PREVENTING DISASTER BEFORE IT STRIKES:

DEVELOPING A CANADIAN STANDARD FOR NEW FLOOD-RESILIENT RESIDENTIAL COMMUNITIES

20 BEST PRACTICES

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NATALIA MOUDRAK AND DR. BLAIR FELTMATE | INTACT CENTRE ON CLIMATE ADAPTATION | SEPTEMBER 2017

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The Intact Centre on Climate Adaptation (Intact Centre) is an applied research centre at the University of Waterloo. The Intact Centre was founded in 2015 with a gift from Intact Financial Corporation, Canada's largest property and casualty insurer. The Intact Centre helps homeowners, communities and businesses to reduce risks associated with climate change and extreme weather events. For additional information, visit: www.intactcentreclimateadaptation.ca.

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EXECUTIVE SUMMARY

This report profiles 20 best practices to be incorporated into the design and construction of new flood-resilient residential communities in Canada. Ensuring that new communities are built under the direction of these practices is necessary to combat ever-worsening extreme weather that, if not addressed, will result in costly and unremitting flood damage. Examples of the need to address current and future residential flood damages are many:

- **Financial and Mental Health Stress:** Flooding is the most frequent and costliest natural disaster in Canada. Thousands of homeowners across the country experience property damages, loss of personal belongings, and the consequent financial and emotional distress that follows floods.

- **Insurable Risk:** In communities across Canada that experience repeated basement flooding, insurance premiums are increasing in concert with growing flood risk - in cases where risk is excessive, flood insurance coverage may be reduced or withdrawn altogether.

- **Mortgage Defaults:** With limited flood insurance coverage, some homeowners in Canada may not be able to pay for flood damages. Due to limited liquidity to redress flooding, some homeowners may default on their mortgage (as homes with sewer water in the basement are generally uninhabitable).

- **Legal Risks:** Homeowners, developers, municipalities, provinces and insurance companies are increasingly facing lawsuits for flood-related damages.

- **Municipal Credit Ratings:** Credit rating agencies (e.g., DBRS, Moody's and Standard & Poor's) are beginning to examine the potential for communities to be impacted by substantial flood recovery costs which, in turn, could cause a municipality to default on a bond. If the probability of a weather-induced default is material, the municipality may receive a downgraded credit rating.

To address the evolving drivers outlined above, and in an effort to "get ahead of storms," newly built communities in Canada must incorporate best flood risk reduction practices into their design.

Accordingly, the Intact Centre on Climate Adaptation (Intact Centre) engaged with municipal stormwater and flood management experts, engineering consultants, developers, homebuilders and other stakeholders across Canada to identify best practices for flood-resilient residential community design (Table 1).

The Standards Council of Canada supported this effort, with the objective that the report will inform the development of a flood-resilient community design standard for new residential subdivisions in Canada.

FLOOD-RESILIENT COMMUNITY DESIGN: INTRODUCING BEST PRACTICES

The scope of the draft best practices in this report is specific to greenfield community development only (i.e., not infill or redevelopment) and the following building types:

- detached homes
- semi-detached homes
- row houses (including stacked and back-to-back townhomes)

The types of flood hazards considered by the draft best practices include:

- riverine flooding
- overland flooding
- storm and sanitary sewer surcharge
- drainage system failures
- groundwater seepage

The types of flood hazards not addressed by the draft best practices include:

- coastal flood hazards
- unique flood hazards (e.g., dam failures)

To develop the draft best practices profiled in this report, the following selection criteria were used:

- **National applicability:** stakeholders from every province in Canada confirmed that best practices proposed in this report are generally relevant and applicable for community design and construction. However, since each community may have unique flood management challenges (e.g., a combination of impermeable soil, flat terrain and high water tables), best practices to address unique and area-specific challenges were not included in the report.

- **Effectiveness in reducing flood damages from severe rain events:** the focus of the proposed best practices was on reducing flood damages from severe rain events (e.g., a months' worth of rain falling in a city within 24 hours).

- **Technical feasibility for implementation:** best practices in the report reflect technology and skill sets that are broadly available in Canada.

- **Cost-effectiveness:** the cost of implementing the proposed best practices over their lifecycle was comparable, or better than alternative methods to address flood risk reduction.

While the proposed best practices are expected to be relevant across Canada, their application may be limited in the areas with permafrost, such as Yukon, Northwest Territories and Nunavut, as well as in coastal areas of Canada, where sea level rise and storm surge pose additional flood risk.

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Table 1: Draft Best Practices for Flood-Resilient Residential Community Design in Canada (Low-Rise, Greenfield Development)

CATEGORY 1: DESIGN FOR RESILIENCE (DR)

DR1. New homes should not be built in the floodway. New homes should also not be built in the flood fringe, unless flood-proofing addresses flood risks in the flood fringe.
DR2. "Safety Factors" should be used in new community design to account for potentially more frequent and severe rainfalls and stormwater system failures. (e.g. locating buildings further distance away from the edge of the floodplain).
DR3. New development should not increase the risk of flooding for existing communities.
DR4. New development should be designed to minimize the risk of basement flooding from groundwater infiltration.
DR5. Heating, ventilation and air conditioning (HVAC), fuel and electrical systems should be well-elevated from the basement floor or located above grade.

CATEGORY 2: STORM SEWER DESIGN (STO)

STO1. If the home foundation drainage system connects to a storm sewer*:
• the water level in the storm sewer should stay at least 30 cm lower than the foundation drainage system during a major design flood event (e.g., 1-in-100 year flood event) AND
• a backwater valve should be installed on the storm sewer lateral to prevent stormwater from backing up into the basement if the storm sewer is overloaded; this backwater valve should be accessible for maintenance.
STO2. If the home foundation drainage system does not connect to the storm sewer*:
• sump pumps should be installed and equipped with one or more backup power systems.
STO3. Inlet control devices (ICDs) should be used to restrict the flow of stormwater from the street into storm sewers.
*Alternatively, a separate foundation drain collector system should be provided with no risk of backing up to basement levels during design flood events.

CATEGORY 3: SANITARY SEWER DESIGN (SAN)

SAN1. Basements connected to sanitary sewers should have a backwater valve to mitigate sewage backup into the basement, if the sanitary sewer is overloaded (e.g., during heavy rain).
SAN2. Downspout, foundation drain and sump pump discharge should not be directed to the sanitary sewers.
SAN3. Design of sanitary sewers should have a factor for "normal" infiltration of rainwater during typical rain events and a higher "Safety Factor" for infiltration and inflow during extreme rain events.

CATEGORY 4: STREET DESIGN (SD)

SD1. Roads and public spaces should be designed to convey excess runoff so that it does not flow through homeowner property.
SD2. Road design and lot grading should be such that the water on the road remains at least 30 cm below the lowest building openings (e.g., basement windows) during design flood conditions.
SD3. Roads should be designed so that the maximum depth of water during the extreme design condition does not exceed 30 cm at the curb.
SD4. Driveways should be built to slope away from homes or garages (i.e., reverse-slope driveways should not be permitted).
SD5. Sanitary sewer manholes should not be located in low-lying areas. If sanitary sewer manholes need to be located in low-lying areas, manhole covers should be sealed to minimize inflow of accumulated runoff into the sanitary sewer.

CATEGORY 5: WASTEWATER PUMPING STATION DESIGN (WP)

WP1. Wastewater pumping stations should be located in areas where they will remain fully-operational and fully-accessible during extreme rain events and riverine flood events.
WP2. Wastewater pumping stations should have backup power to allow for a minimum of 48 hours of uninterrupted service and an overflow in case of catastrophic failure.

CATEGORY 6: PRESERVATION OF NATURAL FEATURES (PNF)

PNF1. New development should not encroach on riparian buffers (land and natural vegetation adjacent to waterbodies), and sufficient setbacks should be maintained along waterbodies to reduce the risk of flooding due to stream movement and bank erosion.
PNF2. New development should aim to minimize runoff from impervious areas.


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NOTE ON ISSUANCE OF REPORT

With issuance of this report, the Intact Centre shares a list of 20 best practices for flood-resilient residential community design. These best practices constitute elements of residential community design and construction that, if implemented together, should achieve significant flood risk reduction.

The Intact Centre welcomes feedback from key stakeholders (including government representatives, industry associations, developers and homebuilders, engineering consultants and other organizations involved in flood risk management), as well as the general public. Feedback sought includes:

- Comments on the effectiveness of best practices to reduce flood risk and their practicality for implementation;
- Suggestions on additional best practices that can lead to flood risk reduction for new residential communities in Canada;
- Discussion of barriers to implementation, which may hinder the uptake of best practices; and
- Feedback on the discussion questions, included in Chapter 2 of the report (questions are specific to each of the best practices listed below).

The stakeholder consultation period ends October 31, 2017. Feedback received will further inform the development of a new National Standard of Canada for flood-resilient residential community design.

DEFINITIONS[i]

Backwater valve: a device that mitigates against storm or sanitary sewage in an overloaded main sewer line from backing up into a basement. The valve automatically closes, if the flow from storm or sanitary sewage attempts to back up into a basement from the main sewer.

Coastal Flooding: flooding associated with a defined shoreline along an ocean. Can occur due to a combination of high tides, storm surges, waves, rising sea levels.

Combined Sewer: sewer that carries both wastewater and stormwater.

Design Flood: a flood elevation or peak flow used for planning, infrastructure design or floodplain management investigations. It is typically defined by its probability of occurrence, or estimated using a selected design storm.

Floodplain: an area adjacent to a lake, river or coast, which can be expected to be regularly inundated or covered with water. It typically includes two zones:

- **Floodway:** the channel of the river or stream and the adjacent land that must remain free from obstruction so that the regulatory flood can be safely conveyed downstream.
- **Flood Fringe**: the remaining portion of the floodplain, where flood depths, flow velocities, or wave energies are relatively low and some development may be permitted, if adequate levels of flood protection are provided.

Flood Mitigation: a sustained action taken to reduce or eliminate long-term risk to people and property from flood hazards and their effects. Mitigation distinguishes actions that have a long-term impact from those that are more closely associated with preparedness for, immediate response to, and short-term recovery from specific events.

Flood Risk Map: maps that contain the flood hazard or inundation delineations along with additional socio-economic values, such as potential loss or property vulnerability levels. These maps serve to identify the social, economic and environmental consequences to communities during a potential flood event.

Floodproofing: any combination of structural or non-structural measures that reduce or prevent flood damage to the structure and/or its contents.

Flood Protection: any combination of structural and non-structural additions, changes, or adjustments to structures, which reduce or eliminate risk of flood damage to real estate or improved real property, water and sanitation facilities, or structures with their contents.

Flood Risk: flood risk is a combination of the likelihood of occurrence of a flood event (flood frequency) and the social or economic consequences of that event when it occurs (through exposure to the flood hazard).

Flow: the rate of flow of water measured in volume per unit time (e.g., cubic metres per second).

Freeboard: the height added to a design flood elevation to account for the many unknown factors and uncertainties in estimates that could lead to the underestimation of predicted water surface elevations or inaccuracies associated with construction practice.

Hydraulic Analysis: an engineering analysis of flow scenarios carried out to provide estimates of the water surface elevations and velocity for selected recurrence intervals.

Hydrologic Analysis: estimation of food magnitudes as a function of precipitation.

Hydraulic Grade Line (HGL): a level to which the water would rise in an open channel system or road. In addition, the level to which the water would rise in a pipe system which, when compared to the level of the basement, will indicate a risk of basement backup. The HGL is determined by subtracting the velocity head ($V^2/2g$) from the energy gradient.

Hydrograph: a graph showing the discharge of a river in cubic meters per second at a given point over a period of time.

Hyetograph: a graph showing rainfall intensity (e.g., in millimeters per hour) with respect to time (e.g., hour).

Groundwater Seepage: groundwater that enters through cracks, pores or gaps in foundation walls, cracked pipes or other openings.

Infiltration (Sewer): the water entering a sewer system, including building sewers, from the ground through defective pipes, pipe joints, connections or manhole walls.

Extraneous Sewer Inflow: the water discharged to a sanitary sewer system, including service connections, from roof leaders; cellar, yard or area drains; foundation drains; drainage from springs and swampy areas; manhole covers; interconnections from storm sewers; combined sewers and catch basins; storm waters; surface runoff; street wash waters or drainage.

Invert: the lowest point of the internal cross section of a pipe or sewer.

Intensity-Duration-Frequency (IDF) curve: a graphical representation of the probability that a given depth of rainfall will occur, shown in rainfall intensity (e.g., in millimeters per hour) with respect to rainfall duration (e.g., hour).

Lateral: any pipe from a building connected to the main sewer.

Lake Flooding: flooding associated with defined land area along a lake. Can occur due to a combination of high water levels, waves, and storm surges.

Minor Drainage System: storm sewers, catch basins, inlets, inlet control devices, street and roadway gutters, ditches and swales designed to convey runoff from frequent storms.

Major Drainage System: streets, channels, ponds, natural streams and valleys that accommodate runoff, including excess runoff from storms over and beyond the minor drainage system capacity.

Overland Flooding: flooding that occurs when runoff water flows from the streets onto properties causing flood damages. It can happen anywhere in the community, independent of an overflowing water body.

Peak Flow: the maximum flow rate occurring during a flood event measured at a given point in a river, street, or pipe system.

Regulatory Flood: the defined flood event used to delineate areas prone to flooding for the purposes of regulating land use. The minimum regulatory flood criteria standard in Canada is the 100-year return period flood, which is the peak flood flow with a one percent chance of occurring in any given year. Some regions, provinces, and territories implement standards that are more stringent.

Riverine Flooding: excess of stream flow in a watercourse, such that land outside the normal banks is submerged or inundated. Can be caused by extreme rainfall or snowmelt, or physical conditions (such as ice jams and undersized watercourse crossings) associated with a watercourse.

Roof leader: a drainpipe that conveys storm water from the roof of a structure to a sewer for disposal onto the ground and removal from the property.

Runoff: the amount of water deriving from precipitation/ snowmelt, not otherwise evapotranspirated or stored, that flows across the landscape.

Sanitary sewer: part of the public sewage works for the transmission of sanitary sewage (includes human and industrial waste, and septic waste, but not stormwater).

Standardization: the development and application of standards that establish accepted practices, technical requirements, and terminologies for products, services, and systems.

Storm Surge: the increase in coastal water levels above predicted astronomical tide levels (i.e. tidal anomaly) resulting from a range of location-dependent factors including low atmospheric pressure, wind and wave set-up and astronomical tidal waves, together with any other factors that increase tidal water levels.

Stormwater: rain, melting snow and ice that washes off driveways, parking lots, roads, yards, rooftops, and other surfaces.

Stormwater Management: the planning, design and implementation of systems that mitigate and control the impacts of man-made changes to runoff and other components of the hydrologic cycle. Stormwater management is better known as "rainwater management" in much of the world.

Storm sewer: a sewer, the purpose of which is to carry stormwater (including surface and rainwater, melted snow and ice) and water in underground pipes and foundation drains.

Sub-watershed: a part of a larger watershed, which drains to one point within a watershed.

Surcharge: flow condition when the sewer flow exceeds the hydraulic capacity of the sewer.

Velocity of Floodwater: the speed at which floodwaters are moving, typically measured in metres per second (m/s).

Watershed (or an "Area Structure Plan" in Alberta)**:** an area delineated by topography where all precipitation drains to one point or outlet.

Wastewater (Sanitary Sewage): blackwater (used water from sanitary appliances that contains human fecal matter or human urine); greywater (used water, other than blackwater, from sanitary appliances or from other appliances in a kitchen or laundry) that is mixed with blackwater; used water from an industrial, commercial or institutional facility that is mixed with blackwater and surface runoff; as well as stormwater that is mixed with blackwater.

Wet weather flow (WWF): flow observed in sanitary and combined sewers during rainy and snow melt periods caused by precipitation or snow melt-derived infiltration/inflow.

1. INTRODUCTION

The purpose of this report is twofold:

1. To highlight the imperatives for flood risk reduction in Canada; and
2. To identify priority areas of focus and associated best practices for building new residential communities that are more resilient to flooding.

Chapter 1 describes the rising economic costs of natural disasters, including flooding, in Canada; profiles emerging mortgage market risks for areas of the country where repeated flooding has occurred; outlines the rise in flood-related lawsuits; and explains key benefits of establishing a new National Standard of Canada for flood-resilient residential community design.

Chapter 2 describes the method used to derive flood-resilient residential community design best practices. It profiles the draft best practices and features specific questions for the stakeholders and public reviewing this report.

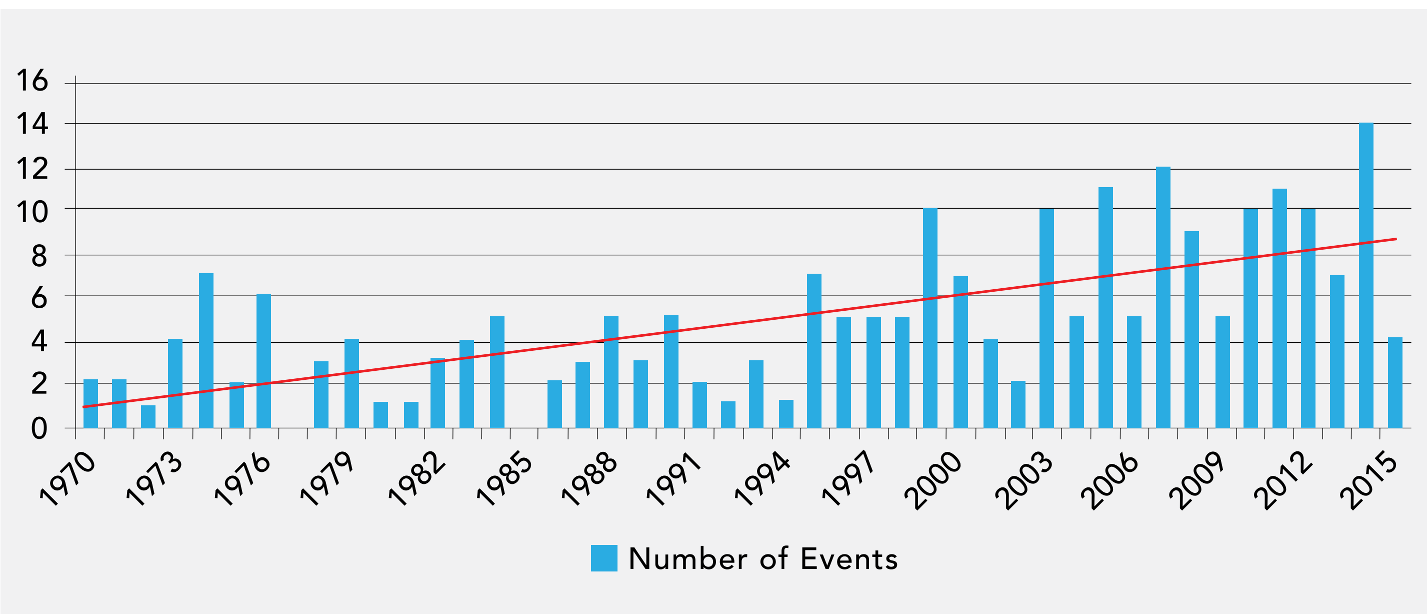
Chapter 3 describes a range of initiatives to complement the uptake of flood-resilient community design best practices; and it outlines the benefits to be realized with the development of a national flood-resilient residential community design standard for Canada.

Chapter 4 contains concluding remarks and provides details on how stakeholders can share their feedback on the report.

1.1 RISING ECONOMIC COSTS OF NATURAL DISASTERS AND EXTREME WEATHER

Natural catastrophes and severe weather are raising costs to governments and, by extension, to all Canadians.[ii] According to Public Safety Canada, the number of natural disasters for which provinces and territories required and obtained federal assistance under the Disaster Financial Assistance Arrangements (DFAA) increased dramatically between 1970 and 2015 (Figure 1), well in excess of population growth.[iii] According to the Office of the Auditor General of Canada, from 2009 to 2015, the DFAA's spending was more than in the previous 39 fiscal years combined.[iv] The DFAA's spending on floods was highest, representing 75 percent of all weather-related expenditures.[v]

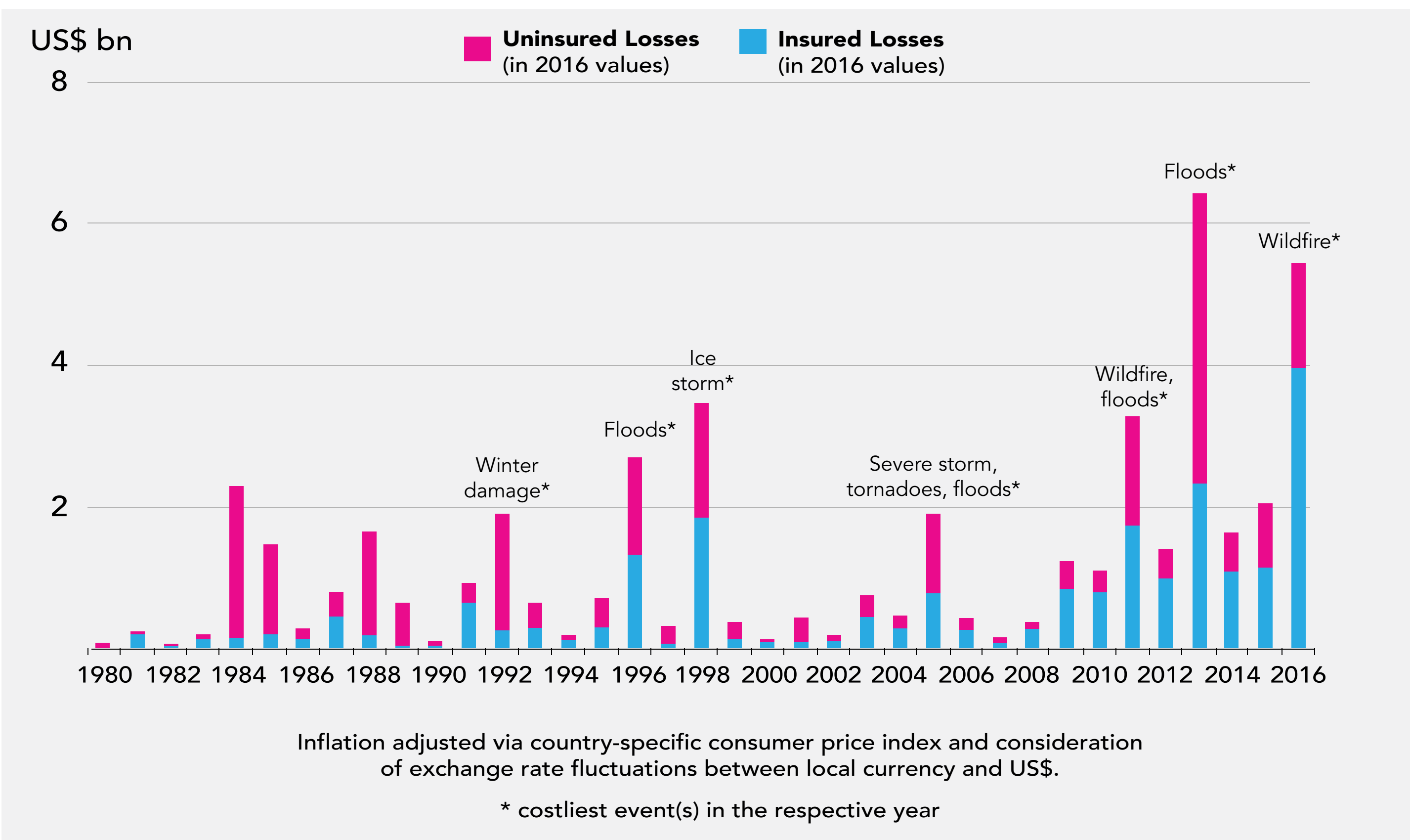
Figure 1: Number of Natural Disasters in Canada Requiring Disaster Financial Assistance Arrangements for Provinces and Territories (1970 to 2015)



Source: Public Safety Canada. 2016-2017 Evaluation of the Disaster Financial Assistance Arrangements.

