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ADAPTATION TO
CLIMATE CHANGE TEAM

CONFERENCE PROCEEDINGS REPORT

NOT WAITING FOR NOAH:

NEW APPROACHES TO ASSESSING FLOOD RISK

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REPORT

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This event was organized as a partnership between the BC Water and Waste Association's (BCWWA) Climate Change Committee, the Okanagan Basin Water Board (OBWB) and the SFU Adaptation to Climate Change Team (ACT).

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PARTNERS

We are deeply grateful to the partners and funders of this project, whose support was invaluable. We are also grateful to the presenters, who donated their time and experience to make this an exceptional event.

The Adaptation to Climate Change Team (ACT) is a policy planning initiative from Simon Fraser University (SFU) designed to develop timely options for sustainable adaptation to climate change impacts. ACT brings leading experts from around the world together with industry, community, and government decision-makers to explore the risks posed by top-of-mind climate change issues and to identify opportunities for sustainable adaptation.

The BC Ministry of Community, Sport and Cultural Development is committed to bringing government services together to build healthy communities that are great places for B.C. families, citizens and businesses to prosper and grow. The ministry provides programs, services and advice, tailored to the needs of local governments and communities – to help them achieve their unique goals.

The BC Water and Waste Association (BCWWA) is a not-for-profit organization with a mandate to safeguard public health and the environment on matters related to water and wastewater. BCWWA facilitates networking and knowledge sharing opportunities for water and wastewater industry professionals in BC and the Yukon. BCWWA also provides a voice for the water and waste community through linkages with government and other organizations, public outreach activities and advocacy. The association's 4,700 members are the people who ensure the quality and quantity of water, from the source to your tap, and back to the source.

The Okanagan Basin Water Board (OBWB) was instituted in 1970 as a collaboration of the three Okanagan regional districts to provide leadership on water issues spanning the valley. Advised by an innovative cross-disciplinary Council, the Board delivers programs and activities to promote coordinated water management throughout the basin.

The Real Estate Foundation of BC (REFBC) acts as a pivotal connection in making land use knowledge and practice in BC a model for the world. As a funder of organizations doing good work related to real estate and land use, the foundation's role is unique in that it has a bird's eye view of many initiatives across the province. The REFBC also have access to new research, case studies, and other fresh information on innovative and exemplary solutions to land use issues. The REFBC's sees its role as being able to make connections as well as to share and promote research and knowledge that the foundation has access to.

Please note: The views expressed herein reflect solely those of the authors and do not necessarily represent the views of the Partners.

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INTRODUCTION

'Non-stationarity' is a state in which historical records no longer provide a roadmap for planning and decision-making, because the past is no longer a good guide to future conditions.

The **Not Waiting for Noah** workshop, held in Kelowna BC on April 24, 2013, brought together researchers and practitioners from Canada and the U.S. The workshop was designed to bring a range of professionals and experts together to share flood risk assessment tools, to build a community of practice, and to expose a broader audience to the subject and to a range of approaches.

The daylong presentations and discussions raised many central challenges to navigating flood management and mitigation in the face of climate non-stationarity, while working with increasing population and development in floodplains. This report is organized around the themes that emerged from the range of issues explored during the workshop:

- Non-stationarity
- The need for risk-based approaches
- Challenges, needs and things that should be changed
- Risk assessment tools

In light of the challenges to achieving a more effective flood management system, the intent of the Not Waiting for Noah workshop was, in part, to catalyze dialogue among a province-wide network of experts to develop a shared understanding of 1) what resources and risk assessment tools are needed; 2) what the barriers are to obtaining them; and 3) how these roadblocks can be overcome.

On March 8th, 2013, a floodplain mapping workshop, 'Planning to Avoid Disaster', convened by the BC Real Estate Association, drew nearly 70 people from the BC government, local governments, academic institutions, the business community, and First Nations. The March 8th workshop produced an Action Plan to update BC flood maps. The Not Waiting for Noah workshop and this report are a further step toward improved flood hazard management in BC.

BACKGROUND

Humans have a long history of settling in floodplains, and BC is no exception. Flat land, rich soil, and ready access to water transportation make shorelines practical for development. Beaches and riverfront areas are also desirable for residential neighborhoods. As BC's population increases, more people are moving into flood prone areas. Consequently, the risk of damage is increasing even without climate change impacts.

The current provincial flood management and mitigation policy regime – legislation, policies, guidelines and programs – in BC was developed using traditional methods of hydrology, calculated by analyzing historical data. Until recently, the frequency of hydrologic events was understood to be relatively stationary, or unchanging over time. Today however, climate change impacts throughout the province, such as increased intensity and magnitude of precipitation (particularly in winter with the exception of the interior where summer precipitation is more significant), an increased number of rain-on-snow events and accelerated sea level rise are exacerbating the risk of riverine and coastal flooding. In a changing climate, events are projected to be increasingly variable and extreme. This state of 'non-stationarity' is one in which historical records no longer provide a roadmap for planning and decision-making, because the past is no longer a good guide to future conditions.

The good news is that awareness of the need to integrate climate change information into flood management is growing. As a result, there are many planning and modeling initiatives underway that aim to address increasing flood risk associated with climate uncertainties, specifically to address risks to people and properties in developed areas. The Not Waiting for Noah workshop catalyzed dialogue to develop a shared understanding of flood risks, how those risks are evolving, and a suite of measures required to avoid the losses that could occur if business as usual were to continue.

WORKSHOP: EMERGENT THEMES

It is critical that risk and vulnerability assessments be conducted to serve as a basis for strategic flood management and mitigation planning.

