Realizing Resilient Buildings in B.C.

A toolkit for local governments

BC HOUSING
RESEARCH CENTRE

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Acknowledgements

Pinna Sustainability would like to acknowledge with respect and gratitude that this toolkit was produced on the territory Sḵwx̱wú7mesh (Squamish), Səl̓ílwətaʔ/Selilwitulh (Tsleil-Waututh) and xʷməθkʷəy̓əm (Musqueam) Peoples.

Climate change and natural hazards disproportionately affect certain communities, with marginalized groups often bearing the greatest burden. While the authors of this toolkit may not have direct experience with these challenges, we emphasize the importance of recognizing these unique needs and collaborating to build a more just and resilient future.

This toolkit represents the input from a broad range of knowledge holders who graciously provided input through participation in workshops, seminars, individual meetings, and document reviews. The authors are grateful for the time and expertise shared by all of these individuals and organizations, that we may advance the state of knowledge and awareness to help us collectively better understand the barriers and enablers to enhance the resilience of buildings across B.C.

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Main entry under title:
Realizing Resilient Buildings in B.C. Toolkit
ISBN 978-1-0399-0121-6 – Print version
ISBN 978-1-0399-0122-3 – Digital version

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This toolkit was commissioned by B.C. Housing's Research Centre, jointly funded by B.C. Housing and the Province of B.C., and was prepared by Pinna Sustainability Inc., together with Gary Penway Consulting, Public Architecture + Communication and Mika Creative.

Acknowledgement is extended to all those who participated in this project as part of the project team or as external reviewers.

1. About this toolkit

This toolkit is designed to provide B.C. regional and municipal governments (local governments) an introduction to strategies and tools that can be used to support more climate- and seismic-resilient buildings in B.C. communities. The toolkit focuses on preparedness and risk mitigation at the building and site scales. It includes a section on how local governments can encourage and support resilience measures among early adopters and pilot projects. Other resources should be consulted for developing community-wide resilience strategies, and strategies to support event response and recovery.

The 2019 Canadian Institute of Planning survey highlighted barriers to incorporating climate change into planning. These barriers include the lack of relevant information, no political support, and no expertise to address climate risks. This toolkit aims to continue building capacity of local government staff and elected officials on climate resilience in the building sector.

There are eight hazard areas considered in this toolkit. For each of these, the toolkit explores:

- What is the risk and how is it changing?
- Examples of building and site design features that make them more resilient to specific hazards and across hazards
- Descriptions of local government strategies and tools that are relevant to the hazard, including examples and resources
- Important considerations for taking an equitable approach to building resilience

The toolkit is organized by hazard and includes the following:


Extreme heat


Flooding: coastal and riverine/lake


Flooding: pluvial


Wildland urban interface fires


Wildfire smoke and air quality


Storms and power outage


Drought and short-term water shortage


Earthquake

2. What is a resilient building?

B.C. is undergoing a transition, with temperatures rising, precipitation patterns changing, and an increase in variable weather conditions that are already taxing our built environment. Changing conditions led to a number of extraordinary events in 2021 - including the western heat dome, Lytton Creek wildfires, and Fraser Valley floods and landslides. These events demonstrate the enormous scale of physical and emotional impacts, not to mention the massive financial impacts. The first principle of hazard risk-based land use is to avoid putting lots of people in harm's way, like in a floodplain. Pressures to grow and expand the built environment to accommodate new residents and economic opportunities are increasing. As a result, we are relying more on resilient buildings in hazard exposed areas. Increasing risks from climate change, a growing population, and aging building stocks and infrastructure are creating a substantial increase in disaster and climate risk. We need forward-looking measures now to address these challenges.[1]

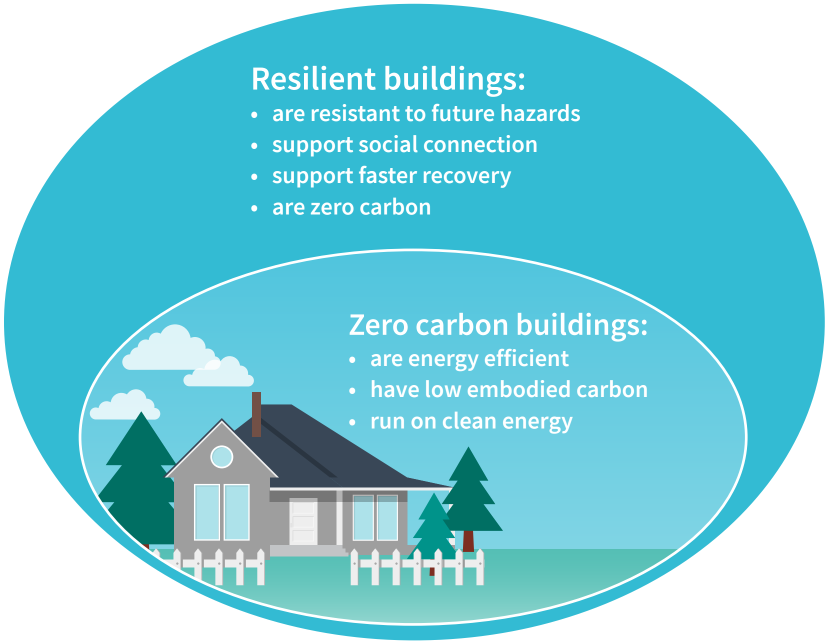
Resilient buildings are resistant to future hazards, support social connection, and support faster recovery

Depending how they are designed and operated, buildings can either compound the hazard threat and resulting stresses, or they can reduce those impacts. The easiest risk management technique is avoiding areas exposed to current and future hazards by siting buildings away from hazards in land use planning. If avoidance is not possible, design risk mitigation for current and future hazard intensity.

It's critical to plan, design, and retrofit buildings to consider multiple hazards, both now and in the future. These buildings should meet the needs of all occupants and support improved social connectivity. This approach will improve the resilience of our buildings and communities. By connecting occupants, neighbours will be more likely to check-in and support each other during times of adversity.

Flexible design can support resilience to changing conditions over time, as can considering strategies for the operation of the site during the design and planning stage. Examples include:

- Changing ground floor use over time in flood prone areas.
- Accommodating evolving technologies.
- Designing space for added system capacity in the future (e.g., space and electrical conduits to support additional mechanical cooling over time).



Resilient buildings are zero carbon

Communities are already making significant investments of resources toward the goal of having all buildings be carbon neutral in B.C. by 2050. While this is a necessary goal, it is critical that these investments are going into buildings that will keep people safe and healthy in the face of increased hazards and risks. These investments must harness opportunities for synergies that achieve both zero carbon and resilient buildings to avoid potential losses in value and ensure they support people to weather future conditions.

Resilient buildings address equity

Effective preparedness, response, and recovery from shocks and stresses rely on considering a broad range of perspectives. It's important to understand the diverse needs of building occupants before, during, and after a disaster event. Where possible, these considerations should come from direct input from equity-deserving individuals or groups representative of current or future occupants. This input can inform building and retrofit design and operations. Priority should be given to individuals who are likely to be disproportionately impacted by shocks or stresses, particularly those facing systemic barriers, living with disabilities, or experiencing pre-existing conditions. Taking this approach to design can also help to address systemic inequities. Throughout the toolkit, there are brief references to the diversity of impacts from specific hazards to consider as a starting point.

SECTION ENDNOTES

[1] Safaie, S., et. al.. (2022). Resilience Pathways Report.

Additional references

- McGill. (n.d.). Disability Inclusive Climate Action Research Programme.
- Weibgen, A. (2015). The Right to be Rescued: Disability Justice in an Age of Disaster.
- Global Disability Innovation Hub. (n.d.). Climate and Crisis Resilience.

3. Designing buildings

3.1. How are buildings and occupants impacted by climate and seismic hazards?

Natural hazards, including both stresses and shocks, can impact all elements of buildings and the occupants in the buildings. Stresses arise from slow-onset climate hazards (gradual sea rise, for example), while shocks occur due to acute climate-related hazards (an extreme heat event or flood, for example) and earthquakes. The severity of the impacts from the hazard varies greatly depending on the exposure to the hazard and the vulnerability of the building and occupants. Compound hazards, like a hot day with poor air quality, and cascading hazards, like a windstorm power outage, can increase impacts and complicate resilience solutions.

The following diagram highlights examples of impacts from climate-related and seismic hazards. The rest of this toolkit highlights measures to address these impacts, and tools and strategies local governments can use to support the implementation of those measures.

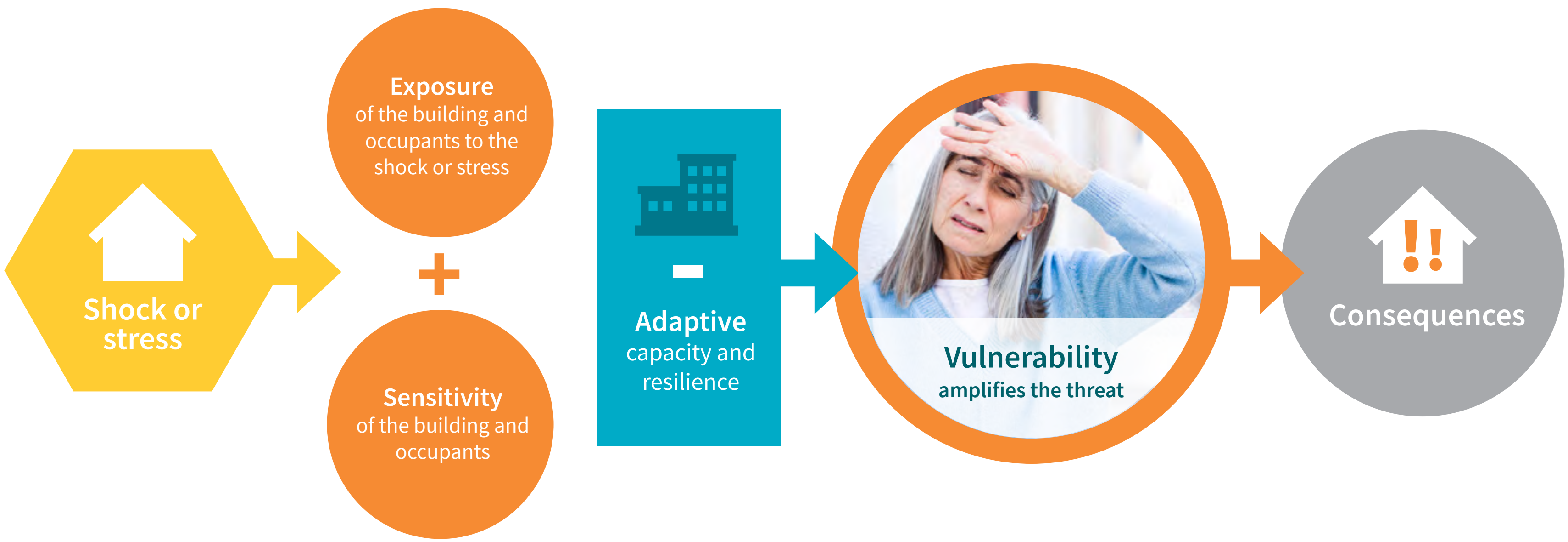
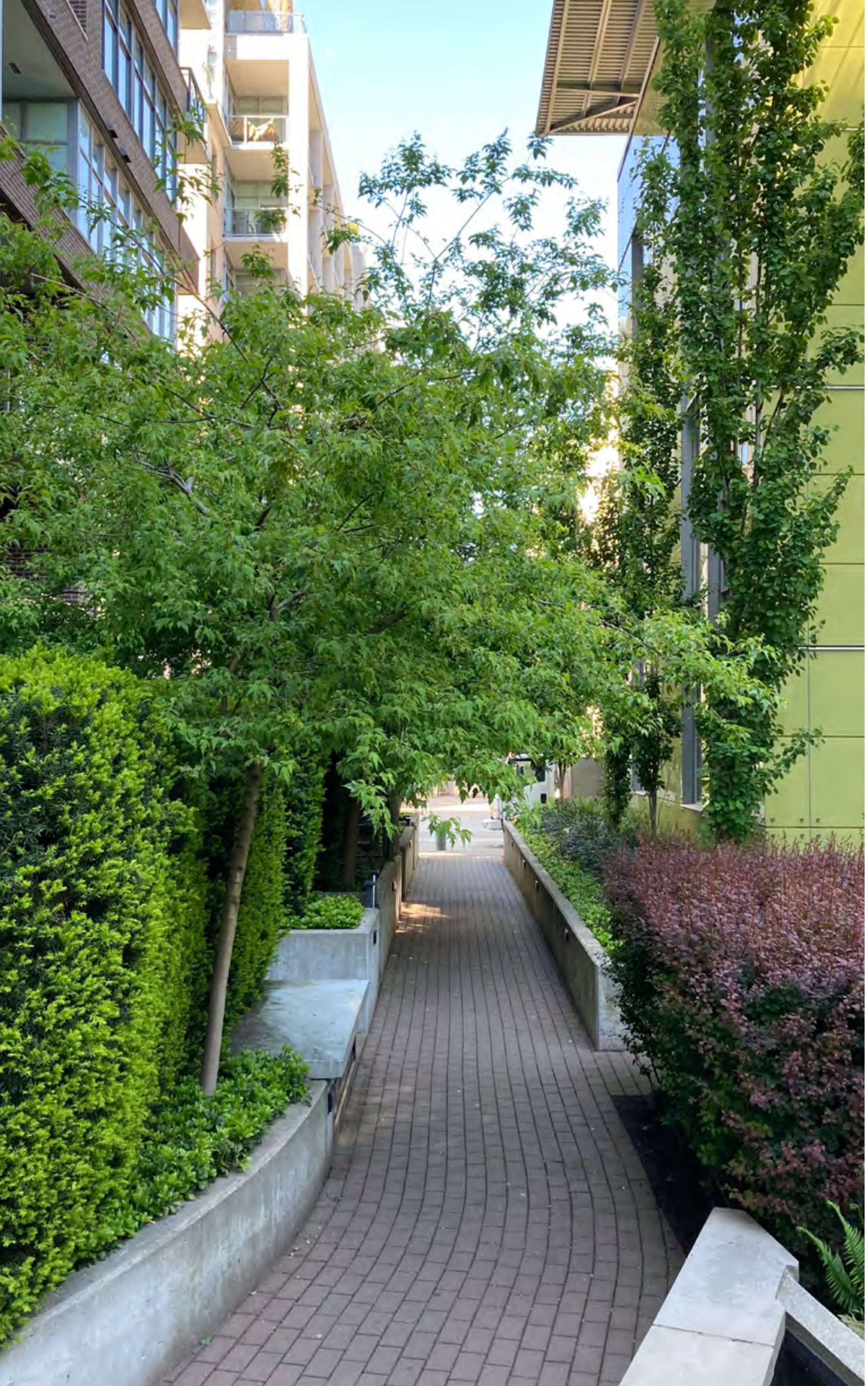


Figure 1: Relationship between the shock or stress, vulnerability and resulting consequences.

Table 1: Examples of types of impacts to buildings

Building Structure and Site	Building Systems	Building Occupants
Structural and architectural: • Building damage • Loss of structural integrity	**Mechanical systems:** • Overheating • Increased energy use • Deterioration from overuse • Winter power outages and frost damage to plumbing system	**Health and wellbeing:** • Physical and/or mental illness due to indoor environment (overheating, poor air quality) • Lowered productivity • Access constraints • Social support system impacts
Envelope and enclosure: • Water ingress • Increased moisture/humidity • Increased risk of mould	**Plumbing and sewerage:** • Flooding • Disruption • Increased insurance premiums • Environmental contamination	**Uses and services in the building:** • Service disruption • Absenteeism
Site and landscaping: • Flooding • Impacts of drought and wind • Damage and death	**Electrical, energy and data:** • Power outages affecting building systems • Loss of data	**Operations and maintenance:** • Increased maintenance costs • New roles for operations staff



3.2. Achieving co-benefits with resilient building design

Buildings need to provide affordable housing and create welcoming, safe, and accessible public spaces. They should be energy efficient, reduce carbon emissions, have healthy interiors, offer spaces for social connection, and recover quickly from hazard events. Frequently these objectives are tackled by different project teams or in siloed one-off approaches. This can lead to more complex design, permitting and approval processes. In an effort to address affordability challenges, there is a large push to streamline regulations and permitting processes at the local level. This push needs to be balanced against the opportunity to meet more objectives over the long term with additional time spent at the design phase. As capacity improves over time, the goal is to have a menu of design and retrofit strategies that can be implemented together cost-effectively while providing multiple benefits.

INTEGRATING RESILIENCE WITH ZERO-EMISSION BUILDING FEATURES

Local government staff may have limited capacity to incorporate resilience in plans, policies and programs. A good initial step is to focus on hazards of greatest concern locally. Build awareness among local developers and builders using existing resources included in the resource section of this toolkit. In particular, local governments can seek opportunities to align and pair resilient strategies with zero-emission building strategies and other co-benefits. The table below provides examples of how to enhance zero-emission buildings with resilient features.

Table 2: Examples of enhancing zero-emission buildings with resilient features

Zero-emission building features	Resilient zero-emission building features	Equitable considerations
Energy efficient building envelopes and mechanical systems	→ Improve airtightness, and include good ventilation and air filtration effective for wildfire smoke	→ Prioritize older buildings with more vulnerable occupants, noting cost challenges may require government support → Address energy poverty
High-efficiency electric heating	→ Include high-efficiency cooling systems → Add backup power	→ Prioritize cooling in units or in rooms on site for populations more vulnerable to overheating in units (e.g., reduced mobility, elderly, certain medical conditions)
On-site renewable energy	→ Add energy storage or backup power suitable for use during future hazard events	→ Consider diverse needs for backup power (e.g., refrigeration of medications, technology that supports those with disabilities)
Passive heating and cooling designs	→ Include options for active heating and cooling in preparation for more extreme conditions → Add space or spare capacity for larger mechanical systems	→ Consider and prioritize cooling needs for populations more vulnerable to overheating
Low-carbon building materials	→ Materials are resistant to all hazards identified by local risk assessment (fire, flood, wind, snow, earthquakes, etc.)	→ Improve access to low-carbon materials in rural areas
Energy and water conservation	→ Plan for backup sources for power outages or periods of drought → Increase occupant awareness of alternative options	→ Make all information and awareness campaigns available to diverse audiences
Site planning preserves and enhances natural carbon sinks	→ Plan for trees and ventilation to provide cooling effects, areas of respite and social connection, water management during high precipitation or drought periods	→ Ensure spaces feel safe and are accessible to those with diverse needs
Redevelop sites for higher density, walkable, accessible, complete communities	→ Redevelop sites in a manner that increases social connection	→ Provide continuity of community and avoid displacement from redevelopment

POTENTIAL DESIGN SYNERGIES AND CONFLICTS

Although there are many opportunities for co-benefits, there are also potential design conflicts that may arise in responses to different hazards or other priorities. It is vital to recognize and seek alternatives to address potential conflicts.

Table 3: Examples of design synergies and conflicts

POTENTIAL SYNERGIES	POTENTIAL CONFLICTS
• Vegetation and trees contribute to stormwater attenuation, urban biodiversity, and reduce the urban heat island effect. • Collecting and reusing rainwater can support landscaping needs, reducing potable water use and enhancing green spaces. • Heat pumps can provide energy efficient heating and cooling, decarbonization, cost effectiveness and resilience. • Structural engineering solutions for flood and seismic resilience can be planned and implemented together. • Larger setbacks could reduce fire following earthquake structure to structure transfer. • Improved filtration aids for other pollutants as well such as traffic related air pollution and indoor air quality generally. • Increased green spaces can improve mental health and community cohesion, alongside environmental benefits like reduced heat island effect and improved stormwater management.	• Increasing site vegetation to provide shade and support stormwater management may conflict with wildland urban interface fire mitigation measures. • Active cooling increases energy use, may require electrical utility capacity increases locally, and may use refrigerants that emit greenhouse gas emissions. • While heat pumps offer efficient heating and cooling, backup power units may not be adequately sized to support heating during power outages. • High energy-efficient buildings may focus on simpler, compact designs to minimize winter heat loss. However, this can lead to increased building depth, potentially limiting opportunities for innovative design solutions that enhance cross-ventilation and reduce overheating. • Bringing outdoor air in was the focus for COVID 19 indoor air quality, however, this may conflict with recirculating air for smoky days.