Catastrophic insurable losses in Canada are also on the rise. According to the Insurance Bureau of Canada, "property and casualty insurance payouts from extreme weather have more than doubled every five to 10 years since the 1980s."[vi] While insurable payouts averaged $400 million per year over the period of 1980 to 2008, for the last seven of eight years leading up to 2016, extreme insurance payouts exceeded $1 billion in Canada. As shown in Figure 2, the insurance gap in Canada is significant: denoted in pink are the uninsured catastrophic losses, in billion US$, which are borne by government, home and business owners.

Figure 2: Catastrophic Insured Losses in Canada (1980 –2016): Overall and Insured, 2016 US$



Source: 2017 Munich Re, Geo Risks Research, NatCatSERVICE. As of February 2017.

1.2 THERE IS NO GOING BACK ON CLIMATE CHANGE: CANADA MUST ADAPT

Natural catastrophes and associated economic losses are expected to increase in the coming years.[vii] The Intergovernmental Panel on Climate Change (IPCC) projects substantial warming and increased frequency of heavy precipitation events globally in the 21st century.[viii] Furthermore, according to the International Energy Association, "while countries are generally on track to achieve many of the targets set in their Paris Agreement pledges to reduce global warming, this is not nearly enough to limit warming to less than 2°C."[ix] Therefore, despite global commitments to reduce global warming, the climate will continue to change, and the associated extreme weather catastrophes, such as floods, will ensue.

Recognizing the pressing need to adapt to a changing climate, the Government of Canada established the Pan-Canadian Framework on Clean Growth and Climate Change. Chapter four of the framework is entirely dedicated to climate adaptation and improving Canada's climate resiliency. Specifically, the Government of Canada made commitments to 1) invest in infrastructure that strengthens resilience and 2) to develop climate-resilient codes and standards:

Federal, provincial, and territorial governments will work collaboratively to integrate climate resilience into building design guides and codes. The development of revised national building codes for residential, institutional, commercial, and industrial facilities and guidance for the design and rehabilitation of climate-resilient public infrastructure by 2020 will be supported by federal investments.[x]

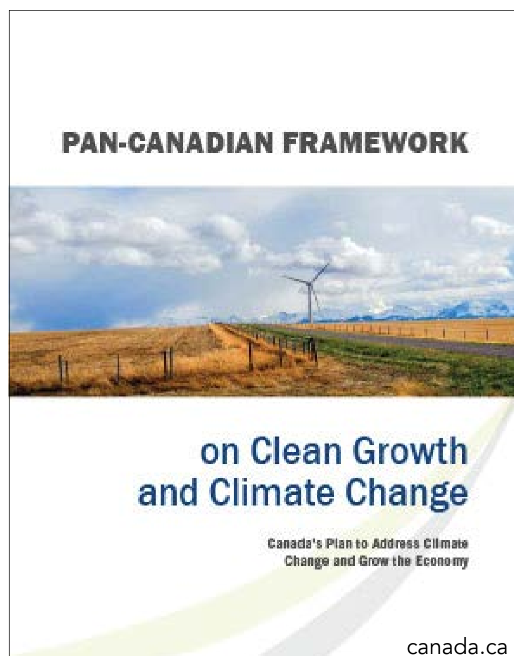
The National Research Council of Canada (NRC), which sets "model codes" for buildings, announced its commitment to update most of its codes to reflect climate change and extreme weather impacts. The NRC also funded the development of a Guideline on Flood Proofing and Flood Prevention Measures to Protect Basement Flooding by the Canadian Standards Association Group (CSA Group).[xi] This is one of six projects launched by CSA Group to incorporate climate change into standards development processes. These include the development of climate change adaptation solutions within the framework of the Canadian Electrical Codes 1, 2 and 3, climate change adaptation provisions for the Canadian Highway Bridge Design Code and creation of new standards for green infrastructure to support flood mitigation and surface water protection.[xii] Concurrently, the Standards Council of Canada (SCC) identified existing standards referenced in National Model Construction Codes, Provincial and Territorial Regulations and Master Building Specification that need to be updated to include climate change considerations.

1.3 FLOODING STRESSES CANADA'S MORTGAGE MARKET

According to the Insurance Bureau of Canada, 1.7 million Canadian households (19 percent of Canada's population) are at risk of riverine and overland flooding.[xii] For areas where flood insurance coverage is limited or not available, and where Canadians are at high risk of flooding, this conveys a significant economic concern.

More specifically, according to the National Flood Insurance Program in the United States, a 15-centimeter flood in a 2,000-square-foot home is likely to cause about $40,000 in damage.[xiv] Similar flood damage costs have been reported in Canada, as well. In 2016, the Canadian Payroll Association reported that almost half of working Canadians are living paycheque to paycheque, and one in four Canadians would not be able to "scrape together $2,000 if an emergency arose next month."[xv]

With limited flood insurance coverage, some homeowners in Canada may not be able to pay for flood damages when the next flood strikes - given limited liquidity to redress flooding, some home owners may default on their mortgage (as homes with sewer water in the basement are generally uninhabitable).



1.4 FLOODING GIVES RISE TO LAWSUITS

Flood-related lawsuits, particularly in the form of negligence lawsuits, are on the rise across Canada. Homeowners, developers, local governments, conservation authorities, Indigenous peoples, provinces and private businesses may initiate these lawsuits.

Table 2 provides examples of flood-related lawsuits, demonstrating the need for flood-resilience, at all levels, to limit culpability.

The law of negligence refers to careless conduct that causes loss to another. It is the most common, and arguably the most important, field of tort law, as it governs most activities of modern society. To be found negligent, a plaintiff must establish that the defendant owed it a duty of care and breached the relevant standard of care. The plaintiff must also show that the defendant's act or omission caused or contributed to the harm suffered, resulting in damages to the plaintiff.

The most significant aspect of the negligence test in many cases is whether the defendant breached the standard of care. The standard of care considers whether the conduct of the defendant was reasonable in the circumstances. A court will consider a number of factors when determining the appropriate standard of care, including but not limited to:

- Relevant statutory requirements and related guidance
- Industry codes of practice
- General industry/sector custom and practice
- Actions of other, similarly situated, plaintiffs

While any of these factors may help determine the applicable standard of care, no one factor alone is determinative. Rather, in each instance, a court will consider the facts and circumstances of the case.

Table 2: Examples of Stormwater Management and Flood-Related Lawsuits in Canada

CASE NAME (YEAR)	DESCRIPTION (damages, cost and settlement amounts included where identified)	DEFENDANTS
Anderson et al v Manitoba et al, 2017 MBCA 14 (CanLII) (ongoing) **Manitoba**	A $950 M class action lawsuit was brought forward by 4,000 residents of four First Nations following severe flooding in the spring of 2011. A flood resulted in damage to property and the evacuation of many people from their homes. Plaintiffs brought claims of negligence, nuisance and breach of treaty rights, alleging that the Government of Manitoba contributed to the flooding through its operation of flood control measures and water control works that affected the water levels around the four First Nations. The class action lawsuit was certified in January 2017 and is moving forward.	Province, Manitoba Association of Native Fire Fighters Inc.
Wight v Peel Insurance, 2016 ONSC 6904 (CanLII) **Ontario**	A plaintiff sued their insurance company in contract for denying her coverage after a section of a nearby dam burst on a neighbour's property, causing a flash flood and damage to the plaintiff's home. The insurer initially denied the plaintiff's claim, but in a decision on the plaintiff's motion for summary judgment, the court found that the dam was a "water management system" and that the plaintiff's policy provided coverage for the accidental escape of water from a sewer or drain.	Insurance company
Muskoka Class Action, 2016 (ongoing) **Ontario**	A $900 M class action was launched by Muskoka residents, cottage owners and business owners against the Province of Ontario after damages were caused by flooding and high water levels. Plaintiffs allege that the Ministry of Natural Resources was negligent for failure to draw down the water levels and/or effectively manage the water levels. The claim is ongoing.	Province
Cerra et al. v. The Corporation of the City of Thunder Bay, 2012 (ongoing) **Ontario**	Floods in May 2012 resulted in severe damage in Thunder Bay. Plaintiffs allege negligence in repair, inspection and maintenance of the water pollution control plant, as well as lack of diligent operation and supervision at the time of the flood (including an allegation that alarms were ignored). The $300M claim is ongoing. The court certified action on consent in 2013.	Municipality
Vancouver Public Library Lawsuit, 2012[1] (ongoing) **British Columbia**	The City of Vancouver sued the developer, construction company, professional services/design consulting firm and contractor company for damage caused by an October 2010 flood at the Kensington branch of Vancouver Public Library. The City claims that the catch basins were not constructed in accordance with the construction design details prepared by the civil engineer, that defendants were aware the library entrance was prone to flooding, and that defendants failed to take action even after the plaintiff notified them of the issue. This action is ongoing.	Developer, construction company, professional services/design consulting firm, contractor company

Maple Ridge Class Action. 2010[2] (ongoing) **British Columbia**	Fifteen households filed a class action lawsuit against a developer and contractor, two engineering firms, and the City of Maple Ridge after a 2010 flood. Plaintiffs allege that defendants were negligent, arguing construction failure, faulty workmanship and design, failure to inspect basements for leaks and failure to repair leaks as requested. Plaintiffs also argue that the houses were not waterproofed to code, despite the municipality's inspection, review and issuance of permits. The trial was scheduled to begin in 2016. The claim is ongoing.	Municipality, developer, contractor, engineering firms
Panza et al v. The Corporation of the City of Mississauga et al., 2012 **Ontario**	Upper and lower tier municipalities, the province and the conservation authority were all named as defendants in a negligence claim related to systemic flooding over several years in the Lisgar area of Mississauga. The $200M action was withdrawn before trial. However, this case shows the potential for systemic flooding to give rise to class action lawsuits.	Province, municipality, conservation authority
Dankiewicz v. Sullivan, 2011 ONSC 3485 (CanLII) **Ontario**	A property owner sued her neighbour, alleging negligence and nuisance after her neighbour's alteration of land caused a reversal of drainage flow and subsequent flooding. The court held that the flooding resulting from the defendant neighbour's actions constituted a nuisance. The court awarded the plaintiff $5,000 in recognition of the distress, inconvenience and interference with her enjoyment of her land, caused by the flooding, as well as $4,257 for replacement trees, a sump pump installation and other expenses related to the damage in her yard.	Homeowner
Dicaire v. Chambly, 2008 (QueCA) **Quebec**	The Quebec Court of Appeal dismissed a class action by owners of 1,723 homes that flooded in 1997 when sewers backed up following heavy rains. The court ruled that the sewers were designed, as provincial guidelines required; to cope with a "5-year storm," and the town was not obliged to do more. However, the court noted that current design standards might not protect municipalities in future lawsuits, in light of "recent climate phenomena" and other scientific advances.	Municipality
Lissack v Toronto, 2008 OJ No 5563 **Ontario**	The City of Toronto's storm sewer backed up following a heavy storm and flooded the plaintiff's basement. The plaintiff brought an action in negligence for damages against the city. The court found that the city breached its duty of care by failing to maintain and improve stormwater management systems.	Municipality
McLaren v. Stratford (City), 2005 CanLII 19801 **Ontario**	A major flood in the City of Stratford after severe rainfall in 2002 left many with sewage in their basement. Plaintiffs claimed negligence in design, construction operation and maintenance of the system. The class was certified by the court in 2005, and the case was settled in 2010, eight years after the flood. Stratford settled for $7.7M after already spending $1.3M in emergency relief and costly improvements to its system thereafter.	Municipality
Ingles v Tutkaluk Construction Ltd., 2000 1 SCR 298, 2000 SCC 12 **Ontario**	The appellant hired a contractor to renovate his basement. The required building permit was not obtained prior to construction. The inspector relied on the contractor's assurances that the underpinnings were properly constructed, without properly verifying this information, except for an examination of the concrete. The appellant began to experience flooding and hired another contractor, who determined that the underpinnings were completely inadequate and failed to meet the standard prescribed in the Building Code Act. The appellant sued the first contractor for a contractual breach and the city for negligence. Even though the owner consented to the construction without a permit, the City was also found negligent for failing to conduct an adequate inspection and ended up paying $185,000 in costs and rewards.	Municipality, contractor
Oosthoek v. Thunder Bay (1996) 1996 CanLII 1530 (ONCA) **Ontario**	After a storm in Thunder Bay, multiple homeowners' basements flooded. The plaintiffs brought an action alleging that the city knew of problems and acted negligently. The City was found liable for the flooding caused by the overloaded combined sewers. The city's negligence was based on its failure to enforce the by-law it passed requiring downspout disconnection from the sewage system.	Municipality

Source: Adapted from Zizzo Strategy. Legal Risks and Requirements to Address Flood Resilience. Prepared for the Intact Centre on Climate Adaptation. April 2017.

[1] http://www.vancourier.com/news/city-of-vancouver-suing-aquilini-over-library-flood-1.381734
[2] http://www.theglobeandmail.com/news/british-columbia/leaky-basement-lawsuit-drags-on-in-maple-ridge/article25051951/

1.5 FLOODING IMPACTS MUNICIPAL INSURANCE COSTS AND MUNICIPAL BOND RATINGS

In Canada, flood risk mitigation is typically a responsibility of local governments (municipalities, regional governments, specialized agencies, boards and commissions). Local governments review and approve new developments and maintain stormwater management systems.[xvi] Local governments can leverage land-use regulations to guide the development away from high flood risk areas and can encourage the adoption of flood-resilient residential community design standards. A combination of these efforts can help local governments reduce lawsuits (Table 2) by mitigating risks to communities and demonstrating that they acted in ways consistent with what courts might find as an appropriate standard of care.

Failure to reduce flood-related lawsuits may increase future insurance costs to local governments. In 2011, the Association of Municipalities of Ontario (AMO) issued a Municipal Insurance Survey, which revealed that, since 2007, municipal liability premiums have increased by 22.2 percent. The AMO projected that insurance costs for municipalities in Ontario will rise to $214 million annually by 2020, not including legal fees, self-insurance costs, settlements, risk management expenses or court mandated awards.[xvii] The AMO noted that the rise in insurance costs is partly due to joint and several liability in the provincial Negligence Act. Joint and several liability is "a form of liability that is used in civil cases where two or more people are found liable for damages. If any of the defendants do not have enough money or assets to pay an equal share of the award, the other defendants must make up the difference."[xviii] As per AMO, joint and several liability may lead to significant costs for municipalities:

The insurance premiums paid by municipalities reflect the legal reality that municipalities are 'deep pocket' defendants, often targeted for litigation because the law has established such a low threshold of responsibility. Just a fraction of fault can cost a municipality millions of dollars. The premiums charged by insurance companies, non-profit insurance reciprocals and pools reflect, in part, this legal risk.[xix]

With the expected rise in flood-related lawsuits across Canada,[xx] the AMO's municipal insurance cost projections can be expected to rise in the future.

Municipal bond ratings may also be affected by how well municipalities manage flood risks and disclose their efforts. According to the Carbon Disclosure Project (CDP), "municipal bond analysts evaluating the likelihood of repayment for municipal bonds would be remiss to ignore an issuer's exposure to risks posed by climate change impacts."[xxi] The CDP finds that tax base, debt levels and management quality are the three main areas that municipal bond analysis will start assessing to determine how well municipalities are addressing climate and extreme weather risks. Robert Fernandez of Breckinridge Capital Advisors notes the questions, which are part of the municipal bond analysis:

Given the widespread impacts of climate change, an analyst might ask: which city governments are aware of climate risks to businesses and which are not? Are cities adequately preparing for these risks? And if they are not, does this lack of preparation suggest that the city government might be falling short in other, more immediate management priorities?[xxii]

In Canada, where flooding is the most common extreme weather risk facing municipalities, the focus of municipal bond analysis will undoubtedly reflect the initiatives put in place by local governments to improve their flood resiliency. Credit rating agencies including DBRS, Moody's and Standard & Poor's are beginning to examine climate change risks and potential impacts on ratings of tradable assets, including municipal bonds. Therefore, to maintain higher credit ratings for municipal bonds, local governments must pursue both flood mitigation in older communities, where flood risk is the highest;[xxiii] and make every effort to ensure that new developments are flood-resilient.

1.6 THE DEFINITIONS OF REGULATORY FLOODS, FLOODWAYS AND FLOOD FRINGES DIFFER IN CANADA

Communities throughout Canada use different approaches to address flood management. As noted in the Federal Floodplain Mapping Framework, "flood management is inherently multi-faceted and involves a wide range of authorities and stakeholders, both within and outside of government."[xxiv]

A range of provincial and territorial policies and regulations govern flood management in Canada, with many responsibilities, as noted earlier, delegated down to local governments and water utilities. Moreover, provinces and territories adopted different target "levels of service" or "levels of risk" to guide flood management. Table 3 provides a summary of definitions for floodway and flood fringe adopted by provinces and territories. The notable differences in these definitions and in regulatory flood standards throughout Canada can add to uncertainty about acceptable flood risks in the country and can hinder national efforts to streamline flood management in Canada.

*Table 3: Defining Regulator Flood, Floodway and Flood Fringe for Riverine Flooding in Canada**

PROVINCES/ TERRITORIES	REGULATORY FLOOD	DEFINITION OF FLOODWAY	DEFINITION OF FLOOD FRINGE
British Columbia	**1-in-200 years** Plus an additional freeboard for hydrologic and hydraulic uncertainties or 1894 Flood of Record for Lower Fraser River	The channel of the watercourse and those portions of the floodplain, which are reasonably required to convey the designated flood. At minimum, the floodway is equal to the width of the channel within the natural boundary plus a minimum setback of 30 metres from the natural boundary on each side of the channel, or unless otherwise approved.	The portion of the floodplain not in the floodway to which flood-proofing requirements apply.
Alberta	**1-in-100 years**	The floodway includes areas where the water is one metre deep or greater, the local velocities are one metre per second or faster and if the river were encroached upon, the water level rise would be 0.3 metres or more.	The flood fringe is the land along the edges of the flood hazard area that has relatively shallow water (less than one metre deep) with lower velocities (less than one metre per second).
Saskatchewan	**1-in-500 years** Plus additional freeboard for hydrologic and hydraulic uncertainties	The portion of the floodplain adjoining the channel where the waters in the 1:500 year flood are projected to meet or exceed a depth of one metre or a velocity of one metre per second.	The portion of the floodplain where the waters in the 1:500 year flood are projected to be less than one metre deep, with velocity less than one metre per second.
Manitoba	**1-in-100 years** 1:700 for the City of Winnipeg	The portion of the floodplain where the depth of flooding is greater than one metre.	The remainder of the floodplain beyond the floodway.
Ontario	**1-in-100 years** OR **Regional Storms** (Hurricane Hazel or Timmins Storm), whichever is greater	Where the one zone concept is applied, the floodway is the entire floodplain. Where the two-zone concept is applied, the floodway is the inner portion of the floodplain, representing that area required for the safe passage of flood flow and/or that area where flood depths and/or velocities are considered to be such that they pose a potential threat to life and/or property damage.	The outer portion of the floodplain between the floodway and the flooding hazard limit.
Quebec	**1-in-100 years**	Part of the floodplain that may be flooded during a 20-year flood event.	Part of the floodplain beyond the high-velocity zone that may be flooded during a 1:100 year flood.
New Brunswick	**1-in-100 years**	Part of the floodplain that may be flooded during a 20-year flood event.	Part of the floodplain between the floodway and the outer limit of the flood risk area, whether it is the 1:100 year flood line or a higher historic flood line.
Nova Scotia	**1-in-100 years**	The inner portion of a flood risk area where the risk of flooding is greatest, on average once in 20 years and where flood depths and velocities are greatest.	The outer portion of a flood risk area, between the floodway and the outer boundary of the flood risk area, where the risk of flooding is lower or average 1:100 year, and floodwaters are shallower and slower flowing.
Newfoundland and Labrador	**1-in-100 years, adjusted for Climate Change**	The inner portion of a flood risk area where the risk of flooding is greatest, on average once in 20 years and where flood depths and velocities are greatest.	The outer portion of a flood risk area, between the floodway and the outer boundary of the flood risk area, where the risk of flooding is lower or average 1:100 year, and floodwaters are shallower and slower flowing.
North West Territories	**1-in-100 years**	The floodway includes areas where the water is one metre deep or greater, the local velocities are one metre per second or faster and if the river were encroached upon, the water level rise would be 0.3 metres or more.	The flood fringe is the land along the edges of the flood hazard area that has relatively shallow water (less than one metre deep) with lower velocities (less than one metre per second).
Nunavut	**1-in-100 years**	The floodway includes areas where the water is one metre deep or greater, the local velocities are one metre per second or faster, and if the river were encroached upon, the water level rise would be 0.3 metres or more.	The flood fringe is the land along the edges of the flood hazard area that has relatively shallow water (less than one metre deep) with lower velocities (less than one metre per second).

**See Appendix A for sources. Prince Edward Island and Yukon did not participate in Canada's Flood Damage Reduction Program.*

Flood Return Period and Risk Analysis

A statistical technique called frequency analysis is used to estimate the probability of the occurrence of a given precipitation event. The recurrence interval is based on the probability that the given event will be equalled or exceeded in any given year. The term "100-year flood" is used to simplify the definition of a flood that statistically has a one percent chance of occurring in any given year. Likewise, the term "100-year storm" is used to define a rainfall event that statistically has a one percent chance of occurring.[xxv]

Recurrence Intervals and Probabilities of Occurrences

RETURN PERIOD, IN YEARS	PROBABILITY OF OCCURRENCE IN ANY GIVEN YEAR	PERCENT CHANCE OF OCCURRENCE IN ANY GIVEN YEAR
100	1 in 100	1
50	1 in 50	2
25	1 in 25	4
10	1 in 10	10
5	1 in 5	20
2	1 in 2	50

Source: U.S. Geological Survey. December 2016.

