ENGINEERS &
GEOSCIENTISTS
BRITISH COLUMBIA

PRACTICE ADVISORY

OVERHEATING CONSIDERATIONS FOR EXISTING MULTI-UNIT RESIDENTIAL BUILDINGS

Version 1.0, Published September 1, 2022

This practice advisory has been issued for registrants of Engineers and Geoscientists BC (engineering professionals) who provide services related to alterations and repairs to existing multi-unit residential buildings (MURBs). While this advisory relates to work on existing MURBs, the considerations outlined may also apply to the design of new MURBs and other building types and occupancies.

This advisory provides guidance related to minimizing the risk and effects of overheating on building occupants, addressing indoor air quality, and reducing greenhouse gas (GHG) emissions in existing MURBs. Specifically, this advisory has been developed to inform engineering professionals who provide mechanical, electrical, building enclosure, and/or energy modelling services for MURBs about their responsibility to consider relevant health and life-safety issues caused by overheating. The activities of these engineering professionals may impact the management and effects of overheating, even where their engagement is not specifically intended to address overheating.

Specifically, this advisory addresses:

- causes and impacts of overheating in MURBs;
- approaches to evaluating thermal comfort and overheating risk;
- strategies to reduce overheating risk; and
- implications of overheating risk reduction strategies as they relate to energy use and GHG emissions.

While this advisory has been issued to engineering professionals, it may also be relevant for others working in the architecture, engineering, and construction industries who provide a variety of services for existing MURBs.

Note that an architect is required for any residential building of five units or greater, per the *Architects Act*. A building enclosure engineer may do repairs without an architect, but changes to the appearance of a building and changes to the interior configuration require the involvement of an architect.

Engineering professionals must be aware of their professional responsibilities to protect public health and safety, protect the environment, and consider the impacts of climate change in their professional activities.

Engineering professionals have a responsibility to notify their clients of current and future climate-related risks, recommend reasonable adaptations to lessen the impact of climate-related risks, and inform their clients of potential impacts should a client refuse to implement the recommended adaptations. Engineering professionals are themselves responsible for being aware of and meeting the intent of any climate change requirements required by a client or an authority having jurisdiction.

BACKGROUND

Most existing MURBs built to previous *BC Building Code* requirements were designed to perform under historical climate conditions. However, historical climate conditions no longer represent current and expected future climate conditions. Many existing buildings rely on operable windows to provide natural cooling, taking advantage of diurnal temperature cycles (when the outdoor temperature drops in the evening and overnight), particularly in coastal regions of BC. Most of these existing MURBs do not have mechanical cooling systems. A report by BC Hydro (2018) estimated that 34% of homes in BC had air conditioning, although this proportion is increasing as more buildings are being designed to address extreme heat events.

Extreme heat events can result in temperatures that do not drop sufficiently overnight to provide natural cooling through opened windows. In June 2021, a “heat dome”—an intense high-pressure system featuring descending air that compresses and warms to record levels at the surface—developed over western North America, including BC. Subsequent heat-related deaths in BC highlighted the need for enhanced cooling strategies in existing MURBs to reduce overheating and its associated risks to occupants (BC Coroners Service 2021).

Climate projections indicate that across BC there will be more than double the number of days with temperatures over 25°C per year by 2050, compared to historical averages.[1] Extreme temperatures above 30°C are also projected to increase in frequency and degrees, with greater temperature increases in valleys, in regions farther from the moderating influence of the ocean, and in urban environments that are susceptible to “heat island effects”[2]. In addition, as the climate changes, wildfire smoke is expected to continue to impact air quality in BC communities, limiting the viability of opening windows for ventilation and cooling. High daytime temperatures combined with nighttime low temperatures above 20°C (tropical nights) and poor air quality will increasingly impact occupants’ health.

There is significant overlap between mitigating overheating risk and improving the resilience of a building to climate change. Building maintenance, repairs, and renewals are all part of a building’s life cycle, and work completed in the near term may be in place for decades.

This advisory is intended to complement the *Practice Advisory – Climate Change Considerations for Building Enclosure Engineers* (Engineers and Geoscientists BC 2022), to apply some of the principles from that advisory to MURBs, and to discuss overheating considerations in more detail. Registrants should apply the guidance in both advisories as it relates to their project.

---

[1] Per the internationally recognized “business as usual” GHG emissions scenario, known as Representative Concentration Pathway 8.5 (RCP8.5). In the Northeast region of BC, by the 2050s, 20 days above 25°C are projected compared to 8 days in the past. In Metro Vancouver, 55 days are projected by the 2050s, more than double the 22 days experienced in the past.

