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Floodplain Mapping Funding Guidebook for BC Local Governments

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Prepared by

British Columbia Real Estate Association
Yuill Herbert, Ian Picketts – *Sustainability Solutions Group*
Tamsin Lyle – *Ebbwater Consulting*

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Executive summary

In carrying out their flood management responsibilities, communities in BC struggle to find funding sources for floodplain mapping projects. Floodplain maps provide visual information on where floodwaters are expected to go; therefore, they are the most logical first step in flood management and must be updated periodically.

Like other critical tasks undertaken by communities, floodplain maps can be costly to produce; unlike physical infrastructure projects, there are no dedicated funding mechanisms in Canada for this work. Of countries that belong to the Organization for Economic Cooperation and Development (OECD), Canada is in the minority in not having a national program that undertakes or funds floodplain mapping.

With few funding options available, BC communities must take creative approaches, often employing multiple strategies. Discussions with municipalities, regional districts, industry groups, practitioners and researchers have resulted in a list of funding strategies that may be suitable for acquiring funding for floodplain mapping activities:

- Common funding options
 - General revenue
 - Grant programs
- Creative funding options
 - Development approval information areas
 - Development cost charges
 - Partnerships and collaborations
 - Civic crowd sourcing
- Innovative options
 - Floodplain authorities
 - Flood protection service or utility
 - Taxation
 - Insurance

While the strategies presented in this guidebook are not exhaustive, they can form a starting point for communities to undertake floodplain mapping.

Introduction and purpose

Floodplain maps and other technical studies form a foundation to inform decisions about how and where communities grow. Unfortunately, many existing floodplain maps in BC are at least 20 years old, which leaves local decision makers with unreliable information with which to effectively assess and manage flood hazards.

In BC, legislative changes in 2003-2004 handed primary responsibility for flood management to local government. Unfortunately, this change was not supported with additional expertise or financial resources.¹ During a workshop in March 2013, stakeholders identified three types of challenges that impede floodplain mapping projects: political, technical and financial.²

This guidebook aims to help communities explore innovative funding strategies. Investigation into funding programs and floodplain mapping activities across British Columbia, Canada and other countries has resulted in a short list of funding strategies that may provide support for floodplain mapping projects.

Where possible, the strategies and incentive options include references to funding programs in communities that have recently completed floodplain mapping exercises. While other funding programs may exist, and several options described represent untested directions that require further investigation, this report provides a basis for those investigations and a starting point to help communities overcome some of the financial obstacles to updating floodplain maps.

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Floodplain mapping funding overview

Understanding and preparing for risk posed by natural disasters is one of many important community efforts. Floodplain maps provide an essential technical tool for flood management, including mitigation strategies and emergency response. Simply put, floodplain maps provide visual information on where floodwaters are expected to go. The level of effort and cost required to develop floodplain maps varies according to the type and scale of map created. A summary of types, uses and costs is available on the BCREA website at www.bcrea.bc.ca/docs/government-relations/2014-FM-background.pdf.

Floodplain mapping funding in British Columbia

Many of the floodplain maps developed in BC were prepared using funds from the Flood Damage Reduction Program (FDRP) that was actively funded from 1975 through 1998. This program led to BC-federal agreements in which federal and provincial governments equally shared the costs.³ Federal participation in flood management was effectively withdrawn at the conclusion of the FDRP, leaving responsibility for floodplain mapping to the provinces. In BC, this responsibility was further devolved to local communities through legislative changes in 2003-2004.⁴ Since then, few communities have initiated floodplain mapping projects.

¹ As well, while the *Local Government Act*, s.910 provides local governments with the power to designate floodplains and create related bylaws and regulations, it does not require them to do so, meaning that the political impetus for floodplain management is left to be provided by local governments.

² BC Real Estate Association, 2013

³ Institute for Catastrophic Loss Reduction, 2010

⁴ Lyle & McLean, 2008

Fewer than ten municipalities and regional districts completed floodplain maps between 2008 and 2013, either as a response to extreme weather events or as a component of a risk reduction strategy. These projects have been funded through a mix of grants, support from other levels of government and partnerships. A few of these strategies are highlighted in Table 1.

Table 1 - Strategies used to fund recent floodplain mapping projects

Major funding resource	Used by	Notes
Gas Tax	Cowichan Valley Regional District District of Squamish City of Vancouver	The Gas Tax fund may provide up to 100% funding for projects; funding from other sources is encouraged, but not required.
Natural Resources Canada's Regional Adaptation Collaborative Program	City of Vancouver	Includes internal matching funds and collaboration with Port Metro Vancouver.
General Revenue	Cowichan Valley Regional District City of Surrey* Maple Ridge District of North Vancouver City of North Vancouver (with the District) City of Vancouver City of Prince George	* Floodplain mapping undertaken as part of City of Surrey's drainage utilities' general fund.
Collaborations	Cowichan Valley Regional District Regional District of Central Kootenay District of North Vancouver and City of North Vancouver	e.g., nearby municipalities, regional districts, First Nations, Fisheries and Oceans Canada, research institutions, utilities, other organizations.

Funding approaches in other provinces

Since the close of the FDRP, other provinces have either continued to fund floodplain mapping or, similar to BC, handed down responsibility to communities. The result of varying approaches to flood management in Canada is a patchwork of floodplain mapping across the country, with some jurisdictions having consistently-regulated and well-funded programs and others having very little oversight and support. Table 2 provides a summary of approaches to floodplain mapping in other provinces. While many of the approaches rely on provincial funds, others highlight opportunities for establishing dedicated agencies responsible for floodplain mapping and in forming strong collaborative partnerships.

In Ontario for instance, Conservation Authorities are responsible for updating floodplain maps using funding from self-generated sources, municipal levies and provincial grants.⁵ Conservation Authorities stem from the 1946 *Conservation Authorities Act*, which created a mechanism for municipalities and the provincial government to form and partner with 36 Conservation Authorities. These authorities, based on watershed boundaries, have a mandate to administer flood control, recreation, education and watershed protection activities.

⁵ Conservation Ontario, 2013

In Nova Scotia and New Brunswick, municipalities have worked with local universities and colleges to undertake floodplain mapping projects using funding from Natural Resources Canada’s Regional Adaptation Collaborative program for adaptation to climate change.

