

COMMUNITY CLEAN AIR SHELTERS

Community Centre's Response to Wildfire Smoke Events in Vancouver

by

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Community Clean Air Shelters: Community Centre's Response to Wildfire Smoke Events in Vancouver

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Abstract

Severe wildfire season occurred in 2017, and 2018 set new records in British Columbia, impacting the health of the communities through immediate fire and smoke exposure. This trend is predicted to occur more frequently in the future due to climate change patterns such as rising temperatures and decreased precipitation. These wildfires are uncontrolled fires from the forests in B.C. that emit smoke, which travels distances impacting not just rural but also the urban areas in B.C. The wildfire smoke consists of gases and fine particles that impact human health and their daily lifestyles. For this reason, providing a safe physical environment by establishing community clean air shelters (CCASs) during wildfire smoke events for the communities was considered a critical public health priority in various jurisdictions across Canada.

These CCAS can be established in any existing community facilities such as community centres, libraries, schools and sports complexes. Since community centres are places that encourage community engagement and provide social support for community development and wellbeing, it is crucial to test the potential of community centres to serve as CCAS during the wildfire smoke event. Therefore, this research aims to understand the emerging needs of communities in Vancouver during wildfire smoke events, analyze the existing conditions of community centres relative to their ability to respond as CCAS, identify the interior spatial requirements of CCAS and deliver design guidelines for existing community centres in Vancouver to function as CCAS during wildfire smoke events.

The research methodology includes a literature review, a comparative case study analysis of four community centres through interviews, site visits and floor plan review, data analysis, and finally, design guidelines proposal and recommendations. The outcome of the analysis distinctly highlights the need for minor or major upgrades, which need to be considered in existing community centres to function as CCAS during wildfire smoke events depending on the building's physical and spatial condition, and project funding. This research underlines the importance of understanding the needs of the community during extreme weather events, planning for renewal of existing infrastructure and designing for building transformation based on the changing needs of the communities.

Lay Summary

Wildfire smoke event impacts the needs and requirements of people and the infrastructure that supports communities. The existing community facility buildings may or may not be able to provide the spatial needs and requirements for community safety and comfort to face the chronic impacts of wildfire smoke events. Therefore, this research aims to understand the emerging needs of communities in Vancouver during wildfire smoke events, analyze the existing conditions of community centres relative to their capacity to respond as clean air shelter, identify the interior spatial requirements of CCAS during wildfire smoke event and deliver design guidelines for existing community centres in Vancouver to function as CCAS during wildfire smoke events.

Preface

This thesis is an original, independent, and intellectual product of the author, Rashmin Sorathiya. The interviews and site visits reported in section 2 were approved by the UBC Research Ethics Board as minimal risk research with certificate number H20-00039.

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List of Abbreviations

BCCDC - British Columbia Centre for Disease Control

CAS - Clean Air Shelter

CoV - City of Vancouver

CCAS - Community Clean Air Shelter

ESS - Emergency Support Services

FCI - Facility Condition Index

HEPA - High-Efficiency Particulate Air

Home CAS - Home Clean Air Shelter

MERV 13 - Minimum-Efficiency Reporting Value

NCCEH - National Collaborating Centre for Environmental Health

Park Board - Vancouver Board of Parks and Recreation

REFM - Real Estate and Facilities Management

VPL - Vancouver Public Library

Glossary

Adjacencies - Relationship of one room/space with the others in a building in terms of location, connection, proximities and services.

Building Function - Purpose of the room/building used for recreational program or activity at the community centres.

Effective Air Filtration - Fulfilling the function of air filtration in the room, along with airtightness and no infiltration.

Major Upgrade - Replacing major equipment, changing the function of a space, expansion or contraction of rooms internally, expansion or contraction of rooms externally, alterations in the walls, windows, roof or floor of the building.

Minor Upgrade - Minimum physical changes, program re-locations, effective communication systems or temporary instalments.

Recreational Program - Recreation and related activities for individuals at the community centres.

Spatial - Relationship of the building elements and human interaction, creating a space inside the building.

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I. Introduction

I.1 Background

Urban areas around the world are facing challenges related to the climate change impacts, high consumption of energy and materials in building construction, inflexible building design, and ageing infrastructure; this results in buildings that are not able to adapt to the evolving needs of the inhabitants over time (Nakib, 2010).

The fields of architecture, city planning, and policymaking are grappling with many critical questions, such as: how can the buildings and cities sustain the changing environment? How can we respond and adapt to the issues that are weakening the urban fabric of the cities? How can the communities be protected from natural hazards and extreme weather events like wildfire smoke, heat waves and heavy precipitation? How can we lead happy and healthy lives in the face of all these issues?

As an initiative towards addressing the impacts of climate change, a preliminary climate risk assessment for British Columbia was conducted by the Ministry of Environment and Climate Change Strategy in July of 2019. The assessment identified fifteen climate risk events impacting the province which range from severe wildfire season, water shortage, heatwave, flooding, coastal storm surge, heavy precipitation and landslide, ocean acidification, glacier mass loss, reduction in ecosystem connectivity, saltwater intrusion, loss of forest resources, increase in invasive species, and increased incidence of vector-borne disease (Ministry of Environment and Climate Change Strategy, 2019).

The assessment studied the impact of each risk on health, social functioning, natural resources, economic vitality and cost to the provincial government. The assessment also identifies the likelihood of occurrence, risk level and confidence level of each climate risk event based on the evidential research, as shown in figure 1. Among all, "severe wildfire season, seasonal water shortage, and heatwave events are the three greatest climate risks to B.C., followed by ocean acidification, glacier mass loss, and long-term water shortage in 2050" (Ministry of Environment and Climate Change Strategy, 2019).

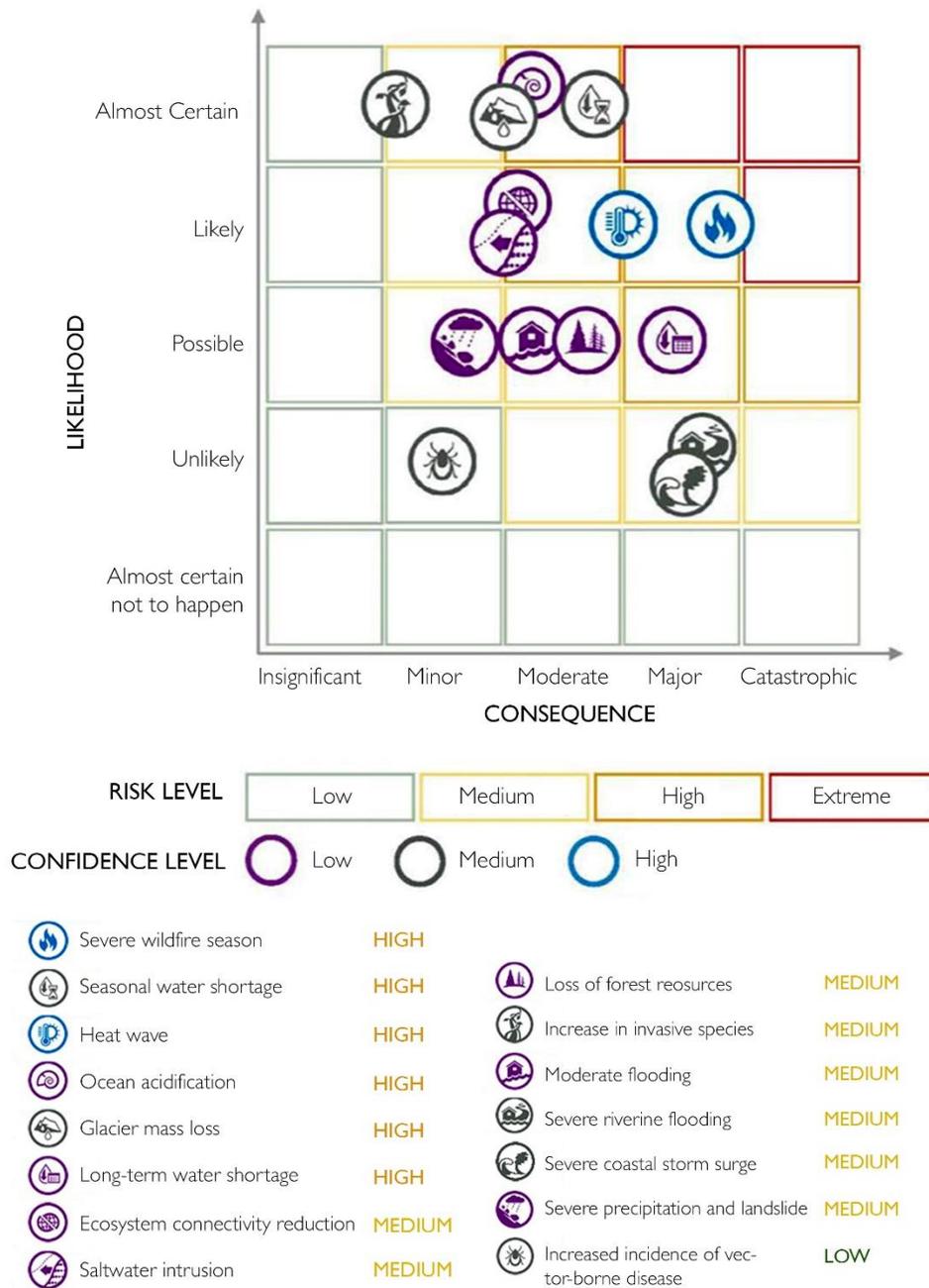


Figure 1. Consequence, likelihood, risk level and overall confidence of each scenario as identified by the Ministry of Environment and Climate Change Strategy for B.C. in the year 2019

(Source: Ministry of Environment and Climate Change Strategy, 2019)

British Columbia experienced severe wildfire events in 2017 and 2018, setting new records, and burning over one million hectares (Ministry of Environment and Climate Change Strategy, 2019). The assessment notes that as the trend of severe wildfire season continues with temperature rise and decreased precipitation, B.C. is more likely to experience extreme wildfires more frequently (Ministry of Environment and Climate Change Strategy, 2019).



Figure 2. Kootenay National Park, B.C. as seen on Aug. 7, 2018
(Photo credit: KootenayNP/Twitter)

Severe wildfire seasons contribute to adverse health impacts, which disrupts the community functioning, infrastructure and economic growth of the communities. The wildfire season is also particularly dangerous for the vulnerable population, including infants, the elderly, pregnant women and people with pre-existing heart and lung conditions (Ministry of Environment and Climate Change Strategy, 2019). The findings from the Ministry of Environment and Climate Change Strategy's 2019 risk assessment show that the risk level, confidence level and the consequences of wildfire season are high, with the likelihood increasing by 2050, as shown in figure 3. Thus, it is important to stress upon the urgency to address this risk.

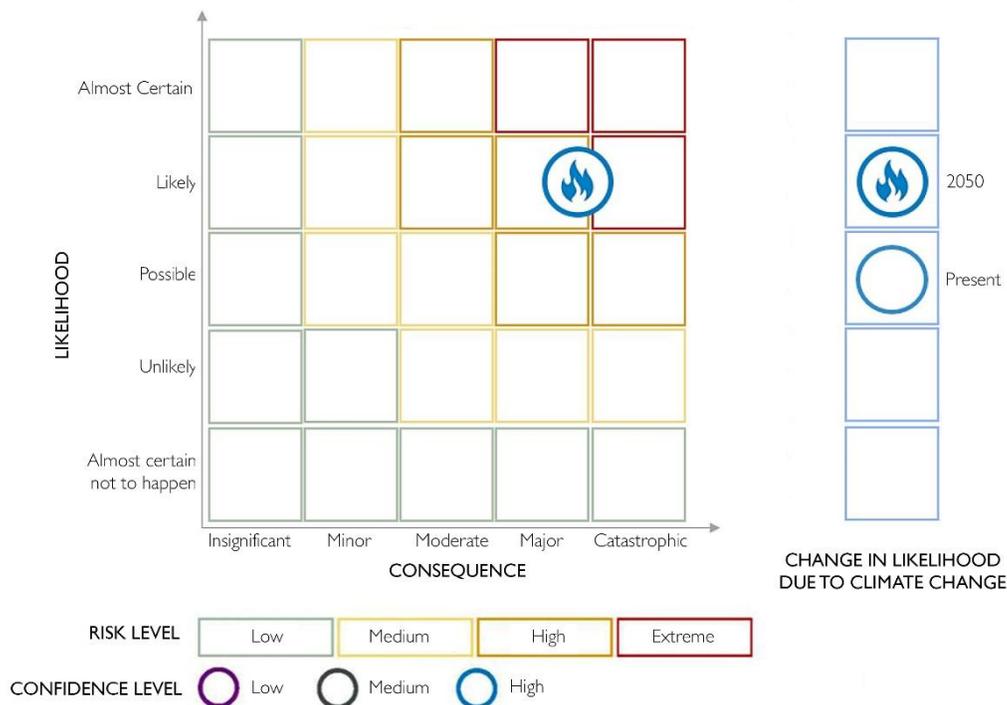


Figure 3. Risk level, confidence level, and consequences of a severe wildfire season event to be high by 2050 identified by the Ministry of Environment and Climate Change Strategy for B.C. in the year 2019.

(Source: Ministry of Environment and Climate Change Strategy, 2019)

Wildfires in B.C. are uncontrolled fires spread from an area of combustible vegetation, particularly from the forests in B.C. that emit smoke, which travels significant distances impacting the communities in rural and urban areas. The wildfire smoke is a mixture of gases and fine particles that can impact the health of people and communities (Centres for Disease Control and Prevention, 2013).

Providing a safe physical environment during the wildfire smoke event was considered as a critical public health priority. As such, Clean Air Shelters (CAS) were cited in several documents as a priority for local authorities and local emergency coordinators during the wildfire smoke event (Maguet, 2018). CASs are indoor areas, rooms or buildings which are equipped with a filtration system to reduce the pollutants and fine particulate matter from the indoor air, as shown in figure 5 (First Nations Health Authority, 2018).



Figure 4. Vancouver skyline under heavy haze as seen from Jericho Beach on Aug. 21, 2018
(Photo credit: Don Mackinnon)

CASs are of two types: Home Clean Air Shelter (Home - CAS) and Community Clean Air Shelter (CCAS) (First Nations Health Authority, 2018). Home – CAS can be an entire house or a particular room in the house. Community CAS can be established in any community building such as community centres, libraries and sports complexes. “There are no specific standards or air quality measurements for clean air shelters (First Nations Health Authority, 2018)”. Hence, the need to develop guidance for community clean air shelter identification and use and documenting experiences with the community clean air shelter implementation was identified as a public health priority (Maguet, 2018).

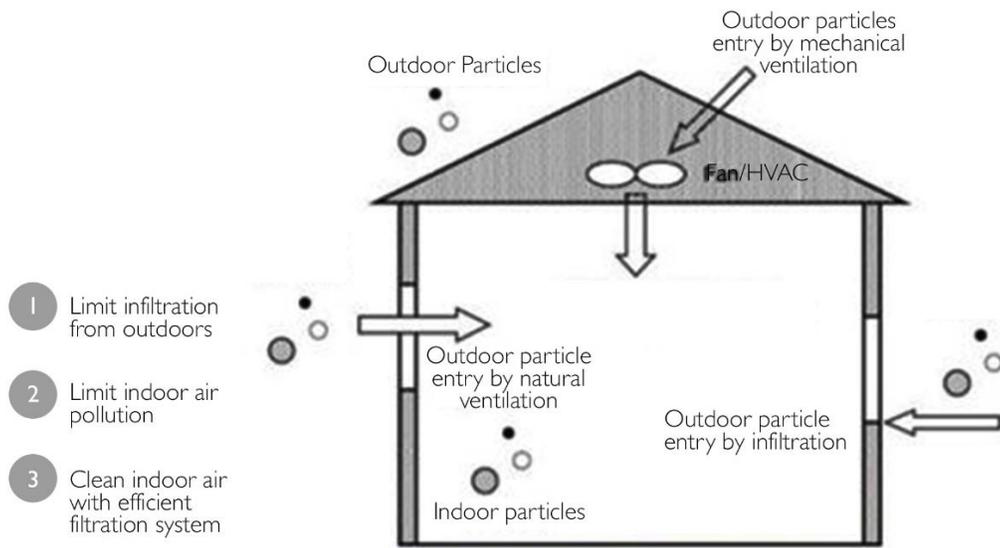


Figure 5. Clean Air Shelter diagram explained by the BC Centre for Disease Control (Source: First Nations Health Authority, 2018)

1.2 The Purpose of this Research

Wildfire smoke event impacts the community's needs and the infrastructure that supports communities. The existing community facility buildings may or may not be able to provide the spatial needs and requirements for community safety and comfort to face the chronic impacts of wildfire smoke events in Vancouver.

Among various community facilities, community centres are places where people meet for social, educational and recreational activities. These community centres aim to encourage community engagement and provide social support for community development and wellbeing. They are evenly distributed in the neighbourhoods of Vancouver, which makes it easily accessible to people. Therefore, testing community centres to function as community clean air shelter (CCAS) during the wildfire smoke events was identified as the primary area of research, which provided a compelling opportunity to contribute to the growing body of scholarly knowledge.

