came to Concert, the area was originally zoned for industrial/commercial, but was then rezoned. There is a huge market for properties in this area. Concert receives regular calls. People do not seem to be worried about sea level rise, they want that water view.

Audience question 3: Do you find the production of guides like the BC Hydro Guide useful in your area [of expertise]?
Answer: Absolutely. The guide is now a part of Concert briefs, future designs must follow the principles in that design guide. Developers have to trust guides, and a guide for sea level rise would be invaluable, as developers [currently] all have a different focus.

APEGBC'S PROFESSIONAL PRACTICE GUIDELINES ON INCORPORATING CLIMATE RESILIENCE IN THE DESIGN OF PUBLIC INFRASTRUCTURE IN BRITISH COLUMBIA

HARSHAN RADHAKRISHNAN, ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF BRITISH COLUMBIA (APEGBC)

A technical circular from the BC Ministry of Transportation and Infrastructure (BCMoTI) serves as a directive to consider climate change and extreme weather events in infrastructure design. With funding and technical support from BCMoTI, APEGBC's Climate Change Advisory Group (CCAG) is currently working on professional practice guidelines that will help APEGBC professionals incorporate climate change resilience in the

design of highway infrastructure in British Columbia. CCAG hopes that these guidelines, drafted as "interim" to allow for a one-year adoption period, will be endorsed by APEGBC Council in the summer of 2016. A steering committee of professionals representing a variety of stakeholders is providing feedback on the development of the guidelines. The initiative focuses on resiliency, rather than vulnerability, of highway structures.

Challenges: uncertainty and regional variability in future climate change projections and impacts, communication to infrastructure owner.
Needs: development of guidelines, including statements of standard of care.

An objective of the guidelines is to bridge a gap between what is needed and what is currently being done with regard to infrastructure vulnerability. They will apply to new and existing BCMoTI highway infrastructures, but will also be relevant for all public infrastructures in the province. They provide context for risk assessment within the public infrastructure management system and will complement existing APEGBC guidelines such as 'Legislated Flood Assessment Guidelines in a Changing Climate in BC' (APEGBC, 2012).

The climate vulnerability risk assessment will consider several regional climate projections. Typically, engineers consider the precautionary principle in their designs, which entails consideration of extreme events. The guidelines contain a standard of care, which encourages designs that are resilient in a range of future climate scenarios, including adaptable and smart designs (e.g. self-drainage). They anticipate enhanced monitoring of projects, involvement of a multi-faceted stakeholder team, and a consideration of the infrastructure's owner's risk tolerance. The guidelines are applicable to both large and small projects.

Communication to the infrastructure owner regarding best available science and tools provides them with assurance. Engineers, in turn, are provided with a tool for providing due diligence.

Audience question 1: I am working with APEGBC to help provide guidelines. An issue is who is a 'qualified professional'. We do not yet have qualified professionals in this new, rapidly evolving environment.
Answer: We want to instill confidence that tools are available.

Audience question 2: There is room for developing guidelines, while recognizing the gap between sectors of the engineering design community as well as the issue of non-stationary data. Engineers dealing with the possibility of flooding are used to working with mostly outdated, historical, stationary data. We are designing things today to last for the next 50+ years using historical data, which is a challenge. How do we do that in a mindful and cost-effective way?
Answer: The Province in working towards developing energy-efficient building codes. APEGBC tries to support energy-efficient and climate-resilient development. We acknowledge lots of gaps, but progress is being made.

Audience question 3: Risk assessment is a foundation for guidelines. From the public health perspective, health risk assessment is a different thing. How is the term 'risk assessment' used here? How does health risk assessment fit into the guidelines?
Answer: Health risks, for example when investing in water treatment plants, should be considered from the Ministry of Health perspective. APEGBC engineers/geoscientists are in tune with these conversations and are happy to help.

Audience question 4: In the standard of care, the issue of the role of professional judgment is raised. We try to use climate change information in different processes/practices, with a balance between new quantitative data and the exercise of judgment. An example is the use of new data in updating flood maps. Some people would like to use climate model output in future frequency-magnitude relations. When can we be confident of such an approach, rather than placing priority on professional judgment?
Answer: There is a lot of misunderstanding in conversations about climate change (e.g. 100-year storm). People are beginning to consider possible impacts rather than only how often rare events happen. Floodplain maps must be

made consistently, using the same criteria, so that makes decisions are based on accepted standards. Maybe we need a series of maps, rather than just one map as a basis for conversations.

PROVINCIAL AND FEDERAL PROGRAMS AND INITIATIVES FOR DEALING WITH CLIMATE CHANGE

Two presentations from provincial government representatives provided insight into current provincial initiatives and programs related to climate change adaptation in the afternoon plenary. These were followed by three presentations from federal government representatives, summarizing the National Disaster Mitigation Plan (NDMP), the Integrated Seasonal Climate Bulletin (ISCB), and three programs within Natural Resources Canada (NRCan).

PROVINCIAL CLIMATE CHANGE HAZARD-RELATED SUPPORT PROGRAMS

THOMAS WHITE, BC MINISTRY OF ENVIRONMENT

Both the federal and provincial governments have made commitments to address climate change. The 2015 Federal Mandate letter to Environment and Climate Change Minister Ms. McKenna states a renewed commitment to climate change adaptation and to review environmental assessment processes in the context of climate change (Prime Minister of Canada Justin Trudeau, 2015). At the provincial level, climate change and adaptation are included directly in the mandates of three ministries and indirectly in the mandates of others. BC's Climate Leadership Plan is now in the second round of consultation. Stakeholders and the public are invited to submit their thoughts on actions to lower greenhouse gas emissions and on the low carbon economy of the future (Government of British Columbia, 2016). The BC government announced in its 2016 budget $65 million to help communities improve safety, including $16 million in public safety preparedness initiatives and $49 million in community hazard mitigation initiatives such as upgrades to dikes and flood protection.

(There were no audience questions for Thomas White).

DIRK NYLAND, BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

The BC Ministry of Transportation and Infrastructure has assessed the vulnerability of its infrastructure and found that the highway system is safe, except when water is transmitted over or under structures (e.g. bridges and tunnels). The Ministry has been working with APEGBC to address the issue of climate change adaptation. Engineers will have to expand their calculations beyond the use of historical data and consider future climate projections. Trade-offs will have to be made between the lifespan and use of infrastructure on one hand and in adapting to climate change on the other.

Audience question 1: Is there any discussion at the provincial level of educating engineers about climate change, maybe through conferences?
Answer: There is nothing specific. There are people available to answer questions and many pertinent presentations have been made at conferences in the past, but nothing has been organized or structured by the Provincial Government.

FEDERAL CLIMATE CHANGE HAZARD-RELATED SUPPORT PROGRAMS

CATHERINE SALES, PUBLIC SAFETY CANADA

The National Disaster Mitigation Program (NDMP) was launched in 2015 to address escalating disaster costs due to increases in mostly water-based hazard events.

The National Disaster Mitigation Program (NDMP) was launched in 2015, after consultation between Public Safety Canada and the provinces and territories, to address escalating disaster costs due to increases in mostly water-relate hazard events. Canada's approach to manage risks of disasters includes research and analysis of flood-related disasters and consultation with the insurance industry to develop a national approach to residential flood insurance. The NDMP aims to reduce the impacts of natural disasters on Canadians by focusing investment on significant, recurring flood risks and costs.

The NDMP has two components:

- provision of $183.8 million over five years to provinces and territories on a merit-based, competitive basis for use in non-structural and small-scale structural flood mitigation measures; and
- expenditures of $9.3 million over five years to develop a national risk and resilience repository and to promote public awareness.

Four project streams provide the provinces and territories with access to cost-shared funding:

- Stream 1: Risk assessments that inform flood risk;
- Stream 2: Flood mapping;
- Stream 3: Mitigation planning;
- Stream 4: Non-structural and small-scale structural disaster mitigation.

The NDMP program ensures that foundational non-structural mitigation measures are in place to inform structural mitigation measures. In addition, the program helps to meet pre-conditions for residential flood insurance (e.g. through risk assessments, flood map updates, mitigation planning), and it systematically contributes to the development of a national risk profile.

The first call under the NDMP program, in April 2015, resulted in 33 proposals from across Canada (funding recipients can only be provincial or territorial governments, which are allowed to redistribute funding to local and First Nations authorities upon approval from the NDMP). Most of these proposals were related to risk assessment and flood mapping. Another call for proposals is expected soon, although no dates have been announced. The government will draft national principles, best practices, and guidelines on flood mapping in support of the NDMP.

Audience question 1: Will there be another call for proposals this spring? What are the deliverables? Will there be guidelines?
Answer: The NDMP will still focus on flood risks, and will invite proposals from the same four streams. Information and guidelines are on the Public Safety website.

Audience question 2: Through the Disaster Financial Assistance (DFAA) program, the federal government helps to cover the costs to rebuild infrastructure to what it was prior to a disaster. But with climate change, will the NDMP improve infrastructure for climate change adaptation?
Answer: Right now, DFAA funding only restores damages to the pre-event state.

MATT MACDONALD, ENVIRONMENT AND CLIMATE CHANGE CANADA

Environment and Climate Change Canada issues an Integrated Seasonal Climate Bulletin (ISCB) four times each year. The bulletin includes a summary of the previous season's weather conditions, events, and statistics, and also includes forecasts for the upcoming season. It is presented to stakeholders in a webinar and is also emailed to a list of subscribers.

The ISCB provides a seasonal forecast, which includes probabilities of temperatures being above or below average. It does not predict daily weather, rather it anticipates how temperatures over a period of three months will compare to averages. Confidence in these seasonal forecasts increases in years with a strong climatological driver (e.g. El Niño or La Niña). Similarly, confidence increases when models from other national weather agencies are in agreement those of Environment and Climate Change Canada. The seasonal forecasts issued through the ISCB can be used by emergency managers and others to better prepare for the upcoming season.

> The Integrated Seasonal Climate Bulletin provides a seasonal forecast that can be used to prepare for the upcoming season.

Notifications are also issued by the Ministry of Environment and Climate Change and are sent to emergency managers in specific regions when significant extreme weather events are expected. These notifications are typically issued three to four days in advance of the anticipated event.

(There were no audience questions for Matt MacDonald).

NICKY HASTINGS, NATURAL RESOURCES CANADA

Natural Resources Canada (NRCan) is involved in three climate change programs. First, the Climate Change and Geoscience Program (GSC-CCGP; up for renewal) provides geoscience expertise to reduce risk and inform adaptation solutions for transportation and community infrastructure and sustainable northern economic development. This expertise is needed for government land-use planners, industry, and regulators to make informed decisions on risk mitigation. The program comprises three projects. The 'coastal infrastructure project' characterizes, maps, and assesses that portion of the Arctic coastline where there is existing or potential coastal infrastructure. The 'land-based infrastructure project' is similar, but is targeted at lands with existing road and airport infrastructure. The 'essential climate variables project' monitors and assesses key climate components such as permafrost, glacier mass balance, and snow cover. Changes in ground conditions in Northern Canada can affect the costs, safety, and longevity of infrastructure, as well as investment risks or rewards. Geoscience knowledge of near-surface ground conditions can support informed decision-making and planning by northern communities.

The second program, the Climate Change Impact and Adaptation Program, facilitates adaptation planning, decision-making, and action across the country to increase Canada's resilience to climate change. The program raises awareness and enhances capacity to understand, prepare for, and adapt to the effects of climate change. Key stakeholder groups from government, industry, and professional organizations collaborate on adaptation priorities and have produced several published assessments (e.g. 2008 Regional Assessment, 2014 Sectoral Assessment, 2016 Marine Assessment, 2016 Transportation Assessment) and guides/primers (e.g. Sea Level Rise Strategies, Climate Scenarios, Climate Change to Infrastructure). The program has also provided more targeted products to assess impacts of climate change.

The third program, the Public Safety Geoscience Program, delivers targeted and national assessments for hazards such as earthquakes, tsunamis, slope failures, space weather events, and volcanoes. The program enables research to develop tools, standards, and guidelines for quantitative hazard and risk assessment and mitigation, as well as outreach activities. It shares experiences through a Disaster Risk Reduction (DRR) Network, for example through presentations in the Canadian HAZUS user group, which is open to interested people. Risk-based planning

requires a six-step process that proceeds from knowledge through analysis and evaluation to action: 1) goals and objectives, 2) hazard magnitude and intensity, 3) vulnerabilities, 4) losses and risks, 5) a plan, and 6) project outcomes.

Audience question 1: The disaster risk reduction database is a great goal, but it is hard to maintain a database over time. Is the goal to create a database that is more than a snapshot? How will the database be maintained?
Answer: We are currently looking into how to develop an online geodatabase.

Audience question 2: Does the transportation report for 2016 include pipelines?
Answer: I cannot answer that question, but I would guess that pipelines are included.

Audience question 3: Can you expand on the Hazus program and its future?
Answer: We are in the process of evaluating options for the future of the Hazus program in Canada and are looking at a variety of solutions to address risk assessment modeling.

Audience question 4: Could you tell us more about the adaptation library and what the future plans for it are?
Answer: You can find out more information on the adaptation library at http://www.adaptationlibrary.ca/

BREAKOUT SESSION RESULTS AND DISCUSSION

Two breakout sessions followed the morning plenary presentations. The first breakout session focused on the challenges to understanding changing natural hazards resulting from climate change. Discussion centered around five questions (see Appendix A and B). To stimulate discussion, participants were placed in breakout pods (eight pods in total) of mixed disciplines.

The second breakout session examined what is needed, in terms of information, tools[1], and governance, to address the challenges to understanding that were identified and discussed in the first breakout session. For this session, the breakout pods (five pods in total) were organized by discipline, and discussions were centered on three questions (see Appendix A and B).

Note on the interpretation of breakout session results:
For a variety of reasons, including style of questioning, facilitator/recorder skills, and the multi-disciplinary audience (see 'Reflection on workshop' on page 50), breakout session questions were addressed differently by some pods. As a result, it was difficult to analyse the breakout session responses uniformly across the pods. Therefore, numerical representations of the results below should not be interpreted as an absolute reflection of comments made by the workshop participants, but should rather be taken as trends. To further summarize results and facilitate interpretation, thoughts and comments written by the participants on sticky notes or flip charts were grouped under common themes or headers in the text and tables below.

QUESTIONS 1 & 2: IDENTIFICATION AND IMPORTANCE OF CHALLENGES IN UNDERSTANDING

The participants were first asked what are their biggest challenges or problems in their discipline or profession in understanding the intensity and recurrence of climate-based and climate-influenced hazard events in a changing climate. Additionally, the respondents were asked to rate the importance of those challenges/problems. The intent of these two questions was to assess the largest challenges in understanding among the different disciplines, and whether or not these challenges are considered and addressed.

The responses to the first question cover a wide spectrum of problems and challenges, however not all of the answers appear to relate to *an understanding* of the intensity and recurrence of climate-based and climate-influenced hazards events in a changing climate. Many answers pertain to a wider range of implications, shortcomings, and restrictions within and between disciplines or professions working on projects or programs involving climate change adaptation.

We grouped the identified challenges and problems in six categories: social, political, economic, environmental, scientific, and technical (Tables 1 and 2). Most breakout pods placed their comments into one of these six categories, although some did not categorize their comments; in the latter cases, we assigned these comments to the most appropriate category. Participants provided a total of 158 comments on sticky notes or flip charts; of these, 145 were placed into one of the six categories, and another 13 comments were out of context, but did not pertain to a new challenge. Most comments were in the political category, followed successively by comments in the scientific, technical, social, economic, and environmental categories (Table 1). To facilitate

[1] For the purposes of this report the term 'tools' can have various meanings, including (but not limited to): methods, procedures, systems, processes, guidelines or templates, databases, programs, models, etc.

interpretation and analysis of workshop outcomes, comments in each category were further grouped post-workshop according to common theme (Table 2).

Table 1. Number of comments by category.

Category	No. of comments
Political	35
Scientific	34
Technical	28
Social	21
Economic	20
Environmental	7
Total	**145**

Not all identified challenges could be tracked to the discipline of the commenter, as some pods listed common thoughts on flip charts. However, some interesting trends became apparent from the available data (Figure 1): Representatives of the federal and provincial governments made the most comments related to economic challenges; engineers and geologists made comments principally in the technical, scientific, and environmental categories; planners and local government were most concerned with political challenges; emergency managers identified mainly social challenges; and researchers provided comments for all except the economic category. These trends, although not absolute and should be considered with caution, may signal discipline-specific challenges. For example, the call for more or better data was mostly made by engineers and geologists, who were also most concerned about how to deal with scientific uncertainty. Federal and provincial government representatives were more concerned with justifications of spending and prioritizing spending, although they also had concerns about the science and data, and dealing with uncertainty. Planners and local governments identified several issues related to governance and regulation, whereas emergency managers expressed concern about personal responsibility and awareness, and plain-language communication.

Identified social challenges fall into four categories (Table 2): responsibility, education and awareness, communication, and mind-set. Comments revealed a concern about personal responsibility, or the lack thereof, evident from other comments related to short-term thinking and NIMBY-ism [Not In My Back Yard]. Increased communication and education/awareness were similarly identified in relation to the need for changing perceptions about climate change, whether to the public or among disciplines and governments. Participants in Pod 1 discussed the need for narratives, for example in the style of the New Yorker magazine, as the public seems to respond well to this type of messaging. Detailed information on impacts (e.g. 'a one degree increase in summer temperature will result in four times more area being burnt') will similarly help to increase awareness. More information on local impacts resonates better than information on national or global scales.