Table 2 - Summary of provincial approaches to floodplain mapping

Province	Funding mechanism
Alberta	<p>Alberta Environment supervises the production of floodplain maps for communities as part of its Flood Hazard Identification Program. Funding for this program is allocated as part of Alberta’s provincial budget.</p> <p>See: Flood Hazard Identification Program http://esrd.alberta.ca/water/programs-and-services/flood-hazard-identification-program/default.aspx</p>
Saskatchewan	<p>The Saskatchewan Water Security Agency was formed in 2012 to oversee issues of water supply, drinking water, water infrastructure and watershed planning—including reducing and preventing damage from flooding. One of the agency’s key actions is to improve flood and drought forecasting tools, but no mention is made of floodplain mapping.</p> <p>See: Water Security Agency Plan for 2015-16 www.wsask.ca/Global/About%20WSA/Annual%20Reports%20and%20Plans/Annual%20Plans/WSAPlan1516.pdf</p>
Manitoba	<p>The Hydrologic Forecast Centre of Manitoba Infrastructure and Transportation created flood forecasts, including inundation maps, in July 2014.</p> <p>See: Flooded Area Maps www.gov.mb.ca/mit/floodinfo/floodoutlook/watersheds_data_maps.html#flooded_area_maps_container</p>
Ontario	<p>Conservation Authorities receive funds from self-generated revenues (e.g., municipal plan review, land rental fees, gate fees, etc.), municipal levies and provincial grants to manage flood control, recreation, education and watershed protection activities. Part of these activities includes updating community floodplain maps.</p> <p>See: Presentation www.iclr.org/images/2007_June_ICLRPRESFloodMapping.pdf</p>
Québec	<p>In accordance with provincial planning legislation, municipal/regional governments must identify their own flood risk areas with the help and support of Ministère du Développement durable, de l’Environnement et des Parcs. No provincial funding program for flood mapping has existed since 2004.</p> <p>See: Quebec flood zones https://www.cehq.gouv.qc.ca/zones-inond/rapports-carto.htm</p>
New Brunswick	<p>The New Brunswick Department of the Environment and Local Government manages floodplain maps for communities, many of which date back to the Flood Damage Reduction Program. In 2008, the province signed on to Natural Resources Canada’s Regional Adaptation Collaborative program for adaptation to climate change, providing funds to update the Flood Risk Assessment Map for the dikelands and Town of Sackville, Town of Amherst and parts of the Cumberland Basin.</p> <p>See: Atlantic Climate Adaptation Solutions www2.gnb.ca/content/gnb/en/departments/elg/environment/content/climate_change/content/adaptation.html</p>

Province	Funding mechanism
Nova Scotia	<p>Following the end of the FDRP, floodplain mapping in Nova Scotia has been a mix of self-directed activities and activities as part of Natural Resources Canada’s Regional Adaptation Collaborative program for adaptation to climate change.</p> <p>For instance, funding from this program supported the Applied Geomatic Research Group in mapping of coastal areas and for floodplain maps for the Town of Oxford and River Phillip.</p> <p>The Town of Bridgewater received Gas Tax revenue to assist in preparing a map of the LaHave River Estuary.</p> <p>See: Atlantic Climate Adaptation Solutions www.atlanticadaptation.ca/reports?term_node_tid_depth%5B%5D=66&term_node_tid_depth%5B%5D=9&term_node_tid_depth_1%5B%5D=30</p> <p>and</p> <p>Integrated River and Coastal Hydrodynamic Flood Risk Mapping of the LaHave River Estuary and Town of Bridgewater www.mdpi.com/2073-4441/6/3/517</p>
Prince Edward Island	Flood risk management in PEI has focused on coastal issues (storm surges and erosion) and inland flooding from extreme rain events. PEI does not have a riverine floodplain mapping program.
Newfoundland and Labrador	<p>The Newfoundland Department of Environment and Conservation manages floodplain maps and funds this through its provincial budget. The province has updated few maps since the FDRP but, in 2012, supported a report on <i>Flood Risk and Vulnerability Analysis Project</i> prioritizing communities for new floodplain maps.⁶ It is not evident whether the province has budgeted funds to update these maps.</p> <p>See: Flooding in Newfoundland and Labrador www.env.gov.nl.ca/env/waterres/flooding/flooding.html#risk</p>

Mapping approaches in other countries

A scan of OECD countries indicates that nearly all have some form of national mapping program to identify flood risk. In the United States, for instance, the Federal Emergency Management Agency (FEMA) maintains two types of floodplain maps. Flood Hazard Boundary Maps identify hazards for emergency management, and Flood Insurance Rate Maps are the official source of flood risk data for communities. Funding for mapping efforts comes from FEMA’s federally-funded Flood Hazard Mapping and Risk Analysis Program Budget and from the National Flood Insurance Program, which collects monthly premiums American households pay for flood insurance.⁷ In Europe, the EU Flood Directive⁸ mandates member states map flood extents and identify assets and humans at risk in these areas, and most European countries have responded with national floodplain mapping programs, funded from general revenues.

⁶ AMEC Environment & Infrastructure, 2012

⁷ US FEMA, 2013

⁸ European Exchange Circle on Flood Mapping, 2007

A review of international mapping programs offers few funding approaches applicable to British Columbia, where mapping is the responsibility of local government. However, in a few cases, national governments have created standards and/or assembled the information needed to create floodplain maps, but left municipalities and regional districts to fund and carry out the mapping program. For instance, water utilities in Denmark often prepare floodplain maps as a mechanism to undertake more detailed and site-specific analysis funded through utility fees or taxes.⁹

The insurance industry in Austria, Germany, Italy and Czech Republic has taken leadership by producing floodplain maps.¹⁰ The HORA project in Austria provides a partnership example between the national insurance association and the Austrian government to jointly create national floodplain maps. The German Insurance Association and the Czech Republic national insurance association produce maps to determine insurance premiums, while the Italian national insurance agency also produces maps that identify damage potential.

Moving forward

Examples from Europe and across Canada suggest that, while a national program may likely be most effective, there are other options for funding local floodplain mapping programs. In addition, interviews with British Columbia municipalities and regional districts have shown how some communities are exploring partnerships with industry and other governments. The Appendix provides a summary of these interviews and highlights the need for creativity. The remaining sections of this guidebook consider options to address this need through exploring creative and innovative funding opportunities.

Understanding and minimizing the cost of floodplain maps

Broadly, the preparation of a floodplain map involves three steps:

1. Estimating the amount of water accumulated and discharged during a rain or other water inflow event.
2. A hydraulic model is then used to determine where the water might go.
3. Potential flood areas are mapped by combining water levels from a hydraulic model with a digital elevation model (a virtual interpretation of the topography) or base maps and surveys.

The process outlined above can be expensive if starting from nothing or a poor baseline. Costs can range from \$100,000 for a small community if there exists topographic and hydrometric data, to \$250,000 for a similarly-sized community with no base information, to many more times this for large areas with limited data.