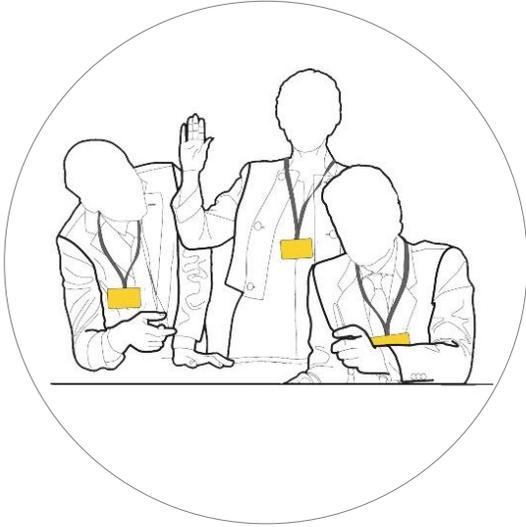
The research aims to understand the emerging needs of communities in Vancouver during wildfire smoke events, analyze the existing conditions of community centres relative to their ability to respond as CCAS, identify the interior spatial requirements of CCAS during wildfire smoke event and deliver design guidelines for existing community centres in Vancouver to function as CCAS during wildfire smoke events.

I.3 Significance

This research strives to be a resource and a discussion point for the operators of the community centres in Vancouver (the Vancouver Board of Parks and Recreation (Park Board)), the design team that will be involved in the renewal of the existing community centres or new design proposals and to other jurisdictions with community centres that are or will be expected to face similar wildfire smoke events. This research significantly informs these key stakeholders on the renewal of existing community centres, as shown in figure 6 and promotes the effective utilization of the existing resources during the wildfire smoke events in Vancouver.

The Vancouver Board of Parks and Recreation owns and maintains 24 community centres in Vancouver, which are jointly operated by the Community Centre Associations. The Park Board plays a role in regulating, policymaking, and planning for facility improvement and consulting stakeholders like designers, engineers and planners for any project renewals. The Park Board works in partnership with Real Estate and Facilities Management (REFM), the Vancouver School Board and the Vancouver Public Library. The Park Board will be provided with this research in an effort to better inform the policies for community centre renewals and planning for accommodating the changing needs of the community.

Design teams, including architects, building engineers and HVAC consultants, are influential in facility planning, spatial layouts, energy, water and waste efficiency, renovations or upgrades, placemaking, and providing safe, comfortable and resilient building infrastructure. This research will be made accessible to the design team interested in this research to inform design decisions, including prioritizing spaces and considering the interdependency of building elements to serve the needs of the community with the changing time.



Operators/Client:

Vancouver Board of Parks and
Recreation



Design Team:

Architects
Building Engineers
HVAC Consultants

Figure 6: Audience of the research: Vancouver Board of Parks and Recreation and Design Team
(Graphic source: BC Housing, 2019; Editing: Author)

I.4 Report Structure

The research report is divided into eleven sections, as shown in figure 7, starting with an introduction on the background, the purpose and significance of the research, which is then followed by the research methodology. The research methodology section describes the methodology adopted and the scope of the research.

The impacts of wildfire smoke event section present the impacts on the communities in Canada and North America, including the occurrences of the wildfire smoke events in the past and expected events in the future, the effect on the health of the people, and the vulnerable populations, air quality assessments and the public health priorities set by the government authorities in Canada.

The community clean air shelter section defines community clean air shelter, discusses the need for such spaces, types of community clean air shelters and the challenges and concerns of establishing a clean air shelter that is identified in the literature.

The specific requirements of CCAS section present the four areas requirements to establish a CCAS in existing community centres during the wildfire smoke events in Vancouver.

The city of Vancouver in context section presents the context of community centres in Vancouver by establishing the importance of community centres, the existing condition of the buildings and introduces the Vancouver Board of Parks and Recreation community centre renewal plan.

The case study analysis section presents the comparative case analysis of four community centres in Vancouver: Britannia, Hillcrest, Mount Pleasant and Roundhouse. This section presents the interview results and analysis of building function, recreational programs, the air/ventilation filtration system, lessons learned and needs identified from the past responses to extreme weather events and renewal plans of the four community centres.

The outcome of analysis section identifies the spatial requirements for community clean air shelters from the literature review, interviews and case study analysis. This section further analysis the presence of spatial requirements of CCAS in the four selected community centres. The results of this comparative analysis lead to informing a set of design guidelines in the following section.

The design guidelines for CCAS section present a set of design guidelines for adapting community clean air shelter in the existing community centres in Vancouver. These

guidelines inform the design team in decision making and meticulously considering the changing needs of the community during extreme wildfire smoke events in building design of community centres.

The recommendation for community centre renewal plan section provides recommendations for consideration of CCAS in the planning of community centre renewal.

Finally, the report ends with the conclusion, discussion on the limitations of this research and the future research areas.



Figure 7. Structure of the research report

2. Research Methodology

2.1 Methodology

This research was conducted in four stages, as shown in figure 8, which included literature review, comparative case study development, which includes interviews, site visits, floor plan review and data analysis, and finally, development of design guidelines recommendations. Each phase is described in detail in the paragraphs that follow.

2.1.1 Literature Review

Stage one comprised of a literature review on wildfire smoke data and future predictions, the meaning of adaptable building design, the definition of clean air shelters, needs of CCAS and the existing conditions of the community centres under the Park Board in Vancouver. This stage provided information on the existing research and gaps in knowledge of establishing CCAS during wildfire smoke events, which was used for comparative case study analysis of four selected community centres.

2.1.2 Comparative Case Study Analysis

In stage two, a comparative case study analysis of four community centres was conducted to inform the design of guideline development. A comparative case study approach was selected to understand the functions of the existing community centres to identify the missing requirements that need to be accommodated for wildfire smoke events.

Four community centres for case study analysis were selected based on a set of criteria, including building age, range of amenities, historical value and surrounding context. The comparative case study analysis was conducted through site visits, interviews, floor plan reviews and case analysis, which are described in the paragraphs that follow.

1. Site Visits: Site visits of the four selected community centres included taking photographs of the spaces, studying the room locations, and adjacencies and proximities to essential services like bathroom and water facilities.
2. Interviews: Interviews were conducted with the planner of the community centre renewal plan at the Park Board, the building/recreational program supervisors for each of the selected four community centres, and a climate and energy engineer at UBC involved in building operation management and energy policymaking. These interviews played an essential role in informing this research about the process of renewal planning for the community centres, the existing

building condition and functioning of the community centres in Vancouver, and the challenges of designing buildings for future climate, respectively.

3. Floor Plan Review: Floor plans of the four community centres were used to study the spatial layout and communicate the comparative analysis through colour coding the information.
4. Case Analysis: The components of the comparative case study analysis included spatial function, recreational facility program, air filtration systems, past response to extreme weather events, and spatial analysis.

2.1.3 Data Analysis

Data analysis was conducted by combining the information obtained from the case study analysis and data from the literature to identify the spatial requirements of CCAS during wildfire smoke events. The outcome of the analysis led to informing the development of design guidelines and recommendations.

2.1.4 Design Guideline Development

Stage three of the research involved the development of design guidelines and providing recommendations for community centre renewal planning to accommodate CCAS spatial requirements in existing community centres in Vancouver.

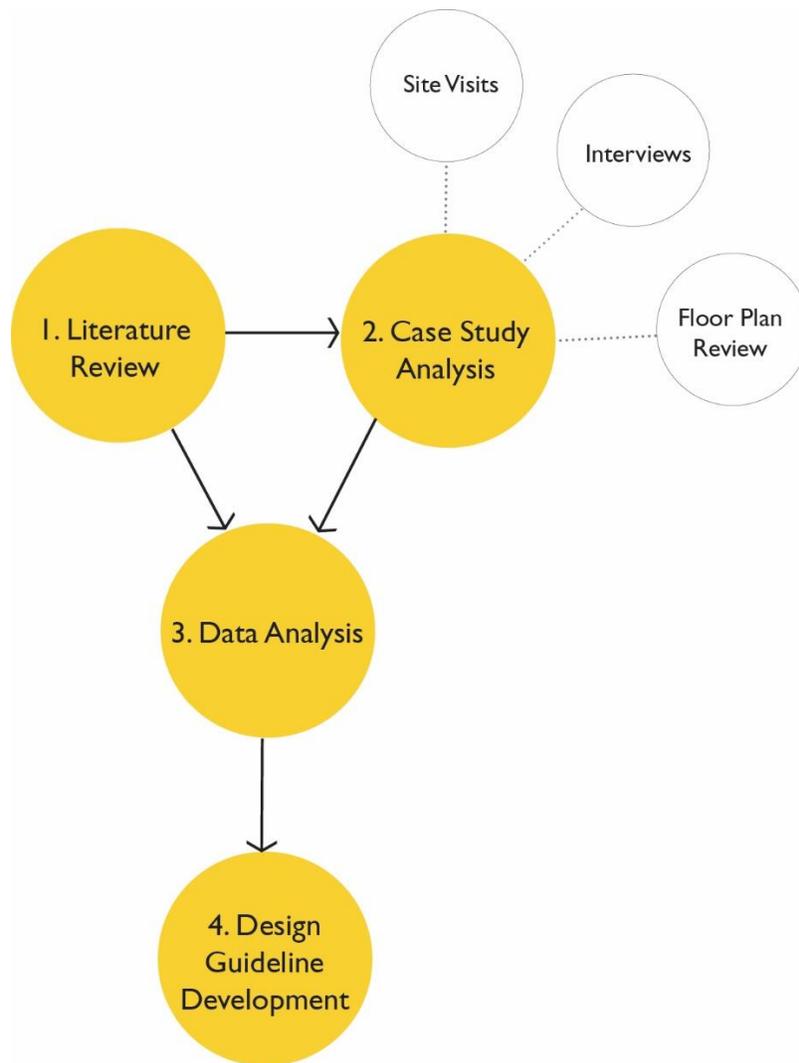


Figure 8. Structure of the research methodology adopted

2.2 Scope of Research

This research aims at addressing wildfire smoke events in a non-emergency situation that provides support and helps the general and vulnerable population with a non-critical health condition to sustain life during changing environmental conditions. The areas of research that are within and out of the scope are listed as follows.

The following areas are included in the scope of this research:

- Reviewing the literature on the impact of wildfire smoke events and public health protection responses to the communities;
- Case study analysis of the building function, facility program, amenities, spatial layout and past responses to stressful events of the selected community centres;
- Analysis of the spatial needs and requirements of the community centres during a wildfire smoke event;
- Developing guidelines to accommodate the interior spatial requirements of CCAS in the existing community centres in Vancouver during the wildfire smoke event.

The following are excluded in the scope of this research and may be considered as future research topics:

- Analysis of other climate risk events or hazards that may have a cascading impact with a wildfire smoke event in Vancouver, such as heatwaves, earthquakes, power outages and more. A cascading impact is the impact of multiple events simultaneously causing greater damage than one risk event;
- Analysis of other community infrastructure in Vancouver that has the potential to serve as community clean air shelters, such as Vancouver Public Libraries (VPL), sports complexes and schools;
- In-depth technical analysis of the selected community centre's building structure, services and envelope;
- In-depth analysis of the program scheduling and operations of the community centres; and
- Analysis of building code for community facility design as this research focuses on addressing issues that go beyond the building codes such as user comfort, spatial layouts and adjacencies.

3. Impacts of a Wildfire Smoke Event

3.1 Wildfire Smoke Occurrence

A report on public health responses to wildfire smoke events prepared by British Columbia Centre for Disease Control (BCCDC) in partnership with National Collaborating Centre for Environmental Health (NCCEH) studied the experiences of wildfire smoke event in British Columbia, Manitoba, New Brunswick, and the Northwest Territories. The report states that models predicting forest fires vary due to the uncertainty of changing precipitation and human activity, which makes it a challenge to predict future fires. However, it is estimated by the experts that the overall forest fire activity in Canada will increase by 25% by 2030 and 75% by the end of the 21st century (Maguet, 2018), and annual area burned is expected to increase by up to 4% by 2050 (Ministry of Environment and Climate Change Strategy, 2019).

3.2 Community Health Impact

Wildfire events can cause adverse health impacts on communities within a significant distance of the actual wildfire, primarily due to direct and indirect smoke exposure (Ministry of Environment and Climate Change Strategy, 2019). Wildfire smoke contains primary pollutants such as fine particulate matter 2.5 and 10 (PM2.5 and PM10), Nitrogen Oxides (NO_x) and Carbon Monoxide (CO), as well as secondary pollutant ozone (O₃) (Maguet, 2018). In the 2018 report by BCCDC and NCCEH, it was noted that the smoke exposure with high or moderate levels of PM2.5 affected communities for days, weeks and even months in areas where fires were not an immediate risk (Maguet, 2018).

The smallest particles in smoke are the most damaging materials as they enter deep into the lungs, triggering coughing, runny nose, fatigue, chest pain, burning eyes, rapid heartbeat and difficulty in breathing as illustrated in figure 9 (UC Davis Western Centre for Agricultural Health and Safety, 2019). The 2016 guideline published by the Governments of Northwest Territories on protecting community health and wellbeing during wildfire smoke exposure includes research on how smoke affects human health. According to this report, the effect of smoke on an individual's condition is determined by factors such as the length of exposure time, amount of oxygen and other substances inhaled, the individual's health status, and the concentration of smoke in the air (Government of Northwest Territories, 2016).

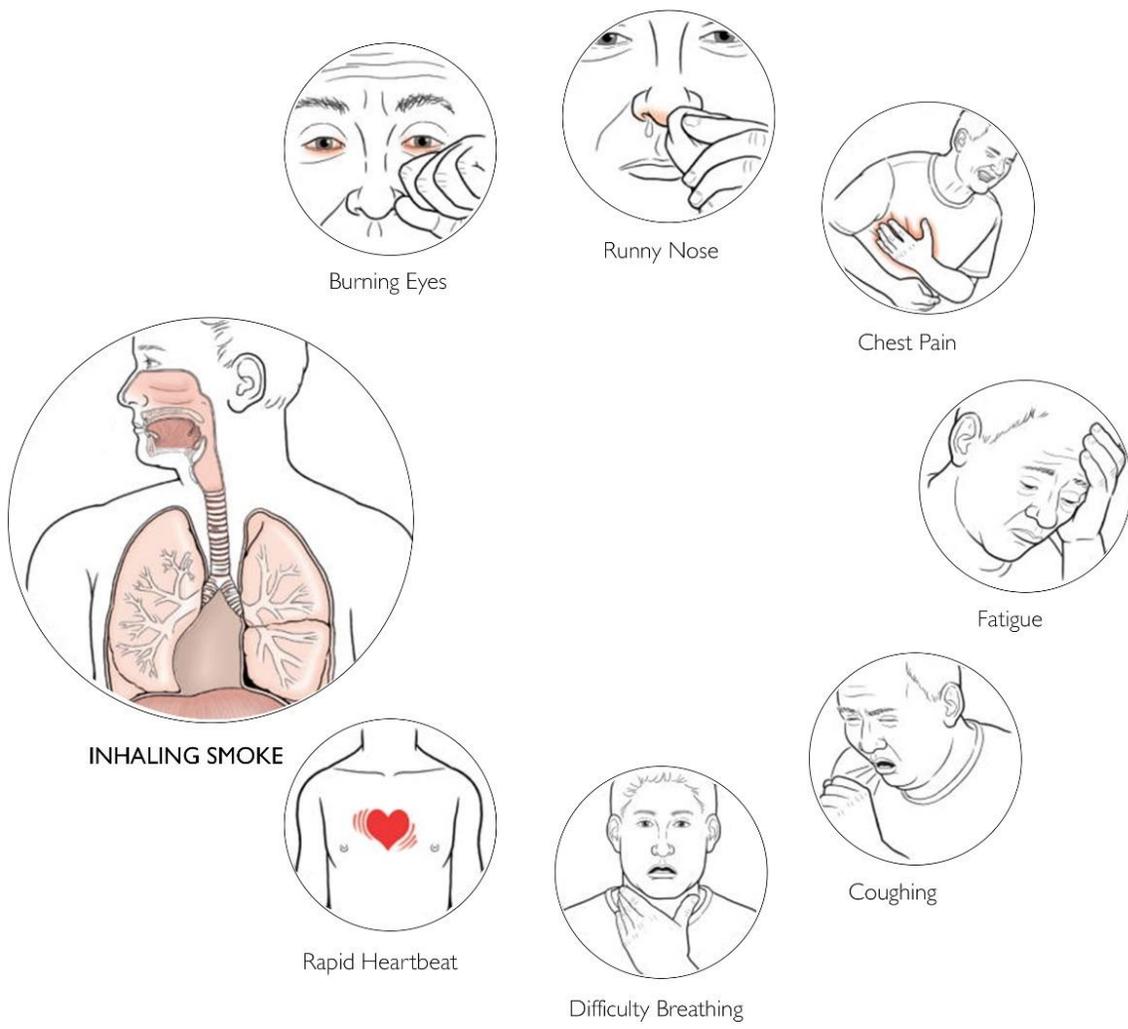


Figure 9. Health effects of inhaling wildfire smoke illustrated by UC Davis Western Centre for Agricultural Health and Safety
 Source: UC Davis Western Center for Agricultural Health and Safety, 2019

Besides smoke inhalation and air pollution, one of the significant consequences of wildfire events is that people experience health risks due to limited access to critical infrastructure and services (Ministry of Environment and Climate Change Strategy, 2019). Increased number of patients for respiratory concerns in healthcare facilities often occur during wildfire smoke events, and community members may also express frustration and anxiety about having to remain indoors for extended periods (Maguet, 2018).

