Institute for Catastrophic Loss Reduction
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Best practices for reducing the risk of future damage to homes from riverine and urban flooding

A report on recovery and rebuilding in southern Alberta

By Paul Kovacs and Dan Sandink

September 2013

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ICLR's mission is to reduce the loss of life and property caused by severe weather and earthquakes through the identification and support of sustained actions that improve society's capacity to adapt to, anticipate, mitigate, withstand and recover from natural disasters. ICLR is achieving its mission through the development and implementation of its programs *Open for Business,* to increase the disaster resilience of small businesses, *Designed for safer living*, which increases the disaster resilience of homes, and *RSVP cities*, to increase the disaster resilience of communities.

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Issue

Flooding in southern Alberta in June 2013 resulted in four fatalities and unprecedented damage to property. Premier Alison Redford met in late July with the Insurance Bureau of Canada and a number of insurance industry CEOs to discuss recovery and rebuilding. The Bureau asked the Institute for Catastrophic Loss Reduction in August to prepare this report on actions the Government of Alberta could take to reduce the risk of flood damage to homes in the province.

The tragic losses in southern Alberta have opened a window of opportunity over the next 12 to 24 months for the Government of Alberta and other stakeholders to take action to reduce the risk of loss from flooding, tornadoes, wildfires and other perils. The Institute's research program on best practices for reducing the risk of loss from natural hazards demonstrates that most disaster damage can be prevented through the application of existing and emerging knowledge about building disaster resilient communities. This paper sets out 12 recommendations on actions the Government of Alberta can take to reduce the risk of flood damage to homes.

Recommendations

Reducing the risk of riverine flood damage

1 Implement the recommendations of the Groeneveld Report on the 2005 Alberta flood. These would include a commitment from the Government of Alberta for additional resources for mapping and communicating flood risk, prohibiting the sale of crown lands in designated floodplains, and other actions to reduce the risk of flood damage.

2 Eliminate flood damage to homes in the floodway, the zone of highest risk of flooding. Prohibit new development in the floodway. Also develop a commitment in terms of structural investments in flood defence or an offer to purchase land and property from homeowners that were allowed in the past to locate in the floodway.

3 Owners of homes in the floodway destroyed in the recent flooding should strongly be encouraged not to rebuild, and should be provided compensation for the building and purchase of the land so it can be converted to use not vulnerable to flood damage. Owners that choose to rebuild in the designated floodway should not qualify for future disaster assistance.

4 Revisit Alberta's 100-year design flood criteria to consider increased protection beyond the floodway like British Columbia's 200-year standard, Saskatchewan's 500-year standard and Manitoba's decision to defend Winnipeg from the 700-year flood.

5 Actively communicate the danger of flood damage to homes in or near the flood fringe, recognizing that flood proofing reduces the cost of recovery from flooding but does not prevent the risk of flood damage.

6 Consider requiring additional flood proofing actions for homes located in areas at risk of flooding including raising the lowest-floor elevation of buildings above the flood elevation with an acceptable safety factor, prohibiting basements where there is a risk of flooding, and prohibiting use of basements for living space.

Reducing the risk of urban flood damage

7 Create a provincial urban flood damage reduction strategy. This strategy should build on existing guidance for stormwater and sanitary sewage management, and should complement actions to reduce riverine flood damage.

8 Develop a provincial strategy for replacing all combined sewer systems with independent sanitary and storm sewers. The strategy should establish a timeframe for completion and clarify funding options for municipal governments.

9 Consider increasing expectations for municipal stormwater management systems to focus on the 10-year storm for the minor system. New standards should include a margin for uncertainty about current and future precipitation for both the minor and major systems, in part due to the impact of climate change on frequency and severity of extreme rainfall events.

10 Revise the Alberta Building Code to reduce the risk of urban flood damage. The Code should remove any ambiguity that new homes should include backwater valves. The revsions should also specify that roof leaders should not be connected to the sewer system and weeping tiles should not be connected to the sanitary sewer system. Further, the Code should prohibit reverse sloped driveways and include other actions to reduce the risk of urban flood damage.

11 Alberta should work with municipal governments and other stakeholders, including the insurance industry, to promote actions that reduce the risk of urban flooding for existing homes. This may include by-laws, regulations and financial incentives to install backwater valves, disconnect roof leaders, disconnect weeping tiles and ensure lot grading that directs stormwater safely away from buildings.

12 Municipal officials responsible for urban flooding, the province, and other stakeholders, like insurance companies, do not presently have the information required to effectively manage and reduce the risk of urban flooding. The Province should require local governments to create and disclose information about the state of the sanitary sewer and stormwater systems, and about the state of the of the major storm water management system. The Province should work with local governments to prepare and make available a lot-by-lot database on actions implemented by homeowners that affect the risk of urban flood damage, such as the disconnection of roof leaders and weeping tiles from the sanitary sewer system.

Most of the damage from flooding and other natural perils is preventable through the application of existing and emerging knowledge.

1. Introduction

There have been six disasters in Canada since 2005 that resulted in more than one billion dollars in economic losses. Four of these large disasters were in Alberta – the 2005 flooding in the province, the 2010 storm in Calgary, the 2011 wildfire in Slave Lake, and the 2013 flood. Damage from the 2013 flood was the largest disaster loss ever recorded in western Canada.

In June, southern Alberta experienced extensive loss and damage from riverine flooding. More than 250 mm of rain fell over a 36 hour period in the foothills west and south-west of Calgary and began rapidly flowing east through the province's river valleys bringing destruction across southern Alberta. This was the largest riverine flood damage ever in Canada. These storms also brought heavy rains, exceeding 50 mm, in many urban centres across southern Alberta, overwhelming stormwater and sanitary sewer systems. Urban flood losses, including damage from water and sewage that entered homes and businesses through the backup of municipal sewers, were extensive, approaching $1 billion. Actions to prevent or reduce the risk of flood damage in the province should include actions to address both riverine and urban flooding.

Riverine floods are the most common natural hazard experienced by Canadians. The Canadian Disaster Database, for example, identifies 62 floods in Canada during the ten-year period from 2003 through 2012, resulting in **$1½ billion in riverine flood damage**. This includes five floods in Alberta accounting for flood damage as great as the combined losses in the rest of Canada. Riverine flood damage from the 2013 flood in southern Alberta is expected to exceed the losses from all of the flood events in Canada over the previous ten years.