Political challenges were grouped under four sub-headings (Table 2): governance, legislation, policies and guidelines, political support, and capacity. Comments about governance mainly addressed governmental authority and responsibility. Many participants commented on the lack of clear governmental guidance on issues such as climate change adaptation and natural hazards, and some questioned who should determine what acceptable risk is. For instance, the transfer of regulations by the provincial government to municipalities or regional districts might result in interference and a lack of understanding of local situations. On the other hand, some local communities may not have the capacity and resources to deal with hazard issues. There is also a lack of consistency among the many federal and provincial government agencies involved, which has created confusion for many of the participants. Better legislation, policies, and guidelines are needed, not only from a government perspective, but also by professionals, for example in the form of best practices or guidelines. Although better legislation or policies might be helpful in setting standards and providing guidance, they may create other

problems, such as liability concerns or inflexible rules and regulations for developers/practitioners. Political support and will were cited by some participants as crucial for reducing risk from climate change and natural hazards. However, short-term (four-year) political cycles and uncertainty in climate change forecasts interfere with marshalling political support. At the local level, there may be political will to act, but it can be constrained by the lack of resources for mitigation or adaptation. Because local communities uphold policies supported by the electorate, it can be difficult to make changes; hence the need for education of the electorate. More political support is needed to integrate risk and hazard into planning, management, and risk assessment. However, climate projections, and subsequent changing hazards and risks, have large uncertainties; thus integrating these issues into decision-making and policies can be complicated. How much credibility can be attached to predictions based on models for the year 2100? There are many different climate change predictions models; who decides which one to believe/use?

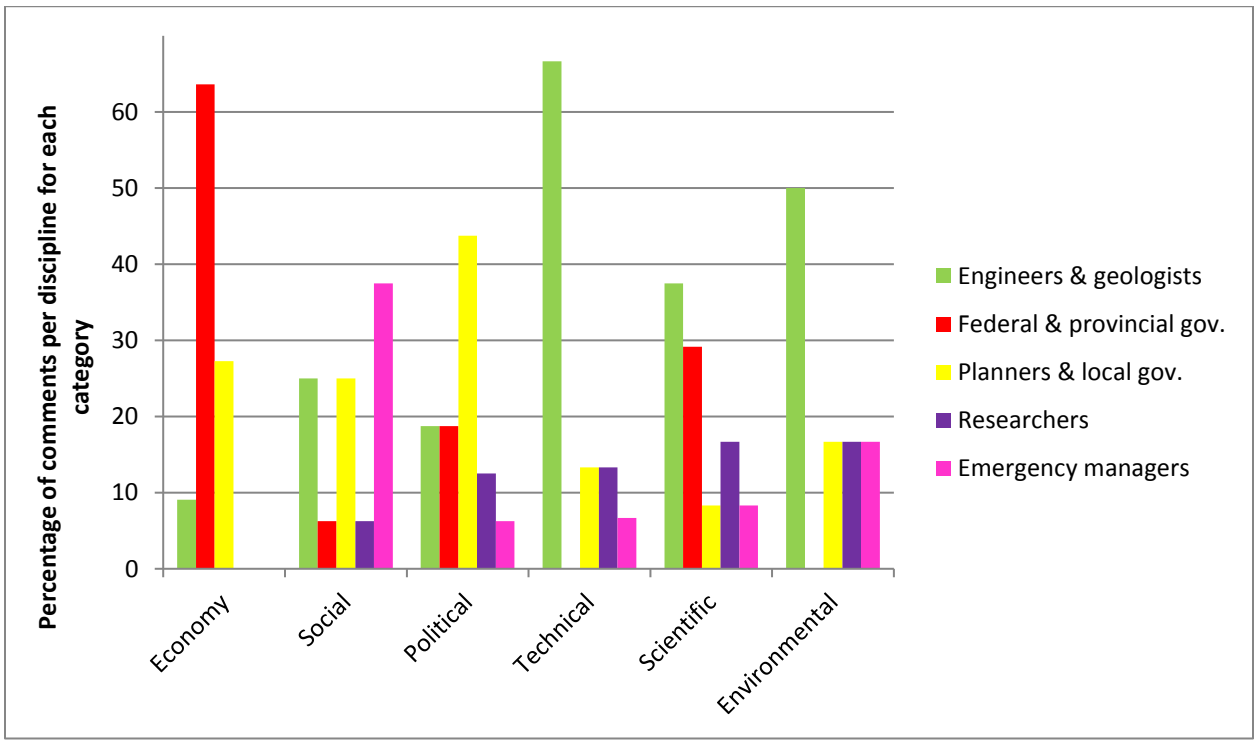


Figure 1. Percentage of identified comments per discipline for each category.

Several economic challenges were identified (Table 2) and can be grouped in three areas: cost-sharing responsibility, data/research expenses, and defining priorities. Cost-sharing is an issue at political as well as social levels. At the political level, short-term political cycles inhibit spending and policy advancement on climate change issues. At the social level, short-term thinking (i.e. 'not in my life time') is blamed for the public's resistance to adapt to climate change. Another major challenge is to define priorities in spending. Accountability to the electorate, whether municipal, provincial, or federal, demands the need for cost-benefit analyses. These analyses should include the negative impacts to communities (i.e. costs), as well as a cross-sector assessment of the impacts of climate change. This approach should yield a better understanding of the return on investment and might facilitate decision-making. Additionally, several participants called for a revision in the allocation of emergency funds to allow for proactive adaptation to climate change, instead of band aid-type solutions after the fact that only allow rebuilding to pre-disaster conditions, effectively building in future vulnerability.

Workshop participants commented least on environmental challenges (Table 2). Some comments were specific, pertaining, for example, to glacier and permafrost changes or saline water intrusion. Others were more general and related to an understanding of the importance of the environment and how environmental systems will change due to climate change.

Scientific problems and challenges fell into four categories (Table 2): lack of knowledge or understanding, scientific uncertainty, communicating science and uncertainty, and better understanding of climate change models. Several identified issues require better knowledge or understanding, ranging from a better understanding of certain scientific principles (i.e. intensity, magnitude, return interval), to causative relationships (e.g. 2nd and 3rd-order effects of temperature or precipitation changes, such as the impacts on soil moisture retention or landslide occurrence), regional or local effects, and the use of historic data for extrapolation. Studies into the cascading effects of climate and hazard change on other disciplines are also needed. Changing hazards and climate will affect many sectors, for example the health sector (e.g. the effects of air quality on an aging, more vulnerable population), the economy (e.g. increasing disaster spending), and transportation (e.g. aging and inadequate infrastructure). Scientific uncertainty is generally deemed to inhibit progress, and the implications of this uncertainty need to be better communicated. However, some participants argued that, while certainty is useful, we cannot ignore the current trend of a warming climate; uncertain projections are better than none. In addition, there needs to be consensus on information regarding climate change and consistent messaging, as there are many different climate change models, and workshop participants indicate difficulties in deciding which ones to choose. Concrete examples or narratives were proposed as possible methods to communicate scientific information, as these methods might resonate better with the public. A better understanding of climate systems and the processes involved in current climate models will help reduce scientific uncertainty related to climate change.

Technical challenges and problems can be placed into three categories (Table 2): improvement of methods, communication and access to data, and data needs. Many participants commented on the need for more uniform methodologies, through standards of care or guidelines. Better methods and interpretation of climate models are also needed by practitioners for local and regional projects. Similarly, there is a need for better methods to deal with uncertainty related to climate change. Currently, there are no standardized methods, and the user is left to interpret uncertainty. Better communication and access to data were also identified by many as a challenge, including sharing and storing data through a common database and improved audience-specific communication. The participants further identified a need for better, high-quality, high-resolution data, including more climate, hydrology, and LiDAR data, and continuous monitoring of the surface environment. Such data would allow engineers and geologists to better address local situations and recommend mitigation and adaptation measures. However, the participants realize that the costs of acquiring such data are considerable.

Among the challenges and problems identified above, two themes recurred. First, communication was identified as a social, scientific, and technical challenge. Second, calls for better regulations were recognized to be technical and political challenges. These recurring themes imply an interconnectedness of challenges and suggest that collaboration among different disciplines is needed to address issues. Many other identified challenges, while situated within a specific category, cross discipline boundaries and cannot be addressed with a siloed mindset. For example, to create increased general awareness of climate change (i.e. alter public perceptions) and to stimulate individual or community adaptation, uniform communication approaches are needed; and these approaches must be based on better data and improved methods to communicate uncertainty. Policies, regulations, legislation, and financial incentives can support efforts to increase climate change awareness. To achieve this, consensus must be reached on several discipline-specific issues, for example how to perform cost-benefit analyses and how engineers and geologists should address climate change issues on local and regional scales, but there is also a need to collaborate, cooperate, and communicate across disciplines.

Table 2. Identified challenges and problems faced by workshop participants in their profession or discipline in understanding the intensity and recurrence of climate-based or climate-influenced hazards events in a changing climate (Question 1).

Social challenges and Problems	
Responsibility	Who is responsible for decisions related climate change? (e.g. Who determines what is an acceptable risk standard?): • Reliance on governments and experts • Lack of personal responsibility • Support of electorate when making decisions • Sharing of data and results; does that also mean sharing of risk (i.e. responsibility)?
Education and Awareness	• Accept that we do not have the perfect knowledge on the future implications of climate change, but need to build on available knowledge. • Need to increase public awareness on the implications of climate change • Need to create narratives or other creative methods to reach the public
Communication	• Lack of uniform messaging from governments and experts (related to uncertainties in climate change predictions) • Lack of clear communication between disciplines and communication to the public
Mind-set	• Short public timeframe (i.e. not in my life time) • Lack of holistic/multi-disciplinary thinking: need to look at multiple aspects (e.g. societal, political, economic, and scientific) of climate change • NIMBY-ism • Need to look for new opportunities; focus on the positives
Political challenges and problems	
Governance	• Overlapping levels of government and agencies - Which level of government has the authority to act? - Which level of government is responsible? - Which level of government sets the rules? - Which level of government decides what is acceptable risk? • Provincial government needs to be engaged and play their rightful role • Political reticence
Legislation, policies and guidelines	• Regulation, need for policy • Engineers need clear legislation: - Liability issues - Lack of professional/practical implications (e.g. governments do not understand costs and liability when adopting certain codes) • Best practices vs. guidelines (with design criteria and exact numbers) • Rules on how to use climate change projections in risk assessments
Political support	• Needs for political will to increase and support regulations (e.g. allow Disaster Financial Assistance to be spent on adaptation strategies): - Integrate risk into planning and project management - Land-use policies that consider risk factors and threats - Need to move forward without perfect information - Opportunity to leverage changes to better meet human needs • Short-term political cycles (four-year) interfere with progress • Need for political support to share and store data (e.g. national databank): - Liability and security issues - Data ownership by clients (e.g. industry); no incentives to share data • Not enough emphasis on climate change in current risk assessments • Electoral support for policy changes
Capacity	• Smaller vs. bigger communities:

	- Availability of resources (i.e. related to local tax base)
Economic challenges and problems	
Cost sharing responsibility	• Funding determined by short-term political cycles (four-year) • Short-term thinking/mind set; people do not want to invest in adaptation strategies that exceed their own life span • Limited financial capacity of smaller communities; dependence on property taxes • Training costs; navigating different funding mechanisms
Data/research expenses	• High costs for certain data (e.g. high resolution data, LiDAR) • Costs of accessing data: - Software user fees • Data ownership by clients (e.g. industry); no incentives to share data
Defining priorities	• Justification of costs: - Cost-benefit analysis used in decision-making process - Accountable to electorate - Negative impacts (i.e. costs to community) should also be considered - Economic analysis of impacts of climate change by sector (e.g. health, energy) - Fulsome accounting for the life decisions people make (e.g. property purchase, infrastructure support) • Emphasis should be on return of investment; understanding return of investment of specific solutions to risk; encourage investment in resilient design • Allocation of emergency funds: - Disaster Financial Assistance (DFA) only allows rebuilding to pre-disaster level; there is no room for more expensive adaptation strategies. Seems like a poor way to spend funds. - Proactive vs. reactive funding of emergency/disaster management activities.
Environmental challenges and problems	
	• Intrinsic value of the environment. How important is the environment? • Failure to understand systems, e.g. transecting/intersecting systems • Conflicting values between environment and emergency management • Lack of knowledge on system changes when certain climate thresholds are reached • Shoreline squeeze: reducing fish and wildlife habitat by building walls and barriers • Conflicting environmental and emergency management values • Lack of understanding of glacier and permafrost changes; permafrost changes are hard to detect • Saline water intrusion; contamination of surface water and groundwater by saline water will lead to changing crop patterns and loss of fertility of lands
Scientific challenges and problems	
Lack of knowledge or understanding	• Lack of understanding by the public of basic scientific principles (e.g. return period, 1-in-50-year flood, intensity, frequency, magnitude) • Lack of understanding of process chains/causative relationships (one process leading to another) • Lack of understanding of local and regional effects of climate change • What is our reliable state of knowledge about the present climate (~10,000yrs)? (need to know that before we can predict hazards in a warmer climate). • Risk quantification • Use of historical data for future predictions • Cascading effects to other disciplines (e.g. compromised air quality due to wildfires)

Scientific uncertainty	• Scientific uncertainty is inhibiting progress • The effects of uncertainty in global climate change models on regional models and predictions • 2^{nd}, 3^{rd}, 4^{th}-order effects of climate change (e.g. what are the effects of increasing storm intensity on the occurrence of landslides?) • Deciding what is reliable information
Communicating science and uncertainty	• Translating scientific information for other users and the public • Consensus on information (need to convey a consistent message) • Need for a clear and common language to explain science • Need to be careful in how to present impacts of climate change without getting to far from scientific facts • Need for concrete examples that resonate with the intended audience (e.g. a one degree rise in summer temperatures will lead to four times more area burned by wildfires).
Understanding of climate change models	• Need better data to predict hydrogeological implications. • Better understanding of what climate models currently capture • Thresholds for complex systems change
Technical challenges and problems	
Improvement of methods	• Need for standardized procedures • Standards of care vs. guidelines • Need for a single unified risk assessment methodology • Translation of climate change scenarios to risk scenarios • Interpretation of general/regional climate data on a site-specific basis • Better methods to deal with uncertainty in models (e.g. how can we use data for future (AD 2100) projections?) • How to account for 2^{nd}, 3^{rd}, 4^{th} order implications of climate change? • How to make decisions dealing with uncertainties?
Communication and access to data	• Need for a better understanding across, and collaboration between, disciplines • Need to share data, information, and tools between disciplines and with the public • Need for a common database/access to data of others • Visualization tool for communication • Target communication to the intended audience (i.e. simplify the message, use of plain language) • Agree on, and use, common terminology • Better access to special software
Data needs	• More climate and hydrology stations, especially at high elevations • Continuous monitoring of climate and hydrology stations • Easier access to regional-scale models • Updated, high-quality data • More/better access to LiDAR data

Note: challenges and problems were grouped during the post-workshop analysis to facilitate interpretation.

Table 3. Prioritized challenges in understanding that were identified in each breakout pod (Question 2).

Pod no.	Category	Comment
1	Social/ scientific	1. Public communication
		2. Scientific uncertainty
2	Technical	1. Availability of data
	Technical	2. Translation of scientific knowledge to stakeholders
	Scientific	3. Layers of uncertainty
	Technical	4. Site-based problems
3	Economical	1. Local governments need to develop/rely on property taxes, whereas in other countries local governments have other resources and thus have less pressure to develop/build at any cost
	Technical	2. Access to regional-scale climate change data
	Social	3. Multi-disciplinary nature of climate change and opportunity to leverage changes in attitude to better meet human needs
4	Scientific	1. Uncertainty in climate change projections and science
	Political	2. Uncertainties about policies and rules
	Political	3. Need for engagement by the provincial and federal governments
	Social	4. Public education and greater understanding
5	Political	1. Sharing and archiving knowledge on climate change adaptation
	Scientific	2. 2^{nd} and 3^{rd}-order effects and corresponding return periods for such events
	Political	3. Clear legislation on requirements to incorporate climate change into design and operation of infrastructure
	Technical/ scientific	4. Projecting intensity and frequency of events well beyond the period of historical/instrumental records and communicating the associated uncertainty
	Social	5. The constellation of human health impacts of climate change acting together (e.g. heat and drought as stressors, air quality decline from wild fire over a period when demographics are shifting (>80 yr, > chronic cardio-respiratory disease)
6	Scientific	1. Lack of certainty (science used to be the driver)
	Social	2. General vote for social issues (including public apathy, resistance to change, cognitive limitations (exhaustion), reliance on government action, dealing with grief (especially among Indigenous peoples))
	Environmental	3. Failure to understand systems. Transecting/intersecting systems
	Political	4. General vote for political issues (including communication of risk and individual responsibilities, political will to change, governance, a lack of coordination, short-term political cycles, and opportunities
7	Economical	1. Understanding of the return on investment of specific actions to lower risk
	Social	2. Personal responsibilities; develop neighbourhood resilience plans
	Political	3. Integrating risk into planning and project management
8	Political	1. More data and studies in the public domain
	Political	2. Regulation challenges; political will to uphold regulations
	Economical	3. Need for fulsome accounting for the important decisions people make (e.g. property purchase, infrastructure support)

Note: Colours indicate common themes across pods: blue = communication; green = uncertainty; red = data availability; purple = political/governance; orange = cascading (social) effects.

The participants were asked to prioritize the identified challenges (Table 3) by selecting their personal top three challenges. Table 3 summarizes the challenges that received three or more votes in each pod. Pod 1 did not vote on the identified challenges, but the participants widely agreed on scientific communication and uncertainty as the top priorities. In five of the seven other pods, political challenges were ranked among the most important challenges. Clear legislation and policies, integration of risk in planning and project management, and lack of provincial engagement were among the political priorities cited. In three of the seven pods, technical challenges were among the three most important priorities. Technical challenges are mostly related to data availability and how to best use data. Five pods identified social challenges among the most important challenges, which include concerns over cascading effects, personal responsibility, and opportunities for change. Five pods rated scientific priorities highly, mainly around uncertainty in climate change projections.

SUMMARY:

- We grouped 145 comments into six categories; of these, almost half relate to political or scientific challenges or problems.
- Many identified challenges do not pertain to understanding climate-based or climate-influenced hazard intensities or recurrence, but rather to challenges in managing changing natural hazards from the perspective of different disciplines.
- A trend in discipline-specific comments was observed among the different groups (Figure 1): federal and provincial government participants identified mainly financial challenges; engineers and geologists identified technical, environmental, and scientific challenges; and planners and local governments identified mainly political challenges.
- Among the different pods, political challenges were identified as a priority (Figure 2), followed by scientific, technical, and social challenges:
    1. Political challenges include political engagement, clear legislation and policies, and incorporation of risk into planning and project management.
    2. Technical challenges focus mainly on data availability and how to best use data.
    3. Social challenges address cascading effects on other sectors (e.g. health), lack of personal responsibility/awareness, and opportunities for change.
    4. Scientific challenges are mostly concerned with uncertainty in climate modeling.
- Communication challenges were identified as social, scientific, and technical issues.
- Better regulation and legislation were identified as political and technical challenges.
- There is a need to address discipline-specific issues, and a simultaneous need to collaborate, cooperate, and communicate across disciplines.