Notably, a 100-year flood is not always caused by a 100-year storm. The level of soil saturation before the storm, the size of the drainage area contributing to the stream, the duration of the storm and various changes in development over time (e.g., increased impervious areas) all play a role in whether or not a 100-year storm will produce a 100-year flood.[xxvi]

Moreover, since return periods are computed using past data, as more updated climatological data becomes available, what was understood as a 100-year flood in the past may change. For instance, 100-year floods could become 50-year floods due to increased severity and frequency of rain events.

From the standpoint of risk analysis, the probability that a 100-year flood will happen more than once in a given 100-years period is a representation of the risk. The following equation relates the return period to flood risk:

$R = 1 - (1 - P)^N$

Where R is the risk that an event with a probability P be reached or exceeded at least once in N years.[xxvii] For example, the risk that a 100-year flood will happen at least once during a 25-year period is not 1% but 22% (or 40% for a 50-year period). The relationship between return period and the mean probability of occurrence per year is illustrated below.

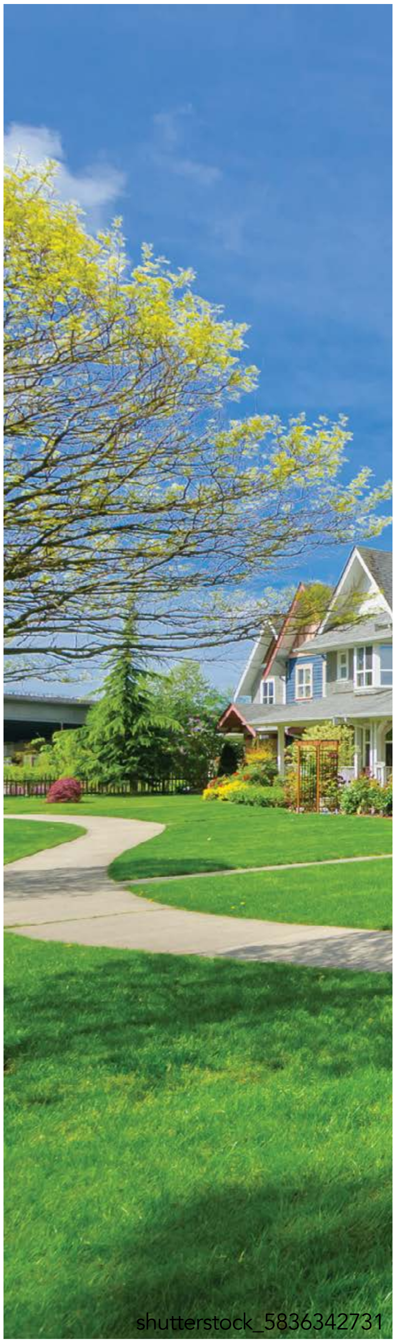
Flood Risk Associated with Different Return Periods and Mean Probability of Occurrence per Year

RETURN PERIOD (YEARS)	MEAN PROBABILITY OF OCCURRENCE PER YEAR	FLOOD RISK FOR A GIVEN PERIOD OF N YEARS				
		N = 100	N = 50	N = 25	N = 10	N = 1
100	1%	64%	40%	22%	10%	1%
50	2%	87%	64%	40%	18%	2%
25	4%	98%	87%	64%	34%	4%
10	10%	100%	99%	93%	65%	10%
5	20%	100%	100%	100%	89%	20%

Source: Adapted from Stormwater Management Guide, Ministry of Environment, Quebec, 2011.

The design of drainage systems should take into account flood risk (for example, a typical duration of a mortgage is 25 years), as it is not economically feasible to have protection against very rare events.

Notwithstanding the range of definitions and flood management approaches adopted across Canada, some common elements and broadly applicable best practices for flood-resilient community design can be identified from coast to coast to coast. These best practices can serve as a foundation for a national standard for flood-resilient residential community design and are noted in the following chapter.



1.7 BENEFITS OF A NATIONAL STANDARD FOR FLOOD-RESILIENT RESIDENTIAL COMMUNITY DESIGN

A national standard for flood-resilient residential community design can help local governments, developers, homebuilders, design professionals and contractors to better understand the minimum expected design and construction requirements for building new residential subdivisions that are less prone to flooding. This would lead to multiple benefits, including:

- **Reduced liability:** Demonstrating compliance with a flood-resilient residential community design standard (and with existing legislative requirements) can help local governments, developers and homebuilders reduce the potential for flood-related negligence lawsuits. Applying agreed-upon industry standards could help to demonstrate that an applicable standard of care was met and proper due diligence was exercised in the design, construction and approval of new residential communities.

- **Improved local coordination and planning:** Communities located within the same watershed may have different requirements for stormwater and floodplain management. This may create conflicts and duplications, as developers, homebuilders, design professionals and contractors comply with different sets of design guidelines for nearby lands. Having a standard can offer a more predictable playing field for developers, design professionals and contractors.

- **Clarity for developers:** Standardization improves understanding of the minimum requirements for land use and land development, which developers, design professionals and contractors have prior to land acquisition and construction. The greater the certainty that new homes are not permitted in the flood-prone areas, the lower the incentive for developers to acquire this land for new residential community development.

- **Improved construction quality:** New developments that comply with the flood-resilient community design standard provisions are less likely to incur flood damages. Enforcement of the standard can aid in maintaining quality of life and property values.

- **Improved public awareness:** Having a recognized standard can help increase public awareness and drive market demand for flood-resilient homes and communities. Enforcement of the standard can also help protect homebuyers from purchasing substandard housing.

- **Improved inspections:** Compliance inspections can become more effective and efficient if they are administered under a single set of provisions. Building inspectors familiar with flood mitigation provisions are more likely to identify flawed construction.

2. FLOOD-RESILIENT RESIDENTIAL COMMUNITY DESIGN: SCOPE AND BEST PRACTICES

Recognizing the need to identify broadly applicable best practices for flood-resilient residential community design in Canada, the Intact Centre engaged with a group of municipal stormwater and flood management experts, engineering consultants, developers, homebuilders and other stakeholders from across Canada to identify priority areas of focus and best practices for building new residential communities that are more resilient to flooding.

The Standards Council of Canada supported this effort through funding of this report, with the objective that the report will inform the development of a flood-resilient community design standard for new residential subdivisions in Canada. The expected end users of the standard would largely be municipalities, developers and homebuilders.

2.1 SCOPE OF THE FLOOD-RESILIENT RESIDENTIAL COMMUNITY DESIGN BEST PRACTICES

The scope of the draft best practices was specific to greenfield community development only (i.e., not infill or redevelopment) and the following building types:

- detached homes
- semi-detached homes
- row houses (including stacked and back-to-back townhomes)

The types of flood hazards addressed by the draft best practices included:

- riverine flooding
- overland flooding
- storm and sanitary sewer surcharge
- drainage system failures
- groundwater seepage

The types of flood hazards not addressed by the draft best practices included:

- coastal flood hazards
- unique flood hazards (e.g., dam failures)

To develop the short list of 20 best practices (Section 2.3), the Intact Centre used the following selection criteria:

- **National applicability**: Stakeholders from every province in Canada confirmed that the best practices proposed in this report were generally relevant and applicable for community design and construction. However, since each community may have unique flood management challenges (e.g., a combination of impermeable soil, flat terrain and high water tables), best practices to address these unique and area-specific challenges were not included in the report.

- **Effectiveness in reducing flood damages from severe rain events:** It is acknowledged that Low Impact Development (LID) measures, such as rain gardens and bioswales, can be effective to treat rainwater "at the source" during small, frequent rainfall events. Usually, traditional stormwater design features, such as stormwater end-of-pipe facilities, continue to be required to accommodate large, infrequent rainfall events, in addition to the LID measures.[xxviii] Since the focus of the proposed best practices was on reducing flood damages from severe rain events, best practices aimed at managing frequent rain events were not explicitly included in the report. However, feedback on LID measures is welcome (e.g., under report Section 2.3, Category 6; Preservation of Natural Features).

- **Technical feasibility for implementation:** Best practices in the report reflect technology and skill sets that are broadly available in Canada.

- **Cost-effectiveness:** The cost of implementing the proposed best practices over their lifecycle was comparable to alternative methods to address flood risk reduction.

While the proposed best practices are expected to be relevant across Canada, their application may be limited in areas with permafrost, such as Yukon, Northwest Territories and Nunavut, as well as in coastal areas of Canada, where sea level rise and storm surge pose additional flood risk.

The decision to limit the scope to exclude northern and coastal areas was deemed reasonable. First, CSA Group has already published a national standard of Canada that will help northern communities design and implement effective community drainage systems (CAN/CSA-S503-15 Community Drainage System Planning, Design, and Maintenance in Northern Communities).[xxix] Second, due to tremendous variability both among and within Canada's three marine coast regions (East Coast, North Coast and West Coast),[xxx] a stand-alone effort to identify flood-resilient community design best practices would be more appropriate.

Canada's Marine Coasts in a Changing Climate

The magnitude, importance and, at times, direction of climatic changes vary both among and within Canada's three marine coastal regions.

- The North Coast region (which includes about 70 percent of Canada's coastline) is very sparsely populated; the majority of residents are Inuit, First Nations or Métis; and sea ice is a defining element of the coast for much of the year.
- The East Coast region is characterized by several cities and an abundance of small towns and hamlets, with a diverse economy in which coastal resources continue to play an important role.
- The population of the West Coast region is concentrated in British Columbia's lower mainland and southeastern Vancouver Island, with the number of residents and built-environment asset value of the greater Vancouver area far exceeding that of any other part of Canada's marine coast.

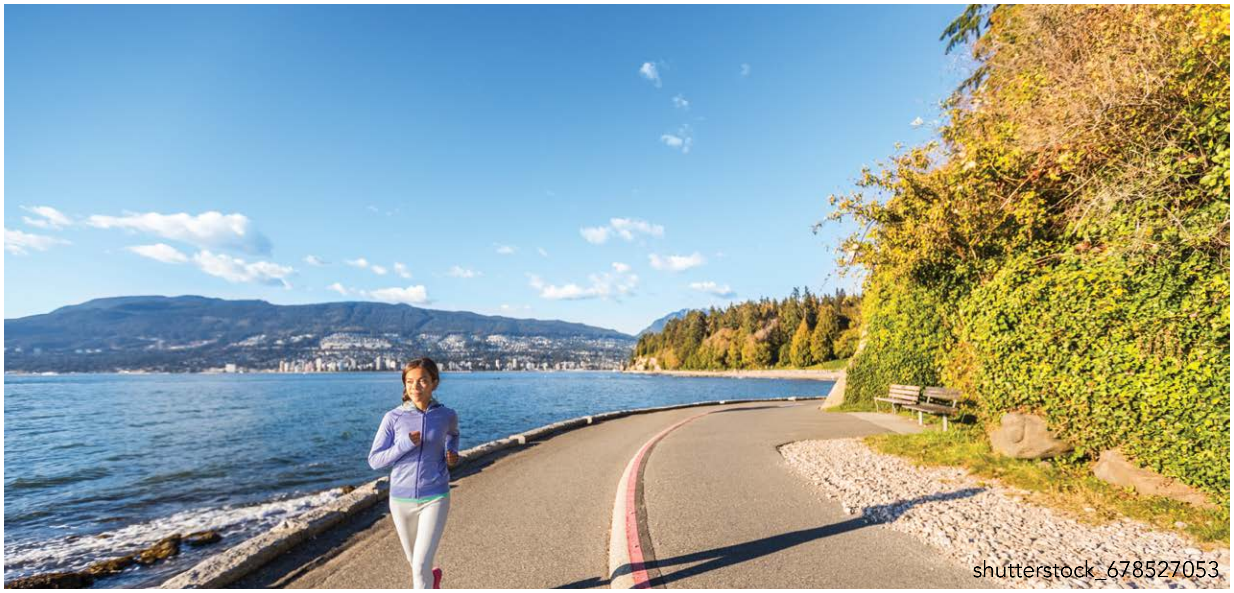
Flood management approaches range from new dike construction and dike maintenance to beach nourishment, protection, revegetation and stabilization of dunes, to provision of buffer zones, to rolling easements or setbacks that allow the landward migration of the coastline.

Source: Government of Canada. 2016. Canada's Marine Coasts in a Changing Climate.

Accordingly, the priority areas of focus and best practices for flood-resilient community design identified by the Intact Centre (Section 2.3) will apply to most regions in Canada. However, additional work is required to address flood-resilient community design considerations for northern and coastal areas.

Lastly, it is expected that new standards for green infrastructure to support flood mitigation and surface water protection from CSA Group will provide relevant guidance for LID implementation. Accordingly, duplication of this effort in this report is not justified.


SFU Community Trust, SITE Photography



2.2 METHOD TO DEVELOP DRAFT FLOOD-RESILIENT RESIDENTIAL COMMUNITY DESIGN BEST PRACTICES

Figure 3 outlines the process that the Intact Centre followed to identify priority areas of focus and best practices for flood-resilient residential community design.

Figure 3: The Process of Developing a Seed Document for a Flood-Resilient Community Design Standard

The first step in the process of developing best practices was a literature review focused on understanding provincial policies and guidelines that govern stormwater management and flood mitigation in Canada (see Appendix B for a summary of this review). Industry guides and other relevant documents were also reviewed to identify common requirements for a flood-resilient community design (see Appendix C).

Next, the Intact Centre consulted with technical experts to develop a first draft of flood-resilient residential community design best practices. These draft best practices were shared with 100 stakeholders and stormwater management experts from across Canada, to determine their predisposition for on-the-ground implementation across different regions in Canada. The stakeholders consulted had expertise in flood-resiliency and community design - Appendix D lists organizations engaged in the consultation. Notably, the Intact Centre engaged stakeholders from at least one city from every province in Canada. In summary, the following stakeholder groups took part in the consultation:

- Municipalities
- Developers and homebuilders
- Insurance industry representatives
- Government departments and agencies
- Academic institutions
- Standards development organizations
- Engineering consulting firms
- Conservation authorities
- Lawyers
- Non-governmental organizations
- Industry associations

Based on stakeholder feedback, the Intact Centre identified priority areas for flood-resilient community design and best practices.

Once priority areas and draft best practices for a flood-resilient community design were prepared, the Intact Centre led a workshop with 25 stakeholders to rank best practices in terms of their effectiveness to reduce flood risk and financial feasibility for implementation; to share suggestions for modifications; and to identify areas for further research.

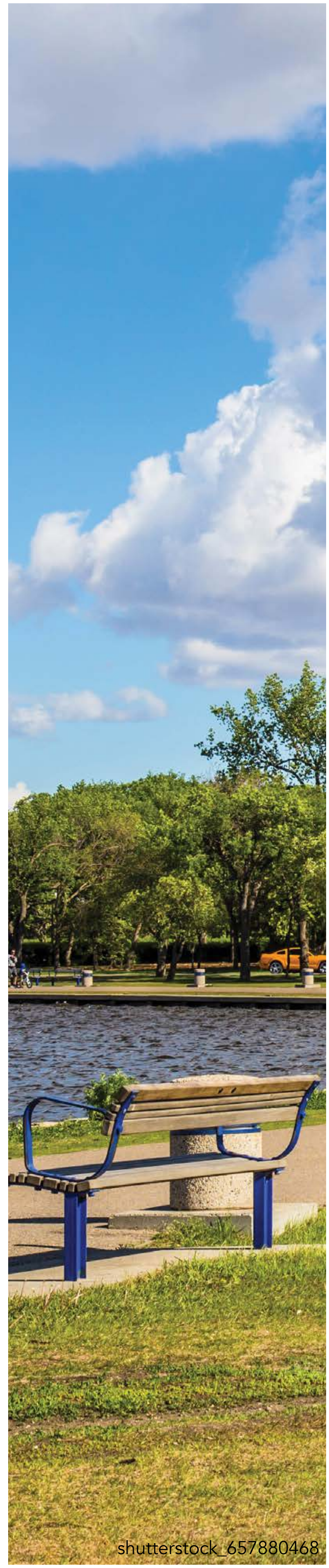
To gauge the effectiveness of the draft best practices to reduce flood risk and their financial feasibility for implementation, the Intact Centre asked workshop participants to rank each draft best practice on a scale from low to high.

Low ranking meant that the draft best practice was unlikely to lead to a significant flood risk reduction and/or is not practical to implement due to cost limitations.

Medium ranking meant that the draft best practice was likely to lead to flood risk reduction and/or may be practical to implement, under certain conditions.

High ranking meant that the draft best practice was very likely to lead to a significant flood risk reduction and/or is practical to implement (i.e., financially and technically), under most conditions.

Appendix E contains professional profiles of the workshop participants. Section 2.3 outlines the highest-ranked best practices for flood-resilient community design, as determined at the workshop and though national consultations.



2.3 FLOOD-RESILIENT COMMUNITY DESIGN BEST PRACTICES

Flood resilience in new residential communities is defined as the ability of the storm and sanitary infrastructure systems to perform as designed and to have capacity to minimize flood damages during some extreme events that exceed design capacities. Flood resilience also includes the siting of new communities beyond natural flood hazard areas.

There will inevitably be conditions and events that will exceed infrastructure system design capacities or extend natural hazards beyond regulated limits and may result in flood damages in vulnerable areas within communities where there are insufficient safety factors in place. However, the intent of the flood-resilient community design is to aid in reducing the negative impacts of these conditions and events, as well as to improve the recovery process following a flood. The report makes a key assumption that all new (greenfield) residential communities in Canada are designed in accordance with the following:

- Community design is in compliance with provincial, regional and local codes, standards and by-laws, which can also specify design and Regulatory Flood levels.

- Minor drainage systems are designed to convey runoff from 5-year recurrence-interval floods and more frequent rainfall events.

- Major drainage systems are designed to convey runoff for rainfall events, which exceed the capacity of the minor system and serve up to the design storm.

- Major and minor drainage systems are designed concurrently.

- Storm and sanitary sewer systems are fully separated.

- Sanitary sewers are designed to convey extraneous flow from frequent rainfall events without surcharging (i.e., water backing up) and from the design storm events without damaging property (as per the minimum threshold requirements for a given community).

- Watershed and sub-watershed studies (or area structure plans in Alberta), official land use and master drainage plans guide the modelling, design objectives and sizing of drainage infrastructure.

The draft best practices (below) are organized into six broad categories of flood-resilient residential community design considerations:

1. Design for resilience to address weather and operational uncertainties
2. Storm sewer design (minor drainage system considerations)
3. Sanitary sewer design (wastewater drainage system considerations)
4. Street design (major drainage system considerations)
5. Wastewater pumping station design
6. Preservation of natural features

For each draft best practice, specific feedback sought from the reviewers of this report is included in question format.

CATEGORY 1: DESIGN FOR RESILIENCE (DR)

DR1. New homes should not be built in the floodway. New homes should also not be built in the flood fringe, unless flood-proofing addresses flood risks in the flood fringe.

- Stakeholders noted that development in the floodplain (floodway and flood fringe) always runs a higher risk of flooding and therefore should be avoided.

- Stakeholders also noted that there is a significant degree of variation in how floodway and flood fringe are defined across Canada. Stakeholders expressed that consistent definitions of floodway and flood fringe should be developed and applied across all regions in Canada.

- Some stakeholders were divided on whether or not new community development should be permitted in the flood fringe.

- No matter the definitions, all stakeholders agreed that new community development should not be permitted in the floodway.

Feedback Sought:

- Should new homes be permitted to be built in the flood fringe?

- If yes, what are the most pertinent design considerations for new homes to be built in the flood fringe?

DR2. "Safety Factors" should be used in new community design to account for potentially more frequent and severe rainfalls and stormwater system failures. (e.g. locating buildings further distance away from the edge of the floodplain)

Stakeholders noted that safety factors should be used in the design of new developments to account for severe weather and operational uncertainty. At minimum, the following safety factors were recommended:

1. Factor of safety for the floodplain
2. Factor of safety for major drainage systems
3. Factor of safety for minor drainage systems

For example, a <u>safety factor for the floodplain</u> was introduced by the Government of Newfoundland and Labrador – Climate Change Flood Zone delineation. In Newfoundland and Labrador, a Climate Change Flood Zone is the area (based on the extension of a flood fringe) which is likely to be impacted due to the latest forecasted effects of climate change.[xxxi] New residential community development in the Climate Change Flood Zone is given the lowest preference (i.e., such development is the least likely to be approved by the Newfoundland and Labrador Department of Municipal Affairs and Environment). For any development in the 1-in-100 year and 1-in-100 year, climate-change-adjusted flood zones, the development has to be flood proofed to the 1-in-100 year, climate-change-adjusted flood elevation, plus 0.6 meters. The 0.6 meters is an additional factor of safety.
In addition to flood proofing, the Newfoundland and Labrador government requires that entrances and exits from the building can be used safely used, without hindrance, in the event of a flood.

Incorporating freeboard in floodplain mapping may be helpful to account for uncertainty when a quantitative approach to assessing the flood impacts is not feasible. Some stakeholders noted that factors of safety could take the form of buffers from the floodplain. For example, Toronto Region Conservation Authority uses horizontal (10 meter) and vertical (0.3 to 0.5 meter) buffers from the floodplain to establish development limits.

<u>Safety factors for major and minor drainage systems</u> that were suggested also relied on freeboard considerations (i.e., adding extra height to a flood elevation to account for uncertainties in precipitation and to account for inaccuracies during the construction of a community).

Stakeholders noted that updated Intensity-Duration-Frequency (IDF) curves, downscaled General Circulation Models and updated hyetographs and runoff coefficients could be used to account for climatic uncertainties.

Some stakeholders mentioned that Intensity-Duration-Frequency under Climate Change (IDFCC), a computerized tool developed by Western University Professor Slobodan Simonovic, could be leveraged to draw future climate change projections to adjust IDF curves for any province in Canada.[xxii] Stakeholders also identified other online climate service tools that can be used to carry out climate projections, such as the Climate Change Hazards Information Portal (CCHIP).

It is important to distinguish relative strengths and weaknesses of these tools prior to their use and application.

Lastly, some stakeholders noted that over time, there may be a degradation of safety factors (e.g., gradual accumulation of grease in sewers, urbanization) and consideration should be given to their longer-term efficacy.

Feedback Sought:

- What safety factors should be used to account for operational and design uncertainty in a new community design?

- What safety factors should be used to account for climate uncertainty in floodplain estimation?

DR3. New development should not increase the risk of flooding for existing communities.

- Stakeholders noted that new developments add impervious area. Where poor master planning and stormwater management strategies are in place, this may introduce a greater burden on the existing drainage systems, increasing the risk of flooding for existing developments.

- Stakeholders recommended that modelling should be completed at a watershed scale to account for future land use when developing flood plain mapping.

- Stakeholders noted that a useful target would be to set post-development peak flow rates not to exceed the corresponding pre-development peak flow rates for stormwater runoff during design storm events.