In the 1960s and 1970s few Canadians experienced damage from urban flooding. However, over the past few decades there has been an alarming increase in urban flood losses. Indeed, water damage from sewers backing up into basements and other osses due to extreme rainfall in urban areas likely resulted in more than **$20 billion in urban flood damage** over the ten year period between 2003 and 2012, including $3 to 5 billion in Alberta. Most years, recent urban flood losses have been more than ten times greater than riverine flood damage.

Best practices to prevent and reduce the risk of loss from riverine flooding are well known, and have been tested around the world for several decades. Prohibition of development in zones of flood risk, investments in structural flood defence and a variety of other tools are available to eliminate or reduce the expected loss from riverine flooding. The foundation for riverine flood management involves a clear determination of acceptable risk of flood damage.

Best practices for reducing the risk of urban flooding have emerged over the past 25 or 30 years and are distinct from actions to reduce the risk of loss from riverine flooding. The frequency and severity of urban flood damage is determined by factors that include rainfall patterns, lot level actions by property owners and the state of the local sewer infrastructure. Every household connected to the storm or sanitary sewer system is at some risk of loss. Best practices to reduce the risk of urban flood damage include lot level actions by property owners and public investments in sewer systems.

A variety of policy tools should be included in a comprehensive flood management strategy – risk mapping, flood forecasting, land use planning, building codes, defensive infrastructure, public awareness, and a variety of other actions. Best practices find a different balance in the roles for each of these tools when addressing urban flooding and riverine flooding. Moreover, best practices differ when the focus is on new development or on homes that were permitted to locate in zones that are later determined to be at risk of flooding.

2. Managing the risk of loss from natural hazards

Effective disaster management and risk reduction must be based on risk management practices. The risk of loss from natural hazards can not be eliminated, but most future losses can be mitigated or reduced through the application of current and emerging knowledge.

Experience demonstrates that investments in disaster risk reduction are effective, and can result in dramatic savings, providing a return of 400 percent or more on society's investment. For example, the Red River Floodway was opened in 1968 following an investment of $63 million by the Government of Manitoba and the Government of Canada. It provided protection for the 90-year flood risk, and has prevented $32 billion in flood damage for the province. The recent $665 million expansion of the Floodway now provides protection for the 700-year flood, an event that otherwise would cause $12 billion in losses. Investments in disaster risk reduction can significantly reduce or eliminate the cost of recovery and rebuilding following a disaster.

2.1 Managing riverine flooding

The present flood design standard in Alberta is the 100-year flood. A 100-year flood has a one percent probability of being equaled or exceeded in any given year. The province discourages municipalities from permitting new development in the floodway where the risk of flood damage is greatest, and encourages municipalities to require flood proofing for new development in the flood fringe.

The government could eliminate the risk of flood damage in the floodway by prohibiting new development and taking aggressive action to protect or remove existing structures that were permitted in the past to locate in the floodplain.[1]

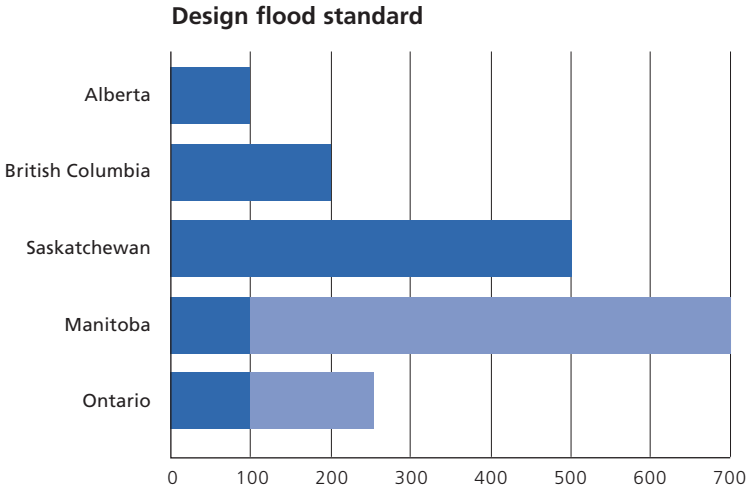
The government could reduce the risk of future loss outside of the floodway through more aggressive management of riverine flood risk. Alberta, for example, defines the flood fringe as lower risk areas in the designated 100-year flood hazard area outside of the floodway. Other provinces have adopted higher standards. Saskatchewan has adopted a 500-year design standard, and Manitoba has chosen to invest in structural flood defence that provides protection for Winnipeg from the 700-year flood.

As a starting point, the government should adopt the recommendations of the Groeneveld Report on the 2005 Alberta flood. In particular, analysis and disclosure of the risk of flooding is an essential foundation for riverine flood management. Flood maps should be completed for all of the 66 communities across Alberta identified in the 1989 Flood Damage Reduction Program agreement with the Government of Canada. Moreover, the government must commit to regularly update existing flood maps so they reflect current knowledge about development and hydrology.

The tragic loss caused by the 2013 flooding provides an opportunity for Alberta to revisit its commitment to flood risk management to consider a higher standard of protection for Albertans.

[1] Appendix 1 includes a definition of terms used in this report like 'design flood', 'floodway' and 'flood fringe'.

2.2 Comparison with other provinces



The design flood in Alberta is lower than the standard in British Columbia, Saskatchewan, Manitoba and Ontario. The design standard in Alberta is the 100-year flood, a flood with a one percent chance of occurring each year. The design standard in British Columbia is the 200-year flood, plus a margin for uncertainty. Most of the heavily populated regions of Ontario use the historic flooding from Hurricane Hazel as the design standard, effectively a 250-year return period, while the standard for other regions include the historic Timmins flood or a minimum 100-year return period. Saskatchewan has adopted a 500-year return period, plus a margin for uncertainty. Manitoba uses a minimum 100-year design standard but has invested in structural defence in some regions to achieve a much higher level of protection, including the recent expansion of the Red River Floodway to protect Winnipeg from the 700-year flood.