Each floodplain mapping effort is unique to the area and local context, so no one solution works in every situation; however, the following are a few insights shared by municipalities, regional districts and practitioners.

- Focus first on high-priority areas — outcomes can be maximized and costs minimized if a municipality or regional district considers its greatest areas of concern and focuses mapping activities on these areas first.
- Consider a less sophisticated map — municipalities and regional districts may consider employing a less sophisticated approach by utilizing historical data (e.g., flood extents from previous flooding periods) and overlaying this data on existing floodplain maps or municipal GIS maps.¹¹ This method

⁹ Klimatilpasning, 2012

¹⁰ de Moel et al., 2009

¹¹ See example at: www.floodmap.net

has been used to represent sea level rise under changing climate conditions.¹² In addition, these maps can prove viable for learning and creating support for more detailed maps, but may lack specific detail to support all land use decisions.

- Utilize GeoBC data – GeoBC is a provincial government agency that creates and manages geospatial information and products across all natural resource sector agencies, and may have data specific to area municipalities and regional districts, including hydrometric and streamflow data.
- Review recent work from British Columbia universities and colleges – graduate students often undertake small, but overlapping, research projects that may provide a foundation or data for creating and updating floodplain maps.

Funding strategies

Discussions and interviews with municipalities and regional districts, industry groups, practitioners and researchers have resulted in a list of strategies that may be suitable for acquiring funding for floodplain mapping activities. The list is organized by common, creative and innovative options:

- Common funding options
 - General revenue
 - Grant programs
- Creative funding options
 - Development approval information areas
 - Development cost charges
 - Partnerships and collaborations
 - Civic crowd sourcing
- Innovative options
 - Floodplain authorities
 - Flood protection service or utility
 - Taxation
 - Insurance

¹² Municipality of North Cowichan Climate Action and Energy Plan

Common funding options—build a case for using general revenue

Many municipalities and regional districts fund floodplain mapping exercises through general revenue sources (see Table 1), either integrating mapping work into capital improvement projects, operating budgets or utilizing existing tax revenues. There is simplicity in this approach, but it requires competing against other programs and projects. Floodplain mapping exercises are often viewed as additional costs, despite evidence that preparation and planning ahead of a disaster greatly reduces the costs and suffering incurred during and after a disaster event.⁴³

Before floodplain mapping can occur, there must be interest in and support for the initiative. Practitioners in BC have taken several different approaches to gain support for floodplain mapping projects. Information garnered from community interviews suggests communities that have recently been subjected to severe flooding events receive a great deal of political support for flood management, both locally and provincially. Other communities are undertaking mapping as part of broader climate change adaptation initiatives.

Taking the time to actively communicate with the public and politicians—about vulnerabilities, flood management guidelines and floodplain mapping projects—is considered to be a highly worthwhile investment. Involving many local departments in flood management, and not simply relegating the responsibility to one department (or even one individual), is seen as a good way to improve knowledge and raise the visibility of the issue, thereby increasing the chances of general revenue being made available for floodplain mapping.

One strategy for building the business case for floodplain mapping exercises among other general revenue expenditures is to highlight future cost reductions to municipal accounting offices. One might do so by preparing a simple cost benefit analysis using information from recent studies and events. For example, Hinkel et al. 2013 highlights that flood mitigation is far more cost effective than cleaning up after flooding. Another is the *North Carolina Floodplain Mapping Program: 2000 – 2008 Program Review*, which states that floodplain mapping in North Carolina saved \$100 million per year in reduced flood damages.⁴⁴

Another ideal opportunity for floodplain mapping is during the development of an official community plan (OCP)⁴⁵ or regional growth strategy. This ensures that the results of the floodplain mapping are fully integrated into the planning process, and that areas at risk can be appropriately identified in official plans.

⁴³ Public Safety Canada, 2008

⁴⁴ State of North Carolina, 2008

⁴⁵ District of North Vancouver, 2011

Common funding options—grant programs

While none of the following granting programs are specific to floodplain mapping projects, an inventive funding application may produce a successful bid. As with all grant programs, local governments are wise to first contact the funding agency to confirm eligibility.

Gas Tax Fund

Source: Federal government, under the New Building Canada Plan.

Description: The Gas Tax Fund provides local governments with predictable, long-term, stable funding to help build and revitalize local public infrastructure. Two of the program’s three streams include disaster mitigation as an eligible expense: Community Works Fund and Strategic Priorities Fund. Municipalities and regional districts have been successful in applying for and receiving funds from this program (see Table 1).

Eligibility: Local governments are eligible for community works and/or strategic priorities funds, depending on their location.

Strengths: The 2014 federal Budget expanded the eligibility of the Gas Tax to include a broader range of infrastructure that will increase the demand on the available dollars. Gas Tax funding is legislated as a permanent source of federal infrastructure funding for municipalities and regional districts, but subject to program changes.

Weakness: There are competing demands for Gas Tax funds within municipalities and regional districts, as these monies are also used to finance critical infrastructure upgrades.

Contact: Union of British Columbia Municipalities, www.ubcm.ca/EN/main/funding/renewed-gas-tax-agreement.html

Regional Adaptation Collaborative

Source: Natural Resources Canada.

Description: A former option was the Regional Adaptation Collaborative program, but it ended in 2015. This program was part of a national strategy on climate adaptation. BC’s regional collaborative focuses on “Preparing for Climate Change—Securing British Columbia’s Water Future.” The Fraser Basin Council and BC Ministry of Environment – Climate Action Secretariat work together in managing BC RAC.

Eligibility: Local governments and First Nations.

Strength: While this program has reached its funding cycle, it is included here because it has been a source of funding for some floodplain mapping projects in BC and elsewhere (see Tables 1 and 2). The regional collaboration approach provides a flexible funding model that encourages partnerships and efficiencies.

Weaknesses: Currently, there are no open calls for proposals. Requires a detailed project submission, partnerships and matching funding.

Contact: Fraser Basin Council, www.fraserbasin.bc.ca/ccaq_bcrac.html

Green Municipal Fund

Source: Federation of Canadian Municipalities, through an endowment from the federal government.

Description: The Green Municipal Fund (GMF) provides low-interest loans, usually in combination with grants, and knowledge services to support sustainable community development. Funding is allocated to plans, feasibility studies and pilot projects, and capital projects in five sectors of municipal activity: brownfields, energy, transportation, waste and water.

