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Flood-proofing Vancouver: Policies for a Resilient City

October 16, 2013

DISCUSSION GUIDE

Acknowledgements

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Introduction

With the wind blowing waves and water onshore across New York and New Jersey, Superstorm Sandy had a storm surge of 14 feet in October 2012. The following summer, in July 2013, Toronto broke records that had stood for almost 60 years when they received 126 millimeters of rain in a single day. Some parts of Alberta that were recently impacted by floods received half of the expected total annual precipitation in just 36 hours.

The Insurance Bureau of Canada reports that claims related to rainfall damage from such events now make up more than half of all claims and have been growing steadily over the years. Coastal and overland flooding is expected to worsen with climate change and damage to infrastructure and the well-being of our communities is likely to increase. It is through making our communities more resilient that we can hope to bounce back and recover after these kinds of events. Building resilience includes proactive risk mitigation measures, response capacity, and our ability as a community to adapt.

Our own region is particularly susceptible to these threats; The City of Vancouver anticipates an increase in the frequency and intensity of rainfall and sea level rise (Provincial figures suggest planning for a 1 metre rise to 2100). The City has been planning for such climate change impacts and in July 2012 the Council unanimously adopted the Climate Change Adaptation Strategy. Amending flood-proofing policies and undertaking a **Coastal Flood Risk Assessment** are both priority actions currently underway.

With each year, scientific understanding and projections of sea level rise are refined. Flood-proofing methods and measures will continue to evolve as well. The implementation of new flood-proofing policies, including raising the minimum elevations for new buildings, has the potential to conflict with existing streetscape design, accessibility, zoning, filling, and drainage. Creative mitigation measures and flexibility will be needed as planning for sea level rise becomes the new normal.

In 2004, when the Province transferred responsibility for flood management to local governments, the City adopted Provincial standards. The Province has since published guidelines to support municipalities in developing policies and bylaws. The current official guidelines are the 2004 Flood Hazard Area Flood Management Guidelines. The Province released draft guidelines in May 2011 outlining methods and figures to include sea level rise in flood management: Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. The Province is currently working on an amendment to the 2004 guidelines to incorporate information from the 2011 draft guidelines.

The 2011 guidelines introduced sea level rise figures of 1 metre by 2100 and 2 metres by 2200 to be used by BC municipalities in planning flood hazard management and calculating flood construction levels (FCLs). In response, the City has been encouraging a 1 metre increase (from 3.5/3.8 metres to 4.5/4.8 metres) in FCLs. Staff are now revising the flood-proofing policies to require these increased levels and add additional application and implementation measures.

Recent major flooding events (clockwise from top-left): Calgary, June 2013; New Jersey, Fall 2012; New Orleans, August 2005; Toronto, July 2013)

Background

There are several flood hazards in Vancouver.

Overland flooding can occur when rainfall or snowmelt exceeds the capacity of the sewage system or when a rainstorm exceeds the capacity of overland flow routes – streets, swales, and parks designed to carry flood water away from urban areas as occurred in Toronto this summer.

River flooding can also occur given the right conditions. The water levels in the City of Vancouver portion of the Fraser River are more defined by ocean conditions than by springtime freshet.

Coastal flooding occurs when low-lying land is flooded by sea water. It is a function of the topography of coastal areas and can be caused by storm surge, sea level rise, a combination of the two, and tsunamis. Storm surge is the increased height of water resulting from high winds causing the water to pile up higher than usual. Secondary causes include low pressure systems 'pulling' the water up, and the depth of water. A 'perfect storm' of high tide, wind onshore, and low pressure can create a large storm surge. During the recent Hurricane Sandy, storm surge pushed water to a record 4.23 metres at the tip of Manhattan.

Inundation is used to describe areas of land where the water at high tide will exceed the elevation of the land. There are very few areas in Vancouver where this may occur.

Flood prone areas are those that may suffer temporary flooding during a storm at high tide.