2.3 Managing urban flooding

Stormwater management in Alberta is based on a minor and a major system. Rain water from events that are likely to occur every five years or more frequently, should be carried safely by the minor system of storm sewers and other municipal infrastructure without risk of urban flooding. The major stormwater management system is designed to manage the rainfall from large storms, up to the 100-year storm, through municipal infrastructure but also over private and public property without causing damage to homes, buildings or infrastructure. The risk of urban flooding is distinct from the riverine flood hazard.

Almost every home located in an urban centre in Alberta is connected to the stormwater and sanitary sewer systems and are at risk of basement flooding. Damage depends on the severity of rainfall, overland stormwater flow conveyance capacity, the state of the sewer infrastructure, and lot level actions by property owners.

Information to manage and reduce the risk of urban flood damage for homeowners across the province requires public information concerning each of the key elements affecting the risk of loss. Accurate knowledge about intensity, duration and frequency of extreme rainfall is needed for each community in the province. Ideally this information would include projections of expected change in precipitation regimes. Detailed knowledge is also needed about the state of municipal storm and sanitary sewer systems across the province. In addition, the risk of urban flooding depends on actions taken by property owners, like disconnection of downspouts, installing a backwater valve and other lot level actions. Municipal officials responsible for urban flooding, the province, and other stakeholders, like insurance companies, do not presently have the information required to effectively manage and reduce the risk of urban flooding.

3. Reducing the risk of loss from riverine flooding

Flooding can damage property and, in extreme events, result in loss of life. The Government of Canada's Disaster Database reports that flooding is the most common hazard in Canada that results in economic damage. The Database identifies 62 flood events across the country over the ten year period between 2003 and 2012, resulting in losses of $1½ billion. Losses from the 2013 southern Alberta floods will be much larger.

3.1 The floodway

There is a risk in the floodway of catastrophic damage from flooding. There is a one percent chance each year that swift moving water more than one metre in depth will enter the floodway and destroy structures in its way. This watercourse must be reserved as a channel for the river to flow. New construction and development should not be permitted in the floodway. The risk of loss from flooding should be viewed as unacceptable. Safe use of this land is for purposes that do not create or enhance flood risk--not for homes, businesses and locating essential infrastructure. Alberta should require that no future development be permitted in the floodway in every municipality in the province.

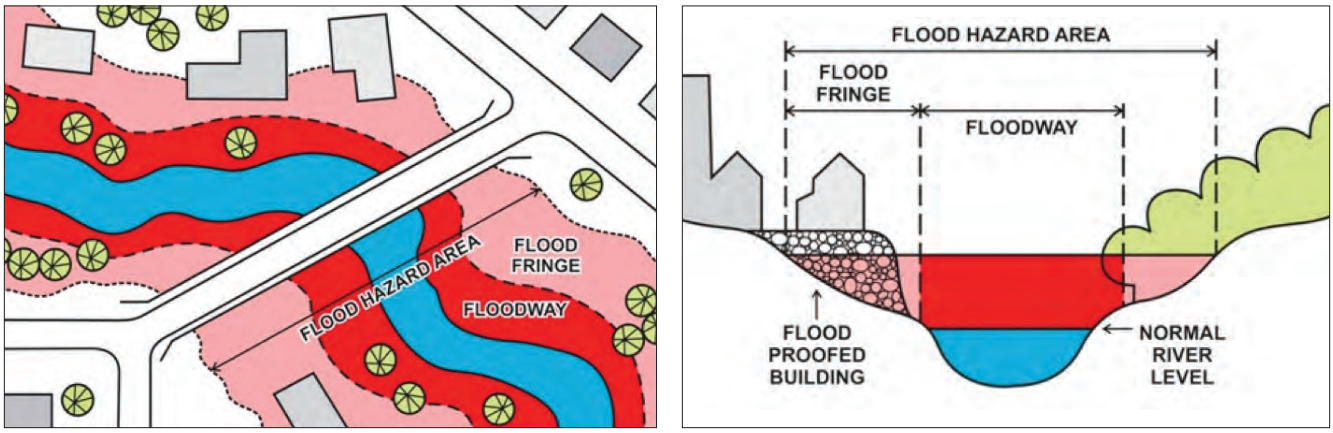
The risk of loss and damage to homes and businesses in the floodway could be reduced through investments in structural protection, including dikes, levees and dams, in combination with prohbiting future development. The risk of loss could be eliminated if properties located in the floodway are purchased by the government and used for recreation. These options are expensive but are required if the risk of flood loss and damage is to be reduced to acceptable levels. Consultation with residents and rigorous economic analysis is required to determine the best policy for a specific property at risk. Consultation is also required to determine the cost that should be borne by the Government of Alberta or shared with local governments and property owners. It should not be acceptable to leave properties in locations where the risk of loss has been determined to be unacceptable without a commitment and plan of action to reduce, eliminate or significantly reduce the risk over a reasonable period of time.

A special circumstance involves properties that were recently destroyed by flooding in southern Alberta. It is important to provide property owners with the option of not rebuilding in harm's way, likely including an offer from the Government of Alberta and the local government to purchase the land so they can prohibit future development. If the property owner chooses to rebuild in the floodway then the owner should expect a number of conditions, including a requirement to include flood proofing features and exclusion from future flood damage compensation. Just as new development should not be permitted in the floodway, homeowners should strongly be discouraged from rebuilding in designated zones of unacceptable risk.

3.2 The flood fringe

The risk of flood damage is high in the flood fringe but lower than in the floodway. The Government of Alberta presently encourages local governments to require flood proofing when development is permitted in the flood fringe. In many cases, development adjacent to the flood fringe is also exposed to significant flood risk. It is important that properties be flood proofed in a manner that reflects their risk of flooding, regardless of their location in areas currently defined as floodway or flood fringe.

Figure 1: Floodway and flood fringe areas as defined by the Government of Alberta



Source: Government of Alberta, 2013 (http://environment.alberta.ca/01655.html)

Structural measures can reduce the risk of flood damage in floodplains. Dams, berms, dykes and other flood defence infrastructure can be built by local governments, the province or private property owners. These measures, however, do not preclude the need for additional protection through property-level flood proofing when homes and properties are located in areas exposed to flood risk.