GMF grants can cover up to 50 per cent of the total eligible costs, up to a maximum of \$175,000 (\$350,000 for pilot projects). Applications are accepted year-round, and funding decisions are made twice per year (February and September).

Eligibility: Local governments.

Strength: Specific to municipal studies and projects.

Weakness: Funding from this program requires matching funds and is not exclusive to British Columbia.

Contact: Federation of Canadian Municipalities, www.fcm.ca/home/programs/green-municipal-fund.htm

BC Flood Protection Program

Sources: Building Canada Fund – Communities Component and BC government.

Description: The Flood Protection Program assisted local governments with funding for flood protection works across BC, though its last intake for applications occurred in 2013.

Eligibility: Local governments.

Strength: Specific funding for flood protection infrastructure projects.

Weakness: This program did not support assessment or plans; however, it is included in this guidebook in the likely event that technical studies will be supported outright in the future, as floodplain mapping has been supported in special circumstances in the past. For instance, the City of Prince George received funding for floodplain mapping from Emergency Management BC after an ice jam occurred on the Nechako River in 2008.¹⁶

Contact: Emergency Management BC, www.th.gov.bc.ca/BCFCC

¹⁶ Appendix (interviews by Sustainability Solutions Group)

National Disaster Mitigation Program

Source: Public Safety Canada, through Canada Economic Action Plan 2014.

Description: The National Disaster Mitigation Program (NDMP) provides \$200 million over five years to build safer and more resilient communities. The NDMP is intended to address rising flood risks and costs, and build the foundation for informed mitigation investments that could reduce, or even negate, the effects of flood events in the future.

The program was implemented in April 2015 with a call for proposals in four funding streams: risk assessments, flood mapping, mitigation planning and investments in non-structural and small scale structural mitigation projects.

Eligibility: Provincial and territorial governments, though they are not precluded from partnering with local governments.

Strength: Unlike many other senior government funding programs, the NDMP emphasizes technical studies and mitigation.

Weakness: \$200 million over five years is not a significant investment for the entire country, and provinces and territories do not receive allotments; that is, they must compete for all available funds in a given year.

Contact: Public Safety Canada, www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgn/ndmp

Creative funding options

This section describes several options and possibilities for funding floodplain mapping projects. Most of these options have yet to be applied in British Columbia for floodplain mapping, and further investigation by municipalities and regional districts would be required before implementation.

Development approval information areas

In addition to the authority to designate development permit areas (DPAs)¹⁷ in their official community plans to protect development from hazardous conditions, such as floods,¹⁸ local governments can designate areas where information related to the impact of development is required. Conceivably, a local government could create development approval information areas (DAIAs) where floodplain mapping information must be provided as part of a development application; for example, as part of the subdivision approval process, or in an application for rezoning.

A program of this nature is in place in the United Kingdom, where the UK Environmental Agency suggests new development undertake a Flood Risk Assessment for planning applications.¹⁹ In BC, the Cowichan Valley Regional District can require new developments to utilize the region's hydraulic model to ensure the development does not increase the flood hazard for neighbouring areas. A similar approach used by the Squamish Lillooet Regional District requires proponents of new subdivisions to prepare and pay for integrated stormwater management plans for the watershed where the subdivision will be located, if one has not already been done.²⁰

¹⁷ The District of Saanich has a Floodplain DPA and other municipalities, such as the District of North Vancouver, have DPAs that address flood hazards.

¹⁸ This DPA does not allow a local government to vary any existing floodplain specification under s. 910 of the *Local Government Act*.

¹⁹ UK Environment Agency, 2012

²⁰ SLRD, Electoral Area D Subdivision and Development Servicing (Planned Communities) Bylaw No. 741, 2002, Schedule A, 3.3.2.

Strength: A DAIA would effectively shift some of the costs of floodplain mapping to developers, which is a benefit from the perspective of local governments.

Weaknesses: Preexisting knowledge of the extent of the floodplain and flood-prone lands may be required to designate an area as a DAIA; alternatively, local governments may be tempted to designate large areas as DAIA, even if they are not prone to flooding. There may also be a disincentive for a developer to make an application and pay the costs associated with floodplain mapping, which could increase the cost of housing. Issues of scale and costs may preclude requiring a floodplain map on land below a certain size, or by smaller developments. Even considering larger developments, DAIA may lead to a patchwork of floodplain mapping efforts within a local jurisdiction.

Development cost charges

The *Local Government Act* has a strict definition of the current use of development cost funds. Funds collected are deposited in a separate special development cost charge (DCC) reserve fund and are restricted to capital costs that relate directly or indirectly to the development in respect of which the charge was collected. Capital costs, as defined by the *Local Government Act*, include planning, engineering and legal costs directly related to the work for which a capital cost may be incurred.²¹

While there are no known bylaws requiring updating regional floodplain maps as part of new development in BC, the examples offered by the Cowichan Valley Regional District and the Squamish Lillooet Regional District provide a working precedent for consideration.

Strength: The opportunity to streamline floodplain map updates is substantial.

Weaknesses: Community-wide floodplain mapping is not explicitly an eligible cost for DCCs under the *Local Government Act*. DCCs are intended to enable municipalities and regional districts to provide infrastructure to development projects.

The use of DCC funds for floodplain mapping would be limited to new development and would need to be justified as directly related to the provision of infrastructure. A community-wide floodplain mapping analysis undertaken as a standalone project would not meet the requirements for DCC funding. If DCCs could be charged for floodplain mapping, the local government would have to cover the costs of the study and the infrastructure for the rest of the community, beyond the new development—by far, the majority of the costs.

In addition, DCCs are funding mechanisms that allow responding to development by providing infrastructure once a project has been approved. Whereas floodplain mapping should occur earlier in that process, during land use planning, to proactively inform the location of development.

Local governments already use DCCs to a considerable extent. Increasing the scope of this financing mechanism could negatively impact housing affordability. Also, as with DAIA, this approach may lead to a patchwork of floodplain mapping efforts within a local jurisdiction.

²¹ *Local Government Act*, section 932.

Requirements: Flood protection infrastructure or services are not categories specified in the legislation, meaning that legislative reform would be required before DCCs could be used to fund floodplain mapping, as a planning service associated with flood protection infrastructure. In addition, the case for direct benefit incurred from the DCCs, and the added cost of development, would need to be presented to developers and future buyers.

Partnerships and collaborations

Floodplains extend beyond the jurisdictional boundaries of many municipalities and regional districts, creating natural partnerships among municipalities, regional districts and key asset holders in the floodplain. Despite additional management requirements, some municipalities and regional districts have demonstrated success in forming partnerships in support of floodplain mapping work (see Tables 1 and 2). For instance, the City of Vancouver enlisted financial support from Port Metro Vancouver, which has significant assets within floodplain areas and desire to understand their exposure to flood hazards.