4. How can local governments advance resilient buildings in B.C. communities?

This toolkit focuses on local government strategies and tools. It recognizes that successful implementation of resilient building policy and regulation depends on support from the provincial government and all actors in the sector, including:

- Indigenous and non-Indigenous governments across scales
- Design and development industries
- Construction industry
- Financial institutions
- Insurers
- The public

The Realizing Resilient Buildings in B.C. Discussion Paper, a companion to this toolkit, discusses the roles of this broader set of actors in advancing resilient buildings across B.C.[1]

4.1. Barriers to implementing more resilient buildings

The Recommendations Report highlights barriers to implementing more resilient buildings in four areas: technical training and capacity, political and regulatory, economic and financial, and social and informational. Many of the responses to these barriers require action at the provincial or national scale. However, there are opportunities for local governments to support approval of resilience measures in pilot projects in the shorter term. Examples of barriers relevant for local governments to consider in each of categories include the following:

- **Technical training and capacity**: Lack of information on resilience measures that can be cost-effectively integrated into buildings, lack of guidelines or best practices to support resilience.
- **Political and regulatory**: Local policies to protect form and character, or zoning requirements for setbacks may unintentionally inhibit uptake of resilience measures.
- **Economic and financial**: Some resilience measures may be more costly to implement, may require floor space that is at a premium, or may be further disincentivized if the development approval process does not streamline resilience measures.
- **Social and informational**: Social connectivity may not be prioritized or even considered in building design, missing a key opportunity to enhance resilience through design.

4.2. Supporting resilient buildings for early adopters and pilot projects

Local authorities play an important role in shaping communities, including the building and renovation process. For local governments, the role is largely defined by the ***Community Charter*** and ***Local Government Act***. These regulations provide the authority for local governments (municipal and regional) to develop tools and requirements. This includes higher-level plans such as regional growth strategies, official community plans, and climate adaptation plans. They also enable establishing policies and regulations such as:

- Zoning bylaws
- Density bonuses
- Development variance permits and development permits
- Development cost charges and amenity cost charges
- Subdivision and development control bylaws

Through these strategies and tools, local governments can streamline approval of resilient design elements and innovations that are not yet mainstream. A summary of the appropriate strategies and tools by hazard are outlined in Section 5 of this toolkit. While many strategies and tools take time to plan and implement, local governments can support resilience measures in pilot projects in the short term. They should focus on key areas where existing policies may present barriers to adoption:

- Building height and roofs
- Gross floor area calculations
- Site coverage, setbacks, and noise bylaws
- Form and character guidelines
- Landscaping, trees and water-related regulation

BUILDING HEIGHT AND ROOFS

Providing building height relaxations are important to improve resilience because:

Green roofs can provide initial stormwater management.

Mechanical equipment and emergency backup generator or power may be located on the roof, ensuring it is above the flood construction level, to reduce flood risk and improve operational resilience.

Higher floor-to-ceiling heights can help interior spaces maintain comfortable temperatures in summer.

No habitable space is allowed below the flood construction level (FCL). As FCLs creep up, height relaxations may be needed to ensure sufficient habitable space above the flood construction level.

Other important things to consider for building roofs:

- Roof pitch stipulations and required setbacks from roof edge and ridge may limit the effectiveness and therefore desire for adding solar panels.
- Green roofs can provide initial stormwater management, with careful consideration for roof warranty and wildfire risks.
- Future wind and snow loads in roof design.

Figure 2: Building height relaxations can enable mechanical equipment to be placed on the roof, rather than on the lower floors below the flood construction level

GROSS FLOOR AREA CALCULATIONS

Gross floor area calculations can be a barrier to implementing a number of resilience measures. Exemptions for these measures will increase resilience by allowing for:

Indoor amenity spaces to store emergency supplies, provide water and power during power outages, allow for social connection, provide cooling space, and more.

Mechanical equipment that needs to be located above the flood construction level.

Larger mechanical rooms that allow for future expansion to meet changing cooling needs

Thicker walls to meet higher energy standards.

Non-potable water systems including extra space for treatment equipment and storage tanks.

Note that the zoning bylaw definition of gross floor area may also be a barrier, and can be changed to measure the interior face of exterior walls or a consistent plane beyond the interior finish (e.g. 6 inches), rather than to the exterior face.

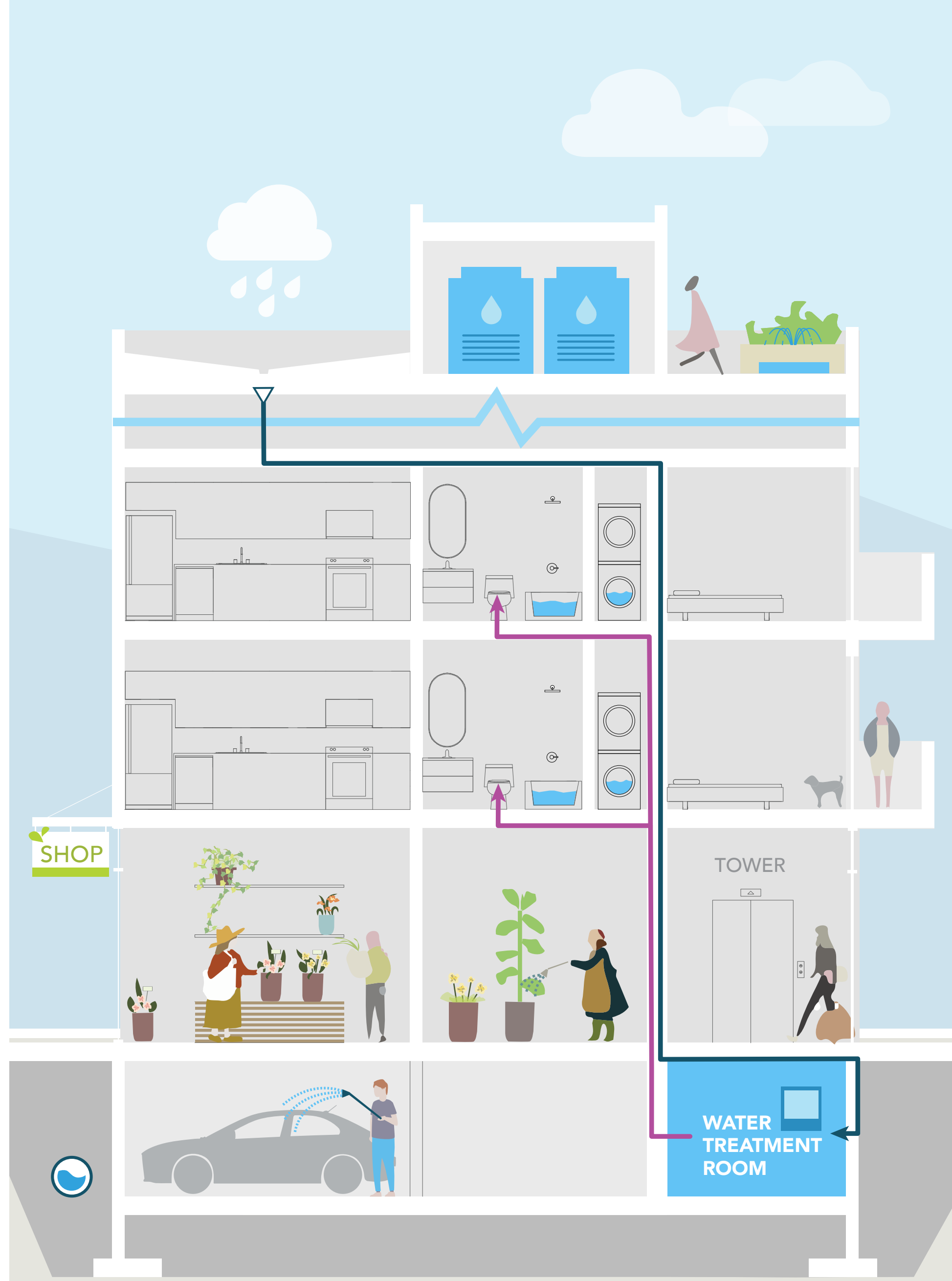


Figure 3: Buildings containing a non-potable water system require additional floorspace for water storage and treatment. Gross floor area exclusions can support various resilience measures.

Credit: Concept and creative courtesy of Metro Vancouver.

SITE COVERAGE, SETBACKS, BALCONIES AND NOISE BYLAWS

Setback requirements or restrictions may limit the adoption of important resilience measures. Exemptions for these measures will increase resilience by allowing for:

Heat pumps in setback areas and on private decks or balconies.

Solar shading devices that project into setbacks.

Exterior insulation that has minor projection into setbacks if achieving highest tiers of energy performance.

On-site stormwater detention tanks, rain gardens, and other **stormwater management** features.

Other important things to consider for site coverage and setbacks:

- Review noise bylaws to ensure they do not preclude air sources heat pump installation.
- Structure configuration, density, and proximity to treed areas can impact the probability of structure-to-structure fires.

Figure 4: Ensuring heat pumps are allowed on balconies and in lot setbacks can support improved uptake of this measure. This can apply to other resilience measures such as stormwater management features in setback areas.

FORM AND CHARACTER GUIDELINES

Form and character guidelines may limit the uptake of certain resilience measures. For example:

Design guidelines may limit the use of solar panels.

Site plans and building orientation may not allow for optimal solar orientation, reducing energy performance and impacting occupant thermal safety and comfort.

Guidelines may limit use of **exterior shading devices** that help reduce solar gain and overheating.

Higher window-to-wall ratios (WWR) may allow excess heat to enter the building, causing overheating. Allowances can be made for higher ratios at grade.

Guidelines that require complex building massing may result in increased **thermal bridging, air leakage, and moisture infiltration**.

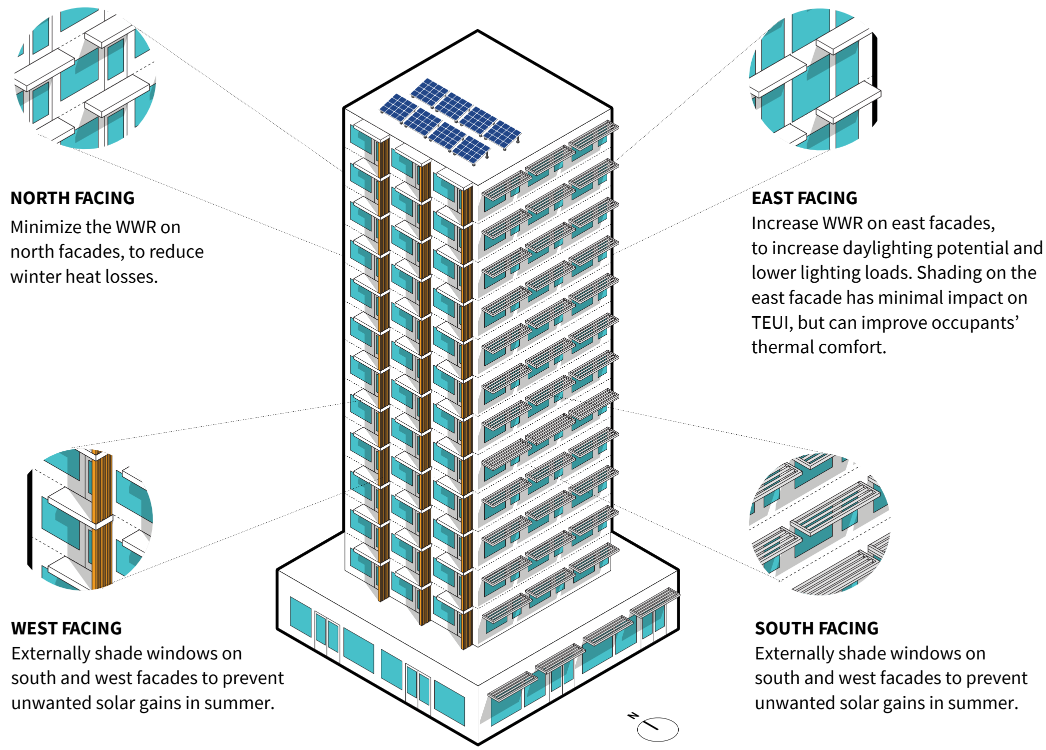


Figure 5: Allowing the use of **exterior shading devices** can be an effective measure to reduce solar heat gain in summer.

LANDSCAPING, TREES AND WATER

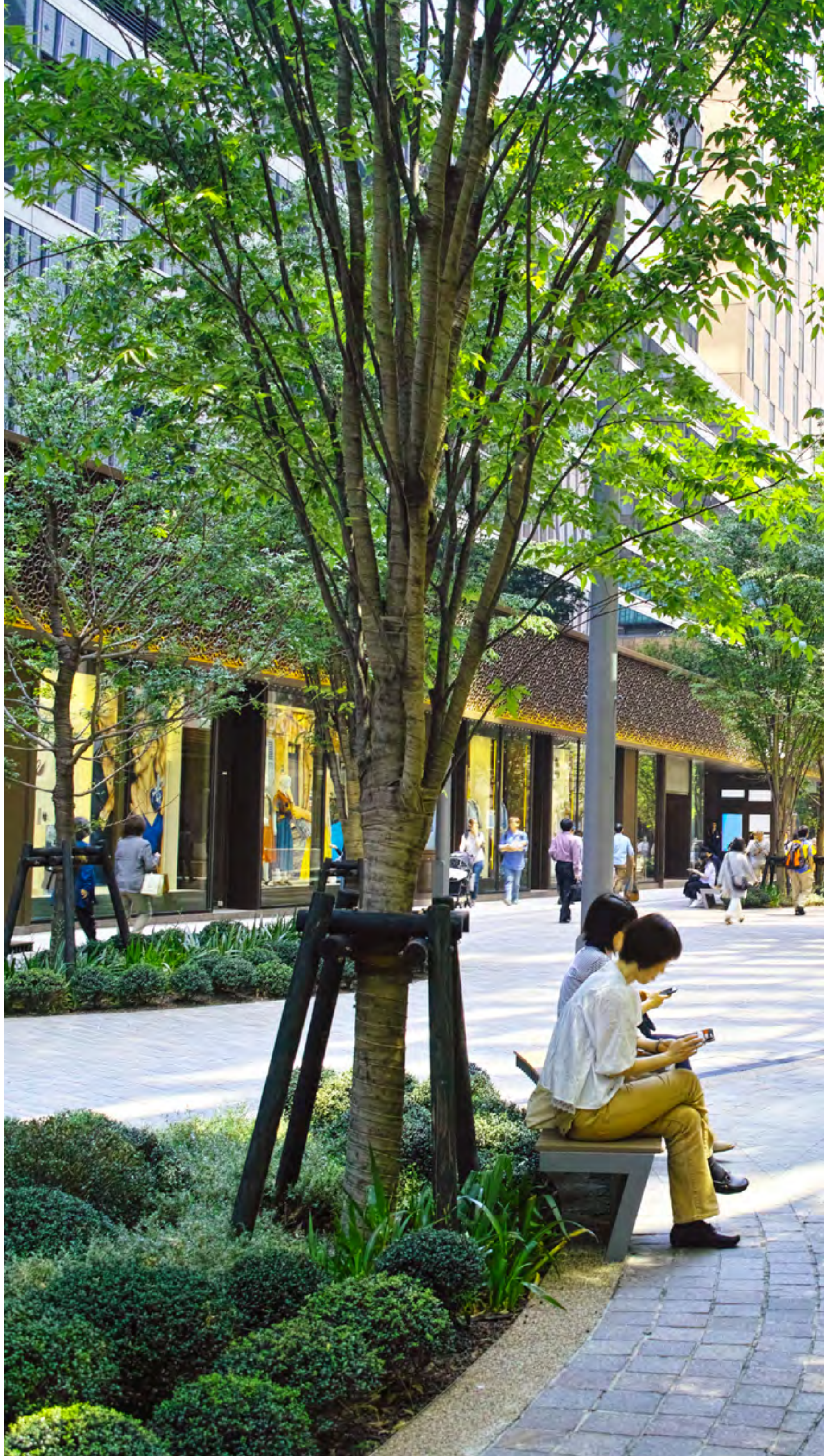
Appropriate landscaping will be dependent on the local hazards of concern. Landscaping can be a valuable opportunity to address many co-benefits, including reducing urban heat island effect, providing respite from sun, supporting infiltration of stormwater, and more. However, in potential wildfire interface areas, limiting vegetation near structures and carefully choosing fire-resistant species are very important. Considerations include:

Use vegetation to mitigate **urban heat island effect**, provide shading to lower building storeys, and provide outdoor respite areas, which are all important strategies to reduce potential overheating.

In potential wildfire interface areas, **maintain buffers** between trees and subdivisions, and follow FireSmart principles for specific actions at various distances from buildings.

Drought-tolerant landscaping can reduce use of potable water for irrigation during droughts.

Non-potable water systems reduce reliance on potable water during droughts. Local governments can establish policies for minimum greywater surface discharge for irrigation, or establish policies for minimum stormwater retention and reuse.



HOUSING TYPOLOGIES WITH BETTER CLIMATE RESILIENCE

Varying housing typologies can increase resilience by supporting stronger connections among occupants. This helps them to support each other during a hazard event. In B.C., standard low and mid-rise buildings feature double-loaded corridors and high-rise buildings have scissor stairs. These typologies create larger floor plates (18m+), single-oriented units (less daylight and natural ventilation), and enclosed common spaces that do not foster social interaction. Larger floor plates also limit space for green areas. Single-aspect units facing south or west can overheat significantly in summer. If they face a road, traffic noise can prevent tenants from opening windows at night to cool down. Socially-isolated people were at a higher risk of heat-related mortality during the 2021 heat dome event, based on the Coroner's Report.

Two alternative building forms–**point access blocks** and **courtyard buildings** with outdoor corridors–can enhance social interaction. While common in Europe and Asia, these forms are rare in Canada and the U.S. due to past code requirements[2] and floor area disincentives (e.g., in single-loaded corridors external walkways are often included in floor area while balconies are excluded). However, these alternative forms offer benefits like dual-aspect units, cross ventilation, and more daylight. The slimmer floor plates can allow more site area for the planting of trees and larger outdoor social spaces.

Vienna House, a social housing project in Vancouver, is using a single-loaded corridor design with exterior walkways and a courtyard. This design maximizes opportunities for social interaction in well-lit safe common areas, helping to build connection and resilience. Approval of this design required additional steps to obtain buy-in from stakeholders, and approval from the City of Vancouver.

Credit - Public: Architecture + Communications

Figure 8. The Vienna House development demonstrates implementation of a single-loaded corridor with exterior walkways to maximize opportunities for social interaction

SECTION ENDNOTES

[1] Pinna Sustainability. (2024). Realizing Resilient Buildings Discussion Paper: Recommendations.

[2] Effective August 27, 2024, BCBC includes amendments to enable construction of single exit stair buildings.

5. Recommendations by hazard area

5.1. Overview for all hazards

HOW ARE THE RISKS FOR BUILDINGS CHANGING?

The climate is changing, and the change is accelerating. The diverse bio-regions across the province experience climate change impacts differently. However, a clear trend is emerging: rising temperatures at all elevations, especially in valley bottoms; shifting and increasing seasonal precipitation patterns; and more frequent and severe extreme weather events. These changes are consistent across different future climate scenarios up to mid-century, with variations becoming more pronounced later in the century.

The following sections include hazard-specific insights based on published RCP 8.5 climate projections from the Pacific Climate Impact Consortium. These projections highlight how future climate changes will impact buildings and communities, with changes referenced against an observed 30-year historical baseline (1971-2000). Alongside the increased frequency and intensity of hazards, we are also increasing the density of communities, often in hazard prone areas, thereby heightening the overall risk.