The Alberta Building Code and local bylaws about construction practices can reduce the risk of future riverine flood loss and damage. Once the risk of flooding in the flood fringe has been appropriately identified, including both the probability of flooding and the exposure of homes and infrastructure to flood, there are several options that may be applied to reduce the risk of flood damage.

3.3 Protecting homes in and near the flood fringe

The most effective means of reducing flood risk in the floodplain is to prohibit development and rebuilding in these areas. For homes allowed in flood risk areas there are measures at the property level that can reduce the damage from future flooding. Homeowners will need appropriate risk information as well as expert/professional advice on how to appropriately protect individual properties from flooding.

As of August 15, 2013, Government of Alberta minimum requirements for homes in defined flood fringe areas included:

- Providing a safe means to de-energize and re-energize buildings during and shortly after a flood;
- Minimization of moisture damage to basements through use of building materials that better facilitate disposal after a flood, selecting materials to increase the flood resilience of basements, or through choosing not to refinish basements;
- Sealing of utilities penetrations in basement walls, and possibly sealing of other flood entry-points in specific circumstances (e.g., windows), and;
- Protection of homes from backflow from public sewers.

The first and most important step in identifying appropriate measures to protect properties in areas exposed to flooding is to accurately define flood risk areas. Once these areas have been appropriately defined, property level flood proofing measures can be considered. To reduce the damage to homes from riverine flooding:

- The government should strongly encourage or require homeowners to move out of areas exposed to flood hazards.
- Where the government deems it acceptable to allow homes to stay in **areas exposed to flood risk**, the risk of flood damage will be reduced if lowest-floor elevation of buildings is raised above the flood elevation, plus an acceptable safety factor (for example, a freeboard of 0.6 metres).
- Where homes are allowed to stay in **areas exposed to low flood risk**, the risk of floodwater ingress into buildings should be reduced in combination with addressing the effects of hydrostatic pressure on buildings and foundations. Homes that have been protected from water ingress are at risk of structural damage as a result of hydrostatic pressure and buoyancy forces exerted on walls, foundations and basement floors. These forces are particularly severe in homes with basements, so basements should be eliminated where possible, and not used as living space.
- Households allowed to stay in **areas exposed to extremely low flood risk** should be prohibited from using their basements as living spaces, regardless of the flood resilience of materials that are used to finish basements. Homeowners should also be discouraged from using basements as storage areas for items that are vulnerable to flood damage. As part of this recommendation, utilities in basements, including electrical utilities, furnaces, water heaters and the like, should be raised above flood elevations, protected-in-place against floodwaters (for example, through use of interior floodwalls) or moved to a location in the building that is above the defined flood elevation in the floodplain.
- All homeowners with properties vulnerable to riverine flooding should be encouraged or required to adopt flood proofing measures, even those beyond the currently defined flood fringe. Flood proofing assistance and recommendations should be provided to all homeowners who are at risk, regardless of whether they experienced damage in the 2013 southern Alberta floods or made a claim to provincial disaster financial assistance programs.
- Future homebuyers and tenants should be notified that homes are located in flood risk areas and the specific mitigation measures that have been incorporated.

Appendix 3 provides a more detailed summary of property-level actions that can be taken, beyond the minimum requirements announced by the government. This is not a comprehensive/inclusive list of floodproofing measures for homes exposed to flood risk. Property owners will need the assistance of relevant authorities (e.g., professional engineers) to identify and engage in appropriate flood proofing measures, and appropriate measures must be based on accurately assessed flood risk. Most importantly, homeowners need to understand that homes in areas exposed to flood risk should expect to experience flooding and flood damage, as investments in flood proofing serve to reduce but not prevent future losses.

4. Reducing the risk of loss from urban flooding

Thousands of Albertans have experienced basement flooding. Almost any structure located in urban areas is at some risk of experiencing damages from extreme precipitation and sewer backup. Much of the damage from urban flooding can be prevented.

No national data are available tracking damage from urban flooding. The Insurance Bureau of Canada estimates that insurance companies pay $1.7 billion a year in water damage claims across Canada resulting from urban flooding and sewer backup. If 85 percent of homeowners have water damage insurance coverage then the annual losses experienced by homeowners would be $1.7 billion for those with insurance and an estimated $0.3 billion for those who are without insurance. In addition, municipal governments pay for repairs to public infrastructure destroyed by extreme rainfall events and may pay for basement flood damage for some homes without insurance. Insurance companies and local governments have reported a significant increase in urban flood damage costs over the past thirty or forty years. Urban flood damage in Canada over the past decade was likely in excess of $20 billion, perhaps including $3 to $5 billion in Alberta.

Reduction of the risk of basement flooding requires investments in municipal stormwater and sanitary sewer infrastructure to rebuild the capacity of these aging systems to that evident in the 1970s and 1980s. Detailed engineering analysis is required to identify the specific investments needed.

Alberta presently requires independent connections for new homes to sanitary sewer and stormwater systems. Independent sanitary and stormwater management has been best practice in Alberta for more than 50 years. Nevertheless, an estimated 20 percent of the homes in the province were built before 1960, and most are likely connected to combined sewer systems. Sewers that combine sanitary waste with stormwater are at risk of urban flooding through sewer backup. Combined systems are also designed to discharge waste into waterways during extreme rainfall events, a national environmental concern. Edmonton has stated its intention to opportunistically replace combined sewer systems when major sewer work is required, an approach that is likely followed by local governments across the province. British Columbia requires that local governments must replace all combined sewer systems by 2050.

Reduction of the risk of basement flooding also requires action by property owners. The Institute for Catastrophic Loss Reduction is the leading organization in Canada documenting best practices for homeowner participation in reducing the risk of basement flooding. Lot grading to encourage water flow away from buildings, installation of backwater valves to prevent sewers from backing up, and disconnection of weeping tiles from sanitary connections are three actions that can and should be

taken by homeowners. These protective actions take place on the homeowners' property and can be encouraged by government but are the responsibility of property owners. There are a number of actions that provincial and municipal governments can take to encourage loss prevention and reduction actions by property owners. For example, Edmonton provides a financial subsidy for homeowners that install a backwater valve.