[2] The urban heat island effect is a result of surfaces such as asphalt and concrete that absorb heat rather than reflect it.

CAUSES AND IMPACTS OF OVERHEATING IN MURBs

Managing the thermal conditions of a building is key to the health and well-being of building occupants. Many of the conditions in existing MURBs in BC facilitate increased summer heat gains, and these buildings are at risk for overheating as the climate changes. Overheating within the buildings context is defined as the cumulative effect on the thermal comfort (or heat stress) and health of building occupants directly exposed to continuous daily indoor heat events (Laouadi et al. 2021).

The following factors contribute to overheating in MURBs:

- Direct solar gain through glazing/windows or building cladding/roof assemblies (particularly in older buildings)
  - Solar gain through windows can be significant, particularly through south- and west-facing units. While internal blinds or curtains may mitigate some immediate heating effects, the solar radiation absorbed through the windows will eventually be absorbed internally. In older buildings, solar gain may also be high in attic spaces and wall assemblies with insufficient insulation.
- Heat island effects
  - Urban environments with a high density of building structures and few green spaces or trees are often warmer than suburban and rural environments (i.e., areas with more green space and trees). Solar radiation absorbed by structures, along with heat discharged by buildings' refrigeration plants, can make nighttime temperatures in urban environments as much as 4°C warmer than suburban and rural areas.
- Internal heat gain
  - Internal heat gain results from occupant activities such as cooking, bathing, and laundry, as well as from occupants themselves. In addition, electronic equipment and appliances, such as refrigerators and freezers contribute to internal heat gain.
- Inadequate ventilation
  - Many older existing MURBs primarily rely on windows that can be opened and ventilation through door undercuts to provide air exchange. These methods are often insufficient to offset solar and internal gains.

Overheating in MURBs negatively impacts occupant health and comfort. Although all residents of MURBs without heat mitigation measures are vulnerable in extreme heat events, the most vulnerable populations are young children, the elderly, and people with pre-existing medical conditions, as their bodies may be less efficient at regulating internal temperatures. Additionally, low-income residents are often at higher risk due to limited access to air-conditioned and/or green spaces, and an increased likelihood of pre-existing conditions (City of Toronto 2011).

Duration of heat events is an important factor; in the absence of active (mechanical) cooling measures, indoor temperatures tend to increase each day of a heat event when nighttime temperatures remain high. In addition to occupants' health and age, duration of exposure is also critical; those exposed to high heat for prolonged periods are most at risk for heat stroke and mortality.

EVALUATING THERMAL COMFORT AND OVERHEATING RISK

Engineering professionals should consider both passive and active design strategies when evaluating the thermal comfort and risk of overheating in a building.

It is recommended that both temperature limits and peak interior operative temperature are considered, to ensure a robust assessment of overheating. Additional work is needed to develop industry consensus on overheating criteria and limits, and to establish common methodology to assess performance.

Briefly, the steps to evaluate the risk of overheating are as follows:

1. Assess existing building performance and condition, and identify units that are most at risk.
2. Work with the client and/or building owners to determine performance expectations (i.e., the desired outcome of the building modifications, and acceptable temperature limit for units most at risk of overheating).
3. Document and gather information in the units on internal gains, hours of operation, cooking equipment, wall thermal performance, and window specifications, to ensure enough information is available to evaluate the units and/or the building for overheating.
4. Identify passive cooling, mixed-mode (partial cooling) strategies and active cooling strategies that meet the desired outcome and budget.
5. Identify future strategies to implement in tandem with any upcoming maintenance or asset renewal projects.
6. Complete the design and review the implementation, including reviewing identified solutions with the building owner and occupants after periods of high temperatures, to confirm the effectiveness of solutions and fine-tune as required.