1. NON-STATIONARITY

The assumption that underlies traditional flood risk assessment methods is that climate is relatively stationary, and that variation occurs within a predictable envelope of natural variability. The standard practice was to predict that the regularity of flood events will be the same in the future as they have been in the past – augmenting historical flood records with evidence of earlier events if available. Human-induced climate change and an improved understanding of both short and long-term climate variability mean that this assumption is no longer valid. Scientists and flood management professionals need new risk assessment tools to replace traditional methods based on historical data that are now of little use.

In general, the flood protection legislation, policy and programs across the province have not been adapted to increased flood risk due to climate change. Climate models project that flood events will be more frequent and severe. Due to ongoing development in hazardous areas, and because sea level rise is creating flood risk in areas that have not previously been vulnerable, the consequences of flood events will be more disruptive and costly. It is therefore critical that risk and vulnerability assessments be conducted to serve as a basis for strategic flood management and mitigation planning. These studies must integrate the most up-to-date climate information to guide decision-making and the allocation of limited resources to where they are most needed.

It must also be recognized that increasing climate variability makes estimating future flood events more difficult. Irreducible uncertainty will require the development of adaptive and flexible management strategies to address a range of possible future scenarios.

2. THE NEED FOR RISK-BASED APPROACHES

Traditionally, flood design estimates have been based on the expected water level of what is called a ‘design flood’, which is normally either a 200-year return period flood (0.5% annual probability) or the largest flood on record. For example, the largest recorded flood for the Fraser River was in May 1894, when rapid snowmelt caused river levels to rise dramatically causing flooding from Harrison

to Richmond. There was widespread flooding throughout the province that year, but the greatest consequences were experienced in the Fraser Valley floodplain because the area had been developed. Structural protection, such as dikes, has generally been built to accommodate the design flood plus a standard additional increment, the 'freeboard', to account for uncertainties. This method is problematic mainly because, despite having the best available information, uncertainty and variability cannot be completely eliminated. It is critical that a wide range of factors are considered in flood risk assessments and in structural protection design, such as the duration of the record used for frequency analysis, river sedimentation, bank stability, and the potential for cascading/domino events (e.g. a landslide triggering a flood event). The limitations of traditional flood design estimates are compounded by climate change and human-induced hydrological change such as urban land use patterns increasing the rate and volume of storm water runoff, and agricultural drainage adding to flood flows.

The need for a new approach is particularly important in light of the extent to which floodplains throughout the province have been, and continue to be, developed. Assessment methods and mitigation planning need to be commensurate with the elevated risks and consequences that a flood in a highly developed area would have today. The quickly changing risk landscape necessitates new flood management strategies and risk-based approaches. The 2012 guidelines for professional practice for legislated flood assessment in BC, developed by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC), are an important step in that direction. The guidelines emphasize risk-based approaches and the need to plan for hydrological change in light of both climate change and land use changes.

3. CHALLENGES, NEEDS AND THINGS THAT SHOULD BE CHANGED

The Fraser Basin Council (FBC) 2008 study entitled 'Flood Hazard Land Use Management Review' provides an assessment of the impact of 2003 and 2004 legislative changes, when significant responsibility for flood protection was downloaded from the province to local governments. Notably, local governments were given the authority to designate flood hazard areas, to approve subdivisions in floodplains and to create floodplain bylaws within flood hazard areas. The FBC's findings include the fact that local governments do not have sufficient legislation or tools to manage land use in floodplains. More specifically, the study found that flood management is particularly challenging for local governments due to the need for:

- Updated floodplain mapping
- Technical flood hazard information
- Risk assessments
- Coordination across jurisdictions
- Increased expertise/capacity

These capacity issues make flood risk management in a stationary climate challenging. Climate changes such as sea level rise that increase the vulnerability of coastal communities to impacts such as flooding, reduced drainage capacity and coastal erosion, are exacerbating existing risks and creating flood risk in areas previously not prone to such hazards. Many issues noted during the Not Waiting for Noah workshop echoed and built upon what the 2008 FBC study found. The box below captures the 'needs' discussed throughout the workshop.

WHAT IS NEEDED TO ADEQUATELY ADDRESS FLOOD RISK IN A CHANGING CLIMATE?

- Improve technical information
- Address data gaps that make forecasting and monitoring flooding very challenging
- Secure adequate funding for flood management (particularly in small communities)
- Identify and fill research gaps (e.g. projections for and impacts of rain on snow events)
- Create guidelines for standardized, quantitative flood risk assessments that estimate expected consequences and factor in the potential for cascading impacts
- Develop case studies and best practices
- Establish a forum to discuss policy implications, options and trade-offs
- Determine an acceptable level of risk tolerance, while recognizing that risk tolerances will vary geographically and socially
- Implement proactive provincial mitigation policies that address known flood hazards
  - The Black Mountain Irrigation District in the Okanagan highlights the previous point as flooding poses significant risks to facilities, storage reservoirs, staff safety, residents, property, water quality and ecosystem health
- Develop regional, strategic, adaptive, flexible and proactive flood management and mitigation strategies
- Investigate transferable models of regional collaboration and governance
- Effectively communicate risk to the public
  - The District of North Vancouver is a leader in the area of risk communications (see Appendix C for details)

4. RISK ASSESSMENT TOOLS

Not Waiting for Noah presentations illustrated the different methods available for modeling flood risk and flood hazards. Descriptions of the various models presented are given below.