The Institute for Catastrophic Loss Reduction has published detailed research and guidelines for encouraging homeowner participation. Publications, tips and videos can be found at www.BasementFloodReduction.com. A comprehensive strategy for reducing the risk of basement flooding requires a combination of public investments in municipal infrastructure and action by property owners. The Government of Alberta has prepared guides for municipalities on stormwater management and treatment of municipal waste. These are particularly helpful for new development. The government is encouraged to also prepare an urban flood damage reduction strategy. The strategy should set out the province's expectations with respect to documenting the state of the current storm water and sanitary sewer systems, a commitment to infrastructure renewal and maintenance, and clarify the funds available to improve infrastrcuture. The strategy should also clarify the importance of reforming the Alberta Building Code to remove ambiguity about backwater valves and other actions to reduce the risk of water damage in new homes, and support or require municipal actions to encourage existing homeowners to maintain appropriate lot grading, disconnect roof leaders, disconnect weeping tiles, install backwater valves and other actions to reduce the risk of urban flood losses.

Most homes in urban Alberta are vulnerable to the risk of basement flooding. Most years urban flood damage in Alberta is significantly higher than riverine flood losses. Actions to support recovery and rebuilding following the 2013 flooding in southern Alberta provide an opportunity for actions to reduce the risk of urban flood damage across the province. Appendix 2 identifies specific lot-level actions the Government of Alberta and local governments can recommend that homeowners take to reduce the risk of urban flood damage. Other stakeholders, including the insurance industry, have knowledge and information that could contribute to preparation and implementation of an urban flood reduction strategy.

5 Conclusions and recommendations

The 2013 flooding in southern Alberta was the largest loss event ever experienced in Alberta. Recovery and rebuilding provides a unique opportunity to create a province that is more resilient to natural disasters. In particular, these floods provide an opportunity for the Government to revisit its views about acceptable risk of loss from future urban and riverine flooding. The literature on disaster management finds that there will likely be a 12 to 24 month window when there will be strong public interest in and support for actions by the Government of Alberta and other stakeholders to invest in actions to reduce the risk of loss from flooding and other hazards.

Some families live in the floodway and flood fringe. The southern Alberta flooding in 2013 demonstrated that riverine flooding can result in death, injury and catastrophic damage to property. The process of recovery and rebuilding provides an opportunity for the government to consider a new approach to managing riverine flooding. The province needs to complete and update its mapping of flood risk, consider expanding its definition of the design flood, prohibit development in the floodway, invest in structural measures to defend homes that were allowed in the floodplain, and consider purchasing homes destroyed by the recent flooding so this land is used for recreation. Where homes are allowed to stay in the flood fringe this report identifies actions, beyond the minimums announced by the government, to reduce the damage to homes in the fringe and elsewhere outside of the floodway when they experience flooding in the future.

Most households in Alberta are at risk of urban flooding. Losses from urban flooding have been growing across the province for several decades. Thousands of homes experienced basement flooding during the June flooding when municipal infrastructure was overwhelmed. These losses are largely preventable. The province should create an urban flood damage reduction strategy setting out a plan for investing in storm water and sanitary sewer infrastructure, and for promoting homeowner participation in reducing the risk of loss in urban centres across the province. The Institute for Catastrophic Loss Reduction can be a partner in the identification of best practices for lot level action by homeowners.

Reducing the risk of flood damage requires actions by the Government of Alberta, local governments, property owners and other stakeholders. Below are 12 recommendations for the Government of Alberta to reduce the risk of flood damage:

1 Implement the recommendations of the Groeneveld Report on the 2005 Alberta flood. These would include a commitment from the Government of Alberta for additional resources for mapping and communicating flood risk, prohibiting the sale of crown lands in designated floodplains, and other actions to reduce the risk of flood damage.

2 Eliminate flood damage to homes in the floodway, the zone of highest risk of flooding. Prohibit new development in the floodway. Also develop a commitment in terms of structural investments in flood defence or an offer to purchase land and property from homeowners that were allowed in the past to locate in the floodway.

3 Owners of homes in the floodway destroyed in the recent flooding should strongly be encouraged not to rebuild, and should be provided compensation for the building and purchase of the land so it can be converted to use not vulnerable to flood damage. Owners that choose to rebuild in the designated floodway should not qualify for future disaster assistance.

4 Revisit Alberta's 100-year design flood criteria to consider increased protection beyond the floodway like British Columbia's 200-year standard, Saskatchewan's 500-year standard and Manitoba's decision to defend Winnipeg from the 700-year flood.

5 Actively communicate the danger of flood damage to homes in or near the flood fringe, recognizing that flood proofing reduces the cost of recovery from flooding but does not prevent the risk of flood damage.

6 Consider requiring additional flood proofing actions for homes located in areas at risk of flooding including raising the lowest-floor elevation of buildings above the flood elevation with an acceptable safety factor, prohibiting basements where there is a risk of flooding, and prohibiting use of basements for living space.

7 Create a provincial urban flood damage reduction strategy. This strategy should build on existing guidance for stormwater and sanitary sewage management, and should complement actions to reduce riverine flood damage.

8 Develop a provincial strategy for replacing all combined sewer systems with independent sanitary and storm sewers. The strategy should establish a timeframe for completion and clarify funding options for municipal governments.

9 Consider increasing expectations for municipal stormwater management systems to focus on the 10-year storm for the minor system. New standards should include a margin for uncertainty about current and future precipitation for both the minor and major systems, in part due to the impact of climate change on frequency and severity of extreme rainfall events.

10 Revise the Alberta Building Code to reduce the risk of urban flood damage. The Code should remove any ambiguity that new homes should include backwater valves. The revsions should also specify that roof leaders should not be connected to the sewer system and weeping tiles should not be connected to the sanitary sewer system. Further, the Code should prohibit reverse sloped driveways and include other actions to reduce the risk of urban flood damage.

11 Alberta should work with municipal governments and other stakeholders, including the insurance industry, to promote actions that reduce the risk of urban flooding for existing homes. This may include by-laws, regulations and financial incentives to install backwater valves, disconnect roof leaders, disconnect weeping tiles and ensure lot grading that directs stormwater safely away from buildings.