The following are potential partners and collaborators. Not only can partners provide additional funding, but many funding programs described earlier require or give additional backing to collaborative proposals.

Solicit support from large land owners – Identify large owners of land, being sure to consider both private and public, along waterfront areas and seek support from these individuals or organizations.

Strength: Large land owners have a direct interest to protect their assets and may see benefit in supporting a regional floodplain mapping program.

Weakness: Some large asset owners may feel the municipality and province already have responsibility for assessing and providing flood management.

Partner with emergency management organizations – Organizations such as Emergency Management BC have a mandate to prepare for hazards and risks that could affect all or any part of BC and to prepare plans such as the BC Flood Response Plan. The BC Flood Response Plan indicates that, where there is the possibility of a significant flood event, cross-government working groups can be prepared on a range of issues, including mapping. The City of Prince George has received funding for floodplain mapping from Emergency Management BC.

Strength: Emergency Management BC already has a goal to increase safety and resilience for individuals and communities and responds to flood risk, making it a natural partner in mapping flood risks.

Weakness: The general emphasis of emergency management is to respond to hazards; therefore, a case needs to be made that this includes proactive approaches to eliminate or reduce the hazard before a flood event.

Coordinate through regional districts – A regional district is a federation of municipalities and electoral areas for a geographical area, managed by a board that consists of appointees and a director elected from each electoral area. Regional districts are financed by property taxes and fees and, unlike municipalities, regional districts are required to match the benefits and costs of services to the people who pay the taxes. Regional districts are mandated to provide region-wide services and inter-municipal services and to act as local governments for electoral areas. The inclusion of floodplain mapping as a regional district service would require a decision by the regional board. A specific project would also likely require a board decision to approve a budget and work plan, unless there is an existing budget envelope.

Cowichan Valley Regional District recently undertook floodplain mapping on behalf of its constituent municipalities. The Capital Regional District is undertaking a sea level rise project with the City of Victoria and the District of Saanich.²²

Strengths: Regional districts are advantageous organizations for floodplain mapping because their geographic scope is larger than municipalities; they offer opportunities for economies of scale and have existing governance and implementation systems for delivering collaborative projects. The provision of high-quality data is also an expensive component of floodplain mapping; municipalities and/or regional districts may be able to reduce costs by partnering to collect and/or purchase this data.²³

Weaknesses: The complexity of regional district governance can undermine the effectiveness of projects. For example, if one municipality has ambitious intentions, it may have to compromise those intentions as part of a regional project. Municipal representatives often govern regional governments, so municipal support for floodplain mapping must be obtained first.

Partner with insurance industry – To identify risk from flooding for particular buildings, the insurance industry requires an assessment of flood hazard at the building level. Insurance companies do not currently offer residential overland flood insurance broadly in Canada, but current discussions are underway, giving rise to a potential opportunity for a partnership and investment in current and accurate flooding data.²⁴ Municipalities and regional districts may consider discussing floodplain mapping projects with insurance industry representatives.

Strengths: Such collaborations already exist in Austria, Germany, Italy and many other jurisdictions. The insurance industry may be interested in partnering on a provincial or national approach, for example with the Federation of Canadian Municipalities or Union of BC Municipalities.

Weaknesses: Residential overland flood insurance is not provided in Canada, which means insurance companies do not have a revenue stream to fund flood-related programs. Because insurers are looking for a solution allowing the measurement of flood risk posed by rivers and rainfall, the maps may need to be at a higher level of resolution than currently being considered. As well, insurers are interested in maps across the entire country, which means collaboration at the local or provincial level may not meet that need.

Partner with academic institutions – Partnerships with academic institutions have shown promise in other provinces (see Table 2), illustrating the possibility of establishing extended collaborations with groups across BC. The University of British Columbia’s Forest Resources Management/ Landscape Architecture-Collaborative for Advanced Landscape Planning (CALP), Simon Fraser University’s REM Water Research Group, and the University of Northern British Columbia’s Natural Resources and Environmental Studies Institute are all groups that have worked on floodplain mapping related projects. Academic institutions may also bring additional funding to a floodplain mapping project through the Natural Sciences and Engineering Research Council of Canada and the MITACS research grant.

²² City of Victoria, 2012

²³ Cowichan Valley Regional District purchased LiDAR at the cost of \$375,000, a benefit over member municipalities purchasing LiDAR individually.

²⁴ On May 25, 2015, The Co-operators announced the availability of Comprehensive Water in Alberta, which provides residential coverage against flooding caused by an overflow from a body of water, sewer/water backup and accumulation of surface water caused by heavy rain. The company plans to make the product available across Canada.

Strengths: Such collaborations provide opportunities to reduce costs through funding an appropriate number of graduate students. Further, academic institutions can facilitate the documenting and publishing of relevant hydrological data for use in flood forecasting protocols.

Weaknesses: Working with academic institutions can often be a time-intensive process, and there are risks that a given institution may not have graduate students working on floodplain mapping projects unless a multi-year funding program is established.

Civic crowd sourcing

Civic crowd sourcing is a growing option in the United States for communities faced with unanticipated costs. Civic crowd sourcing allows ordinary citizens to direct their money to local civic projects. For instance, Detroit citizens crowd sourced \$50,000 to fund improvements and art installations downtown. A similar approach might work to fund floodplain mapping activities. This would, however, require a significant effort to educate potential funders of the benefits of flood mapping.

Strength: Crowd sourcing has grown in popularity, providing a channel for matching investors and projects. And many crowd sourced projects include a return on investment beyond civic improvements.

Weakness: There is legal ambiguity as to whether municipalities and regional districts can collect and utilize funds through what are essentially online donations.

Innovative options

During the course of researching funding programs, several innovative options for funding floodplain mapping projects were identified. These are presented below as possibilities for British Columbia, recognizing that they describe new directions for BC and would require significant discussion at all levels of government before a municipality or regional district could utilize these funding approaches.

Floodplain authorities

The example from Ontario illustrates that regional authorities can be tasked with the responsibility for preparing and updating floodplain maps. It may be worthwhile considering establishing a set of floodplain authorities in British Columbia with the responsibility for coordinating and managing floodplain maps. While there is some overlap with regional districts in BC, floodplain authorities can be unique in their mandate and be based on watersheds, whereas regional authorities are often tied to municipal boundaries. One possible model is the Okanagan Basin Water Board, which was initially established by letters patent to carry out very specific and limited tasks, and which has taxing authority (it levies a parcel tax) within the regional districts where it functions.