- For riverine development, stakeholders suggested that encroachment analysis and hydraulic modeling should demonstrate that the impact of new development on water levels for adjacent developments is negligible.

Feedback Sought:

- What are critical considerations for analyzing flood impacts of new development on downstream and existing communities?

DR4. New development should be designed to minimize the risk of basement flooding from groundwater infiltration.

- Stakeholders noted that additional clarity about groundwater seepage risk and how it can be minimized in new developments is required.
- In some areas, where groundwater levels are high, basements should not be constructed, or should be sufficiently protected from seepage.
- Some suggested that a hydrogeological assessment should be completed prior to new development approvals being granted.

Feedback Sought:

- What are critical considerations for assessing and minimizing groundwater seepage risk for new developments?

DR5. Heating, ventilation and air conditioning (HVAC), fuel and electrical systems should be well-elevated from the basement floor or located above grade.

- Stakeholders noted that HVAC systems (including air conditioning compressors, heat pumps, furnaces, ductwork); fuel systems (including natural gas lines and fuel storage tanks); and electrical systems (including wiring, switches, outlets, fixtures, and fuse and circuit breaker panels) all need to be elevated and secured in case basement flooding does occur.

- Isolation of electrical systems (e.g., turning off the electricity to the circuit) located in the basement was noted as good practice.

Feedback Sought:

- What are critical considerations for HVAC, fuel and electrical systems in the context of flood-resilient residential community design?

CATEGORY 2: STORM SEWER DESIGN (STO)

STO1. If the home foundation drainage system connects to a storm sewer*:

» the water level in the storm sewer should stay at least 30 cm lower than the foundation drainage system during a major design event (e.g., 1-in-100-year flood event) AND

» a backwater valve should be installed on the storm sewer lateral to prevent stormwater from backing up into the basement if the storm sewer is overloaded; this backwater valve should be accessible for maintenance.

- Backwater valves on storm sewer laterals can mitigate against storm sewer backups when the storm sewers are overburdened during extreme rain events and the design capacity of the storm sewer system is exceeded.
- Stakeholders were divided on whether storm sewer connections to foundation drains should be a requirement for new developments or not. Stakeholders who supported the idea of storm sewer connections suggested weeping tile discharge to ground surface needs to be avoided, as it may lead to icing or algae growth on sidewalks.
- Stakeholders suggested that a freeboard of 30 cm should be included between the underside of the foundation footing and the hydraulic grade line of the storm sewer, in the event of a surcharge of the minor system (e.g., during extreme rain events).
- For properties adjacent to the floodplain and where the hydraulic grade line can be affected by the flood level in the floodplain, a freeboard of 50 cm was suggested.

Feedback Sought:

- What are critical considerations for determining freeboard requirements for a minor drainage system?
- Should the freeboard be determined as the distance between the finished floor slab and the hydraulic grade line of the storm sewer for easier measurement?
- What are the pros and cons for requiring backwater valves on storm sewer laterals?
- What are key considerations for accessibility to backwater valves for easier maintenance?

STO2. If the home foundation drainage system does not connect to the storm sewer*:

» sump pumps should be installed and equipped with one or more backup power systems.

Feedback Sought:

- Is there any freeboard required if sump pumps are installed?

**Alternatively, a separate foundation drain collector system should be provided, with no risk of backing up to basement levels during the design flood events.*

STO3. Inlet control devices (ICDs) should be used to restrict the flow of stormwater from the street into storm sewers.

- This draft best practice was effective in reducing flooding in the Cities of Ottawa and Calgary by limiting the inflow of rainwater into the storm sewer during extreme rain events.
- Stakeholders noted that ICDs could be used in catch basins, along with flow controls located at the external inflow locations, to ensure that inflow of storm water does not surpass the design capacity of the storm sewer.
- Stakeholders recommended that the design capacity of the storm sewer should include surcharge conditions with adequate freeboard to basement elevations. They also noted that consideration should be given to the overland drainage and to the depth and extent of ponding on the road during the design storm events.
- Stakeholders noted that ICDs should be inspected and cleaned on a regular basis and that maintenance staff should not easily remove them during routine maintenance.

Feedback Sought:

- What are critical considerations for inlet control device implementation for new community developments?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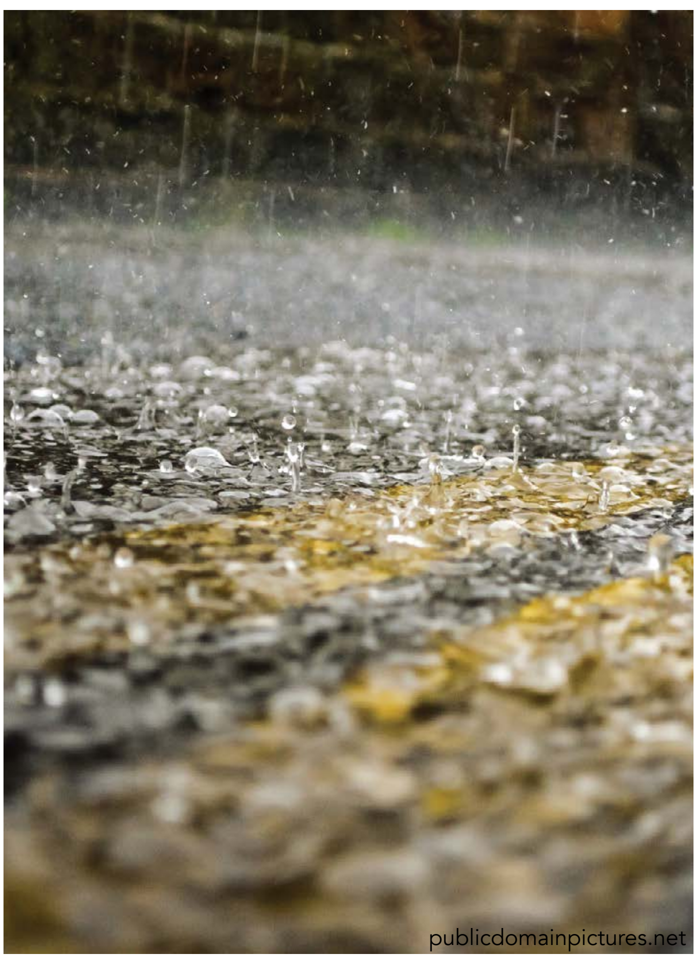
CATEGORY 3: SANITARY SEWER DESIGN (SAN)

SAN1. Basements connected to sanitary sewers should have a backwater valve to mitigate sewage backup into the basement if the sanitary sewer is overloaded (e.g., during heavy rain).

- This draft best practice aims to minimize the risk of sanitary sewer backups during extreme rainfall through installation of backwater valves.
- Stakeholders noted that backwater valves should be accessible for regular maintenance by the property owner/resident.
- Stakeholders noted that homeowner education on backwater valve inspection and maintenance is critical.

Feedback Sought:

- What are critical maintenance and accessibility requirements applicable to backwater valves?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SAN2. Downspout, foundation drain and sump pump discharge should not be directed to the sanitary sewers.

- This draft best practice aims to minimize sanitary sewer backups during extreme rainfall

.

- Most stakeholders agreed this is a critical/mandatory best practice. Most stakeholders also noted that backup power for sump pumps is an important consideration, as power outages are frequent during floods.
- Stakeholders noted that sump pump discharge has to connect to the nearest storm sewer. If that is not an option, sump pumps need to discharge far enough from the basement foundation to prevent/minimize flow from coming back into the basement.
- Stakeholders noted that discharging downspouts to a pervious area may be problematic, due to icing issues in the winter and algae growth in the summer.
- Stakeholders noted that discharging downspouts to pervious areas tends to attenuate peak flow rates and volumes in the storm system; however, downspouts should not discharge too close to homes to avoid basement infiltration.
- Specific requirements can consist of the discharge distance being at least 2 meters away from the house, with at least a 2% grade distance from the house.

Feedback Sought:

- Under what circumstances should downspouts be allowed to connect to the storm sewer?
- What are the minimum distance and slope requirements for discharge to a pervious area?
- What is the optimal backup power solution for sump pumps?
- What are critical considerations for sump pump design and selection?

SAN3. Design of sanitary sewers should have a factor for "Normal" infiltration of rainwater during typical rain events and a higher "Safety Factor" for infiltration and inflow during extreme rain events.

- Stakeholders noted that a certain amount of infiltration and inflow (I&I) is unavoidable and is accounted for in the sanitary sewer design. During extreme rain events, I&I frequently exceeds traditional design allowances, increasing the risk of sewer overflows and backups.
- Some stakeholders noted that the I&I design allowances from the Federation of Canadian Municipalities' (FCM) InfraGuide (2003) "Infiltration/Inflow Control/Reduction for Wastewater Collection Systems" are highly variable and while these may be appropriate for typical "base flow" conditions, they may be of limited value for new community design, specifically when considering extreme wet weather conditions.
- Others suggested that a stress test should be used to account for "extreme weather I&I" demonstrating that sewer surcharge does not result in excessive surcharge (i.e., a freeboard between 100-year hydraulic grade line and basement elevation remains similar to storm system design).
- Stakeholders noted that the safety factor would change over time (see comments in DR1.)

Feedback Sought:

- What are key considerations to determine an appropriate Safety Factor for I&I during extreme rain events?

CATEGORY 4: STREET DESIGN (SD)

SD1. Roads and public spaces should be designed to convey excess runoff so that it does not flow through homeowner property.

- Stakeholders suggested that overland flow routes should be contained on public property to avoid potential obstruction and maintenance issues if they are located on private land.
- Some stakeholders noted that landowners might build over the overland flow routes or neglect their maintenance.
- Moreover, in a large city, there can be too many kilometers of such overland flow routes to effectively inspect and maintain. Therefore, some stakeholders suggested that stringent protection for these features is warranted.
- Lastly, some stakeholders noted the importance of protecting rear yard catch basins, where applicable, through easement agreements.

Feedback Sought:

- Do easement agreements enable sufficient protection of the overland flow routes or should the overland flow routes be contained on public property?

SD2. Road design and lot grading should be such that the water on the road remains at least 30 cm below the lowest building openings (e.g., basement windows) during design flood conditions.

- This draft best practice aims to reduce adverse impacts of overland flooding.
- Stakeholders suggested that a freeboard of 30 cm should be included between the overland flow runoff water level and the lowest building opening for storms in excess of 1-in-5 years and up to the 100-year storm.
- Stakeholders noted that freeboard requirements should differ based on the road types (e.g., arterial, major collector, and local roads). They suggested that the freeboard should be lower for high speed, high traffic roads and high for residential roads.

Feedback Sought:

- What is an appropriate level of freeboard for a major drainage system?

SD3. Roads should be designed so that the maximum depth of water during the extreme design condition does not exceed 30 cm at the curb.

- Some stakeholders noted that a maximum allowable flow depth needs to be defined for roads.
- Some stakeholders noted that emergency vehicle access is limited to 35 cm of water.

Feedback Sought:

- What is the maximum depth of ponding on the right of way that should be permitted?

SD4. Driveways should be built to slope away from homes or garages (i.e., reverse-slope driveways should not be permitted).

- This draft best practice aims to prevent overland flooding through runoff entering through depressed driveways.
- Some stakeholders noted that changes to zoning and building height limits might be required to support the uptake of this draft best practice. For example, if a community has restrictions on the maximum building height, such restrictions may "push buildings down into the ground." Therefore, the implementation of this draft best practice may depend on zoning and building height limits amendments.

Feedback Sought:

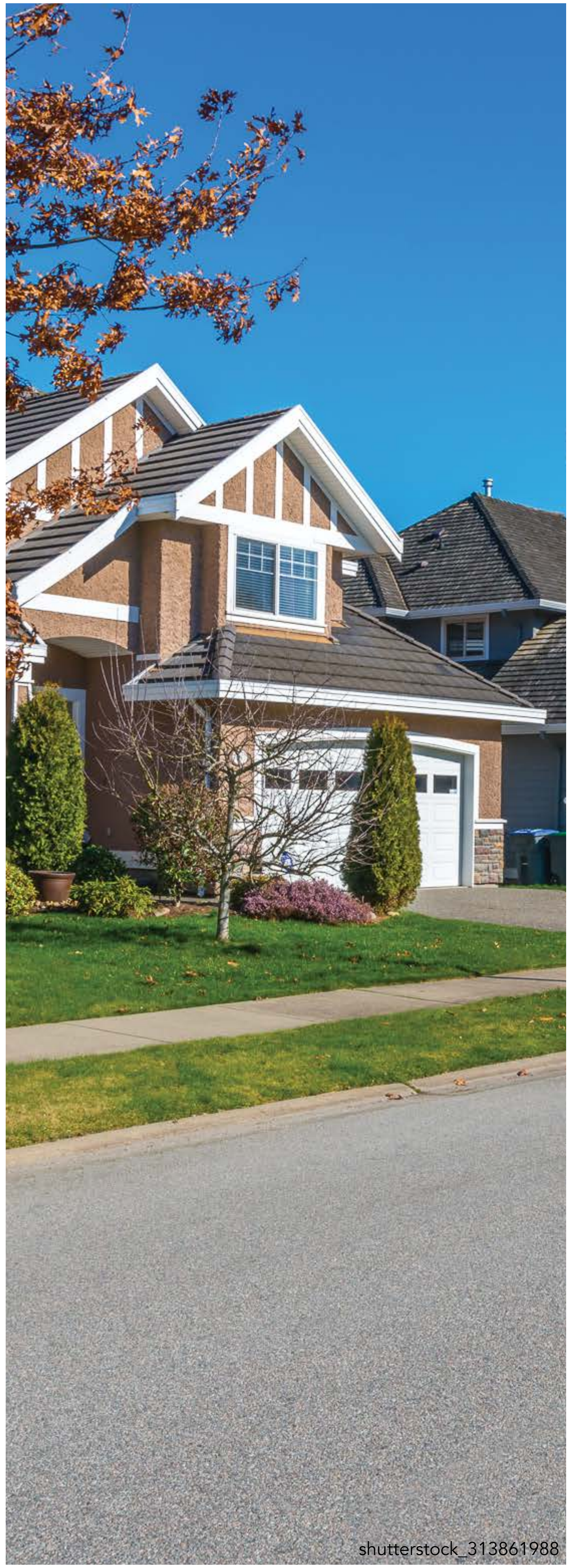
- What are key implementation challenges to restricting depressed driveway construction for new low-rise residential communities?

SD5. Sanitary sewer manholes should not be located in low-lying areas. If sanitary sewer manholes need to be located in low-lying areas, manhole covers should be sealed to minimize inflow of accumulated runoff into the sanitary sewer.

- Stakeholders noted that venting of sanitary sewers is important, as there may be gas build-up in the sewers, if the manhole covers are sealed.
- Others suggested that sealed manhole covers should be used in all cases to minimize inflow during critical events (unless ventilation issues dictate otherwise).
- Stakeholders also suggested that it is important to prescribe appropriate manhole sealing methods and materials (e.g., the use of rubberized products).

Feedback Sought:

- What are key considerations for manhole sealing in new developments?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CATEGORY 5: WASTEWATER PUMPING STATION DESIGN (WP)

WP1. Wastewater pumping stations should be located in areas where they will remain operational and fully accessible during extreme rain events.

- Stakeholders noted that pumping stations might fail during extreme events.
- Lawsuits have emerged from pumping station failure, which has caused property damages due to sanitary sewer backups.
- Some stakeholders suggested that critical equipment within wastewater pumping stations should be located above the 1-in-100-year flood hydraulic grade line level.

Feedback Sought:

- What is the appropriate level of service for wastewater pumping stations?
- Should there be a freeboard requirement for wastewater pumping stations, consistent with a major system freeboard?

WP2. Wastewater pumping stations should have backup power to allow for a minimum of 48 hours of uninterrupted service and an overflow in case of catastrophic failure.

Feedback Sought:

- What is the appropriate duration for backup power for wastewater pumping stations?

CATEGORY 6: PRESERVATION OF NATURAL FEATURES (PNF)

PNF1. Development should not encroach on riparian buffers (land and natural vegetation adjacent to water-bodies), and sufficient setbacks should be maintained along the water bodies to reduce the risk of flooding due to stream movement and bank erosion.

- Stakeholders noted that protection of riparian buffers and meander belts (lands across which streams can shift from time to time, especially during flooding) is critical to achieve flood risk reduction.
- Over time, banks of lakes, rivers and streams can erode and alter floodplain delineation.
- Stakeholders noted that setbacks should account for such potential changes in the floodplain (DR2) and that riparian buffers should remain in public ownership.

Feedback Sought:

- What are key considerations for determining minimum setbacks along water bodies and minimum vegetated buffer zones?

PNF2. New development should aim to minimize runoff from impervious areas.

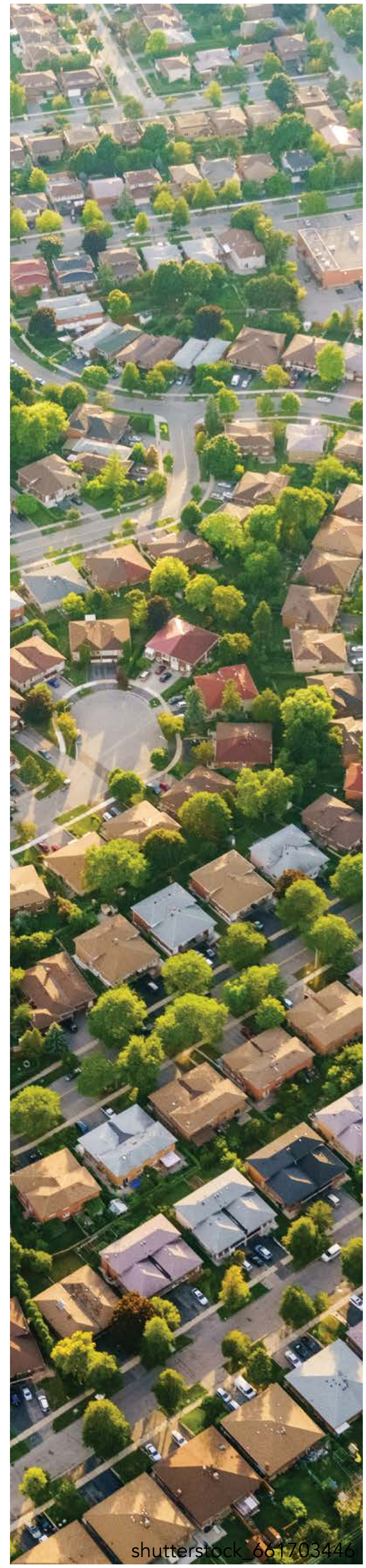
- Stakeholders noted that impervious areas, such as asphalt roads, paved parking lots, driveways, sidewalks and building rooftops prevent stormwater from soaking into the ground. These areas generate more runoff and transport it more quickly than pervious surfaces, such as lawns, parks, etc., to discrete locations, which may affect flooding.
- Stakeholders noted that new developments should be designed to minimize runoff from impervious surfaces.
- Some stakeholders noted that post-development peak flow rates should not exceed the corresponding pre-development peak flow rates for the design storm events (DR3). The role of techniques that promote infiltration, reuse and rainwater harvesting could be considered, where feasible.

Feedback Sought:

- What are key considerations for determining impervious surface area limits?

3. NATIONAL STANDARD FOR FLOOD-RESILIENT RESIDENTIAL COMMUNITY DESIGN: ENABLING ENVIRONMENT

It is expected that a flood-resilient residential community design standard will help streamline the construction of communities that would be less prone to flooding. The following initiatives would further complement the standard and support flood risk reduction in Canada:



- **Up-to-date, forward-looking floodplain maps:** Current floodplain maps underpin any flood management effort. Accordingly, modelling, topographic and land development information to derive floodplain maps should be updated on a periodic basis and should incorporate future weather projections and uncertainty. Guidance contained in the Federal Floodplain Mapping Framework developed by Natural Resources Canada and Public Safety Canada should be used for any new developments in Canada. Other documents under development, which can aid in floodplain mapping efforts, include Federal Hydrologic and Hydraulic Procedures for Floodplain Delineation, Federal Geomatics Guidelines for Floodplain Mapping and Case Studies on Climate Change in Floodplain Mapping.[xxxiii] A review of hydrologic and hydraulic modelling calibration techniques, including data collection, is another important area of focus where guidance may be required.

- **Consistent definition of floodway and flood fringe:** The variation in how provinces and territories define the terms "floodway" and "flood fringe" hinders efforts to streamline flood management in Canada. Natural Resources Canada and Public Safety Canada need to develop nationally acceptable definitions of floodway and flood fringe, which will guide decisions about permissible land use for new residential developments in Canada.

- **Homeowner education:** Homeowners play a critical role in reducing flood risk and maintaining flood resiliency in their community. Homeowners need to be aware of their responsibilities in flood risk management (such as maintain proper lot grading around houses, ensure that backwater valves and sump pumps are in operational condition and keep drainage swales and catch basins free of dirt and debris). Homeowners also need to be aware of flood mitigation technologies, such as inlet control devices, which may lead to occasional "nuisance" flooding on the street. Therefore, regular outreach to homeowners is necessary; especially, as when home ownership changes, knowledge of proper maintenance activities may be lost.

- **Ongoing maintenance:** Some stakeholders suggested that a maintenance standard needs to be developed to ensure that a "flood-resilient community" remains flood-resilient over time. To address this need, CSA Group is working to develop a lot-level flood risk assessment standard. The utility of the standard is that it can be applied both to new and existing communities in Canada to assess the flood-resiliency of a home. Assuming municipal assets are maintained in a state of good repair, this standard can be applied within "flood-resilient communities" to ensure that they remain flood-resilient over time.

- **Inspections and monitoring:** Stakeholders noted the importance of ensuring that new communities are 1) built as designed, and 2) perform as designed. Stakeholders recommended that as-built drawings, certified by a professional engineer, should be mandated prior to local governments' assumption of any new developments to confirm that flood-resilient residential community design best practices were integrated. Stakeholders suggested that third party testing could be used to confirm the quality of design, for example, testing of sanitary sewers for water tightness (to reduce the probability of leaks).

- **Engagement with developers and homebuilders:** To ensure the uptake of a flood-resilient residential community design standard, early engagement with developers and homebuilders is critical. Grandfathering policies (where old flood management rules continue to apply, while new standards will need to be met in all future cases), could be used for development approvals. Furthermore, local governments may consider amending certain by-laws and zoning requirements to incentivize the adoption of a flood-resilient community design standard.

4. CONCLUSION AND NEXT STEPS

This report outlines the urgent need for flood risk reduction in Canada in light of the rising economic costs associated with flood damages, mortgage market stresses and legal liabilities. The report establishes a transparent and streamlined approach for flood risk reduction for new (low-rise, greenfield) residential communities built in Canada through the identification of critical best practices, which, if collectively implemented, can lead to new communities being less prone to flooding.