12 Municipal officials responsible for urban flooding, the province, and other stakeholders, like insurance companies, do not presently have the information required to effectively manage and reduce the risk of urban flooding. The Province should require local governments to create and disclose information about the state of the sanitary sewer and stormwater systems, and about the state of the of the major storm water management system. The Province should work with local governments to prepare and make available a lot-by-lot database on actions implemented by homeowners that affect the risk of urban flood damage, such as the disconnection of roof leaders and weeping tiles from the sanitary sewer system.

Much of the damage from flooding and other natural perils is preventable through the application of existing and emerging knowledge.

Appendix 1: Terminology and definitions used in Alberta

Riverine Flooding (Source: Alberta Environment, Flood Hazard Identification Program Guidelines, July 2011)

Design Flood - The current design standard in Alberta is the 100-year flood, determined when a flood hazard study has been undertaken. A 100-year flood is defined as a flood whose magnitude has a one percent chance of being equalled or exceeded in any year. The design flood can also reflect computed 100-year water level resulting from an ice jam or be based on a historical flood event.

Design Flood Levels - Flood hazard area water elevations computed to result from a design flood under encroachment conditions. Design flood levels do not change as a result of development of obstruction of flows within the flood fringe.

Encroachment Conditions - The flood hazard design case that assumes a scenario where the flood fringe is fully developed and flood flows are conveyed entirely within the floodway.

Flood Fringe - The portion of the flood hazard area outside of the floodway. Water in the flood fringe is generally shallower and flows more slowly than in the floodway. New development in the flood fringe may be permitted in some communities and should be flood proofed.

Flood Hazard Area - The area affected by the design flood under encroachment conditions. The flood hazard area is typically divided into floodway and flood fringe zones, and may also include areas of overland flow.

Floodway - The portion of the flood hazard area where flows are deepest, fastest and most destructive. The floodway typically includes the main channel of a stream and a portion of the adjacent overbank area. The floodway is required to convey the design flood. New development is discouraged in the floodway and may not be permitted in some communities.

Overland Flow - Areas of overland flow are part of the flood hazard area outside of the floodway, and typically considered special areas of the flood fringe.

Urban Flooding (Sources: Alberta Environmental Protection, Stormwater Management Guidelines for the Province of Alberta, January 1999; Canadian Council of Ministers of the Environment, Canada-wide Strategy for the Management of Municipal Wastewater Effluent, February 2009)

Minor System - Underground sewers, catch basins and other drainage works that convey storm water from minor storms. For most communities in Alberta a storm with a return period of 5 years or less would be considered a minor storm and should not result in loss or damage. Some have proposed raising the standard for a minor storm in Alberta to a 10-year event.

Major System - The drainage system in place to convey stormwater from major storms. This includes municipal infrastructure but is largely dependent on managing flows across private and public property through lot grading, roadways and storage facilities. For new development in Alberta, the major system is to manage a 100-year storm without causing unacceptable downstream impacts. Surcharge in the sewer system during a 100-year storm should not exceed basement levels. Many existing homes do not have this level of protection.

Master Drainage Plan – Municipal and regional plans to ensure development of the optimal drainage system to meet present and future storm water drainage requirements.

Sewer Backup – Sewers flowing in a surcharged condition can result in the backup of water with the potential to cause basement flooding and structural damage. This risk is increased when weeping tiles and roof leaders are connected to the sewer system.

Impervious Ground Cover – Forests, grasslands, and waterways have been extensively replaced in urban centres by paved roads, rooftops, parking and other impervious surfaces unable to absorb rainfall.

Lot Grading – The grade adjacent to new buildings should be sufficient to allow for settlement of the fill and maintenance of positive drainage away from the structure.

Roof Leaders – The most common means of roof drainage is through the use of roof leaders to ground that is graded away from buildings onto grass surfaces. Some communities discourage or prohibit the connection of roof leaders directly to the sewer system, because the direct connect of roof leads has the potential to significantly increase the water flow in the minor system during major storm events, increasing the risk of basement flooding and other urban flood damage.

Backwater Valves – A backwater valve is a backflow prevention valve that prevents sewage from backing up into property through the sewer lateral.

Combined Sewer – A sewer intended to receive both stormwater and wastewater.

Sanitary Sewer – A sewer intended to receive wastewater.

Storm Water Sewer – A sewer intended to receive only stormwater.

Sanitary Sewer Overflow – A discharge to the environment from a sanitary sewer system.

Combined Sewer Overflow – A discharge to the environment from a combined sewer system.

Appendix 2: Lot-level urban flood risk reduction measures

Measures to reduce the risk of urban and infrastructure-related flooding at the household level include:

- Homeowner communication about flood coverage with insurance providers.
- Contacting municipal authorities to report historical basement flood events and to seek appropriate advice on risk reduction.
- Lot grading to direct surface drainage away from foundations, footings and backfill zones.
- Ensuring maintenance of stormwater conveyance features on lots, including swales and catch basins.
- Use of window wells and window well covers to accommodate appropriate lot grading.
- Prohibiting the building of reverse slope driveways.
- Removal of below-grade openings, including below-grade basement windows, below-grade basement access/doorways and reverse slope driveways, where possible.
- Capping of backfill areas with clay/impermeable cover.
- Sealing utilities penetrations in walls and foundations.
- Avoiding storing items directly on basement floors.
- Avoiding finishing basements or using basements as living spaces.
- Maintenance and repair of sanitary and storm sewer connections.
- Disconnection of downspouts from public sewer systems.
- Extending downspouts beyond the foundation backfill area and using splash pads at downspout discharge points.
- Protection of homes from public, sanitary sewer system backflow, including
  - Installation of backwater valves on fixtures below the adjoining street level or on the main sewer connection, in combination with the disconnection of foundation drainage and/or downspouts from sanitary sewer connections.
- Protection of homes from public, storm sewer system backflow, including:
  - Reducing risk of backflow into foundation drainage through the use of backwater valves on storm sewer connections, or by pumping of foundation drainage to grade or exterior grade-level standpipe that drains into storm sewer.
- Proper sump pump capacity and backup systems, including:
  - Provision of backup power for the sump pump and the provision of backup/emergency sump pumps to protect the home in the event of primary pump failure or power failure.

Homes without basements but with fixtures below the nearest upstream manhole cover are also vulnerable to flooding from public sewer infrastructure.