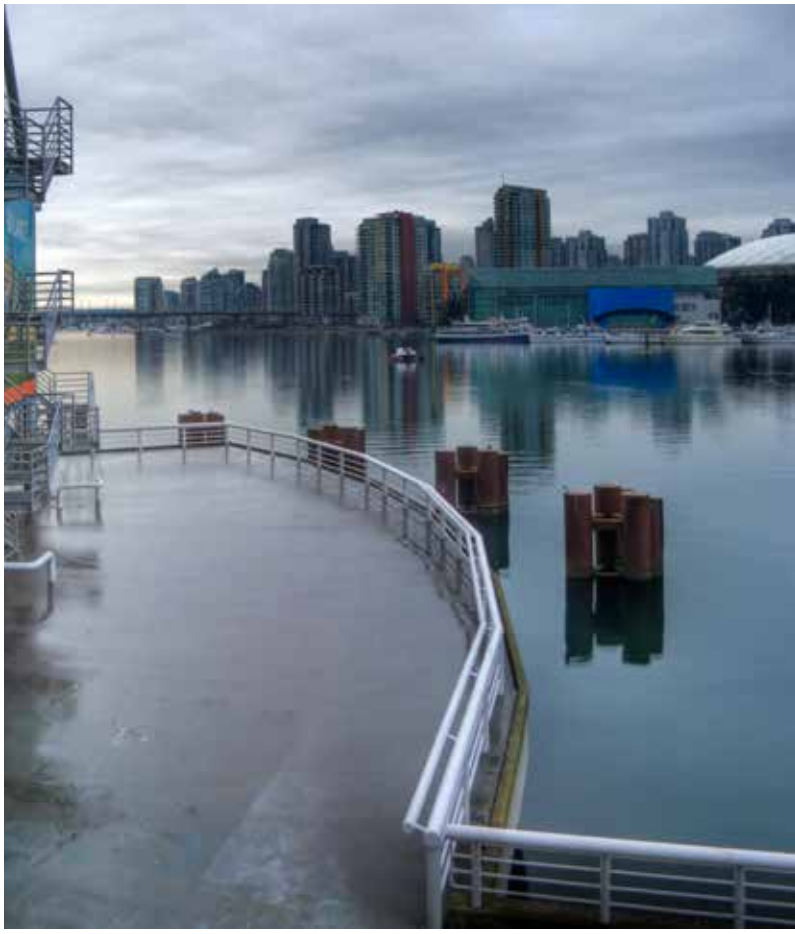
Flood hazard management regimes attempt to minimize the risk of all types of flooding. Flood-proofing policies are an important proactive measure but have to be complemented with other actions. For overland flooding, important actions include separating sanitary and storm sewers, catch basin cleaning, addition of green infrastructure, or back-water valve installation – all underway at the City. For coastal flooding, the Coastal Flood Risk Assessment currently underway will explore additional adaptation options such as protective measures and accommodation of floodwater.

Dikes have long been a flood hazard management tool for both river and coastal flooding. While numerous municipalities in the lower mainland maintain many kilometers of dikes, the City of Vancouver has relied on other tools such as flood construction levels (FCLs) and setbacks. FCLs are minimum heights for building construction to keep living spaces and areas used for storage above potential flood levels.

In January, 2012, triggered by the release of new draft Provincial guidelines on flood hazard management and sea level rise, the City began encouraging an additional 1 metre over and above existing FCLs (up to 4.5 or 4.8 metres, location specific). An alternate covenant was drafted and signed in cases where applicants chose not to take the City's advice.

Staff are now working on an amendment of the Flood-proofing policies to the 'encouraged' FCL +1 metre and additional changes to increase flood-resilience. Staff are seeking your input and advice on these amendments and implementation of flood-resilience measures as sea level rise is the new normal.

Key tools applied through flood-proofing policies are the elevation of buildings (Flood Construction Levels) and distance from bodies of water (setbacks). Flood construction levels (FCLs) apply in areas of flood hazard which are currently located along the Fraser and specific portions of False Creek, English Bay and Burrard Inlet.



The Guidelines

Since the government of British Columbia last published sea level rise projections in 2008, there have been advancements in the understanding of land and sea ice melt. The provincial government's scan of recent projections is illustrated below in Figure 1 by the grey band.