Strength: A floodplain authority would provide for an efficient means for developing and maintaining floodplain maps. Floodplain authorities would partner with municipalities and regional districts within the authority area and collect fees on behalf of these partners. In this way, floodplain mapping costs could be distributed among all partners, potentially reducing the cost to any one municipality or regional district.

Weaknesses: Establishing a new regional government structure may result in some ambiguity between other regional government units. Funding for the authority would need to come from some sort of tax requisition authority (such as that held by the Okanagan Basin Water Board), which some municipalities may be reluctant to support. Mapping carried out by multiple authorities could result in maps of varying detail and quality.

Flood protection service or utility

The *Community Charter* and *Local Government Act* provide municipalities and regional districts with the authority to provide a local service or utility within a municipality or regional district.²⁵ A municipal utility can be operated within existing operations, run through a subsidiary or operated on behalf of the municipality or regional district by the private sector. The utility can then charge user fees to homes or businesses that experience the benefit of the service or levy a property value tax or parcel tax to recover the costs of the service. While Local Improvement Charges are based on parcel or property taxes, fees are based on the provision of the service. Fees levied under either section 363 of the *Local Government Act* or 194 of the *Community Charter* must be justifiable to the public, and the municipality or regional district must provide a report detailing how the fee or charge was determined.

One possibility would be to establish a flood protection utility with a mandate to protect citizens from flooding. The utility would plan, design and implement strategies designed to mitigate damage to houses, businesses and infrastructure from flooding and charge a fee for that purpose. This mechanism makes explicit the relationship between the cost of mitigating the risk and the cost of locating in the area where the hazard is present.

Support of the electors within the area would be required and can be demonstrated through a proposal by council that is not opposed by petition or by elector assent. There must also be a connection between the cost of the service and the amount levied for it to be considered a fee, though precise matching is not required. In the case of regional districts, a new service can only be established where participants petition the regional district to have it, or assent to it. Property or parcel taxes may be used to fund the service.

While this approach has not been used as yet for floodplain mapping, similar approaches have been utilized in Denmark for flood protection²⁶ and in the US and BC for stormwater management. The City of Minneapolis has a stormwater utility that calculates its fee based on the impervious area of the property and issues reductions in the fee for actions to manage stormwater.²⁷ In BC, The City of Victoria has created a stormwater utility that aims to reward property owners who manage rainwater on site, and reduce the demand on conventional municipal infrastructure. One of the advantages of this approach, which separates the charge for the service from general property taxes, is that it allows property owners to see the cost savings benefit they are receiving when they manage their rainwater on site. Further, the City of Surrey drainage utility's contribution to floodplain mapping gives some precedence to local utilities broadening flood management activities. The Okanagan Basin Water Board also essentially fits this model, shared among three regional districts.

²⁵ *Community Charter*, Part 7, Division 5- Local Service Taxes. *Local Government Act*, section 14.2 (4), (5).

²⁶ Klimatilpasning, 2012

²⁷ City of Minneapolis, 2014

Strengths: This type of service is well suited to municipalities and regional districts, because they can make investments and undertake projects with longer time horizons and lower rates than private companies. Further, floodplain mapping is often most effectively carried out on a scale larger than some smaller municipalities are prepared for, requiring cooperation. The *Community Charter* provides for “inter-municipal services” providing greater flexibility than relying on a regional district-level service alone. That said, a regional district may also, through an establishing bylaw, create a service that would involve developing and maintaining floodplain maps in place of separate municipal utilities.

Weaknesses: Using a local area service to support floodplain mapping would likely require an outreach effort to develop public support for the proposal. It would also potentially provide a higher profile to floodplain mapping, which may or may not be a conversation that municipalities are prepared to have with their citizens, depending on the flood risk implications for existing development, and the level of preparedness of the municipality and the community in the face of that risk. One other challenge may be in drawing the border of local area services prior to conducting floodplain mapping.

Further, the costs associated with this approach are borne directly by those who live or do business on the floodplain. And it can be argued that society as a whole benefits from good flood management and should, therefore, bear some of the costs. For example, major transportation routes that run through floodplains if flooded, cause disruption for all the neighbouring communities. Mapping and mitigating these damages benefits the wider community.

Taxation

Several tax avenues may provide for increased revenue and funding for floodplain mapping. These options include local improvement charges, consumption taxes and carbon tax redistribution.

Property Transfer Tax²⁸ – In BC, The Property Transfer Tax is currently imposed by the provincial government at a rate of 1 per cent on the first \$200,000 of fair market value, 2 per cent between \$200,000 and \$2 million, and 3 per cent over \$2 million. Municipal governments could request a portion of this tax be returned to them and used to finance floodplain mapping projects.

Strength: There is an existing structure for collecting the tax, which provides an easier path and lower overhead costs than other taxes.

Weaknesses: There is currently no framework for municipalities to utilize this tax. The difference in property values between municipalities in different floodplain areas would result in an uneven distribution of tax revenues, unless a specific fund was created to distribute floodplain mapping funds equally across BC. There is only a weak rationale for tying the cost of floodplain mapping to the purchase of real estate. Further, earmarking provincial PTT revenue for any reason has been dismissed by several provincial governments over the past 25 years.

²⁸ The British Columbia Real Estate Association maintains the position that the Property Transfer Tax has a negative impact on housing affordability and is unfair to homebuyers (www.bcrea.bc.ca/government-relations/shelter-taxes).

Consumption taxes - Consumption taxes are imposed on specific goods and services, with the classic example being the tobacco tax. This tax is intended to act as a deterrent against tobacco use and to recover the social costs of tobacco use. Other examples include environmental levies on batteries, pesticides and disposable containers. In the context of floodplain mapping, a floodplain tax could be imposed on new dwellings located on floodplains. This tax could then be used to fund floodplain mapping and flood prevention strategies.

Strength: Directly imposes the cost of flood management on development within a floodplain area. A direct tax on new development in floodplain areas would discourage new construction in high-risk areas, resulting in a reduction of emergency management and recovery costs in the event of a flood.

Weaknesses: Similarly, a direct tax on development could discourage development. This could be eased with a graduated tax based on flood risk. Administering a consumption tax could be costly and could create issues between municipalities and regional districts with different levels of taxes or no tax, influencing development in unintended ways. In addition, consideration of the legal flexibility of BC municipalities and regional districts to create such a tax would be required.