While there is currently no consensus on acceptable overheating limits in existing MURBs, the following new construction resources may be adapted for existing buildings, and other in-progress initiatives are moving toward standardization:

- The City of Vancouver *Energy Modelling Guidelines* (City of Vancouver 2018), which are referenced by the *BC Energy Step Code*, specify overheating criteria for non-mechanically cooled buildings.
  - The overheating limits are based on a location's weather file and calculated following the methodology defined in ASHRAE Standard 55. Interior temperatures must not exceed the overheating temperature limit[3] for more than 200 hours per year, or 20 hours per year for spaces that house vulnerable groups (the overheating temperature limit varies by month, location, and weather file, but, for example, is 28°C in July on the coast of BC).
  - Future-shifted weather files have been produced by the Pacific Climate Impacts Consortium (PCIC) for three different 30-year periods (i.e., current conditions, the 2050s, and the 2080s), using the high-GHG-emission scenario (RCP8.5 concentration pathway). These open-source weather files are available online and can help energy modellers assess the impacts and risks of a future climate on building occupants (PCIC 2022).
- The BC Housing bulletin titled, "Builder Insight No. 19: Modelling the Future Climate in Passively Cooled Buildings" (BC Housing Research Centre 2020) provides a simple summary of the process of calculating overheating temperature limits.

---

[3] The overheating temperature limit (°C) is defined as the *(0.31 x average monthly dry bulb temperature) + 21.3.* The average dry bulb temperature can be extracted from the weather files.

- Certification programs such as Passive House Institute and LEED include their own specific criteria and considerations but do not explicitly provide guidance on overheating.
- The Integrated Building Adaptation and Mitigation Assessment Framework developed by the University of British Columbia and BC Housing (Pacific Institute for Climate Solutions 2020) is a decision-making tool to help MURBs adapt to and mitigate climate change; however, it does not explicitly provide guidance on overheating.

Note that compliance with the *BC Energy Step Code* alone does not guarantee thermal comfort or occupant safety, as it only limits the number of hours during which a space can exceed the defined overheating temperature limit, and does not limit the magnitude (i.e., acceptable maximum temperature) or duration of overheating within a space. Even during short periods of overheating, extreme temperatures can have significant negative impacts on occupants. Evaluating peak interior operative temperature (as opposed to using only dry-bulb temperature) provides valuable information about overheating risk. The “Builder Insight No. 19” bulletin recommends reporting hours over 26°C and peak interior temperature[4], until further requirements have been established (BC Housing Research Centre 2020).

The National Research Council has developed a proposed approach for evaluating overheating risk in buildings, which is detailed in “Climate Resilience of Buildings: Overheating in Buildings: Development of Framework for Overheating Risk Analysis” *(*Laouadi et al. 2019)*.* The framework incorporates the development and use of reference summer weather years (that account for more extreme temperatures than average weather files) and selects a physiological heat stress metric that accounts for acclimatization and occupant vulnerability. The standard effective temperature (SET) thresholds excerpted in Table 1 below represent the temperatures above which a given occupant population might be at risk.

Table 1: Summary of SET Thresholds (adapted from Laouadi et al. 2019)

	SET_{SLEEP} (°C)		SET_{AWAKE} (°C)	
	UN-ACCLIMATIZED	**ACCLIMATIZED**	**UN-ACCLIMATIZED**	**ACCLIMATIZED**
Healthy occupants	26	27.2	30	31.2
Vulnerable occupants	26	27.2	26	27.2

NOTES: C = centigrade; SET = standard effective temperature

STRATEGIES TO REDUCE OVERHEATING RISK

Many people living in existing MURBs are already experiencing overheating. Implementation of passive cooling strategies to mitigate solar heat gain should be considered in concert with, or prior to, considering active cooling strategies. This approach will minimize the impact on occupant health and the monthly cost of active cooling, while improving resilience to extreme weather-related events such as power outages. Most passive cooling strategies for existing MURBs are related to the building enclosure and can be considered either as a standalone project or integrated into other planned building enclosure maintenance and upgrades.

Engineering professionals should approach the development of these strategies with a collaborative mindset. An architect can bring a valuable holistic perspective to developing viable

---

[4] Note that the BC Housing “Builder Insight No. 19” bulletin (2020) does not specify peak interior operative temperatures.

solutions. In addition, where passive strategies impact the building enclosure or the interior layout, an architect needs to be involved.

Passive cooling strategies can minimize heat gain in interior spaces, reducing active cooling system requirements. However, in a warming climate, even the most effective passive cooling strategies may be insufficient to reduce overheating hours to ensure the thermal comfort of occupants. Combined passive and active cooling strategies should be considered.

The following sections describe both passive and active cooling strategies in more detail.

PASSIVE COOLING STRATEGIES

Passive cooling strategies should be modelled using an hourly modelling approach, to quantify the expected impact on operative temperatures prior to implementation, understand the impact on active cooling system requirements, and balance occupant comfort with the design and its maintenance implications. Passive measures can reduce the energy demand for active cooling.