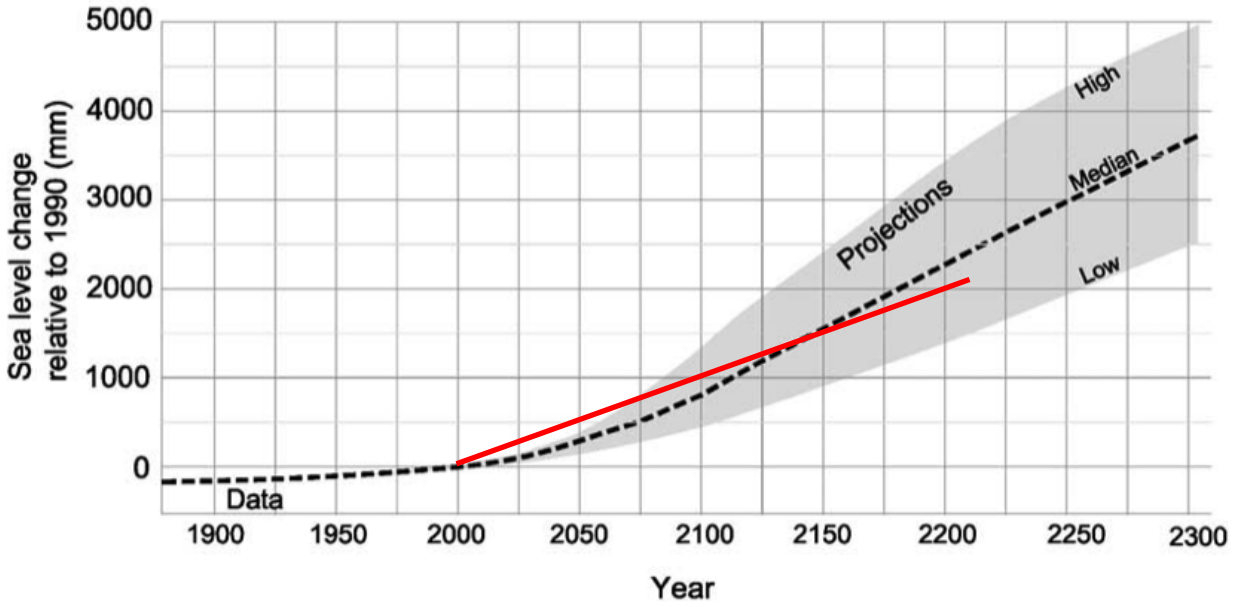


Figure 1: Recent Projections of Expected Global Sea Level Rise (Source: Draft Policy Discussion Paper, BC Ministry of Environment)

The Province chose a median line (red line in Figure 1) to recommend figures for BC sea level rise planning and policy as described in Table 1 below. Once a development timeframe is chosen, the associated sea level rise number is added to elevations for tide, storm surge, and wave action to calculate final FCLs.

Development Timeframe	Global Increase in mean sea level
Lifespan to Year 2050	0.5 m
Lifespan to Year 2100	1.0 m
Lifespan to Year 2200	2.0 m

Table 1: Sea Level Rise Recommendations for BC Sea Dike and Coastal Flooded Land Management Guidelines

Response to the Guidelines

There were several drivers pushing the City to act on the guidelines within a reasonable timeframe. First, planning for climate change adaptation is a priority in the City's Corporate Business Plan and the planning process to date has identified sea level rise as a significant impact. Second, a new neighbourhood site in the City was raised by 1 metre following discussion with City staff and the results of a study commissioned by the developer. Third, a window of opportunity exists with considerable development around the False Creek shoreline currently being planned. Other drivers include the due diligence of incorporating best available information.

To build awareness and understanding around the guidelines, the City partnered with the Province to convene a workshop including municipal staff, developers and engineers from across the lower mainland. City staff began discussions with Port Metro Vancouver, the Vancouver International Airport, the Vancouver Economic Commission, the Fraser Basin Council and others.

The City also partnered with Port Metro Van to undertake a coastline engineering study to apply the province's methodology to 80 coastline sites across Vancouver. While the study was underway, the interim measure of an added 1 metre to FCLs was implemented. This interim approach matches the anticipated increase in global mean sea levels by the year 2100 as recommended in the Provincial guidelines. City staff agreed 2100 was an appropriate planning horizon given the lifecycle of most infrastructure.

The Urban Development Institute (UDI) Technical Committee was updated throughout the process and provided feedback on draft interim measures.