Figure 2. Flip chart from Pod 8, reflecting its conclusion that political (POL) and scientific (SCI) challenges are important.

QUESTIONS 3, 4 & 5: HAZARD THREAT AND CHALLENGES IN UNDERSTANDING

Questions 3, 4, and 5 targeted the level of understanding of climate-based/climate-influenced hazards that pose the largest threat to, respectively, Canada, British Columbia, and southwest British Columbia (i.e. the Lower Mainland). Question 3 asked the workshop participants to list and rank up to three potential climate-based/climate-influenced phenomena that pose the largest threat to Canada, British Columbia, and southwest BC, whereas Question 4 asked them to identify climate-based/climate-influenced hazards that pose the biggest challenge in understanding. Question 5 sought discussion of differences between the answers to questions 3 (largest threat) and question 4 (understanding).

In general, the workshop participants agreed well on the top hazard threats and top challenges in understanding, and almost the same hazards were ranked among the top three in both categories (with the exception of 'landslides' in BC; Table 4).

Table 4. Top three hazard threats and top three challenges identified.

	Hazard threat				Challenges in understanding		
	Canada	BC	SW BC		Canada	BC	SW BC
1	Flood	Flood	Flood	**1**	Flood	Flood	Flood
2	Drought	Wild fire	Storms	**2**	Drought	Wildfire	Drought
3	Wild fire	Drought	Sea-level rise	**3**	Sea-level rise	Landslides	Storms

Twenty different hazards were identified by the participants as the largest threat (Table 5). Canada received the largest number of distinct hazards (20), which is reflective of the country's size and topographic and climatic variability. In comparison, participants identified 11 hazards for British Columbia and 14 for southwest BC. For example, hazards related to snow and ice were not listed for BC and southwest BC. In contrast, landslides were considered a large threat for BC and southwest BC, but not for Canada. Overall, flooding was deemed the largest threat for Canada, BC, and southwest BC, followed by wildfire and drought for Canada and BC, and storms and sea-level rise for southwest BC (Tables 4 and 5).

Some of the hazards identified in Table 5 are not climate-based or climate-influenced per se (listed in italics in the table); rather they are either an impact or consequence of changing hazard conditions resulting from climate change (i.e. climate refugees, food security, resource extraction, water resources), an identified vulnerable group (i.e. aging population), or a geophysical hazard (i.e. earthquake).

Workshop participants identified 25 challenges in understanding climate-based or climate-influenced hazards. They listed floods as the biggest challenge in understanding for Canada, BC, and southwest BC, followed by drought and sea-level rise for Canada, wildfire and landslides for BC, and drought and storms for southwest BC (Tables 5 and 6). As in the case of the response to Question 3 (largest threat), some of the identified challenges in understanding are not related to climate-based or climate-influenced hazards per se (listed in italics in Table 6), but are either related to impacts (i.e. impact of flooding on local communities, water availability, food security, climate refugees/migration), availability of data (i.e. detailed weather data, communities at risk), conceptual challenges (i.e. Intensity Duration Frequency (IDF) principles, multi-disciplinarity, risk acceptance, effectiveness of mitigation), governance challenges (i.e. decision-making, weak land-use planning, water resource management), or risk acceptance (i.e. collective appreciation of climate change, wilful ignorance).

Table 5. Climate-based or climate-influenced hazards that pose the largest threat for Canada, BC, and southwest BC.

Hazard	Canada	BC	SW BC
Flood	28	28	24
Sea-level rise	2	7	13
Extreme rainfall	1	1	2
Water resources	1		
Storms	4	5	15
Wind			3
Drought	17	12	9
Temperature increase	9	3	1
Wildfire	10	20	5
Permafrost degradation	1		
Arctic warming	2		
Ecological collapse	1		
Disease	2		
Insect-borne illness	1		
Insect plagues	1		
Winter season length	1		
Low snowpack	1		
Ice storm	1		
Snow	1		
Landslide		3	2
Ground disturbance			1
Food security			1
Climate refugees	1		
Aging population	1		
Earthquake			2
Interaction with resource extraction		1	
Other identified hazards (not voted)			
Avalanche		*	
Air quality			*
Tsunami due to landslide		*	
No. of identified hazard types	**20**	**11**	**13**

Note: italicized items are not directly climate-based or climate-influenced hazards.

Table 6. Identified climate-based or climate-influenced hazard events that pose the greatest challenges in understanding (italicized items are not directly climate-based or climate-influenced hazards).

Challenge in understanding	Canada	BC	SW BC
Flood: Fraser River flood peak flow ***Flooding in local communities with limited resources*** **Erosion related to flooding**	10	11	13
Sea level rise (e.g. Impacts on infrastructure, economy, etc.)	5	1	3
Storms	5	3	4
Drought: **- *Accommodating long-term impacts in decision-making***	7	2	5
Wildfire: Boreal forest **Impacts of wildfire**	3	8	1
Increasing temperature	1	1	1
Arctic sea ice?	1		
Permafrost degradation	1	1	
Coastal erosion	1		
Landslides: Debris flows **Post-wildfire debris flows**		5	2
Ecosystem collapse	2		
Insect plagues	1	1	
Disease	1		
Detailed weather data	1		
Intensity-duration-frequency (IDF) principles	1	1	1
Higher-order effects	1	2	1
Extreme events	1		
Atmospheric patterns	1		
Water availability		1	2
Air quality			1
Food security	1		
Climate refugees / migrations	1		
Weak land use planning		1	1
Population at (un)known risk/ "Oso scenarios"			1
Multidisciplinary nature of risk	1		
Mitigation effectiveness	1		
Risk acceptance	1		
Collective appreciation of Climate Change	1		
Wilful ignorance/ psychology	1		
Other identified challenges (not voted)			
Data & understanding of cumulative risk assessment (multi-disciplinary)	*	*	*
Water resources management (incl. apportioning water in late summer/ low flows)			*
No. of identified challenges in understanding	**25**	**14**	**15**

Note: italicized items are not directly climate-based or climate-influenced hazards.

Floods were identified as the largest threat and the biggest challenge in understanding for Canada, BC, and southwest BC (Tables 4, 5, and 6; Figure 3). Most insured losses from disasters between 2009 and 2014 were due to water damage (IBC, 2014), in line with the recognition of floods as the largest threat. Participants in one of the breakout pods rightfully questioned: "What do government officials and planners mean when they list floods as a challenge?" It is likely that, aside from engineers and geologists, some responses to Question 4 (e.g. from government officials, emergency managers, and planners) were not referring to the technical or scientific understanding of flood hazard, or for that matter some of the other hazards included in Tables 5 and 6, but rather to a lack of information at a policy level (i.e. a lack of knowledge transfer between scientists and policy makers), interpretation of available data (i.e. simple uniform messages), or accessibility of data (i.e. common database).

The responses to Question 4 furthermore indicate that workshop participants are concerned about some conceptual challenges, for example risk acceptance and the multi-disciplinary nature of hazards and climate change. Similarly, the participants identified several practical challenges (e.g. data management, land-use planning, and availability of detailed weather data), as well as more 'novel' challenges, such as dealing with climate refugees and food security, and the cascading effects of sea-level rise. One response identified a public safety issue, comparable to the Oso landslide in Washington State in March 2014, namely how many communities are at known or unknown risk and how do we deal with this?

SUMMARY:

- The largest threat, as well as the biggest challenge in understanding, for Canada, BC, and southwest BC is flooding (Figure 3).
- Among the top three threats and challenges in understanding are (in different order for Canada, BC, and southwest BC): drought, wildfire, storms, and sea-level rise.
- Depending on the participants' disciplines (e.g. hydrologist vs. government official) 'challenge in understanding' might not be related to the actual understanding of flood hazard or flood science, but instead could imply a lack of information, or might be related to interpretation of, or access to, data.
- If not directly related to a natural hazard, identified challenges in understanding are conceptual, practical, novel, or a public safety concern.

Figure 3. Floods, floods, floods…

IDENTIFICATION OF NEEDS

The afternoon breakout session focussed on identification of needs, in the form of information, tools, and governance (Questions 6-8, Appendix A and B) to address challenges in understanding or managing natural hazards in a changing climate. In the discussions below, we focus on those needs that address the most important challenges identified by the workshop participants, which are political, technical, social, and scientific (see Table 3).

The afternoon five breakout pods represented different disciplines: researchers, engineers and geologists, planners and local government, federal and provincial government, and emergency managers.

QUESTION 6: INFORMATION

The workshop participants listed information needs under seven headings: data, communication and education, professional/regulatory, governance, financial, conceptual, and decision-making (Table 7). Not all comments submitted by the participants directly refer to information needs, but rather pertain to needs for political leadership or improved collaboration.

Political challenges can be addressed by improvements in governance and better guidelines and regulations for planners and local governments setting standards for incentives or penalties. Similarly, planners and local governments, as well as federal and provincial government officials, recognize a need for cost-benefit analyses that can generate new or improved information regarding the effectiveness of adaptation and mitigation measures. Engineers, geologists, planners, and local government representatives emphasized a need for professional guidelines. Whereas engineers and geologists question government involvement in defining specialties and regulations and would like regulations to be flexible (Pod 3), planners and local government officials want the provincial government involved and "need something with more weight than just guidelines (Pod 5)". Furthermore, guidelines should incorporate climate change adaptation, and clear rules are needed for collecting and using data for assessments that include hazard and risk. Better information about the costs and benefits of mitigation or adaptation measures will help inform the electorate about the impacts of climate change and the implementation of local measures. The Provincial Government can assist by ensuring appropriate legislation is in place.

Extensive data needs were highlighted mostly by researchers and engineers/geologists, and focus mainly on continuous and higher resolution climate data, and a central database. Such data would address some of the technical challenges that were identified. Specific suggestions include a provincial database that would include all studies down to the municipality scale, and public access to data similar to the Alberta Rock Core inventory. Additionally, a need for more dense local data was identified, as current monitoring stations commonly are distant from study sites. Regional data and projections are helpful, but local communities will experience large differences in climate impacts.

Better communication and education methods were identified as needs by all disciplines, mostly in the context of addressing communication and education barriers between disciplines and the general public. The methods could be used to address scientific and social challenges. Participants in Pod 1 questioned how well organizations like the Geological Association of Canada (GAC) and universities are doing in communicating science. The participants agree that there is a need for a communication medium that the public will use. Other comments refer to a common simple language for communication or the translation of information, and the need for additional education for scientists/researchers, policy-makers, and communicators on the limits of science and communication of risk and uncertainty. In tandem with the need to improve communication is the need for better information on some conceptual issues, such as a definition of acceptable risk, uncertainty, and decision-making frameworks.

Table 7. Comments from the workshop regarding information needed to address challenges in understanding or managing changing natural hazards.

Comments	Researchers	Engineers and geologists	Planners and local government	Federal and provincial governments	Emergency managers
Data	Basic monitoring information (stream gauges, sediment measurements, etc.)	Higher resolution climate data	Local science data	Base-level data collection	Centralized data sharing
	Continuous monitoring	Historical and current data		Data and knowledge management	More emphasis on emergency management and planning vs. privacy of data
	Paleo-data	Access to climate modellers			Perceived and actual liability of owning information
	Climate observations	Second third-order effects			
	Spatial correlation and temporal variation	Common digital database			
	National LiDAR database	Dealing with uncertainty			
	Central data storage				
Communication and education	Improved communication: Breaking down barriers between disciplines	Common language for communication	Education of electorate on climate change, adaptation, regulation and legislation	Educating policy-makers on limits of science	Process for transfer of knowledge from academic research to practitioners/policy makers
	Collaboration at all government levels and stakeholders	Translation of information		Training for scientists on communicating risk and uncertainty	Common language and consumable information
		Education on climate change models			
	Better public communication	Communication/ knowledge transfer skills training for scientists		Communication of climate change to users	

Comments	Researchers	Engineers and geologists	Planners and local government	Federal and provincial governments	Emergency managers
Communication and education	Training of communicators (e.g. liaisons, researchers)	Communication experts		Promotion/marketing of governmental services and efforts	
Professional/ regulatory		Design guidelines	Professional practice guidelines		
		Non-restrictive guidelines	Checklists of best practices		
Governance			Leadership entity	Interdisciplinary platforms	
			Coordination at Provincial and regional levels		
			Common process/framework/ monitoring process		
			Guidelines and regulations; Incentives vs. penalization		
			Regional coordination of codes/bylaws		
Financial			Costs and benefits; limited by resources and capacity	Funding from Federal government	Increased funding for practitioners (e.g. planners and disaster managers)
				Determining costs and benefits (opportunity, liability, hidden consequences of inaction)	
Conceptual		Definition of acceptable risk	Discussion regarding 'uncertainty'		
		Decision-making framework			
		Dealing with uncertainty			

Comments	Researchers	Engineers and geologists	Planners and local government	Federal and provincial governments	Emergency managers
Decision-making				Commitment to activities longer than political cycles	
				Connecting practice and decision-making	
				Insulate climate change adaptation from politics	

QUESTION 7: TOOLS

Several tools that could help address some of the challenges in understanding or managing changing natural hazard risk were identified. We have grouped them in five categories: technical, communication, financial, professional, and government/governance (Table 8). Some other items were identified that are not considered tools.

Financial, professional, and governmental/governance tools can help address political challenges. Financial tools include cost-benefit analyses, financial support programs, and insurance incentives. Financial support should be available not only to researchers but also to practitioners (e.g. planners or emergency managers). Additionally, there should be municipal funding for retroactive fixes (e.g. houses that are already in the floodplain). Professional tools include guidelines, such as building and construction codes. Governments should pursue better regulations, in the form of set standards, performance measures, or liability protection, and support for new technologies, to address political challenges.

Participants suggested several tools to address technical challenges: better visualization tools in climate models, linkages between climate and engineering tools, and Google-compatible mapping programs. Additionally, there was a suggestion for a data-sharing tool, although details were not provided.

To address some of the social challenges (i.e. lack of personal responsibility, awareness, and willingness to adapt), participants suggested a number of communication tools, mainly to inform and educate the general public. Suggested tools include online availability of data and use of popular social media (e.g. Twitter, Facebook, and YouTube). A novel approach was the use of artists to help visualize adaptation strategies. Furthermore, participants identified the need for consistent messaging. Additional methods include the use of narratives and information on local impacts instead of national and global impacts.

Interestingly, none of the tools described above and in Table 8 addresses the scientific challenge of dealing with uncertainty, which was a challenge that was prioritized in several pods (Table 3; colour-coded green). Having no standardized tools or guidelines to deal with uncertainty may lead to a misrepresentation of risk, which could affect risk management and the implementation of adaptation practices or strategies.

QUESTION 8: GOVERNANCE AND/OR PARTNERSHIPS

Workshop participants identified several governance and partnership needs, summarized under three main headings: leadership, organizations, and methods (Table 9).

An increase in capacity and resources is needed at both the federal and provincial levels of government. The planners and local government officials stressed a need for a provincial regulatory framework. Additionally, increased collaboration and cooperation among different branches and levels of government are needed and might lead to better access to information. Collaboration with other stakeholders and a focus on sustainable partnerships are also needed. Several government organizations are deemed essential for providing governance or partnerships: Environment and Climate Change Canada, BC Ministry of Forests, BC Ministry of Environment, Department of Fisheries and Oceans (DFO), the provincial Agricultural Land Commission (ALC), and Natural Resources Canada. Other important groups include universities; community planners; GeoBC, which provides geo-spatial products; FICOM (Financial Institutions Commission), which provides equitable and balanced regulation of provincially regulated financial institutions in British Columbia and deals with pension plans, real estate, mortgage brokers, and financial institutions; and the Credit Union Deposit Insurance Corporation (FICOM, 2016). Professional organizations, including an IPCC subcommittee on hazard change, as well as several private and other organizations and individuals were also mentioned by the workshop participants.

Several methods that might assist in establishing governance or partnerships were suggested. Some suggestions relate to communication (i.e. integration in school curriculum, small community champions, and a governing body for translation of science) and might help address social challenges through education, thereby creating more awareness. Other methods are related to a regulatory framework for practice and data collection (i.e. guidelines for local projects, regulation of data collection, standardized tools, and transparency) and might be of value in tackling technical challenges.

SUMMARY

- Information needs (Table 7) fall into the following categories: data, communication and education, professional/regulatory, governance, financial, conceptual, and decision-making.
    - More information and improved communication and education are needed to address social and scientific challenges, such as personal responsibility and awareness, and communication between stakeholders and the public.
    - More information regarding financial impacts, effectiveness of mitigation and adaptation methods, and regulation and policies can help build a political framework.
- Tools needed (Table 8) fall into the following categories: technical, communication, financial, professional, government/ governance.
    - Tools to address political challenges include cost-benefit analysis, building and construction codes, liability protection, and government support for new technologies.
    - Tools to address technical challenges include visualization tools, Google-compatible mapping, and tools to link climate science and engineering.
    - Communication tools, such as online platforms, online data storage, narratives, and artistry, can be used to address social challenges. Focus should be on local and personal impacts of climate change and changing hazards, as they will resonate best for most people.
- Governance and/or partnership needs (Table 9) include leadership, organizations, and methods.
    - Capacity and resources at the federal and provincial level.
    - Collaboration among governments and other stakeholders.
    - Government, professional (including a to-be-established IPCC sub-panel on hazard change), private, and other organizations and/or individuals were identified.

Table 8. Comments from the workshop regarding tools needed to address challenges in understanding or managing changing natural hazards.