WHAT MAKES BUILDINGS MORE RESILIENT TO ALL HAZARDS?

Design objectives that support resilience include:

- Integrated co-design with potential future occupants and local community-serving organizations, where possible.
- Embracing and integrating Indigenous knowledge and practices at the project outset.
- Including a refuge space or common area, where buildings are large enough, can provide cooling, clean air, water access when the power is out, charging of devices with backup power, accessible washroom facilities, refrigerators for medication, and more.
- Designing to facilitate increased social connections and programming to increase those social connections.
- Emergency plans for buildings, with information posted on the closest public cooling and refuge centres.
- Post-occupancy training for building occupants on emergency procedures and behaviour to make use of building systems during events.
- Resilience buddy systems that use neighbours to check-in on each other.

LOCAL GOVERNMENT STRATEGIES AND TOOLS RELEVANT TO ALL HAZARDS?

Strategies:

- **Building relationships with Indigenous communities**: Establish a memorandum of understanding outlining engagement and decision-making protocols with adjacent Indigenous communities.
- **Climate adaptation and/or resilience plans**: The UN Disaster Resilience Scorecard for cities includes 10 essentials, one being: Pursue resilient urban design and development. Many existing adaptation plans can be reviewed for building-focused actions. These plans can be community facing, corporately focused or both. An assessment of the resilience of local government facilities can be included. Devise indicators and targets for risk reduction in the building sector. Through engagement with the community and higher levels of government, consider programs that relocate buildings and infrastructure from high-risk areas.

- **Integrated governance**: Historical division of climate change planning (generally environmental professionals) and disaster risk reduction (generally emergency management professionals) is disappearing. In line with the Sendai Framework principles and emerging best practices, merge the common components of climate change adaptation and disaster risk reduction.
- **Official Community Plans and Regional Growth Strategies:** Include policies and objectives for land use that reduce hazard exposure and risk and policies/intentions for resilient buildings.
- **Zoning**: Consider the appropriate density and use relative to hazard threat. Small-scale multi-unit hazard guidelines allow for exemptions in hazard areas.
- **Climate and disaster risk assessments**: In order to tailor programs to the local hazards of concern, local governments can undertake integrated assessments of disaster and climate risk that include assessing current and future risk with climate change.
    - **Example**: B.C. Climate Risk Assessment Framework (2019) and upcoming Disaster and Climate Risk and Resilience Assessment
- **Hazard risk disclosure**: Building sector actors need to have the best information in hand when designing or retrofitting buildings that have a lifespan for decades. Disclosing hazard risk today and in the future and/or providing future projected building design files are all helpful in supporting resilient buildings in a community.
    - **Example:** Calgary Disaster Risk Explorer for hazard risk disclosure
    - **Example:** PCIC Design Value Explorer for projected design values
- **Social infrastructure strategy**: Development of this strategy, including mapping, supports community-wide development of recovery capabilities and can help during event response.
    - **Example:** City of Richmond Social Development Strategy

- **B.C. Energy and Zero Carbon Step Codes**: Advance adopting of the step codes ahead of the provincial schedule.
- **Design exemptions and allowances:** Provide these for demonstrated high performance buildings for select resilience strategies. Allow applicants to describe what form and character guidelines their project needs to be exempted from with a rationale as to why with a streamlined pathway to approval.
- **Incentivize common areas as refuge spaces**: Incentives, requirements and/or relaxation of gross floor area calculations for common areas that can serve as refuge locations and build social connections.
- **Governance and financing:** Shift from reactive to anticipatory governance and financing for disaster and climate-related risk reduction and response. Consider tools such as density bonuses and transfers to support relocation where appropriate.
- **Establish resilience hubs**: Popular in Australia, New Zealand and the U.S., resilience hubs provide a pre-signed meeting place for people to go during a disaster event. Resources and communication can then be routed to these locations by government and mutual aid provided by the community. These hubs can become gathering places for learning outside times of crisis.
    - **Example:** Baltimore City Community Resiliency Hub Program
- **Engagement and collaboration**: Work with stakeholders, community organizations, advisory committees, and disability advocates. This will help you understand the needs and gaps in support for individuals likely to be disproportionately impacted. Work with a third-party convenor or directly with community serving organizations to understand how to best support them in building the resilience for local community members most impacted.
    - **Example:** City of Vancouver Resilient Neighbourhoods Program and Hey Neighbour Collective
- **Education and awareness**: Link to existing EMBC guidebooks and other resources through government websites for information on climate-related hazards and what residents can do to take care of themselves and loved ones. Provide links to resources on climate-resilient design. Involve the local building sector, LandlordBC and the Condominium Home Owners Association in engagement regarding changes to policies.
- **Worksheets for developers**: Municipalities are developing climate risk assessment worksheets to be applied at rezoning to help designers work through the risk assessment steps listed above and incorporate strategies as listed in this toolkit, the Climate-ready Housing Design Guide, and others.
    - **Example:** City of Boston Resiliency Checklist
    - **Example:** City of Vancouver large site rezoning resilience worksheet (under redevelopment)

ADDITIONAL REFERENCES

- Grunwald, B., Reback, M., & Warsing, R. (2022). Weathering Climate Disasters with Resilience Hubs.
- Jarrah, A., & Tanabe, K. (2022). Energy Equity for Renters: A Toolkit to Expand Energy Efficiency and Preserve Affordable Housing.
- ICLEI – Local Governments for Sustainability. (n.d.). Equitable Climate Adaptation: Considerations for Local Governments.
- Government of Canada. (2024). Codes, Standards and Guidance for Climate Resilience.
- City of Vancouver. (2023). Primer: Resilient Buildings Planning Worksheet.

5.2. Extreme heat

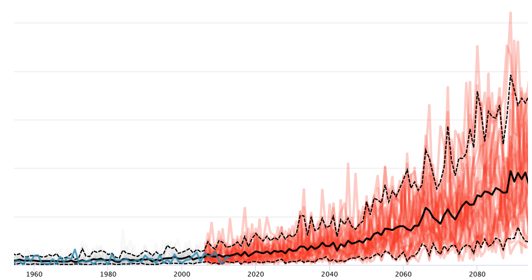
HOW IS THE RISK OF EXTREME HEAT CHANGING?

Summers in B.C. are projected to get hotter and drier over time. The average hottest summer days will be about 3°C to 6°C hotter by mid-century, depending on geography. In addition, night time temperatures will stay above 20°C more often, resulting in sustained periods without significant temperature drops overnight. Regionally, in Osoyoos, there will be on average 20+ more of these 'tropical nights', and 15 more for Vancouver and Kelowna. The number of days with temperatures above 25°C will likely more than double in the South Coast, West Coast, Omineca, and Northeast regions. Days above 30°C may triple in the Thompson-Okanagan, Boundary, and Cariboo regions.[1] Hotter temperatures during the day without passive nighttime cooling will pose an increasing health risk over time, particularly in buildings without cooling.

The hottest days presented above are averages across climate models and do not include the extremes such as those experienced during the heat dome event in summer 2021. This event was described as a 1:1000-year event and broke records across B.C., including a recorded temperature of 49.6°C in Lytton. The B.C. Centre for Disease Control reported a total of 740 deaths due to the 2021 heatwave in B.C. alone.

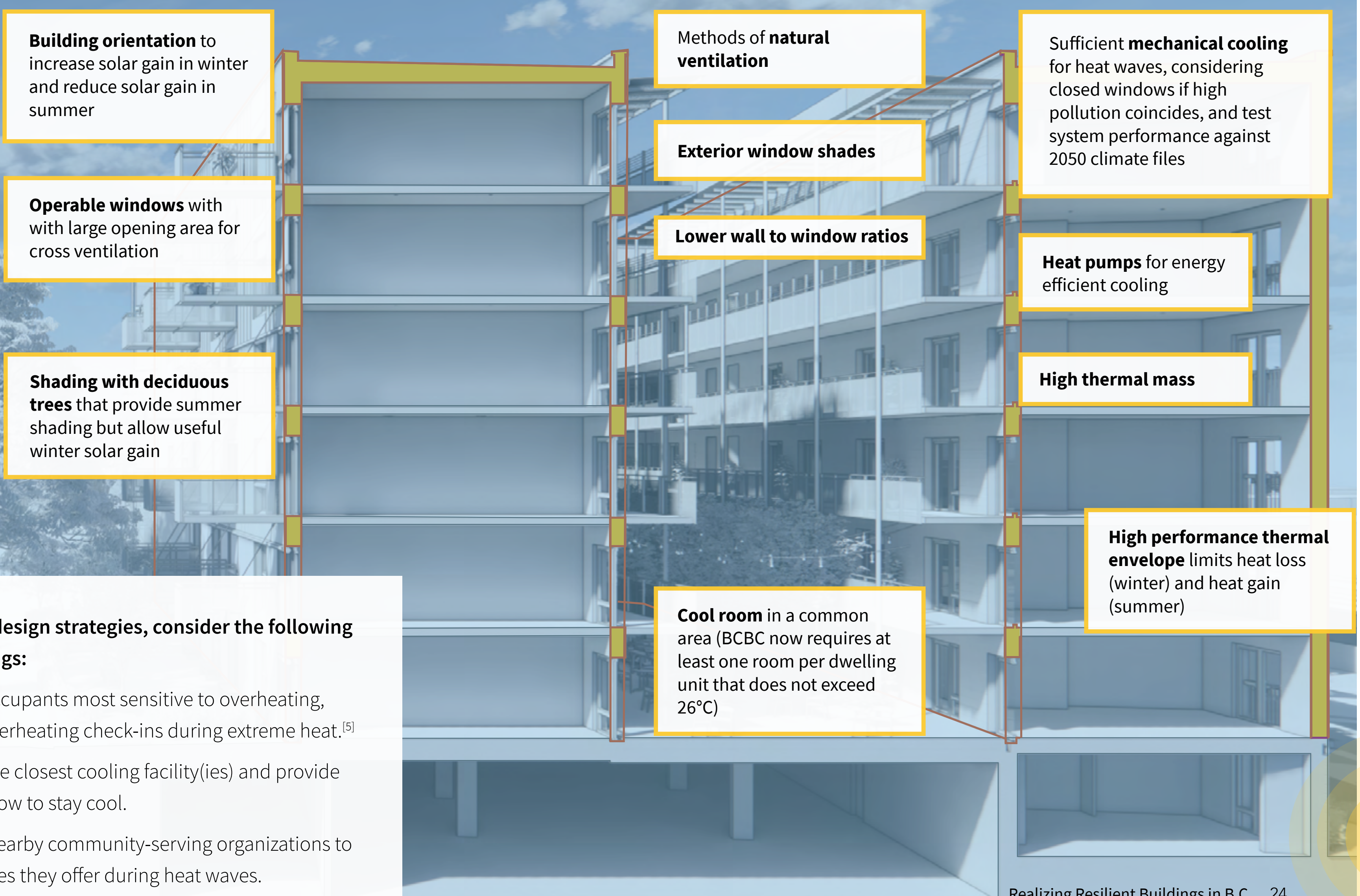
The majority of deaths were caused by people living alone in unventilated homes, who had underlying health conditions.[2] We can continue to expect extreme heat events over time, and with more frequency. By the 2050s, we can expect a 1 in 20-year extreme heat event to happen once every 5 years.[3]

Figure 9: Very Hot Days (Over 30°C) in British Columbia (RCP 8.5)[4]



WHAT MAKES BUILDINGS MORE RESILIENT TO EXTREME HEAT?

This diagram shows some examples of building-scale strategies that are important to increase resilience to extreme heat.



In addition to these design strategies, consider the following for multi-unit buildings:

- Keep a list of occupants most sensitive to overheating, and perform overheating check-ins during extreme heat.[5]
- Post maps of the closest cooling facility(ies) and provide reminders on how to stay cool.
- Connect with nearby community-serving organizations to see what services they offer during heat waves.

LOCAL GOVERNMENT STRATEGIES AND TOOLS RELEVANT TO EXTREME HEAT

Strategies:

- **Official Community Plans:** Ensure adaptation and resilience to increasing intensity and frequency of heat waves are covered in municipal long-range plans.
- **Thermal safety planning**: This may involve several steps:
    - Conduct more in-depth overheating risk and needs assessments, for example, by generating maps that overlay temperature data with health vulnerability data.
    - Identify higher-risk areas, populations and building types that can be targeted to remove barriers to cooling (e.g., heat pump incentives).
    - Work with property owners and organizations to remove barriers. Work with your local health authority to discuss what temperature limits are advised for indoor temperatures.
        - **Example:** Capital Regional District Extreme Heat Information Regional Heat Map
        - **Example:** Vancouver Coastal Health Community Health and Climate Change Mapping
- **Public facility planning**: Inventory the existing cooling capacity of public facilities and compare it to relative temperature mapping and vulnerability indicators (as available). Prioritize facilities for temporary cooling or permanent retrofits. Where possible, integrate energy efficiency upgrades with provision of cooling.
- **Engage with equity-deserving groups:** Engage with disproportionately impacted groups and community-serving organizations to better understand the diverse needs during heat events. Coordinate with community-serving organizations on extreme heat response.
- **Heat pump implementation strategy**: Develop a strategy that identifies the most suitable tools for your community. Prioritize support for non-profits, community-serving organizations and areas with high temperatures and health vulnerabilities. Address energy poverty by ensuring financial assistance for heat pumps. Identify existing policy barriers, such as:
    - Setback requirements limiting heat pump installation.
    - Noise bylaws penalizing heat pumps.
    - A permitting process less streamlined than for conventional systems.
    - **Example:** Low Carbon Building Policy Toolkit (p.26)

- **B.C. Step Codes**: Advance adoption of the B.C. Energy and Zero Carbon Step Codes through the building bylaw. There are options available through the step codes to encourage the use of heat pumps. These options include:
  - Easing or reducing energy efficiency requirements if you install a low-carbon heat pump.
  - Implementing strict greenhouse gas (GHG) intensity requirements.
- **Zoning bylaw**: Create exemptions in floor area definitions for low carbon mechanical equipment in order to better accommodate such equipment that may require more floor area. New buildings may require additional space for future upgrades to mechanical cooling systems.
  - **Example:** City of North Vancouver Zoning Bylaw Gross Floor Area exemption for Green Building Systems
- **Rezoning policy**: Include criteria to support energy efficient construction in addition to heat pump installations. Rezoning policies can set expectations for cooling in new construction in addition to those required in the B.C. Building Code. For example, establish a standard for mechanical cooling in new MURBs. Require use of future projected design temperatures for testing thermal comfort limits (as per ASHRAE Standard 55).
  - **Example:** Climate Ready Rezoning Policy | District of North Vancouver
- **Development permit form and character guidelines:** Review guidelines to ensure they do not deter high performance design strategies including:
  - Lower overall window to wall ratio (with allowances for higher WWR at grade).
  - Optimized orientation to balance solar gains and losses.
  - Need for articulation.
  - Exterior shading devices on building facades.
- **Building height exemptions**: Create exemptions from height limit calculations for:
  - Low carbon mechanical equipment (e.g., rooftop heat pump condensing units).
  - Renewable energy systems (e.g., rooftop solar PV systems).
- **Design review**: Consider non-typical designs (point access blocks or exterior walkways and stairs) that improve cross-ventilation. Review compilations of pilot projects from B.C. Housing's MBAR project.
- **Education, awareness and incentives**: Examples include:
  - Offer resources for building managers to share information on public cooling centres and provide cool common areas during summer.
  - Work with health authorities to inform property owners about removing barriers for tenants to cool their units.
  - Engage building industry, trades, and public on heat pump installation, benefits, and available incentives.
    - **Example:** London, U.K. Cool Spaces mapping
    - **Example:** Township of Langley heat pump education webinars
    - **Example:** Jump On A New Heat Pump | District of North Vancouver

IMPORTANT CONSIDERATIONS

Buildings today should be designed to ensure the comfort and safety of their occupants throughout their lifespan. Thermal comfort varies by factors like medical conditions or mobility, which can affect heat tolerance. The 2021 heat dome showed that relying on public cooling facilities was insufficient, as over 90% of deaths occurred at home. Designers must incorporate both passive and mechanical cooling strategies to maintain livability.

Certain groups are more exposed to heat, including those who are marginally housed, pregnant, children, elderly, socially isolated, or taking specific medications that increase heat sensitivity, as well as people with substance abuse disorders, pre-existing medical conditions, or limited mobility.

Buildings at higher risk of overheating include:

- Older buildings that lack airtightness, cooling, and ventilation.
- Multi-unit buildings with high window-to-wall ratio, limited window operability, and minimal cross-ventilation opportunities.
- Buildings without cooling systems or direct outdoor access.
- Buildings with high solar exposure.
- Buildings in neighbourhoods with strong urban heat island effects due to limited tree cover and shading.

To reduce heat-related illness and death, it's crucial to strengthen social networks, collaborate with community organizations for heat event support, and improve both physical (e.g., cooling equipment, shade) and social infrastructure.

SECTION ENDNOTES

[1] Chia, E. (2021). Regional Projections & Impacts - Retooling for Climate Change.

[2] B.C. Lung Foundation. (2022). State of the Air 2022.

[3] Daust, D., & Morgan, D. (2011). A Climate Change Vulnerability Assessment for British Columbia's Managed Forests: Climate Change in B.C.

[4] British Columbia Very Hot Days Time Series. (n.d.). Climate Atlas of Canada.

[5] Vancouver Coastal Health. (2022). Heat Check-in Support Framework for Non-Governmental Organizations.

Additional references:

- City of Vancouver. (2020). Heat Pumps and Noise: A Neighbourly Installation Guide.
- Miller, D., & McEwen, B. (2021). Local Government Low Carbon Building Policy Toolkit. *See the heat pump permitting flow chart on page 38*.
- B.C. Housing. (2020). Builder Insight Number 19: Modelling the Future Climate in Passively Cooled Buildings.
- Integral Group. (2016). Designing for Energy Efficient Buildings: A Reference for Planners and Designers. Prepared for: City of Surrey.
- Clean BC. (n.d.). Heat Pump Rebates in B.C.
- Eyquem, J., & Feltmate, B. (2022). Irreversible Extreme Heat: Protecting Canadians and Communities From a Lethal Future. University of Waterloo, Intact Centre on Climate Adaptation.
- Government of Canada. National Research Council Canada. (2023). Climate resilience buildings: guideline for management of overheating risk in residential buildings. NRC Publications Archive.
- North Shore Emergency Management [NSEM]. (n.d.). Extreme Heat.

5.3. Flooding: Coastal and Riverine/Lake

HOW IS THE RISK OF COASTAL AND RIVERINE FLOODING CHANGING?

The west coast receives 20 to 25% of its annual precipitation in heavy-rainfall events resulting from atmospheric rivers.[1] An analysis of the 2021 atmospheric river event in southwestern British Columbia found that the probability of such extreme streamflow events has increased by a best estimate of 100 to 300%. This indicates that events like this will likely be more frequent in the future.[2]

Across many parts of the province, increased intensity and frequency of precipitation is expected to fall as rain in the colder seasons (autumn, winter, and spring), and be accompanied by increasing spring temperatures, on average. These changes are likely to result in changes to snowpack over time, creating faster melting conditions. As a result, winter streamflow is anticipated to increase and the spring freshet peak to move earlier in many snow-dominated watersheds.[3] Fluvial or river flooding can be caused by a singular event (like an extreme rainfall event) or by several events occurring simultaneously (like concurrent heavy rainfall, snowmelt and ice jamming). The 2019 B.C. Climate Risk Assessment projections show that today's moderate floods (51 to 100 year events) can be expected to occur once every 11 to 50 years by 2050. The same assessment indicated that today's 500-year Fraser River flood may become five times more likely by 2050.

For coastal communities, coastal flooding due to high tides, high winds, seiches, storm surge or tsunami, singularly or in combination, can be expected to happen more frequently. The B.C. Flood Hazard Land Use Management Guidelines that provide direction for floodplain designation and associated bylaw development now assume 0.5m of sea level rise to the year 2050 and 1m to 2100. King tide season in the late fall and winter have already caused flooding along the coast when coincident with a winter storm.