The City initiated a comprehensive **Coastal Flood Risk Assessment** project this summer. The two-phased project includes detailed coastal modeling and mapping that will result in additional refinement to our understanding of flood hazard and recommended FCLs per flood prone area. The project also includes an assessment of potential damages and impacts from flooding and identification of vulnerable areas and populations. The second phase of the project will focus on crafting and analyzing trade-offs between various area-specific adaptation options. The four recognized categories of response are:

- Protect (walls, storm gates, dikes);
- Accommodate (raise buildings, FCLs, flood-resilient building);
- Retreat (gradually remove development from coastline); and
- Avoid (impose restrictions to development along coastline).

Communication with applicants and staff began early in the process and a formal customer letter was sent to all development applicants detailing the interim FCL approach.

Regional dialogue on the draft Provincial Guidelines has been animated and has coalesced around the lack of implementation direction and the low risk tolerance represented by the methodology. Mannerstrom et al. state that the provincial methodology disregards the joint probability of high tide, storm surge, and local wind set up occurring simultaneously.[1] Instead it adds a very high tide to a large storm surge to high winds etc. "Based on the more detailed statistical analysis, the 200 year level estimated using the guidelines was found to have a return period of approximately 10,000 years, suggesting the guidelines are quite conservative." In other words, all of these events occurring at the same time – high tide, storm surge, and local wind – is likely to occur only once ever 10,000 years. Traditionally, flood management was planned to a level of a 200 year return period. Initial joint probability estimation methods used resulted in approximately 0.5 metres less than the levels computed following the provincial guidelines methodology.

The current "Flood Hazard Area Land Use Management Guidelines" published in 2004 are the only 'official' guidelines as they were issued by the Minister under section 5 of the Environmental Management Act. They do not include any information about sea level rise as presented in the Ausenco Sandwell reports from 2011. The Province's stated intention is to write an amendment to the 2004 guidelines based on: the information in the 2011 reports and feedback received to date, and through consultations with local governments and professionals. This process is set to begin later this fall.

1. M. Mannestrom et al. "A Continuous Simulation Approach for Estimating Future Flood Hazards Due to Joint Occurrence of High Ocean Levels and High Runoff" (Paper presented at the 21st Canadian Hydrotechnical Conference, Banff, Alberta May 14-17, 2013).

Flood-proofing in the Lower Mainland

Current tools used in the lower mainland to mitigate flooding at the site and building level include FCLs, setbacks, structural protection (dikes and drainage) covenants and development permit areas / development variance permits. Several municipalities, such as **Squamish** and **Surrey** require site specific flood assessment studies. Beyond site specific flood mitigation measures such as pumps and sand bags, there are few examples of flood resilient construction measures in the lower mainland.

Richmond uses flood-plain designation bylaw #8204 with language from the 2004 Provincial guidelines. FCLs depend on location within the agriculture land reserve and whether development is inside or outside standard dikes. Richmond's Flood Risk Protection Strategy identifies flood protection needs, responsibilities and strategies.

The **City of North Vancouver** and the **District of North Vancouver** recently collaborated on a stream and coastline engineering study to help recommend new FCLs with sea level rise. The City of North Vancouver uses FCLs as a flood mitigation strategy but has no policy in place to date. The District of North Vancouver has Natural Hazard Development Permit Areas to protect development from creek hazards, wildfire hazards, and slope hazards.

Creek Hazard Development Permit Area guidelines include, but are not limited to:

- Development should comply with flood construction requirements identified by a qualified professional in a preliminary assessment or detailed assessment report
- Structural and/or non-structural flood protection measures should be implemented to mitigate the impacts of flooding within areas already developed
- Proposed flood construction levels should be clearly defined by a qualified professional, preferably in Geodetic Survey of Canada datum (guidelines for an assessment report by a qualified professional include identifying suitable building envelopes, setbacks, FCLs and areas that should remain devoid of development

Delta completed a flood risk and consequence study that examined the impacts of flooding due to storm surge and sea level rise, and are now working to address the impacts of climate change and are planning future adaptation work. Actions include:

- dike improvement works to address sea level rise;
- fore bay, flood box and pump upgrades to reduce the impacts of flood events and storm surge;
- agricultural adaptation initiatives; and
- land based flood mitigation measures, e.g. FCLs, that will enhance the resilience of future development.