4.1 HAZUS

HAZUS is a powerful risk assessment program, methodology and software for analyzing potential losses from natural hazard events. The program was developed by the Federal Emergency Management Agency in the U.S. and Natural Resources Canada has recently released a Canadian version. HAZUS combines current scientific and engineering knowledge with the latest geographic information systems (GIS) technology to produce estimates for hazard-related damage and loss before or after a disaster occurs. The program allows a user to look at the consequences of various natural hazards to their community, rather than just knowing where the hazard zones are. Earthquake, flood, and hurricane hazards are included in the model, and it may soon be expanded to include fire. Economic losses as well as social losses are calculated by the program for any hazard event, and the program then provides broad information useful for planning and emergency management. Inputs to HAZUS include information about the hazards (flood maps for example) and information about the assets and people that are vulnerable to the hazards (census information, critical infrastructure locations, etc.). This is a new tool for Canada and has yet to be widely applied, however it will likely be most suitable for use in jurisdictions with high-quality spatial data, and specifically in regions that may be subject to multi-hazard scenarios (an earthquake followed by a tsunami for example). For more information see the Canadian HAZUS Users Group data at http://hazuscanada.ca and http://www.usehazus. com/canadianhug/.

4.2 PIEVC Risk Assessment Tool

To meet the climate change challenge, Engineers Canada and its partners established the Public Infrastructure Engineering Vulnerability Committee (PIEVC) in August 2005 to look at infrastructure vulnerability to climate change from an engineering perspective. The committee developed the PIEVC Engineering Protocol, which is a formalized process to assess engineering vulnerability and risk from current and future climate impacts on infrastructure.

The Protocol has been proven to work for any type of infrastructure that is impacted by climate including: buildings; roads and associated structures; storm water and wastewater systems; water resources; utilities, airports and public housing. The results of this work have been used to complete an assessment of existing infrastructure codes, standards and related instruments as well as climate design parameters to recommend reviews based on identified vulnerabilities. Case studies are available on the PIEVC Website at http://www.pievc.ca.

4.3 Municipal Risk Assessment Tool – Insurance Bureau of Canada

Water damage is now the highest source of residential insurance claims in Canada, and these claims are expected to increase with climate change. But without accurately understanding risks, the insurance industry can't set premiums to protect homeowners. On behalf of its member companies, and with funding from Natural Resources Canada, the Insurance Bureau of Canada

(IBC) has worked with a multi-disciplinary team to develop a risk assessment tool to analyze the chance of failure for municipal storm and sanitary infrastructure during extreme storm events: the Municipal Risk Assessment Tool (MRAT).

The tool uses a top-down approach. For a given municipality, the model combines risk indicators with present and future climate return periods, and represents risk zones on a neighborhood GIS map. In effect, this map is a visual representation of storm sewer back-flow risk zones within the municipality, based on climatic parameters calibrated using the back flow threshold and return periods. This information is made available through a web portal. The tool output is not designed to identify the solutions to the vulnerabilities, but simply to identify where vulnerabilities exist.

The City of Coquitlam is the first BC municipality to pilot this tool. The City's experience is that, although extensive local infrastructure and land use data must be accessed and uploaded, guidance was provided by the IBS. If there is a GIS expert on staff, the required procedures are not onerous or time consuming. Through working with the IBC, City staff appreciated that the assessment was tailored to be locally relevant. The model is designed to predict current risk and future risk scenarios for 2020 and 2050. Applying and developing the tool for other local needs is now in the final stages. For information on other municipalities where the IBC risk assessment tool is being piloted see Appendix C.

4.4 HEC-RAS Model

HEC-RAS is a computer program that models the hydraulics of water flow through natural rivers and other channels. The program is one-dimensional, meaning that there is no direct modeling of the hydraulic effect of cross-section shape changes, bends, and other two and three-dimensional aspects of flow. It was developed by the US Department of Defense, Army Corps of Engineers to manage rivers, as well as harbours, and other public works and has gained wide acceptance and use since its public release in 1995.

Although this program does not technically fit into the category of a risk assessment tool, RAS can be used in conjunction with hydraulic expertise and topographical information to define a flood hazard. The advantages of RAS are that it is relatively user friendly, and the software is free. Therefore, really good information can be obtained with limited resources. In turn, the information can be used in a risk assessment.

The Black Mountain Irrigation District (BMID) used HEC-RAS to model flood inundation areas for Mission Creek, in the Okanagan Valley of BC, to plan for potential dam breaks. The forecasting uses online stream flow data along with provincial snow pillow data.

BMID has modeled Mission Creek from the upper watershed reservoirs in the Graystoke Range down to the mouth of the creek at Okanagan Lake. The flow model allows BMID to simulate stream flow along the creek including velocities, depths, and area of flooding. The model is also being used by the BMID to estimate dam failure inundation areas downstream and adjacent to Mission Creek.

4.5 Variable Infiltration Capacity Hydrology Model

As with the RAS model, the Variable Infiltration Capacity (VIC) model is not a risk assessment tool but it does produce results that can be incorporated into a risk assessment. VIC is a spatially distributed macro-scale process-based hydrology model. Some distinguishing features include: (i) multi-layer characterization of the soil column; (ii) subgrid variability in soil infiltration, represented by a spatial probability distribution; (iii) drainage from the lower soil layer (baseflow) as a nonlinear function of soil water storage; (iv) subgrid variability in land surface vegetation classes; v) subgrid variability in topography represented using elevation bands; (vi) multiple soil rooting zones and variable root distribution; (vii) multi-layer energy balance snow model incorporating canopy effects (e.g. attenuation of wind and solar radiation, canopy interception and sublimation); (viii) wet canopy evaporation, dry canopy transpiration and bare soil evaporation represented using the Penman-Monteith approach.

Using gridded meteorological data, the VIC model solves the 1-dimensional water and energy balance for each grid cell. Surface runoff and baseflow is routed downstream using an offline routing model.