In the Lower Mainland, there are many areas close to sea level which are vulnerable to the potential effects of sea level rise. Over 15,000 hectares of industrial and urban residential areas in the Lower Mainland are located within 1m of sea level. On Vancouver Island, many communities have ocean exposure with vulnerable coastlines or low-lying areas. Along the northern coast of B.C., critical infrastructure in the Port of Prince Rupert is close to sea level, as are most settlements on Haida Gwaii.[5] [6]

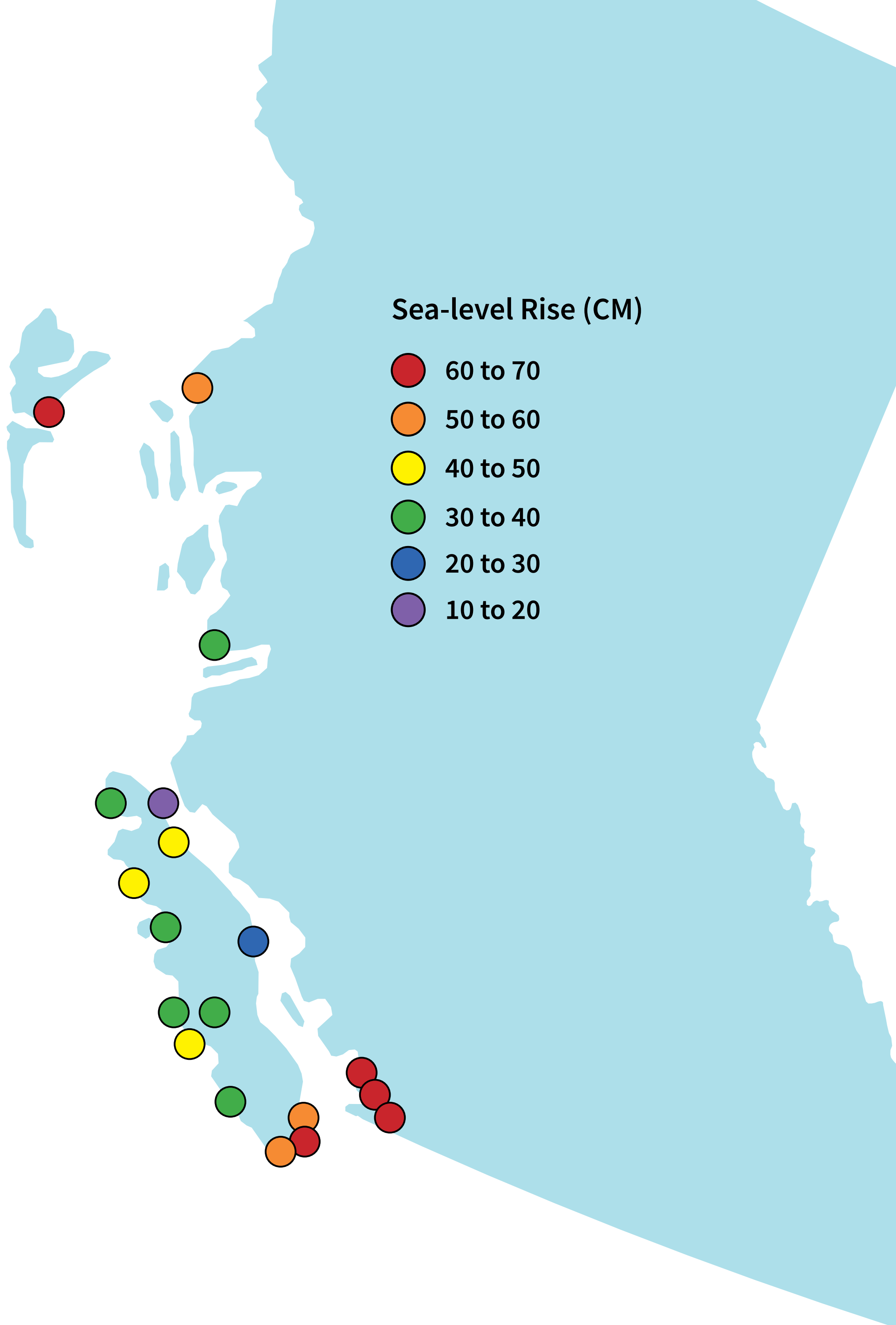


Figure 10: Projections of relative sea-level rise for the year 2100 for the median value of the high-emissions scenario (RCP8.5)[4]

WHAT MAKES BUILDINGS MORE RESILIENT TO COASTAL AND RIVERINE FLOODING?

This diagram shows some examples of building-scale strategies that are important to increase resilience to coastal and riverine flooding. See the B.C. Flood Hazard Land Use Management Guidelines for more direction on coastal and fluvial flood hazard.

In addition to the design strategies, consider the following:

- Dry floodproofing to waterproof the structure with appropriate materials (research shows it can be done up to 1m of the wall).
- Wet floodproofing designs to allow flooding with minimal damage (waterproof drywall, mould-resistant flooring).
- Consider flexible first floor uses.
- Proactive vegetation management along water courses and debris removal.
- Access to temporary flood barriers.
- Plan for modes of access (egress) in case of a large flood event.

LOCAL GOVERNMENT TOOLS RELEVANT TO COASTAL AND RIVERINE FLOODING

Strategies:

- **Official Community Plans**: Hazard areas and associated land use designations and policies should reflect updated mapping and or modelling of current and future flood hazard extent.
- **Flood risk assessment/ flood hazard management plan**: Many local governments are developing flood hazard management plans to address future risks. They begin by assessing risks and identifying long-term mitigation actions, typically focusing on protect, retreat, or accommodate strategies. Alternatives include:
    - Property buy-outs.
    - Rolling easements.
    - Transferring development rights out of the floodplain.
    - Protective measures like Green Shores certification and shoreline restoration.
        - **Example:** City of Vancouver Coastal Flood Risk Assessment
        - **Example:** City of Surrey Coastal Flood Adaptation Strategy
        - **Example:** District of Squamish Flood Hazard Management primer for developers
- **Flood response plans**: It's invaluable to develop response plans that are tied to regularly monitored water level thresholds or other flood risk indicators. Equally important is establishing an associated alert system.
    - **Example:** City of Pitt Meadows Flood Response Plan

- **Development permit areas**: Establish guidelines for development in floodplain areas and along shorelines. This includes:
- Parcel-level protective measures such as erosion or flood protection walls.
- Guidance for protecting the natural riparian environment.
- Bylaws that regulate the removal and deposit of soil can work in tandem with floodplain bylaws or flood-related development permit areas, as fill is often used for protective works and to meet flood construction levels.
    - **Example:** City of West Vancouver Foreshore Development Permit Area
    - **Example:** Parksville DPA 11 Coastal Protection and DPA 12 Floodplain (p.214 & p.219)
- **Floodplain management bylaws**: Section 56 of the *Local Government Act* allows local governments to designate floodplains and regulate associated development. They cover floodplain designation, flood construction levels, setbacks, specific applications, exemptions, and must follow the B.C. Flood Hazard Land Use Management Guidelines.
    - **Example:** District of Squamish floodplain bylaw
- **Subdivision and development servicing bylaw**: Approving officers rely on qualified professionals to provide assurance that the site is safe for the intended use.
- **Zoning bylaw**: Incorporate changes such as relaxation of building height maximum or changes to how height is measured in flood zones and allowance of certain uses below the FCL.
    - **Example:** B.C. Housing Design and Construction Standards: Relaxations/ exemptions from gross floor area calculations are allowed for utility rooms above FCL
    - **Example:** District of Squamish Zoning bylaw update
- **Site specific investigations for building permits**: The *Community Charter* Section 54 allows for Qualified Professionals to complete site-specific investigations prior to building permit issuance for hazardous areas. Qualified professionals can be provided with a terms of reference for the assessment from the local authority and rely on their professional association guidelines.
    - **Example:** District of Squamish Flood Hazard Assessment Terms of Reference
- **Restrictive covenants on title:** Covenants in favour of the municipality are recommended in the B.C. Flood Hazard Land Use Management Guidelines for any exemption from FCL or setback. They are frequently put on title for any building in the floodplain.
- **Cultural monitors or representatives from Indigenous Communities**: Indigenous organizations and communities can be invited to monitor nearshore excavation given the cultural sensitivity of these areas.
    - **Example:** K'omoks First Nation Cultural Heritage Investigation Permit Application and reference to it by the City of Courtenay for development permits
- **Education for homeowners**: Provide management practices for homes on the foreshore.
    - **Example:** Qathet Regional District
- **Education for builders**: Provide information and expectations about dry and wet floodproofing methods and temporary flood barriers.

- **Restoration and stewardship**: Complete a natural asset valuation of floodplains (e.g., estuaries) to support restoration and stewardship plans.
    - **Example:** City of Nanaimo Municipal Natural Assets Initiative
    - **Example:** City of Vancouver New Brighton Salt Marsh - developed to support stormwater management while providing some protection from storm surge
- **Green Shores certification**: Promote and encourage certification from the Stewardship Centre of B.C., which can be obtained for shoreline development, for homes, or for local governments. The program also offers training in addition to certification.

IMPORTANT CONSIDERATIONS

B.C.'s floodplains are generally highly developed, and areas that previously had little to no flood risk are now experiencing flooding. The value of assets, infrastructure, and people exposed to riverine and coastal flooding is increasing with climate change. Many stormwater drainage systems back up when heavy rain coincides with the highest tides of the year. Low-elevation coastal infrastructure, such as the Vancouver Seawall, has seen annual maintenance and repair costs increase significantly.

In the U.S., relocation programs have become more common since Superstorm Sandy hit the east coast in 2012. Although less frequent in Canada, there are opportunities to use land use tools to gradually reduce density in high flood hazards areas. Currently, Disaster Financial Assistance in B.C. does not incentivize rebuilding away from flood-prone areas. Provincial support will be required to balance the supply of affordable housing with the need for development outside floodplains.

In B.C., riparian rights allow property owners to protect their property from erosion. However, erosion protection measures built on the foreshore can have significant environmental impacts, affect cultural sites, and increase flood risks for neighbouring properties. Even when constructed at the property edge, these measures can exacerbate flooding to others. Green Shores certification, educational guides for coastal living and development permit areas provide guidelines for appropriate shoreline and riverine development.

SECTION ENDNOTES

[1][4][6] Lemmen, D. S., & Warren, F. J. (2016). Canada's Marine Coasts in a Changing Climate.

[2] Pacific Climate Impacts Consortium. (n.d.). Human Influence On The 2021 British Columbia Floods.

[3] Bonsal, B.R., Peters, D.L., Seglenieks, F., Rivera, A., & Berg, A. (2019). Changes In Freshwater Availability Across Canada; Chapter 6 In Canada's Changing Climate Report, (ed.) E. Bush and D.S. Lemmen; Government of Canada, Ottawa, Ontario, p. 261-342.

[5] The Arlington Group Planning + Architecture Inc., EBA, DE Jardine Consulting, & Sustainability Solutions Group. (2013). Sea Level Rise Adaptation Primer A Toolkit To Build Adaptive Capacity On Canada's South Coasts. Prepared for: British Columbia Ministry of Environment.

Additional references:

- Ministry of Environment and Climate Change Strategy. (2021). Flood Hazard Land Use Management - Province of British Columbia.
- Coulbourne, W. L., Kriebel, D. L., Behm, R. L., & McKenna, K. K. (2021). Guide For Design Of Flood-Resistant Buildings. National Research Council of Canada.
- Regional District of Central Okanagan. (2021). Non-Structural Flood Mitigation Resource Guide.
- B.C. Housing. (2024). Flood Resilience for New and Existing Buildings: Four Part Video Series.
- British Columbia Real Estate Association, Picketts, I., Herbert, Y., & Lyle, T. (2014). Floodplain Mapping Funding Guidebook for B.C. Local Governments.
- Ebbwater Consulting. (2022). Ebbwater Flood Map Project – People living in B.C. floodplains.
- U.S. Federal Emergency Management Agency (FEMA). (2010). Home Builder's Guide to Coastal Construction: Technical Fact Sheet Series.
- American Society of Civil Engineers (ASCE). (2014). Flood Resistant Design And Construction Standard. *This US guideline provides practical advice and design standards for property-level flood protection.*
- The British Standards Institution. (2023). BSI 851188 The British Standard for Flood Resistant Products. *The standard provides a minimum standard for building materials used for floodproofing. No similar standards exist in Canada.*
- Department of City Planning City of New York. (2014). City of New York Retrofitting Buildings for Flood Risk Design Manual.
- Engineers and Geoscientists of British Columbia. (2021). Seismic assessment and seismic design of dikes in B.C.
- British Columbia Ministry of Environment. (2011). Climate Change Adaption Guidelines for SeaDikes and Coastal Flood Hazard Land Use Sea Dike Guidelines Risk Assessment of B.C. Orphan Dikes.

5.4. Flooding: Pluvial (Extreme Rainfall)

HOW IS THE RISK OF PLUVIAL FLOODING CHANGING?

B.C.'s annual average precipitation is projected to increase on average by approximately 5% across the province by the 2050s, and by approximately 10% by the 2080s.[1] Northern regions will experience the most significant increase in precipitation (14% by the 2080s). The south interior and coastal regions can expect approximately 10% more precipitation during the fall, winter, and spring over the same period.[2] Across the province, by the 2080s, the single-wettest day may become nearly 20% wetter. Additionally, the maximum total precipitation over a consecutive five-day period may increase by more than 15%, with the largest increases projected in B.C.'s coastal regions.

Atmospheric rivers are projected to increase substantially in frequency and intensity – with a doubling of days with these conditions by the 2080s. This will also contribute to an increase in pluvial flooding. This is particularly the case in regions susceptible to coastal weather patterns, where fall/winter atmospheric river activity can lead to pluvial flooding.[3] The 2021 Atmospheric River event resulted in $675 million in insured losses and costs of up to $17 billion for the Province. In addition, coastal locations are also prone to strong summertime convective precipitation events. The further inland the region, the less susceptible they are to pluvial flooding from atmospheric rivers. Though, such areas are exposed to substantial pluvial flood risk from summertime convective storms.[4]

Pluvial flooding depends on the amount and timing of rainfall, soil conditions (whether the ground is dry, wet, absorbent, or frozen), and the condition of natural and engineered drainage systems.

In non-urban areas, hotter, dryer summers across many parts of the province are expected to contribute to impermeable soils, further exacerbating pluvial flood risk. In heavily urbanized areas, drainage system capacity relative to increased rainfall intensity, if not addressed, will likely cause an increase in pluvial flooding.[5]

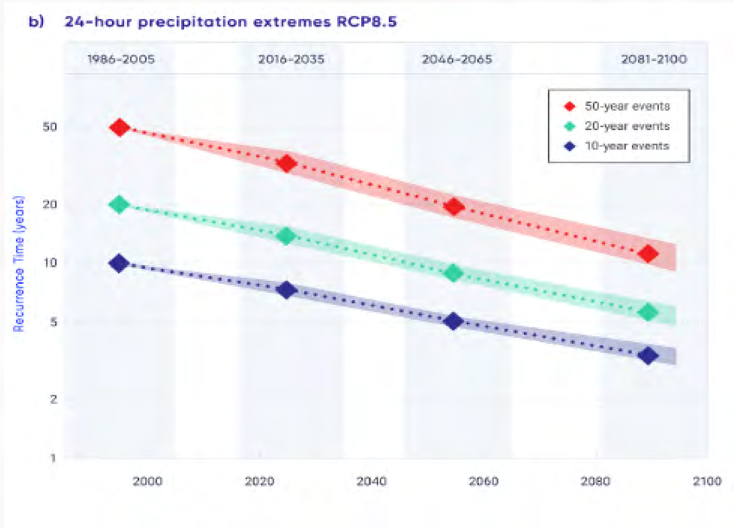


Figure 11: Projected changes in recurrence time (return periods) for annual maximum 24-hour precipitation that occurs, on average, once in 10, 20, and 50 years in the late century across Canada.[6] The graph illustrates how heavy rainfall that occurred once in a while in the early 2000s will occur much more frequently by the end of the century.

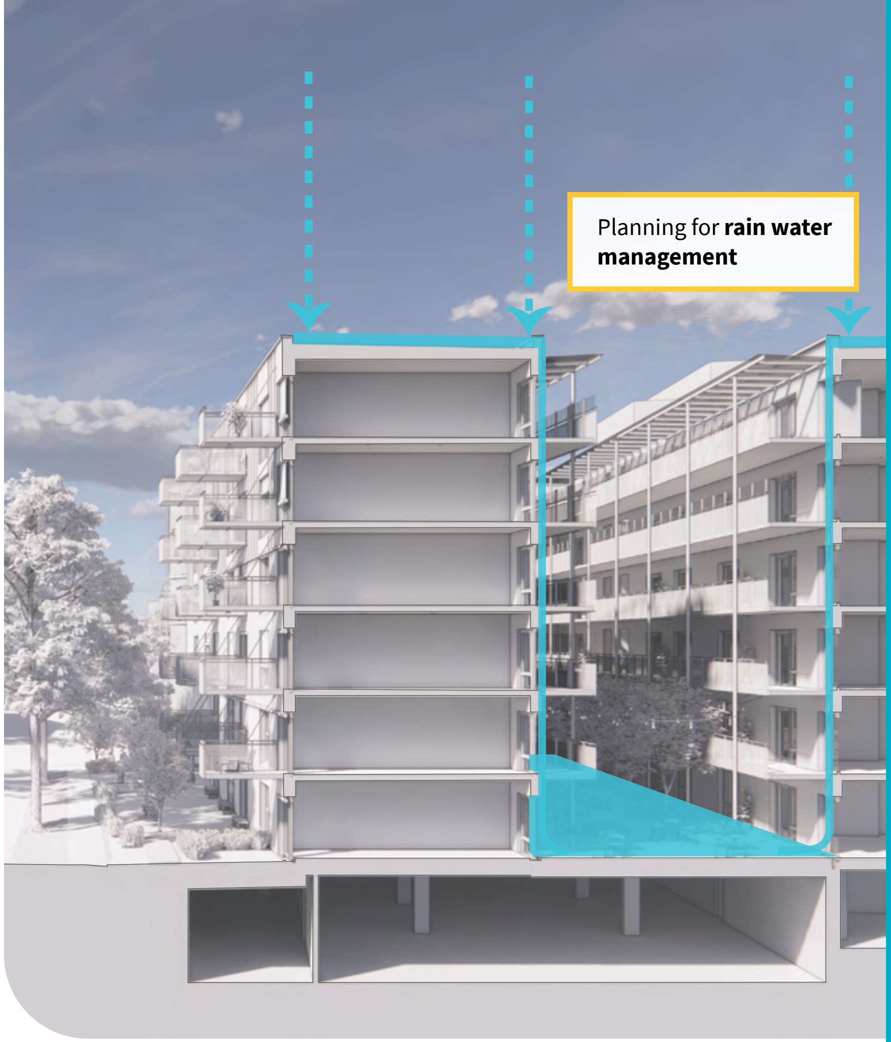
WHAT MAKES BUILDINGS MORE RESILIENT TO PLUVIAL FLOODING?

Consider these design strategies to increase resilience to pluvial flooding:

- Install sump pumps at the lowest point of the floor, with backup power supply, failure alarm and regular testing (low rise).
- Design window wells above ground and water resistant.
- Install check valves or backwater valves in third pipe, storm and sanitary sewer lines and permanently seal any floor drains that are not in use.
- Use rain resistant building materials.
- Ensure floor slab/foundation is properly filled and detailed to avoid capillary rise.
- Install utility penetrations above-grade.
- Incorporate means of accessing the foundation drainage systems, devices and technologies to facilitate inspection and maintenance.