Comments	Researchers	Engineers and geologists	Planners and local government	Federal and provincial government	Emergency managers
Tools - technical		Better visualization tools in climate models			
		Connection between climate tools and traditional engineering tools			
		Google-compatible mapping programs			
		Data sharing tools			
Tools-communication	Public online libraries	Publically available data		Professionals who bridge climate science and other models (economic, etc.)	Public education
	Popular communication media (e.g. Twitter, Facebook, YouTube videos)			Visualizing adaptation: engage artists with science	Consistent messaging
				Consistent messaging	
				Modeling that is accessible to the public	
Tools - financial	Support programs (e.g. discovery programs)	Municipal funding for retroactive fixes	Cost-benefit analysis (translating impacts into dollars)		Pay-off model (i.e. showing justification of spending vs. future savings)
		Tracking of risk information: cost of impact	Insurance incentives		
					Incentives
Tools - professional		Professional practice guidelines			Long-term building and construction codes
Tools - government/ governance		Set standards for municipal mapping programs (Google compatible)		Government support for innovative new technology	Performance measures/ tools: helps with universal risk

Comments	Researchers	Engineers and geologists	Planners and local government	Federal and provincial government	Emergency managers
					assessment/influence behaviour)
Tools - government/ governance		Professional practice guidelines		Better regulation	Liability protection
				Climate change plans (e.g. sea-level rise plans; extension of OCP)	
Other		Good quality climate prediction data at local scale	Social values and social benefits. How to quantify resilience? (e.g. trade-offs flooding of agricultural lands)		Reconsideration of funding (e.g. DFA to include adaptation measures)
		Access to climate scientists			
		More applied science			

Table 9. Comments from the workshop regarding governance and/or partnerships needed to address challenges in understanding or managing changing natural hazards.

Comments	Researchers	Engineers and geologists	Planners and local government	Federal and provincial government	Emergency managers
Leadership – provincial		Province needs to match capacity to responsibilities	Provincial leadership: resources and capacity		
		Consensus/decision-making at provincial level	Provincial regulatory framework with cost-sharing and defined cost-benefit analysis		
Leadership - federal	Partnerships between ministries at federal government level	National guidelines with input from municipalities	Federal capacity		
		Backed federally, supported provincially			
Leadership - collaboration	Consistent government support of science	Involvement of insurance industry (i.e. guide development); need for residential flood insurance	Coordination of all governments and stakeholders		Focus on sustainable partnerships
		Governance must be multi-level and collaborative			
Organizations - professional		IPCC sub-committee for hazard change, which has funding for scientific studies		Professional organizations	Facility and property management organizations
Organizations - government	Environment Canada Ministry of Forest Ministry of Environment		Environment Canada Department of Fisheries and Oceans Agricultural Land Commission Transport Canada?	Community planners	Environment Canada meteorologists NRCan FICOM GEOBC
Organizations - private	BC Hydro BC Rail			Private sector (finance, re-insurance)	
Organizations – other				Philanthropists Communications Artists	

Comments	Researchers	Engineers and geologists	Planners and local government	Federal and provincial government	Emergency managers
Organizations - other				Educational institutions NGOs	
Methods		Better integration in school curriculum	Standardized tools and transparency		
		Enabling champions from small communities			
		Governing body that translates academic science into private-sector practice			
		Applicable guidelines for local projects			
		Physical boundaries at watershed level			
		Regulation on data collection			

MURAL COMMENTS

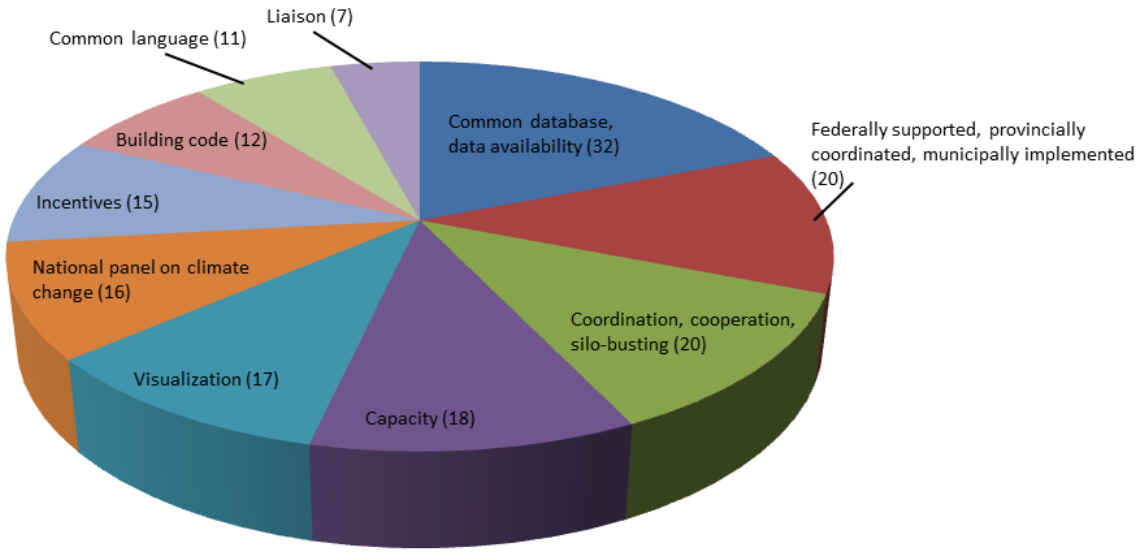
During the afternoon plenary, workshop participants were invited to write anything they wanted to share on the topics of priorities, needed work, and lists of actions on sticky notes and place them on a 'mural' (i.e. large sheet of paper; Appendix C).

Several common themes were apparent among the comments that were offered (Figure 4). They can be considered thoughts or ideas that resonated with the workshop participants, and could provide guidance for future endeavours. Most of these comments reflect the findings of the breakout sessions, in which data issues, governance/leadership, and communication were central themes. Data needs appear to be central to understanding and managing challenges related to climate-based and climate-focused hazards, as are clear governmental leadership at all levels, and coordination and cooperation.

A few comments placed on the mural stood out as not having been extensively discussed in the breakout sessions or during the plenary talks, and were only mentioned in one pod. These comments provide additional opportunities or strategies to increase awareness and collaboration:

- Promotion of earth system and climate science in all levels in the education system, with early engagement and visualization tools.
- A 'good Samaritans act' that applies to risk assessors.
- Involvement of artists in climate change story-telling (e.g. theatre documentation, public art, social media, festivals).
- Engagement of economists, financiers, and accountants in discussions.

Figure 4. Common themes based on participants' comments. (Note: number of comments in brackets).



WORKSHOP EVALUATIONS

Participants were invited, via an email sent to them after the workshop, to fill out an online workshop evaluation questionnaire. Comments were received from 32 of the 80 workshop participants.

Overall, the workshop was well received by the respondents – 78.1% of them found the workshop very valuable, and only 3.1% (one person) concluded that the workshop not very valuable (see Appendix D). Most respondents indicated they felt invigorated (50%) or glad (40.6%) when they left the workshop, although 3.1% felt frustrated and 6.3% 'ho-hum' (see Appendix D).

The workshop participants valued the perspectives of the different disciplines that were represented, and the wide range of ideas and thoughts that were voiced in the discussions and breakout sessions. They particularly enjoyed the opportunity to meet and interact with people from other disciplines and to learn from their experiences on the issues of climate change and adaptation. The plenary presentations were also well received and provided a good overview of different stakeholders' perspectives and experiences when dealing with climate change issues. Many workshop participants thought the mixed-discipline and discipline-centred breakout sessions provided a good opportunity to solicit information, ideas, and experience. The ability to speak freely (i.e. the Chatham House rule) was also valued.

Participants made several suggestions for changes to the structure of the workshop. Some suggested different presentations, for example on the effects of climate change on specific ecosystems, how jurisdictions are addressing climate change and related hazards, examples of risk assessment in a changing climate, and national strategies. Others commented that the focus of the workshop could have been different, i.e. more technical. Some participants suggested that there should have been a more equal representation of disciplines, for example, more emergency managers and possibly elected politicians. Other respondents thought that some of the facilitators could have been better prepared or that professional facilitators should have been used. Some mentioned that the workshop could have easily spanned more than one day, as they felt rushed in the breakout sessions. One respondent suggested that professionals who disagree about widely accepted ideas of climate change should have been invited to the workshop, to include their perspective and experience in the discussions. Another participant mentioned that he/she would have liked to have heard new perspectives on climate change adaptation, for example from small municipalities with few resources or from First Nation communities in vulnerable areas, instead of the 'usual suspects' – well-resourced communities such as the City of Vancouver.

Participants offered many suggestions for follow-up events and actions. Some would like to see the discussions and results of the workshop documented, distributed, or promoted through, for example an online summary report, proceedings or paper, summary reports geared to specific government levels, an online forum, public lectures, a public fieldtrip, special sessions at the GSA (Geological Society of America) or GAC (Geological Association of Canada), a website, or presence in social media. Other participants suggested a follow-up workshop, more narrowly focussed mini-workshops, or the formation of working groups around specific topics. Some suggestions for more opportunities for cooperation were offered, for example additional opportunities to interface with government agencies working on climate change and hazards, partnerships, or the creation of an annual inventory of relevant projects. Some respondents identified a need for more knowledge or tools. One participant would like to see a report with climate change predictions for specific communities in British Columbia to aid local governments with adaptation, planning, and mitigation. Another respondent would like a national framework for risk assessment related to climate change, including basic tools, in a common, easily understood language. Other respondents would like to have information on how the workshop results will be translated into policy, guidelines,

or bylaws; how action could be taken; or what the implications are for education and training for hazard-focused decision-making.

Only a few respondents thought that they gained little from the workshop to bring back to their organization. Many others commented that the multi-disciplinary nature of the workshop had brought them a better appreciation of the variety of effects that a changing climate could impose on other stakeholders (e.g. developers, municipalities). Furthermore, the workshop provided some respondents with a greater awareness of federal and provincial agencies, guidelines, and programs (e.g. NDMP) related to climate change. Some participants thought the workshop provided a good background resource for future decisions and actions, or a greater awareness of hazard change in relation to climate change. Participants further commented that they are now better aware of professional practices or guidelines (e.g. Risk-Based Land Use Guide) in relation to climate change and have shared resources (e.g. the BC MoTI Technical Circular) with their colleagues. Another respondent realized there is a need to communicate risk to infrastructure owners, operators, or jurisdictional authorities.

Several participants suggested a need for a more technical workshop or 'expert-only' meeting, followed by a meeting of users, decision-makers, and policy-makers. Suggestions for inclusion in a technical meeting included examples of known hazards in British Columbia or specific hazard/risk/vulnerability assessments. One respondent wondered if there would be an opportunity for the Centre for Natural Hazards Research (CNHR [at SFU]) to offer courses such as terrain mapping. Another person asked if we saw an opportunity for their agency to provide professional training in this topic as part of providing professional development credits.

MOVING FORWARD

REFLECTION ON WORKSHOP

Although the workshop was positively received, produced many new insights, and facilitated new connections among the participants, we acknowledge that it failed to properly address the two main goals we had set:

1. improve knowledge and confidence of practitioners and policy makers when making land-use decisions or changing professional practices in consideration of climate change; and
2. spark a national initiative to produce an understandable document that summarizes changes to hazards driven by changes in climate.

The first question of the morning breakout session was asked to address challenges faced by the workshop participants in *understanding the intensity and recurrence* of climate-based and climate-influenced hazard events in a changing climate (i.e. the technical and scientific basis). However, many responses to this question referred to a much broader set of implications, shortcomings, and restrictions within and among disciplines. Overall, in this first exercise, political challenges were cited more often than technical or scientific challenges (see page 22). From the answers as well as comments made on the online evaluation form, it was apparent that workshop participants had different interests and expectations of the workshop than the organizers had originally perceived. Some participants expected more emphasis on technical talks, whereas others thought more information relevant to local jurisdictions or national programs would have been useful.

Reflecting on the outcomes of the workshop and the evaluations, the steering committee recognizes that the intent of the workshop, the breakout session questions and the invited multidisciplinary audience were overly ambitious. However, although the workshop findings were different than anticipated, the workshop was successful in starting a multi-disciplinary discussion about understanding the problem of changing natural hazards in a changing climate, and in revealing and discussing some of the many issues that require cooperation, collaboration, and continued communication across disciplines. The workshop started that discussion and provided several pathways to move forward (see next section).

Participant feedback has taught the organizers some valuable lessons for future endeavours:

- Plenary presentations:
  - The plenary presentations were valued by the participants and helped set the stage for the breakout sessions, but more novel or challenging perspectives could have been addressed. For example, to provide contrast to the presentation of the relatively well-resourced City of Vancouver, the perspective of a smaller community with limited resources, struggling with the impacts of climate change, could have been included.
  - Similarly, the full range of disciplines of the workshop participants was not reflected in the plenary presentations, mostly due to time constraints. Missing among the plenary talks was a presentation from an engineering/consultant company that might have illustrated their perspective and challenges. Also, emergency managers were not given time to present their views and challenges.

- Breakout sessions:
    - The questions during the breakout sessions proved overly ambitious; there was too much to discuss in too little time. Some pods were unable to properly address some of the questions and felt rushed.
    - The breakout session questions could have been better formulated, specifically they could have better matched the goals of the workshop, leaving less room for open interpretation and less opportunity for the discussions to go off-track.
    - Better training for volunteer workshop recorders and facilitators would have improved the breakout sessions. Professional recorders and facilitators were preferred, but the organizers did not have the resources to hire them. Investing in the assistance of a professional workshop facilitator should be considered for any follow-up event, as professional facilitator could help organize and structure a workshop, provide guidance to volunteers, and set realistic goals for the duration of any future endeavor.
- Workshop participants:
    - The workshop participants represented many disciplines, but in hindsight, and given the general nature of discussions, several missing stakeholder groups would have provided unique additional contributions to the discussions. For example educators and outreach specialists, and climate change advocates such as NGOs (e.g. David Suzuki, Greenpeace, Ecojustice, and WWF) were not represented. Research institutes and think-tanks such as the Pembina Institute and the Fraser Institute were similarly absent. These groups might have provided valuable input on applied, grassroots, or 'on-the-ground' research and communication activities and should be invited to future workshops of this type.
    - Similarly, representatives of smaller communities and First Nations communities were not involved in the workshop. Their presence would have provided unique additional perspectives to some of the issues raised.
    - Care should be taken to invite participants whose experience or professional interest best meet the goals of any future workshop of this type.

SUGGESTIONS FOR FUTURE INITIATIVES

Based on the comments of workshop participants and the steering committee evaluation, it is clear that the momentum this workshop created should be maintained. Several participants expressed interest in a follow-up workshop; some indicated that workshops of this type should be held on an annual basis. Others would like to see more narrowly focussed mini-workshops on discipline-specific issues. The steering committee recognizes that the workshop did not meet the needs of technical specialists and researchers, and that it did not address specific concerns of governments, developers, and even private citizens. As a result, consideration is being given to two follow-up workshops in the near future that would examine the technical and practical aspects of understanding and of using hazard and risk data and assessments in a world undergoing rapid climate change. To promote and advance multi-disciplinary cooperation and collaboration, the proceedings of these two suggested workshops should be clearly communicated to, and discussed among, all stakeholders, perhaps through an over-arching multi-disciplinary meeting.

Other suggestions for future initiatives include establishing working groups or online forums to disseminate results. Such initiatives could be incorporated into the goals of future workshops. One goal could be the establishment of tools for direct action and/or increased collaboration and cooperation. The CanHUG online platform/discussion forum is an example of an online working group that provides Canadian users of the Hazus risk estimation tool an opportunity to engage in discussion and present case study results (Hazus Canada, 2016).

Any subsequent initiatives that build on the discussion and outcomes of this workshop would be welcomed by the workshop organizers. As a result of delivering this workshop, the organizers further acknowledge that the multi-disciplinary nature of assessing and understanding the impacts of hazards and risks associated with a changing global climate, including generating adaptation options, should remain a primary focus of future initiatives. It seems clear from the participants' remarks that progress in this field is dependent on continued collaboration and cooperation among all stakeholders. Given the breadth of organizations that contribute to understand and advice on natural hazards and climate change, the organization of future workshops or initiatives may also present a challenge of leadership. The workshop described in this report was organized by researchers from various government and academic institutes, mostly through in-kind support and on a low budget. As pointed out above, participants' reflected an interest in successive (possibly annual) events. Moreover, extrapolating the results from this workshop, there seems an obvious need to improve the focus and goals of such events. This may require resources, time, and expertise in organizing and facilitating workshops, but also a champion (or champions) to capitalize on the momentum from this multi-disciplinary and multi-jurisdictional challenge of 'changing hazards in a changing climate'.

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ADDITIONAL USEFUL WEBSITES OR RESOURCES

C40 Cities. http://www.c40.org/about (C40 is a network of the world's megacities committed to addressing climate change).

C40 Cities. *A New Adaptation Framework*. http://www.c40.org/custom_pages/climate-risk-adaptation-framework-and-taxonomy

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APPENDIX A – BREAKOUT SESSIONS QUESTIONS

MORNING BREAKOUT SESSION

1. Identify the biggest challenges or problems you face in your discipline/ profession in understanding the intensity and frequency of climate-based and climate-influenced hazard events in a changing climate.

2. Rate the importance of each identified challenge or problem. Each participant will get to identify up to 3 challenges they think are the most important.

3. List and rank up to three potential climate-based / climate-influenced hazards that pose the largest threat for Canada, British Columbia and Southwest BC.

4. List and rank up to three potential climate-based / climate-influenced hazards that pose the biggest challenge in understanding for Canada, British Columbia and Southwest BC.

5. Are there any striking differences in the answers to the above two questions?

AFTERNOON BREAKOUT SESSION

6. What more information do you need to address the challenges in understanding changing hazards? (e.g. from your discipline, from other disciplines). And why is that information lacking currently?

7. What further tools do you need to address the challenges in understanding changing hazards? (e.g. funding, support programs, online libraries, professional practice guidelines, new technologies).

8. What kind of governance and/or partnership support do you need? (identify people, organizations, current programs that need to be involved).

APPENDIX B – BREAKOUT SESSIONS RESULTS

QUESTION 1 & 2 - IDENTIFIED CHALLENGES AND PRIORITIZATION

1. Identify the biggest challenges or problems you face in your discipline/ profession in understanding the intensity and frequency of climate-based and climate-influenced hazard events in a changing climate.