Community responses stated in the 2018 report by BCCDC and NCCEH noted that anxiety and uncertainty were present among families during wildfire smoke events (Maguet, 2018). Families did not know how to respond to the risk of exposing young children to smoke during outdoor activities and the health-benefit analysis of limiting the physical activity of their children by keeping them indoors. In addition to this, the respondents recognized that their homes might not have sufficient filtration systems, air conditioning, or well-sealed doors and windows to provide a safe and healthy indoor environment (Maguet, 2018). Hence, the health impacts from the smoke, pre-existing health condition and the indoor air quality need to be fundamentally considered in community centre building design to provide a safe and comfortable enclosed space during wildfire smoke events.

3.3 Vulnerable Population

Wildfire smoke especially impacts the vulnerable segments of the population in respect of susceptibility to smoke inhalation, which includes infants, young children, the elderly, pregnant women and their unborn children, and people with pre-existing respiratory, cardiovascular and chronic inflammatory diseases (Elliott, 2014). The 2016 study by the Government of Northwest Territories outlined reasons as to why the vulnerable population are at high risk, which includes:

- Infants and young children have elevated metabolic rates and immature immune systems;
- The respiratory, cardiovascular and immune systems of the elderly are not as strong as a young adult;
- Wildfire smoke contains many of the same compounds as cigarette smoke can lead to health risks for both pregnant women and the unborn child;
- People with existing heart and lung diseases have compromised lung and cardiovascular function, which increases the risk of severe health conditions.

In addition to the above groups, low-income populations, homeless, and others who have limited access to resources could also be heavily impacted by wildfire smoke events.

3.4 Air Quality Assessment

There are three sources of data required to assess the air quality, which includes: the readings of particulate matter (PM) 2.5 concentration, Air Quality Health Index (AQHI) rating and smoke forecasts. As such, an air quality health index (AQHI) message was prepared by the Government of Canada in 2017, as shown in Table 1, to inform people about necessary measures they could take to avoid health issues based on their existing health conditions. The health messages are recommendations on the extent of reducing the outdoor and indoor physical activity based on their pre-existing health condition. These messages are provided based on the health risk level, which is categorized into low, moderate, high or very high.

Health Risk	AQHI Level	PM2.5 Concentration (1-3Hrs average)	Health Messages	
			At-Risk Population*	General Population
Low	1-3	0-40 $\mu\text{g}/\text{m}^3$	Enjoy your usual outdoor activities.	Ideal air quality for outdoor activities.
Moderate	4-6	41-175 $\mu\text{g}/\text{m}^3$	Consider reducing strenuous activities outdoors if symptoms occur.	No need to modify outdoor activities unless symptoms occur.
High	7-10	176-500 $\mu\text{g}/\text{m}^3$	Reduce strenuous activities outdoors. Children and elderly should take it easy.	Consider reducing strenuous activities outdoors if symptoms occur.
Very High	> 10	>500 $\mu\text{g}/\text{m}^3$	Avoid strenuous activities outdoors. Children and elderly should avoid outdoor physical exertion.	Reduce strenuous activities outdoors if symptoms occur.

Table 1. Air quality health index messages provided by the Government of Canada for at-risk and the general population

Source: Government of Canada, 2020, https://weather.gc.ca/airquality/healthmessage_e.html

These health messages considerably lead to changes in the daily lifestyles of people who might need to rely on indoor facilities for physical and mental health to avoid outside smoke exposure which may challenge the functioning and capacity of the existing community centre in Vancouver to address the needs of the people during the wildfire smoke events.

4. Community Clean Air Shelters

4.1 Definition of Community Clean Air Shelters

Government authorities define a community clean air shelter (CCAS) as a building or an area of a building which has efficient air filtration and improved air quality with a reduced concentration of contaminants which is made available to the community members during the wildfire smoke event (First Nations Health Authority, 2018; Maguet, 2018).

There are no substantial precedents available in the literature on the use of CCAS or clean air refuge for communities during wildfire smoke events. The research on CCAS in Canada is in the preliminary phase, which needs to be well-defined and further investigated.

As per the above definition, a CCAS needs to be accommodated in existing community facility buildings, which may have a predefined building function. Though improved air quality and efficient air filtration are significantly crucial in a CCAS, establishing CCAS into existing community facility buildings could be challenging due to the building's physical condition, mechanical, spatial and site constraints, existing resources and project funding. Therefore, considering these challenges, a CCAS can be defined as a building or a part of the building that meets the mechanical, structural, and spatial requirements to function as temporary clean air space for the community during the wildfire smoke events to protect the public health and wellbeing.

4.2 Types of CCAS

Community clean air shelters can be provided in any publicly accessible buildings such as community centres, schools, libraries, community halls, sports facilities, and potentially even shopping malls. (Maguet, 2018). There are two types of clean air shelters applicable to homes and community facility buildings: ventilated and unventilated shelters (Government of Northwest Territories, 2016). Ventilating and unventilated shelters can be further categorized into three classes of shelters. Table 2 describes each of the categories with the level of protection, cost assumption, advantages and limitations.

Class 1 is ventilated and filtered with pressure, which draws outdoor air, filters and then discharges the filtered air in the room with a pressure that prevents the infiltration of outdoor air. Class 2 is further dividing into two sub-sections: ventilated and filtered with little or no pressure, and unventilated and filtered with little or no pressure. Class 2 ventilated and filtered with little or no pressure draws outdoor air at a low flow rate, which does not create a measurable differential pressure. Class 2 unventilated and

filtered with little or no pressure draws indoor air from the cleaner air shelter, filters and discharges back inside. Finally, Class 3 is unventilated and not filtered that retains the air within its tight enclosure.

The protection provided by Class 1 is much higher compared to Class 2 and 3 because of an effective air filtration system. The comparative cost is higher for Class 1, which is much more effective and arguably the best option as it retains the filtered air, which is required for spaces in the community facility buildings to serve a large group of people. Class 2 or 3 may be used in circumstances where infrastructure limitations persist; however, when serving large groups of people, this method is less effective at delivering clean air.

Shelter Class	Class 1: Ventilated and filtered with pressure	Class 2: Ventilated/Unventilated and filtered with little or no pressure	Class 3: Unventilated with no filtration
Description	Outdoor air is filtered and discharged inside the building at a rate sufficient to produce internal pressure.	Class 2 ventilated: Outdoor air is filtered and discharged inside at a low flow rate. Class 2 unventilated: Indoor air is filtered and discharged inside at a low flow rate.	Derives protection only by retained clean air within its tight enclosure.
Protection	High	Medium	Low
Cost	High	Medium	Low
Advantage	Eliminates accumulation of carbon dioxide (CO ₂)	Protective against gases	–
Limitations	Provides no protection against some toxic chemicals of high vapour pressure	Protection diminishes with duration of exposure	Protection diminishes with duration of exposure

Table 2. Types of clean air shelter classes with the description provided by the Government of Northwest Territories

Source: Government of Northwest Territories, 2016

4.3 Challenges and Concerns

Various challenges and concerns have been highlighted by government authorities in Canada and the United States during the wildfire smoke events. Common challenges identified in the literature were the impacts on the physical and mental health due to the reduction of outdoor activities, mobilization of existing community resources, transportation or mobility challenges of the vulnerable population, improving indoor air quality, and adjusting recreational facility programs. Additional challenges include:

- Encouraging physical exercises as a public health effort to reduce obesity rates were challenging to reinforce when it was advised to stay indoors and avoid physical exertion during severe smoke events (Maguet, 2018).
- Residents might have to travel long distances or have mobility issues that may not be able to reach the community clean air shelter and may be exposed to the smoke in transit, which might be a health risk to the individual's health (Oregon Health Authority, 2017).
- Mobilizing the existing community resources was challenging as it required organizational capacity (Maguet, 2018).
- During prolonged smoke exposure and an increasing number of visitors, the buildings designated as clean air shelters might not be large enough to accommodate many people depending on the condition of the community facility (Maguet, 2018).
- Alterations in the building's HVAC system might be possible or not depending on the efficiency of the system, which can have other implications on indoor air quality that might require expertise (Maguet, 2018).
- Encouraging individuals to stay longer when the need arises at the community clean air shelter may be a challenge due to the operation hours and staff capacity (Oregon Health Authority, 2017).

Mobilizing the existing community resources, designating community clean air shelter, and the need for effective HVAC systems are some of the major areas of assessments that require further research to formulate design guidelines. These assessments will inform the areas of transformation required in the existing community centre to function as CCAS during the wildfire smoke event.

5. Specific Requirements for CCAS

Government and health authorities across British Columbia and the Northwest Territories in Canada and Oregon in the United States have identified specific requirements for community clean air shelters. Requirements such as air filtration, efficient HVAC systems, universal accessibility, transportation to and from the facility, water supply, washroom facilities, emergency supplies, and communications were identified as necessary for establishing community clean air shelters.

Air filtration, spatial requirements, building structures and services, and emergency preparation have been identified as the areas of intervention to be considered for establishing community clean air shelters in community centres in the literature, as illustrated in figure 10. These requirements will be exercised in the case study analysis in section 6 of the report. Each of them is described in detail in the paragraphs that follow.

5.1 Air Filtration

It is key to select filters with a minimum performance of minimum-efficiency reporting value 13 (MERV 13) for year-round air quality and swapping higher-performing filters like high-efficiency particulate air (HEPA) filters during poor air quality events (BC Housing, 2019). Including activated carbon filters and cooling in the HVAC system is essential as the impacts of wildfire smoke events are often compounded by the impacts of extreme heat and outdoor pollution (BC Housing, Integral Group, 2019).

Some of the key design strategies and issues on the use of filters are provided in BC Step Code Design Guide Supplement S3 which include ensuring system location away from any pollutants and located in a shaded place, using demand control ventilation to reduce energy use, selecting filters with a minimum depth of 1000mm for energy efficiency, locating carbon filters in areas with high pollutants and design to include heat recovery to improve energy efficiency (BC Housing, 2019).

5.2 Spatial Requirements

CCAS needs to ensure that the community members have a place of respite, which is safe and comfortable. Priority access should be provided to the vulnerable population as they are at health-risk and need special care (First Nations Health Authority, 2018). These spaces should be provided with both private and social areas that are close to drinking water, washroom facilities and emergency supplies (BC Housing, 2019). It is also important to place furniture and equipment with consideration for air circulation,

temperature control, and pollutant removal functions of the HVAC systems (BC Housing, Integral Group, 2019).

5.3 Building Structures and Services

Designing a clean air shelter should be done with consideration for enhanced seismic resilience (BC Housing, 2019). Airtightness of the building should be maintained by having a low rate of air exchange between outdoors and indoors and sealing all the openings to avoid infiltration of outdoor air (Government of Northwest Territories, 2016). Accessible toilet facility and drinking water supply should be available to the occupants in a clean air shelter (Government of Northwest Territories, 2016).

5.4 Emergency Preparation

Priority should be given to ensuring a minimum of 72 hours of energy storage/backup power to critical systems and areas to prevent system overload due to the high use of mechanical ventilation/cooling during wildfire smoke events (BC Housing, Integral Group, 2019). Ensuring emergency supplies like food and water are stored in the refuge areas (BC Housing, 2019). Introducing on-site renewable systems for energy, rainwater and greywater harvesting ensures the continuing functioning during power or service failures (BC Housing, Integral Group, 2019).

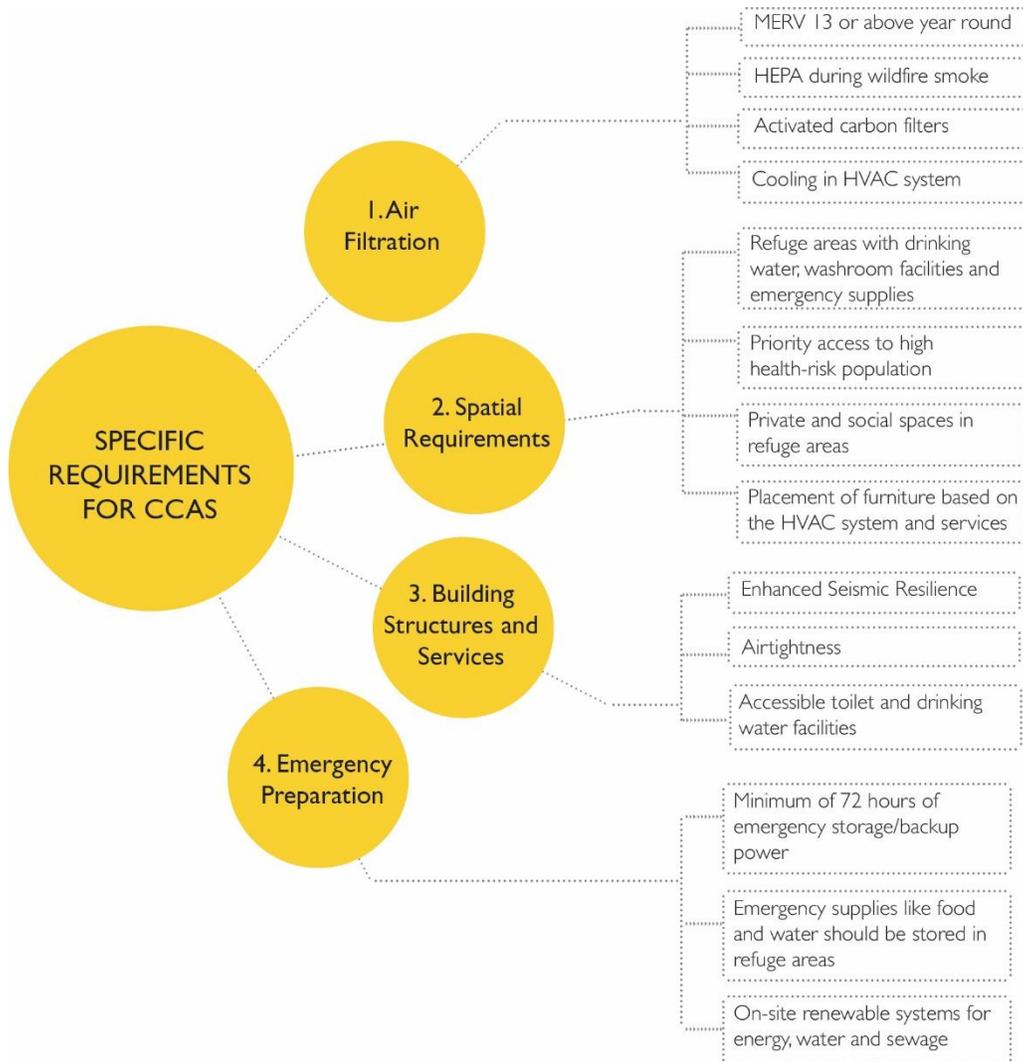


Figure 10. General requirements identified from the literature for CCAS which is used in the case study analysis

6. City of Vancouver in Context

6.1 Role of Community Centres

There are 24 community centres in Vancouver that are owned and maintained by the Vancouver Board of Parks and Recreation and jointly operated by the Community Centre Associations. Community centres are places where people meet for social, educational and recreational activities. The community centres are evenly distributed across the city of Vancouver, consisting of pools, ice rinks, fitness centres, meeting rooms, libraries and childcare and are available to people of all ages and abilities (Vancouver Board of Parks and Recreation, 2020).

Community centres are natural places for people to go in an emergency, and hence they are also designated as natural disaster hubs where people can congregate following an earthquake or any other natural disaster. Many community centres also serve as cooling and warming centres during extreme weather events to provide relief from heat waves during summer and cold in winter (Vancouver Board of Parks and Recreation, 2018). As the community centres in Vancouver play a vital role in providing social support and wellbeing of the community, it is vital to consider the potential of community centres to function as CCAS during the wildfire smoke event.

To understand the action plans of the community centre renewal plan, an interview with a planner at the Park Board, who is involved in the renewal planning, was conducted. As per the information shared, the inventory and analysis of the community centres and the scope of work of the Parks Board for strategy development for the renewal plan have been undertaken. Any guidelines or information on cooling centres and clean air shelters in Vancouver are currently in the early stages of development, which requires further research.

As per the inventory and analysis report conducted by the Park Board for the community centres in 2019, majority of the community centre which were built before the 1980s as shown in the figure 11 will require significant investment or replacement within the next ten years (Vancouver Board of Parks and Recreation, 2020). Out of the 24 community centres, 5 of them: Dunbar, Kitsilano, Kerrisdale, Marpole-Oakridge and Hastings, were built between before the 1950s. 11 of the community centres: West Point Grey, West End, False Creek, Douglas Park, Ray-Cam, Strathcona, Britannia, Kensington, Thunderbird, Renfrew Park and Champlain Heights were built between the 1960s to 1980s. Furthermore, 8 of the community centre: Coal Harbour, Roundhouse, Creekside, Mount Pleasant, Trout Lake, Hillcrest, Sunset and Killarney were built after the 1990s.