Carbon Tax redistribution – The Carbon Tax in BC collects \$30/tonne of carbon²⁹ and is then redistributed through tax reductions to households and businesses as a revenue neutral tax. There is an argument that the Carbon Tax revenues could be applied to efforts that reduce the generation of carbon in society and, as carbon goes down, the tax burden is reduced. There is a case to be made for using these funds to increase the resilience of society to climate change. In other words, tax the pollution and use the revenues to mitigate the impacts of the pollution.

Strength: Directly imposes the cost of flood management on contributing factors to increased flood risk; e.g., climate change.

Weaknesses: The Carbon Tax is currently revenue neutral, and employing carbon tax revenues for anything other than rebates may not be politically viable. Further, a method for transferring funds between the provincial government and the municipality or regional district for floodplain mapping would be needed.

Insurance

Flood insurance rates maps in the US provide a comparative example for funding floodplain maps in British Columbia,³⁰ although there is no residential overland flood insurance program in Canada. Insurers are looking for potential flood maps that would be developed based on the most up-to-date input data, have a pan-Canadian scope, be able to assess both riverine and urban flood risk and be of sufficient resolution to assess both frequency and severity of flood risk at the property level.

Public desire for residential flood insurance (particularly from those in high-risk areas), combined with the need for accurate and current floodplain maps, create a natural partner with the insurance industry. The principle of developing floodplain maps through insurance premium fees serves as a useful possibility. The FEMA program represents an example of what is possible when a federal government decides to reduce flood losses by funding floodplain maps and requiring municipalities and regional districts to follow management standards.

²⁹ The tax rates on July 1, 2012 are based on \$30 per tonne of CO₂ equivalent emissions (www.fin.gov.bc.ca/tbs/tp/climate/A4.htm).

³⁰ Stevens, 2013

The following conditions are necessary for establishing a residential overland flood insurance program in Canada:

- accurate and up-to-date flood mapping,
- ongoing targeted investment to build and maintain flood defenses,
- widespread risk awareness from governments, communities and individuals of the physical and financial consequences of flood risk, and
- limited recourse to government revenues to finance post-disaster compensation to provide an incentive for effective mitigation and reduce the impact of disasters on taxpayers.

Strength: Examples from the US illustrate the extent to which floodplain mapping is possible. Canadian environmental law and policy is often influenced by the US, and these connections may facilitate adopting a similar approach to floodplain mapping

Weaknesses: Lack of national support for floodplain mapping minimizes the likelihood of a national insurance program, though there has been some recent movement at the federal level: the 2014 federal Budget proposed examination of residential overland flood insurance, and Public Safety Canada initiated a project in 2013 to assess the state of floodplain mapping across the country. Even if a flood insurance program was established, the cost of insurance for individual property owners could be significant and prohibitive, and many existing international flood insurance programs (including the American model) are not financially sustainable.

Summary

Local governments clearly have many competing priorities and limited funds to carry out all of their responsibilities. Financing has been cited as an obstacle to undertaking floodplain mapping projects, and this guidebook confirms that only limited options are currently available. Even so, motivated local governments can make the most of these opportunities—with some ingenuity.

Creative and innovative funding options for floodplain mapping projects may be possible in the future, though they require further investigation, perhaps in the context of the technical and political obstacles that local governments face.

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Appendix: Summary of interviews with BC municipalities

conducted in January 2014

The following summaries were based on interviews with eight cities and regional districts and are not an exhaustive or representative list of floodplain mapping activity.

Jurisdiction	Description of activities	Costs, collaborators & funders	Incorporates climate change?	Incorporates pop. growth?	Availability of information & data	Opportunities & challenges
Cowichan Valley RD (CVRD)	<ul style="list-style-type: none"> In 2009 mapping was completed for the Cowichan and Koksilah floodplain areas. Hazard, planning, emergency management, emergency response and ecological opportunities maps were created for 25, 50, 100 and 200 year return periods. In 2013 a preliminary coastal analysis was completed for the eastern zone of CVRD. Assessment included a projected 1m rise in sea levels and surge effects. 	<ul style="list-style-type: none"> Some funding came from EMBC after a 2009 flood event. 2009 mapping cost about \$500,000 and was completed with Gas Tax innovation funding, contributions from CVRD and Cowichan Tribes, and also internal CVRD staff time. Collaborations with DFO, research institutions and local groups guided the project also. Preliminary coastal analysis cost \$5,000 and was funded internally. 	Yes	Yes	<ul style="list-style-type: none"> DEM is available and the CVRD has invested in LiDAR. Some hydrologic data is available from the Cowichan and Koksilah hydrometric networks maintained by the WSC. 	<ul style="list-style-type: none"> Many collaborations have occurred and several partnerships were developed. Currently updates generally only occur with grant funds, as it is difficult to generate local funds for floodplain mapping.

Jurisdiction	Description of activities	Costs, collaborators & funders	Incorporates climate change?	Incorporates pop. growth?	Availability of information & data	Opportunities & challenges
District of Squamish	<ul style="list-style-type: none"> In the process of preparing flood hazard and floodplain maps. Beginning to update flood risk and flood inundation mapping. These maps will consider river and sea level rise flooding. The details of what will be addressed will be determined through community consultation. 	<ul style="list-style-type: none"> Flood risk and flood inundation mapping project will cost \$375,000, and will be funded entirely through the Gas Tax. Have attended regional group meetings, and worked with the Fraser Basin Council. 	Yes	Yes	<ul style="list-style-type: none"> DEM and LiDAR data available. Lots of hydrometric data for rivers available from Province and WSC. Ocean and tidal data available from Province. 	<ul style="list-style-type: none"> Work falls within Gas Tax scope, so funding was relatively easy to obtain. Council support related to recognition that sea level rise guidelines require plan updates. Development pressure motivated action: in the past Squamish was not proactive and this stalled development. Would like to update flood and erosion studies in creeks in the area and debris flow hazard studies.

Jurisdiction	Description of activities	Costs, collaborators & funders	Incorporates climate change?	Incorporates pop. growth?	Availability of information & data	Opportunities & challenges
City of Surrey	<ul style="list-style-type: none"> No new regulatory floodplain mapping since provincial maps completed in 1993. Detailed flood modelling of flood levels under different storm events throughout the city completed. Internal sea level rise assessments and mapping completed. Stormwater management plans finished throughout city. 	<ul style="list-style-type: none"> Over \$50 million of work done in Surrey to date. Most of the work has been paid by the drainage utility that exists within the City. City has minimal internal capacity: therefore consultants usually required for studies. Fraser Basin Council has led regional initiatives. Many internal departments are involved in flood management. 	Yes	Yes	<ul style="list-style-type: none"> DEM and LiDAR available. Gauges on drainage pump stations, sea dams and Rivers – all tied into SCADA. City took over federal rainfall stations. 	<ul style="list-style-type: none"> The drainage utility provides consistent funding toward flood management. Council has been very supportive, as in the past they were frequently sued. City has significant floodplain mapping planned as part of a climate change adaptation initiative. Uncertainties regarding liability with the Province have been a major obstacle to continued work. Easier to get funding if you have completed the studies and are ready to go.