2. Rate the importance of each identified challenge or problem. Each participant will get to identify up to 3 challenges they think are the most important.

POD1

Category	Comments	Commenter Discipline
Economy	Small municipalities can't deal with problems.	GEOT
	Economic Analysis on the impact of climate change (by sector, e.g. health, energy etc.)	FPGOV
Social	Who is responsible for deciding acceptable risk?	GEOT
	Difficult to communicate complexity in a simple, understandable way to people will remember.	PLOC
	Communicating to stakeholder and acceptance from them.	GEOT
Political	Education, communication, common language.	GEOT
	Who chooses the future climate scenario we are preparing for? (of how to deal with uncertainty/ range of projections).	PLOC
Technical	Uncertainties with second order (landslide etc.) with uncertainties in first order effects.	GEOT
	Visualization tools for communication.	GEOT
Scientific	What is our reliable state of knowledge about the present climate (last 10,000 years)? We need to know that before predicting hazards with a warmer climate.	RES
	Rather than speak to uncertainty, speak to trends.	FPGOV
	Use of modelling to explain/demonstrate impact.	FPGOV

No voting done in Pod 1 to prioritize challenges

Discipline abbreviations:

GEOT	Engineers/geologist/geo-technicians
FPGOV	Federal and provincial government
PLOC	Planners and local government
RES	Researchers
EM	Emergency managers

POD 2

Inferred Category	Comments that were voted on	Votes
Other	Public education.	1
Other	Availability of data.	3
Political	Incorporating policy and planning into modeling is a challenge.	1
Technical	Lack of formalized qualitative mechanisms.	-
Economic	Economic analysis.	-
Scientific	Translation of scientific knowledge to stakeholders.	3
Political	Translation into policy.	-
Scientific	Layers of uncertainty that interact (confidence bands trumpet outward quickly). Error margin can be unplannable.	3
Scientific	Inadequate state of knowledge; including understanding of sequential impacts, translation into social, economic, environmental challenges.	1
Technical	Site based problems unique: uncertainties > hard to apply physics on site.	3
Scientific	Thresholds for complex system changes (step changes).	2
Other	Ultimate goal: make people + infrastructure safer.	1
Political	Professionals must say they don't know when they don't.	-
	Additional comments on sticky notes	
Scientific	Translation of scientific knowledge to public stakeholder.	-
Technical	Lack of knowledge among stakeholders about the land use management & how this may impact their adaptation capability to climate change impacts.	-
Technical	Data insufficiency.	-
Technical	Lack of data/ quality of data.	-
Other	Communication.	-
Economical	Funding.	-
Other	Research/ study/ training.	-
Social	Intensity vs. severity: for the lay person intensity can be a rather theoretical term unless it is grounded in a practical effect.	-
Political	Intensity of debate: climate change has become a more political issue.	-
Social	The relative level of change is quite gradual. Coupled with short corporate memory it is sometimes difficult for an individual to see an effect at a personal level.	-
Political	Translating scientific data into policy recommendation is difficult because of the myriad of variables.	-
Scientific	Interpreting significance for hazards affected by climate among many other factors, or for which the link between hazard behaviour + climate is not exactly understood (e.g. Δtemp/ precip. on large landslide).	-
Scientific	Intensity of climate change is a measure of energy. Uncertainties complicate this measure.	-
Technical	Communication of hazard + risk crosses disciplines but actual practice varies considerably. Data sources variable as well as quality.	-

POD 3

Category	Comment	Commenter discipline	Votes
Economic	Tax dollars. Local governments need to develop/ property tax vs. other countries where LG don't rely as much on this >> Less pressure to develop/build at all costs.	PLOC	6
	Encouraging developers to invest in resilient design when the requirement is not in building code and costs dollars.	PLOC	1
	Matching infrastructure lifespan with proper design levels. Prioritizing the improvements of managing expectations.	FPGOV	-
	Need to change practice of design based on statistics to design based on anticipation (engineering).	FPGOV	3
Social	Connecting climate change and its urgency[?] & specifically[?] what the [??] the push [?] is or could be. Linking potential impacts to need to country resilience[?]	RES	3
	Shifting priorities, turning back the clock. Behavior and public perspective change.	FPGOV	1
	People afraid to tackle challenges because they can't tackle it all. (Got to start somewhere and have a strategic plan!).	PLOC	2
Environmental	Saline water intrusion. Surface and groundwater contaminated by salinity. Crop patter[n?] will change & fertility of agricultural land will be changes.	GEOT	1
Political	Working regionally on large scale adaptation measures for SLR (beyond the control/ jurisdiction of local gov.).	PLOC	1
	Authority to act does not lie in one body - i.e. different levels of government.	PLOC	2
	Thinking holistically, systems thinking across professional sections.	RES	-
	Multidisciplinary nature of climate adaptation & huge opportunity to leverage changes to better meet human needs.	FPGOV	5
	Coherent strategy that meet needs of existing building and infrastructure while capturing opportunity offered by new development.	FPGOV	1
	Clients (Govt?) want consideration but don't want to spend $$ >> Marrying will with budget (Design redundancy).	GEOT	-
	Political will is there but authority to spend $$ to mitigate risk is not always forthcoming.	PLOC	1
Technical	Existing design guidance based on historical evidence. How do we turn into protection?	GEOT	-
	SLR: a lot of uncertainty in terms of how/when. We use 2100/2200 guidelines but SLR can change rapidly. Hard to incorporate in budgeting/ planning.	PLOC	1
	Access to regional scale climate change data (i.e. PCIC).	PLOC	6
	Design inputs! How do we take a 'climate' input such as rising sea level and interpret the corresponding geotech[nical] input (groundwater).	GEOT	4

Category	Comment	Commenter discipline	Votes
Scientific	Using RCM data is key to projecting changes in rainfall. We need standardized procedures to develop hydro-meteorological parameters that consider the complex changes.	GEOT	1
	Engineers should be able to use the climate science but aren't empowered.	GEOT	1
	Understanding sources of uncertainty GCM's vs. regionally scales etc. on various time horizons.	PLOC	1
	Getting accurate information & effective monitoring data.	FPGOV	1
	Developing/ implementing policies that rely on uncertain science & lack of agreement between Qps[?].	PLOC	-
	How do we interpret increased rainfall events? Rainfall >> infiltration (missing link!) >> landslides/debris flows.	GEOT	-

POD 4

Inferred category	Comment	Votes
Technical	Too many sources for knowledge.	1
Other	Experts: no-one listening to each other.	1
Technical	Uncertainty in projections of climate. Which do I use?	6
Technical	Quality of data & long-term collection. Continuity of data monitoring.	7
Political	Decision case with resolved uncertainty.	6
Political	Certainty for policy rules.	7
Political	Governance.	4
Technical	Info use guide for risk assessment.	-
Other	Education.	4
Political	Regulation- legislation.	5
Economical	Funding.	2
Technical	Info access.	-
Political	Consensus on regional rules.	1
Political	Capacity at jurisdiction levels.	3
Political	Lack of provincial engagement (abdication of responsibility).	6
Political	Liability deterrent to action.	-
Social	Resistance to change.	-

POD 5

Category	Comment	Commenter discipline	Votes
Economic	Cost of data	-	-
Environmental	Shoreline squeeze > reducing habitat for fish as adaptation often means wall or barriers to protect built infrastructure from rising sea levels	GEOT	2
Political	Clear legislation on requirements to incorporate climate change into design and operation of infrastructure	GEOT	3
	Sharing and archiving knowledge on climate change adaptation	FPGOV	6
	In interdisciplinary teams selecting[?] the appropriate player/stage to integrate climate change into hazard assessment	GEOT	1
Technical	Projecting intensity and frequency of events well beyond the length of the historical/ instrumental record, and communicating the associated uncertainty	GEOT	3
	Data availability regionally: climate and hydrology stations, not enough statistic, records not long enough	GEOT	-
	Climate/ hydrology stations often in valley bottom & not representative of nearby elevations where study area is located	GEOT	-
	Which climate models are the most appropriate for the region that is being studied	GEOT	-
	Data like LiDAR would be helpful, but rarely available	GEOT	-
Scientific	Quantifying climate change risk for different kinds of floods (river, coast, storm water)	FPGOV	-
	Limited length of monitored period > are we recording fluctuations or actual long-term trends?	RES	1
	Encourage shared databases	RES	1
	Associating secondary effects and assigning return periods to such events (i.e. temperature rise (primary) leading to increased frequency of large storm events (secondary))	GEOT	6
Other comments	Translating climate scenarios into risk scenarios	FPGOV	1
	The constellation of human health impacts of climate change hazard acting together: e.g. heat & drought a stress, air quality decline from wild fire in a time frame where health risk demographics are shifting (>80 yrs, >chronic cardio-respiratory disease etc.).	RES	3

POD 6

Category	Comment	Commenter Discipline	Votes
Economical	Cost of upgrading. Financial burden on local authorities.	-	1
	Defining priorities - how much do we need to spend? Capacity vs. technology (multiple trade-offs).	-	-
	Cost of training in an uneven playing field, navigating different funding mechanisms.	-	-
	Silos across disciplines and government levels. Harmonized planning across all levels of government for local/regional projects.	FPGOV	-
	Reactive vs. pro-active during disasters. Financial framework constraints. Separation between capital and operation.	-	2
	Funding determined by 4-year political terms.	PLOC	
Social	(General vote for social challenges)		3
	Public apathy.	EM	-
	Resistant to change.	PLOC	-
	Cognitive limitation (exhaustion).	GEOT	-
	Reliance on government action.	EM	-
	Dealing with grief, especially among Indig[neous?].	EM	-
Environmental	Intrinsic value. How important is the environment?	RES	2
	Educating the public.	-	-
	Conflicting values between environment and emergency management (i.e. Firesmart + 3 bylaws in North Van).	EM	-
	Transecting/intersecting issues. Failure to understand systems.	PLOC	3
Political	(General vote for political challenges)		3
	Communicating risk and individual responsibility.	EM	-
	Will to change.	PLOC	-
	Governance and lack of coordination.	-	1
	Short-term [political] cycles + opportunity.	-	-
Scientific	Shifting baselines.	GEOT	-
	Has to be useful at the ground level [applicability]. Not always practical + useful at the ground level.	EM	-
	Easy to communicate.	EM	-
	Lack of certainty (science used to be the driver).	-	5
Technical	Shift in applying the science.	-	-
	Approach to design.	-	-
	5-year code; reconciling modifications.	-	-
	How can we provide assurance about the future which is unknown?	RES	-
	The challenge of transitional data: what do we do in the interim until our statistical data is better?	GEOT	-

POD 7

Category	Comment	Commenter discipline	Votes
Economical	[Hazard] Events deplete resources for other events. Competition with other priorities for limited resources.	FPGOV	-
	Understanding the ROI [Return on Investment] of specific solutions to risk.	FPGOV	7
	Convincing evidence to spend more money > guarantees problem.		-
	Societal costs: how do we quantify.		-
Social	Personal responsibility: develop neighbourhood resilience plans.	EM	7
	Communicating uncertainties into the evaluation of policy alternatives.		-
	Understanding of hazards generally & how impact city business.		-
	Coordination: Change habits (where to live, how to prepare and plan for disasters).	EM	4
	Plain language and different levels of ability: Getting the public to understand and believe in the increased risks to the public from climate change.	EM	4
Political	Political will to increase regulation. Risk assessment is expensive for small communities, Qps. Showing cost in a defensible way-explicit accounting.	FPGOV	3
	Integrating risk into planning & project management.	PLOC	5
	Land use policies that consider risk factors and threats.	EM	-
Scientific	Spatial variation of climate related hazards at the neighbourhood scale. Need to match knowledge with scale of decision making.	GEOT	3
	Geographic scale. Application of the level of detail of climate science to consulting engineering projects.	GEOT	-
	Access to past studies for hazard assessment > municipal coordination to make studies available to scientists, engineers & owners.	GEOT	-
	Developing assessment frameworks that quantitatively consider climate change inputs as opposed to "tacking them on at the end" as a factors adjustment.	GEOT	-
Other	Challenge to get attention without a hazard.		-
	Incorporating uncertainty > still getting to action.	PLOC	-
	Planning time/ Horizons: Replacement with long-term view.	PLOC	-

POD 8

Category	Comment	Commenter Discipline	Votes
Economical	Need fulsome accounting for the life decisions people make (e.g. property purchase, infrastructure support).	FPGOV	5
Social	Engineers learning a new language of climatology. I.e. to move from qualitative analysis (high level) to quantitative analysis and design and construction.	GEOT	2
	Shared information and language required for the fulsome collaboration.	PLOC	1
Environmental	Need to extrapolate from an imperfect record of past events to estimate what might happen in the future.	GEOT	1
Political	Legal/judicial framework to handle uncertainty (case studies? To help, but cost too $$).	FPGOV	-
	Regulation challenges: political will to uphold.	FPGOV	7
	How to manage scientific uncertainty. E.g. use flexible guidelines and best practices.	FPGOV	3
	Political framework requires the leverages in order for professionals to create/ designing & implement required Climate change measures.	PLOC	4
	More data and studies into the public domain (everything from private and public sectors).	FPGOV	8
Technological	Absence of unified risk assessment process.	EM	5
Scientific	Permafrost degradation, rock slides, Mt. Meager (big process as need landscape scale assessment).	FPGOV	1
	Sea level projections: do not know what Antarctica is going to do? (Scientific uncertainty).	RES	1
	El Nino (Scientific uncertainty).	FPGOV	-
	Data, e.g. LiDAR, into public domain.	FPGOV	2
	Process chains: one event causes another.	FPGOV	-
	Landscape hazards approach. Mountain permafrost, displacement waves [?].	FPGOV	1
Other	The problem is here now… yet we would prefer time to learn more to apply the science.	GEOT	-

QUESTION 3 - LARGEST THREAT

3. List and rank up to three potential climate-based / climate-influenced hazards that pose the largest threat for Canada, British Columbia and Southwest BC. (*Each participant was supposed to do this exercise individually, hence the multiple listing of hazards in the tables below.*)

POD 1

Rank	Canada	BC	SW-BC
1	Flooding	Flooding	Flooding
	Flooding	Flooding	Severe storms
	Flooding	Flooding	Flooding (coastal)
	Flooding	Flooding	Flooding
	Flooding	Flooding	Flooding
	Flooding	Flooding	Flooding
2	Drought	Drought	Sea level rise/ storms
	Drought	Drought	Drought
	Drought	Severe storms	Drought
	Drought/ Extreme heat	Forest fires	Drought
	Forest Fires		Earthquake
3	Heat wave	Wildfire	Drought/ declining snowpack
	Wild fire	Wildfire	Sea level rise
	Heat	Wildfire	Wildfire
	Wildfire	Drought	

POD 2

Canada	BC	SW BC
Coastal inundation and shoreline erosion	Wildfire + drought	Sea level rise (soil, water salinity)
River basin flooding	Pine beetle	Heat waves
Heatwave/ droughts (crops)	Avalanche	Air quality (wild fire)
Ecosystem collapse	Flooding	Water availability
	Winter storms	

POD 3

Canada	BC	SW BC
Temperature rise	Wildfire	Earthquake
Temperature rise	Fire	Earthquake and tsunami
Insect plagues	Rainfall amounts	Water related extreme weather events
Extreme drought	Floods/ SLR (all kinds)	Sea level rise (City of Van)
Extreme temperature	Water cycle uncertainty (extreme weather/ drought)	Sea level rise
Water cycle uncertainty (extreme weather, drought)	Sea level rise	Landslides
Floods (all kinds)	Earthquakes	Debris flows
Food security	Tsunami	Drought
Public safety during extreme heat and cooling		Flooding (SLR + rain)
Earthquake		
Earthquake		

POD 4

Rank	Canada	BC	SW BC
1	Heat	Storm surge	Sea level rise
	Sea level rise	Sea level rise	Fraser river flooding
	Fraser River flood	Extreme rainfall	Floods
	Extreme flows	Forest fires	Extreme rainfall
	Drought	Sea level rise	Floods
	Drought	Forest fires	Sea level rise
	Extreme rainfall	Fraser river flooding	Sea level rise
	Floods	Storms	
2	Storm flood	Floods	Storm surge floods
	Metro Van Coastal flood	Extreme flows	Metro Van coastal flooding
	Drought	Extreme drought	Wind/ storm events
	Riverine flooding	Storms/ floods	Extreme drought
	Floods	Riverine flooding	Storm surge
	Storms/ floods	Drought	Storms/ floods
	Drought	Metro Van coastal flooding	Storms
	Drought	Fire	
3	Drought	Heat	Fall atmospheric river
	Snow	Drought	Landslide
	Drought	Sea level rise	Sea level rise
	Disease	Rising temp (melting glaciers)	Wind
	Sea level rise	Wild fires	Drought
	Disease that affect food production	Flooding	Landslide
	Insect plagues	Fall atmospheric river	
		Sea level rise	

POD 5

Rank	Canada	BC	SW BC
1	Flood- river	Interaction with resource extraction	Flooding (coastal and riverine)
	Permafrost degradation: Thermokarst damaging infrastructure. Coastal erosion as hazard for coastal communities	Infrastructure (resistant to flooding)	Precipitation
	Water resources (quantity and quality)	Floods	Flood (coastal, extreme rain)
		Floods	Riverine floods
			Floods
2	Change in winter season length	Wildfires	Sea level rise
	Temperature	Landslides	Sea level rise
	Temperature increase (floods, storms)		
3	Forest fire	Sea level rise	Ground disturbance
		Forest fire	Storms
		Wildfire	

POD 6

Canada	British Columbia	SW British Columbia
Sea level rise	Water	Sea level rise
Permafrost (transportation networks)	Pine beetle	Storm water management + power
Future water demand	Ecosystem decay	Earthquakes
Weather extremes (hot, cold, water)	57 hazards [?]	Storms
Forest fires	Huge variety [?]	Population growth
Drought		Drought
		Forest fires
		Urban vs. rural (lack of social facilities [?]
		Critical infrastructure
		Coastal [?]
		Poor economic [?]