The expectation is that these critical draft best practices will serve as a foundation for the subsequent development of a National Standard of Canada.

There are 20 draft best practices outlined in the report, for which specific stakeholder feedback is being sought, as per the questions presented in Section 2.3.

In addition, the Intact Centre welcomes comments on:

- The effectiveness of best practices to reduce flood risk and their practicality (technical and cost) for implementation;
- Suggestions of additional best practices that can lead to flood risk reduction for new residential communities in Canada; and
- Discussion of barriers to implementation, which may hinder the uptake of best practices.

Following stakeholder consultation, the Intact Centre will assess all feedback received and pursue the development of a national standard.

Stakeholder Consultation Details

The stakeholder consultation period ends October 31, 2017.

Electronic submissions are preferred and should be sent to Natalia Moudrak: nmoudrak@uwaterloo.ca

Written submissions can be mailed to:

Attention: Natalia Moudrak
Intact Centre on Climate Adaptation
Faculty of Environment, University of Waterloo
EV3 4334 - 200 University Avenue West
Waterloo, ON, CANADA, N2L 3G1

An electronic version of this document is available on the Intact Centre's website at:
http://www.intactcentreclimateadaptation.ca/programs/natural-infrastructure-adaptation-program

Please note that the Intact Centre intends to make submissions received publicly available. If you indicate that you do not want your submission or specific parts of your submission to be public, we will treat the submission, or the designated parts, as confidential.

APPENDIX A: DEFINING REGULATORY FLOOD, FLOODWAY AND FLOOD FRINGE IN CANADA (SOURCES)

Province/ Territory	Source(s):
British Columbia	Province of British Columbia. Ministry of Forests, Lands, and Natural Resource Operations. Floodplain Mapping Definitions. 1994. Accessed at: http://www.env.gov.bc.ca/wsd/data_searches/fpm/definitions.html Province of British Columbia. Ministry of Water, Land and Air Protection. Flood Hazard Area Land Use Management Guidelines. 2004. Accessed at: http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/guidelines-2011.pdf Government of Canada. Environment and Climate Change Canada. Flood Damage Reduction Program. 2013. Accessed at: https://ec.gc.ca/eau-water/default.asp?lang=En&n=0365F5C2-1
Alberta	Alberta Environment. Water Management Operations, River Forecast Section. Flood Hazard Identification Program Guidelines. 2011. Accessed at: https://www.alberta.ca/albertacode/images/Flood-Hazard-Identification-Program-Guidelines.pdf Government of Alberta. Environment and Parks. Flood Hazard Mapping. 2017. Accessed at: http://aep.alberta.ca/water/programs-and-services/flood-hazard-identification-program/flood-hazard-mapping.aspx
Saskatchewan	City of Regina, Saskatchewan. The Statements of Provincial Interest Regulations, Chapter P-13.2 Reg 3. 2012. Accessed at: http://www.publications.gov.sk.ca/freelaw/documents/English/Regulations/Regulations/P13-2R3.pdf Government of Canada. Environment and Climate Change Canada. Flood Damage Reduction Program. 2013. Accessed at: https://ec.gc.ca/eau-water/default.asp?lang=En&n=0365F5C2-1
Manitoba	MMM Group Limited. Public Safety Canada. National Floodplain Management Assessment – Final Report. 2014. Accessed at: https://www.slideshare.net/glennmcgillivray/national-floodplain-mapping-assessment
Ontario	Government of Ontario. Ministry of Municipal Affairs and Housing. Provincial Policy Statement. 2014. Accessed at: http://www.mah.gov.on.ca/page10679.aspx Ontario Ministry of Natural Resources. Technical Guide, River & Stream Systems: Flooding Hazard Limit. 2002. Accessible at: http://www.renaud.ca/public/Environmental-Regulations/MNR%20Technical%20Guide%20Flooding%20Hazard%20Limit.pdf
Quebec	Gouvernement du Québec. Centre de services partagés du Québec. Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains - Environment Quality Act. 2005. Accessed at: http://legisquebec.gouv.qc.ca/en/ShowDoc/cr/Q-2,%20r.%2035
New Brunswick	Government of New Brunswick. Environment and Local Government. Defining a Flood Plain. 2017. Accessed at: http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/flood/flood_plain.html
Nova Scotia	Government of Nova Scotia. Municipal Government Act. Statements of Provincial Interest. 2001, 2013. Accessed at: https://novascotia.ca/just/regulations/regs/mgstmt.htm
Newfoundland and Labrador	Government of Newfoundland and Labrador. Department of Municipal Affairs and Environment. Policy for Flood Plain Management. 1996, 2014. Accessed at: http://www.mae.gov.nl.ca/waterres/regulations/policies/flood_plain.html
Northwest Territories	Institute for Catastrophic Loss Reduction. An Assessment of Flood Risk Management in Canada. 2013. Accessed at: https://www.iclr.org/images/An_Assessment_of_Flood_Risk_Management_in_Canada.pdf
Nunavut	Institute for Catastrophic Loss Reduction. An Assessment of Flood Risk Management in Canada. 2013. Accessed at: https://www.iclr.org/images/An_Assessment_of_Flood_Risk_Management_in_Canada.pdf

APPENDIX B: EXAMPLES OF PROVINCIAL GUIDELINES, ACTS AND POLICIES AND MUNICIPAL BY-LAWS FOR FLOOD MANAGEMENT

CATEGORY 1: DESIGN FOR RESILIENCE (DR)

The following are draft best practices and examples of related municipal by-laws (and, where applicable, examples of Provincial Guidelines, Acts and Policies).

DR1. New homes should not be built in the floodway. New homes should also not be built in the flood fringe, unless flood-proofing addresses flood risks in the flood fringe.

Alberta	Government of Alberta. Flood Hazard Identification Program Guidelines. Alberta Environment, Water Management Operations, River Forecast Section. July 2011. "In extreme flood hazard areas such as floodways, appropriate development would mean uses that would not adversely affect flood elevations and that would minimize threats to public safety while decreasing the potential for flood damages. For the floodway, appropriate development would typically be non-obstructive development or infrastructure that needs to be near the river (such as a drain outlet)." https://www.alberta.ca/albertacode/images/Flood-Hazard-Identification-Program-Guidelines.pdf
British Columbia	Province of British Columbia. Flood Hazard Area Land Use Management Guidelines. Ministry of Water, Land and Air Protection. May 2004: "Official Community Plans must contain general land use policy statements and maps respecting restrictions on the use of land that is subject to hazardous conditions [e.g., flood prone areas]" http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/guidelines-2011.pdf
Manitoba	Government of Manitoba. The Planning Act. Provincial Planning Regulation. June 20, 2011. "5.2.1 Land subject to flooding, erosion and bank instability or that has been designated under the Designated Flood Area Regulation, Manitoba Regulation 59/2002, must be identified. Development of this land may be permitted only if the risks are eliminated or ways are identified to ensure that a) no additional risk to life, health or safety is created as a result of development; b) buildings and other things constructed, such as septic fields, are protected from the risks related to flooding, erosion and bank instability; and c) water flow, velocities and flood levels will not be adversely altered, obstructed or increased as a result of development. 5.2.2 Appropriate flood protection and mitigation measures must include the following: a) the identification of protection levels i) for land subject to flooding, that maintain a minimum 0.67 metres (two feet) of free board at a flood level equalling the design flood, and ii) for lands adjacent to lakes and large reservoirs, incorporate the effects of wind set-up and wave uprush." http://web2.gov.mb.ca/laws/regs/current/081.11.pdf
New Brunswick	Government of New Brunswick Community Planning Act, Interpretation (Flood Risk Area By-Law). Chapter C-12. Jan 2015. "41.1(1) Where a municipality requests, the Minister may designate any area within the municipality to be a flood risk area. 41.2(4) A flood risk area by-law may prohibit development that would obstruct or interfere with the normal floodway or free flow of flood waters during a flood period. 41.2(5) A flood risk area by-law may require that all development in a flood risk area or in any portion thereof shall be carried out so as not to reduce the flood water storage capacity of such area, and may prohibit development in any other manner." https://www.canlii.org/en/nb/laws/stat/rsnb-1973-c-c-12/latest/rsnb-1973-c-c-12.html

Newfoundland and Labrador	Government of Newfoundland and Labrador. Policy for Flood Plain Management. Municipal Affairs and Environment. 2014. 2014. "6.01 Development in a designated flood risk area, development in a flood plain and development in a climate change flood zone shall be subject to the prior written approval of the Minister of Environment and Conservation (the "Minister") in accordance with the Act. AND Residential and other institutional development is Not Permitted in all Flood Plains, and in Floodway (1:20 year Zone), where Flood Plains are Designated." http://www.mae.gov.nl.ca/waterres/regulations/policies/flood_plain.html
Nova Scotia	Government of Nova Scotia. Statements of Provincial Interest, Section 193 and subsections 194(2) and (5), Municipal Government Act. 2013. "For Flood Risk Areas that have been mapped under the Canada-Nova Scotia Flood Damage Reduction Program planning documents must be reasonably consistent with the following: (a) within the Floodway, (i) development must be restricted to uses such as roads, open space uses, utility and service corridors, parking lots and temporary uses, and (ii) the placement of off-site fill must be prohibited; (b) within the Floodway Fringe, (i) development, provided it is floodproofed, may be permitted, except for (1) residential institutions such as hospitals, senior citizen homes, homes for special care and similar facilities where flooding could pose a significant threat to the safety of residents if evacuation became necessary, and (2) any use associated with the warehousing or the production of hazardous materials, (ii) the placement of off-site fill must be limited to that required for floodproofing or flood risk management." https://novascotia.ca/just/regulations/regs/mgstmt.htm
Ontario	Government of Ontario. Ontario Provincial Policy Statement, Under the Planning Act. Provincial Planning Policy Branch, Ministry of Municipal Affairs and Housing. 2014. "Development shall generally be directed to areas outside of a) hazardous lands adjacent to the shorelines of the Great Lakes - St. Lawrence River System and large inland lakes which are impacted by flooding hazards, erosion hazards and/or dynamic beach hazards; b) hazardous lands adjacent to river, stream and small inland lake systems which are impacted by flooding hazards and/or erosion hazards; and c) hazardous sites." "Development and site alteration shall not be permitted within: a) the dynamic beach hazard; b) defined portions of the flooding hazard along connecting channels (the St. Marys, St. Clair, Detroit, Niagara and St. Lawrence Rivers); c) areas that would be rendered inaccessible to people and vehicles during times of flooding hazards, erosion hazards and/or dynamic beach hazards, unless it has been demonstrated that the site has safe access appropriate for the nature of the development and the natural hazard; and d) a floodway regardless of whether the area of inundation contains high points of land not subject to flooding." "Where the two zone concept for flood plains is applied, development and site alteration may be permitted in the flood fringe, subject to appropriate floodproofing to the flooding hazard elevation or another flooding hazard standard approved by the Minister of Natural Resources." http://www.mah.gov.on.ca/AssetFactory.aspx?did=10463 Ontario Ministry of Natural Resources. Technical Guide, River & Stream Systems: Flooding Hazard Limit. 2002. Accessible at: http://www.renaud.ca/public/Environmental-Regulations/MNR%20Technical%20Guide%20Flooding%20Hazard%20Limit.pdf
Prince Edward Island	Government of Prince Edward Island (PEI). Coastal Property Guide: What you should know about living on PEI's coast. PEI Department of Communities, Land and Environment. 2016. "Within the provincial planning jurisdiction, a subdivision of a coastal property(s) must allow for: A coastal subdivision buffer that is at least 18.3 m (60 ft) wide, or 60 times the annual rate of erosion." Almost all activity within the Buffer Zone is prohibited. Within the Buffer Zone, you need a permit to: build, repair, or remove structures or obstructions, including seasonally removable stairways and floating docks." https://www.princeedwardisland.ca/sites/default/files/publications/prince_edward_island_coastal_property_guide.pdf

Quebec	Government of Quebec. Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains Q-2, r.35, Environment Quality Act. Publications Quebec. "4.1. Prior authorization for activities in floodplains: All structures, undertakings and works that are liable to alter the water regime, interfere with the free flow of water during flood periods, disturb plant or wildlife habitats or threaten the safety of persons or property are subject to prior authorization. The pre-verification should be performed as part of the process when permits or other forms of authorization are issued by municipal authorities, the Government or its departments or bodies, according to their respective jurisdictions. The authorizations granted by municipal and government authorities are to take into account the scope for action allowed by the measures relating to floodplains, protect the integrity of the environment and ensure that the free flow of water is maintained. 4.2. Measures relating to the high-velocity zones of floodplains: All structures, undertakings and works are in principle prohibited in the high-velocity zone of a floodplain and in identified floodplains where high-velocity zones are not distinguished from low-velocity zones, subject to the measures under Subsections 4.2.1 and 4.2.2." http://legisquebec.gouv.qc.ca/en/ShowDoc/cr/Q-2,%20r.%2035
Saskatchewan	Government of Saskatchewan. Statements of Provincial Interest, 2012. "To assist in meeting the province's public safety interests, planning documents and decisions shall, insofar as is practical: 1. Identify potential hazard lands and address their management; 2. Limit development on hazard lands to minimize the risk to public or private infrastructure; 3. Prohibit the development of new buildings and additions to buildings in the flood way of the 1:500 year flood elevation of any watercourse or water body; 4. Require flood-proofing of new buildings and additions to buildings to an elevation 0.5 metres above the 1:500 year flood elevation of any watercourse or water in the flood fringe" http://www.publications.gov.sk.ca/freelaw/documents/English/Regulations/Regulations/P13-2R3.pdf

DR2. "Safety Factors" should be used in new community design to account for potentially more frequent and severe rainfalls and stormwater system failures. (e.g. locating buildings further distance away from the edge of the floodplain)

Alberta	Specific policy references not found.
British Columbia	Government of British Columbia, Professional Practice Guidelines: Legislated Flood Assessments in a Changing Climate in BC, APEGBC V1.1, Natural Resources Canada. 2012. "Practitioners should recognize that the effect of changes in land use, hence storm runoff, may have to be superimposed on projections of hydroclimatic change to arrive at the most appropriate estimates of future flood flows. This is particularly important in urbanizing areas, where dramatic changes in storm runoff accompany land use conversion." https://www.apeg.bc.ca/getmedia/18e44281-fb4b-410a-96e9-cb3ea74683c3/APEGBC-Legislated-Flood-Assessments.pdf.aspx
Manitoba	Government of Manitoba. Provincial Planning Regulation, The Planning Act, C.C.S.M. c. P80. 2011. "5.2.2 c) In areas where the flooding and erosion risks cannot be readily defined, that the required set-back for permanent structures from water bodies be at least 10 times the height of the bank above the normal summer water level or 30 metres, whichever is greater, unless a geotechnical engineering investigation shows that the set-back may be altered without creating any additional risks." http://web2.gov.mb.ca/laws/regs/current/081.11.pdf Government of Manitoba. Planning Resource Guide: Climate Change Adaptation through Land Use Planning. 2015. Through development plans, secondary plans and zoning by-laws, municipalities are required to: "Ensure planning takes account of future trends in flooding. Use geographic information systems (GIS) and climate models to guide development away from flood prone areas. Designate these areas in the development plan for agricultural or recreational uses rather than residential or commercial. Use the zoning by-law to re-site infrastructure and routes so that disruption during flooding is minimized." https://digitalcollection.gov.mb.ca/awweb/pdfopener?smd=1&did=23005&md=1

New Brunswick	Government of New Brunswick. Climate Change Action Plan 2007-1012, Planning Policy. Department of Environment, New Brunswick. 2007. "The Province is developing a provincial planning policy to guide development to appropriate locations. This policy will be an integrated initiative designed to develop statements of provincial interest, such as coastal areas protection, smart growth for settlement patterns, floodplain and drinking-water protection, and industrial uses. It will also set out the framework for delivery and implementation at the provincial, regional and local levels necessary to protect these interests and promote sustainable communities. A provincial planning policy will organize and direct development activity with consideration of its impacts on the environment, society and the economy. Climate change predictions will be considered in land, air and water planning." http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/2007-2012ClimateChangeActionPlan%20.pdf
Newfoundland and Labrador	Government of Newfoundland and Labrador. Policy for Flood Plain Management. Department of Municipal Affairs and Environment. 2014. "Development Requires Written Approval Development in a designated flood risk area, development in a flood plain and development in a climate change flood zone shall be subject to the prior written approval of the Minister of Environment and Conservation (the "Minister") in accordance with the Act." http://www.ecc.gov.nl.ca/waterres/regulations/policies/flood_plain.html
Nova Scotia	Government of Nova Scotia. Municipal Climate Change Action Plan Guidebook, Canada-Nova Scotia Agreement on the Transfer of Federal Gas Tax Funds. Service Nova Scotia and Municipal relations Canada-Nova Scotia infrastructure Secretariat. November 2011."For new infrastructure projects climate change risk assessment should be included in the 'Request for Proposal' for the design engineer to consider." http://www.fcm.ca/Documents/tools/PCP/municipal_climate_change_action_plan_guidebook_EN.pdf
Ontario	Government of Ontario. Provincial Policy Statement, Under section 3 of the Planning Act. Ontario Ministry of Municipal Affairs and Housing. 2014. "Planning authorities shall consider the potential impacts of climate change that may increase the risk associated with natural hazards." http://www.mah.gov.on.ca/AssetFactory.aspx?did=10463
Prince Edward Island	Government of Prince Edward Island. Report of the Task Force on Land Use Planning Policy. January 2014. Task Force on Land Use Policy recommended that the Province "Prohibits or regulates development in areas potentially at risk from flooding, storm surges and the adverse effects of climate change; identifies non-development areas, required setbacks, buffer zones." https://www.princeedwardisland.ca/sites/default/files/publications/report_on_land_use_policy.pdf
Quebec	Government of Quebec. Manuel de calcul et de conception des ouvrages de gestion des eaux pluviales. Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques. March 2017. "Section 5.5. [translated] For new development, flow calculations for all precipitation events above 1:2 year, must increase the Intensity-Duration-Frequency curves by 18%." http://www.mddelcc.gouv.qc.ca/eau/pluviales/manuel-calcul-conception/manuel.pdf

DR3. New development should not increase the risk of flooding for existing communities.

Government of Alberta. Water Act: Storm Water Management. 2000.

"Storm water systems that are demonstrated to have an adequate outlet do not require a Water Act approval. More specifically, if the impact of the post-development flow cannot be detected, then the outlet is expected to be adequate; or if the discharge performs within its design capacity during the peak in 1-in-100 year storm event and will not create an adverse impact on the environment and others, then the outlet is expected to be adequate."

http://aep.alberta.ca/water/education-guidelines/documents/StormWaterManagement-FactSheet.pdf

Government of Manitoba. Planning Resource Guide: Subdivision in Manitoba. October 2016.

"Hydraulic design calculations are to be provided for review using a design scenario that details how post-development storm water runoff rates of the subject property are to be equal to, or less than predevelopment run-off rates subject to the following criteria:

The site design must be able to handle a minimum of 1-in-25 year storm event. Water-ponding volumes should equal the difference between a one-in-five year allowable outflow, and a 1-in-25 year post-development flow hydrograph. The allowable outflow is the one-in-five year peak flow based on predevelopment conditions. The ponding storage is typically accomplished through retention ponds, or internal storage via ditches and drainage patterns.

In cases where increased post development runoff cannot be accommodated within the development, the Subdivision Development Drainage Plan must detail how the developer will mitigate negative downstream impacts of an increase in surface water flows. Mitigation may include upgrading existing drainage infrastructure, such as culverts and drainage channels downstream, to accommodate additional runoff."

http://www.gov.mb.ca/imr/mr/land_use_dev/pubs/guide_subpr.pdf

City of Saint John. Storm Drainage Design Criteria Manual. March 2016.

"It is the responsibility of the Developer and/or Consultant to ensure that the proposed development does not create a downstream flooding problem, or aggravate an existing downstream flooding problem.

When adequate downstream capacity does not exist, one possible option is to upgrade downstream infrastructure. Alternatively, the Developer and/or Consultant may reduce peak flow through the use of storage, and a "zero-increase" covenant may be implemented that will limit post-development peak discharge to the existing pre-development peak discharge. In following this alternate approach, it is the responsibility of the Developer and/or Consultant to exercise innovative engineering design, including various methods of on-site storage, to mitigate the detrimental effects of their development by any storm up to the 1 in 100 year return period storm."

http://www.saintjohn.ca/site/media/SaintJohn/Storm%20Drainage%20Design%20Criteria%20Manual%20March%207,%202016.pdf

City of Moncton. Design Criteria Manual for Municipal Services. June 2013.

"For the post-developed condition, hydrologic analysis should be based on the land parcel in its altered impervious condition. The time concentration (Tc) should be based on altered flow patterns. Runoff hydrographs must be prepared for the 2, 5, 10, 25, 50 and 100(+20%) -year design storm events for the post developed condition. Adequate detention storage must be provided within the development to ensure that the post-developed hydrographs, after routing through the detention storage, do not exceed the pre-developed hydrographs."

https://www.moncton.ca/Assets/Government+English/Department+English/Engineering+and+Environmental+-Services/Engineering+Design+Criteria+Manual.pdf

City of Barrie. Storm Drainage and Stormwater Management Policies and Design Guidelines. November 2009.

"Post-to-pre quantity control shall be provided unless otherwise directed by the City or Conservation Authority, or unless otherwise indicated in an approved master drainage plan or watershed plan. Under certain circumstances where the proposed development is located in close proximity to Lake Simcoe and where there are no downstream land owners, the post-to-pre peak flow control requirements may be waived subject to approval by the City and Conservation Authority."

http://www.barrie.ca/Doing%20Business/Development-Services/Documents/City-Standards/StormDrainageandStormwaterManagementPoliciesandDesignGuidelines.pdf

City of Saskatoon. Design and Development Standards Manual, Section Six Stormwater Drainage System. January 2017.

"Minor System: The release rate from any proposed development shall not exceed the capacity of the downstream system.

Major System: Continuity of flow routes between adjacent development shall be maintained."

https://www.saskatoon.ca/sites/default/files/documents/transportation-utilities/construction-design/new-neighbourhood-design/6._2017_section_six_-_storm_water_drainage_system.pdf

DR4. New development should be designed to minimize the risk of basement flooding from groundwater infiltration.

Government of Saskatchewan. Guidelines for Sewage Works Design. Saskatchewan Ministry of Environment. January 2008.

"Where sewers are proposed to be located below groundwater table or where they may pass through sensitive groundwater recharge areas, consideration should be given to use of watertight sewers."

http://www.saskh2o.ca/DWBinder/EPB203GuidelinesSewageWorksDesign.pdf

Halifax Regional Municipality. By-law L-400 Respecting Lot Grading. May 2016.