Jurisdiction	Description of activities	Costs, collaborators & funders	Incorporates climate change?	Incorporates pop. growth?	Availability of information & data	Opportunities & challenges
Maple Ridge	<ul style="list-style-type: none"> In 2007-2008, the Flood Control Levels were updated internally based on the new Fraser River Profile from the Fraser Basin Council and Province. The work was done with a limited hydraulic/mapping study. Some additional modelling and mapping was initiated on the Alouette River in 2009, but data and budget limitations restricted the project outputs. 	<ul style="list-style-type: none"> Work completed mostly through internal budgets and/or staff time. Hydraulic/mapping study of the Alouette Rivers had a budget of about \$100,000. Some in-kind provisions from BC Hydro. 	No	No	<ul style="list-style-type: none"> DEM and LiDAR available. North Alouette River connected to BC Hydro dam, so data available. However, due to geomorphic and resource issues, the quality of this data is limited. 	<ul style="list-style-type: none"> Potential opportunities may come out of upcoming Integrated Stormwater Management Planning. Lack of governance and provincial oversight related to floodplain mapping made it very difficult to move forward.

Jurisdiction	Description of activities	Costs, collaborators & funders	Incorporates climate change?	Incorporates pop. growth?	Availability of information & data	Opportunities & challenges
RD of Central Kootenay (RDCK)	<ul style="list-style-type: none"> No extensive mapping completed, but newer maps show flood hazard levels on important reservoirs and lakes. Recent mapping project looked at inundated structures, and determined most were built illegally or before building permits were required. Recently a proposal was put forth to four RDs to put an RFP out for floodplain mapping: but it was rejected. 	<ul style="list-style-type: none"> The Columbia Basin Trust tried to help bring four regional districts work together on floodplain mapping and did significant background work. Potential to work with First Nations in the area to share information and resources. 	No	No	<ul style="list-style-type: none"> Minimal information or data available to the regional district. No DEM or LiDAR available. 	<ul style="list-style-type: none"> DEM would help in making decisions regarding sighting buildings near reservoirs, and would also help First Nations with cultural mapping. Local politicians reluctant to perform floodplain mapping, and feel that efforts should be led by the Province. Insufficient funding available. Some reservoir levels controlled in Montana so hard to know what is happening.

Jurisdiction	Description of activities	Costs, collaborators & funders	Incorporates climate change?	Incorporates pop. growth?	Availability of information & data	Opportunities & challenges
District of North Vancouver	<ul style="list-style-type: none"> In 2013, flood hazard area maps were completed that include sea level rise impacts for 2100 and 2200, overland flooding and creek flooding. The 2013 maps also consider debris flows and debris floods. 	<ul style="list-style-type: none"> Total cost was about \$100,000, plus some staff time. Work completed in 50% partnership with the City of North Vancouver. Have attended regional group meetings, and are sharing information with other local governments. 	Yes	No	<ul style="list-style-type: none"> DEM and LiDAR available. Rainfall gauge information available. Creek flow monitoring stations. 	<ul style="list-style-type: none"> New OCP helped justify floodplain mapping. Many creeks need additional study. Difficult to take action before the floodplain mapping amendments occur and they are no longer only guidelines.

Jurisdiction	Description of activities	Costs, collaborators & funders	Incorporates climate change?	Incorporates pop. growth?	Availability of information & data	Opportunities & challenges
City of Prince George	<ul style="list-style-type: none"> In 2011, floodplain maps were created that identified three different levels of flooding on the Fraser and Nechako River: <ol style="list-style-type: none"> 1:200 year severe flood hazard area (i.e., area with >1m of water) and flood construction levels. 1:20 year flooding. 1:300 year flooding. 	<ul style="list-style-type: none"> Total costs of flood investigations was about \$500,000, but just the mapping would have been about \$150,000. Mapping half funded by EMBC, and half internal budgets. The internal funds were largely diverted from infrastructure planning budgets. 	Yes	No	<ul style="list-style-type: none"> DEM and LiDAR available. Several gages run by Water Survey of Canada provide upstream and downstream information on both major rivers. 	<ul style="list-style-type: none"> As a result of the flooding events from 2007-2008 (particularly the ice jam) the city was able to get a large amount of flood-related investigation and mapping completed. Very hard to persuade people that dredging is not an effective solution to flooding; this is a persistent challenge in Prince George. Without the emergencies, the funding would not have come available and the political support probably would not have been present to undertake mapping.

Jurisdiction	Description of activities	Costs, collaborators & funders	Incorporates climate change?	Incorporates pop. growth?	Availability of information & data	Opportunities & challenges
City of Vancouver	<ul style="list-style-type: none"> In process of creating flood hazard maps that incorporate multiple sea level rise and storm surge scenarios (10,000 and 500 year return periods). Maps will show flood extent, depth and velocity, and flood construction levels will be recommended. 	<ul style="list-style-type: none"> Mapping cost about \$400,000, and ongoing decision-making and risk analyses work will cost more. Funded by Gas Tax and NRCan, and matched internally. Have attended regional flooding meetings, and are communicating actively with other local governments. 	Yes	Yes	<ul style="list-style-type: none"> DEM data available. Some hydrometric information available from Port Metro Vancouver. The city put out its own wave buoys. 	<ul style="list-style-type: none"> Two external funding opportunities came available to spur action, but had to prove the business case to get matching internal funding. When council approved the adaptation strategy it brought support for this work. Collaborating with localities in region, working groups and UBC has been helpful. Project has taken a lot of time: ongoing project management is significant. Very hard to know best method or approach before the release of formal guidelines.

Acronyms used in the appendix:

DEM – digital elevation model: A file with terrain elevations recorded for the intersection of a fine- grained grid and organized by quadrangle as the digital equivalent of the elevation data on a topographic base map.

DFO – Department of Fisheries and Oceans.

EMBC – Emergency Management BC.

LiDAR – Light Detection and Ranging: a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light.

NRCan – Natural Resources Canada.

OCP – official community plan.

SCADA – supervisory control and data acquisition: monitoring and controlling industrial and manufacturing processes and facilities.

WSC – Water Survey of Canada.