POD 7

Rank	Canada	BC	SW BC
1	Cold [polar] region becoming less cold	Flooding (River, ponding, street flooding, coastal)	Flooding
	Flooding (overland and river)	Flooding (Increased river/ stream discharge, increased intensity, duration precipitation)	Sea level rise flooding (=loss of land , $ cost to society)
	Arctic Warming	Flooding (Lower Mainland)	Hydro-geomorphic hazards (e.g. water & it's influence on geomorphic processes, floods, debris floods/flows
	Heat waves (drought, food supply, fires)	Wildfires	Flooding, intensive rain events
	Floods	Sea level rise	Floods/ heavy rains
	Interface fire	Flood/ heavy rains	Sea level rise
	Insect borne illness		Sea level rise
2	Heat: increase in illness and mortality	Drought	Coastal flooding
	Flooding	Drought	Wind storms
	Flood/ heavy rains (landslides, destroyed homes, fish impacts)	Flooding	Drought
	Drought in agricultural regions		Flooding
	Flooding		
	Heat wave		
3	Low snow pack (impacts weather systems, water reservoirs)	Heat waves	Heat, temperature rise, low snow pack
	Climate refugees	Sea level rise	Wild fire
	Ice storm	Interface fire	Interface fire
	Coastal flooding and erosion		Storms and extreme events (including extreme heat)
	Drought		

POD 8

Rank	Canada	BC	SW BC
1	Flood (SLR +river)	Flood	Flood
	Flood	Rockslide displacement wave(surprise event; likely fatal)	Flood
	Flood	Floods	Flood
	Ecological collapse due to climate change implications	Flood	Flood
	Flood	Flood	Flood
	Flood	Flood	Flood
	Floods	Flood	Flood
	Flood	Flood	Earthquake
2	Fire	Storm/ severe weather	Storm/ severe weather
	Wild fire	Fire	Wildfire
	Drought	Drought	Sea level rise
	Storm/ severe weather	Summer drought	Drought
	Storms	Wild fire	Severe storm
	Drought	Wild fire	Wildfires
	Wild fire	Wild fire	Extreme weather events
	Drought	Wild fire	Damage from high wind
3	Aging population + capacity to cope	Rockslide/ debris flow (landslide)	Wildfire
	Drought	Wildfire	Food security
	Wildfire	Wildfire	Storm surge floods
	Extreme weather events	Storms	Storm surge tsunami
	Storms	Drought	Storm surge floods
	Heat wave	Drought	Sea level rise
	Wildfire		Drought

QUESTION 4 – BIGGEST CHALLENGE IN UNDERSTANDING

4. List and rank up to three potential climate-based / climate-influenced hazards that pose the biggest challenge in understanding for Canada, British Columbia and Southwest BC. (*Each participant was supposed to do this exercise individually, hence the multiple listing of hazards in the tables below.*)

POD 2

Rank	Canada	BC	SW BC
1	Ecosystem collapse	Landslides	Landslides
	Coastal erosion	Wildfire	Heat waves
	Detailed weather data (flood, heat, drought)		
	Drought	Wildfires	Air quality
2	Flooding	Flooding	Flooding
		Flooding	Flooding (SLR+ river)
	Crop production scenario under climate variability - food security	(weak) land use planning to attend the climate hazards	(weak) land use planning to attend the climate hazards
	Extreme events	Water availability/ drought	Floods (SLR+ river) + erosion
	The smaller the spatial scale the more uncertain the prediction of higher order effects and interaction- teleconnection of all hazardous geophysical phenomena.	The smaller the spatial scale the more uncertain the prediction of higher order effects and interaction- teleconnection of all hazardous geophysical phenomena.	The smaller the spatial scale the more uncertain the prediction of higher order effects and interaction- teleconnection of all hazardous geophysical phenomena.
3	Drought/ fires	Drought/ fires	Water availability
	Atmospheric patterns	Ecological (Pine beetle etc.)	Drought
		Floods + erosion	Water availability

POD 4

Rank	Canada	BC	SW BC
1	Fraser river flood peak flow. Changed by climate change	Fraser river flood peak flow. Uncertainty caused by climate change	Limited understanding Fraser river Peak flood- how affected by climate change?
	Understanding appreciation of IDF principles	Flood	Lower mainland flood
	Flood	Understanding of IDF principles	Understanding of IDF principles
	Drought	Drought	Wind/ storm events
	Flood	Flood	Sea level rise
	Riverine flooding	Debris flows	Drought
	Diseases affecting crops/ food production	Sea level rise	
	Temp	Rising temp/ melting glaciers	
	Sea level rise		
	Disease		
2	Sea level rise	Flooding	Flooding
	Storms	Forest fires	Floods
	Storms	Forest fires	Floods
		Landslides	
3	Floods	Storms	Debris flows
	Flooding	Floods	Sea level rise
	Sea level rise	Riverine flooding	
	drought		

POD 5

Canada
Data & understanding of cumulative risk assessment (i.e. across multiple hazards).
Watershed and large scale changes to the environment (i.e. post mountain beetle, post wildfire, changing from snow dominated to rainfall dominated).
British Columbia
Watershed and large scale changes to the environment (i.e. post mountain beetle, post wildfire, changing from snow dominated to rainfall dominated).
Forest fire - climate and forest management interactions.
Wild fire
Flooding
SW British Columbia
Watershed and large scale changes to the environment (i.e. post mountain beetle, post wildfire, changing from snow dominated to rainfall dominated).
Managing the water resources.
Flooding: extreme rain, changing snow.
Apportioning water in the late summer/ low flows.
Storms and their effects.

POD 7

Rank	Canada	BC	SW BC
1	Heat/ drought	Increase in rain = increase in flooding, risk landslides etc.	Climate affected hazards
	Sea level rise	Flooding in local communities with limited resources.	Coastal flooding
	Climate refugees & mass migrations		Sea level rise, particularly across multiple local jurisdictions.
2	Flooding	Wildfires	Heat/ drought
	Insect plagues		
3			Overland flooding

POD 8

Rank	Canada	BC	SW BC
1	Wildfire (boreal forest)	Extreme storms	Extreme storms + related storm surges
	Flood	Mountain permafrost degradation	Flood
	Scope/volume/ quantity of info over a vastly different landscape and risks	Flood	Flood
	Lack of framework to evaluate trade-offs for risk mitigation across scales and jurisdictions (National, provincial and local).	Landslides. How will changes in storm patterns & melting permafrost influence the occurrence and magnitude of events.	Do we have any "Oso" scenarios? [public knowing/unknowingly at risk in landslide areas]
	Extreme storms	Water	Extreme events/ storm water
	Risk acceptance. What do we mean?		Floods
	Storms		Droughts
	Flood		
	Flood (costs, decision implications, risk absorption)		
	Water (too much, too little)		
	Arctic ice melt		
2	Sea level rise impacts on infrastructure (and trade and economy)	Post-wildfire debris flows	Droughts
	Permafrost degradation	Forest impacts (fire, pests, impacts of suppression)	Storms
	Extreme storms	Drought	
	Drought (accommodating long term implications of drought into all decision-making)	Flood	
	Ecological collapse due to climate change implications	Storms	
	Collective appreciation of climate change > the potential impacts		
3	Drought	Wildfire	Flood events (all, river, debris flows, storm sewer)
	Wilful ignorance; the psychology of changes impedes		Flood
	Drought		Wildfire
	Wildfire		

QUESTION 6 – INFORMATION NEEDS

6. What more information do you need to address the challenges in understanding changing hazards? (e.g. from your discipline, from other disciplines). And why is that information lacking currently?

Pod 3 – engineers and geologists

- ✓ More climate and hydrology stations with long records and located at various elevations – not just valley bottoms/ climate stations.
- ✓ Higher resolution climate models (local).
- ✓ A common language between climatologists and engineers (the scientists and those who apply the science).
- ✓ Education to enhance, foster and increase knowledge and skills.
- ✓ Deciphering natural from anthropogenic changes (statistic):
  - Info from climatologists/botanists/glaciologists/fluvial geomorphologists;
  - Definition of critical intrinsic thresholds;
  - Detailed fine-scale forecasts of changes in ppt [precipitation?] [Sed?] rate;
- ✓ Climate response data by region to temperature rise.
- ✓ A suite of standardized models to establish climate change variables.
- ✓ New approach to replace return period.
- ✓ Second/ third order effects of climate change (landslides, floods, etc.).
- ✓ Knowledge gap: precipitation changes (type, quantity, timing).
- ✓ Knowledge gap: extreme weather events (frequency, duration).
- ✓ Transitional data/guidance to move from stationary historic to non-stationary future climate data.
- ✓ Definition of acceptable risk (who is responsible and what is it?).
- ✓ Access to studies (digitized) grouped by hazard (as per usual).
- ✓ A process to link/translate climate data to risk analysis.
- ✓ Transfer of communication strategies (infographics, public displays etc.).
- ✓ Translation of risk statistic knowledge.
- ✓ Information on most effective hazard interventions by area, type, etc.
- ✓ Update to risk thresholds > taking climate change into account.

Pod 4 – engineers and geologists

- ✓ Communication: Need wider set of disciplines so that we can help engineers/scientists communicate (e.g. behavioral economists, psychologists).
- ✓ Data/info/ knowledge: fundamental data collection, management and dissemination. Topography, hydrology, stream networks, etc.
- ✓ Narrow uncertainty: academic effort to shrink the uncertainty or guidance on what is acceptable uncertainty.
- ✓ Value analysis: science, policy, technique.
- ✓ Practice: descriptive guide.

Pod 5 – local government and planners

- ✓ Political engagement (break silos).
- ✓ Costs-benefits >> doing something or not on adaptation.
- ✓ Uncertainty.

Pod 6 – federal and provincial government

- ✓ Base-level data collection.
- ✓ Better data and knowledge management (e.g. electronic 'book burning'):
  - Archiving.

- ✓ Commitment to activities longer than political cycles.
- ✓ Educating policy-makers on the limits of science.
- ✓ Training for scientists on communicating risk and uncertainty.
- ✓ Interdisciplinary platforms (e.g. NRCan) to reduce silos.
- ✓ Funding on the table (from federal government).
- ✓ Climate change extension (connecting practice and decision-making).
- ✓ Insulate climate change adaptation/implementation from politics.
- ✓ Promotional and marketing of governmental services [and] efforts.
- ✓ Communicate Climate Change knowledge to users, outside of peer-to-peer networks. Getting public buy-in.
- ✓ Determining costs – opportunity costs, liability costs, other hidden costs:
    - Consequences of inaction across disciplines (e.g. health, socioeconomic impacts).

Pod 7 – emergency managers

- ✓ Perceived liability is a restriction. Liability is a challenge to getting/releasing more information. Need access from: planning, municipalities, government.
- ✓ Centralized/ public database >> incentives to contribute (share info, get info/interpretation).
- ✓ Less permissions because not a ministry (agency limited) >> fighting freedom of info. I.e. Ministry of forests won't allow access to .shp [shape] file.
- ✓ Need prioritization, recognition of importance and need to access data.
- ✓ Streamlining policies.
- ✓ Understanding of what we need to do:
    - By politicians, public, organizations;
    - Conflicting priorities – short term need vs. long-time horizons/ risks.
- ✓ Need analyses – even if results differ;
- ✓ Knowledge about management;
- ✓ Knowledge sharing;
- ✓ Process;
- ✓ Consumable information – need more common understanding.
- ✓ Practical research – diminishing funding opportunities:
    - Knowledge that exists is usually only applicable to research = GAP;
    - Research funding access >> need more like JEPP/SEPP [?]funds.
- ✓ MEOPAR [Marine Experimental Observation Prediction and Response Network] and PCIC [Pacific Climate Impacts Consortium] – need more like this to link academic research to practice.

QUESTION 7 – TOOLS

7. What further tools do you need to address the challenges in understanding changing hazards? (e.g. funding, support programs, online libraries, professional practice guidelines, new technologies).

Pod 3 – engineers and geologists

- ✓ Professional practice guidelines:
  - in part to remove commercial incentive to ignore;
  - In part to provide guidance to practitioners and clients/owners.
- ✓ Incentives for low risk development.
- ✓ Scaling up and scaling down.
- ✓ Tools that progress from flexible guidelines to more prescriptive codes.
- ✓ Higher level of agreement of what the standard should be.
- ✓ Professional practice guidelines:
  - Like MoTI resilience practice guide for adaptation;
  - Need for mitigation (energy efficiency) practice guideline for building, resource development.
- ✓ Access to climate scientists (- shortage potentially).
- ✓ Clarity – guides, best practices, due diligence in considering hazards for design.
- ✓ Municipal funding for addressing (proactive) hazards (think of cost benefit).
- ✓ Climate data visualization tools.
- ✓ Climate model output data clarification (need special download packages – comes as text sites[?] often).
- ✓ Connection tool between climate models and traditional engineer tools (i.e. IDF curves).
- ✓ Data base of climate models and data downscaled to watershed level.
- ✓ Release of project data for public use (e.g. Alberta Rock Core inventory).
- ✓ Data base >> Arc/ Google compatible (for public sake too). Hope example.
- ✓ Case studies (real world examples); categorized and searchable.
- ✓ Best practices guides:
  - NWT- developed CSA guide on snow loading;
  - Dealing with permafrost.

Pod 4 – engineers and geologists

- ✓ Hazard-o-meter.
- ✓ Clear guidelines/ standards of practice for incorporating climate change prediction into risk assessment and design.
- ✓ Fundamental scientific methods (basic stuff).
- ✓ Communication/ visualization tools.
- ✓ Site-specific climate prediction data, with uncertainty bars.
- ✓ Monitoring and evaluation of changing hazard and base data that informs it.
- ✓ Neptune[?] on land.
- ✓ Data sharing system. Allow private/competing groups to share monitoring data and even analysis results.
- ✓ Progress monitoring to evaluate project outcomes.
- ✓ Data (public) of impacts and consequences of hazards/ disasters.

Pod 5 – local government and planners

- ✓ Uncertainty: framework/ new system and parameters to be defined.
- ✓ Cost-benefit: how do you quantify social benefits and values? Scales is very important to be defined.

Pod 6 – federal and provincial government

- ✓ Government should support innovative new technology. E.g. mobile/ web-based maps vs. paper.
- ✓ Modelling needs to be accessible to public. Models >> demonstrate the impacts.
- ✓ Visualizing adaptation – engaging artists with science (landscape visualization).
- ✓ Better regulation.
- ✓ Consistent messaging.
- ✓ Dedicated professionals who bridge climate science to other models ($ economic, etc.).
- ✓ Moving away from negative messaging.
- ✓ Climate change plans >> e.g. SLR plans:
    - Extension of OCP [Official Community Plan]

Pod 7 emergency managers

- ✓ Public education:
    - Need to get into people's psyche;
    - Need to personalize hazards;
    - Information needs to be consistent and updated;
    - Consistent, key messages: currently have some materials with outdated information.
- ✓ Long-term codes and land use planning focused on resilience:
    - Affected by political cycle.
- ✓ Clearly defined financial model of payoff:
    - I.e. If I put in $1 now, I will get $...;
    - Cost comparisons.
- ✓ Performance measures to create incentives:
    - I.e. how your property performs vs. others;
    - Measure and reward (loss potentials, risk reduction measures);
    - Insurance company incentives;
    - Government incentives.
- ✓ Universal risk assessments. Better access to information would make these less costly.
- ✓ Downloading of costs (federal > provincial > local) without downloading of grants/ funding.
- ✓ Response funding becoming more difficult to access/ secure (DFA > need to be able to use beyond building back to same state (for sustainability purposes)).
- ✓ Infrastructure investments to separate water (drinking vs. grey) supplies.

QUESTION 8 – GOVERNANCE

8. What kind of governance and/or partnership support do you need? (e.g. identify people, organizations, current programs that need to be involved).

Pod 3 – engineers and geologists

- ✓ Team approach: recognize that collective knowledge is more effective and produce a system/ holistic approach.
- ✓ Best practices + post event reviews ("post-mortems") > unpunishable.
- ✓ Identifying knowledge gaps where further study is required and supporting researcher in those areas.
- ✓ Need for monitoring.
- ✓ CCME – [?] organization to develop & publish guidelines as a step in the process of legislation practices (codes). CCME – Fed/prov/municipality/industry/stakeholder.
- ✓ Province: MoTI has partnered with PCIC, APEGBC, and ACEC to develop guidelines for adaptation to climate change.
- ✓ Like the Netherlands: governance at a national level to set out areas for various programs. E.g. areas to abandon; areas for intermittent flooding; areas to resist flooding.
- ✓ Coordination across sectors.
- ✓ Collaboration between different levels of government (Fed: Environment Canada; BC: Pacific Climate Impact Consortium).
- ✓ Governance has to be multi-level and collaborative (Professional association, Federal, Provincial, Municipal).
- ✓ National level guidelines based on municipal input.
- ✓ Provincial level > based on national standard > best practices. Provincial Govt. well [?] to fund climate change issues.
- ✓ Provincial decision-making panel for picking climate change models & impacts (consensus).
- ✓ Insurance/ re-insurance.
- ✓ Liability insurance for research.
- ✓ Better integration of Climate Change into school curricula (elementary >> post-secondary).
- ✓ Education at schools and post- secondary institutions.
- ✓ Education: insert climate change into sustainability req[uirements?].

Pod 4 – engineers and geologists

- ✓ Gather related risk data assessors.
- ✓ X-silos.
- ✓ Government system matches like work & responsibility. System to bridge the academic/ practitioner gap >> translate IPCC predictions into hazard predictions.
- ✓ Enable (fund/legislate) local champions with [??].
- ✓ Intergovernmental panel on hazards change.

Pod 5 – Local government and planners

- ✓ Provincial government leadership.
  - Government needs to provide resources;
  - Capacity at the provincial and federal level;
- ✓ Coordination with government (provincial/ federal), engineers, planners, stakeholders.

Pod 6 – federal and provincial government

- ✓ Philanthropists.
- ✓ NGO's (have specialized interests).
- ✓ Professional associations.

- ✓ Broader private-sector participation:
  - Insurance, re-insurance, financial sectors.
- ✓ Communications.
- ✓ Artists.
- ✓ Education (elementary, high schools).
- ✓ Community planners.