Site design:

- Design site stormwater conveyance away from structures for increased volumes and flows.
- Ensure site grading is appropriately moving water at least 2m from the foundation.
- Where applicable, ensure downspouts are directed to a permeable surface and away from backfill zones and rainwater volumes are not directly conveyed to the sanitary or storm sewer systems, except where stormwater systems are designed to accommodate flows.
- Increase lot permeability and include detention tanks or stormwater ponds to reduce peak flow.



Maintenance:

- Develop a regular maintenance schedule for sewer valves.
- Inspect buildings regularly for signs of moisture damage, waterproofing performance and proper drainage.
- Proactively clear catch basins and culverts.

LOCAL GOVERNMENT TOOLS RELEVANT TO PLUVIAL FLOODING

Strategies:

- **Official Community Plans (OCPs)**: In its OCP, a local government may establish a link between climate change, the increasing frequency and intensity of precipitation, and the resulting increased risk of pluvial flooding. The OCP may also include wording with respect to meeting rainwater management requirements to reduce these risks.
- **Runoff control requirements:** Section 523 of the *Local Government Act* Section grants local authorities the power, through bylaws, to regulate runoff and stormwater management on and from lands under various circumstances. This includes setting the proportion of permeable land and mandating either connection to the municipal storm sewer or on-site management of surface runoff through retention, detention, and infiltration.
- **Integrated rainwater or stormwater management plans (ISMP)**: A community or watershed-scale ISMP can cover wide-ranging topics, such as:
    - Stormwater sewer system capacity.
    - Private side sewer connection programs.
    - Elimination of combined sewer overflows (CSO).
    - Requirements for rainwater detention and infiltration.
    - Best management practices for stormwater.

  An ISMP may establish objectives or targets for stormwater management. Development of an ISMP will allow a local government to explore application of the various tools listed below, and determine which are best suited to their community. For example, during the development approval process, local governments may require site-specific ISMPs that demonstrate how these objectives or targets will be met for the development.

    - **Example:** City of Surrey Stormwater Management Plans

- **Street operations:** Local governments can establish a regular maintenance program and pre-storm clearing of streets and storm drains, especially in the fall. As part of the program, track storm flood calls spatially, if possible, to identify risk areas. Establish an "Adopt a Catch Basin" program to provide engagement and build awareness with residents to clear clogged catch basins.
- **Sewer use bylaws**: The *Community Charter* allows local governments to:
- Require a person to maintain proper flow of water in stream, ditch, sewer, or drains within a municipality.
- Prohibit infiltration and inflow (I&I) from private sewer laterals.
- However, studies have found that laterals are often left unmaintained, and over time develop cracks that allow stormwater to pour into the sewer system during rain events.[7] In addition, studies have also found unacceptable levels of I&I in new construction.[8] Enforcement of these bylaws is difficult. Some municipalities include mandatory private lateral connection replacement when over certain renovation thresholds. Bylaws may also reference the CSA Z800-18 standard.
    - **Example:** City of Surrey: Property owners must replace an existing sanitary service connection when building or renovating a home, if the following applies: the value of the building / renovation work is more than $100,000, and the existing service connection is more than 30 years old
    - **Example:** City of North Vancouver sewerage and Drainage Utility Bylaw: Property developments (including renovations) between $50,000 and $150,000 in value may choose not to install new sanitary private service pipes but shall be required to perform a private service pipe inspection to identify any defects. Property developments between $150,000 and $250,000 in value may choose not to install new sanitary private service lines, but shall be required to perform a sanitary private service line upgrade to reduce inflow and infiltration.
    - **Example:** Capital Regional District and Metro Vancouver have developed model sewer use bylaws to address I&I from private sewer laterals
- **Lot grading drainage regulation or policies**: Section 69 of the ***Community Charter*** allows B.C. municipalities to regulate drainage on public and private property. Division 11 of the ***Local Government Act*** enables local governments to establish a bylaw to require drainage works as part of subdivision servicing. Lot drainage plans are required by zoning and buildings bylaws and associated plan requirements can be detailed by the local authority. Stormwater utility fees may include additional charges for impermeable areas.
    - **Example:** City of Victoria Impervious Area Stormwater Rate
    - **Example:** City of Edmonton Bylaw
    - **Example:** Builder Guide for Site and Foundation Drainage
- **Protection and management of rainwater bylaw**: A bylaw can be used to establish strong rainwater management controls. Section 909 of the ***Local Government Act*** enables local governments to require, set standards for, and regulate provision of landscaping. Some considerations include how surface runoff and stormwater are captured and disposed of, and the maximum percentage of land area that can be covered by impermeable material.
    - **Example:** District of Metchosin Bylaw for the Protection and Management of Rainwater

- **Integrated rainwater or stormwater management plans (site-scale)**: Local governments may require submission of a management plan for stormwater for any new development. The plan should demonstrate how the development will meet the local government's objectives or targets for rainwater or stormwater management (for example, on-site water infiltration during storm events through infiltration fields or low-impact development features that are separated from building foundations). For zero lot line projects, alternative strategies may be needed to manage infiltration features effectively, ensuring they do not adversely impact building foundations. Provide standards or specifications that describe the expected best management practices.
    - **Example:** City of North Vancouver Stormwater Management Requirements for New Development
    - **Example:** City of Vancouver rainwater requirements for Part 3 buildings include calculations using a future-projected IDF curve to the year 2100 to take precipitation changes into account
    - **Example:** City of Coquitlam Stormwater Management Policy and Design Manual (Appendix C)
- **Section 219 covenant**: The *Land Title Act* allows a municipality to impose an obligation on the property owner in favour of the municipality. This can be used to register an approved Rainwater / Stormwater Management Plan on title with the property. This legally ensures the ongoing application, operation and maintenance of any management plan tools and actions. Discuss this approach with the Condominium Home Owners Association.
- **Zoning bylaws**: These can be amended for rainwater-friendly development. Amendments to consider include:
    - Specify a minimum topsoil depth.
    - Specify that all downspouts are to be directed to pervious surfaces (as per B.C. Building Code).
    - Apply a maximum impermeable surface area.
    - Specify minimum tree requirements.
    - Include things like swimming pools, decks and other structures that replace natural vegetation and soil with compact coverings.
- **Development Permit Areas (DPAs)**: Where a DPA is designated for the protection of the natural environment, it may require measures such as adding or maintaining vegetation and trees to control drainage. Where a DPA is designated to protect development from natural hazards (such as landslides), the local authority may require a drainage system to be constructed.
- **Form and character guidelines**: DPAs for form and character can apply to intensive residential, resort, commercial, industrial, and multi-family developments. To address humidity issues, promote simpler designs in form and character guidelines. A building with a complex building envelope provides more opportunities for thermal bridging, air leakage, and moisture infiltration to occur at complicated envelope junctions. Green roofs can also be included in the guidelines, with consideration of roof warranties and wildfire risks.
- **Reference climate-change-adjusted intensity duration frequency (IDF) curves:** Engineers, planners and policy makers use IDF curves in the design of infrastructure and drainage systems. These curves are changing as climate change brings increasing frequency and intensity of precipitation. Local and regional governments may have undertaken studies to future-cast these IDF curves to use in planning. Local governments should reference use of climate-change-adjusted IDF curves in all applicable policies and bylaws.

- **Example:** Metro Vancouver Study of the Impacts of Climate Change on Precipitation and Stormwater Management
- **Example:** Climatedata.ca provides a lesson on Best Practices for Using IDF Curves

- **Home flood protection program:** Local governments may implement a program to encourage and incentivize inspections and maintenance that reduces pluvial flooding or sewer backups in homes.
  - **Example:** Home Flood Protection Programs (City of Windsor, Intact Centre)
  - **Example:** Toronto Mandatory Downspout Disconnection
  - **Example:** Edmonton Flood Protection Homeowner Programs
  - **Example:** Edmonton subsidies for backwater valves

- **Education for homeowners**: Protect Your Basement From Flooding, Three Steps to Cost Effective Flood Protection, and the Intact Centre self-assessment tool (Home Flood Protection Checkup).
  - **Example:** Capital Regional District educational brochure: Maintenance of Underground Pipes to Protect From Basement Flooding - Generally Accepted Principles

- **Natural climate solutions:** Many local governments are valuing their green infrastructure assets in their asset management plans and developing plans for restoration and protection. Natural climate solutions also sequester carbon.
  - **Example:** City of Vancouver's Climate Action Plan includes a Natural Climate Solutions Big Move area
  - **Example:** Toward Natural Asset Management in the Township of Langley

IMPORTANT CONSIDERATIONS

Higher sensitivity to pluvial flooding includes areas where stormwater systems are already at capacity, areas where there were historical creeks and streams that are now piped and water collecting sites/ low topography. Older buildings, poorly graded sites, damaged connections to stormwater systems are other elements that may increase susceptibility to overland flooding during heavy storms. WIth limited enforcement of the maintenance of private sewer laterals, older buildings are particularly vulnerable to clogged, root-filled, or even collapsed sewer pipes. Sewer backups may cause health impacts for occupants.

Cities are becoming more urbanized and dense at the same time that rainfall is increasing and stormwater systems age, creating increased risk of pluvial flooding. Natural climate solutions such as restoration of riparian areas, green infrastructure and green/blue roofs must accompany grey infrastructure upgrades.

In addition to pluvial flooding, heavy rain and wind-driven rain can cause moisture ingress and increased humidity inside the buildings leading to mold and damage to building systems and the interior environment.

SECTION ENDNOTES

[1] Relative to a 1961-1990 baseline historical period.

[2] Pacific Climate Impacts Consortium. (n.d.). Plan2Adapt.

[3] Pacific Climate Impacts Consortium & Pinna Sustainability. (2014). The Future of Atmospheric Rivers and Actions to Reduce Impacts on British Columbians.

[4] Associated Engineering (B.C.). (2021). Investigations in Support of Flood Strategy Development in B.C. B-1: Impacts of Climate Change.

[5][6] Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON.

[7] Metro Vancouver. (2008). Private Sewer Lateral Programs: A Study of Approaches and Legal Authority for Metro Vancouver Municipalities.

[8] Robinson, B., Sandink, D., & Lapp, D. (2019). Reducing the Risk of Inflow and Infiltration (I/I) in New Sewer Construction A National Foundational Document for the Development of a National Standard of Canada. Institute for Catastrophic Loss Reduction.

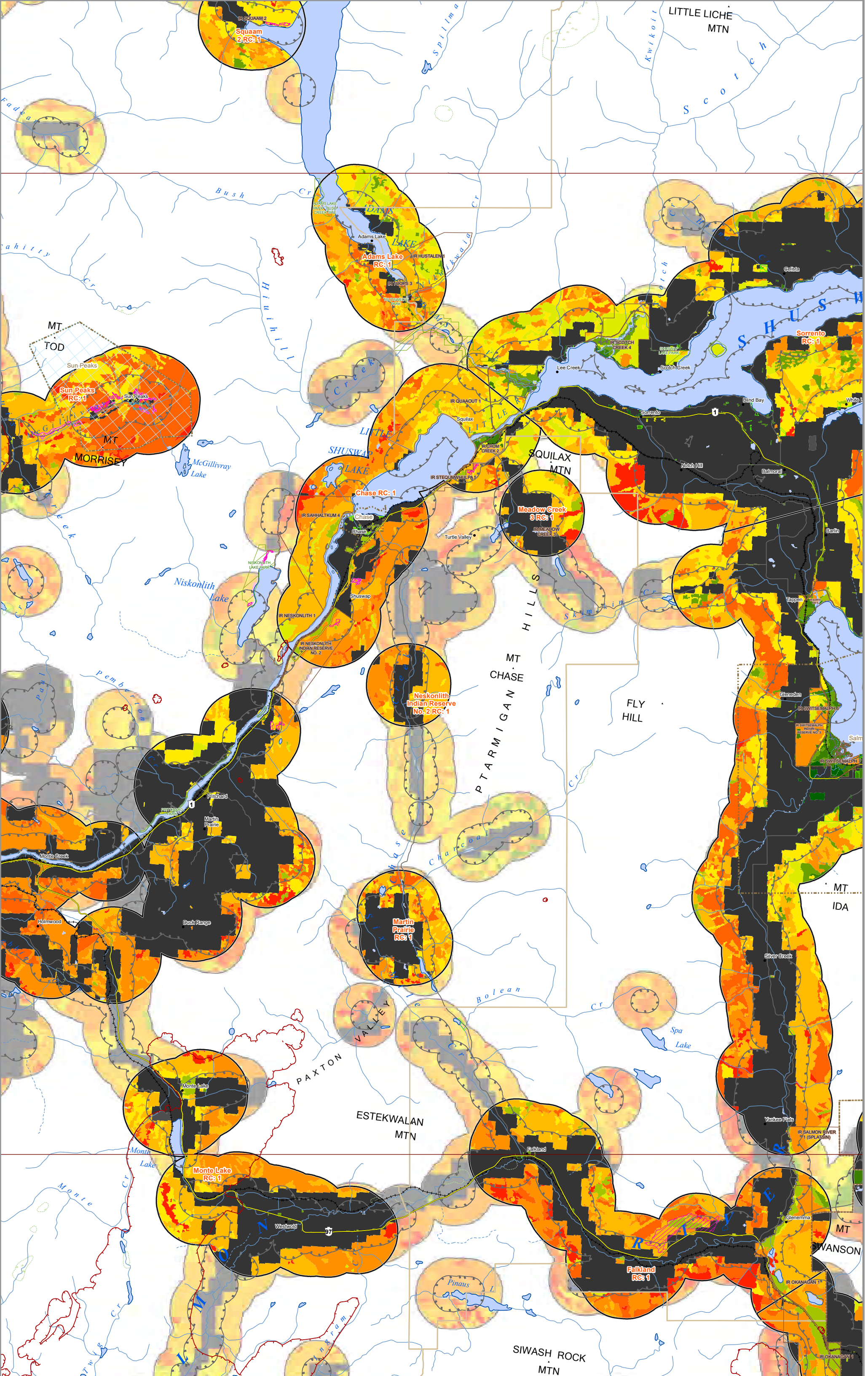
Additional references:

- Metro Vancouver. (2022). Direction on Integrated Stormwater Management Plans.
- Canadian Standards Association. (2018). CSA Z800-18 Guideline on Basement Flood Protection and Risk Reduction.
- B.C. Housing. (2024). Flood Resilience for New and Existing Buildings: Four Part Video Series.
- Institute for Catastrophic Loss Reduction (ICLR). Resources On Basement Flooding, Sump Pumps And Backwater Valves.
- Intact Centre for Climate Change Adaptation. Flood Protection Resources.
- Kovacs, P., Guilbault, S., & Sandink, D. (2014). Cities Adapt to Extreme Rainfall: Celebrating Local Leadership. Institute for Catastrophic Loss Reduction.
- Climate Data Canada. (2023). IDF Data and Climate Change. *Module explaining IDF curves and incorporation of climate change and projected IDF curves available under variables.*
- Sandink, D., Robinson, B., Dale, N., Okrutny, P., & Institute for Catastrophic Loss Reduction. (2021). Practical Guidance For Private-Side Drainage Systems To Reduce Basement Flood Risk: Addressing Critical Information Gaps. National Research Council of Canada.

5.5. Wildland urban interface fires

HOW IS THIS RISK OF FIRE CHANGING?

Climate Projections: Mean temperatures across the Province are projected to increase by 2 to 4°C by the 2050s, with hottest days getting 3 to 6°C hotter, on average. Coastal and southern interior regions of the province will see, on average, approximately 15% less summer rain; snowpack is expected to decline across the province. The projected increases in temperature and decreases in summer precipitation are key drivers of wildfire. Along with disease and pests, they contribute to a growing abundance of dry fuel across the province.



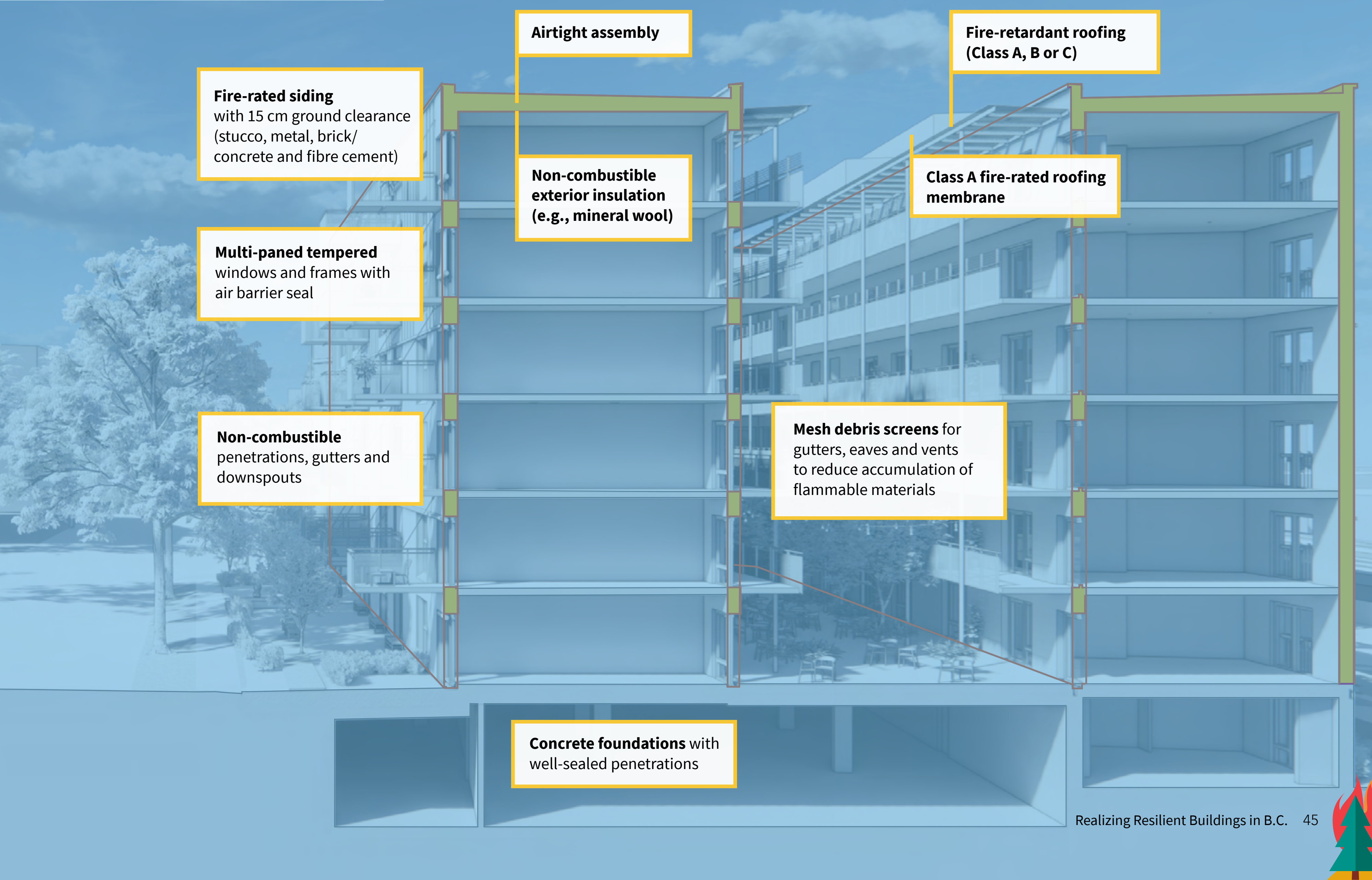
Fire Projections: Each year, B.C. experiences approximately 1,600 wildfires on average.[1] With increased storms and longer periods with dry fuel, a higher rate of ignition and increase in wildfire activity is likely. Research predicts that western Canada, where the fire potential is already high, will see a 50% increase in the number of dry, windy days that let fires start and spread over this century.[2] Annual area burned is projected to increase by up to 4% by 2050, exceeding 9 million hectares across Canada.[3]

The Province publishes wildland urban interface risk class maps, which were updated in 2021. The maps show the wildfire threat level based on the likelihood of the event, potential consequence of damages, and vulnerabilities to wildfire.