Table 2 below outlines select passive cooling strategies, benefits, and design considerations to reduce the likelihood and magnitude of overheating in individual units. Note that similar strategies may also be used for other spaces (e.g., areas of refuge, amenity rooms). A more detailed design matrix is included in the report "Future Climate Design for Multi-Family Buildings" (RDH 2021).

Passive and active cooling strategies are not necessarily mutually exclusive; engineering professionals should consider as many passive measures as are required, in combination with active cooling strategies, to achieve the desired level of performance. It is unlikely that one passive cooling strategy implemented on its own will eliminate or effectively minimize the overheating risk. The combination of appropriate strategies will be unique to each building location, design, age, and upcoming maintenance or asset replacement schedule.

It is important that every building has a plan to address overheating as a part of the building's future maintenance or asset replacement schedule. Passive and active strategies can be phased in as part of the plan, in the order that meets the unique needs and maintenance schedule of the building.

ACTIVE COOLING STRATEGIES

It is important to consider the building as a whole when managing overheating risk in MURBs, recognizing that individual buildings have unique features and requirements. To the extent possible, active cooling strategies should be considered in concert with, or after, the application of passive cooling strategies. Ideally, modelling of the unit(s) at greatest risk of overheating should be completed, to evaluate the impact of passive cooling strategies and determine the remaining cooling load to be met by active cooling. These are typically south- and southwest-facing units.

Engineering professionals should also consider the service life of the strategy and test the solutions using appropriate future climate files from PCIC (refer to the Evaluating Thermal Comfort and Overheating Risk section above), representing the possible climate conditions under which the measure will be expected to perform.

Table 3 below outlines active cooling strategies and design considerations for reducing overheating in individual units. Note that similar strategies can be undertaken if designing a common area or refuge area, or when taking a localized cooling approach (e.g., cooling for an amenity room).

Refer to the report "Future Climate Design for Multi-Family Buildings" (RDH 2021) for a more in-depth analysis of various active cooling strategies.

Table 2: Passive Cooling Strategies

	STRATEGY	BENEFITS	DESIGN CONSIDERATIONS OR IMPLICATIONS
SOLAR HEAT GAIN REDUCTION	• Adding shading on east, south, and west façades – Fixed: overhead on south façades; vertical on east or west – Operable: manual or automatically controlled by interior temperature (e.g., interior set point 22°C)	• Reduces direct solar heat gain	• Most local governments and strata buildings have bylaws regarding aesthetics. • Consider adding, or planning to add, shading during other building enclosure work. • Focus on south and west exposures first, if budget is a concern. • Consider structural implications. • Consider maintenance of operable shades. • Note: Operable shading performs better than fixed (RDH 2020).
	• Replacing or upgrading windows – Reduced solar heat-gain coefficient (SHGC) glazing – Dynamic glazing (changes with seasons)	• Reduces solar heat gain through windows • Low maintenance	• Should be considered if window replacement is occurring. • Consider high-performing units. • Consider adding films to existing windows as an interim measure.
IMPROVED ENCLOSURE PERFORMANCE	• Air sealing – During general maintenance, seal cracks and ensure weatherstripping on exterior doors and windows are intact	• Improved efficiency for cooling and heating • Low cost • Easy to implement	• Only addresses convective heat gain and will be overpowered by poor-performing glazing if windows are not also addressed. • In the absence of active cooling or adequate passive cooling, air sealing may trap heat gains, leading to overheating.
	• Replacing windows – Replace single pane, non-thermally broken windows with higher performing units	• Improved window performance (heating and cooling seasons) • Low maintenance	• To be considered when upgrading windows. • This strategy works well with selecting dynamic glazing with reduced solar heat-gain coefficients.
	• Upgrading roof and/or walls – Add insulation during upgrade/replacement – Apply reflective roof coating – Re-roof with light colour membrane or reflective cap sheet – Re-roof with green roof	• Improved thermal performance of roof (heating and cooling seasons) • Low maintenance • Insulation above roof membrane improves durability of membrane	• To be considered if roofing work is planned and in conjunction with active cooling strategies. • In the absence of active cooling or adequate passive cooling, improved thermal performance can worsen overheating.