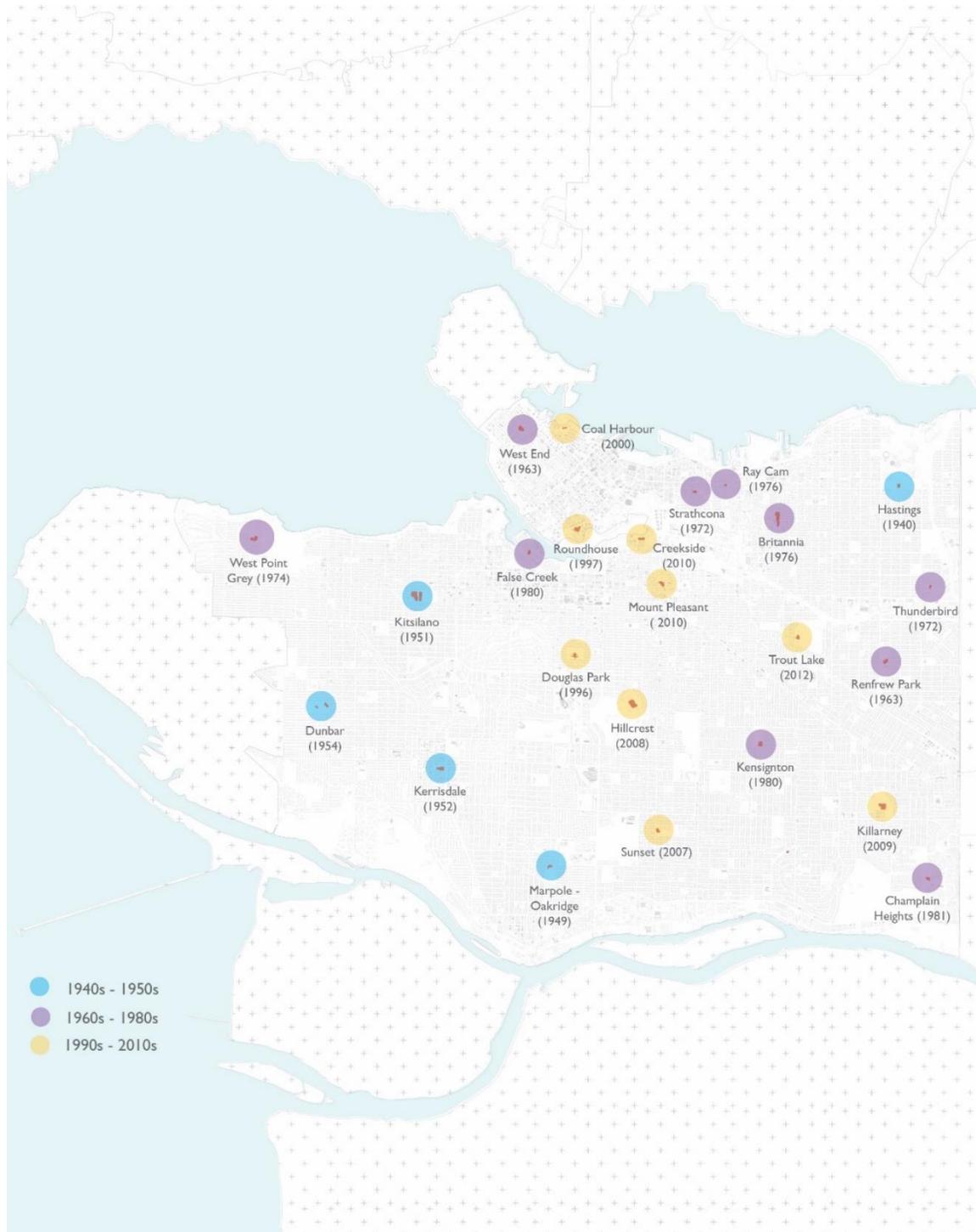


Figure 11. Map of 24 community centres in Vancouver with building age

6.2 Existing condition of Community Centres

A Facility Condition Index (FCI) for 2016 shown in figure 12 and 2026 shown in figure 13 was conducted in the inventory and analysis report of the Van Play initiative for the existing community centres by Park Board. FCI was set as a benchmark to compare the condition of one community centre to the others in order to gauge the current and future condition of the buildings. The FCI also aids in the decision making of renewal funding needs and comparing the priorities for renewal. The FCI considered only the physical infrastructure of the building and did not include the qualitative aspects, seismic risk, capacity or needs of the facility.

As per the FCI, 84% of the community centres in Vancouver will be in poor or critical condition by 2030 without any interim repairs (Vancouver Board of Parks and Recreation, 2018). Some of the critical challenges of the existing community centres that were stressed upon were the increasing cost of operation and maintenance, lack of adaptability to changing needs and demands of the community and barriers to access the facilities (Vancouver Board of Parks and Recreation, 2018). These challenges emphasize the importance of renewing the condition of the ageing buildings and integrating the current and future needs of the community in the community centre renewal planning and building design.

The 2019-2022 Capital Plan by the City of Vancouver report identifies that inefficient building layouts are one of the pressing issues of the ageing community centre buildings in Vancouver. Inadequate pedestrian walkways, parking and service access, unwelcoming and poorly defined entryways, constrained lobby/reception areas, inadequate storage, poor visual connectivity, lack of connection to green spaces and identified need for universal accessibility and wayfinding strategies are contributions to the deteriorating condition of the community centres (City of Vancouver, 2018). Hence it is essential that physical structure and spatial design, both should be taken into account to improve the conditions of the community centres and also serve the rising needs during the extreme weather events such as wildfire smoke event.

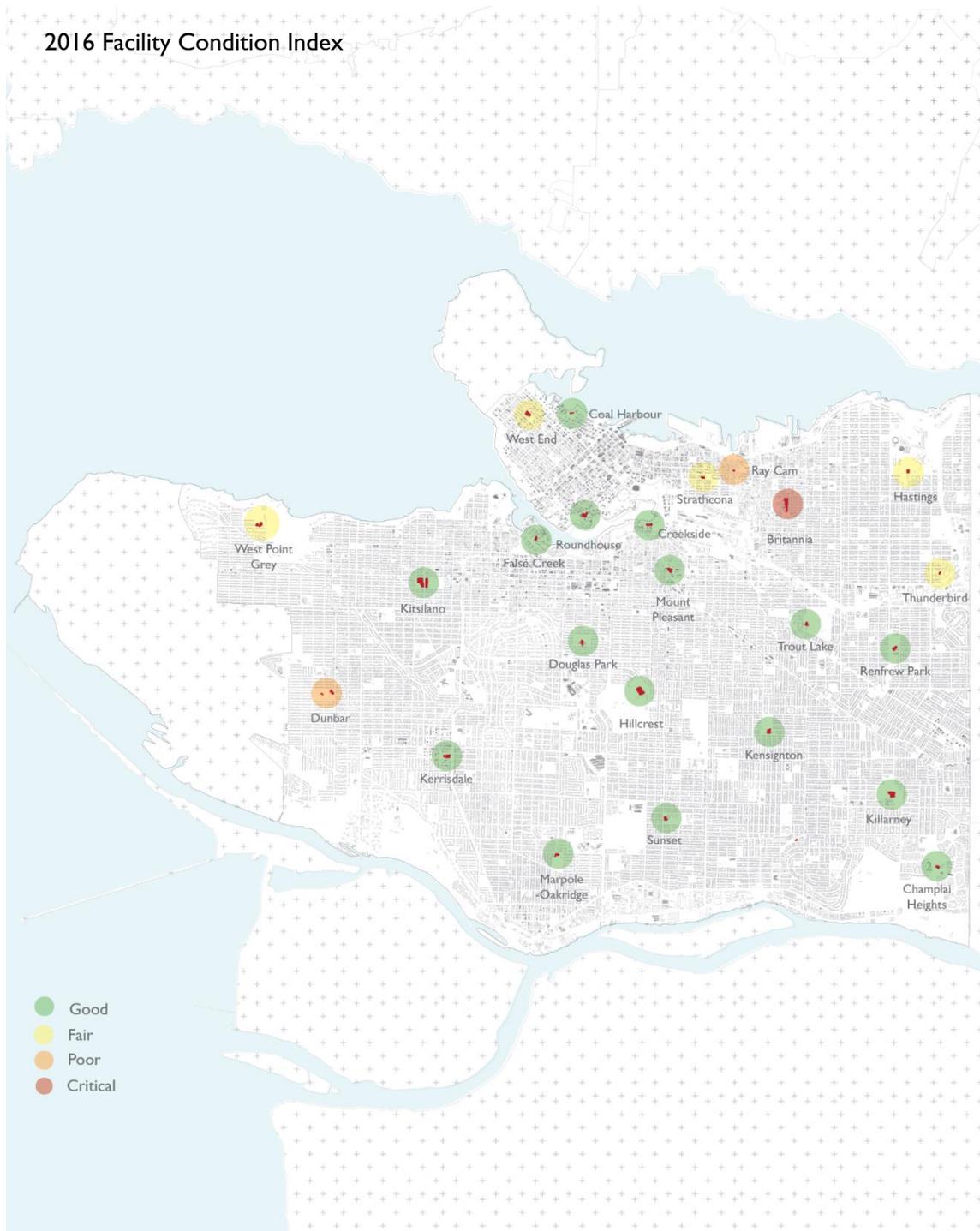


Figure 12. Map of Facility Condition Index, 2016 of the existing community centres in Vancouver
 Source: Vancouver Board of Parks and Recreation, 2018; Graphics: Author

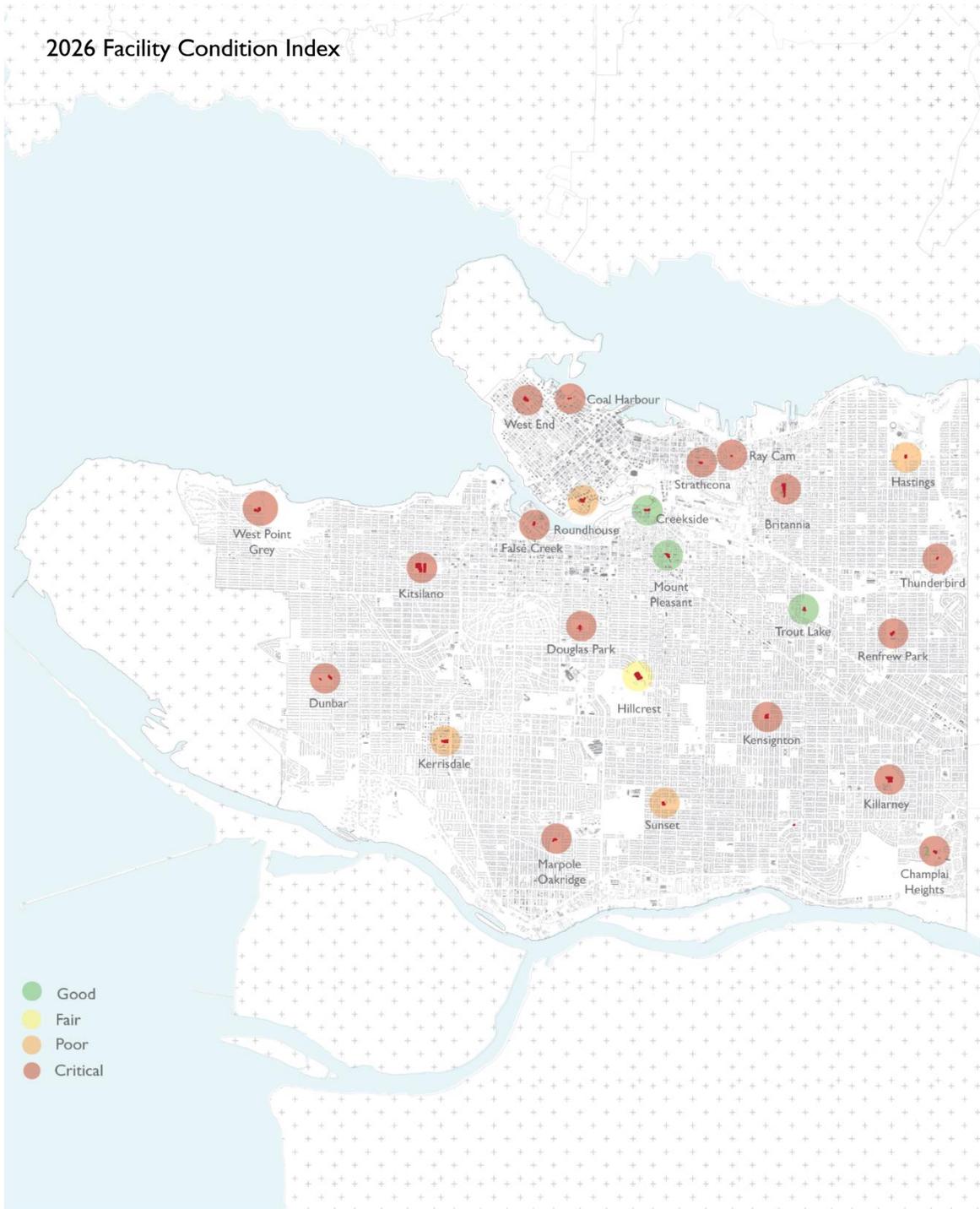


Figure 13. Map of Facility Condition Index, 2026 of the existing community centres in Vancouver
 Source: Vancouver Board of Parks and Recreation, 2018; Graphics: Author

6.3 Community Centre Renewal Plan

The strategy for the renewal of 24 community centres is being developed by the Vancouver Board of Parks and Recreation. The community centre renewal plan is set as a priority by the City of Vancouver under the Capital Plan 2019-2022. The renewal strategy aims at (Vancouver Board of Parks and Recreation, 2020):

- Assessing the capacity, community service needs, demands and building conditions of existing community centres in Vancouver.
- Identifying a plan for the collection and management of the data required for the facilitation of renewals.
- Proposing a set of principles and functional planning guidelines.
- Associating with the community or First Nations Rights Holders and stakeholder engagement.

As shown in figure 14, the distribution of community centres per capita is variably different across Vancouver, which directs to the need for capacity building of the community centres. Hence, The community centre renewal strategy plans to renew/rebuild two community centres per capital plan and maintain 1.2 sq/capita with a growing population, especially in the higher growth areas of Vancouver (Vancouver Board of Parks and Recreation, 2020). Increasing the capacity of the community centres is complex due to factors such as project funding, changing community needs, building design and site constraints. However, the Park Board planner informed in the interview that this area of research is underway and taken into consideration in the renewal planning.

Equipping community centres to act as emergency hubs or refuge during an earthquake and extreme weather conditions is on-going in the action plan of the Capital plan 2019-2022 (City of Vancouver, 2018). As the community centre renewal plan is in the early stages of development and outlines the consideration of refuge areas in community centres during extreme weather conditions, this research study plays a significant role in informing the policymaking and strategy development for renewal of the community centres in Vancouver.

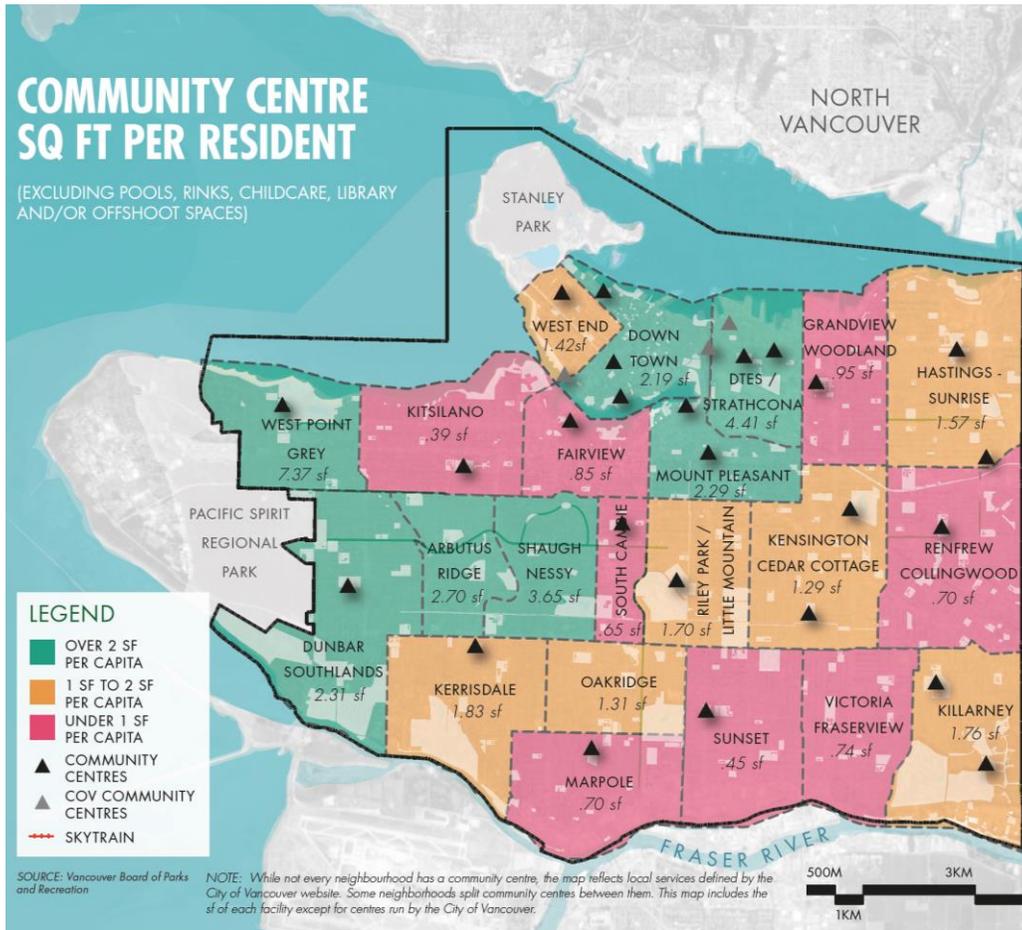


Figure 14. Community centre sq. ft per resident in Vancouver
 Source: Vancouver Board of Parks and Recreation, 2018

6.4 Case Study Selection

For the comparative case study analysis elaborated in section 7 of the report, a sample of four community centres was to be selected. The sample community centres were selected to be broadly representative of 24 community centres in terms of amenities, recreational program, age of the buildings, and surrounding context. The criteria for selecting the sample set of community centres was based on the following three criteria:

- An old facility, since renovations and renewal planning, was identified as pertinent to serve the growing population and changing needs of the community.
- A facility with a historical value which is likely to be considered for renovation and not replacement to preserve the heritage structure and history associated with the building and site.
- A new facility that might be equipped with the latest mechanical technology and systems that offer air filtration and indoor air quality, which is essential for a CCAS.