Learning from other jurisdictions

Jurisdictions around the world are coming to terms with the reality of increased chances of flooding and the associated costs. The full costs of Hurricane Katrina were recently estimated to be between $96 and $125 billion USD (including $50-$66 billion in insured losses), not including impacts on national economic growth. The impacts of Superstorm Sandy are still being experienced, but property damages alone are estimated to be approximately $20 billion. In 2012 the United States government spent nearly $100 billion dollars recovering from droughts, floods, storms and fires; this was triple what was paid out by private insurers.

More recently – and closer to home – flood damages in Calgary were significant. Statistics Canada has estimated that workers in Alberta collectively lost 5.1 million hours of work as a result of the flood that devastated southern parts of their province. The Insurance Bureau of Canada (IBC) reports that last June's southern Alberta floods are now considered the costliest natural disaster in Canadian history. The latest PCS-Canada estimate of the insured property damage caused by the floods exceeds $1.7 billion.

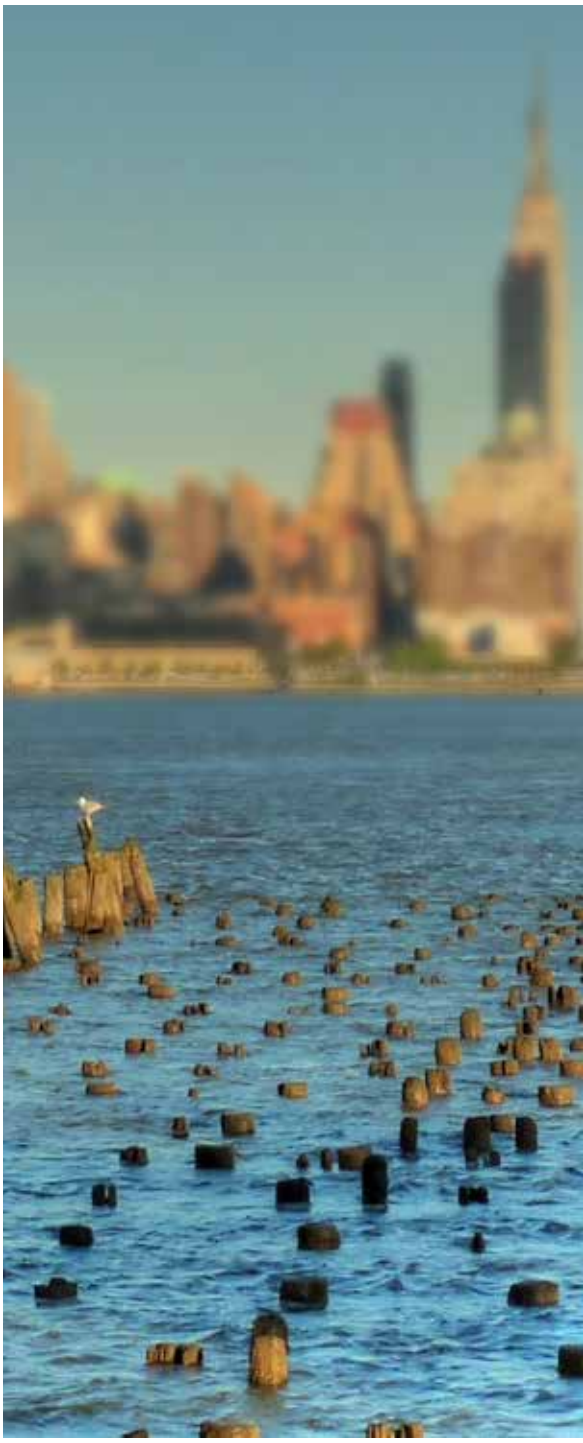
As these cities work to recover from these disasters, they are looking at implementing a series of guidelines based on important lessons they have learned. Our own city can study these lessons as it looks to update its own guidelines.

New York City

Upwards of 30,000 housing units located in 9,000 buildings suffered damage as a result of Hurricane Sandy. Long-term utility outages in some areas of the City made some buildings uninhabitable when residents were unable to get fresh water, flush toilets, or safely navigate hallways and stairways. New York City commissioned an extensive study following Sandy and released a series of recommendations.