The hydrology group at the Pacific Climate Impacts Consortium (PCIC), at the University of Victoria, is using the VIC model to quantify the hydrologic impacts of climate change for watersheds in British Columbia. The VIC model has been applied at a resolution of 1/16-degree (approximately 27-32 km^2, depending on latitude) in the Peace, Fraser, upper Columbia and Campbell River watersheds. At a model resolution of 1/16-degree, the VIC model is best applied to watersheds larger than several hundred square kilometres

4.6 Flood Hazard Study: a Flood Assessment for the Regional District of East Kootenay

The approach taken for the Regional District of East Kootenay (RDEK) is a method to prioritize flood risk assessments across a large region with scarce data. The RDEK assessment plan involves three phases, the first of which is a flood hazard baseline study. The second phase is to conduct detailed flood risk assessments and the third phase is to recommend flood risk management strategies. The hazard baseline study aims to prioritize areas subject to flooding, describe potential effects of projected climate change on flood hazards, and outline a regional flood management plan framework.

The study is challenging due to the large size of the region, the limited availability of information on hazards, hydrology and flood control infrastructure. Furthermore, the climate change data is coarse in resolution and has much statistical uncertainty as to exactly what will occur. Nevertheless, the study provides a starting point as it is based on existing conditions and identifies hazard intensity and potential for loss. It should be noted that unlike a more detailed flood

risk assessment, it does not estimate the likelihood of damage or loss for specific flood scenarios for specific areas nor does it estimate the magnitude of damage or loss that could occur due to specific flood scenarios.

The results for phase 1 include an inventory of existing hazard information, mitigation works and elements at risk, a review of potential climate change implications for flood hazards and a flood management framework. The methodology is transferable across British Columbia.

4.7 Related Flood Planning Initiatives

The Climate Action Secretariat of the BC Ministry of Environment, supported by funding from Natural Resources Canada, has contracted the Arlington Group to conduct a study entitled 'Evaluation of BC Flood Policy Performance for Coastal Areas in a Changing Climate'. The purpose of this project is to evaluate the ability of BC's flood management policy regime to achieve its goals in the context of a changing climate. The project is expected to assess aspects of provincial government policies and programs that support or hinder adaptive measures, consider policy alternatives, and identify entry points to integrate climate change adaptation considerations into the provincial government's existing flood hazard management policies and programs.

The BC Real Estate Association (BCREA) is undertaking a floodplain mapping project that recognizes the risks that flooding poses to BC's economic vitality, safety, environment, property owners and communities. The project focuses on the need to update existing floodplain maps, and create maps for areas that were never properly surveyed. Without such maps, decision makers have a limited ability to effectively assess and manage flood risks. To launch this initiative, the BCREA held a multi-stakeholder workshop on March 8, 2013 to explore concrete steps that can be taken to update existing floodplain maps and keep them current. The key output of the workshop is an Action Plan that includes creating a Working Group to move the actions in the plan forward; assessing the capacity of local governments to update floodplain maps; recommending that the provincial government take back responsibility for floodplain mapping, with maps being updated every ten years; and leveraging funds to create a province-wide plan to complete floodplain mapping.

The Fraser Basin Council is developing a business plan that is exploring the value of advancing a regional response to sea level rise, storm surge, and river flooding across the Lower Mainland and what steps would need to be taken to initiate a regional response. This project is funded by Metro Vancouver, Natural Resources Canada and the BC Ministry of Forests, Lands and Natural Resource Operations. The purpose of the Business Plan is to communicate the key findings – to date – from a collaborative and consultative process, which has explored a wide range of interests, challenges, and opportunities to advance a regional approach to flood management in the Lower Mainland. The plan also provides a rationale for the development of a Regional Flood Management Strategy and lays out the steps and estimated costs associated with its development and initial implementation. For more information on these projects and others please see Appendix C.

CONCLUSIONS

Integrating climate change information into all aspects of flood management is critical as BC's population increases and development in flood-prone areas continues.

The Not Waiting for Noah workshop brought a range of speakers together, including engineers, municipal managers, provincial water policy experts, and agricultural experts, along with real estate and insurance professionals. This diverse group spoke out on what they think ought to be done to address the growing threat that flooding, caused by a combination of extreme weather events and sea level rise, poses to British Columbia's economy and communities.

During the course of the day, participants offered a number of suggestions to improve provincial flood management and mitigation. The discussion included the need for increased planning coupled with dedicated long-term funding for flood protection projects. One idea put forward to improve flood policy was to centralize flood hazard management within the provincial government. This would ensure that flood risks are addressed in a systematic and consistent manner. Another complementary proposal involves introducing a standards-and results-based approach in which the province would set objectives that must be met, and would then monitor the objectives for compliance. These proposals recognize that, where senior governments are providing funding, an evaluation methodology should be in place to assess the effectiveness of the expenditures in light of long-term government policy objectives. These proposals would assist in bringing greater consistency to the current system.

Participants also stressed the need for broader-based, sustained funding mechanisms. For instance, local governments need ongoing support for floodplain mapping, updating floodplain maps and the development of locally-tailored policies, plans and implementation strategies. However, hazard risk reduction measures can only be effective if funding is made available for capital projects and other appropriate flood management and mitigation approaches. Furthermore, it was recognized that there is a significant range of local knowledge and expertise on flood management issues. Generally, larger municipalities have staff with knowledge of flood issues while smaller jurisdictions need more assistance. In all cases, local government would benefit from additional support from provincial staff experts when developing floodplain maps, policies, bylaws etc.

Regarding the need for floodplain mapping, it was suggested that partnership funding models be developed to encourage municipalities to conduct floodplain mapping projects in communities throughout the province. It was also suggested that the current provincial Flood Protection Funding Program could be expanded to include funding for floodplain mapping and cost/benefit evaluations. This would enable municipalities to identify the most appropriate and cost effective flood mitigation strategies.

As it stands, the three pillars of provincial flood hazard management in BC are land use management, structural controls, and flood response. Adapting to climate change will require implementing and enforcing existing legislation, policies and programs, and strengthening all three pillars, including flood response efforts. Integrating climate change information into all aspects of flood management will be critical as BC's population increases and development in flood prone areas continues. These land use changes will alter the hydrology of the province, likely requiring even more structural controls and flood response efforts.