Pod 7 – emergency managers

- ✓ Support continuation of partnership with Environment Canada, meteorologists
- ✓ FICOM (Financial Institutions Commission)
- ✓ GeoBC
- ✓ NRCan – continuation
- ✓ Sustainable partnerships that change positively together
- ✓ Property and facility management associations (BOMA [Building Owners and Managers Association], IREM [Institute of Real Estate Management], PAMA [Professional Association of Managing Agents)

APPENDIX C – MURAL COMMENTS

PRIORITIZATION LIST

Discipline	Comments
Researchers (purple)	✓ Intra-governmental panel ✓ Incentives for low risk development ✓ Liaison person/ connector ✓ Silo-buster: invest in boundary spanners ✓ Coordination, scaling ✓ Coordination ✓ Collaboration ✓ Connectors/ translators ✓ Incentives for action ✓ Insurance ✓ Federally supported, provincially coordinated, municipally implemented ✓ "Future building code" ✓ Uncertainty for decision makers and data scientists needs a common tool – tractable + explicit! ✓ Capacity investment
Geologists and engineers (green)	✓ Central public database ✓ Central public database ✓ Access to climate scientists/ specialists for engineering projects ✓ Common language ✓ Monitoring/ measuring ✓ Federally supported, provincially coordinated, municipally implemented
Planners and local govt. (yellow)	✓ Federally supported, provincially coordinated, municipally implemented ✓ Solutions, Ideas, Actions ✓ More frameworks, less tools (or more tools that integrate) ✓ Re-establishing baseline monitoring: - Information needed for future generation - Setting up parallel gauges that are not impacted by urbanized impacts - Flow monitors rather than dependence on rainfall data + runoff models ✓ Better visualization tools ✓ Common language ✓ Enhanced HR capacity > more connectors (interdisciplinary staff), extension

Discipline	Comments
Emergency managers (pink)	✓ Future building code ✓ Incentives for low risk ✓ Federally supported, provincially coordinated, municipally implemented
Fed. and prov. Govt. (red)	✓ Integrate Climate Adaptation and community resilience to leverage biggest opportunities to serve human needs ✓ Rebuild capacity, specifically at Provincial level ✓ New building codes ✓ Central public database ✓ Decision-based tools (multi-sources of information) ✓ Reinvest in capacity
Policy specialists (orange)	✓ Change detection ✓ Canadian or provincial panel on hazards

NEEDED WORK

Discipline	Comments
Researchers (purple)	✓ Visualization tools ✓ Scaling up and scaling down, CCA guidance ✓ Future building code ✓ Federally supported, provincially coordinated, municipally implemented ✓ Reinvest in capacity monitoring ✓ Better visualization tools ✓ Translation to local level and general public (interdisciplinary liaison ✓ Coordination ✓ Visualization at community level ✓ Accountability toward tax payers (at municipal and provincial level), in relation to cost-benefit of projects that are meant to serve the best interest of the public ✓ Central public database ✓ Enhance data collection with environmental monitoring programs ✓ Ensure data is archived and open source with simple user interface for analysis ✓ Paleo-science will allow us to educate using a long-term perspective. Need to know your ecosystem and states in past ~2000yrs
Geologists and engineers (green)	✓ Better visualization tools ✓ Central public database ✓ Central database ✓ Coordination between government, research and practitioners

Discipline	Comments
Geologists and engineers (green)	✓ Better visualization tools ✓ Coordination between sectors and jurisdictions ✓ Consistent, continuous basic data ✓ Archiving of experience ✓ Central public database ✓ Central public database ✓ Basic data collection: streamflow and rainfall in alpine and remote areas ✓ Long term maintenance ✓ Future building code and incentives for low risk development ✓ Central public database ✓ Systems for data and knowledge sharing
Planners and local govt. (yellow)	✓ Capacity (at different levels of government) ✓ Rebuilding capacity (I have crossed this path before) ✓ Public database (webmap/ CAD/ visuals) ✓ National panel on hazard change (or province "proactive hazards mgt.) ✓ People who coordinate between profession and governments ✓ Coordination across silos (different orders of government, different groups within government) ✓ Central public database ✓ Central database (case studies, climate info) ✓ Monitoring of data management ✓ Leadership (federal → provincial → local/municipal) ✓ Capacity ✓ Federally supported, provincially coordinated, municipally implemented ✓ Common language ✓ Visualization tools + communications ✓ Public database (LiDAR, Climate models, climate data) ✓ Federally supported, provincially coordinated, municipally implemented ✓ Liability protection ✓ Intra-governmental panel ✓ Federally supported, provincially coordinated, municipally implemented ✓ Reinvest in capacity ✓ Climate knowledgeable folks available to consultants (role for govt. scientists?) ✓ Longevity + commitment for federal and provincial programs ✓ Intra governmental panel on climate change
Emergency managers (pink)	✓ Capacity ✓ Better visualization tools ✓ Central public database

Discipline	Comments
	✓ Grant funding → critical infrastructure replacement ✓ Don't lose the info → a proper library (that the info doesn't[?] need a program to read it; (re) paper copies are important ✓ Collaboration and coordination among levels of government and other stakeholders (Federally supported, provincially coordinated, municipally implemented) ✓ Panel on hazard change (national) ✓ Central public database + knowledge management ✓ Common language ✓ Common language ✓ Better visualization tools, public education tools, key messages
Fed. and prov. Govt. (red) Fed. and prov. Govt. (red)	✓ Reinvest in capacity ✓ Visualization tools of quality data ✓ Visualization tools ✓ Common language (better communication) ✓ Capacity building for interdisciplinary work in climate change impacts ✓ Archived experience of scenarios/ case-study work ✓ Coherent strategy that reconcile needs of existing communities and infrastructures with opportunities offered by new development ✓ Common language for common understanding ✓ Federally supported, provincially coordinated, municipally implemented ✓ Federally supported, provincially coordinated, municipally implemented ✓ Future building code ✓ Central data base
Policy specialists (orange)	✓ Future building code (more than buildings, e.g. resource dev.) ✓ Central database (at a watershed level) ✓ Increase monitoring, especially where data gaps exist (stream, LiDAR, high elevation climate) ✓ Better visualization tools ✓ Central public database

LIST OF ACTIONS

Discipline	Comments
Researchers (purple)	• Promote earth system and climate science in all education systems using early engagement and visualization tools • Publically open databases! • National panel on hazards/ hazard change • Future building code

Discipline	Comments
	• Federal/ provincial storm water management legislation • SUDS approval body (sustainable urban drainage system)
Geologists and engineers (green) Geologists and engineers (green	✓ Coordination across silos/ disciplines ✓ Good Samaritans act equivalent for risk assessors ✓ Intergovernmental panel (on hazard change) ✓ Coordination ✓ Interdisciplinary liaison ✓ Reinvest in capacity ✓ Collaboration and coordination through sectors and disciplines ✓ Coordination ✓ Central public database ✓ Long-term funding + implementation of basic environmental monitoring (climate, river, topographic etc.) ✓ Coordination (interdisciplinary liaisons) ✓ Incentives for low risk development ✓ Canadian expert assessment ✓ Making sure we reinvest in capacity ✓ National panel of hazard change ✓ Intra-governmental panel ✓ Coordination between silos (interdisciplinary "connectors") ✓ Better visualization and communication tools → learn to speak a common language ✓ Inter-governmental panel/ collaboration ✓ Consultation, communication with stakeholders and general public ✓ Coordination between government levels and united direction
Planners and local govt. (yellow)	✓ Incentives for low-risk development ✓ Communication training for practitioners ✓ Involve artists in telling the story of climate change impacts and opportunities (e.g. theatre documentation, public art, social media, festivals) ✓ Incentives for low risk development ✓ Knowledge transfer (both up and down) ✓ Publically available high resolution data and case studies ✓ Future building code ✓ Public education: raise up that 44% to 88% [in relation to the number of Canadians who deny climate change] ✓ Federally supported, provincially coordinated, locally implemented ✓ Incentives ✓ Common language ✓ Panel on hazard change ✓ Archive experience ✓ Central public database ✓ Incentive for low risk development ✓ Better visualization tools

Discipline	Comments
	✓ Rebuild capacity ✓ Coordinate across agencies ✓ Future building code ✓ Engaging economists, financiers, accountants on this discussion ✓ Incentives for low risk development ✓ Changing the economic paradigm ✓ Federally supported, provincially coordinated efforts that are developed at LG [local government?] level ✓ Better visualization tools
Emergency managers (pink)	✓ Federally supported, provincially/ regionally coordinated, municipally implemented (subsidiarity!!) ✓ Publically available risk information (the database that is maintained + updated overtime) ✓ Liability protection for research ✓ Incentives for sustainable development ✓ Central public database ✓ Future building code ✓ Common terminology ✓ Federally supported, provincially coordinated, municipally implemented ✓ Liability concerns + sharing information (liability protection for research)
Fed. and prov. Govt. (red) Fed. and prov. Govt. (red)	✓ Central public database ✓ Coordination of levels of government ✓ Common language ✓ Federally supported, provincially coordinated, implemented at municipal level ✓ Central public database ✓ Incentives for low risk development ✓ Better visualization tools ✓ Federally supported, provincially coordinated, implemented at municipal level ✓ Central public archive of adaptation experience ✓ Extension of connector agent ✓ Central public database ✓ Visualization tools ✓ Intergovernmental panel/ Subcommittee on hazard change ✓ Proactive hazards management ✓ Community of practice (to facilitate coordination) ✓ Incentives for low risk development ✓ Coordination across silos + government + organizations ✓ Interdisciplinary coordination ✓ Create new job description of connectors or extension services

Discipline	Comments
	✓ Federally supported, provincially coordinated, implemented at municipal level
Policy specialists (orange)	✓ Incentives for desired change ✓ Coordination + collaboration ✓ Proactive hazards management ✓ Federally supported, provincially coordinated, implemented at municipal level ✓ Invest in capacity ✓ Future building code ✓ Central public database ✓ Common language ✓ Liability protection ✓ Coordination like CCME [Canadian Council of Ministers of the Environment] (that developed guides on environ issues) with all levels of government, industry and other stakeholders ✓ Province takes lead role, provides guidance and regulation to help local government ✓ Federally supported, provincially coordinated, implemented at municipal level ✓ Coordination and intergovernmental panel
Policy specialists (orange)	✓ Rebuild capacity ✓ Rebuild capacity ✓ Incentives for low risk development

APPENDIX D - EVALUATIONS

A total of 32 participants provided comments on the online evaluation form.

1. How valuable was the workshop to you?

	Count	Percentage
Very valuable	25	78.1%
Somewhat valuable	5	15.6%
Not valuable	1	3.1%

2. How did you feel leaving the workshop?

	Count	Percentage
Invigorated	16	50.0%
Glad	13	40.6%
Frustrated	1	3.1%
Ho-hum	2	6.3%

3. What did you like most about this workshop?

- ✓ *To hear different perspectives from people with different and diverse backgrounds.*
- ✓ *The range of disciplines and organizations represented, including from APEGBC, industry, government & academia provided different perspectives to be heard and appreciated.*
- ✓ *I learned the extent of managers' and regulators' frustration.*
- ✓ *How it brought together people from many different disciplines - this allowed for really valuable building and cross-pollination of ideas and issues.*
- ✓ *Diverse speakers - developer was a good add. It showed the real world conflicts of values. Short term money vs long term environmental actions.*
- ✓ *As a working scientist, I appreciate opportunities to interact with the adaptation community to understand how the science is perceived and utilized.*
- ✓ *The opportunity to network with experts and hear their take on climate adaptation challenges.*
- ✓ *Equally important:*
  - *Opportunity to obtain new insights on the complex topic of climate change;*
  - *Chance to make new connections and nurture existing ones;*
  - *It was free and because of that my participation was an easy sell to my supervisor.*
- ✓ *The engaged discussions.*
- ✓ *Meeting different people.*
- ✓ *Having people say they enjoyed the meeting.*
- ✓ *The wide range of backgrounds of the participants. Great opportunity for exchange of ideas in a non-threatening process.*
- ✓ *Breakout sessions.*

3. What did you like most about this workshop?
✓ *The presentations giving different perspectives from government agencies, developers, etc.* ✓ *On the first question period, the first person that stood up, that suggested that we should not lose perspective on what we are trying to achieve.* ✓ *Presentations from people working in different sectors, relating their own experiences in dealing with climate-related hazards and hazard change.* ✓ *Presentation by City of Vancouver, Concert Developers. Small group session in AM.* ✓ *That ideas were compiled by discipline and in combined groups. If all of the information can be compiled in a meaningful way and distributed to all of the government agencies, professional associations, it should provide useful guidance.* ✓ *Diversity of professions and expertise.* ✓ *Great presentations! Stimulating crowd. Thank you.* ✓ *Hearing relevant science and how climate change will impact hazards.* ✓ *I enjoyed the opportunity to exchange ideas and information with such a broad cross section of stakeholders.* ✓ *I thought this was a well-organized and effective workshop that brought an appropriate mix of individuals and organizations together. It was a valuable use of my time and I heard that feedback from others as well. The combination of speakers, plus the two workshop perspectives (mix of sectors, and single sectors at the table) was particularly good. One of the organizers mentioned that it would be valuable to record the results of this meeting. While I agree, it's worth pointing out that the act of having the workshop itself is valuable - face to face contact that can't be replaced. As such, I think a key value would be to collect results for the purpose of re-organizing a similar workshop in a year. E.g. to summarize progress made, success and failures, and move forward.* ✓ *The mix of disciplines and stakeholders.* ✓ *The workshop provided a very useful platform to exchange information, ideas, and experiences in hazard change caused by climate change. Mixing of various working groups was a great idea to identify challenges in different disciplines and gain new and useful knowledge from the discussions.* ✓ *I enjoyed the quick-fire presentations from several different stakeholders. It helped give a good feel for some of the wider issues from a number of different perspectives.* ✓ *Wide variety of stakeholders and the opportunities to work in small groups.* ✓ *It was nice to get the perspectives from a broad group of professionals with diverse backgrounds.* ✓ *Nice to touch base with others that I see infrequently.* ✓ *Opportunity to bring together stakeholders from many different areas.* ✓ *Interaction of various groups (government, technical, policy makers)* ✓ *Thank you to the organized for this event. I really enjoyed the overall trusting atmosphere of the workshop and the explicit use of the Chatham House Rule. The developer perspective was very interesting to hear about. The breakout sessions were nicely done. In general, this was a really well-organized event.* ✓ *The interaction of the various agencies present.* ✓ *The chance to interact with people of other specialities.* ✓ *The opportunity to interact with other stakeholders at the one time in the same venue, as well receiving updates on climate change.*

4. What would you have liked changed or done differently?

- ✓ *I would have enjoyed more state of the art presentations that set the tone which parts of the ecosystems and physical systems have been affected by climate change and which ones are likely going to be. More information on how different jurisdictions are addressing climate change in terms of hazards, and what those issues/concerns/challenges are. It would have been good to have short talks from key consultants on the central issues they face. Having had someone like Markus Schnorbus or Zwiers at the meeting would have been helpful.*
- ✓ *Nothing for I think it served the purpose for which it was intended.*
- ✓ *Considering how little is still known about the hazards I expected more discussion (well, any discussion) of ways to mobilize some improvement in our understanding of the actual hazards.*
- ✓ *More equal representation from the different disciplines (i.e. more health, more emergency management) although I recognize this is difficult to control.*
- ✓ *Break out facilitators could have been better prepared.*
- ✓ *Not much. It was pretty good.*
- ✓ *More time, it felt a little rushed. Perhaps make the workshop over 1.5 days and present a summary of all the discussion from day 1 on the morning of day 2.*
- ✓ *Perhaps premature to comment on as I have not seen the final product, but at times the workshopping steps were unclear (e.g. adding round stickers to posted sticky notes on flip pad). There was a general understanding of the purpose but our facilitator was not 100% clear on the exact things we should be doing.*
- ✓ *It would have been good to have had a better system for creating a summary of the challenges. The meeting wasn't really what I had in mind (technical meeting). It did give me an idea of how little is understood about risk and risk mitigation.*
- ✓ *More time exchanging experiences and less time being talked at. However, the talks were also appreciated.*
- ✓ *More time for presentations by NRCAN or other national government agencies; more information about the national strategy and commitments to addressing hazards and climate change.*
- ✓ *More experienced practitioners, with 30 years plus experience, in direct application of the theories, who represent the other 45% (the other half). The seminar discounted the point of view from a significant number of professionals simply because they disagree on the ideas of climate change; this should not mean their professional experience means little. The group needs to find a common ground to draw this expertise into the discussions. A more respectful process. When ideas where being brought forward there were particular groups that would immediately squash the idea to retain their perspectives. Not including the other 50% is disrespectful.*
- ✓ *Would have liked to see a presentation related to risk assessment in a changing climate- i.e. incorporating non-stationarity of natural hazards.*
- ✓ *Perhaps clearer questions for small group in AM.*
- ✓ *Well done and well organized.*
- ✓ *Nothing suggested.*
- ✓ *More representation from the emergency management community.*
- ✓ *I think it would be quite helpful to have elected politicians present.*
- ✓ *Nothing - a very well-structured day.*
- ✓ *More time for discussion.*
- ✓ *One could easily add a day or two.*
- ✓ *More emphasis on outcomes. Clear action items for the next workshop.*

4. What would you have liked changed or done differently?
✓ *Questions between the two workshops [breakout sessions] were very similar. Would change the questions to be more different.*
✓ *It would have been interesting to include a broader perspective on climate change adaptation in BC/Canada beyond the usual suspects given the stated objectives of this workshop. Having been to a number of regional events over the years I have seen presentations from ACT many times. Similarly, while there is some value in hearing the City of Vancouver adaptation story again, I cannot help but wonder what action is happening beyond the big, well-branded and well-resourced cities. How are smaller municipalities with urgent needs addressing these issues? Regional districts in BC? What about First Nations that are in some highly vulnerable zones? Other municipalities in Canada? I felt that part of the program was a missed opportunity by focusing on well-established narratives instead of introducing new perspectives.*
✓ *Nothing.*
✓ *I liked the format. More time in the breakout sessions would have been nice but hard to fit in.*
✓ *Perhaps have mixed sectoral groups for both breakout sessions. Also does connecting comments or suggestions with a given sectoral group influence the weighting of the input? If not then anyone's input would have equal standing*