Figure 12: Example wildland urban interface risk class maps published by the Province of B.C.[4]

WHAT MAKES BUILDINGS MORE RESILIENT TO WILDLAND URBAN INTERFACE FIRES?

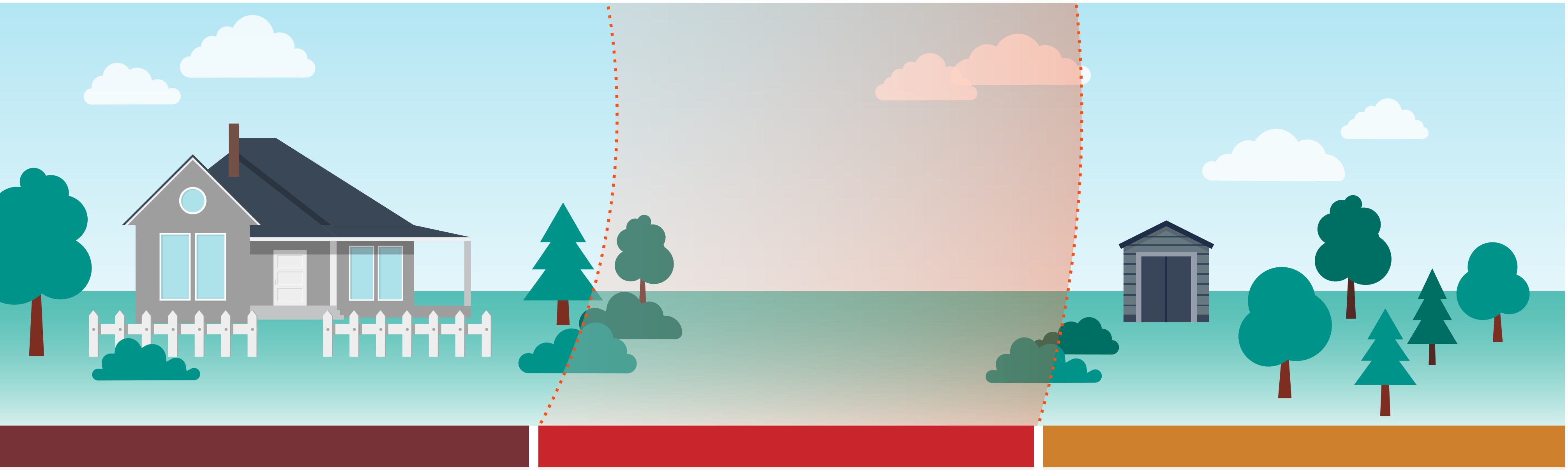
This diagram shows some examples of building-scale strategies that are important to increase resilience to wildfires.



Site strategies

In addition to improving the fire-resistance of buildings, there are a number of key strategies for the building site to improve resilience. FireSmart®, the Institute for Catastrophic Loss Reduction and others found that the greatest contributor of fire risk for homes in Fort McMurray is a result of vegetation management (ICLR, 2019).

Figure 13: Example site strategies to improve fire resistance



Zone 0
Maintain a non-combustible surface for a minimum of 1.5m around entire building, including decks.

Zone 1
Within 10m of building, keep free of all materials that could easily ignite, including keeping grass short and clearing leaves.

Zone 2
Over 10m from building, thin and prune lower branches, space trees at least 3m apart, and plant with fire resistant vegetation (e.g., poplar, birch, aspen, maple, ash, cherry).

In higher density areas, setbacks and alternate configurations will limit structure-to-structure fire progression. For more detailed strategies, see:

- National guide for wildland-urban-interface fires
- Wildfire-resilience best practice checklist for home construction, renovation and landscaping
- FireSmart BC homeowner's manual

LOCAL GOVERNMENT STRATEGIES AND TOOLS RELEVANT TO WILDFIRE

As highlighted above, it is important to implement wildfire risk management, response and recovery at all scales from the building to the site and community.

Strategies:

- **Community wildfire resiliency plan**: A holistic plan covering assessment of wildland urban interface fire risk, review of legislation, bylaws and development planning for wildfire resilience, and selection of implementation tools for prevention, mitigation, response / evacuation, and recovery. Funding is often available to support plan development.
  - **Example:** Regional District of Nanaimo Community Wildfire Resiliency Plans
  - **Example:** FireSmart BC Community Wildfire Resiliency Planning Guide
- **FireSmart program**: FireSmart BC is the primary resource for wildfire prevention in the province for community leaders and members. Key resources include training, toolkits, assessment checklists, homeowner's manual, and more. Local governments can offer FireSmart programs, such as chipping programs for fuel management and FireSmart landscaping grants.
  - **Example:** FireSmart BC
  - **Example:** City of Kelowna FireSmart Community Chipping Program
  - **Example:** City of West Kelowna FireSmart Landscaping Grant
- **Emergency response plan**: Develop a response guideline that articulates emergency preparedness to wildfire danger levels (monitored daily on the B.C. Wildfire Service website). Coordinate with volunteers and community-serving organizations to mobilize resources and include evacuation plans for high-risk areas.
  - **Post-wildfire event recovery strategy**: Recovery strategies developed during non-crisis times provide thoughtful strategies for incorporating increased resilience during redevelopment, which is a recommendation from the Fort McMurray report (2019).

- **Zoning bylaw:** Structure configuration and density and setbacks from treed areas or screening barriers impact the probability of structure to structure fire progression. Give consideration to lot sizes, land uses, setbacks, etc. in high hazard exposure areas.
- **Subdivision control:** A highly effective tool for ensuring new neighbourhoods or developments are set up to be FireSmart. Example: buffers between homes and coniferous vegetation, adequate fire design (access, cisterns, hydrant network etc.) and lot layout that provides or plans for secondary access/egress to a neighbourhood.
- **Development Permit Areas (DPAs)**: The Local Government Act allows for the use of DPAs in hazard exposed areas, including across the whole community. There are increasing examples of wildfire interface DPAs that outline requirements or guidelines for wildfire risk assessment, construction and landscaping.
    - **Example:** District of North Vancouver Wildfire Hazard Development Permit Area
- **Review development applications not under DPA for wildfire**: Where there is no DPA for wildfire, a wildfire risk assessment can be completed during the development application stage, either through a rezoning or a development variance process.
- **Landscaping bylaw**: A local government may establish a bylaw to manage landscaping that supports mitigation of wildfires. Bylaw enforcement and regular inspections are required to ensure effectiveness. Bylaws should be accompanied by regular education campaigns to remind property owners of the requirements and encourage compliance. Landscape bylaws need to be consistent across hazards such as incorporating drought tolerance and water conservation, invasive species management, etc.
    - **Example:** District of Squamish Wildfire Landscaping Management Bylaw
- **Distribute education materials:** Many existing resources about design and maintenance practices that reduce the potential impacts of wildfire are readily available.
- **Provide alerts:** In development of emergency plans, include monitoring the B.C. Wildfire Service fire danger levels and providing community communication as needed.

The recommended actions for construction in areas with relatively high wildfire hazard exposure are over and above the B.C. Building Code in some cases. In 2012, the Canadian Commission on Building and Fire Codes rejected a proposal from National Fire Protection Association (NFPA) Canada and Partners in Protection to establish a wildfire code (Porter et. al., 2021). To address this gap, several organizations collaborated to create the Wildfire-Resilience Best-Practice Checklist for Home Construction, Renovation and Landscaping.

IMPORTANT CONSIDERATIONS

Evacuation plans must account for the diverse abilities and needs of the community. Wildfire response planning should involve individuals with disabilities in the community and/or working with a disability expert to ensure a broad set of needs are met. Additionally, neighbouring communities must collaborate to ensure sufficient capacity to support coordinated evacuations.

When offering financial incentive programs, grants or education campaigns, prioritize:

- Areas with high wildfire exposure.
- Vulnerable buildings (e.g., those with more combustible materials).
- Communities facing barriers to adapting, such as lower-income neighbourhoods.

Although Disaster Financial Aid does not cover wildfire-related losses, private insurance may provide coverage. However, securing coverage in high-risk areas has become increasingly difficult in recent years. While wildfires can sometimes occur far from homes or infrastructure, at other times, they directly threaten homes and livelihoods. It is essential to consider Indigenous knowledge and perspectives on wildfire management and its role in the landscape.

SECTION ENDNOTES

[1] British Columbia Prepare B.C. (2023). Wildfire Preparedness Guide.

[2] Wang, X., et.al. (2017). Projected changes in daily fire spread across Canada over the next century. Environmental Research Letters, 12(2), 025005.

[3] Ministry of Environment and Climate Change Strategy. (2019). Preliminary Strategic Climate Risk Assessment for British Columbia.

[4] B.C. Wildfire Service. (2023). Wildland Urban Interface Risk Class Maps.

Additional references:

- Bénichou N., Adelzadeh M., Singh J., Gomaa I., Elsagan N., Kinateder M., Ma C., Gaur A., Bwalya A., & Sultan M. (2021). National Guide for Wildland-Urban Interface Fires. National Research Council Canada.
- B.C. Wildfire Threat Assessment Guide and Worksheets.
- B.C. Wildfire Service. (2019). Wildfire Threat Assessment Guide and Worksheets Sub-component and Descriptor Definitions.
- FireSmart BC. (n.d.). Guides & Manuals.
- Government of British Columbia. (2003). FireStorm 2003 Provincial Review.
- B.C. Wildfire Service B.C. Community Resiliency Investment Program for more information on funding to reduce wildfire risk.
- Intact Centre on Climate Adaptation. (2022). Wildfire-Resilience Best-Practice Checklist for Home Construction, Renovation and Landscaping.
- Intact Centre on Climate Change Adaptation (n.d.). Three Steps To Cost Effective Wildfire Prevention. This guide provides impactful risk mitigation actions between $0 and $300, $300 and $3000 and $3000 to $30,000.
- Institute for Catastrophic Loss Reduction & Zurich. (2019). Fort McMurray Wildfire: Learning From Canada's Costliest Disaster.
- Porter, K.A., Scawthorn, C.R., & Sandink, D. (2021). An Impact Analysis for the National Guide for Wildland-Urban Interface Fires. Prepared for the National Research Council of Canada. Institute for Catastrophic Loss Reduction.

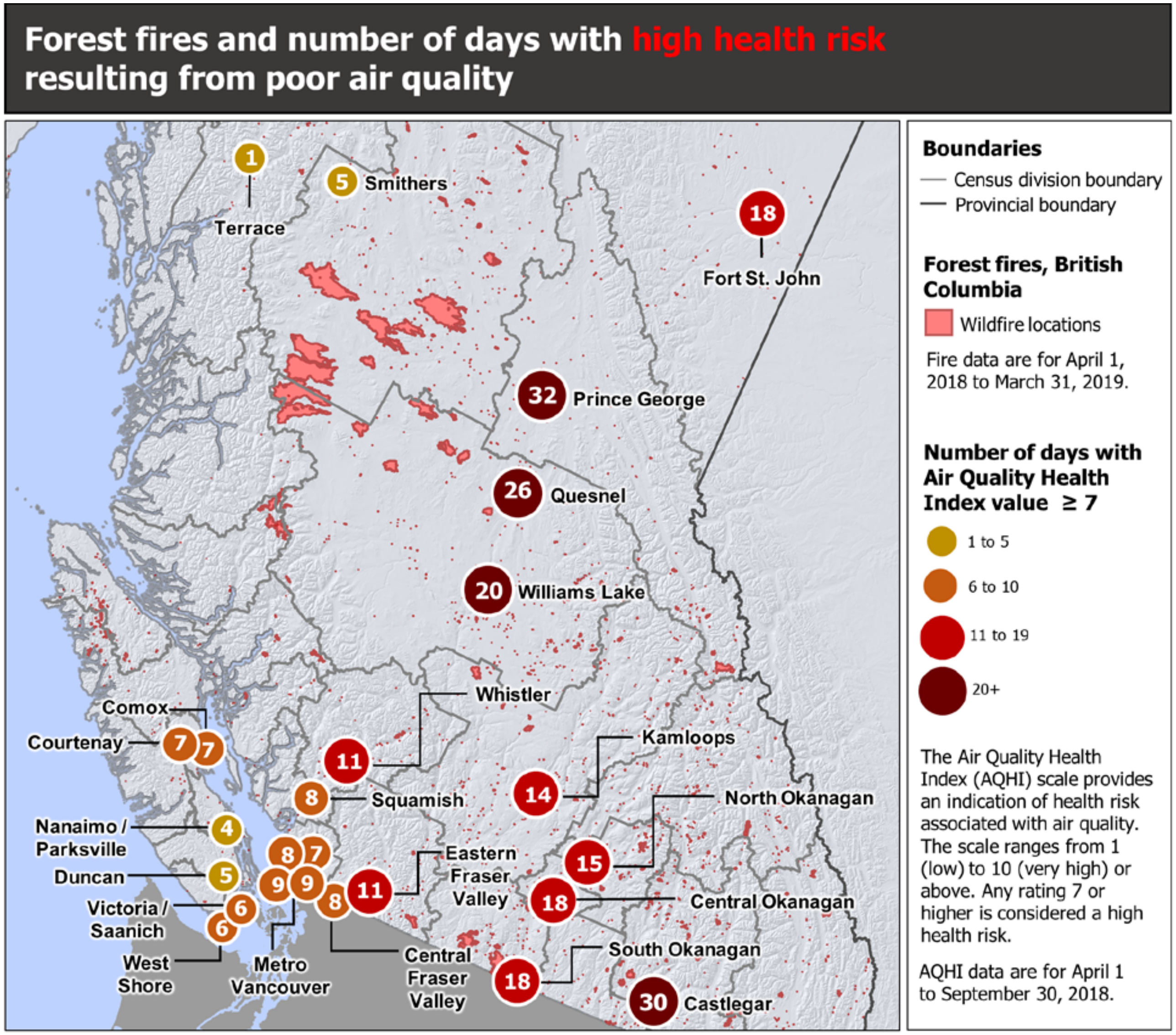
5.6. Wildfire smoke and air quality

HOW IS THE RISK OF WILDFIRE SMOKE CHANGING?

Wildfires in B.C. have become more frequent and more severe during the past 10 years. B.C. experiences smoke from fires burning nearby, across the province, and from other jurisdictions. Due to a mountainous topography and prevalence of inversions, this smoke can become stagnant in valley areas than in other flat/non valley areas. As a result, B.C. communities have experienced poor air quality due to increased fine particulate matter (PM2.5) with many days of air quality health index warnings. With projections of increased heat and drought, wildfire and the associated smoke may get worse in the future until a point where the fuel volumes are declining. Wildfire smoke is particularly concerning for people with lung/cardiovascular disease, pregnant women, children and infants, and the elderly.

As temperatures rise, concentrations of ground-level ozone (a major component of smog) will increase across Canada. Modelling shows that, with the temperatures projected for the end of the century, average summer ozone concentrations could increase by more than 20%. A recent study from NOAA shows that wildfire emissions are contributing equal or greater amounts of ozone to the atmosphere than urban pollution. This illustrates the impact of wildfire smoke in B.C., and across the globe.[1] Unless action is taken, future healthcare costs of ozone exposure could increase to one quarter of current healthcare costs linked to cancer (Canadian Climate Institute).[2]

Figure 14. Map of forest fires and days with high health risk due to poor air quality, 2018[3]



Note: Wildfires smaller than 0.01 hectares are represented by points.

Sources: British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, BC Wildfire Service (FLNRORD), 2019, "Fire Incident Locations – Historical" and "Fire Perimeters – Historical," *British Columbia Data Catalogue*, https://catalogue.data.gov.bc.ca/dataset/fire-incident-locations-historical and https://catalogue.data.gov.bc.ca/dataset/fire-perimeters-historical (accessed May 6, 2019); Environment and Climate Change Canada, 2018, "Air Quality Health Index Forecast," *Open Government*, https://open.canada.ca/data/en/dataset/a563e47d-6eb9-4f7f-933c-222ae49fe57f (accessed October 9, 2018).

WHAT MAKES BUILDINGS MORE RESILIENT TO WILDFIRE SMOKE AND POOR AIR QUALITY?

Here are some examples of building-scale strategies that are important to increase resilience to wildfire smoke and poor air quality.

- Airtight assembly, verified by a blower door test at completion of construction.
- Provide space for air handling equipment to be located above the flood construction level.
- Design air handling units to work with MERV 13 and higher filter media.
- Include active or passive cooling measures that provide summertime thermal comfort so that windows can remain closed during poor air quality.
- Design balanced ventilation system to mitigate air infiltration through the building envelope (avoids de-pressurizing a home and drawing pollutants in).
- To reduce the impact on energy use, select deeper filters (minimum 100mm) and only insert secondary filters during poor air quality episodes.
- Design dedicated outdoor air systems (if applicable) to include heat recovery to improve energy efficiency.
- High traffic exterior entrances can include vestibules with double doors.
- Ensure tight control of different pressure zones.
- Provide information to tenants on portable filters.
- Provide information to tenants during smoke events.
- Develop health and safety procedures for staff working outside the building.
- Provide operational guidance on filter maintenance and increase budgets for filters during summer season.

Additional strategies for existing buildings include:

- Understand that higher grade MERV filters may not be suitable for buildings with poor airtightness or with lower power air handling units.
- Improve the building envelope as a priority to improve effectiveness of air filtration.
- Purchase portable HEPA filters if the central air handling unit is not available or insufficient.
- Consider stockpiling low cost ***Corsi Rosenthal Box*** air filter parts for distribution to residents experiencing acute wildfire smoke that can provide higher clean air delivery rates for much less cost than HEPA filters.

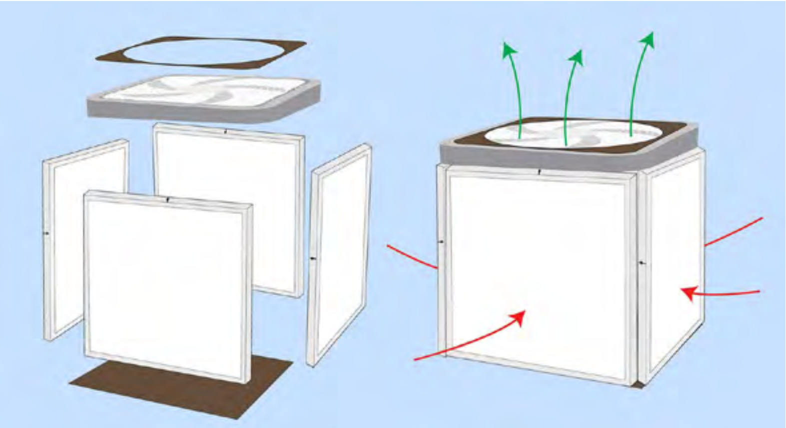


Figure 15. Corsi Rosenthal Box. Credit: Amanda Hu (CC BY 2.0)

LOCAL GOVERNMENT STRATEGIES AND TOOLS RELEVANT TO WILDFIRE SMOKE AND AIR QUALITY

Strategies:

- **Regional air quality plan**: These plans provide an opportunity to establish regional goals, objectives and actions to reduce air contaminants and improve local air quality. Reducing fine particulate matter from other sources reduces the impacts of wildfire smoke. Additionally, actions to reduce contaminants indoors may apply to multiple sources.
  - **Example:** Fraser Valley Regional District Air Quality Management Plan
  - **Example:** Metro Vancouver Clean Air Plan
  - **Example:** Comox Valley Regional Wood Smoke Reduction Program

- **Cooling and smoke response plan**: While different hazards, hot summer days often correspond with smoky days. Heat response plans can include thresholds related to the Air Quality Health Index for specific public actions, such as activating smoke relief / healthy air spaces during poor air quality episodes.
  - **Example:** City of Seattle Healthy Air Centre

- **Zoning:** Ensure there is sufficient space for air handling equipment to be located above the flood construction level and exempt it from gross floor area. Include height exceptions for rooftop units.
- **Rezoning incentives or requirements:** Identify certification with Passive House, LEED, or WELL building standards. Passive House requires MERV 13 on air handling units. LEED has an optional credit requiring MERV 13 filtration that is commonly targeted, especially for Gold or Platinum certification. The WELL standard requires different levels of MERV filters based on particulate matter concentration thresholds.
- **Recommend building air systems**: Systems designed to accommodate MERV 13 filters should be flexible enough to use higher or lower-grade filters as needed. Consider the building type, as energy efficiency may be compromised in buildings with poor air tightness or air handling units with limited power.
- **Measure air quality:** Improve the local government and public understanding of local air quality by installing low-cost air quality monitors inside and outside public facilities. These monitors are increasingly available and can provide real-time crowd-sourced mapping in some cases.
    - **Example:** Purple air real time air quality mapping
    - **Example:** Metro Vancouver Air Map with Air Quality Health Index
- **Education and awareness**: Build awareness including health impacts and how to reduce exposure. Provide reminders in the spring and provide resources such as links to portable air filters.
    - **Example:** BCCDC information on Wildfire Smoke
    - **Example:** BCCDC fact sheet and guide for do-it-yourself box fan air filters

IMPORTANT CONSIDERATIONS

Many homes, especially older buildings, lack air filtration systems and often rely on open windows to reduce summer heat due to the absence of air conditioning (see important considerations under extreme heat, page 27). This can be problematic when trying to balance air quality during events like wildfires.