Workshop participants pointed out that all levels of government seem to be underestimating long-term risks. It was suggested that there ought to be a shift from reactive responses to proactive, preventive measures such as re-engineering landscapes and restoring ecosystems to reduce risk. One presenter noted, "An ounce of prevention is worth a pound of cure because for every dollar put into protection, you save five in damage." Throughout BC, 1-in-100 and 1-in-200 year standards are widely used, which will no longer provide the kind of protection required in rapidly changing hydro-climatic conditions. Furthermore, much of the province's present flood protection infrastructure does not even meet the current, out-of-date standards. Large investments are needed to act on these known risks. For instance, a recent report commissioned by the province found that it will cost over $9.5 billion to protect the Lower Mainland alone from flooding considering projected sea level rise and storm surges. The fact that climate change is making risks increasingly difficult to predict or to price highlights the importance of new approaches to assessing flood risk. Part of this challenge is the need to communicate these growing risks to the public.

In conclusion, the central goals of the Not Waiting for Noah workshop were to bring together a community of practitioners, and together discuss problems and solutions for flood management and mitigation in a changing climate. The workshop also aimed to highlight best practices and proactive strategies to address the changing risk landscape and the increasing number of vulnerable people and assets in flood prone areas. Participants agreed that seminars like Not Waiting for Noah are highly valuable. As we tackle the complex and evolving challenges of climate change, ongoing dialogue that includes as many perspectives as possible will be an essential part of the process.

APPENDIX A

LIST OF TERMS

Adaptation: In human systems, adaptation is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities[1].

Flood: An overflowing of a large amount of water beyond its normal confines, especially over what is normally dry land. It was noted in the workshop that flooding is a natural occurrence and that it is development in flood prone areas and exposure of people and property that creates a hazard.

Flood Risk: The likelihood or probability of a flood hazard in combination with the consequences.

Flood Hazard: A flood process with the potential for causing harm. Scope includes floods, debris flows & debris floods.

Flood Hazard Exposure: Elements at risk in areas subject to flood hazard.

Flood Hazard Intensity: The destructive power of flooding.

Risk Assessment: The process to prioritize risks focusing on the potential consequences of an impact.

Vulnerability Assessment: The process to prioritize climate change risks focusing on where we are most susceptible.

1 Intergovernmental Panel on Climate Change (IPCC), 2011.

APPENDIX B

BC PROVINCIAL FLOOD MANAGEMENT POLICIES

This appendix provides an overview of the primary pieces of provincial legislation, regulations, guidelines, standards, programs, policies, and information services related to flood management in BC.

LEGISLATION

Community Charter: Section 56 of this Act pertains to flood management as it contains provisions governing the ability of a building inspector to issue or refuse a building permit for land that is likely subject to flooding and other hazards.

Dike Maintenance Act: This Act authorizes the Inspector of Dikes and Deputy Inspectors of Dikes to set dike design and maintenance standards and best management practices; to approve changes to dikes and new dikes; to monitor management of works by diking authorities; and to provide technical expertise for high risk diking issues.

Drainage Ditch and Dike Act: This Act deals with the administrative aspects of diking such as construction, taxes, enforcement, expropriation, compensation, and asset transfer. Please note that this ACT is being repealed by the Province (sunset clause deadline of December 31, 2015) with the intention of transferring responsibility of diking districts to local governments.

Emergency Program Act: This Act provides the legislative framework for emergency management including a description of the powers and obligations of the provincial government and local authorities in planning for emergency response.

Environmental Management Act: This Act regulates industrial and municipal waste discharge, pollution, hazardous waste, and contaminated site remediation. It also requires preparation of environmental plans for flood control, drainage, soil conservation, water resource management, waste management, and air quality management. Section 5(f) and 138(3)(e) provide the minister with broad flood management powers including the authority to establish guidelines, regulations and flood hazard management plans.

Land Title Act: The sections of this Act that pertain to flood management are:

- s.219 – Gives property owners the authority to make agreements in favour of other bodies, putting restrictions on the use and development of the owners' property; outlines provisions for registration of a covenant and provisions for the approving officer to refuse to approve a subdivision plan if the land is subject to flooding.
- s.86 – This section states that if the land may be subject to flooding either or both of the following conditions may be required: 1) an engineering report 2) one or more registered covenants.

Local Government Act: The sections of this Act that pertain to flood management are:

- s.302 & 312 – A regional district may expropriate real property or works for the purpose of exercising or performing its powers, duties and functions.
- s.849-852 - The Regional Growth Strategy should limit development in areas subject to natural hazards.
- s.875-878 – Official Community Plans must include statements and map designations respecting restrictions on the use of land subject to hazardous conditions.
- s.903 – A local government may, by bylaw, create zones and establish boundaries for each zone; regulate the use of land, buildings and other structures. This regulatory power includes the power to prohibit any use or uses in a zone.
- s.910 – Addresses construction requirements.
- s.919.1(1)(a)(b) – Provides the ability to establish Development Permit Areas (DPA) to protect from hazardous conditions.
- s.920 & 927 – In a DPA, a Development Permit must be issued prior to any subdivision or alteration of land, or any construction.
- s.920.01& 920.1 – Concerns the impact of development on the natural environment.

REGULATIONS

Compensation and Disaster Financial Assistance Regulation: Key parts of this regulation include the establishment of disaster financial assistance amounts, maximum number of payments unless preventative actions have occurred, and that no assistance is to be provided for structures in floodplain areas unless they are flood protected.

Dam Safety Regulation: The objective of the Regulation is to mitigate loss of life and damage to property and the environment from a dam breach by requiring dam owners to: inspect their dams, undertake proper maintenance, report incidents and take remedial action and ensure that the dams meet current engineering standards.