Based on the set of criteria, the community centres that were selected for the comparative study include the Britannia Community Centre, Hillcrest Community Centre, Mount Pleasant Community Centre and Roundhouse Community Centre.



Figure 15. Britannia Community Centre highlighted on the google map

The Britannia Community Centre is situated in Grandview Woodland and built in 1976, which is one of the oldest community centres in Vancouver. This community centre is recognized to be currently in a critical physical condition, and if no renewal is planned will continue to be in its critical state in 2026 (Vancouver Board of Parks and Recreation,

2018). A renewal masterplan is proposed for this centre, which will be executed entirely in phases in the next 10-20 years.



Figure 16. Hillcrest Community Centre highlighted on the google map

The Hillcrest Community Centre is situated in Riley Park and is a relatively new structure that was first designed to be used for the Olympics in 2010 and then was transformed into a community centre in 2011. This community centre is recognized to be in good physical condition. It will continue to be in a fair state until 2026 (Vancouver Board of Parks and Recreation, 2018).



Figure 17. Mount Pleasant Community Centre highlighted on the google map

The Mount Pleasant Community Centre is situated in Mount Pleasant and built in 2010. It is recognized to be in good condition currently and will be in good shape until 2026 (Vancouver Board of Parks and Recreation, 2018). The centre is a part of a mixed-use project integrated with housing units from level 2 and above.

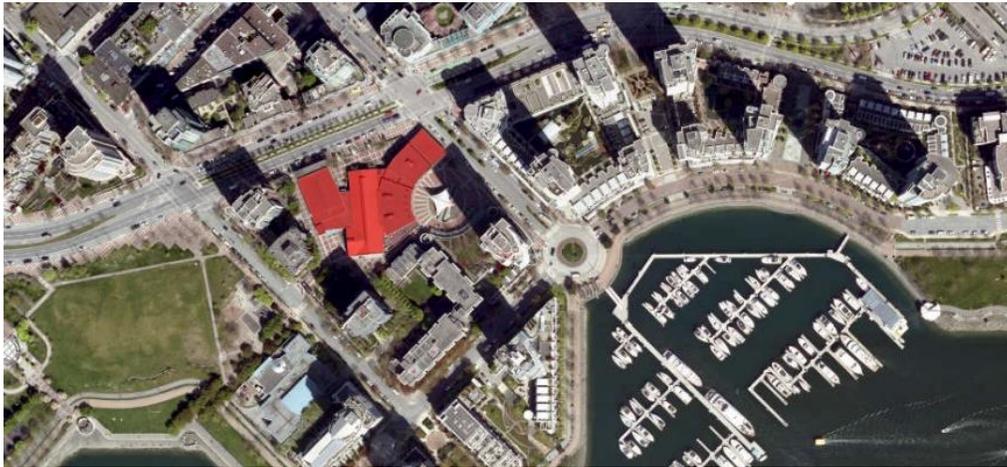


Figure 18. Roundhouse Community Centre highlighted on the google map

The Roundhouse Community Centre is situated in the downtown area of Yaletown and was originally built in 1886. The initial function was to store and service the steam locomotives, which eventually was vacated due to the advent of diesel engines. This community centre has a rich history and a series of spatial and functional transformations with the conversion of the building for Expo86 in 1986, and then finally into a community centre in 1997. The centre is recognized to be in good condition currently but, if not maintained, can fall into a poor state (Vancouver Board of Parks and Recreation, 2018).

These four community centres are situated in different neighbourhoods, consisting of a broad range of amenities, different building structures, design and services, which provides wide-ranging aspects for analysis in the next section of the report.

7. Case Study Analysis

To analyze the existing building function, spatial design, filtration system and past response to extreme weather events, a sample comparative case study of the selected four community centres was conducted. The analysis also draws upon the results of the interviews with the building/recreation supervisors of the four community centres, site visits and a study of the floor plans.

7.1 Summary of Interview Results

To inform the case study analysis, the building/recreational program supervisors of four community centres were interviewed. Their role at the community centre involved the supervision of recreational services, programs, staff management, training, coordination with community and city partners, and community engagement.

The interviews informed that all the centres were previously used as cooling centres during extreme heat events in the past. However, there was no specific planning or publicity in place to respond to the community needs during the events. Response to wildfire smoke events by the community centres was unprecedented, and planning was either unknown or at preliminary stages. Knowledge about dedicating a clean air space was varied across each community centre. Spaces such as ice rinks, pools, games rooms and senior centres were initially identified by the supervisors to use them as clean air shelters. These spaces have challenges and potentially be able to serve as a clean air shelter, and hence the following sections of analysis explore the possibilities.

7.2 Functions and Partnerships

The primary functions of the community centres revolve around recreational, educational and social programs for the community. Table 3 shows the existing functions and partnerships of the selected four community centres in Vancouver. All four community centres include recreational and community engagement activities. All the centres have dedicated licenced childcare except for Roundhouse. Roundhouse actively functions as an art and performance centre, which is a unique function compared to other community centres.

The community centres run in partnerships with Vancouver Public Library (VPL) and schools by sharing the physical infrastructure, site and services. VPL is a part of all the community centres except Roundhouse, whereas only Britannia community centre works in collaboration with the elementary and secondary school during special occasions or functions. The public library and school function independently from each

other, with a minimum overlap of space sharing with the community centre. Hence, VPL and elementary and secondary schools are not considered in the case study analysis as they require further in-depth research to understand their function and space utilization during the wildfire smoke event.

Community Centre	Functions	Partnerships
Britannia	Recreation Community Engagement	Vancouver Public Library School (Elementary/Secondary)
Hillcrest	Licensed Childcare	Vancouver Public Library
Mount Pleasant		Vancouver Public Library
Roundhouse	Recreation Community Engagement Arts and Performance	None

Table 3. Functions and partnerships of the four community centres

7.3 Existing Spaces

Each community centre has a set of functions that may or may not overlap with other community centres. These functions arise from the specific needs of the community, facility planning and the finances available for the project. Table 4 compares the list of spaces existing in each of the community centres. All four community centres provide programs for all age groups and fitness. Aquatics and ice skating are available only at Britannia and Hillcrest, whereas performing arts, pottery and woodwork workshops are unique to Roundhouse only. Plan layouts of the four community centres are shown in figures 19, 20, 21 and 22, which presents an understanding of the type of amenities, spatial adjacencies, and connectivity that are used for analysis in the following sections.

Areas	Britannia	Hillcrest	Mount Pleasant	Round house
 Aquatic Centre	✓	✓		
 Sports (Ice Rink/Curling)		✓	✓	
 Fitness Centre	✓	✓	✓	
 Fitness Studio	✓	✓	✓	✓
 Gymnasium	✓	✓	✓	✓
 Childcare	✓	✓	✓	
 Dedicated Centres (teen/pre-teen, family)	✓			
 Senior's Centre	✓			
 Cafeteria/Kitchen		✓	✓	
 Lounge		✓	✓	✓
 Multipurpose Rooms	✓	✓	✓	✓
 Classrooms				✓
 Games Room		✓	✓	✓
 Arts and Crafts Room		✓		✓
 Exhibition/Art Gallery				✓
 Performance Centre				✓
 Workshops (Pottery/Woodwork)				✓
 Offices	✓	✓	✓	✓
  Washrooms and Shower	✓	✓	✓	✓

Table 4. Existing spaces in selected four community centres

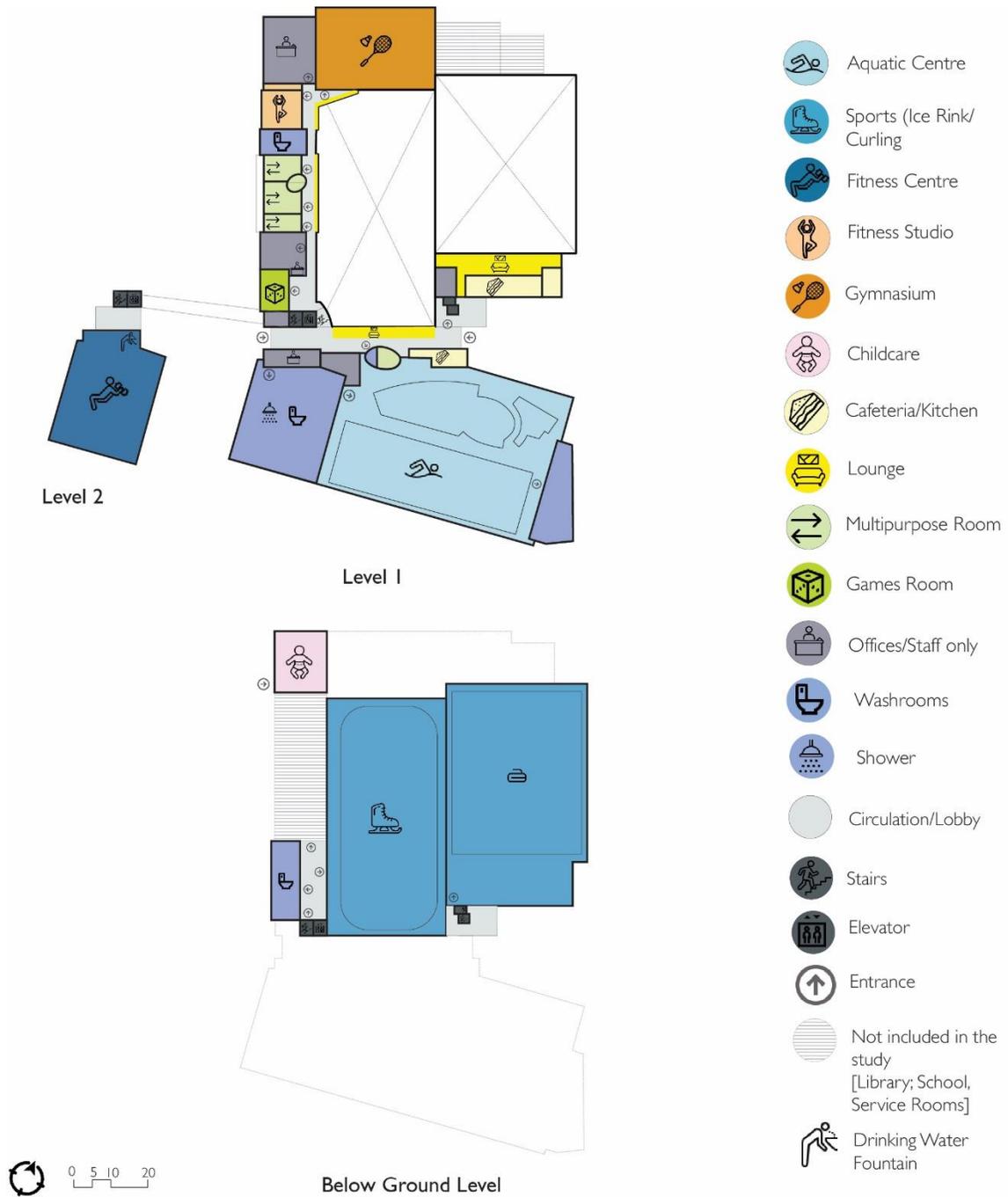


Figure 20. Spatial layout of Hillcrest Community Centre

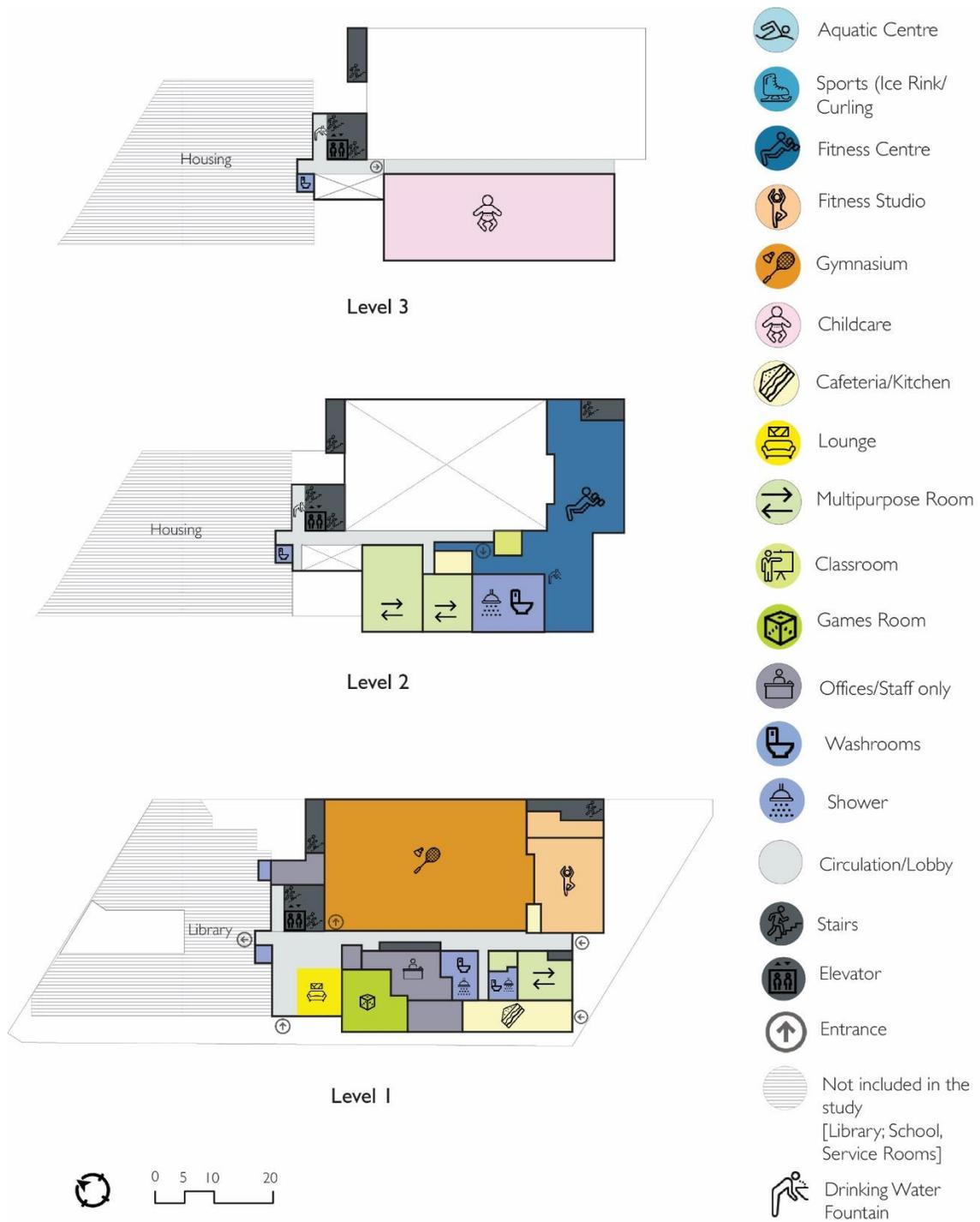


Figure 21. Spatial layout of Mount Pleasant Community Centre



Figure 22. Spatial layout of Roundhouse Community Centre

7.4 Multifunctional vs Dedicated Function

This analysis involved identifying spaces that are multifunctional or dedicated in function, which could potentially accommodate changing requirements for CCAS during the wildfire smoke events.