Recommended strategies include:

1. Improve **resiliency of buildings** by removing impediments to upgrades and establishing best practices that include but are not limited to:
    a. Increasing building elevations
    b. Wind resiliency measures
    c. Requirements for storage of oil and hazardous materials
    d. Requirements for location of fire protection systems, electrical boxes and other systems above flood construction level.
    e. Requirements for back-flow valve on household sewer connections.
2. Improving **back-up power**
    a. require the installation of external electrical hookups for temporary generators and elevate back-up systems.
    b. Amend building code to keep residential stairwells lit during blackouts.
3. Improve **essential safety**
    a. Amend the New York City Plumbing Code to require that toilets and faucets be capable of operating without an external supply of electrical power and that drinking water is supplied to a common area in residential buildings through pressure in the public water main.
4. Better **planning**
    a. develop guidelines for how residential and commercial property owners shall prepare for and communicate certain information to the tenants of such buildings in the event of a weather emergency or extended utility outage



Calgary

Recent flooding of the Bow and Elbow Rivers has resulted in many applications to the Disaster Recovery Program. Applicants must meet minimum flood mitigation measures in order to receive funding to perform repairs or rebuild on their property. The measures are referred to as “wet flood-protection” and are intended only to minimize damage, and to speed restoration in the event of a flood, not to prevent damage.

Preventing damage is accomplished in four primary ways:

- Leave basements unfinished or refinish with materials and finishes that resist water damage and are cleanable.
- Move the main electrical panel and isolate circuits feeding electrical outlets and equipment in the basement so that power can be restored quickly in the event of a flood.
- Seal piping, wiring, and conduit penetrations at basement walls to minimize water seepage into the building.

Hamburg, Germany

Hafen City, located in the port of Hamburg on the River Elbe, is a complex built with flooding in mind. About 6000 homes sit along side offices, a concert hall, and public parks all on a series of elevated industrial piers retrofitted with flood-secure plinths. A number of the buildings have two sets of first floors: some lower floors feature thick aquarium glass and watertight storm doors, while the upper floor features pathways accessible to emergency services. Developers are responsible for adding their own additional plinths for new buildings; these plinths often hold parking spaces, removing the need for above-ground parking structures.

London, United Kingdom

London has needed to invest significantly in flood risk defense; over 1 million people sit within its floodplain. The last major tidal flood near London was in 1958, spurring the construction of the Thames Tidal Defences, made up of over 400 floodgates and 300 kilometres of floodwalls. With expected sea level rise, London is looking to the future and considering additional walls or embankments and pumping stations, as well as better planning to ensure limited new developments on the floodplain.

Ferndale, California

Since 1980, the City of Ferndale had been declared a Federal disaster area 7 times due to flooding of Francis Creek; one major flood in 1995 caused $1.76 million USD in damages. To increase its resilience and avoid future disasters, Ferndale instituted a plan to widen and shore up the creek, introduce native vegetation, and restore the creek's natural channel. The project ultimately cost $3.75 million USD, and two more major storms in 2002 proved its worth: all homes stayed dry.

City of Vancouver Flood-proofing policy changes

Vancouver's flood-proofing policies were last amended in 2007 following findings from a new Fraser River model and an improved understanding of climate change and of flood potential in the False Creek area. Flood construction levels in False Creek Flats were increased by 0.5 metres to provide greater resilience against ponding resulting from a combination of wave action, winter storm surges, and major rainfall events.

In 2007, staff added the following language to the policies: "the current FCL of 3.5m within 300 metres of the natural boundary (3.0m when beyond 300 metres) will need future review and possible revision as more conclusive scientific study is completed on climate change".

City staff have been encouraging an added 1 metre since January 2012. This would have two implications:
1. FCLs are now 4.5m or 4.8m (East of Oak on the Fraser River)
2. The extent of the flood-prone area is expanded.