Emergency Program Management Regulation: Section 2 states that the Province must prepare and maintain a Hazard Risk and Vulnerability study to identify potential emergencies and disasters; assess potential impact to people and property; recommend legislation, regulation and policy on emergency management; and prepare provincial emergency plans.

PROGRAMS

Dam Safety Program: In British Columbia, the *Water Act* has authority over dams and holds dam owners liable for any damage caused by the construction, operation or failure of their dam. The British Columbia Dam Safety Regulation applies to all owners of licensed dams. The function of regulating the licensed dams is carried out by Regional and Victoria staff. Dams nine metres

or greater are the responsibility of Victoria staff and dams below nine metres are a Regional responsibility.

Flood Protection Program: This program is administered by Emergency management BC, runs from 2007-2017 and is providing $100 million for flood protection infrastructure initiatives over that time. It is a federal-provincial cost shared program with funding from the Building Canada Plan. Projects are selected through an application-based process.

POLICIES

BC Flood Response Plan: This plan is a component of the Comprehensive Emergency Management Plan, and aligns with the BC Emergency Response Management System. The methods the government will use to coordinate activities to manage a flood event are described and clarified along with the roles and responsibilities of the ministries involved during an integrated provincial response.

Living Water Smart: *Living Water Smart* sets the direction for changes to water management and water use. The plan has two actions that address flooding issues. Action #21 states that where new development on flood plains is unavoidable, it will be flood-proofed to high provincial standards. Action #22 states that the government will provide $100 million for flood protection over 10 years to help communities manage flood losses.

GUIDELINES

Coastal Floodplain Mapping Guidelines and Specifications: The purpose of these maps is to identify coastal flood hazard(s) and to provide the technical basis for land use planning and developing floodplain bylaws. The report provides a methodology to develop floodplain maps for coastal communities for flood hazards, including sea level rise. Guidance is also provided to estimate flood construction levels based on best mapping and engineering practices.

Flood Hazard Area Land Use Guidelines: These guidelines have been prepared pursuant to section 2 of the Environment Management Act and must be considered by local governments in making bylaws under section 910 of the Local Government Act. These guidelines establish setbacks and flood construction levels for specific coastal areas, areas protected by a standard dike, development on landfill, and where there are erosion protection works.

Guidelines for Management of Coastal Hazard Land Use: Provides guidelines for the management of lands that are exposed to coastal flood hazard arising from exposure to sea and to expected sea level rise. The guide aims to help local governments, land use managers and approving officers develop and implement land use plans.

Sea Dike Guidelines: Provides updated sea dike design methodology for coastal protection measures.

STANDARDS

Seismic Design Standards for Dikes: This document describes factors that need to be considered in the seismic design of High Consequence dikes located in Southwestern British Columbia. This document provides guidance on:

- Seismic ground motions to be considered for the analysis and design of dikes along with corresponding performance expectations;
- Suitable geotechnical investigation methods to characterize and obtain engineering properties of the site soils;
- Commonly used methods for seismic analysis considered appropriate for dikes;
- threshold seismic events that should trigger a post-event evaluation of the integrity of the dike system;
- Seismic rehabilitation and strengthening measures; and
- Post-earthquake temporary emergency repair and permanent remediation measures.

INFORMATION

River Forecast Centre: River Forecast Centre (RFC) is where snow, meteorological and streamflow data is collected and interpreted to provide warnings and forecasts of stream and lake runoff conditions around the province. The RFC provides:

- Flood Advisories and Warnings
- Water Supply and Low Streamflow Advisories
- Collection, quality assurance, analysis and archiving of snow data

Sea Level Rise Information: The Ministry of Environment has a webpage dedicated to sea level rise in BC. Information about global and regional projections and impacts is provided. Links to resources are provided regarding what local government can do to adapt, technical studies completed by the BC Government, and initiatives to monitor and raise awareness about sea level rise. The webpage can be found at: www.env.gov.bc.ca/cas/adaptation/sea_level.html

APPENDIX C

FLOOD MANAGEMENT & CLIMATE CHANGE ADAPTATION INITIATIVES

This appendix includes a range of initiatives that address aspects of flood risk and adaptation to climate change.

BC Ministry of Agriculture: Flood Planning and Response in the Lower Fraser

The Ministry of Agriculture is taking the lead to plan protocols for the protection, movement and possible disposal of deceased animals in the event of flooding. There are viable options to manage chickens but developing a plan to manage cows is proving to be a big challenge.

Due to the large number of cattle in the area – approximately 11, 000 - it is critical that they not be allowed to congest roads as this could result in evacuation routes being blocked. Ideally cows would be evacuated before a flood event. However, if this fails and casualties do occur, the best option for disposal may be an engineered landfill. The Ministry is working with the agricultural community to navigate these challenges and developing plans according to various flooding scenarios.

BC Real Estate Association Flood Mapping Project

The project focus is on the concern that existing floodplain maps are outdated, and that this limits the ability of decision makers to effectively assess and manage flood risks. To launch this initiative, the BCREA held a multi-stakeholder workshop on March 8, 2013 to explore concrete steps that can be taken to update existing floodplain maps and keep them current. Approximately 70 flood management, land use and emergency management decision makers and practitioners attended to discuss technical, financial and political challenges and opportunities. The key output of the workshop is an Action Plan to advance progress to update existing floodplain maps. The document entitled 'Planning To Avoid Disaster: Action Plan to Update Floodplain Maps in British Columbia' can be found at: www.bcrea.bc.ca/docs/floodplainmaps_action_plan

Coastal Cities at Risk: Building Adaptive Capacity for Managing Climate Change in Coastal Megacities Program