In this analysis, the multifunctional spaces are defined as enclosed rooms that can accommodate different functions, programs for different age groups and activities, and ideally have an open floor plan with storage and movable furniture whereas dedicated spaces are enclosed rooms with a single function, fixed furniture layout or heavy equipment that might not be suitable to accommodate any new functions if needed during the wildfire smoke events.

As shown in Table 5, all the community centres have both dedicated and multifunctional spaces in different ratios. Childcare facility and senior's centre are majorly dedicated to young children and the elderly, which caters to their specific needs and requirements. A childcare facility is available at Britannia, Hillcrest and Mount Pleasant, whereas senior's centre is available at Britannia only. As these age groups fall under the health-risk population during wildfire smoke events, it is essential to consider having separate childcare and senior centre in each community centre.

Fitness, aquatic, ice skating, pottery and wood workshop programs have dedicated spaces in the community centres with heavy equipment, specific functions and services, whereas the rest of the rooms are all multifunctional used by different age groups, which keeps shifting based on room availability and program schedule. Hillcrest, Mount Pleasant and Roundhouse are highly multifunctional compared to Britannia due to a higher number of multifunctional rooms. This analysis explicitly highlights the areas that can be multifunctional, and that can potentially be transformed to accommodate any changing needs and requirements of CCAS during wildfire smoke events.

Areas	Britannia	Hillcrest	Mount Pleasant	Round house
 Aquatic Centre	Dedicated	Dedicated		
 Sports (Ice Rink/Curling)		Dedicated	Dedicated	
 Fitness Centre	Dedicated	Dedicated	Dedicated	
 Fitness Studio	Multi	Multi	Multi	Multi
 Gymnasium	Multi	Multi	Multi	Multi
 Childcare	Dedicated	Dedicated	Dedicated	
 Dedicated Centres (teen/pre-teen, family)	Multi			
 Senior's Centre	Dedicated			
 Cafeteria/Kitchen		Dedicated	Dedicated	
 Lounge		Multi	Multi	Multi
 Multipurpose Rooms	Multi	Multi	Multi	Multi
 Classrooms				Multi
 Games Room		Multi	Multi	Multi
 Arts and Crafts Room		Multi		Dedicated
 Exhibition/Art Gallery				Multi
 Performance Centre				Multi
 Workshops (Pottery/Woodwork)				Dedicated
 Offices	Dedicated	Dedicated	Dedicated	Dedicated
  Washrooms and Shower	Dedicated	Dedicated	Dedicated	Dedicated

Table 5. Existing spaces in selected four community centres that have either dedicated function or multifunctional.

7.5 Filtration system

As per the description in section 5.1 on the filtration system required for CAS, it was essential to understand the existing filtration system of the four community centres. Filtration system required for CCAS is a minimum performance of MERV 13 year-round and higher performing HEPA filters during the wildfire smoke event (BC Housing, 2019). In addition to that, carbon filters and cooling is also required during the wildfire smoke event due to outdoor pollution and extreme heat in summer (BC Housing, Integral Group, 2019).

Among the four centres, only Hillcrest and Mount Pleasant have the minimum filtration system of MERV 13, as shown in table 6. The entire facility of Mount Pleasant is provided with MERV 13 filtration system, whereas at Hillcrest, only the rooms are provided with MERV 13. None of the community centres have high-performance HEPA filters, which are required during the wildfire smoke event. Britannia and Roundhouse have filtration systems below MERV 13, which needs a significant upgrade to provide clean air without the particulate matter into the community centre.

In the case of an ineffective filtration system, portable units can be used for short term use, which may be challenging for public buildings with large volumes and a higher number of people depending on the room size, volume and airtightness. Though Hillcrest and Mount Pleasant meet the minimum requirements for the filtration system, it needs to be upgraded to HEPA filters to provide clean air during the wildfire smoke event. In addition to the upgrade, the spaces in the community centres need to be assessed for air infiltration and efficiency.

Community Centre	Filtration Type	Supplied to	Meeting Requirements
Britannia	Old filtration system (built in 70s)	Entire Facility	Needs to upgrade to HEPA
Hillcrest	MERV 8 + MERV 13	MERV 8: Corridors & Circulation Spaces MERV 13: Rooms	Needs to upgrade to HEPA
Mount Pleasant	Pre-filter - MERV 8 Final filter - MERV 13 Carbon filters	Entire Facility	Needs to upgrade to HEPA
Roundhouse	MERV 8	Entire facility except for Gymnasium	Needs to upgrade to HEPA

Table 6. Filtration specification of the selected four community centres
(Source: *Building/recreational supervisor of the selected four community centres*)

7.6 Past Response to Extreme Weather Events

Past responses to the extreme weather events or certain emergencies were analyzed to identify the space utilization, allocation, constraints and challenges. This analysis informs the research about the community needs and requirements during extreme weather events by identifying the recreational program changes, room allocations for the particular needs and challenges faced. It also reflects the preparation of the community centres and the issues of responding to extreme weather events, which will inform the development of design guidelines.

All four community centres were identified to serve as cooling centres during an extreme heat event, as shown in Table 7. During the last occurring wildfire smoke event in 2018, Britannia partially served as a clean air shelter. Last year in 2019, Hillcrest had planned to activate a designated space in the community centre as clean air shelter, but due to no wildfire smoke event, the plan was not activated. In a different scenario, Roundhouse was activated for an emergency of the gas leak in social housing in 2015, which led to converting the community centre into an emergency shelter for five days.

Past Response	Britannia	Hillcrest	Mount Pleasant	Roundhouse
 Extreme Heat: Cooling Centre	Was Activated	Was Activated	Was Activated	Was Activated
 Extreme Cold: Warming Centre	Not Activated	Not Activated	Not Activated	Not Activated
 Wildfire Smoke: Clean Air Shelter	Partially Activated	Was Planned	Not Activated	Not Activated
 Emergencies: Emergency Shelter	Not Activated	Not Activated	Not Activated	Was Activated

Table 7. Community centres that responded to extreme weather event or a specific emergency

(Source: Building/recreational supervisor of the selected four community centres)

Emergency Support Services (ESS) is part of the Provincial Emergency Program, which provides emergency support and services during the fire, floods, earthquake or any other emergencies (Government of British Columbia, 2020). ESS directs the community centre to activate for emergencies or extreme weather events. The guidance includes program cancellations, volunteer provision, area selection to accommodate the needs, and operations based on the event type, number of people and seriousness of the situation.

The function of the community centres during regular functioning and extreme weather events are similar compared to the emergency mode, as shown in Table 8. In non-emergency mode, the community centres function in regular mode for 10-16 hours with no functional change. Whereas in emergency mode, the function of the community centre changes completely and operates 24 hours based on the directions provided by the ESS.

Scenario	Function	Function Mode	Hours of Operation
Regular Functioning	Community Social, Educational and Recreational activities	Regular	10-16 hrs
Extreme Weather event (1-2 weeks)	Community Social, Educational and Recreational activities + Relief Centre	Temporary relief hub	10-16 hrs
Emergency Event (varies)	Community Social, Educational and Recreational activities + Emergency Hub	Shelter	24 hrs

Table 8. The functioning of community centres in different scenarios
(Source: Building/recreational supervisor of the selected four community centres)

Responses to each of these events were different at all the four community centres based on the event type, community centre capacity, community needs, number of people to be accommodated and urgency of the event.

7.6.1 Space Allocation:

The spaces allocated for each extreme weather event were also different, as shown in table 9. For the cooling centre, spaces that had air conditioning in the community centres were generally assigned as a cooling centre with no function or program change. For the wildfire smoke event, the Britannia Community Centre prioritized the senior's centre to serve as clean air shelter for the elderly as they were the most vulnerable to the wildfire

smoke. Since the filtration system at Britannia did not meet the specification requirement of minimum MERV13 or HEPA filters, portable filter units were used in the space.

The Hillcrest Community Centre had planned to dedicate the games room as a clean air shelter during the wildfire smoke event. The programs in that particular room were decided to be cancelled and provide leisure activities for engagement like watching TV, reading and lounging. The room was assessed for indoor air quality and was found to have ineffective air filtration due to the large volume of the room. This issue emphasizes the importance of installing HEPA filters and assessing the rooms for filtration effectiveness. Portable filter units were planned to be used for effective filtration of air in the space. This plan was not activated due to no occurrence of a wildfire smoke event last year in 2019. Hence, the challenges and potential issues with this plan are currently unknown.

Past Response	Britannia	Hillcrest	Mount Pleasant	Roundhouse
 Extreme Heat: Cooling Centre	- Pool - Ice Rink	Entire Facility	Entire Facility	Entire Facility except Gym
 Extreme Cold: Warming Centre				
 Wildfire Smoke: Clean Air Shelter	Senior's Centre	Games Room		
 Emergencies: Emergency Shelter				- Gymnasium - Main Lobby - Multipurpose Room - Arts & Crafts Room

Table 9. Rooms used as a relief/refuge area from extreme weather events or specific emergency

(Source: Building/recreational supervisor of the selected four community centres)

The Roundhouse Community Centre was the only community centre amongst the four that was activated as an emergency shelter for 24 hours for five days during a gas leak in nearby social housing. The gymnasium, main lobby, arts and crafts room and a multipurpose room was used to accommodate 40 people for five days to serve as a temporary shelter, which provided a place to sleep, eat and shower. The programs in these spaces were cancelled for five days. The gymnasium was the main accommodating area where people resided and slept as shown in figure 23.

Some of the challenges faced during the gas leak emergency event were addressing the conflicts rising among people and lack of enough shower facilities. This event's response provides an emphasis on the emergency preparation factor of the community centre renewal design.



Figure 23. Gymnasium used as an emergency shelter for five days during the gas leak at nearby social housing at the Roundhouse community centre
(Source: Building/recreational supervisor of the Roundhouse community centres)

7.6.2 Community Needs:

During the extreme weather events like the extreme heat and wildfire smoke, specific needs were identified by the building/recreation supervisor for the four community centres. Each community centre faced challenges specific to its community's needs and was dependent on the community centre's design, functioning and neighbourhood. Some of the needs of the community members at four community centres identified during the past extreme weather events were drinking water facility, shower and bathroom facilities, more open to public spaces (such as a library, lounge or cafeteria), air filtration system, adjustable thermal comfort, wayfinding and transportation facility to and from the facility as shown in table 10.

Transportation to and from the facility was one of the challenges mentioned in the literature and interviews. People at health-risk may not be able to travel to the facility as they might get exposed to the smoke in transit and would instead prefer to stay home. However, due to prolonged smoke exposure, inefficient air filtration at homes and frustrations of staying indoors for an extended period can lead to the rising need of CCAS to provide social support and temporary relief during the event. With no precedents and experience with response to wildfire smoke, it is difficult to measure the number of visitors and judge the capacity which may require a pilot study.

As such, the bathroom and shower facilities were highlighted as an essential need at the Britannia community centre due to the increased percentage of the homeless population in the neighbourhood compared to the other three community centres. Hence, this implies that there could be specific needs of each community centre that may not overlap with other community centres and will require to be considered in their renewal planning.

Past Response	Britannia	Hillcrest	Mount Pleasant	Roundhouse
 Extreme Heat: Cooling Centre	<ul style="list-style-type: none"> - Drinking Water - Public Shower & Washroom 	Wayfinding	More open to public spaces	Temperature control for each room
 Wildfire Smoke: Clean Air Shelter	<ul style="list-style-type: none"> - Water Stations - Public Shower & Washroom - Transportation 	Efficient Filtration System		

Table 10. Needs of the four selected community centres during extreme weather events (Source: Building/recreational supervisor of the selected four community centres)

7.7 Renewal Plans

There are no current renewal plans in place for Hillcrest and Mount Pleasant as they are newer facilities compared to Britannia and Roundhouse. As per FCI 2026 figure 13, if no interim repairs are considered for Britannia and Roundhouse, they will eventually be in a critical condition in the next 10-15 years. Hence, these community centres require immediate guidance on resilience planning and integrating CCAS requirements to respond to extreme weather events such as wildfire smoke.

Britannia is planned to be replaced by a new facility that aims at optimizing sustainability and resiliency of the project by adopting current and future needs (City of Vancouver, 2018). Though the masterplan for Britannia identifies building social support during

emergencies, crises or extreme weather events, by creating an area of refuge for the vulnerable population, the planning is in the preliminary stage and consideration for CCAS is not included in the masterplan.

Roundhouse renewal plans include replacing the HVAC system two at a time, making the entrances automatic for wheelchair accessibility and extending the studio room to increase the capacity of the community centre. These upgrades are highly dependent on the availability of funding, which makes it challenging to accommodate all the requirements of CCAS in one step and requires upgrades in phases over time. Hence, a set of design guidelines on CCAS is crucial in the planning and design stage to meet the needs of the community during the wildfire smoke event.

8. Outcome of Analysis

The literature review and case study analysis revealed that a CCAS requires a list of spatial requirements that need to be accommodated in community centres. These spatial requirements specifically cater to the needs of the community during the wildfire smoke event which includes a dedicated space for health-risk population, space for event education or workshop, lounge, lobby and cafeteria for visitors not enrolled in any programs, access to universally accessible public toilets, drinking water, rest area, emergency supply storage, efficient wayfinding and flexible building design. The spaces of the four community centres are analyzed to determine if they meet the spatial requirements of the CCAS, as shown in table 11.

Each community centre can potentially fall into three categories of the renewal design phase. The first category meets the spatial requirement without any interventions; the second category would require a minor/major upgrade depending on the building design and condition like knocking down the wall, providing necessary services, relocating functions or merging rooms; the third category includes spaces that are not present in the community centres and would require either major renovation or build a new structure. Hence, in table 11, the four community centres are analyzed and tested for the presence of the spaces required for CCAS.

8.1 Identified Spatial Requirements

Brief reasoning on each spatial requirement, along with the spatial analysis of the four community centres is described below:

8.1.1 Dedicated Space for Health-Risk Population

A dedicated clean air room is required for the health-risk population to prioritize their access while also provide immediate aid, support and care in a non-acute health situation. This space would be provided with all the necessary facilities like drinking water, washroom facilities and kitchen/pantry along with social engagement and leisure activities.

In addition to a dedicated space for health-risk population, licensed childcare facility and senior's centre can be established for infants, toddlers and seniors as they are among the health-risk population. All the four community centres except roundhouse have a childcare facility, and only Britannia has a senior's centre, as shown in figure 24, which could potentially be assigned as CCAS for the young children and elderly.



Figure 24. Picture of Senior's Centre at Britannia Community Centre (PC: Author)

8.1.2 Emergency Supply and Storage

In 2016, the City of Vancouver designated 25 community centres in Vancouver as disaster support hubs, which intends to serves as a public gathering area following an earthquake or natural hazards. These disaster support hubs have emergency supply storage in shipping containers, which are situated on site of the community centres. Since no natural hazard occurred in the past five years after the disaster support hub planning, there is no information provided on the additional storage requirement. All four community centres have their emergency supplies in the shipping container, as shown in figure 25, which would be actively used in an emergency during the wildfire smoke event.



Figure 25. Emergency storage container located in the loading area at Mount Pleasant Community Centre (PC: Author)

8.1.3 Space for Medical Help/First Aid

During the wildfire smoke event, there might be a higher number of people that may require minor medical help/first aid, which would be challenging to access if the health care facilities are at full capacity. Hence a part of office space or a multipurpose room adjacent to office/staff rooms, can easily be accommodated in all the four community centres, as shown in figure 26.



Figure 26. Games room near the entrance and reception which can be used as a first-aid/medical help space during wildfire smoke event (PC: Author)

8.1.4 Access to Drinking Water Fountain at Entrance

As the wildfire smoke event coincides with the summer season, public drinking water facilities should be given high priority. Though all the community centres have drinking water facilities, the location is equally important for easy access by the public.

Among the four community centres, only Roundhouse had a drinking water fountain situated in the entrance lobby, as shown in figure 27, which was easily accessible by the visitors and community members. Britannia, Hillcrest and Mount Pleasant (figure 28) had drinking water fountains either away from the entrance or inside the fitness rooms, which is hard to locate by a visitor. Hence, drinking water fountain locations should be considered during building design.



Figure 27. Drinking water fountain located near the entrance in the lobby of Britannia Community Centre (PC: Author)



Figure 28. Drinking water fountain located on the first floor at Mount Pleasant Community Centre (PC: Author)

8.1.5 Access to Public Toilets and Shower Facilities

Access to public toilet and shower facilities was one of the top priorities for the Britannia community centre due to the higher number of homeless populations in the neighbourhood. Public toilet and shower facilities (in the fitness centre and pools) are typically available in all the community centres. Hence, the need for additional public shower facilities is highly relative to the demographics of the homeless population in the neighbourhood.



Figure 29. Washroom facility located in the corridor space which is near to the multipurpose rooms at Hillcrest Community Centre (PC: Author)

8.1.6 Vestibule with Double Entrance

Vestibule with a double entrance is present in most of the new buildings to avoid heating, cooling or filtered air loss from the building. Hillcrest (figure 30) and Mount Pleasant have the vestibule with double entrance, whereas Roundhouse and Britannia do not have it. Since Britannia has multiple blocks with multiple entries, it would be challenging to implement the vestibule with a double entrance in the existing structure without major renovation or building replacement.