"The Storm Drainage Systems, be they Community Systems or Individual Lot Systems, designed within the context of the Lot Grading By-law, and the siting and grading of the house, shall achieve the following objectives: To provide for convenient and reasonable use of lot areas during and following rain and snow events and from subsurface or groundwater flow, e.g. continuously saturated backyard, significant continuous icing."

https://www.halifax.ca/sites/default/files/documents/city-hall/legislation-by-laws/By-lawL-400.pdf

City of Moncton. Design Criteria Manual for Municipal Services. City of Moncton Department of Engineering and Environmental Services. June 2013.

"4.2.1.14 Groundwater Migration: The Consultant shall assess the possibility of groundwater migration through mainline sanitary sewer, and service lateral trenches resulting from the use of pervious bedding material. Corrective measures, including provision of impermeable collars or plugs, to reduce the potential for basement flooding resulting from groundwater migration should be employed."

https://www.moncton.ca/Assets/Government+English/Department+English/Engineering+and+Environmental+Services/Engineering+Design+Criteria+Manual.pdf

DR5. Heating, ventilation and air conditioning (HVAC), fuel and electrical systems should be well-elevated from the basement floor or located above grade.

City of Chilliwack. Floodplain Regulation Bylaw 2004, No. 3080. March 2007.

"Furnaces, hot water heaters and electrical panels shall be located above Flood Construction Level (FCL) & any electric circuits extending below FCL shall be equipped with ground fault circuit breakers"

http://www.chilliwack.ca/main/attachments/Files/363/BL%203080%20Floodplain%20Regulation%20Bylaw%20%28Consolidated%29.pdf

Town of Halifax. Zoning Regulation, As Amended. March 2012.

"All development [in Special Flood Hazard Area] shall be: Constructed with electrical, heating, ventilation, plumbing and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding; and

Required to locate any fuel storage tanks (as needed to serve an existing building in the Special Flood Hazard Zone) a minimum of one foot above the base flood elevation and be securely anchored to prevent flotation; or storage tanks may be placed underground, if securely anchored as certified by a qualified professional."

https://halifaxvermont.com/wp-content/uploads/2013/11/Halifax-Zoning-Bylaw-2012-03-06.pdf

Credit Valley Conservation. Technical Guidelines for Floodproofing. 2011.

"Electrical control panels, wiring, and outlets must always be above the flood and freeboard elevation. No electrical equipment or appliances should be below the flood elevation except a submersible sump pump with protected wiring."

http://www.creditvalleyca.ca/wp-content/uploads/2011/09/007-Technician-Guidelines-for-Floodproofing.pdf

CATEGORY 2: STORM SEWER DESIGN (STO)

The following are draft best practices and examples of related municipal by-laws (and, where applicable, examples of Provincial Guidelines, Acts and Policies).

STO1. If the home foundation drainage system connects to a storm sewer*:

- **» the water level in the storm sewer should stay at least 30 cm lower than the foundation drainage system during major design event (e.g., 1-in-100- year flood event) AND**
- **» a backwater valve should be installed on the storm sewer lateral to prevent stormwater from backing up into the basement if the storm sewer is overloaded; this backwater valve should be accessible for maintenance.**

STO2. If the home foundation drainage system does not connect to the storm sewer*:

- **» sump pumps should be installed and equipped with one or more backup power systems.**

**Alternatively, a separate foundation drain collector system should be provided, with no risk of backing up to basement levels during the design flood events.*

City of Vancouver. BY-LAW NO. 10908, Section 1: Adoption of Building Code and Interpretation. July 2014.

"Where a storm sump is provided there shall be a backwater valve within the sump attached to the outlet pipe.

A backwater valve is not required if the storm sump and the storm sump piping are both located above the level of the next upstream manhole of the public storm sewer."

http://former.vancouver.ca/blStorage/10908.PDF

City of Winnipeg. Plumbing Installations. Planning, Property and Development Department. June 2016.

A homeowner guide to the City of Winnipeg plumbing requirements for a single-family dwelling

"All fixtures installed below street level must be protected by a backwater valve arranged to prevent sewer back-up. The backwater valve must be installed to protect the branch drain. A backwater valve may be installed on a building drain or building sewer if listed for that location."

http://www.winnipeg.ca/ppd/pdf_files/Brochures/Plumbing-Installations.pdf

Province of Saskatchewan. Stormwater Guidelines EPB 322. Water Security Agency. January 2014.

"Development standards may permit foundation drains to be connected to the storm sewer in some municipalities. Instead of connecting to the storm sewer, an alternative can be made by pumping foundation drainage to surface ponding/infiltration trench systems."

http://www.saskh20.ca/DWBinder/epb322.pdf

City of Regina. Bylaw No. 2003-7. The Uniform Building and Accessibility Standards Act. The Cities Act. 2011

"2.17.1 Any building or structure that is constructed, reconstructed or relocated shall be required to meet the following flood proofing measures: (a) an automatic backwater valve or backflow preventer approved by the authority having jurisdiction must be installed in the sanitary and storm sewer lines that service the building or structure where the finished basement floor elevation is at or below the 1:500 design flood level"

http://www.regina.ca/opencms/export/sites/regina.ca/residents/bylaw/.media/pdf/building_bylaw_no_2003-7.pdf

STO3. Inlet control devices (ICDs) should be used to restrict the flow of stormwater from the street into storm sewers.

City of Saint John. Storm Drainage Design Criteria Manual. September 2008.

"Inlet control devices (ICDs) must be provided where there is risk of surcharging the minor storm drainage system by storm events that exceed the 1 in 5 year return period. Typical ICD sizing requirements for medium density residential development are provided in Table 2.7."

http://www.saintjohn.ca/site/media/SaintJohn/Storm%20Drainage%20Design%20Criteria%20Manual.pdf

City of Ottawa. 2016. Technical Bulletin PIEDTB-2016-0:

"Inlet controls should be designed to fully capture the design event on local and collector streets without any ponding on the surface, while minimizing surcharging during the 100-year event and meeting the HGL and water level requirements as stated in Section 5.1.4. of the Sewer Design Guidelines."

Information provided by the City of Ottawa.

CATEGORY 3: SANITARY SEWER DESIGN (SAN)

The following are draft best practices and examples of related municipal by-laws (and, where applicable, examples of Provincial Guidelines, Acts and Policies).

SAN1. Basements connected to sanitary sewers should have a backwater valve to mitigate sewage backup into the basement, if the sanitary sewer is overloaded (e.g., during heavy rain).

British Columbia Plumbing Code 2012, includes Version 1.02, Revision 7. December 2014.

"2.4.6.4. Protection from Backflow 1) Except as permitted in Sentence (2), a backwater valve or a gate valve that would prevent the free circulation of air shall not be installed in a building drain or in a building sewer.

Except as provided in Sentences (4), (5) and (6), where a building drain or a branch may be subject to backflow, a gate valve or a backwater valve shall be installed on every fixture drain connected to them when the fixture is located below the level of the adjoining street. 4) Where the fixture is a floor drain, a removable screw cap may be installed on the upstream side of the trap. 5) Where more than one fixture is located on a storey and all are connected to the same branch, the gate valve or backwater valve may be installed on the branch. 6) A subsoil drainage pipe that drains into a sanitary drainage system that is subject to surcharge shall be connected in such a manner that sewage cannot back up into the subsoil drainage pipe."

http://www.bccodes.ca/BCPC_Update_01.16.pdf

City of Toronto. Sewer and Watermain Design Criteria Manual. November 2009.

"Storm backwater prevention valves or backflow prevention devices are required on all foundation drain systems connecting to storm or combined sewer systems to minimize backup of stormwater, where an exemption has been made by the City to allow foundation drain connections. Backwater prevention valves will be located inside the building, if there is a sump pump or outside the building with a riser to allow ease of access and maintenance—if a sump pump is not part of the system."

https://www1.toronto.ca/city_of_toronto/toronto_water/articles/files/pdf/package_sewer_and_watermain_manual.pdf

City of Charlottetown. Water & Sewer Utility Minimum Standard of Acceptability for Water, Sewer & Sprinkler Connections. December 2012.

"All sewer services shall be installed with a 100 mm (minimum) clean out immediately inside the foundation wall and a 100 mm back water valve installed on the upstream side of the clean out as indicated on the Typical Service Installation. The clean out and backwater valve are to be accessible for maintenance by the homeowner and exposed for inspection."

http://www.city.charlottetown.pe.ca/pdfs/ServiceStandard.pdf

City of Regina. Bylaw No. 2003-7, Including Amendments to December 19, 2011. The Uniform Building And Accessibility Standards Act and The Cities Act. 2003.

"Any building or structure that is constructed, reconstructed or relocated shall be required to meet the following flood proofing measures: (a) an automatic backwater valve or backflow preventer approved by the authority having jurisdiction must be installed in the sanitary and storm sewer lines that service the building or structure where the finished basement floor elevation is at or below the 1:500 design flood level;"

http://www.regina.ca/opencms/export/sites/regina.ca/residents/bylaw/.media/pdf/building_bylaw_no_2003-7.pdf

SAN2. Downspout, foundation drain and sump pump discharge should not be directed to the sanitary sewers.

Government of Alberta. Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems; Part 5 Stormwater Management Guidelines. March 2013.

"Roof leaders shall not be connected to storm sewers in residential areas, but shall discharge to grassed or pervious areas."

http://aep.alberta.ca/water/programs-and-services/drinking-water/legislation/documents/Part5-StormwaterManagementGuidelines-2013.pdf

City of Winnipeg. Lot Grading By-law No.4569/87. 1998.

"All building roof downspouts shall be located such that effective positive drainage away from the building is achieved. All downspouts shall discharge through a suitable elbow onto a splash pad as detailed in Schedule "C" or by an equivalent method approved by the designated City Administrator. Building roof downspouts shall not be located nor directed so as to cause storm water to drain directly onto adjacent property."

http://clkapps.winnipeg.ca/DMIS/Documents/DocExt/BL/1998/1998.7294.pdf

City of Winnipeg. Sump Pits & Pumps: The Winnipeg Building By-law No. 4555/87, Subsurface Drainage, Section 23. September 1990.

"Where in the opinion of the Commissioner of Works and Operations, the landscaped area around the building is adequate to dispose of subsurface drainage without causing a nuisance to adjoining properties, the discharge from the sump pump shall be directed to the outside of the building and discharged on to a splash pad as specified in the City of Winnipeg Lot Grading By-law No.4569/87."

http://www.winnipeg.ca/ppd/pdf_files/sumppump.pdf

City of Saint John. Storm Drainage Design Criteria Manual. September 2008.

"For residential developments, roof drains shall not be connected to storm drains, but shall discharge onto splash pads at the ground surface a minimum of 600 mm from the foundation wall in a manner that will carry water away from the foundation wall."

http://www.saintjohn.ca/site/media/SaintJohn/Storm%20Drainage%20Design%20Criteria%20Manual.pdf

Halifax Water. Design and Construction Specifications for Water, Wastewater & Stormwater Systems. Halifax Regional Water Commission June 2017.

"Roof drains are not permitted to be connected to stormwater system mains and shall be managed onsite. Appropriate lot grading measures shall be provided as per Halifax Regional Municipality requirements."

https://www.halifax.ca/sites/default/files/documents/home-property/water/2017%20Design%20Specification.pdf

City of Toronto. Sewer and Watermain Design Criteria Manual. 2009.

"Roof drains will be discharged to the ground surface onto splash pads with flows directed away from the building onto grass filter strips, where possible and towards the road. Any above ground discharge will be contained on the property in a manner that is not likely to cause damage to any adjoining property or create a hazardous condition on any stairway, walkway, street or boulevard."

"The connection of foundation drains to the sanitary sewer system is not permitted for new developments."

https://www1.toronto.ca/city_of_toronto/toronto_water/articles/files/pdf/package_sewer_and_watermain_manual.pdf

City of Charlottetown. Lot Grading Guidelines. January 2007.

"Downspouts must have an elbow and splash pad. A downspout elbow should be directed away from the foundation walls towards a drainage easement or to a public right-of-way. Downspout extensions or splash pads must not project past the property line and must maintain a minimum distance of 15 cm from an adjacent private property and 30 cm from an adjacent City property."

"A sump pump discharges groundwater from weeping tile to the ground surface or directly to a storm sewer system. If a sump pump discharges to the ground surface, then it is important to provide a splash pad or a flexible hose at the discharge point. This minimizes soil erosion at the foundation wall and the re-circulation of the groundwater back to the weeping tile."

http://www.city.charlottetown.pe.ca/pdfs/Lot_Grading_Guidelines.pdf

Town of Beaumont. General Design Standards. September 2011.

"A sump pump discharge collection service shall be provided to each newly developed single family lot and to each multi-family unit. The system is dedicated to collection of weeping tile system discharges. There shall be no roof leaders, garage drain, sanitary line or any other plumbing systems connected to the sump pump/weeping tile system. The collection system shall discharge to the minor storm sewer system by connection of the service lateral to the fronting collection main."

http://www.beaumont.ab.ca/DocumentCenter/View/47

SAN3. Design of sanitary sewers should have a factor for "normal" infiltration of rainwater during typical rain events and a higher "Safety Factor" for infiltration and inflow during extreme rain events.

Government of Alberta. Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems; Part 5 Stormwater Management Guidelines. 2013.

"In computing the total peak flow rates for design of sanitary sewers, the designer should include allowances as specified below to account for flow from extraneous sources.

1. General Inflow / Infiltration Allowance

A general allowance of 0.28 L/s/ha should be applied, irrespective of land use classification, to account for wet-weather inflow to manholes not located in street sags and for infiltration flow into pipes and manholes."

http://aep.alberta.ca/water/programs-and-services/drinking-water/legislation/documents/Part4-Wastewater-SystemsGuidelines-2013.pdf

City of Toronto. Sewer and Watermain Design Criteria Manual. 2009.

"In computing the total peak flow rates for the design of new sanitary sewers, an allowance of 0.26 litre/second/ gross hectare will be applied, irrespective of land use classification to account for ground water infiltration and wet weather inflow into the pipes and maintenance holes. Assume no roof drains or foundation drains are connected directly or indirectly to the sanitary sewer."

"The flow data and any applicable parameters must be provided to the City prior to being used in any computation. Wet weather flow monitoring will take place during the late spring, summer and early fall in order to collect data during severe summer storm events. "

https://www1.toronto.ca/city_of_toronto/toronto_water/articles/files/pdf/package_sewer_and_watermain_manual.pdf

Environment Canada. Atlantic Canada Wastewater Guidelines Manual for Collection, Treatment, and Disposal. 2006.

"Prior to the preparation of a pre-design report on an existing sewerage system, a comprehensive infiltration/ inflow investigation should be conducted. This will give the designers a better indication of extraneous flow contributions, as well as aid in design solutions, (i.e. the potential for reducing flows at an existing plant). "

"When designing sanitary sewer systems, allowances must be made for the leakage of groundwater into the sewers and building sewer connections (infiltration) and for other extraneous water entering the sewers from such sources as leakage through manhole covers, foundation drains, roof down spouts, etc."

https://novascotia.ca/nse/water/docs/AtlCanStdGuideSewage.pdf

Government of Saskatchewan. Guidelines for Sewage Works Design. Saskatchewan Ministry of Environment. January 2008.

"Sanitary sewers should be designed on a peak design flow basis using values established from an Infiltration / Inflow study, if practical. In cases where such data are not available, peak design flow may be determined using a peaking factor (ratio of extreme flow to daily average flow) derived from a generally accepted and reliable formula."

http://www.saskh2o.ca/DWBinder/EPB203GuidelinesSewageWorksDesign.pdf

CATEGORY 4: STREET DESIGN (SD)

The following are draft best practices and examples of related municipal by-laws (and, where applicable, examples of Provincial Guidelines, Acts and Policies).

SD1. Roads and public spaces should be designed to convey excess runoff so that it does not flow through homeowner property.

City of Maple Ridge. Design Criteria Manual. October 2015.

"Major flow routing is generally accommodated along roadways, swales and watercourses. These designated flow paths shall be protected by restrictive covenants or right-of-ways and clearly identified in the stormwater management plan."

https://www.mapleridge.ca/DocumentCenter/View/6033

City of Winnipeg. Residential Lot Grading, Lot Drainage. February 2014.

"A swale easement is an agreement that is registered against a property. This agreement reserves a portion of land for land drainage purposes so that neighboring properties may properly drain their storm water runoff. Swales must be unobstructed and free draining."

http://www.winnipeg.ca/waterandwaste/drainageFlooding/lotgrading/lotDrainage.stm

Halifax Water. Design and Construction Specifications for Water, Wastewater & Stormwater Systems. Halifax Regional Water Commission 2016. "Where this stormwater forms part of the major overland flow path, the developer shall secure easements to ensure the continued use of the drainage course except where the drainage course is a designated watercourse as per NSE regulations. In the case of a watercourse, the developer shall obtain all necessary permits prior to construction of the stormwater system."

https://www.halifax.ca/sites/default/files/documents/home-property/water/2016%20Design%20and%20Construction%20Specifications.pdf

City of Pickering. Stormwater Management Design Guidelines.

"Major system flow paths shall be in public ownership."

https://www.pickering.ca/en/city-hall/resources/DC-StormwaterManagementGuidelines.pdf

City of Ottawa. Technical Bulletin PIEDTB-2016-0. 2016.

"In order to prevent water from accumulating at or near the buildings and thus prevent damage to structures, an overflow must be provided from all sags or depressions which must ensure that the water level must not touch any part of the building envelope and must remain below the lowest building opening during the stress test event (100-year + 20%). Furthermore, there must be at least 15 cm of vertical clearance between the spill elevation on the street and the ground elevation at the nearest building envelope that is in the proximity of the flow route or ponding area."

Information provided by the City of Ottawa.

SD2. Road design and lot grading should be such that the water on the road remains at least 30 cm below the lowest building openings (e.g., basement windows) during design flood conditions.

Town of Beaumont. General Design Standards. September 2011.

"Lot grading and general grading shall provide protection of property for a 1-in-100-year return frequency design storm. Designs shall provide that maximum flooding or ponding shall be 600 mm below the lowest anticipated ground elevation at buildings. Overflow routes and provisions shall be designed such that the maximum depth of ponding is not more than 300 mm."

http://www.beaumont.ab.ca/DocumentCenter/View/47

City of Maple Ridge. Design Criteria Manual. October 2015.

"The freeboard between the Minimum Building Elevations (the elevation of 0.1 m above the lowest floor slab in a building or the underside of the floor joists where the lowest floor is constructed over a crawlspace) and the 1:100-year hydraulic grade line may be reduced to 0.2m."

https://www.mapleridge.ca/DocumentCenter/View/6033

City of Kamloops. Design Criteria Manual, Schedule "B" of Subdivision and Development Control By-law No. 4-33. Development and Engineering Services Department. 2012.

"Roadway and other surface features along the major flow path shall provide a minimum of 300 mm freeboard to the finished ground elevation of buildings on adjacent properties."

"Protection of habitable floor space from flooding is to be provided up to the 200-year flood level (inclusive of 0.6 m freeboard) for areas in the flood plains of the Thompson River systems. As identified on City Flood Mappings, all other areas will be protected from the 100-year flood level (plus 0.6 m freeboard).

http://www.kamloops.ca/development/pdfs/12-DesignCriteriaManual.pdf

City of Pickering. Stormwater Management Design Guidelines.

"Major systems shall be sized to capture and convey the Regulatory Storm to a safe outlet without flooding adjacent properties and should provide a minimum of 300 mm of freeboard from the maximum water surface elevation of the major system flow path to the minimum opening of structures. Hydraulic Grade Line in the storm sewer for the 100 year storm is a minimum of 300 mm below the basement footing elevation."

https://www.pickering.ca/en/city-hall/resources/DC-StormwaterManagementGuidelines.pdf

City of Ottawa. Technical Bulletin PIEDTB-2016-0. 2016.

"The water level in the major system must not touch any part of the building envelope, and must remain below the lowest building opening that is in the proximity of the flow route or ponding area, during the stress test event (100-year plus 20%). This test must be applied to all areas of the major system, including rear yards. There must be at least 15 cm of vertical clearance between the spill elevation on the street and the ground elevation at the building envelope that is in the proximity of the flow route or ponding area."

Information provided by the City of Ottawa.

SD3. Roads should be designed so that the maximum depth of water during the extreme design condition does not exceed 30 cm at the curb.

City of Mississauga. Development Requirements Manual. 2009.

"Overland Flow Route:

- Maximum ponding depth is 0.35 m
- Where overland flow is directed between two dwellings, the depth and width of the swale must be such that the 100-year flow does not come in contact with the dwelling. Basement windows will not be permitted on the side of the dwelling abutting the overland flow route swale."

http://www.mississauga.ca/file/COM/Section2Revised2010.pdf

City of Waterloo. Development Engineering Manual. 2013.

"Surface ponding shall be minimal and a maximum ponding depth of 0.3 m is permitted for the 100 year storm event in parking areas and 0.8 m in grassed areas. No ponding of water is permitted within 0.3 m of an opening to a building."

"The 100 year storm is used to represent an extreme event for which maximum surface ponding depths (0.3 m) and major system flow capacity should be designed. The SWM design may allow overland flow from the extreme event after a reasonable and safe amount of ponding to the municipal right of way."

http://www.waterloo.ca/en/contentresources/resources/business/DEM_2013_Chapter7.pdf

City of Pickering. Stormwater Management Guidelines.

"The maximum ponding depth shall be 300 mm and grading shall be between 0.5% and 5%."

https://www.pickering.ca/en/city-hall/resources/DC-StormwaterManagementGuidelines.pdf

Town of Beaumont. General Design Standards. September 2011. "Depths of flows and ponding in roadways and public utility lots shall be a maximum of 350 mm. Water depths at the crown in arterial roadways shall not exceed 150 mm."

http://www.beaumont.ab.ca/DocumentCenter/View/47

SD4. Driveways should be built to slope away from homes or garages (i.e., reverse-slope driveways should not be permitted).

City of Maple Ridge. Design Criteria Manual. October 2015.

"Driveway access grades shall be designed to permit the appropriate vehicular access for the zone, without "bottoming-out" or "hanging-up." From edge of pavement to property line, the driveway shall follow proper boulevard slope to drain towards the road. For the first 10 m on private property, the maximum grade shall be limited to 10% if accessing a collector, or if a commercial or industrial zone."

https://www.mapleridge.ca/DocumentCenter/View/6033

City of Toronto. Sewer and Watermain Design Criteria Manual. November 2009.

"Reverse Driveway Drainage: The City discourages the installation of reverse driveways. Should they be installed, drainage will comply with the Sewer Use Bylaw, Section 681-11-O of the Toronto Municipal Code."

https://www1.toronto.ca/city_of_toronto/toronto_water/articles/files/pdf/package_sewer_and_watermain_manual.pdf

City of Markham. Design Criteria Section F - Lot Grading. 2012.

"Lot Grading Minimum driveway slope = 2%; all driveways must slope away from the dwelling units."

http://www3.markham.ca/Markham/aspc/engineering/drawings/getPDF.aspx?ATTACHMENTRSN=459908

City of Ottawa. Technical Bulletin PIEDTB-2016-0. 2016.