The overall objective of this program is to develop the knowledge base and enhance the capacity of mega-cities to successfully adapt to and cope with risks posed by the effects of climate change, including sea level rise, in the context of urban growth and development. The CCaR project takes an interdisciplinary approach involving natural, engineering, socio-political-economic and health scientists and builds upon leading programs, which are also partners in the research program. This is a five-year project (March 2011 to March 2016) funded by the International Development

Research Centre together with the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada, and the Social Sciences and Humanities Research Council of Canada. More information on this research program can be found at: www.coastalcitiesatrisk.org/wordpress/

The Delta Regional Adaptation Collaborative Sea Level Rise Adaptation Visioning Study - Policy Report

The Delta Regional Adaptation Collaborative (RAC) is a partnership between the University of British Columbia's Collaborative for Advanced Landscape Planning (CALP) and the Corporation of Delta that works to identify, model, visualize and evaluate potential flood impacts and adaptation options for the Corporation of Delta. CALP has produced a series of 2D and 3D visualizations based on local hydrological modelling for sea level rise and storm surge dike breaches. Visualizations have also been produced for a range of possible future scenarios ranging from "Reinforce and Reclaim" to "Managed Retreat". The visual materials are being used with staff and a citizens' Working Group to measure the performance of, and assess the policy implications and social acceptability of the various adaptation strategies.

To learn more about the visualizations of future adaptation scenarios, visit the website about CALP's sea level rise project with the Corporation of Delta: www.delta-adaptation-bc.ca

District of North Vancouver: Natural Hazard Management Program

The fatal 2005 Berkley landslide catalyzed development of a new approach to natural hazards risk management in the District. In 2007 the Natural Hazards Management Program was initiated and funding was allocated for risk assessment and mitigation. The program is designed to provide greater public access to hazard and risk information. A risk-based approach to natural hazards management focuses on both the likelihood and consequence of natural hazard. DNV's approach is unparalleled in Canada and is based on engaging in open, transparent dialogue about hazards and risk with local residents and businesses. The DNV website provides access to Hazard and Risk Information including educational information about each potential natural hazard. Noteworthy among DNV's innovative initiatives are:

- Developing community-based risk tolerance criteria for accepting land-use proposals; the debris flow warning system
- Training and education with the real estate sector
- Community-based geo-hazards mapping via their web site
- The Natural Hazards Task Force

For more information visit: www.dnv.org/article.asp?c=1024

Evaluation of BC Flood Policy Performance for Coastal Areas in a Changing Climate

The Climate Action Secretariat of the BC Ministry of Environment, supported with funding from Natural Resources Canada, has contracted the Arlington Group to conduct an Evaluation of BC Flood Policy Performance for Coastal Areas in a Changing Climate. The purpose of this project is to evaluate the ability of BC's flood management policy regime to achieve its goals in the context of a changing climate. The project will be completed in 2013.

Flood Risk Reduction: Low Impact Stormwater Management & Other Alternative Building Methods

Much of today's built environment includes a significant amount of impervious surfaces, which is one of the underlying causes of flooding. The following articles and documents are about alternative building methods and low impact stormwater management strategies. Note that as of 2012, the Washington State Department of Ecology has mandated that all new projects, as well as renovation projects, must include Low Impact Development methods for their roadway and site improvements.

Low Impact Development (LID) Guidance Manual

This manual incorporates new information and results of recent research regarding the LID approach and techniques appropriate to the Puget Sound region. The manual can be downloaded here: 2012 LID Technical Guidance Manual for Puget Sound. http://www.psp.wa.gov/downloads/LID/20121221_LIDmanual_FINAL_secure.pdf

Capacity Building Tool for Planners hoping to achieve Net Zero Water Buildings and Neighbourhoods

This website focuses specifically on the practical ins-and-outs of green building and sustainable development. To celebrate World Water Day, and its 2011 focus on urban water systems, the Cascadia Green Building Council (CGBC) released "Toward Net Zero Water: Best Management Practices for Decentralized Sourcing and Treatment."

The website can be found at: http://buildingcapacity.typepad.com/blog/2011/03/capacity-building-tool-for-planners-hoping-to-achieve-net-zero-water-buildings-and-neighborhoods-marks-world-wa.html

Urban agriculture blossoms in Ballard – Greenfire used the Living Challenge as its roadmap

This May 21, 2013 article by Mark Buehrer, PE founder/director of 2020 Engineering (http://www.2020engineering.com), describes how the Living Building Challenge (https://ilbi.org/lbc), a cohesive "deep green" building standard, is used as a guide for Greenfire Campus. The article can be found at: Urban agriculture blossoms in Ballard (http://www.djc.com/news/en/12053559.html).

Insurance Bureau of Canada: Municipal Risk Assessment Tool

Canadian municipalities are struggling to manage increased precipitation associated with climate change. Heavy rainfall events are causing more frequent flooding of roads, homes and business. Local governments are challenged to identify which parts of the city's infrastructure need to be upgraded in what order, and how to allocate limited resources. The Insurance Bureau of Canada is helping to address this problem by developing a web-based tool to assist municipalities and insurers assess potential infrastructure failure. The tool provides a visual representation of risk zones to locate areas where infrastructure will likely fail so that resources can be put to work where they are most needed. The tool is calibrated for sewer back up, but could theoretically be used to predict the probability of failure of water distribution networks or the incidence of flooding. The tool went through a proof-of-concept phase with the participation of nine municipalities. Of these, three (Coquitlam, Hamilton, and Fredericton) worked to validate the tool. The pilot project, in partnership with these three municipalities, was formally launched by IBC's President & CEO Don Forgeron on November 21, 2013. MRAT will be rolled out in several more municipalities across Canada in 2014.