5. What would you like to see included as follow-up events and actions?
✓ *Information on how the often very thoughtful comments will be translated into policy, guidelines, bylaws.*
✓ *Over the long-term, I would like to see a National framework for risk assessments related to climate-change established, with appended sections on basic tools presented and explained in a way that a non-climatologist can understand. The excellent framework documents produced by the CCME [Canadian Council of Ministers of the Environment] for both ecological and human health risk assessment is an example. Basic equations (tools) are presented in a way than even a non-toxicologist can understand. Basic information on climate models used (the physics, form of the basic numerical calculations, assumptions, input parameters, and uncertainties) should be provided. This is not a user-reference manual.*
✓ *Perhaps a series of more narrowly focused mini-workshops, with some inter-workshop reporting (e.g., what do the managers need from people like me?; I'm a 'researcher') .*
✓ *Summary report as mentioned in the closing comments.*
✓ *The promised summary and prioritization of items will be valuable.*
✓ *Having a summary of the breakout sessions posted to your website. Another similar workshop with stronger deliverables, using the information and recommendations gathered from this workshop.*
✓ *I don't know but somehow addressing the fact that 45% of Canadians (was that the statistic) do not believe in climate change needs to be addressed to facilitate the implementation of many of the things that were discussed.*
✓ *An online forum, report.*
✓ *How can action be taken on some of the feedback collected in the workshop? Make the workshop participants aware of this action so that they know that there time was well spent.*
✓ *The proceedings volume, workshop materials posted to the website and an article in the various publications about the significance of speaking about and acting on hazard change and risk change as climate adaptation / mitigation.*

5. What would you like to see included as follow-up events and actions?

- ✓ *Annual inventory of relevant projects and suggestions for partnerships between the sectors.*
- ✓ *Summary of discussion/ideas/follow up actions.*
- ✓ *Any other opportunities to interface with government agencies working on climate change and related hazards.*
- ✓ *More objective approach. It seemed the discussions did not stay on context and did not address the intent of the workshop. The conversations were dominated by a single perspective that seemed to continuously distract from the objective of the workshop. Generally there was very little space for objectivity. The real issues need to be hashed out which is incorporating the ideas of the other 50%, this needs to be done soon otherwise the ideas of this group will be lost and a lot of time will be ill spent. A more respectful process, include professional curators to draw out the ideas and create a more objective discussion. Professional curators should be taking notes from the discussions and not a selected person from the table.*
- ✓ *Summary report of the break-out sessions, documenting general themes raised.*
- ✓ *Implications for training and education in the area of Hazard focused decision making and for what audience.*
- ✓ *More workshops!*
- ✓ *A report on predictions on how climate change will affect specific hazards in specific BC communities. This would aid local governments in adaptation, planning and mitigation efforts.*
- ✓ *1) Re-organize in a year - same format - but hopefully a place to move forward off our success at the previous workshop. 2) Disseminate summary by government (e.g. Federal) as to their main takeaways, and path forward. I'd like to see how our feedback from the private sector was interpreted.*
- ✓ *From the scientific standpoint:*
    - *A volume of papers;*
    - *Special sessions at GSA, GAC;*
    - *An article in APEGBC's Innovation;*
    - *A public lecture;*
    - *A public field trip or series of them;*
    - *A website and presence on social media.*
- ✓ *I think that strengthening of cooperation and good coordination among these working groups in the future are indeed important and necessary to identify solution and take proper action.*
- ✓ *Workshop report and perhaps progress reports in the future.*
- ✓ *Meeting summary - video links.*
- ✓ *Maybe links to publications.*
- ✓ *Form working groups around specific topics.*
- ✓ *Summary of the proceedings and directions forward.*
- ✓ *It would be great to learn more about the discussions that happened in the parallel breakout sessions e.g. How are qualified professionals tackling non-stationarity in practice?*
- ✓ *The follow up action should be to examine the relationship of developer to authority having jurisdiction regarding future liability for owner / operator and then back to AHJ. Recommendations for standardized costing to include future liability costs would be useful.*

6. How will you take the results of this workshop into your career and organization?

- ✓ *So far not much as our organization (a consulting firm) already has solid climate change work footings.*

6. How will you take the results of this workshop into your career and organization?

- ✓ *There are still challenges in scaling that make practical application in a small real project challenging.*
- ✓ *Little effect.*
- ✓ *Appreciated the insights from different disciplines - I hope to incorporate these.*
- ✓ *Mostly background for future decisions and actions.*
- ✓ *It has confirmed for me that some plans that I have for future work with sea-level projections will be useful and valuable, and as such, the workshop is providing a stimulus to promote that work within my organization.*
- ✓ *I've written a summary of the workshop and shared it with my colleagues and managers (~20 people).*
- ✓ *Today I shared with members of my internal water group the BC MoT Technical Circular on Climate Change, of which I learned about at your workshop.*
- ✓ *User inputs shape research...*
- ✓ *I will write the article on hazard change and risk change as climate adaptation / mitigation.*
- ✓ *I could use the e-mail addresses of all participants. I expect to benefit from consultation with several of the participants.*
- ✓ *More structured dialogue.*
- ✓ *Will be more aware of the professional practice requirements for addressing climate change on MoTI projects in BC. Will familiarize myself with the risk-based land use guide. Will be looking for opportunities to work on projects/studies in National Disaster Mitigation Program or other government programs designated to addressing climate change and hazard issues.*
- ✓ *Very little since there was very little objectivity in the program. It was very difficult to extract an informed objective context from the workshop.*
- ✓ *Greater awareness of the need for considering potential hazard change related to climate change when preparing hazard/risk assessments.*
- ✓ *I would like to know what kind of professional development environmental professionals require in this subject -as the director of professional programs in the Faculty of Environment I am seeking to development relevant and timely programs.*
- ✓ *Found out about additional agencies and sources of information that I wasn't aware of before.*
- ✓ *We will be reviewing the new federal government guides published for hazard assessments.*
- ✓ *This workshop reinforces the need to update our HRVA to reflect the impacts of climate change.*
- ✓ *Awareness of what is currently being done at the Federal and Provincial level will influence our strategic planning as private consultants - e.g. expanding how we can help within our niche. It was great to see the Feds back at the table on climate change and free to communicate in a public arena!*
- ✓ *I am currently scoping a volume of contributed papers through Cambridge University Press on urban geology. My co-editor and I have decided that climate change and its effects on natural hazards facing urban areas will be a thematic section of this volume as a result of this workshop.*
- ✓ *I think I have gained a better appreciation for the wider ramifications of climate change and for the scope of the effects on stakeholders. I think I have also gained a better understanding of some of the cross-over activities and intersecting lines of effort between different organizations that could create synergy.*
- ✓ *Taking insights from difficulties encountered with municipal government into technical work.*
- ✓ *Re-in-force the need for integration of adaptation across all levels of government in an area to ensure solutions aren't "silo-ed".*
- ✓ *More awareness of issues and constraints affecting others.*
- ✓ *There is a need for me and others to work on explaining the risk to owner / operators as well as to the authority having jurisdiction.*

7. Any other comments?
✓ *"It was telling that the ministry has allocated $ 50 M to flood mitigation! and very little to actual risk assessments that focus on prioritizing funds.*
✓ *It was well-run.*
✓ *Excellent workshop, thank you for all you hard work!!*
✓ *Thanks for organizing. Hopefully more of these free or low-cost events can be organized in the future! That is how you will get consultant attendance. Please keep me in the loop.*
✓ *Excellent workshop.*
✓ *Thank you as always for pulling these great events together!*
✓ *In any future workshop it is important to state up front that the workshop is organized and operated by subject matter experts and not professional workshop organizers and facilitators. I missed having a technical meeting with experts. It was a very weird meeting. I learned about challenges, though they were not on topic. We should hold an expert only meeting next, and then get back to users, policy makers and decision makers. Use the technical meeting to discover the technical issues surrounding non-stationarity of risk assessment and particularly hazard change.*
✓ *Congratulations on an excellent initiative.*
✓ *Presentations were rushed and hard to follow. I realize it was a lot to get through in a short amount of time, but would have loved a more relaxed pace.*
✓ *There were very few experienced practitioners (30 years [of] experience or greater). The workshop was very one sided and did not open an opportunity for objective thoughts or any type of outside the box thinking. A lot of the conversation was being dominated by the same groups. If you are a speaker, then that particular group should limit its involvement in the discussions. The APEG group from the same committee should have participated as listeners to draw in ideas for their consideration; it seemed the group kept on attempting to direct the process. Need to incorporate a significantly more objective view point of the challenges and the group needs to be prepared to listen to all sides of the ideas, concerns and issues to create a balanced solution.*
✓ *Thank you for organizing the workshop and contributing to a valuable inter-disciplinary conversation.*
✓ *Thank you for inviting me. I enjoyed meeting the diverse cross section of participants.*
✓ *Great job!*
✓ *Thank you all for putting together a good workshop.*
✓ *Excellent job and much appreciated.*
✓ *Well done!*
✓ *Certainly, there is a lot do to in disaster prevention, mitigation, preparedness, response and recovery, and I believe organizing this kind of workshop will help to enhance and improve the existing system and programs relevant to the topic. I believe this workshop has been a very good step in moving forward toward the goal. I'm interested in natural hazard/risk and multi-hazard interactions with focus on flood and landslide processes, particularly how they affect human population and environment. I'm currently working at Decision Support Section, GeoBC, FLNRO. In my current project entitled: Kootenay Boundary Investigation on Landslide Assessment Using LiDAR, I'm attempting to analyze landslide and assess level of proneness to slope movement using high resolution data. I am keenly interested to participate in the future workshops and looking forward for any collaboration in the future.*
✓ *Thank you for the opportunity to attend!*
✓ *It would be interesting to have a future technical workshop show-casing some known hazards in BC and working through hazard/risk/vulnerability assessments.*

7. Any other comments?
✓ *2-3 days might be nice as well.* ✓ *Also - 20 years ago UBC put on a terrain mapping course (June Ryder) and a terrain stability mapping course (Doug Van Dine). Could the centre offer such courses?* ✓ *I appreciated the opportunity to provide input.*

APPENDIX E - BACKGROUND: WEATHER HAZARDS AND ISSUES IN A CHANGING CLIMATE

Overview of hazards induced by climate change, and the challenges and opportunities of those hazards.

A changing climate, in itself, is not a hazard and it does not create a new hazard. What it does is affect the location and recurrence interval of existing hazards that are caused and triggered by weather and climate.

A changing climate, alters the potential that a particular type and magnitude of hazard event to occur. It makes the hazard potential non-stationary. In other words, the hazard potential of today is not the hazard potential of 10 years from now, and the hazard potential of 20 years from now is not the same as that of 10 years from now. An issue when assessing the risk resulting from a particular hazard is how to predict the potential of the hazard when that hazard potential changes with time. When hazard potential is non-stationary, risk is non-stationary.

The following tables provide an overview of some of the hazards either driven by weather or climate, or triggered by weather or climate. An example of a hazard driven by weather is a hurricane. An example of a hazard triggered by a weather event is a landslide on a slope saturated with water produced by a storm.

Climate-affected hazards	Implications and examples
Sea level rise	Due to rising sea levels the zone of coastal flooding is moved inland, posing an added flood risk for coastal communities. Rising sea levels may also result in changes or loss of near-shore habitat. *Examples: increased flood potential for major coastal cities (e.g. New York, Miami), loss of swamp land.*
Habitat/ecosystem changes	The boundaries of habitat area/ecosystems shift because the conditions (i.e. temperature, precipitation) that control the region change. *Examples: loss of polar bear habitat, species migration.*
- **Insect plagues**	*Example: pine beetle infestation.*
- **Insect-borne disease migration**	*Examples: mosquito transmitted West Nile and Zika virus.*
Climate refugee migration	A complicated situation where resource over-consumption is exacerbated by reduced agricultural output or limited access to fresh water caused by severe drought or soil loss. This could lead to scarcity, civil unrest and pollution.

Weather hazards	Implications and examples
Ponding (pluvial) floods	(Urban) flooding due to extreme precipitation events, often in combination with poor, blocked, or ill-functioning drainage systems.
Storm surge floods	Abnormal rise of sea level due to a storm (e.g. hurricane) may cause flooding in coastal areas. *Example: Flooding of New Orleans by Hurricane Katrina (2005).*
- **Storm tide**	Rising sea levels when storm surge coincides with (extreme) astronomical tides.
Storms	Climate change can lead to an increase in the frequency and intensity of storms. *Examples: cyclone, straight wind, tornado, rain, lightning, ice, snow*
Heat wave	Increased temperatures over prolonged periods may lead to drought, increases in wild fire events, and loss of crops.
Cold snap	Prolonged periods of cold can harm infrastructure and people.
Drought	Prolonged periods of reduced precipitation may lead to droughts (any season), increases in wild fire events and loss of crops.

Weather-triggered hazards	Implications and examples
Riverine floods	Large volume rain storms, with or without snow melt, can overwhelm watershed river systems and cause flooding at vulnerable sections of a river.
- **Ice damming**	Frozen sections of rivers may break up and form ice dams in sections of the river where flow is restricted (e.g. naturally restricted or through bridges or other infrastructure). Flooding may occur along stretches of the river behind the ice dam.
Lacustrine floods	Large volume rain storms, with or without snow melt, can overwhelm watershed lakes.
Landslides	Can be triggered when vulnerable (hillside) soils are saturated by rain storms. *Example: Oso landslide, Washington State (2014).*
Debris flows	Can be triggered by rain storms, and increased run-off from those storms.
Avalanches	Can be triggered by fluctuations in temperature, snowfall, and weak planes in the snowpack combined with snow storms.
Ground disturbance	Changes in temperature or precipitation can cause ground disturbances, which can have major implications for buildings and infrastructure. *Examples: swelling clays, subsidence, sink holes, permafrost.*

APPENDIX F - PARTICIPANT LIST

Participant	Organization
Munira Afroz	
Joanna Ashworth	SFU Faculty of Environment
Brent Baron	Indigenous and Northern Affairs Canada
Carrie Baron	City of Surrey
Steven Bibby	BC Housing
Brent Burton	Metro Vancouver
Nastenka Calle Delgado	Pacific Institute for Climate Solutions
Christine Callihoo	Associated Environmental Consultants Inc.
Emily Carrigan Gray	UBC School of Community and Regional Planning
Caroline Chen	UBC School of Community and Regional Planning
Mike Church	UBC Geography
John Clague	SFU department of Earth Sciences
Robert Cocking	Natural Resources Canada, Earth Sciences Sector
Steward Cohen	Environmental and Climate Change Canada
Arielle Dalley	UBC School of Community and Regional Planning
Fiona Dercole	District of North Vancouver
Bill Elsner	Sunshine Coast Regional District
Paul Evans	Thurber Engineering
Jeff Fisher	Urban Development Institute
David Flanders	UBC School of Architecture and Landscape Architecture
Jim Forest	BC Housing
Marten Geertsema	BC Ministry of Forests, Lands & Natural Resource Operations
Douglas Hallett	ISL Engineering and Land Services Ltd. Canmore/ Biogeoscience Institute University of Calgary
Deborah Harford	SFU Adaptation to Climate Change Team
Nicky Hastings	Natural Resources Canada, Earth Sciences Sector
Marit Heideman	Natural Resources Canada, Earth Sciences Sector
Gabriel Henshold	BGC Engineering
Lauren Hockin	BGC Engineering
Kris Holm	BGC Engineering
Lionel Jackson	SFU department of Earth Sciences
Matthias Jakob	BGC Engineering
Tom James	Natural Resources Canada, Earth Sciences Sector
Murray Journeay	Natural Resources Canada, Earth Sciences Sector
Nathalie Lapierre	Indigenous and Northern Affairs Canada
Robert Larson	Advisian
Carie-Ann Lau	SFU department of Earth Sciences
Wilma Leung	BC Housing
Tamsin Lyle	Ebbwater, CWRA-BC President

Participant	Organization
Matt MacDonald	Environment and Climate Change Canada
Sarah Marshall	UBC School of Community and Regional Planning
Michelle Marteleira	UBC School of Community and Regional Planning
Dorit Mason	North Shore Emergency Management
Sarah McKenzie	Pure North
Jonathan Meads	Concert Properties Ltd.
Kate Miller	Cowichan Valley Regional District
Normal Miller	BC Real Estate Association
Tamsin Mills	City of Vancouver
Emily Moase	BGC Engineering
Dirk Nyland	BC Ministry of Transportation and Infrastructure
Glen Parker	
Neil Peters	BC Ministry of Forests, lands and Natural Resource Operations
Mark Porter	Associated Engineering
Harshan Radhakrishan	Association of Professional Engineers and Geoscientists BC
Azadeh Ramesh	Government of British Columbia
Conor Reynolds	Metro Vancouver
Nick Roberts	SFU department of Earth Sciences
Catherine Sales	Public Safety Canada
Carina Schmitz	University of Bonn
Glen Shkurhan	Urban Systems
Jessica Shoubridge	Thrive Consulting
Paul Siddhartho	UBC Faculty of Land and Food Systems
Olav Slaymaker	UBC Geography
Zane Sloan	ISL Engineering and Land Services Ltd.
Jessica Steward	Madrone Environmental Services
Jamie Stirling	Northwest Hydraulics
Bert Struik	SFU department of Earth Sciences/ Natural resources Canada
Ananthan Suppiah	Indigenous and Northern Affairs Canada
Tim Takaro	Simon Fraser University
Sonia Talwar	Natural Resources Canada, Earth Sciences Sector
Kristen Tappenden	University of Calgary
Polly Uunila	Polar Geoscience Ltd.
Betsy Waddington	BGC Engineering
Allison Westin	SFU department of Earth Sciences
Bill White	BC Housing
Thomas White	BC Ministry of Environment – Climate Action Secretariat
Abderrahmane Yagouti	Health Canada
Gunther Yip	Thurber Engineering
Lily Yumagulova	UBC School of Community and Regional Planning
Lillian Zaremba	Metro Vancouver