Table 3: Active Cooling Strategies

	STRATEGY	BENEFITS	DESIGN CONSIDERATIONS OR IMPLICATIONS
ACTIVE COOLING STRATEGIES	• Installing individual air conditioning units (partial cooling) – Window units – Portable units	• Easy to install • Individual approach • Low first cost • Can also use the unit for space heating at a coefficient of performance (COP) of 3 in the Lower Mainland, as this will reduce operational costs and carbon and energy	• Will increase electrical load and utility costs (only provides cooling). • There are labour costs associated with installing in-window units. • Many local governments and strata buildings have bylaws regarding aesthetics. • Portable units are inefficient due to heat radiation from plastic ducts and generally leaky duct openings in windows. • Seasonal storage of portable units may be an issue for small spaces.
	• Installing high-efficiency heat-recovery ventilators (HRVs) (85%) – Boost and bypass mode – Boost and bypass mode with a cooling coil	• Improved in-suite, filtered ventilation • Energy efficient	• Without the cooling coil, HRVs will typically improve air quality but provide limited cooling given the low air volumes delivered. An HRV without a cooling coil will only provide a cooling effect when the outdoor air temperature is colder than the indoor temperature. • HRVs with cooling coils are more feasible for central or semi-centralized units. • HRVs with cooling coils will provide some cooling benefit but will likely not meet full cooling demand given the low air volumes delivered. Cooling potential is considered low compared to full mechanical cooling and should be used in conjunction with other measures.
	• Installing full mechanical cooling – Ductless in-suite air source heat pump	• Provides heating and cooling • Can replace fossil fuel heating • Energy efficient • Can be sized to meet full heating and cooling demand	• High cost compared to other measures. • Many local governments and strata buildings have bylaws for aesthetics, envelope penetrations, and placement of outdoor units. • Must consider building and suite electrical capacity, which may require upgrades. • Some new unitary products include heat-recovery ventilation and no outdoor unit but have lower heating/cooling capacity than split heat pumps.

GENERAL CONSIDERATIONS

Developing strategies to mitigate overheating in existing MURBs should first focus on minimizing direct solar gains. Poorly insulated enclosures and non-shaded windows are the most significant source of direct solar gains, particularly in older MURBs. A simple shading solution—for example, hanging blinds from balcony soffits (with proper detailing)—can be considered as an interim measure while planning more permanent solutions.

Active cooling can be an effective solution, particularly when employing a high-efficiency heat pump that can also offset heating demand. Multiple measures have synergistic effects and can help a building meet future peak load (e.g., into the 2050s)[5] more efficiently. Passive cooling measures can, for example, reduce the likelihood that an electrical upgrade be required to provide active cooling. However, a combination of both passive and active strategies is an important component of any maintenance or asset replacement plan. Active strategies (e.g., heat-pump cooling) may not be sufficient if passive strategies are not considered as well.

Engineering professionals must also consider the financial implications of any planned measures and identify synergies in deploying strategies and upcoming maintenance and asset renewal timelines. For example, the most cost-effective time to add passive and/or active cooling strategies is during planned renewal or maintenance. Adding operable shading during envelope work (exterior cladding and/or window replacement) ensures cohesive building appearance and can make use of existing scaffolding structures. Additionally, replacing long lifespan items such as windows can be effective in reducing overheating risks and have a positive long-term impact.

Engineering professionals should consult with clients or building owners on timelines for planned building upgrades and repairs; for example, for building enclosure work (e.g., improvements to windows, walls, roof) or upgrades to air-handling equipment. Engineering professionals should ensure that building resilience and performance are considered when planning the work. Condition assessments and depreciation reports can identify building assets that will need replacement or upgrading and should identify how the planned work can improve resilience against the overheating risk in a warming climate. Strategies to reduce overheating can be implemented in a staged approach to meet financial constraints and timelines for future maintenance and asset replacement work.

Planning considerations include the following:

- Assessing other renewals that are planned or needed (e.g., windows, walls) and determining how these renewals can incorporate strategies to mitigate overheating; for example, by incorporating shading into a wall renewal, or including proper detailing for refrigerant or duct openings to accommodate future cooling equipment.
- Scheduling projects to minimize disruption to occupants and effectively use funds (e.g., completing all projects that require scaffolding concurrently).
- Identifying other occupant needs; for example, if poor ventilation is a known issue, addressing this problem may lead to developing solutions than can improve both cooling and ventilation.
- Determining energy and emissions performance goals.
- Identifying space and noise implications, especially if split heat-pump units are planned.

---

[5] Engineering professionals must consider the expected design life of the equipment/measure when designing systems to meet future loads (e.g., a window's expected lifespan is 15 to 30 years).