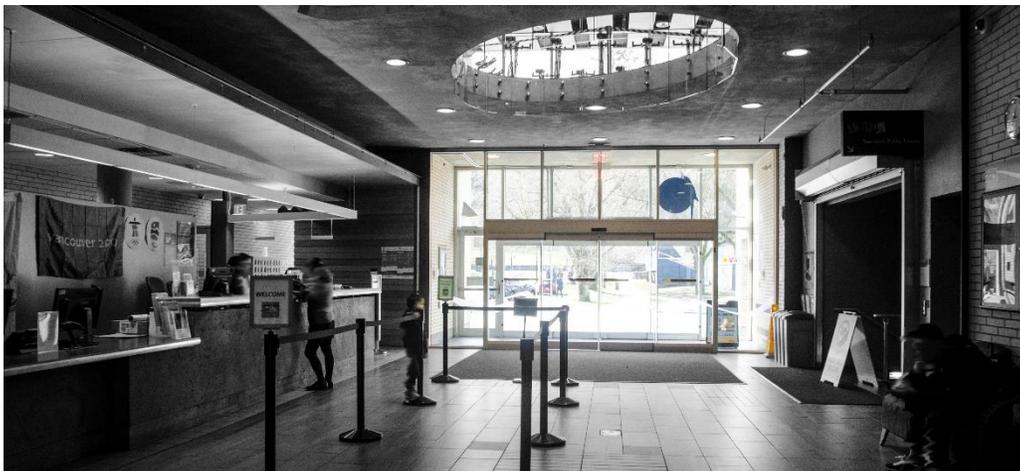


Figure 30. Vestibule with a double entrance at Hillcrest Community Centre which prevents unfiltered air from entering inside (PC: Author)

8.1.7 Space for Event Education

Need for an event/workshop room for educating the community members on health protection from wildfire smoke is depended on the programs designed by the city or provincial officials and health care practitioners. Spaces like multipurpose rooms, classrooms, gymnasiums and performance halls can be used for this need would not require any special equipment other than regular event equipment. All the community centres can comfortably accommodate this need as multipurpose rooms, classrooms and gymnasiums are present in all the four community centres.



Figure 31. Gymnasium at Britannia Community Centre which can be used for wildfire smoke event education (PC: Author)



Figure 32. Games room at Hillcrest Community Centre which can be used for wildfire smoke event education (PC: Author)

8.1.8 Lounging Space

As the outdoors are unsuitable during the wildfire smoke event, and in many cases, the houses do not have an effective filtration system, community members need clean indoor places to go to, especially during stressful situations. Many people visiting the community centre may or may not be enrolled in any programs and might need a place just to sit and take in the fresh air. At the community centres, people can lounge in the waiting areas, cafeterias, corridors with seating, entrance lobby with seating and library. The library has great potential to accommodate this need, which requires further in-depth research on the adaptability of spatial layout and function during the wildfire smoke events.

All the community centres have lounging spaces with different typology and capacity except Britannia, which has no closed lobby, common gathering place, or cafeteria, as shown in figure 33. Hence, increasing the lounge space capacity of a community centre during the wildfire smoke event is dependent on the building design layout of the community centres, number of visitors, and building flexibility to expand the room sizes.



Figure 33. No closed entrance/lobby at Britannia Community Centre which can be challenging during wildfire smoke event (PC: Author)



Figure 34. Closed lobby space with lounge/waiting area at Hillcrest Community Centre (PC: Author)

8.1.9 Wayfinding and Communication Strategies

As the community centres are multifunctional with programs constantly interchanging between the rooms, wayfinding was highlighted as a challenge in the interviews with the building/recreational supervisor of the community centres. Though there are maps provided at the entrance and nameplates near the rooms at all the community centres, each has a different design of signage, which can be difficult to perceive during a stressful situation. Only Mount Pleasant of all the community centres has a replaceable nameplate system that is flexible and could be used widely during spatial transformations.

During the stressful situations like wildfire smoke event, it is important to communicate the information and direction with the community members efficiently with minimum support from the staff. Hence, it is vital to establish a standard wayfinding and communication strategy at all the community centres during wildfire smoke events.

8.1.10 Building Design Flexibility

As the functions, needs and demands of the community centres are constantly changing with time, it is important to consider flexibility in the spatial design of the building. Building flexibility is defined as rooms/spaces which can be physically transformed by expanding, contracting and changing floor layouts of the rooms for different functions and needs. As some of the CCAS requirements can be accommodated without any

physical transformations in the community centre, having flexible building design increases the potential of adapting to the evolving needs of the community.

Out of four community centres, Britannia has more dedicated spaces compared to the other three community centres with little or no furniture movement and not enough storage. Hence, space constraints limit the potential to adapt to new functions. Hillcrest, Mount Pleasant and Roundhouse comparatively have a higher number of multipurpose rooms but with fixed walls that do not allow the space to be expanded or contracted. As the future wildfire smoke events are unpredictable, and the needs will keep changing, it is important to consider how the community centre building design can be flexible and multifunctional.

8.2 Summary

Based on the above analysis, all four community centres can accommodate some of the spatial requirements of the CCAS. In contrast, some of them may require a minor upgrade, major upgrade or replacement based on the building structure, services, and project funding.

Dedicated space for health-risk population, senior's centre, wayfinding and communication strategy and building design flexibility are absent in most of the case studies, which are fundamental to establishing CCAS. Whereas, requirements such as license childcare facility, immediate access to drinking water facility, access to public toilet and shower facilities, vestibule with double entrance and lounging space are present in some and absent in others. Finally, spatial requirements like emergency supply and storage, space for medical help/first aid and space for event education can be easily accommodated with minor or no physical interventions.

The spatial requirements listed are commonly applicable to all the community centres in Vancouver. Note that there might be some additional spatial requirements specific to a community or neighbourhood in Vancouver. One such example is the need for additional shower facilities for the homeless population at the Britannia Community Centre, which was not identified for other community centres.

The spatial requirements that are missing and require upgrades are considered in developing a set of guidelines presented in section 9 of the report.

Spatial Requirements	Britannia	Hillcrest	Mount Pleasant	Round house
 Dedicated Space for Health-Risk Population	Absent	Absent	Absent	Absent
 Licensed Childcare Facility	Present	Present	Present	Absent
 Senior's Centre	Present	Absent	Absent	Absent
 Emergency Supply and Storage	Present	Present	Present	Present
 Space for Medical-Help/First Aid	Present	Present	Present	Present
 Access to Drinking Water Fountain at Entrance	Absent	Absent	Absent	Present
 Access to Public Toilets	Needs Upgrade	Present	Present	Present
 Vestibule with Double Entrance	Absent	Present	Present	Needs Upgrade
 Space for Event Education	Present	Present	Present	Present
 Lounging Space	Absent	Present	Present	Present
 Wayfinding and Communication Strategy	Absent	Absent	Absent	Absent
 Building Design Flexibility	Absent	Absent	Absent	Absent

Table 11. Spatial requirement assessment of four community centres for design guideline development

9. Design Guidelines for CCAS

The case study analysis of four community centres gives a broad narrative of the function and spatial orientation of the community centres. These community centres are actively used by the people of all age groups for different purposes, which positively impacts their health and wellbeing. Community centres are the hubs where people come to relax, learn, socialize, exercise and engage in meaningful activities. Hence, a community centre is well-positioned to play a vital role in providing support and help during stressful events, such as extreme weather events that often disrupt the daily lifestyle and routine of the people.

To provide temporary relief and support during a wildfire smoke event, community centres should entirely function as CCAS. To accommodate the spatial needs of the CCAS in community centres, it is crucial to install high performing air filters and ensure envelope airtightness, which needs to be part of any major retrofit/new building. Without efficient filtration and airtightness of the building envelope, there is a limit on the ability of the community centres to function as CCAS.

Factors such as unprecedented event response, ineffective filtration system, project funding, site or design constraints, and the existing condition of the building structures and services might hinder the best-case scenario of converting an entire facility into a CCAS. Therefore, the following guidelines are proposed to accommodate the spatial requirement of CCAS in existing community centres in Vancouver. These guidelines are proposed based on the analysis of four facilities as case studies, that were selected to be broadly representative of the 24 community centres in Vancouver.

9.1 Guidelines Structure

The proposed guidelines to accommodate the spatial requirements of the CCAS in community centres in Vancouver make a distinct assumption that either the entire facility or designated spaces will have filtration system with HEPA filters during wildfire smoke event. Without installing a filtration system, the community centre will not be able to function as CCAS. The three interventions for community centre renewal are a minor upgrade, major upgrade and replacement with a new building design which are described as follows:

- Minor upgrade: Minimum physical changes, program re-locations, effective communication systems or temporary instalments.

- Major upgrade: Replacing major equipment, changing the function of a space, expansion or contraction of rooms internally, expansion or contraction of rooms externally, alterations in the walls, windows, roof or floor of the building.
- New building: Demolishing the existing structure to replace with a new building on the existing/new site.

While these guidelines are applicable to existing community centres, which require a minor or major upgrade, the principles are also applicable to the planning and design of new buildings.

9.1.1 Applicability:

The proposed guidelines apply to a broad range of scenarios that might potentially occur during the wildfire smoke events in Vancouver. Some of the scenarios may include:

- Regular Mode (10-16 Hrs): When the wildfire smoke occurs for just a few days to a week, the entire facility might function as usual with some transformation in the spaces to accommodate the immediate needs of the community.
- Stressful Mode (10-16 Hrs): When the wildfire smoke event lasts for more than a week to a month, where a lot of regular functions of the community centres might need to be transformed for clean air shelter functions, like program relocation, dedicated refuge area, having more informal spaces like a lounge, cafeteria, etc.
- Emergency Mode (24 Hrs): When an unexpected event occurs, which might change the entire function of the community centres based on the instructions provided by the ESS to the community centre staff and coordinators.

The illustrations provided for each guideline is representative of building elements and not the potential scenarios. Therefore, it is important to consider the guidelines in these scenarios for implementation in a community centre renewal project.

9.1.2 Capacity Consideration:

Increasing the capacity of the spaces for community clean air shelter during the wildfire smoke event is equally important in making design decisions for building transformations. As mentioned earlier that the capacity building research is underway by the Vancouver Park Board, this research identified some factors that need to be considered for capacity building. The factors include the site constraints, building design constraints, length of wildfire smoke event, types of spaces available (multifunctional/dedicated), number of visitors, HVAC and filtration systems.

9.2 Guidelines

9.2.1 Prioritize Clean Air Space Activation

This guideline highlights the hierarchy of spaces that should be activated to function as clean air shelter. The order of space activation is based on the literature review and interviews that specify four factors of adaptation, which are air filtration, spatial requirements, flexibility, and building structures and services. Since activating the filtration system for an entire facility comes with significant challenges, this guideline plays a crucial role in the efficient service planning and spatial design of a community centre. The guidelines for this need are summarized below.

- A. Provide priority to existing child/senior areas and multipurpose rooms in the community centre. Spaces such as childcare and senior's centre can provide special care for the elderly and children who are among the vulnerable population whereas spaces such as multipurpose rooms and studio rooms are highly multifunctional, which can accommodate a dedicated refuge area, first aid or basic medical help.
- B. Provide second priority to offices to provide health protection for the staff and to family rooms and games room to increase the capacity of changing needs like dedicated refuge area, first-aid or basic medical help.
- C. Provide third priority to spaces such as lounge, waiting areas, cafeterias and lobby that play an essential role in welcoming people, disseminating information and lounging.
- D. Provide fourth priority to large closed rooms such as gymnasium, exhibition halls and performance halls, which can be activated under compelling circumstances such as to conduct seminars or workshops on event education.
- E. Provide last priority to rooms with heavy equipment and specific purposes such as fitness centre, an ice rink and aquatics with high movement activities.
- F. Group the high priority spaces in one block or adjacent to each other, which can be beneficial in maintenance and resource efficiency.

Table 12 shows the hierarchy of spaces that should be activated as community clean air shelter during a wildfire smoke event.

Spaces	Priority	Reason
 Childcare	1	These spaces can provide care and help for infants, toddlers and elderly as they fall under the health risk population during wildfire smoke exposure.
 Seniors Centre	1	
 Multipurpose rooms	1	
 Fitness Studio	1	Some of the rooms can be combined to serve as a dedicated refuge area or first aid/medical room based on the proximity to the necessary services like drinking water, washrooms and pantry/cafeteria. These spaces are closed spaces with/without storage units and open plan which can be used for various functions
 Games / Youth Room	2	The rooms can also be combined to increase the capacity for dedicated refuge areas or informal areas with lounging activities.
 Dedicated Centres (Preteen/Teen/Family)	2	
 Classrooms	2	
 Arts and Crafts Room	2	
 Offices	2	Staff health safety and protection is important to run the facility efficiently.
 Cafeteria	3	These spaces can be used by visitors as informal space to breathe in fresh air during the wildfire smoke event.
 Lounge / Lobby	3	
 Exhibition	4	Large spaces require an extremely higher-performing filtration system, which may/may not be economically feasible to use all the time. Hence, this space can be activated during large gatherings.
 Gymnasium	4	
 Performance Centre	4	
 Aquatics	5	Large spaces with heavy equipment and high movement activities require high performing HVAC, filtration system and maintenance, which can be activated last based on the community centre resources and capacity.
 Fitness Centre	5	
 Sports (Ice Rink/Curling Club)	5	
 Workshop Studio	5	

Table 12. Hierarchy of spaces to be activated in community centres during wildfire smoke event

9.2.2 Provide Dedicated Refuge Area for Health-Risk Community Members

A dedicated refuge area should be provided for the health-risk population with high performing air filtration system, which can be easily assessed and maintained in order to provide immediate care. Research shows a significant health impact due to wildfire smoke exposure on the health-risk population in the communities (Elliott, 2014). The long-term health impact on the general population is not fully known yet. Hence, it is necessary to provide dedicated spaces that can temporarily serve the needs of the health-risk population, such as community support, health-related information and social engagement. The guideline for this need is summarized below.

- A. Locate the dedicated refuge area near the entrances.
- B. Locate the dedicated refuge areas that encourage passive and active engagements.
- C. Locate spaces that have a visual connection to the outside.
- D. Provide space for seating, reading and lounging.
- E. Provide bathroom and drinking water facilities within/close to the refuge area to limit the exposure to unfiltered air.
- F. Provide kitchen/pantry or cafeteria within the space to offer food facilities.
- G. Provide furniture for different age groups.
- H. A vestibule with double entrances should be installed in spaces that directly open to the outside.
- I. Combine rooms through collapsible walls to be able to increase capacity.
- J. Allocate separate children play area and elderly lounge area within the refuge area.