Recommendations for mitigating air-borne pathogens like COVID-19 include improving air handling in buildings and increasing outdoor airflow. However, during periods of wildfire smoke, these strategies may conflict, requiring careful consideration and planning by facility operators.

SECTION ENDNOTES

[1] NOAA Research (2022). Smoke from wildfires influences ozone pollution on a global scale.

[2] Wang, J. & Strong, K. (2019). British Columbia's forest fires, 2018. For Statistics Canada.

[3] Statistics Canada. (2019). Map: Forest fires and number of days with high health risk resulting from poor air quality.

Additional references:

- B.C. Housing Research Centre. (2019). B.C. Energy Step Code: Design Guide Supplement S3 on Overheating and Air Quality.
- Integral Group. (2021). Filtration Study for the City of Vancouver. Prepared for: City of Vancouver.
- FireSmoke.ca. (n.d.). Canadian Portal For Information On Wildland Fire Weather And Smoke.

5.7. Storms and power outage

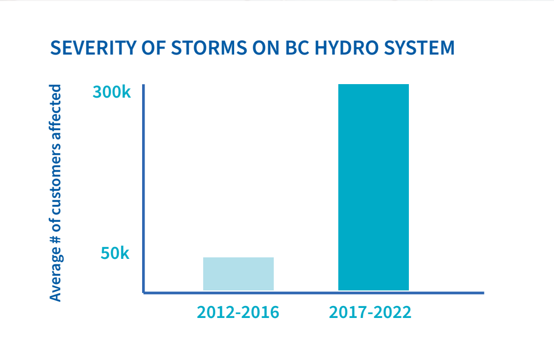
HOW ARE THE RISKS OF STORMS AND POWER OUTAGES CHANGING?

Climate change is affecting the frequency and severity of storms and extreme weather events. Changes impact the security of the provincial electricity grid, among other things. The Province of B.C. released research that indicates climate change is expected to increase the frequency of intense windstorms. Speeds of intense wind events, classified as those among the top 10% of wind events, are expected to increase by approximately 15% in coastal B.C. and the Northern Boreal mountains by mid-century.[1] Storm-related precipitation is projected to increase by 40% to 60% on the south coast of B.C., and by 100% to 150% in the Northern Caribou Mountain region.[2] Strong winds will make power infrastructure more vulnerable to damage from storms. Heavy rains, and snow are likely to increase the risk of flooding, which can damage power plants and substations, further compromising the electrical grid.

With increasing temperatures, we can expect a surge in demand for energy for cooling during the summer months, placing an extra burden on the power grid that was originally designed to handle winter peak loads related to heating. Combined, these stresses result in increased risk of power outages across the province.

The impact of climate change is particularly severe in the coastal regions of British Columbia, where the risk of flooding and sea level rise is highest. In the past five years,[3] the average number of customers affected by a winter storm has risen over 500% compared to the previous five years, and the average number of individual storm events BC Hydro has responded to in the province has tripled in the same period.[4]

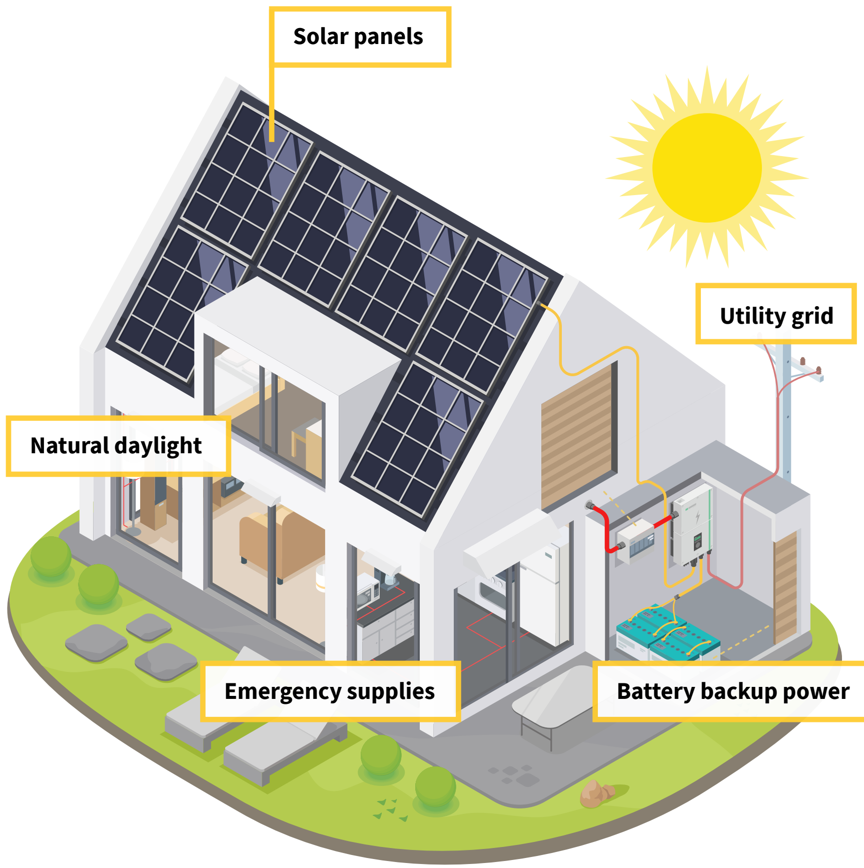
Figure 15: Severity of storms on BC Hydro System, 2012-2016 compared to 2017-2022[5]



WHAT MAKES BUILDINGS MORE RESILIENT TO STORMS AND POWER OUTAGES?

This diagram shows some examples of building-scale strategies that are important to increase resilience to storms and power outages.

- Provide backup power for control systems, essential loads, and priority service areas (e.g., sump pumps, common refuge areas, cooling).
- Incorporate demand management and load sharing for critical loads to reduce generator needs.
- Test backup power systems regularly.
- Consider options to diversify backup power (e.g., solar PV, batteries, use of EV batteries).
- Maximize natural daylighting in corridors and stairwells.
- Include luminescent strips in dark spaces.
- Design buildings to meet high levels of the B.C. Energy Step Code to minimize dependence on heating and cooling systems.
- Design with zoned spaces for critical and non-critical areas.
- Stock emergency supplies for common areas.
- Ensure roof materials are adequately fixed and roof assemblies are braced and securely connected to walls.
- Select impact-resistant materials where continuous load path is insufficient (e.g., heat-soaked glass).
- Design facades for increased precipitation loads (e.g., overhangs) and consider potential hail damage.
- Mitigate increased wind load with aerodynamic structures, attachment anchorage, and consider wind tunnel effects for entrances.



LOCAL GOVERNMENT TOOLS RELEVANT TO STORMS AND POWER OUTAGES

Strategies:

- **Zero emission building plans and strategies**: Many local governments are developing building electrification plans and strategies to support the transition to zero carbon communities. Incorporate strategies and actions to enhance building-level resilience to electrical grid disruptions and outages into these plans.
- **Emergency response plans and business continuity plans**: Identify where back-up power is needed for safety and business continuity. Mobile generators may offer more flexibility but will require fuel storage and/or fuel delivery contracts.
    - **Example:** City of Vancouver tools for small businesses to develop business continuity plans
- **Refuge area requirements or gross floor area exclusions**: Consider well designed, larger amenity space requirements and/or exclusions from gross floor area. Amenity spaces could include additional power from back-up sources.
- **B.C. Energy Step Code:** Advance adopting the step code ahead of the provincial schedule, to minimize heating and cooling needs.
- **Rezoning resilience worksheet**: Develop a worksheet that asks applicants about the passive survivability of their design including during peak winter and summer conditions. For example, relying 100% on mechanical cooling requires backup power to the system to ensure thermal safety in a power outage. Mixed modes that include natural ventilation and passive cooling methods provide resilience if the power goes out.
- **LEED passive survivability credit**: Encourage the use of this credit in LEED projects
- **Minimum backup power guidelines**: Provide guidelines on minimum backup power with essential loads to improve passive survivability and building operation (such as sump pumps).
    - **Example:** Minimum Backup Power Guidelines for MURBs, Toronto

IMPORTANT CONSIDERATIONS

The B.C. Building Code stipulates the emergency power load for different types of buildings. This minimum backup power may not support various needs for sheltering in place in the case of an extreme event.
For example:

- Breathing equipment may have minimal battery backup and require generator support.
- Blind individuals may lose access to the apps they use for navigation.
- Elevators necessary for evacuation for individuals with reduced mobility may not function.

As communities adopt electrification to transition off of fossil fuels, some level of resilience may be compromised. It is important to consider how to maintain resilience through backup power, local renewable energy supply, and design that minimizes the need for power during this transition time.

SECTION ENDNOTES

[1] Daust, D., & Morgan, D. (2011). A Climate Change Vulnerability Assessment for British Columbia's Managed Forests: Climate Change in B.C.

[2] Daust, D. (n.d.). Climate Change in B.C.

[3][5] BC Hydro. (2022). Storms actually: How BC Hydro is preparing for increasing holiday storms.

[4] BC Hydro. (2020). Climate change: How BC Hydro is adapting.

Additional references:

- EGBC. (2022). Practice Advisory: Electrical Considerations For Decarbonizing Existing Part 3 Buildings.
- Institute for Catastrophic Loss Reduction (ICLR). (n.d.). Resources For Municipalities Regarding High Wind And Buildings.
- IInstitute for Catastrophic Loss Reduction (ICLR). (n.d.). Protecting Your Home From Severe Wind.
- Canada Green Building Council. (n.d.). LEED: Building Resilience to Climate Change.

5.8. Drought and short-term water shortage

HOW IS THE RISK OF DROUGHT CHANGING?

In British Columbia, rising temperatures and changes in precipitation patterns are leading to increased risk of drought and water supply shortages. The 2019 B.C. Climate Risk Assessment rated seasonal and long-term water shortage as one of the highest risks for the province in the future.

By the 2050s, warmer temperatures will bring more intense dry spells and more frequent, longer summer droughts across the province. These effects may be severe in the interior and northern regions, where water resources are scarcer. Snowpack, which serves as a natural reservoir for the dry summer months in snow dominated watersheds, is decreasing and melting earlier in the year,[1] triggering lower streamflows in summer and a need for larger storage infrastructure to capture cold season rains for summer use. Warmer temperatures will increase evaporation and transpiration and contribute to soil water loss on impermeability. Groundwater recharge will likely be affected as well in areas where soils cannot take in water at an accelerated pace.

In addition to these stresses, demand for water generally increases during heat waves, creating conditions for water supply shortages.

Figure 16: 2022 Drought levels at a glance, B.C. Ministry of Water, Land and Resource Stewardship[2]

2022 DROUGHT LEVELS AT A GLANCE

Drought Levels: 0 | 1 | 2 | 3 | 4 | 5

BASINS	30-Jun	14-Jul	21-Jul	28-Jul	04-Aug	11-Aug	25-Aug	01-Sep	08-Sep	15-Sep	22-Sep	06-Oct	13-Oct	20-Oct	27-Oct	03-Nov	10-Nov	24-Nov	01-Dec
Fort Nelson	0	0	0	0	0	0	1	2	3	3	4	4	5	5	5	5	5	5	4
East Peace	0	0	0	1	1	1	1	2	3	3	3	4	5	5	5	5	5	5	5
North Peace	0	0	0	0	0	0	1	1	2	2	3	4	5	5	5	5	5	5	5
South Peace	0	0	0	0	0	0	1	2	3	3	3	4	5	5	5	5	5	5	5
Northwest	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Stikine	0	0	0	1	1	1	1	0	0	0	1	1	1	2	1	1	1	1	1
Skeena-Nass	0	0	0	1	1	1	1	0	0	0	1	2	2	2	2	1	1	1	1
Bulkley-Lakes	0	0	0	1	1	1	1	1	1	1	2	3	3	3	3	3	3	3	3
Finlay	0	0	0	1	1	1	2	2	2	2	2	3	3	4	4	4	4	4	4
Parsnip	0	0	0	1	1	1	1	1	1	1	2	3	3	4	4	4	4	4	4
Upper Fraser West	0	0	0	1	1	1	1	1	1	1	1	2	2	3	2	2	2	2	2
Upper Fraser East	0	0	0	1	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3
Upper Columbia	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
Lower Columbia	0	0	1	1	1	1	1	1	1	1	1	2	2	3	3	3	2	2	2
West Kootenay	0	0	1	1	1	1	1	1	1	1	1	2	2	3	3	3	2	2	2
East Kootenay	0	0	0	0	0	1	1	1	1	1	1	2	2	3	3	3	2	2	2
Kettle	0	0	0	1	1	1	3	3	3	3	3	4	4	5	5	5	3	3	3
Middle Fraser	0	0	0	1	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3
Lower Thompson	0	0	0	0	0	1	1	1	1	1	1	2	2	3	3	3	3	3	3
North Thompson	0	0	0	0	0	1	1	1	1	1	1	2	2	3	3	3	3	3	3
South Thompson	0	0	0	0	0	1	1	1	1	1	1	2	2	3	3	3	3	3	3
-Salmon River	0	0	0	0	0	1	2	2	2	2	2	2	2	3	3	3	2	2	2
Nicola	0	0	0	0	0	1	1	1	2	2	2	3	3	4	4	4	3	3	3
-Coldwater River	0	0	0	0	0	1	2	2	3	3	3	3	3	4	4	4	3	3	3
Okanagan	0	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2
Similkameen	0	0	0	0	0	1	1	1	2	2	2	2	2	3	3	3	3	3	3
Central Pacific Range	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3	3	3	4	3
Eastern Pacific Range	0	0	0	1	1	1	1	2	2	2	3	4	4	5	5	3	3	4	4
Sunshine Coast	0	0	0	1	1	1	2	2	3	3	4	5	5	5	5	4	4	4	3
Lower Mainland	0	0	0	1	1	1	2	2	3	4	4	5	5	5	4	3	3	4	2
Central Coast	0	0	0	0	1	1	2	1	1	2	2	3	4	4	3	3	3	4	1
West Vancouver Island	0	0	0	1	2	2	3	3	3	3	4	5	5	5	4	2	2	4	3
East Vancouver Island	0	0	0	1	2	2	3	3	3	3	4	4	5	5	5	3	3	4	3
Haida Gwaii	0	0	0	0	1	2	3	1	0	0	1	3	4	4	2	0	0	1	0

Prepared By: Water Management Branch - Ministry of Forests

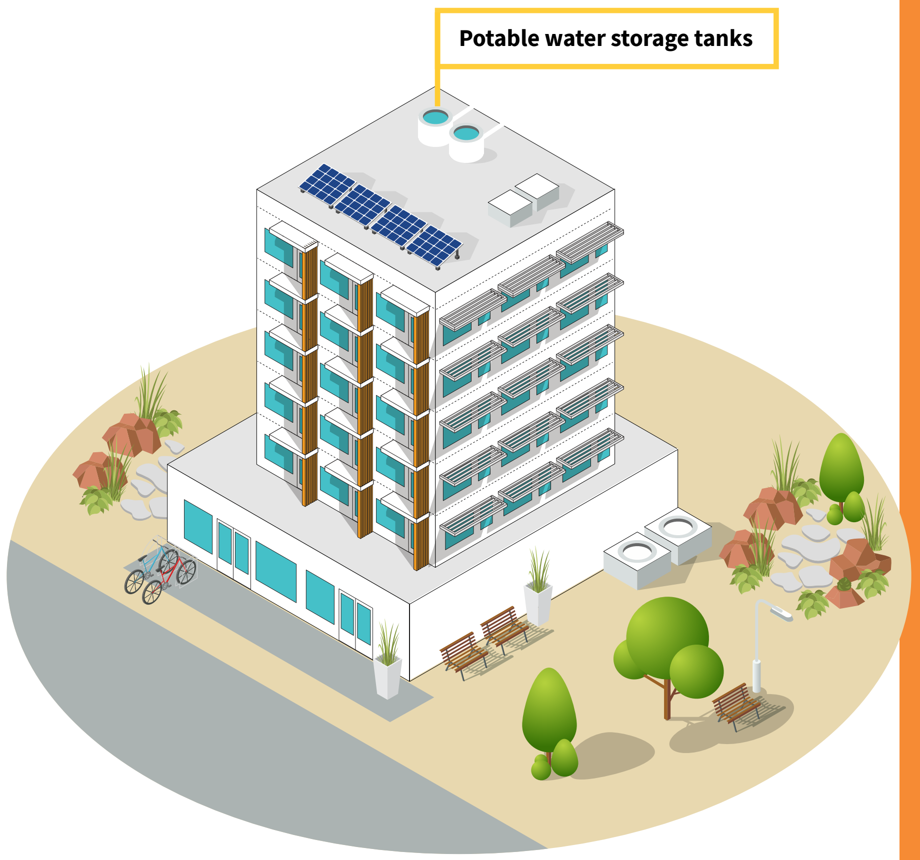
The B.C. Ministry of Water, Land and Resource Stewardship tracks and reports drought levels across the province, using a scale of 0 to 5. This example snapshot from 2022 shows the variation in drought conditions across the province that year, with several basins reaching level 5, particularly in the Fort Nelson and Peace Regions, the Kettle Valley, the South Coast, and parts of Vancouver Island.

During the winter of 2022-2023, Mount Washington ski resort on Vancouver Island was experiencing a severe winter water shortage, with snowpack less than 25% of what is considered normal in December. Residents and guests were asked to bring their own drinking water to the mountain, and the Resort provided porta-potties and disposable plates and cutlery to reduce water demand.[3] Tofino experienced a very dry summer in 2023 and, in response, put out a call with specific measures for residents and businesses to minimize water consumption and avoid Stage 4 mandatory restrictions.[4]

WHAT MAKES BUILDINGS MORE RESILIENT TO DROUGHT AND WATER SHORTAGE?

Consider the following site- and building-scale strategies to increase resilience to drought and water shortage:

- **Provide signage and campaigns to encourage water efficient behaviour** among occupants (only running full loads of dishes or laundry, etc.)
- **Install rainwater, stormwater, or greywater capture** and reuse systems on-site to serve end uses suitable for non-potable water (potentially including toilet flushing, irrigation, cooling towers, laundry, vehicle washing or others, depending on system design).
- **Ensure reuse systems are designed with sufficient storage** to function during severe water restrictions of the future.
- Consider the need for **potable water storage,** particularly for emergency facilities, with appropriate design and treatment for potential pathogens or contaminants.
- Design landscape and open space for drought by planting **drought-tolerant landscaping**.
- **Consider no summer irrigation**. If necessary, use subsurface drip irrigation.
- Install water saving fixtures and appliances.



On-site water storage and reuse requires designers to consider appropriate storage and treatment. This helps to manage the correct water balance, and to manage potential contaminants and pathogens. Non-potable water systems come in many different forms. Non-potable water systems vary widely, from basic rain barrels with no treatment to sophisticated systems that require a trained operator for daily monitoring and management. Standards have been defined to support the design, installation and operation of on-site non-potable water systems (see list on right).