APPENDIX 3: Property-level flood fringe flood proofing measures

Below is a high-level summary of measures recommended by authorities in Ontario, Manitoba, British Columbia and the US Federal Emergency Management Agency (FEMA). Because individual homes in flood risk areas experience different levels of vulnerability and exposure to flooding, flood mitigation measures must reflect the characteristics
of individual homes, lots and neighbourhoods. Further, flood proofing measures must reflect accurately assessed flood risk for properties. In the majority of cases, effective property-level flood mitigation requires the council of relevant professionals, including professional engineers.

For buildings that have been damaged but will not have to be completely rebuilt:

The primary recommendation is that individuals located in high flood risk areas, regardless of whether these areas are currently identified as floodway or flood fringe areas, be strongly encouraged or required to relocate away from areas at risk of flooding. Alternatively, lowest floor elevations should be raised above an acceptable design flood elevation, plus an applicable freeboard (for example, 0.6 m) in areas of lower risk. The lowest floor of a home may include the basement floor.

In flood hazard areas that have a very low risk of experiencing flooding:

- Basements of homes should not be used as living spaces or storage areas for items that are vulnerable to flood damage, regardless of the materials selected for refinishing.
- Home utilities, including furnaces, electrical services and water, should be moved above the flood elevation plus 0.6 m freeboard, or should be protected-in-place. Exterior utilities, for example external central air conditioning condensers, may also have to be raised above flood elevations.

Reducing the risk of water ingress ("dry flood proofing") may be an option for some homes that are exposed to extremely low flood risk in flood hazard areas.* These measures may include, but are not limited to:

- Sealing of cracks in basement floors and foundation walls to reduce the risk of water ingress.
- Sealing utilities penetrations in foundation walls.
- Protecting exterior walls with waterproof coatings and membranes, application of masonry or concrete, among other measures.
- Eliminating or sealing windows and doors that are close-to-grade or below the flood elevation, and/or equipping windows and doors with flood shields.
- Eliminating below-grade openings (for example, reverse slope driveways, sunken basement doors and below-grade windows).

*Considerations for dry flood proofing in floodplains:

- Dry flood proofing will not prevent basements from experiencing hydrostatic and buoyancy forces, and should not be used for homes with basements.
- Homes that have been dry flood proofed may experience significant hydrostatic

pressures in deeper floodwaters, which may cause significant structural damage, even if the homes do not have basements. If dry flood proofed homes in the flood fringe experience floodwaters greater than 0.6 to 1 m in depth, the dry flood proofed homes may experience structural damages that may not have occurred if floodwaters were allowed to safely enter and exist the home (an approach referred to as "wet flood proofing").

- Dry flood proofing measures may not be adequate to protect homes from long-duration flooding events (e.g., if flood duration exceeds 24 hours).
- Sealants and shields require on-going maintenance.
- Installation of removable flood shields requires homeowners to be present shortly before flood events occur.

It is important that homes in areas exposed to riverine flood risk are also protected from urban and infrastructure-related flood risk. Several of these measures are outlined in Appendix 2.

In areas of extremely low flood risk, basements may be included in the homes. Appropriate foundation drainage should be incorporated into the building to help relieve groundwater/hydrostatic pressure on foundation walls. Foundation drainage should be pumped to the surface, and must ensure:

- Appropriate sump pump capacity.
- The provision of backup power for the sump pump and the provision of backup/emergency sump pumps to protect the home in the event of primary pump failure or power failure.
- The sump pump should be serviced by its own outlet and circuit breaker.
- The pump outlet should be located to discharge above the flood elevation, outside of the home.
- Where sump drainage to surface is not possible, the pump discharge may be connected to public storm sewer provided that appropriate backflow protection is provided. Backflow protection for foundation drainage may include use of a backwater valve on the storm connection or pumping of water to an above-grade standpipe that is connected to the municipal storm sewer system. The top of the standpipe should be above the flood elevation plus applicable freeboard.

Additional considerations for reducing risk in the flood fringe:

- Landscaping, including fencing, should not exacerbate flood risk.
- Professionally designed and constructed property-level structural measures (e.g., flood walls, dikes) may also be appropriate in some circumstances.
- Flood risk reduction measures should not increase vulnerability to other local hazards (e.g., high winds).

For homes that experienced significant damage and must be completely rebuilt:

The primary recommendation is that individuals located in high flood risk areas, regardless if these areas are defined as floodway or flood fringe areas, or if they are located outside of flood fringe areas, be strongly encouraged or required to relocate away from areas exposed to flood hazards.

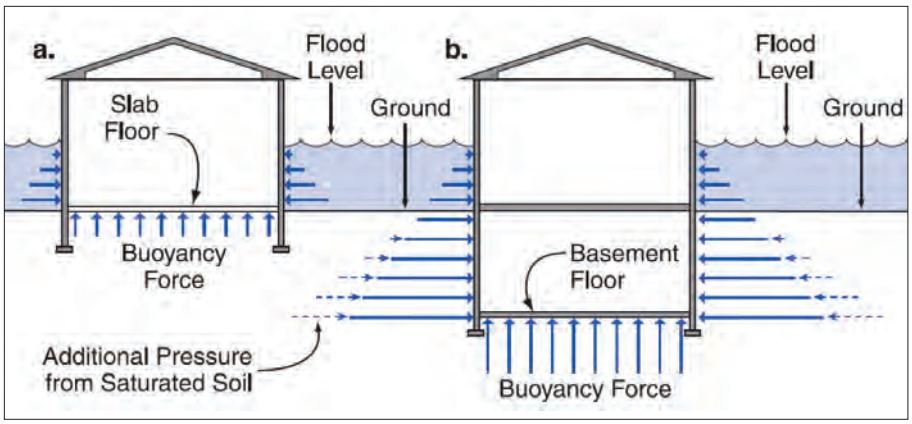
Alternatively, lowest floor elevations should be raised above an acceptable design flood elevation, plus an applicable freeboard (for example, 0.6 m) in areas of lower risk. The lowest floor of a home may include the basement floor. Measures that can be used to raise buildings above the flood elevation include columns, piers, extended foundations, pony walls on existing foundations, fill pads, among other measures.

If buildings are placed on fill pads, the impact of the fill pad on hydraulic parameters of storage, conveyance and water level in the floodplain must be accommodated. Buildings should also be designed to be able to handle additional loads associated with riverine flooding including hydrostatic pressure, hydrodynamic loads and flood borne debris impact, among other risk factors.