More information about IBC's groundbreaking technology can be found at: http://www.ibc.ca/en/Natural_Disasters/Municipal_Risk_Assessment_Tool.asp

Preparing for Climate Change: An Implementation Guide for Local Governments in BC

This guide, developed by West Coast Environmental Law, is a resource that looks at what legal and planning tools are available to local governments and how they can be used to adapt to climate change impacts. The guide provides examples of adaptation measures implemented by municipalities throughout BC, as they may be helpful to other communities. This resource was developed as a project of the British Columbia Regional Adaptation Collaborative, with funding from NRCAN, the BC Ministry of Community, Sport and Cultural Development and the Fraser Basin Council.

The document can be downloaded at: www.wcel.org/resources/environmental-law-alert/help-local-governments-frontlines-changing-climate

Prince George Flood Management Planning

The City of Prince George is subject to spring flooding from the Fraser River and to fall and winter flooding from the Nechako River. After flood events in 2007-08, the City selected Northwest Hydraulic Consultants (NHC) to study flood hazards and solutions and develop a flood protection plan. According to the report produced by NHC, some key solutions identified include:

- Changing land-use along the rivers, to remove existing building and other infrastructure and to prevent future development, which returns the floodplain to a more natural state
- Raising or floodproofing existing buildings to limit future damage
- Providing dykes that are set-back from the main river channel, which protects infrastructure while maintaining the function of the floodplain
- Improving internal drainage behind dykes or roads
- Activating historical side channels which improves habitat and provides relief from ice-related flooding

The study solutions and floodplain mapping were provided to the City to support informed flood management decisions. The full report can be found at: www.nhcweb.com/upload/News/NHC_-_CEBC_2011_Award_of_Excellenc_Managing_Prince_Georges_Rising_Flood_Waters_Rev.pdf

In light of the study findings, the City Council adopted a new Flood Plain Regulation Bylaw in 2011, which replaces the 2007 City of Prince George Flood Plain Regulation Bylaw. The bylaw can be found at: www.princegeorge.ca/citybusiness/currentplanning/floodplainbylaw/Pages/Default.aspx

See the Implementing Climate Change Adaptation Report for more information about how the City is reducing flood risk: http://princegeorge.ca/environment/climatechange/adaptation/Documents/2012_PGRAC_Flooding_volume4.pdf.

Province of BC Sea Level Rise Information

The Ministry of Environment website provides sea level rise (SLR) information and links to resources and innovative approaches such as the King Tide Photo Initiative – a public outreach and engagement campaign that invites people to observe today's high water events (high tide/storm surge events) and imagine the future of B.C.'s coastline with SLR.

Among the resources that can be accessed on the site are:

- The SLR Adaptation Primer – a resource for local governments and land management authorities, providing information on a range of tools that can be used as part of a sea level rise adaptation strategy
- A series of technical studies
- SLR projections based on a global SLR of 1m by 2100.

Access the website here: http://www.env.gov.bc.ca/cas/adaptation/sea_level.html.

Additional reports and studies can be found on the following Ministry of Forest, Lands and Natural Resource Operations website: http://www.env.gov.bc.ca/wsd/public_safety/flood/fhm-2012/draw_report.html#5

Southeast Florida Climate Change Compact

The Compact was formalized in 2009 and represents a joint commitment of Broward, Miami-Dade, Monroe and Pam Beach Counties to partner in mitigating the causes and adapting to the consequences of climate change. The Counties are working together towards regional sustainability and climate resilience.

The Southeast Florida Regional Climate Change Compact released a regional climate action plan in 2012. The plan took two years to develop and includes the development of regionally consistent methodologies for mapping sea-level rise impacts and assessing vulnerability. The plan includes sea level rise projections projections, inundation mapping and a vulnerability assessment of areas at risk. The overall objective of the plan is to integrate climate adaptation and mitigation into decision-making and to have a plan that is implemented through the local and regional agencies, processes and organizations currently in place. The plan contains 110 action items in seven goal areas to be completed over the next five years. The plan can be accessed at: http://southeastfloridaclimatecompact.org/pdf/Regional%20Climate%20Action%20Plan%20FINAL%20ADA%20Compliant.pdf

There is also an implementation guide that can be downloaded at: http://southeastfloridaclimatecompact.org/pdf/Implementation%20Guide.pdf

UBCM Flood Management Resolutions

The Union of BC Municipalities (UBCM) endorsed a resolution (A2) entitled Regional Integrated Approach To Flood Management at the 2013 annual convention. The Resolution Committee notes that from 2001 through 2011, the UBCM membership endorsed numerous resolutions highlighting the need for an integrated approach to flood management and for ongoing funding from the federal and provincial governments for floodplain management. The full 2013 Resolutions Committee report can be found at: http://www.ubcm.ca/assets/Resolutions~and~Policy/Resolutions/Resolutions%20Book%202013.pdf

University of Victoria: Coast GIS 2013 Conference – June 18-21, 2013

The CoastGIS 2013 Conference: Monitoring and Adapting to Change on the Coast was held at the University of Victoria. The conference brought together practitioners and researchers in the field of marine and coastal Geographic Information Systems, remote sensing and computer cartography.

Workshops 8 and 9 – Application of Light Detection and Ranging (LIDAR) Data for Coastal Zone Management Part 1 & Part 2 – scheduled for June 18th were of particular interest. Part 1 aimed to provide an overview of LIDAR in Canada, specifically: technology both terrestrial and

marine including challenges associated with conducting /contracting surveys; the products (depth, elevation, reflectance, photography, video, etc.); the benefits of terrestrial and marine LIDAR for coastal zone management and in particular for adaptation to coastal change on Canadian eastern, western and northern coasts; challenges of processing, data management and production of derived products; and the benefits of terrestrial LIDAR. Part 2 covered the current realities of LIDAR data accessibility and generated recommendations for improving the planning, execution, data management and dissemination of LIDAR survey data. For more information visit: www.coinatlantic.ca/index.php/program/workshops.

APPENDIX D
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