- Determining the impact on energy consumption and associated GHG emissions.
- Considering current and upcoming building code or regulatory requirements that may, for example, require a change in heating system, which may then be an opportunity to consider a system that efficiently provides both heating and cooling.

REFERENCES AND RELATED DOCUMENTS

CODES AND STANDARDS

ASHRAE Standard 55-2017 – Thermal Environmental Conditions for Human Occupancy.

British Columbia Building Code 2018. [accessed: 2022 Jul 06]. https://www.bccodes.ca/index.html.

BC Energy Step Code 2018.

REFERENCES

BC Coroners Service. 2021. Heat-Related Deaths in B.C. – Knowledge Update. Burnaby, BC: BC Coroners Service. [accessed: 2022 Jul 06]. https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/statistical/heat_related_deaths_in_bc_knowledge_update.pdf

BC Housing Research Centre. 2020. Builder Insight No. 19: Modelling the Future Climate in Passively Cooled Buildings. Burnaby, BC: BC Housing Research Centre. [accessed: 2022 Jul 6]. https://www.bchousing.org/publications/Builder-insight-19-Modelling-the-future-climate-in-passively-cooled-buildings.pdf.

BC Hydro. 2018. Cold Comfort: The Rising Use (and Cost) of Air Conditioning in B.C. [Report dated July 2018]. Vancouver, BC: BC Hydro. [accessed: 2022 Jul 06]. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/news-and-features/air-conditioning-report-july-2018.pdf.

City of Toronto. 2011. Protecting Vulnerable People from Health Impacts of Extreme Heat. [Staff Report dated July 6, 2011]. Toronto, ON: City of Toronto. [accessed: 2022 Jul 06]. https://www.toronto.ca/legdocs/mmis/2011/hl/bgrd/backgroundfile-39468.pdf.

City of Vancouver. 2018. Energy Modelling Guidelines. Version 2.0. (Amended: July 11, 2018). Vancouver, BC: City of Vancouver. [accessed: 2022 Jul 06]. https://vancouver.ca/files/cov/guidelines-energy-modelling.pdf.

Engineers and Geoscientists BC. 2022. Practice Advisory – Climate Change Considerations for Building Enclosure Engineers. Version 1.0. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2022 Jul 06]. https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories.

Laouadi A, Lacasse MA, Gaur A, Bartko M. 2021. Climate Resilience of Buildings: Guideline for Management of Overheating Risk in Residential Buildings. Ottawa, ON: National Research Council of Canada. [accessed: 2022 Jul 06]. https://nrc-publications.canada.ca/eng/view/ft/?id=9c60dc19-ca18-4f4c-871f-2633f002b95c&dp=2&dsl=en.

Laouadi A, Lacasse MA, Gaur A, Bartko M, Armstrong M. 2019. Climate Resilience of Buildings: Overheating in Buildings: Development of Framework for Overheating Risk Analysis. Ottawa, ON: National Research Council of Canada. [accessed: 2022 Jul 06]. https://nrc-publications.canada.ca/eng/view/object/?id=f04717ba-4e71-4af9-bc33-cce3d2665160.

Pacific Climate Impacts Consortium (PCIC). 2022. Weather Files. [Website]. Victoria, BC: PCIC. [accessed: 2022 Jul 06]. https://www.pacificclimate.org/data/weather-files.

Pacific Institute for Climate Solutions (PICS). 2020. Adaptive Mitigation: A Framework for Assessing Climate Change Solutions in Urban Multifamily Buildings. [Website]. Victoria, BC: PICS. [accessed: 2022 Jul 14]. https://pics.uvic.ca/projects/adaptive-mitigation-framework-assessing-climate-change-solutions-urban-multifamily.

RDH Building Science Inc. (RDH). 2021. Future Climate Design for Multi-Family Buildings. Burnaby, BC: RDH. [accessed: 2022 Jul 06]. https://planning.ubc.ca/sites/default/files/2021-11/R-21007_001 2021 09 27 UBC Climate Resilience Final Report_ISSUED.pdf.

RDH. 2020. UBC – Designing Climate Resilient Multifamily Buildings. Burnaby, BC: RDH. [accessed: 2022 Jul 06]. https://planning.ubc.ca/sites/default/files/2020-05/REPORT_UBC_Climate%20Resilient%20Multifamily%20Buildings.pdf.

VERSION HISTORY

VERSION NUMBER	PUBLISHED DATE	DESCRIPTION OF CHANGES
1.0	September 1, 2022	Initial version.