The property slope from the building to the street should be minimum 2%. Depressed driveways are discouraged and are not allowed in sag locations. For other locations, the builder must ensure that the maximum depth of flow on the street during the 100-year and stress test events will not spill onto the depressed driveway.

Information provided by the City of Ottawa.

SD5. Sanitary sewer manholes should not be located in low-lying areas. If sanitary sewer manholes need to be located in low-lying areas, manhole covers should be sealed to minimize inflow of accumulated runoff into the sanitary sewer.

Government of Alberta. Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems; Part 5 Stormwater Management Guidelines. 2013.

"Manholes in Sag Locations When sanitary sewer manholes are located within roadway sags or other low areas, and are thus subject to inundation during major rainfall events, the sanitary design peak flow rate should be increased by 0.4 L/s for each such manhole, which is applicable for manholes which have been waterproofed. For new construction, all sanitary manholes in sag locations are to be waterproofed."

http://aep.alberta.ca/water/programs-and-services/drinking-water/legislation/documents/Part4-Wastewater-SystemsGuidelines-2013.pdf

British Columbia Plumbing Code 2012, includes Version 1.02, Revision 7. December 2014. "2.4.7.3. Manholes

1) A manhole including the cover shall be designed to support all loads imposed upon it.

2) A manhole shall be provided with a) a cover that provides an airtight seal if located within a building, b) a rigid ladder of a corrosion-resistant material where the depth exceeds 1 m, and c) a vent to the exterior if the manhole is located within a building.

3) A manhole shall have a minimum horizontal dimension of 1 m, except that the top 1.5 m may be tapered from 1 m down to a minimum of 600 mm at the top.

4) A manhole in a sanitary drainage system shall be channeled to direct the flow of effluent."

http://www.bccodes.ca/BCPC_Update_01.16.pdf

Halifax Water. Design and Construction Specifications for Water, Wastewater & Stormwater Systems. Halifax Regional Water Commission. 2016."The wastewater system manhole inclusive of the grade rings, shaft, precast sections and base shall be constructed with a Blueskin waterproofing membrane and gaskets. Stormwater system manholes are not required to be constructed with a waterproofing membrane."

https://www.halifax.ca/sites/default/files/documents/home-property/water/2016%20Design%20and%20Construction%20Specifications.pdf

Government of Saskatchewan. Guidelines for Sewage Works Design. Saskatchewan Ministry of Environment. January 2008.

"The manholes should be designed to be watertight, durable and of adequate size for ease of entry and maintenance. Minimum diameter should be 1050 mm (42 inches). Bases should be watertight and 'flow-through' channels through manholes should be made to conform in shape and slope to that of the sewers. Wherever manhole tops may be flooded by street runoff or high water, watertight manhole covers should be used. Consideration may be given to providing suspended baskets to catch debris that may enter manholes, such as gravel from unpaved streets."

http://www.saskh2o.ca/DWBinder/EPB203GuidelinesSewageWorksDesign.pdf

Government of Ontario. Design Guidelines for Sewage Works. 2008. "The specifications should include a requirement for inspection and testing for watertightness or damage prior to placing into service. Air testing, if specified for concrete sewer manholes, should conform to the test procedures described in ASTM C 1244."

https://www.ontario.ca/document/design-guidelines-sewage-works

Town of Beaumont. General Design Standards. September 2011. "Where connection is proposed to existing sewers at manholes, the manhole barrel and existing benching shall be disturbed to the minimum required to make the connection, restored and made water tight using appropriate materials and good practice. Benching shall be restored to provide a smooth 'free flowing' channel."

http://www.beaumont.ab.ca/DocumentCenter/View/47

CATEGORY 5: WASTEWATER PUMPING STATION DESIGN (WP)

The following are draft best practices and examples of related municipal by-laws (and, where applicable, examples of Provincial Guidelines, Acts and Policies).

WP1. Wastewater pumping stations should be located in areas where they will remain fully-operational and fully-accessible during extreme rain events.

Environment Canada. Atlantic Canada Wastewater Guidelines Manual for Collection, Treatment, and Disposal. 2006.

"Sewage pumping station structures and electrical and mechanical equipment shall be protected from physical damage from the one hundred (100) year flood. Sewage pumping stations should remain fully-operational and accessible during the twenty-five (25) year flood. During preliminary location planning, consideration should be given to the potential of emergency overflow provisions and as much as practically possible the voidance of health hazards, nuisances and adverse environmental effects."

https://novascotia.ca/nse/water/docs/AtlCanStdGuideSewage.pdf

Government of Ontario. Design Guidelines for Sewage Works. 2008. "Sewage pumping station structures and electrical and mechanical equipment should be protected from physical damage by the 100-year design flood event. Sewage pumping stations should remain fully-operational and accessible during the 25-year flood event. Regulations/requirements of municipalities, provincial and federal agencies regarding flood plain obstructions should be considered."

https://www.ontario.ca/document/design-guidelines-sewage-works/plumbing-stations

Government of Saskatchewan. Guidelines for Sewage Works Design. Saskatchewan Ministry of Environment. January 2008.

"Sewage pumping station structures and electrical/mechanical equipment should be protected from physical damage and should remain fully operational during floods. During preliminary location planning, consideration should be given to the potential of emergency overflow provisions and, as much as practically possible, the avoidance of health hazards and adverse environmental effects."

http://www.saskh2o.ca/DWBinder/EPB203GuidelinesSewageWorksDesign.pdf

WP2. Wastewater pumping stations should have backup power to allow for a minimum of 48 hours of uninterrupted service and an overflow in case of catastrophic failure.

Government of Alberta. Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems. Part 4 Wastewater Systems Guidelines for Design, Operating and Monitoring. March 2013.

"For use during possible periods of extensive power outages, mandatory power reductions, or uncontrollable emergency conditions, consideration should be given to providing a controlled, high-level wet well overflow to supplement alarm systems and emergency power generation in order to prevent backup of wastewater into basements, or other discharges which may cause severe adverse impacts on public interests, including public health and property damage. Where a high level overflow is utilized, consideration should also be given to the installation of storage/detention tanks, or basins, which should be made to drain to the station wet well."

http://aep.alberta.ca/water/programs-and-services/drinking-water/legislation/standards-and-guidelines.aspx

Government of Newfoundland and Labrador. Guidelines for the Design, Construction and Operation of Water and Sewerage Systems. Department of Environment and Conservation. December 2005.

"Emergency Operation Pumping stations and collection systems shall be designed to prevent or minimize bypassing of raw sewage. For use during periods of extensive power outages, mandatory power reductions, or uncontrolled storm events, consideration should be given to providing a controlled, high-level wet well overflow to supplement alarm systems and emergency power generation in order to prevent backup of sewage into basements, or other discharges which may cause severe adverse impacts on public interests, including public health and property damage."

http://www.mae.gov.nl.ca/waterres/waste/groundwater/guidelines_for_design_constr_oper_wss.pdf

Halifax Water. Design and Construction Specifications for Water, Wastewater & Stormwater Systems. Halifax Regional Water Commission. 2016.

"The auxiliary power supply system (loosely referred to here as "generator") shall be designed with adequate capacity to operate the wastewater pump or pumps required to pump peak wastewater flows, control and monitoring systems, and heating and lighting systems within the pump house. The generator is to run automatically on a power outage and to stop when the power returns; the stopping and starting of the generator is to be activated in co-ordination with an automatic power transfer switch."

https://www.halifax.ca/sites/default/files/documents/home-property/water/2016%20Design%20and%20Construction%20Specifications.pdf

Government of Ontario. Design Guidelines for Sewage Works. 2008.

"The designer should evaluate the need for standby power at a sewage pumping station for each specific location and should confirm this assessment with the Ministry. The objective of emergency operation is to prevent (and in the case of combined sewer system to minimize) the discharge of raw or partially treated sewage to any waters and to protect public health by preventing backup of sewage and potential discharge to basements, streets and other public and private property."

https://dr6j45jk9xcmk.cloudfront.net/documents/1122/72-design-guidelines-for-sewage-works-en.pdf

Government of Saskatchewan. Guidelines for Sewage Works Design. Saskatchewan Ministry of Environment. January 2008.

"Emergency Operation Pumping stations (and collection systems) should be designed to prevent by-passing of raw sewage. For use during possible periods of extensive power outages or uncontrolled storm events, consideration should be given for alarm systems and emergency power generation in order to prevent back-up of sewage into basements, or other discharges which may cause severe adverse impacts on public interests, including public health and property damage. Where a high level overflow is necessary, consideration should also be given to the installation of storage/detention tanks or basins which can drain back to the wet well following the emergency. Standby power should be considered for all pumping stations, particularly main pumping stations. Standby power may be provided by means of an emergency standby generator powered by either a diesel engine, a gasoline engine, a natural or propane gas engine or by an auxiliary drive system powered by any of the foregoing primary power sources. For smaller stations, portable generators or portable gasoline or diesel engine driven pumps may be satisfactory. The method of providing standby power should be capable of operating enough pumps to handle peak sewage flows."

http://www.saskh2o.ca/DWBinder/EPB203GuidelinesSewageWorksDesign.pdf

CATEGORY 6: PRESERVATION OF NATURAL FEATURES (PNF)

The following are draft best practices and examples of related municipal by-laws (and, where applicable, examples of Provincial Guidelines, Acts and Policies).

PNF1. Development should not encroach on riparian buffers (land and natural vegetation adjacent to waterbodies) and sufficient setbacks should be maintained along the water bodies to reduce the risk of flooding due to stream movement and bank erosion.

District of Metchosin, British Columbia. Bylaw No. 467, for the Protection and Management of Rain Water. 2004.

"No person, applicant or owner shall:

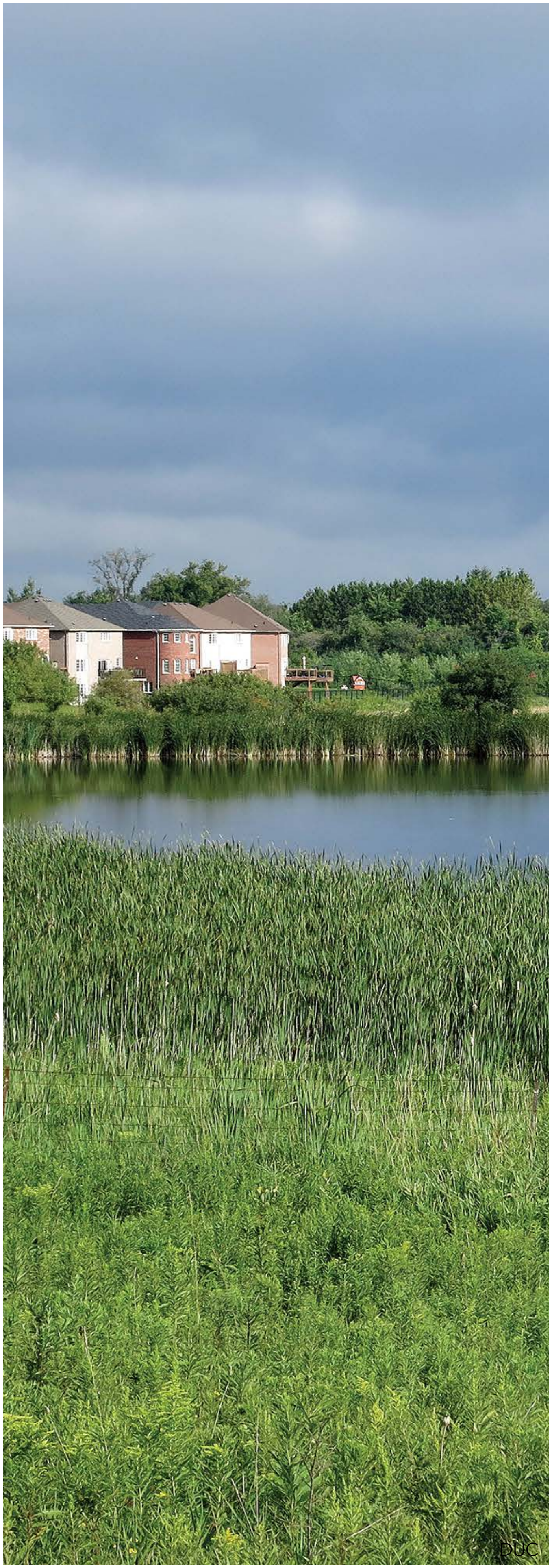
- Alter, repair, remove, fill in, reconstruct, divert, obstruct or impede the flow of water in, remove vegetation or carry out any other works or development within an approved drainage system, a watercourse, water body or Riparian-wetland Area;
- Undertake development within a Riparian-Assessment Area;
- Remove or deposit any soil or material whatsoever within a 200-year floodplain or within a watercourse, water body and/or Riparian-wetland Area;
- Undertake any development on a lot, site, or area of land that will result in a loss of Proper Functioning Condition of a watercourse, water body or Riparian-wetland Area, a loss of water quality in any water body, an increase in runoff rates or volumes of rain water leaving the lot, site, or area of land based on predevelopment levels."

https://metchosin.civicweb.net/document/276

Prince Edward Island. Watercourse, Wetland and Buffer Zone Activity Guideline. 2012.

"In accordance with the Environmental Protection Act of Prince Edward Island, Watercourse and Wetland Protection Regulations, No person shall, without a license or a Buffer Zone Activity Permit, and other than in accordance with the conditions thereof, engage in or cause or permit the engaging in of any of the following activities within 15 metres of a watercourse boundary or wetland boundary: construct or place, repair or replace, demolish or remove, buildings or structures or obstructions of any kind, including, but not limited to bridges, culverts, breakwaters, dams, wharves, docks, slipways, decks or flood or erosion protection works;"

http://www.gov.pe.ca/photos/original/elj_webpkg.pdf



Province of Saskatchewan. Planning Handbook: "Companion Document to the Statements of Provincial Interest Regulations." Ministry of Municipal Affairs. April 2012.

"To assist in meeting the province's interests in biodiversity and natural ecosystems, planning documents and decisions shall, insofar as is practical:

1. Consider the ecological value, integrity and management of wetlands, riparian areas, significant natural landscapes and regional features, and provincially designated lands;

2. Minimize, mitigate or avoid development impacts to safeguard the ecological integrity of wetlands, riparian areas, significant natural landscapes and regional features, and provincially designated lands;"

http://publications.gov.sk.ca/documents/313/98344-spi-planning-handbook.pdf

PNF2. New development should aim to minimize runoff from impervious areas.

City of Vancouver. Best Management Practices "Site Design for Stormwater Management," May 2015.

"Maximize Permeability: Within the development envelope, many opportunities are available to maximize the permeability of new construction. These include minimizing impervious areas, paving with permeable materials, clustering buildings, and reducing the land coverage of structures by smaller footprints. All of these strategies make more land available for infiltration and dispersion through natural vegetation."

http://vancouver.ca/files/cov/Park-Development-Standards-BMP-Stormwater-Management-VPB.pdf

City of Pickering. Stormwater Management Design Guidelines.

"Porous and Pervious Pavement: The City encourages porous and pervious pavement installations provided that they are not receiving runoff from high traffic areas where large amounts of de-icing salts are used or from source areas where land uses or activities have the potential to generate highly contaminated runoff (e.g., vehicle refueling, handling areas for hazardous materials). The design of these systems shall be in accordance with the guidance in the Ministry of the Environment's Stormwater Management manual and Low Impact Development manual."

https://www.pickering.ca/en/city-hall/resources/DC-StormwaterManagementGuidelines.pdf

District of Metchosin, British Columbia. Bylaw No. 467, for the Protection and Management of Rain Water. 2004.

"3.5.2 Where a person is subdividing land, the area of the lands at post-development that may be covered by an Effective Impervious Area shall not exceed 10%, including all new roads, driveways, and potential Impervious Surface Areas for all proposed lots."

https://metchosin.civicweb.net/document/276

APPENDIX C: FURTHER LITERATURE REVIEW

CLIMATE AND OPERATIONAL UNCERTAINTY

Canada, Federal Floodplain Mapping Series	Natural Resources Canada and Public Safety Canada. Federal Floodplain Mapping Framework. 2017. "Floodplain mapping that accurately delineates flood hazards serves as the precondition for such mitigation activities and is therefore the first step to increasing community resilience with regard to flooding. Establishing a national approach to floodplain mapping will facilitate a common national best practice and increase the sharing and use of flood hazard information, thereby improving the foundation from which further mitigation efforts can be initiated." http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/299/299806/gip_112_e.pdf Pending publications: Federal Hydrologic and Hydraulic Procedures for Floodplain Delineation. Spring 2017; Case Studies on Climate Change in Floodplain Mapping (to be developed); Federal Geomatics Guidelines for Floodplain Mapping. Spring 2017; Bibliography of Best Practices and References for Flood Mitigation. Spring 2017.
Australia, Handbook	Australian Institute for Disaster Resilience. AEM Handbook 7. Managing the Floodplain: Best Practice in Flood Risk Management in Australia. 2014. "The goal of increased resilience to floods requires the management of the flood impacts to both existing developed areas of the community, and in areas that may be developed in the future." https://aidr.infoservices.com.au/collections/handbook
Australia, Standard	ACBC. Construction of Buildings in Flood Hazard Areas. 2012. "This Standard provides the requirements for buildings in flood hazard areas consistent with the objectives of the BCA (Building Code of Australia). The objectives primarily aim to protect the lives of occupants of those buildings in events up to and including the defined flood event." http://www.abcb.gov.au/Resources/Publications/Education-Training/Construction-of-Buildings-in-Flood-Hazard-Areas-Standard
United Kingdom, Standard	British Standards Institution (BSI) Group. BS 85500:2015 Flood Resistant and Resilient construction: Guide to Improving the Flood Performance of Buildings. 2015. "National flood risk management policy requires developments to be safe, to avoid increasing flood risk elsewhere and, where possible, to reduce flood risk overall, so it is critical that new buildings in these areas are designed and built appropriately to cope with floodwaters and minimize the time for reoccupation after a flooding event." http://shop.bsigroup.com/ProductDetail/?pid=000000000030299686
United States, Standard	The American Society of Civil Engineers (ASCE). ASCE/SEI 24-05 Flood Resistant Design and Construction. 2016. "Flood Resistant Design and Construction provides minimum requirements for flood-resistant design and construction of structures located in flood hazard areas. Revising the earlier ASCE/SEI 24-98, this standard applies to new structures, including subsequent work, and to substantial repair or improvement of existing structures that are not historic structures. Specific topics include: basic requirements for flood hazard areas; high-risk flood hazard areas; coastal high-risk hazard areas and Coastal A Zones; materials; dry and wet floodproofing; utilities; building access; and miscellaneous construction." http://ascelibrary.org/doi/book/10.1061/9780784408186

United States, Code	Federal Emergency Management Agency (FEMA). Flood Resistant Provisions of the 2015 International Codes. 2015. "This document is a compilation of flood resistant provisions, prepared by FEMA, of the 2015 International Codes (IBC, IRC, IEBC, IMC, IPC, IFGC, IFC, ISPSC, IPSDC, and ICC Performance Code). Also included, as a separate document, is a summary of changes from the 2012 I-Codes. The 2015 edition of the I-Codes contains provisions that meet or exceed the minimum flood-resistant design and construction requirements of the NFIP (National Flood Insurance Program) for buildings and structures." https://www.fema.gov/media-library/assets/documents/100537
United States, Technical Bulletin	Federal Emergency Management Agency. Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program. 2008. https://www.fema.gov/media-library-data/20130726-1502-20490-4764/fema_tb_2_rev1.pdf

MAJOR AND MINOR DRAINAGE SYSTEM

Canada, Guide	The CSA Group. PLUS 4013-Technical guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information, Guideline for Canadian water resources practitioners. 2012. "Canada has significant investments in stormwater, drainage, wastewater, and flood management systems. Every day, Canadians rely on this infrastructure to protect lives, property, and natural systems such as creeks, rivers, and lakes. In designing and managing these works, practicing professionals need to be concerned with the probability of occurrence of extreme values of rainfall amounts, often for specific storm durations. Rainfall IDF Intensity-Duration-Frequency) information commonly forms a critical input when applying the analytical techniques routinely used by practitioners." http://shop.csa.ca/en/canada/infrastructure-and-public-works/plus-4013-2nd-ed-pub-2012/invt/27030802012
Canada, Guide	Federation of Canadian Municipalities and National Research Council. National Guide to Sustainable Municipal Infrastructure, Stormwater Management Planning. 2004. "The document outlines some guiding principles that should be used in implementing stormwater management planning." http://www.fcm.ca/Documents/reports/Infraguide/Stormwater_Management_Planning_EN.pdf
Australia, Standard	Australian Capital Territory (ACT). Municipal Infrastructure Standard, Part 8: Stormwater. 2015. "This present document is part of the ACT Municipal Infrastructure Standard (MIS) series spanning the broad scope of municipal infrastructure development and management in the ACT. Whilst based on the earlier Urban Services Design Standards for Urban Infrastructure Works, this document has been significantly expanded to incorporate new technologies and to bring it into line with Australian best practice." http://www.tccs.act.gov.au/__data/assets/pdf_file/0011/808850/MIS08-Stormwater-Ed0-Rev0.pdf
Hong Kong, Manual	Government of the Hong Kong Special Administrative Region. Stormwater Drainage Manual Planning, Design and Management. Drainage Services Department. 2013. "This Manual offers guidance on the planning, design, operation and maintenance of stormwater drainage works which are commonly constructed in Hong Kong. Such works include stormwater pipelines, box culverts, nullahs, river training works, polders and floodwater pumping facilities." http://www.dsd.gov.hk/EN/Files/Technical_Manual/technical_manuals/Stormwater_Drainage_Manual_Eurocodes.pdf
United Kingdom, Guide	National Building Specification. REP R 139 Water-Resisting Basement Construction. 1995. "Gives guidance on water and vapour protection of new and existing basements; distinguishes between guidance appropriate to deep and shallow basements; includes references to forms of deep basement construction such as diaphragm and secant walls, contiguous bored piles and shallow basements of concrete, masonry or steel sheet piling; provides illustrated examples of construction types; and takes account of the control of dampness by appropriate ventilation and heating." https://www.thenbs.com/PublicationIndex/documents/details?Pub=CIRIA&DocID=282840