Additional considerations for reducing risk in flood risk areas:

- Landscaping, including fencing, should not exacerbate flood risk.
- Lot grading to direct surface drainage away from the home's foundation and foundation footings should be incorporated into properties.
- Flood risk reduction measures should not increase vulnerability to other local hazards (e.g., high winds).
- The risk of infrastructure related flooding in homes without basements is significantly reduced. However, homes with plumbing fixtures below upstream sanitary manhole covers should be protected from backflow from public sewer connections.

Figure 2: Hydrostatic Pressure



Hydrostatic pressure from floodwaters exerts significant forces on homes, and can cause structural damage.

Source: FEMA, 2009

Figure 3: The Potential impacts of hydrostatic pressure

Hydrostatic pressure from floodwaters exerts significant forces on homes, and can cause structural damage.
Image source: http://continuingeducation.construction.com/crs.php?L=175&C=923

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APPENDIX 4: Actions to reduce the risk of loss from other hazards

Alberta experiences a number of hazards including flooding, summer thunderstorms, wildfire, tornadoes, winter storms, hail and lightning. Actions by the Government of Alberta taken to reduce the risk of future damage to homes in the province due to flooding provide scope to also support risk reduction from other hazards.

Wildfire destroyed one third of Slave Lake in 2011, and represents the greatest hazard in many communities across the province, particularly those located in the north. Alberta-based Partners in Protection developed ***FireSmart*** as the national program to promote actions to reduce the risk of wildfire damage. ***FireSmart*** practices were included in the recovery and rebuilding following the fire in Slave Lake, and could be included in the recovery from the 2013 flood.

The Institute for Catastrophic Loss Reduction is Canada's leader in severe wind research. We have tested homes in our research lab, and completed forensic investigations of damaged structures in the field, to demonstrate actions to reduce the risk of damage from tornadoes. At little or no additional cost during initial construction it is possible to design and build homes that should experience no damage even if struck directly by a minor tornado (magnitude 0, 1 or 2). We have been working with homebuilders in Alberta and elsewhere across Canada to discuss how these ideas could be included in new construction, and have recently made a number of submissions proposing changes to the Building Code.

Beyond an active research program on building design and construction practices to enhance the resilience of new homes to natural hazards, the Institute for Catastrophic Loss Reduction has also prepared a series of brochures providing advice about actions homeowners can take to reduce the risk of damage to existing homes from summer storms, severe wind, winter storms and other perils. This information developed to be used by provincial and local emergency management officials, homeowners, insurance companies and other stakeholders involved in building disaster resilient communities.

The tragic flooding in June provides scope for the Government of Alberta to address the risk of loss from a broad range of natural hazards through its responsibility for emergency management, construction of buildings, and the environment. Actions can include increased public awareness about disaster risk reduction, changes in the Alberta Building Code, and promotion of ***FireSmart***.

About the institute

The Institute for Catastrophic Loss Reduction (ICLR) is a world-class, independent, not-for-profit research institute based at Western University in London, Ontario. Institute staff and research associates are international leaders in wind and seismic engineering, atmospheric science, risk perception, hydrology, economics, geography, health sciences, public policy and a number of other disciplines. Core funding for the Institute is provided by Canada's private insurance companies. The majority of the funds supporting research by the Institute and its research associates is provided by the federal and provincial government agencies that support academic research in Canada.

ICLR is committed to reducing disaster deaths, injuries and property damage through the development of disaster prevention knowledge, and the broad dissemination of its research findings. Moreover, the Institute is working to transfer this emerging scientific knowledge into information available to decision makers to support actions to build resilient communities. This research deals with damage from wind, water, wildfire, earthquake, hail and a range of other hazards.

ICLR, the largest disaster risk reduction institute in Canada, is based at Western University and has access to a team of more than 40 researchers at more than a dozen universities. The Institute has extensive experience working in Alberta, including publishing a case study of lessons learned from the Pine Lake tornado in 2000; conducting disaster home retrofits (in Edmonton on the 20th anniversary of the 1987 Edmonton tornado and in Jasper to promote ***FireSmart***); making frequent interventions to champion ***FireSmart*** as a national strategy for reducing the risk of wildfire damage; working with the City of Calgary and City of Edmonton to promote homeowner actions to prevent basement flooding; conducting meetings with Alberta homebuilders in 2012 to promote construction of homes resilient to damage from basement flooding, tornadoes and wildfire; and currently working on a case study of lessons learned from the Slave Lake wildfire.

Principal researchers

Paul Kovacs, Executive Director, ICLR
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Paul Kovacs is founder and Executive Director of the Institute for Catastrophic Loss Reduction at Western University. Since 1996 Paul has been a contributing author to the Intergovernmental Panel on Climate Change (IPCC), the world's leading forum for the study of climate issues. The Panel won the 2007 Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change". He is Canada's leading authority on insurance and climate change and has been a contributing author to numerous international and Canadian reports on reducing the risk of loss from earthquakes, flood and severe wind. For more than thirty-five years

Paul has been a popular commentator on disaster safety and economic policy. He has written more than 200 publications and articles and he is a passionate champion for insurance, disaster resilience and adaptation to climate extremes. Paul has worked in private industry, the public sector and academia. He is Co-Chair of the Infrastructure and Housing Working Group of Canada's Adaptation Platform. He is Co-Chair of the Science and Technology Working Group of Canada's Platform on Disaster Risk Reduction. Paul is also a member of a number of Boards and Advisory Panels.

Dan Sandink, Manager of Resilient Communities and Research, ICLR
Dan Sandink, Manager of Resilient Communities and Research, joined ICLR in 2006 upon completion of his Masters degree in Geography. Dan is one of Canada's leading authorities on actions to reduce the risk of urban flooding. His research experience includes studies on homeowner perceptions of basement flood damage and risk in Peterborough and London, Ontario, and a comparative study of homeowners' perceptions of sewer backup loss prevention across two major Canadian cities. He is also working to identify best practices for municipalities seeking to promote disaster resilience within the Institute's RSVP for cities program. In 2013, Dan completed a M.Sc. in Planning at the University of Toronto.

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