LOCAL GOVERNMENT TOOLS RELEVANT TO DROUGHTS AND WATER SHORTAGE

Strategies

- **Demand side water management program**: Review and update policies for water conservation and develop awareness campaigns for building owners and occupants.
  - **Example:** Metro Vancouver We Love Water campaign
  - **Example:** Okanagan Water Supply and Demand Project
- **Regional or local water supply planning**: Develop and update water supply plans for the future based on projected changes in snowpack. Review the resilience of the water system to multiple and compound hazard events.
  - **Example:** Metro Vancouver planning for future water supply
- **Groundwater management and protection plans**: Short term and long term water supply are climate risks identified in the B.C. Preliminary Strategic Climate Risk Assessment. Groundwater provides a primary and secondary source of potable water. For example, plans can explore requiring the use of other water sources to minimize groundwater use in areas of concern.
  - **Example:** Okanagan Basin Water Board Groundwater Bylaws Toolkit

- **Land use bylaw:** Include requirements for water capture and storage in areas lacking sufficient water supply, or susceptible to drought in future.
  - **Example:** Saturna Island Land Use Bylaw, section 2.17, requirement for rainwater capture and storage (minimum 21,820 litres) to obtain a building permit
- **Building Code enforcement**: There is language in the B.C. Building / Plumbing Code to allow non-potable water systems in certain applications. Ensure building officials are aware of and support these allowances.
- **Development Permit Area (DPA) guidelines**: DPA guidelines may be established for water conservation, including drought-tolerant planting, and the capture, storage and reuse of on-site water.
  - **Example:** City of North Vancouver Moodyville Guidelines, Guideline 4.2.1 states a requirement to provide a minimum amount of rainwater storage that can be drawn for landscaping purposes, or to collect and detain rainwater in accordance with LEED® Gold stormwater design provisions
  - **Example:** Province of B.C. Development Permit Areas for Climate Action
- **Green rezoning requirements:** Include requirements for water conservation or on-site non-potable water systems during rezoning in areas susceptible to drought in future.
- **Landscape bylaw**: A local government may establish a bylaw to manage landscaping that supports water conservation. Bylaw enforcement and regular inspections are required to ensure effectiveness. Bylaws should be accompanied by regular education campaigns to remind property owners of the requirements and encourage compliance. Landscape bylaws need to be consistent across hazards such as considering wildfire mitigation, invasive species management, etc.
- **Greywater discharge bylaw**: A local government may adopt a bylaw that allows surface discharge of greywater. This can enable, for example, the use of laundry water for irrigation.
- **Regional or local water restrictions**: Water restrictions must be enforced through local bylaw officers to conserve potable water during periods of drought, whether established regionally or locally. Provide information and alternatives to potable water use during restrictions.
  - **Example:** Sechelt operates a non-potable water station during water restrictions
  - **Example:** City of Kelowna Water Regulation Bylaw, Part 8: Water Use Restriction Stages
- **Water metering**: Implementing water metering and appropriate rates can support water conservation.
- **Advocacy**: Although there are standards for non-potable water systems, additional provincial guidance would support broader, safer, and consistent adoption of these systems. It would also streamline the approval process. Advocate to the province and health authorities for a consistent set of guidelines or standards for non-potable water use systems.
- **Develop / distribute education materials**: Many existing resources on water conservation practices are available.
  - **Example:** City of Kelowna created a Landscape & Irrigation Guide to Water Efficiency
- **Incentive programs**: Incentives may be developed for water fixtures, or for on-site rainwater, stormwater or greywater non-potable water systems.

Non-potable water systems are currently allowed in the B.C. Building Code and may require approval through the alternative solutions path. In the City of Vancouver, the Vancouver Building Bylaw requires the installation of non-potable water systems for most new buildings for specific end uses (toilet flushing, clothes washing, cooling tower water, and more).[5] Many jurisdictions in Canada and the US use density bonuses to encourage greywater reuse as a conservation measure for new development.

SECTION ENDNOTES

[1] Pacific Climate Impacts Consortium. (n.d.). Plan2Adapt.

[2] B.C. Ministry of Forests. (n.d.). B.C. Drought Information Portal.

[3] CBC News. (2022). Severe water shortage at B.C. ski resort forces staff to ask visitors to bring their own.

[4] District of Tofino. (2023). Call for urgent water conservation.

[5] City of Vancouver. (2023). Vancouver Building By-law 2019, Consolidated changes to July 25, 2023.

ADDITIONAL REFERENCES

- Metro Vancouver. (2020). Residential Water Metering In Metro Vancouver: Best Practices Guide For Local Governments.
- Metro Vancouver. (2022) Non-Potable Water Systems - A Guidebook for the Metro Vancouver Region.
- B.C. Ministry of Health. (2022). Drinking Water Officers' Guide 2020 – Part B.14 | Guidance for Treatment of Rainwater Harvested for Potable Use in British Columbia.
- B.C. Ministry of Health. (2014). Sewerage System Standard Practice Manual.
- B.C. Ministry of Health. (2016). Manual of Composting Toilets and Greywater Practice.
- Health Canada. (2010). Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing.
- Canadian Standards Association. (2023). B128.3:23, Performance Of Non-Potable Water Systems.
- Canadian Standards Association. (2018). B805-18/ICC 805-2018, Rainwater Harvesting Systems.
- Canadian Standards Association. (2021). B128.1-06 (R2021), Design And Installation Of Non-Potable Water Systems/Maintenance And Field Testing Of Non-Potable Water Systems.
- Canadian Standards Association. (2012). B128.2-06 (R2021), Non-potable water systems Maintenance and field testing.
- B.C. Ministry of Environment. (2013). B.C. Ministry of Environment Reclaimed Water Guidelines.
- FCM supported pilot study of home greywater reuse systems in Guelph, Ontario.

5.9. Earthquake

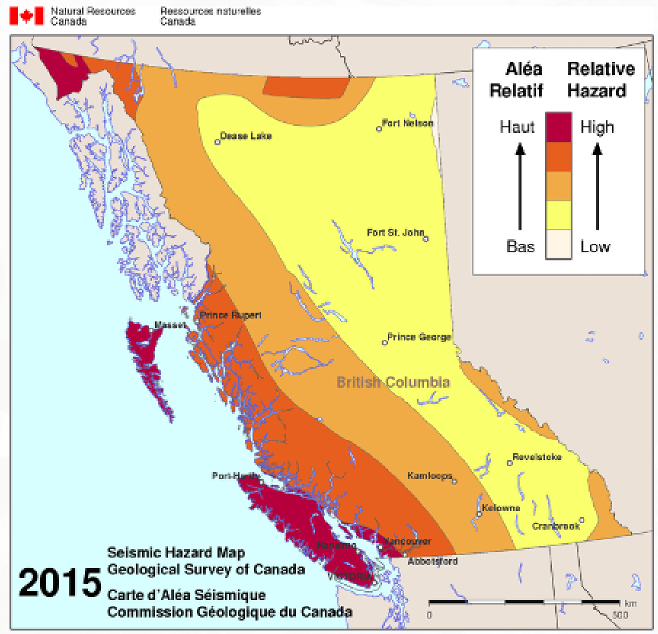
WHAT ARE THE RISKS DUE TO EARTHQUAKES?

British Columbia is one of the most seismically active regions in Canada with earthquakes capable of causing structural damage happening every decade or so in Southwest B.C.[1] Three types of earthquakes can occur in the region:

- Large megathrust earthquakes along the plate boundary off Vancouver Island with magnitudes up to about 9.0.
- Deep intraslab earthquakes with magnitudes up to about 7.5.
- Shallow crustal earthquakes with magnitudes up to about 7.5.

The province also has the highest concentration of assets at earthquake risk in Canada. Of the 1.2 million buildings in B.C., more than 500,000 buildings have 10% chance every 50 years of being exposed to strong shaking (>MMI VII or "very strong shaking") that can cause moderate structural and heavy non-structural damage.[2]

Figure 17. Seismic Hazard Map of B.C., 2015[2]

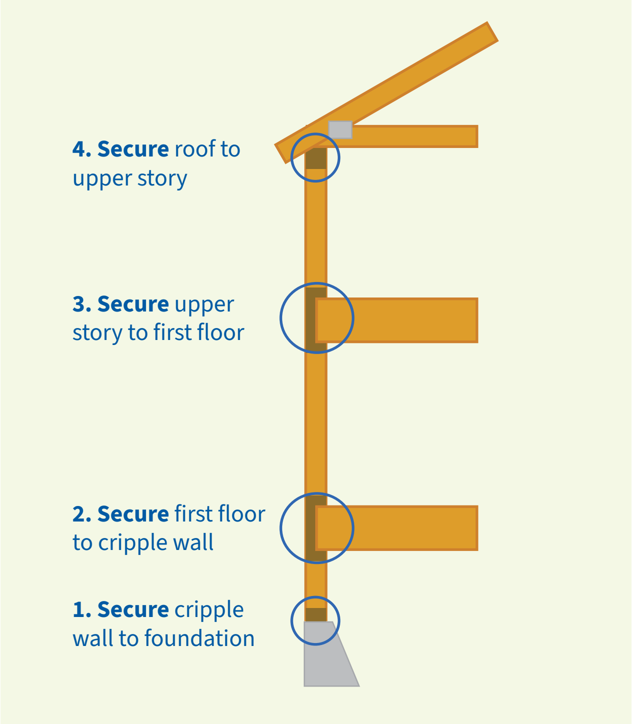


WHAT MAKES BUILDINGS MORE RESILIENT TO EARTHQUAKES?

The B.C. Building Code includes requirements for seismic design. Further earthquake design strategies can be found in resources in BC Housing's Research Centre Digital Library. It should be noted that financial losses from physical risk can never be fully eliminated and remaining losses should be managed by risk transfer mechanisms through insurance, reinsurance, and/or government funding. Social impacts of earthquakes are managed by building social capital through community networks, community resilience hubs, and community support programs—especially for marginalized and vulnerable groups.[3]

Here are some examples of building-scale strategies that are important to increase resilience to earthquakes:

- **Understand the risk:**
  - Use the best, most up-to-date seismic hazard data and consider seismic hazards such as amplification, liquefaction, landslides, and fire following earthquakes.
  - Require site-specific investigation and referral to microzonation mapping where it exists.
- **Increase resilience of the structure:**
  - Retrofit the most vulnerable existing buildings, including unreinforced masonry, non-ductile concrete, and those with "soft storeys".
  - Construct new buildings to achieve 'better than code' performance.
  - Construct with lightweight materials, such as mass timber with energy dissipating devices.
  - Place more emphasis on all mechanical and electrical and non-structural architectural components to ensure post-earthquake functionality of building systems.
- **Evolve approach and improve response and recovery:**
  - Integrate strong motion instrumentation to facilitate post-earthquake inspection.
  - Incorporate the national Earthquake Early Warning (EEW) system currently under development.
  - Consider shifting building codes from minimum requirements for protecting life safety to desired functionality and recovery performance post disaster based on cost-benefit analysis (i.e., the requirement that the building will take only five days to achieve functional recovery after a major earthquake).

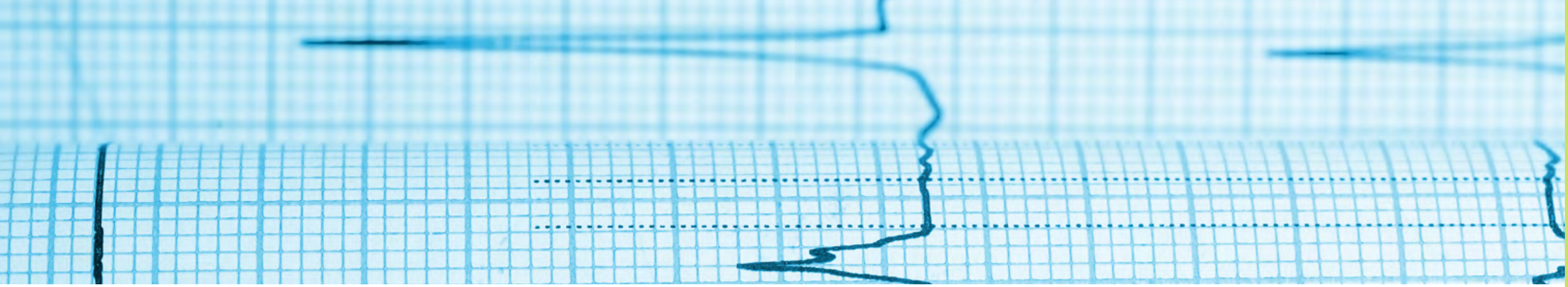


LOCAL GOVERNMENT TOOLS RELEVANT TO EARTHQUAKES

Strategies:

- **Emergency response plan**: Response plans including assignments of response roles such as rapid building damage assessment. Exercises to practice and test response plans.
- **Earthquake strategies**: Ideally, every community should have an earthquake risk profile that includes seismic hazard mapping (e.g., Level 2 and Level 3 microzonation maps) and information about the vulnerability of buildings (e.g., building type and age), occupants, and critical infrastructure. An earthquake plan or strategy would then outline priority actions or targets for risk management, preparedness, response, and recovery.
    - **Example:** District of North Vancouver Earthquake Ready Action Plan
- **Communication and awareness strategies**: Better inform homeowners about how vulnerable their homes may be, the costs of earthquake mitigation measures, and inform elected officials of risk. Raise awareness of vulnerable structures to better prioritize investment.
- **Official Community Plans (OCPs)**: OCPs can include seismic hazard areas from microzonation mapping and associated hazard-related land-use and emergency-management policies.
    - **Example:** City of Victoria OCP seismic hazard area policies and map

- **Advocacy**: Advocate for evolving the building code to a performance-based approach beyond life safety to a focus on swift recovery and better overall seismic performance.
- **Hazard mapping**: Prepare microzonation maps using detailed local information. These maps provide improved seismic hazard details, such as ground shaking and liquefaction, at a more refined level than the National Building Code.
    - **Example:** Metro Vancouver Seismic Microzonation mapping project
    - **Example:** EGBC Guidelines for the Use and Development of Seismic Microzonation Maps in B.C.
- **Development Permit Areas:** Prepare guidelines that require site-specific Qualified Professional assessments of liquefaction potential. Consider effects of mitigation measures, where microzonation mapping exists.
    - **Example:** City of Seattle Environmentally Critical Areas (seismic hazard and liquefaction prone areas)
- **Zoning**: Consider the appropriate use in high seismic hazard areas.
- **Engineering standards and asset management**: Consider the need for specific treatment to reduce risk of failure of infrastructure like water and sewer pipes in high seismic hazard areas. This includes high liquefaction hazard areas.
- **Retrofit programs**: Develop and implement a retrofit program that targets the locations and types of buildings most susceptible to earthquake damage, considering redevelopment in some cases. Currently there are no triggers to require seismic upgrades in existing buildings unless contemplating certain types of building upgrades. Consider working with neighbouring municipalities on developing seismic resilience focused programs and policies.
    - **Example:** San Francisco Earthquake Safety Implementation Plan
    - **Example:** Dunbar Earthquake and Emergency Preparedness (DEEP) is a grassroots effort to ensure the community can take care of itself after a disaster
    - **Example:** The City of Victoria offers a Tax Incentive Program (TIP) to eligible owners of heritage designated commercial, industrial, and institutional buildings
    - **Example:** Expanded use of the Seismic Retrofit Guidelines (SRG) to apply tools used for the provincial school seismic upgrade program to apply to all low rise buildings in B.C. (four storeys or less)
    - **Example:** City of Vancouver Building Bylaw, part 11 provides requirements for seismic performance in existing buildings
- Build awareness and consider offering incentives for brace and bolt retrofits for single family home seismic upgrades.
    - **Example:** California Brace and Bolt Retrofit Program
- **Rooftop equipment bylaws**: Ensure bylaws regulating rooftop equipment include tie downs and other seismic safety considerations.



IMPORTANT CONSIDERATIONS

New buildings designed to meet or exceed current codes for withstanding strong lateral forces will perform better during earthquakes. Older structures, like unreinforced masonry and non-ductile concrete, lack adequate seismic resistance. Buildings with structural irregularities or a disproportionately large open space on the ground level compared to the upper floors may also be more vulnerable to earthquake damage.

It is reasonable to assume that many of the most vulnerable buildings are disproportionately represented in affordable rental housing. Damage to buildings during an earthquake can lead to loss of life, injury, and significant displacement for extended periods, which can have lasting impacts on the social fabric of communities. Evacuation and displacement require careful planning to address the diverse needs of individuals with pre-existing health conditions and disabilities. This ensures their continued well-being.

SECTION ENDNOTES

[1] Natural Resources Canada. (2011). Earthquakes in southwestern British Columbia.

[2] Natural Resources Canada. (2015). Seismic Hazard Map Geological Survey of Canada: British Columbia.

[3] Safaie, S., Johnstone, S., & Hastings, N.L. (2022). Resilience Pathways Report.

Additional references:

- B.C. Housing. (2022). Moving towards Improved Earthquake Performance and Resilience for New Buildings.
- Engineers & Geoscientists of B.C. (n.d.). Seismic Retrofit Guidelines.
- Natural Resources Canada Earthquake reports. (n.d.). Earthquakes Canada.
- Institute for Catastrophic Loss Reduction. (2024). Earthquake Risk Tool.
- Hastings, N., & Hobbs, T.E. (2022). Earthquakes. In Resilient pathways report: co-creating new knowledge for understanding risk and resilience in British Columbia.
- Saiyed, Z., & Safaie, S. (2019). International Best Practices in Seismic Risk Mitigation Policy. Prepared for the DRR Pathways project in support of the City of Vancouver.
- Institute for Catastrophic Loss Reduction. (2020). Assessing the Financial Impacts of an Earthquake in Greater Vancouver.
- American Society of Civil Engineers. (2017). ASCE/SEI 41-17 Seismic Evaluation and Retrofit of Existing Buildings.
- Fathi-Fazi, R., Cai, Z., Jacques, E., & Cortés-Puentes, W. (2021). Methodology for Seismic Risk Screening for Existing Buildings in Canada: Structural Scoring System.

Conclusion

Building resilience into our communities is not just about preparing for the immediate threats posed by climate hazards and earthquakes. It is also about creating a sustainable, adaptable built environment that supports long-term well-being. The strategies and tools outlined in this toolkit provide B.C. local governments with practical strategies and tools to enhance the resilience of buildings. This ensures they can withstand the evolving challenges posed by climate change and seismic activity. By integrating risk mitigation measures at the building and site levels and encouraging early adoption of resilient practices, communities can significantly reduce their vulnerability to future disasters. This also fosters stronger social connections and supports faster recovery times.

As B.C. continues to face the dual pressures of climate change and urbanization, it is crucial that these resilience efforts are coupled with equity-focused approaches and zero-carbon goals. By prioritizing the needs of those most vulnerable and ensuring that resilience measures are inclusive and forward-looking, local governments can create safer, healthier environments for all residents. The toolkit emphasizes the importance of planning for multiple hazards, considering the diverse needs of occupants, and aligning climate resilience with broader sustainability goals. With proactive and thoughtful implementation of these strategies, B.C. communities can build a future where we are better protected against the uncertainties of tomorrow.

About the BC Housing Research Centre

BC Housing's Research Centre collaborates with industry, non-profit, and public sector partners to foster excellence, innovation, and affordability in British Columbia's housing sector. We share leading-edge research, advance science and technologies to encourage best practices, and provide data analysis to understand and find solutions to housing issues across the province. The Research Centre identifies and bridges research gaps in the following topic areas: populations & communities, built environment & design, sustainable & resilient housing, housing assistance & policy, housing & wellbeing. Mobilizing knowledge and research expertise accelerates innovation and facilitates the adoption of new housing models, building methods, and standards. Housing studies and program evaluations drive policy changes and support access to affordable housing in British Columbia. Sign up to receive the latest news and updates from BC Housing's Research Centre at **www.bchousing.org/subscribe**.

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