United Kingdom, Guide	Construction Industry Research and Information Association (CIRIA). Designing for Exceedance in Urban Drainage-Good Practice. 2006. "This guideline includes information on the effective design of both underground systems and overland flood conveyance. It also provides advice on risk assessment procedures and planning to reduce the impacts that extreme events may have on people and property within the surrounding area." http://www.ciria.org/Resources/Free_publications/Designing_exceedance_drainage.aspx
United Kingdom, Standard	British Standards Institution (BSI) Group. BS EN 752-1 Drain and Sewer Systems Outside Buildings. 2008. http://shop.bsigroup.com/ProductDetail/?pid=000000000030292823
United Kingdom, Standard	British Standards Institution (BSI) Group. 2011. BS 8102:2009 NHBC Standard Basements and Waterproofing: "BS 8102 gives recommendations and provides guidance on methods of dealing with and preventing the entry of water from surrounding ground into a structure below ground level. It covers the use of: a) Waterproofing barrier materials applied to the structure b) Structurally integral watertight construction c) Drained cavity construction. It also covers the evaluation of groundwater conditions, risk assessment and options for drainage outside the structure. It applies to structures which extend below ground level and those on sloping sites." http://www.nhbc.co.uk/NHBCPublications/LiteratureLibrary/Technical/TechnicalExtra/filedownload,43882,en.pdf
United States, Guide	US Environmental Protection Agency. EPA 402-F-13053 Moisture Control Guidance for Building Design, Construction and Maintenance. 2013. "This guidance includes information on the effective design of site drainage, foundation, external gutter and downspout and internal roof drainage systems." https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf

WASTEWATER SYSTEMS

Canada, Code	National Research Council Canada. National Building Code of Canada 2015. 2015.
Canada, Standard	Standards Council of Canada. CAN/CSA-B64.10 Selection and Installation of Backflow Prevention Devices 2007. "This Standard provides requirements for the selection and installation of backflow prevention devices." https://www.scc.ca/en/standardsdb/standards/7542
Canada-United States, Standard	Standard for Safety: ANSI/CAN/UL/ULC 1201: Sensor Operated Blackwater Prevention System. 2016. http://canada.ul.com/wp-content/uploads/sites/11/2016/12/ANSI-CAN-UL-ULC-1201-2016-EN.pdf
Canada, Guide	Federation of Canadian Municipalities and National Research Council. National Guide to Sustainable Municipal Infrastructure: Infiltration/Inflow Control/Reduction for Wastewater Collection Systems. 2003. "This best practice describes the implementation of an infiltration/inflow (I/I) control/reduction program with the focus on sanitary sewers." https://www.grandriver.ca/en/our-watershed/resources/Documents/Water_Wastewater_Optimization_InfraguideInflow.pdf

Canada, Guide	Federation of Canadian Municipalities and National Research Council. National Guide to Sustainable Municipal Infrastructure, Selection of Technologies for Sewer Rehabilitation and Replacement. 2003. "Municipalities are provided with a method of selecting the appropriate sewer rehabilitation or replacement technology based on their social, economic, and environmental factors, and on current best practices in the industry." https://fcm.ca/Documents/reports/Infraguide/Selection_of_Technologies_for_Sewer_Rehabilitation_and_Replacement_EN.pdf
United States, Guide	US Environmental Protection Agency. Guide for Estimating Infiltration and Inflow. 2014. "This Guide is intended to provide background and information for managers of wastewater collection systems on estimating the amount of infiltration and inflow (I&I) entering their collection system and for responding to National Pollutant Discharge Elimination System (NPDES) I&I permit reporting requirements." https://www3.epa.gov/region1/sso/pdfs/Guide4EstimatingInfiltrationInflow.pdf

APPENDIX D: ORGANIZATIONS INCLUDED IN THE FLOOD-RESILIENT COMMUNITY DESIGN CONSULTATION PROCESS

- AECOM
- Amec Foster Wheeler
- Canada Mortgage and Housing Corporation
- Canadian Home Builders' Association
- Canadian Water and Wastewater Association
- Canadian Water Resources Association
- City of Calgary
- City of Charlottetown
- City of Edmonton
- City of Fredericton
- City of Halifax
- City of Iqaluit
- City of Kelowna
- City of Markham
- City of Mississauga
- City of Ottawa
- City of Regina
- City of Saskatoon
- City of St. John's
- City of Toronto
- City of Winnipeg
- Conservation Halton
- Cortel Group
- Counterpoint Engineering Inc.
- Credit Valley Conservation
- CSA Group
- Emergency Management BC
- Engineers Canada
- Federation of Canadian Municipalities
- Fieldgate Development
- Greenland Consulting Engineers
- Gray Taylor Law
- Government of Newfoundland and Labrador
- Halifax Water
- Institute for Catastrophic Loss Reduction
- Insurance Bureau of Canada
- Intact Financial Corporation
- International Institute for Sustainable Development
- J.F. Sabourin and Associates Inc.
- Lasalle I NHC
- Laval
- Mattamy Homes
- Montréal
- National Research Council of Canada
- Pollution Probe
- Pristine Homes
- Standards Council of Canada
- Stantec
- Toronto Region Conservation Authority
- Zizzo Strategy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APPENDIX E: PARTICIPANT PROFILES FOR MARCH 24, 2017 WORKING SESSION "FLOOD-RESILIENT COMMUNITY DESIGN: DEVELOPING A NATIONAL STANDARD FOR NEW RESIDENTIAL SUBDIVISIONS IN CANADA"

Anneke Olvera, Manager, Strategy and Stakeholder Engagement Branch, Standards Council of Canada
As a Manager at the Standards Council of Canada (SCC) responsible for Strategic Policy and Sector Engagement focusing on Environment and Climate Change, Indigenous and Northern Affairs, Infrastructure, Transport, Energy and Natural Resources, Ms. Olvera specializes in collaborative working relationships with representatives from governments, industry and other external organisations that are the primary contributors, users, and beneficiaries of Canada's standardization system. Ms. Olvera has 20 years of experience working with practitioners and policy makers nationally and internationally in the field of standardization policy, and engaging with stakeholders to understand their priorities to initiate the development of potential strategies, programs or services that will address their objectives and needs. Ms. Olvera has worked closely with international standards and accreditation bodies, federal and provincial/territorial government, NGOs, and industry in support of setting appropriate standardization priorities as a means to enhance Canada's competitiveness and social well-being. Ms. Olvera holds an MA in English Literature from Carleton University.

Chris Rol, Senior Policy Advisor, Insurance Bureau of Canada
Chris Rol has over 20 years of experience in the public and private sectors. She has served as a political assistant for the Premier of Ontario in addition to various roles for both MPPs and the Progressive Conservative caucus. Following her time in the public sector, she held a management position with a property and casualty insurance brokerage as well as a government relations role with Co-operators Insurance. Having joined Insurance Bureau of Canada (IBC) policy department in 2011 Chris works as part of the Catastrophe Risk and Economic Analysis team. Chris holds a bachelor's degree in political science from Wilfrid Laurier University.

Christie Moore, Sector Specialist, Strategy and Stakeholder Engagement Branch, Standards Council of Canada
As a Sector Specialist at the Standards Council of Canada (SCC), Christie brings advanced knowledge of Canadian and international standardization networks to support federal and provincial/territorial governments, NGOs, and industry in addressing their objectives and needs through effective standardization. Specializing in strategic partnerships management, Christie leads the Northern Infrastructure Standardization Initiative (NISI), a program that addresses the unique circumstances found in northern Canada through the effective use of standards, addressing issues such as permafrost degradation, coastal erosion, rising temperatures and changing precipitation patterns. Christie also supports the strategic directives of the Infrastructure Program at SCC, helping subject matter experts navigate the standards development process and supporting work to develop and adapt standards to ensure infrastructure is climate resilient. Christie's previous experience includes disaster management strategy and operational response, federal intelligence oversight and private sector partnership management. Christie has an MA in International Affairs and recently completed her MBA.

David Crenna, Director, Urban Issues, Canadian Home Builders' Association
David Crenna has been Director, Urban Issues at the Canadian Home Builders' Association (CHBA) since October of 2003. He organizes the work of the CHBA Urban Council in conjunction with a volunteer Chair. This Council is Canada's only national forum for the residential development industry. He also coordinates CHBA policy and government relations research and supports his colleagues in finding and using evidence and data on key housing and urban issues. Prior to joining CHBA, Mr. Crenna worked as a consultant for over 19 years, undertaking projects for a range of government departments and agencies, international organizations, NGOs, and some private sector companies. He has addressed environmental, housing, science policy, innovation, and urban issues in his practice. Prior to that, he had a 13 year career as a policy advisor and executive in the Canada Mortgage and Housing Corporation and in the Prime Minister's Office. David has Master's degrees in political science and political sociology from the University of Toronto and the London School of Economics and Political Science respectively and is currently working toward a doctorate in urban geography at Western University.


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David Lapp, Practice Lead, Engineering and Public Policy, Engineers Canada
David graduated with a bachelor's degree in geological engineering from the University of Toronto in 1978. After nearly 20 years as an engineering consultant, he joined Engineers Canada in July 1997 and served initially as a Director and now Manager, Professional Practice serving the Canadian Engineering Qualifications Board. In recent years his work has focused on environment, sustainability and climate change issues and their relationship to the practice of engineering. From 2005 to the present, he has served as project manager for a long-term national project to assess the engineering vulnerability of Canadian public infrastructure to the impacts of climate change. This project has developed an infrastructure climate risk assessment tool known as the PIEVC Engineering Protocol. David provides advice and ongoing technical and administrative support for applications of the Protocol. Since November 2007, David has managed the Secretariat for the World Federation of Engineering Organizations Committee on Engineering and the Environment, hosted and chaired by Engineers Canada.

Deighen Blakely, Team Lead River Engineering, Watershed Planning, City of Calgary
Deighen is a Civil Engineer with a Master's Degree in Fluid Mechanics and Hydraulics. Deighen over 15 years of experience working both as a consultant and for municipal, provincial and state government in a range of areas including hydrologic analysis, hydrotechnical design, erosion and sediment control planning, drainage design, tender package preparation, on-site construction inspection and emergency response planning. Deighen currently leads the City of Calgary Water Resources River Engineering team. The River Engineering team works in three primary areas: Operations, Capital Projects and Policy. The operations component entails flood response planning, operational monitoring and hydrological modelling. The capital project aspect deals with all river-related construction projects including riverbank erosion protection, bridge construction, outfall repair work and local flood mitigation projects. The policy side covers regulatory review of development applications proximal to Calgary's rivers or creeks, development of bylaws and policies related to near river development and working with provincial and federal agencies in setting development guidelines and policies.

Eric Tousignant, Senior Water Resources Engineer, City of Ottawa
Eric is a Senior Water Resources Engineer with the City of Ottawa. He has 30 year of experience in stormwater management and municipal engineering, fifteen of them in the private sector. For the past 10 years, Eric has been heavily involved in flood remediation projects ranging from basement flooding in combined, separated and partially separated areas, overland drainage issues in urban subdivisions and sanitary sewer flood remediation projects. Eric is also the author of the City's "Sewer Design guidelines" including the Stormwater Management Section. Lately, he has been re-writing these guidelines to address issues such as climate change, intensification and flat topography.

Gilles Rivard, Vice-President, Urban Hydrology, Lasalle NHC
Gilles has 33 years of experience in civil engineering, in the fields of hydrological studies, urban networks, water resources and glaciological studies. He has developed a broad expertise in municipal networks studies and in water resources management while managing numerous projects involving development of master plans for sewer and waterworks systems, hydrology/hydraulics analyses for bridges, river trainings and dams. As an experienced engineer, he has also been called upon as an expert witness for important cases related to urban networks analysis. In the last 20 years, he has specialized in storm water management and has published an impressive number of scientific articles on the subject. As a researcher and innovator, Mr. Rivard is the author of a book pertaining to the application of storm water management concepts in an urban environment (1998, with a second edition in 2005) and is the writer of the Quebec provincial guide on storm water management. His professional journey has led him to fill several management positions, specifically with Dessau (now Stantec) where he was acting as Director – Urban Networks and Water Resources, from 1993 to 2000. From 2000 to 2010, Mr. Gilles Rivard was president of the firm Aquapraxis which specialized in software development, technical training as well as state-of-the-art consultation for urban networks analyses and water resources management. Gilles has also worked at the international level, in Algeria, Burkina Faso, Costa Rica, Jamaica, Grenada, Trinidad and Tobago, Morocco, Mexico, Senegal and Russia. After a period with Genivar (now WSP) and Dessau (now Stantec) from 2010 to 2014, he joined NHC in 2015 as Vice President, Urban Hydrology.

Dr. Henry David (Hank) Venema, Planning Director at the Prairie Climate Centre, International Institute for Sustainable Development
Hank is a professional engineer with a diverse natural resource background spanning water resources, agriculture, energy, climate change mitigation and adaptation, rural development, ecosystem management, environmental economics and environmental finance. He holds a PhD in Systems Design Engineering from the University of Waterloo, an MASc in Water Resources Engineering from the University of Ottawa, and a BASc in Civil Engineering (Gold Medal) from the University of Manitoba.

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Husam Mansour, Chief Operating Officer, Pollution Probe
As Chief Operating Officer at Pollution Probe, Husam Mansour is responsible for leading the development and implementation of programs including energy, human health and transportation. His mandate includes developing and expanding new markets and new lines of business. Examples of his work include the development and implementation of business cases to establish Energy Exchange; a new division dedicated to energy literacy at Pollution Probe and Climate Change Division at Canadian Standards Association. In his current role, Husam was instrumental in completing the transformation of the organization, operationally and at the governance level, to enable a more sustainable pursuit of its public interest mission. Prior to joining Pollution Probe, Husam completed a two year assignment as Project Director responsible for overseeing the development and execution of a $105M project at Masdar Institute of Science and Technology (MIST). MIST is the first project to be completed in Masdar City, UAE which is the first city in the world to be designed as carbon-neutral and zero-waste. Previous to that, Husam had a rewarding career at Canadian Standards Association (CSA) where he held successively progressive positions including Director, Built Environment and Director, Business Management and Life Science. Husam graduated as a mechanical engineer from the University of London, UK, and holds P.Eng and Project Management Professional (PMP) designations.

Jeff Walker, Program Manager, Natural Resources, CSA Group
Jeff is responsible for Canadian, American, and International standards in the water resources, mining, forestry, and oil and gas sectors. In the water sector, Jeff oversees standards in stormwater management, protection of surface and groundwater, erosion and settlement control, service and performance for water utilities, and climate change adaptation related to flooding and drought. Previously, Jeff was the International Secretary for the ISO Carbon Capture and Storage Technical Committee. Jeff also was active in developing training modules with subject matter experts for sustainable stormwater management. Jeff worked on consensus standards in sustainable stormwater management, erosion and settlement control, wetlands, water quality monitoring and watershed health; as well as assessed the readiness of infrastructure professionals to address the impacts of climate change on infrastructure.

Kevin Gray, Manager of Engineering Approvals at Halifax Water
Kevin is the Manager of Engineering Approvals at Halifax Water. Halifax Water is Canada's first water, wastewater and stormwater utility. The Engineering Approvals section performs reviews of all expansions and connections to the Halifax Water systems. Kevin is responsible for creating and maintaining several development charges, which facilitate growth at the local and regional level. Kevin is a geomatics engineer with a graduate degree in urban planning and is a member of various water, wastewater and stormwater specification committees.

Laura Zizzo, Founder and CEO, Zizzo Strategy Inc.
Laura Zizzo is a lawyer and strategic advisor with over a decade of experience leading organizations towards a low-carbon and climate-adapted future through the application of law and policy. Laura started her legal career with a prominent Bay Street law firm before founding the first law firm in Canada focused on climate change in 2009. In 2015, she founded a strategic consultancy focused on advising public and private sector clients on climate risks. Laura is a frequent writer and speaker on the move to the low-carbon economy and has become a leading voice on the legal imperative to adapt to climate change. She has contributed to numerous research and policy papers on legal liability related to climate change adaptation, the use of existing legal mechanisms to address climate change, and the role of markets and flexibility mechanisms in driving emissions reductions. Laura has a degree in Environmental Studies from the University of Waterloo and a law degree from the University of Toronto. She is called to the Bar of Ontario.

Mark Palmer, Executive Director, Greenland Group of Companies
Since 1986, Mark has practiced in the consulting engineering industry. He has been responsible for many watershed protection, municipal infrastructure and new community projects. Mark oversees all international partnerships and 'smart' technology joint ventures involving other businesses and research teams in Canada, U.S. Europe and Pacific-Rim. Mark provides expert testimony at environmental and municipal planning tribunals. Mark was also retained to peer-review work completed by all levels of government and by other engineering companies in Canada.

Nancy Hill, Program Manager, AECOM
Nancy Hill is AECOM's lead facilitator for the Canadian National Water & Wastewater Benchmarking Initiative, Stormwater Task Force. She has been supporting municipalities across Canada in the planning, design and construction of their infrastructure for over 20 years both as a municipal employee (City of Vancouver), as well as a consultant. Although Nancy has helped municipalities in all aspects of their infrastructure, she is currently focused on climate change adaptation, stormwater management (including financing and low impact development) and asset management.

Natalia Moudrak, Director, Intact Centre on Climate Adaptation – Working Session Lead
As a Director of Infrastructure Adaptation Program, Natalia advances the development of best practices for building new residential communities in Canada that are more resilient to flooding; as well evaluates the business case for natural infrastructure preservation. Natalia has experience in sustainability strategy, operationalization, reporting and business case development across a wide range of industry sectors and client organizations. Prior to joining the Intact Centre on Climate Adaptation, Natalia worked at PricewaterhouseCoopers Canada, Risk Assurance Services. Natalia holds a B.A in Economics and a Masters in Urban Planning from the University of Waterloo. Natalia is a member of the International Organization for Standardization (ISO) Technical Committee (TC) 224 "Service Activities Relating to Drinking Water Supply Systems and Wastewater Systems - Quality Criteria of the Service and Performance Indicators", where she is a Subject Matter Expert representing Canada on Working Group 11 "Storm Water Management".

Peter Duncan, Manager, Infrastructure Planning, Halifax Regional Municipality
Peter Duncan is a Civil Engineer, Graduated from Technical University of Nova Scotia, and has practiced Municipal Engineering for 30 years. He has a background in construction, project management, wastewater treatment, land development, environmental policy, infrastructure financing and rate design. He has worked for the Halifax Regional Municipality for the past 18 years, currently as Manager of Infrastructure Planning with Planning and Development Services, and is responsible for joint Stormwater Policy matters with Halifax Regional Water Commission. Prior to this position, previous management portfolios included the Environmental and Utility sections of the HRM Regional Plan, Development Engineering, Development Charges and the Environmental Management Office.

Philip Rizcallah, Program Director, Construction Portfolio, National Research Council of Canada
Philip Rizcallah is currently the Program Director within the Construction Portfolio at the National Research Council. He is responsible for Codes Canada, the Canadian Construction Materials Centre, and several of the associated research labs. He graduated from Dalhousie University with degrees in Mechanical Engineering, and Mathematics. His long career in the federal government also included positions with Labour Canada as a safety officer, the Federal Fire Commissioner as a Fire Protection Engineer, and Public Works Canada as a Senior Project Manager. He is the NRC Policy Advisor to the Canadian Commission on Building and Fire Codes; the Policy Advisor to the Provincial Territorial Policy Advisory Committee on Codes; Member of the CSA Strategic Steering Committee on Civil Engineering and Infrastructure; and the ULC Fire Council Steering Committee.

Robert J. Muir, Manager of Stormwater, City of Markham
Robert manages Markham's long term Flood Control Program, including planning studies, design and construction of remediation works, and funding, as well as lifecycle planning and management of stormwater management facilities, drainage systems and watercourses. He has over 26 years of experience in the planning, analysis, design and approval of municipal drainage and flood hazard management systems - 20 years as a private sector consultant at Dillon Consulting Limited where he led the national Water Resources Practice. His experience involves management of large, complex studies involving hydrodynamic modelling, full life-cycle costing of management alternatives, litigation involving extreme weather events, and peer review of technical studies. Currently he is advising the National Research Council on industry needs for Climate-Resilient Core Public Infrastructure.

Ron Scheckenberger, Principal, Amec Foster Wheeler
Ron currently heads the Water Resources Team based in the Burlington Infrastructure office. He has over 30 years' experience in all aspects of water resources projects from concept, to design, to implementation, to monitoring. Ron has strived to be at the forefront of technology, while focusing on practical and implementable solutions for his clients. He has had the good fortune to be involved in numerous community planning exercises providing stormwater and environmental strategies to protect important ecological functions.

Sameer Dhalla, Associate Director, Engineering Services, Restoration and Infrastructure, Toronto Region Conservation Authority
Sameer Dhalla is the Associate Director of Engineering Services at the Toronto and Region Conservation Authority (TRCA). He has 19 years of experience in both the private and public sector and has worked on various projects from watershed planning to flood plain management. At the TRCA, Sameer leads a team of engineers, scientists and technicians in reviewing development applications, implementing flood remediation projects, developing water management policies and administering TRCA's flood protection and warning program.

Sean Lee, Assistant Director of Engineering & Operations / Manager of Engineering Services, City of Fredericton
Sean Lee is a Civil Engineer and the Assistant Director of Engineering & Operations / Manager of Engineering Services at the City of Fredericton in New Brunswick. Drawing on 20 years of experience, Sean is responsible for the administration of the City's annual capital construction program, providing technical support and guidance for developments, and management of the City's transportation systems and solid waste collection programs. Sean has taken a leadership role in the development of the Canadian Public Works Association (CPWA) Engineer's Council, opening communication between municipal Engineers from all parts of New Brunswick. During his career, Sean has worked in technical, operational and management roles, where he has gained a detailed knowledge of Fredericton's storm water systems and been instrumental in the development of adaptive strategies to address anticipated impacts of climate change.

Scott Adams, Project Coordinator, City of Charlottetown
In his current role, Scott is responsible for overseeing all Public Works' winter and summer maintenance activities and project management of all Public Works and Water & Sewer capital projects at the City of Charlottetown. Past experiences include project manager of highway construction including drainage and culvert construction with the Province of New Brunswick. Scott is a graduate of Civil Engineering and holds a MEng degree in Transportation Engineering from the University of New Brunswick.

Subhi Alsayed, Vice President Sustainable Development, Mattamy Homes
Subhi's main focus as a Vice President Sustainable Development at Mattamy Homes is to investigate and implement strategies for sustainable communities. Prior to Mattamy, Subhi was the innovation manager for the Tridel Corporation, as well as the director of projects with Tower Labs at MaRs. He also co-founded netZED, the first branded net zero energy concept in high-rise living. Subhi is a MBA graduate from Ivey Business School, a Professional Engineer, LEED Accredited Professional, and a Certified Energy manager.

Terry Geddes, Senior Project Manager, Cortel Group
Terry holds a number of urban land development responsibilities at the Ontario-based Cortel Group. Terry is also a Director of the Great Lakes Pilotage Authority. Previously, Terry served as a Warden of the Simcoe County, Ontario; Mayor of Town of Collingwood, Ontario (1997-2006); Director and Secretary for the Great Lakes and St. Lawrence Cities Initiative and Mayor's Association; Member of Federal Minister of Industry Auto Pact Relations Committee, as well as a member on a wide range of other committees focusing on municipal Issues at all levels of government. Terry is a founding Director of the Great Lakes and St. Lawrence Cities Initiative.


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