The current policy revision will change all FCL numbers to include the additional 1 metre. The amendment will also include, but is not limited to, general changes reflected below.
1. Draft Exclusion for crawl spaces will be added to the Zoning and Development bylaw.
2. Streamline policy by tool, such as FCL or setback, not by hazard.
3. Intent of policy now includes reduced recovery time.
4. Definitions changed to include sea level rise in flood level.
5. Add 1 metre to all flood construction levels except Still Creek (Metro Vancouver study starting 2015).
6. Consider removing 300 metre delineating line for all FCLs (City of Vancouver is the only jurisdiction in the Province to have this).
7. Added link to VanMap layer showing flood prone areas.
8. Light industrial removed from FCL relaxation. This now includes uses that could be damaged whereas traditionally it did not.
9. New implementation measures: electrical above FCL, backflow valves, hazardous materials storage above FCL or sealed.
10. Grades, filling and drainage schedule (RA-1 Southlands) will be updated
11. Site specific solutions may be required where the physical characteristic of the lot creates demonstrated hardship. Flood-resilient construction will be required in these cases.
12. Append a flood-resilient construction primer.

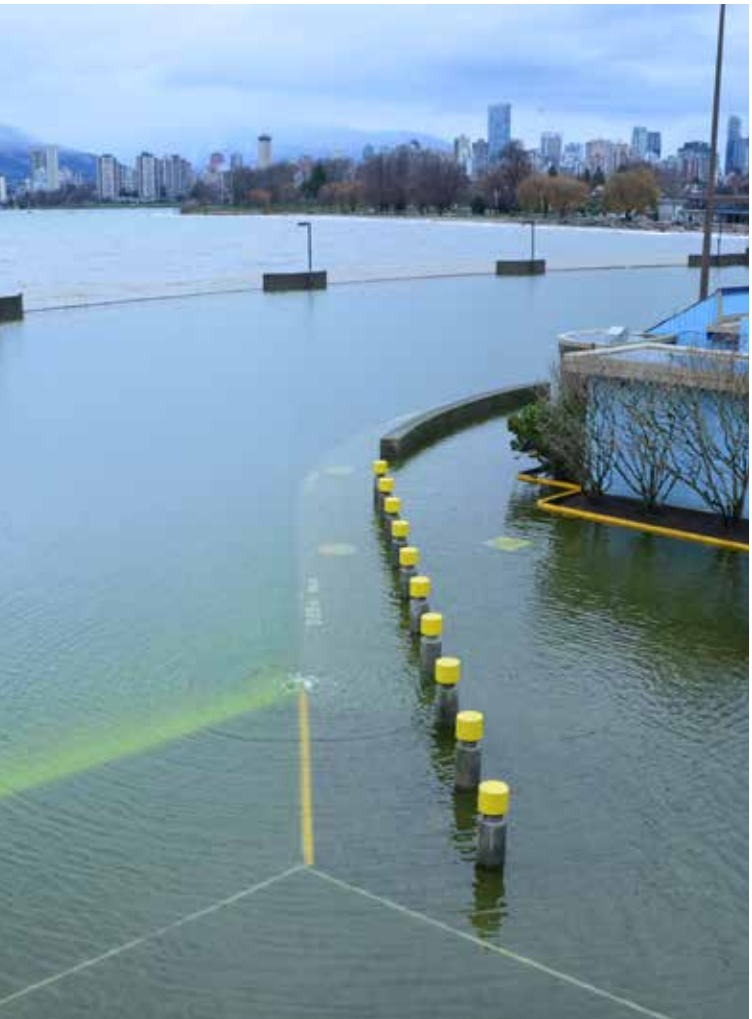
There are a number of well-sited challenges related to an increase in flood construction level. A thorough scan of zoning guidance and regulation implications concluded that a 1 metre increase in FCLs is manageable under the current regime with only small changes. Potential future increases will require exhaustive study of secondary impacts, design options, and associated regulatory changes.

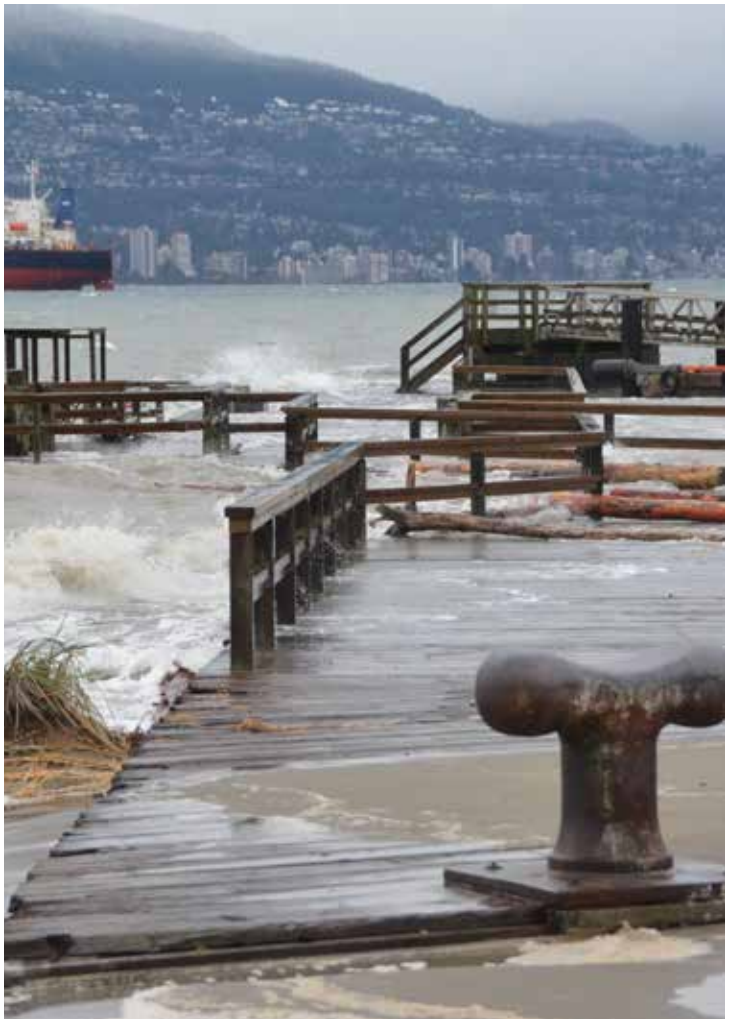
Challenges associated with increased FCLs include:

- Difficulty achieving floor space ratio (FSR) on site;
- Maximum height requirements could mean loss of a storey and relaxations may affect streetscape, view corridors, and adjacent properties;
- Maintaining form and character of the streetscape;
- Increased fill can negatively affect form, character, and drainage.
- Accessibility may be compromised;
- Integrating public and private realm in a functional and visually appealing way; and
- Maintaining commercial at street level to encourage pedestrian access.

An exclusion will be included in section 10 of the Zoning and Development bylaw to deal with an issue that City staff have been challenged by in the interim policy period. For areas in flood prone areas, the Director of Planning will be able to exclude floors located at or below finished grade with a ceiling height of less than 1.5 metres, from the computation of floor space ratio.


Jericho Sailing Centre
NO SWIMMING





Conclusions & Discussion Questions

Vancouver has been a leader in North America on climate change mitigation and sustainability. By implementing an interim FCL policy and taking a conservative approach, we will be ahead of the curve in mitigating against potential future risks and impacts of climate change, including flooding risks associated with sea level rise and more intense storm events. These new FCLs will ensure our neighbourhoods are being built to the safest standards possible, and that Vancouver remains a liveable and resilient city, maintaining its values, character and charm in the face of climate change.

In this context, this guide has provided an overview of why the City of Vancouver needs to update its flood-proofing policies, and points to what changes are likely to be included. The upcoming dialogue will seek your feedback on these changes specifically, and what other considerations should be taken into account as the City works to ready itself for a future of increased flood risk.

The following questions should help to prepare participants for the dialogue:

- Are the policy changes and actions the City is taking to respond to sea level rise appropriate?
    - Where do you see gaps or opportunities for improvement?
    - What aspects would you find challenging?
    - What changes and actions do you specifically support?
- Can you suggest any strategies to ensure effective implementation of these policies and future changes?
- If current modeling shows that even higher building elevations (FCLs) are required, there will be significant impacts to streetscape and design. What are some ideas to deal with this?
- How do you envision streetscapes and building design adapting to new and changing requirements? What innovative designs do you see emerging?
- What other partners or stakeholders need to be brought into this discussion?
- Are there other best practices in Canada or internationally that can help inform how we approach flood-resilience?
- What are the best ways to continue to seek input as we plan for climate change and increased flood risk?

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