Figure 35. Illustration highlighting the key elements of the guidelines 9.2.2- B, C, D and J

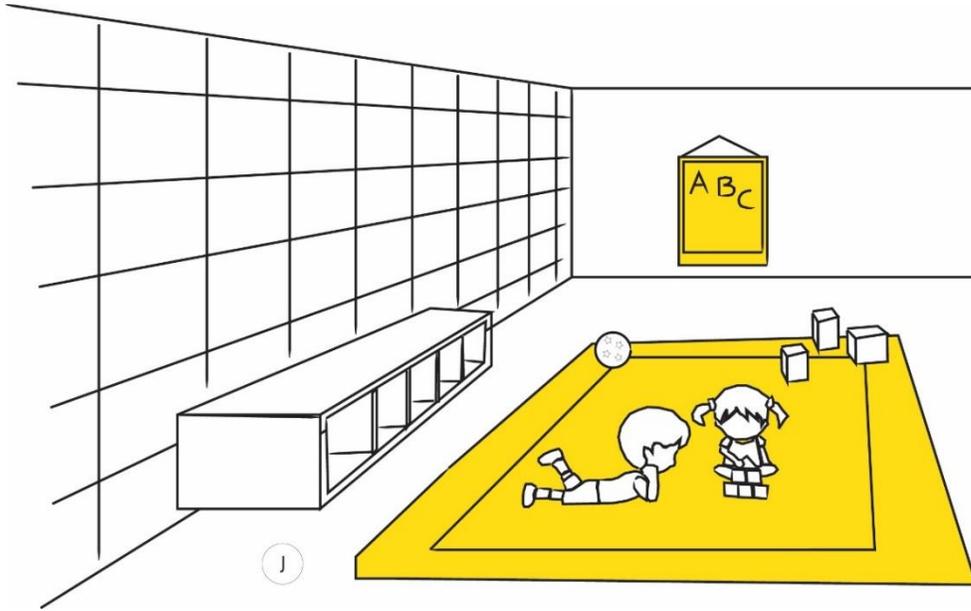


Figure 36. Illustration highlighting the key elements of the guideline 9.2.2 - J

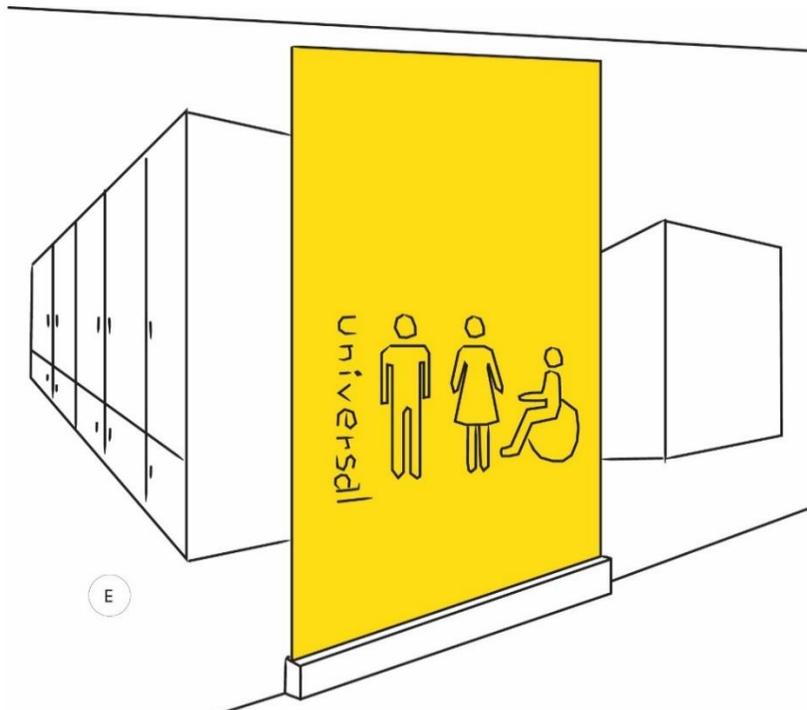


Figure 37. Illustration highlighting the key elements of the guideline 9.2.2 - E

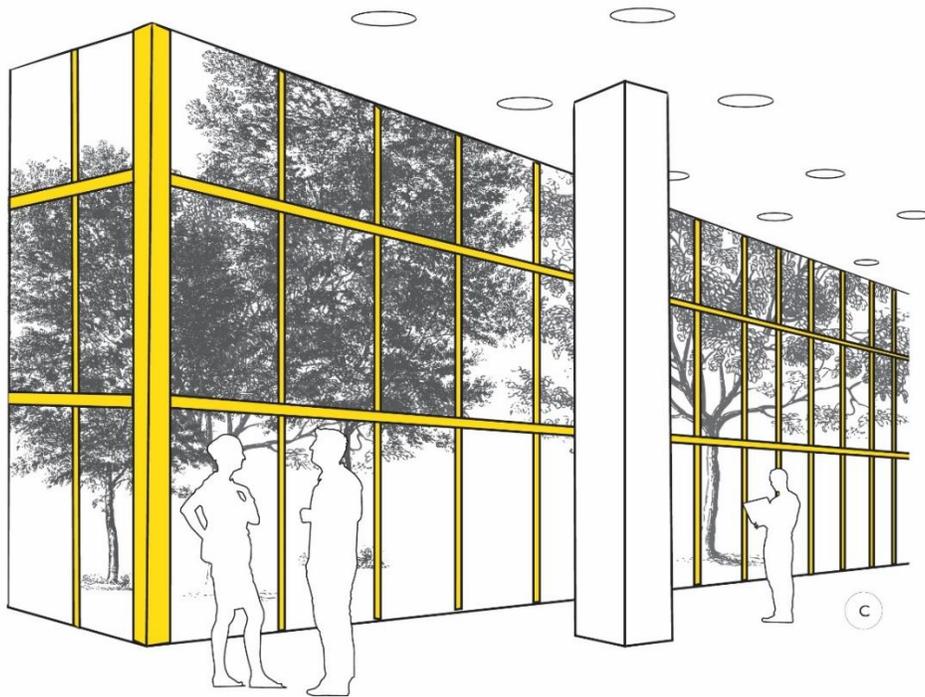


Figure 38. Illustration highlighting the key elements of the guideline 9.2.2 - C

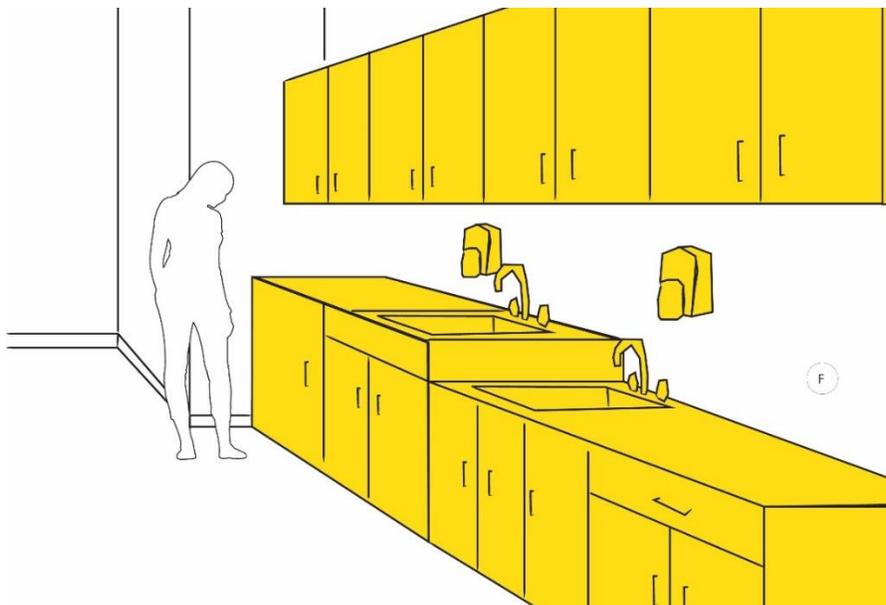


Figure 39. Illustration highlighting the key elements of the guideline 9.2.2 - F

9.2.3 Implement Wayfinding Strategies during Wildfire Smoke Event

Information dissemination plays a vital role in community centres. Many community centres are often overloaded with posters and pamphlets in the corridor, lobby and at the entrance doorways. During times of stress, it is even more difficult to identify vital information due to increased stressors correctly. Directions for room locations were identified as the main challenge as the programs keep shifting from room to room. There is also a need to include multiple common languages in the signage system for an efficient communication system to provide information about an event, program, directions and emergency using minimum resources. The guidelines for this need are summarized below.

- A. Provide a digital screen at the entrances and lobby to communicate necessary information.
- B. Provide changeable name/room plaques that are bold near the door of every room.
- C. Provide a changeable map system to update the area boundaries and program location.
- D. Implement a standard universal signage system with multiple common languages that are legible and perceivable to all age groups and populations.
- E. Develop wayfinding strategies to clean air spaces during the wildfire smoke event.
- F. Limit the space for bulletin boards and information shared to the community.

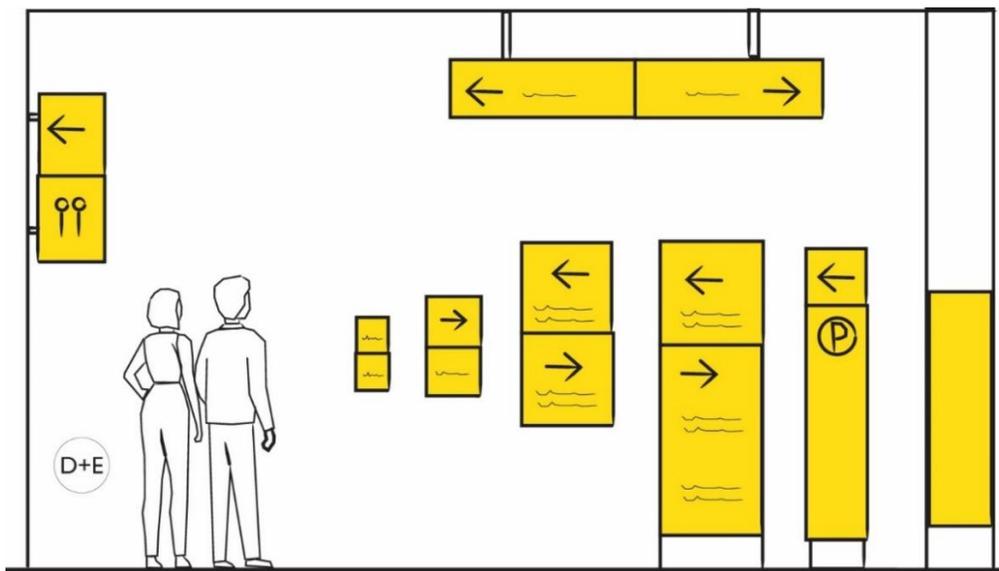


Figure 40. Illustration highlighting the key elements of the guidelines 9.2.3 - D and E



Figure 41. Illustration highlighting the key elements of the guideline 9.2.3 - A

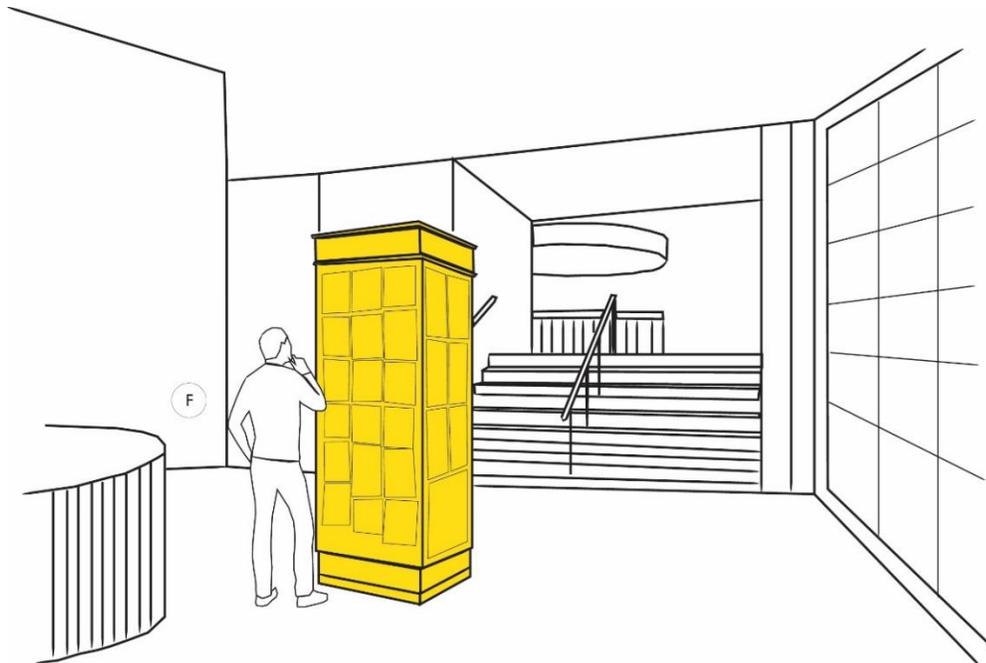


Figure 42. Illustration highlighting the key elements of the guideline 9.2.3 - F

9.2.4 Increase Flexibility in the Spatial Layout of the Facility

Since most of the community centres are multifunctional, multifunctionality is only applied in the use of rooms for different programs and purposes. There is a lack of expansion and contraction of rooms in all the community centres. To design for the unpredictable future climatic conditions and the rising needs, spaces in the community centre should be designed for increased capacity as well as space efficiency to avoid the complications of overcapacity. The guidelines for this need are summarized below.

- A. Make the rooms adjacent to the entrances multifunctional, which can be expanded into bigger lobby or event gathering.
- B. Make all the rooms adjacent to each other with foldable/collapsible internal walls
- C. Provide storage units in the non-expandable area of the room.
- D. Design the HVAC system, daylighting and furniture layout based on multiple spatial and function scenarios in the rooms with different volumes.

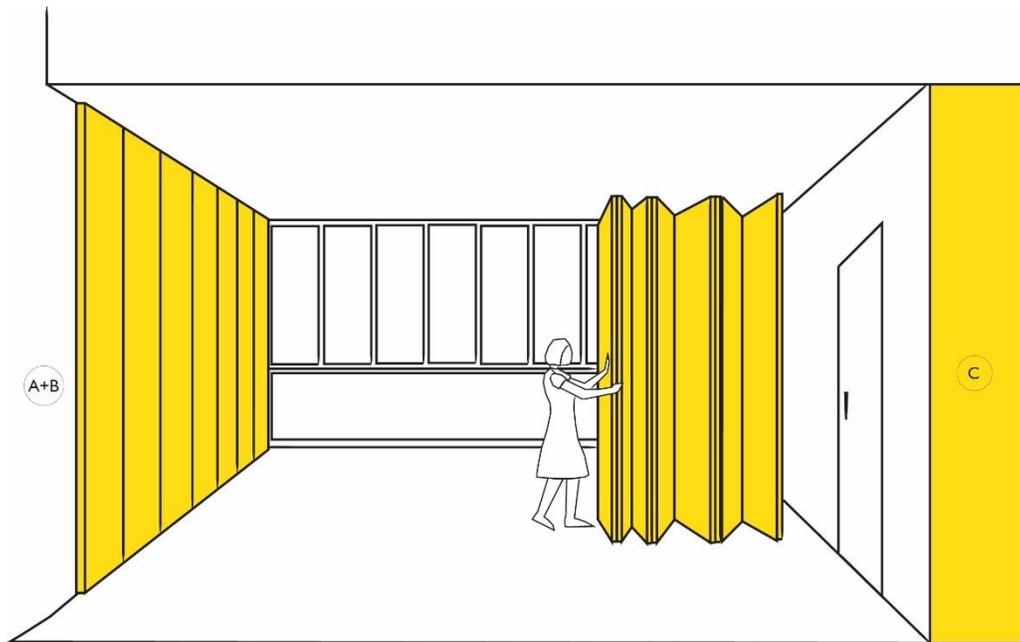


Figure 43. Illustration highlighting the key elements of the guidelines 9.2.4 - A, B and C

9.2.5 Provide Immediate Access to Drinking Water

Access to a drinking water supply in common areas was one of the essential needs identified in the literature and interviews. Only one out of four community centres studied were identified to have drinking water fountains located near the entrance of the building. The other three community centres in the case study had a drinking water facility in the fitness centre, dedicated rooms or corridor away from the main lobby or entrances. Therefore, the location of a drinking water facility is vital to building design. The guideline recommendations for this need are summarized below.

- A. Locate drinking water fountains near the entrances and on every floor near the staircase.
- B. Demarcate drinking water fountain symbol on the community centre map that helps people in easy identification of drinking water.

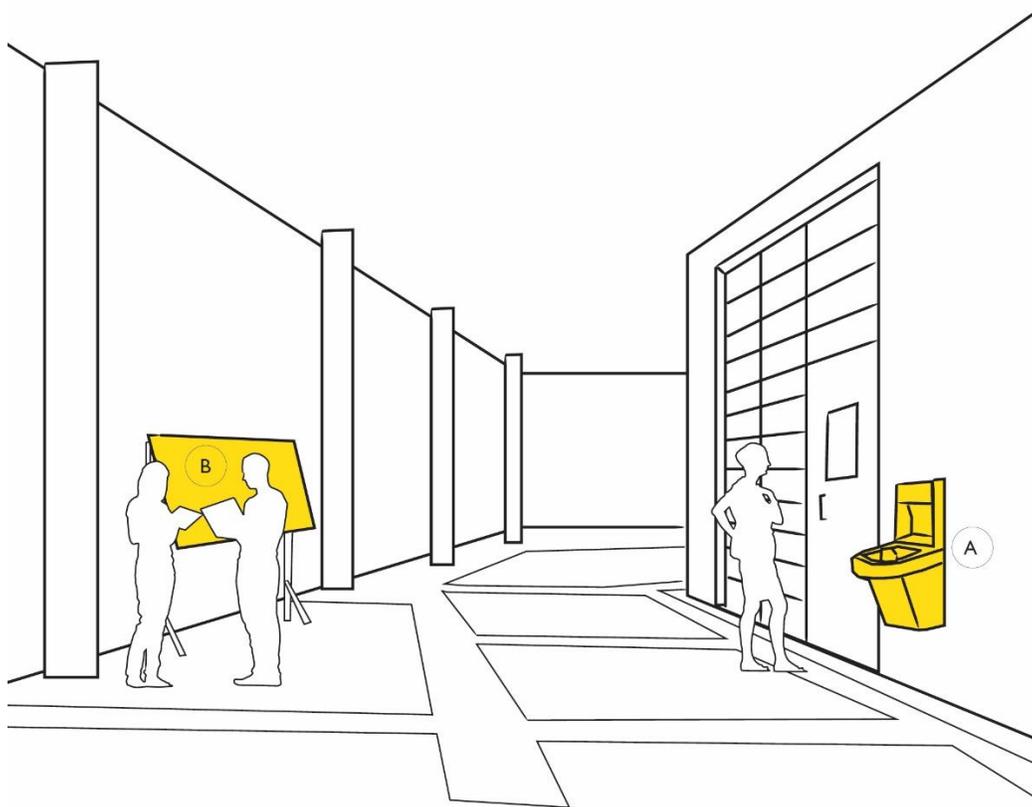


Figure 44. Illustration highlighting the key elements of the guidelines 9.2.5 - A and B

9.3 Guideline Implementation

Some recommendations can be easily applied, and some might need a meticulous design and planning exercise, which can be a layer added to the typical building design process for the community centre renewal plan. The guideline 3, to implement wayfinding strategies during the wildfire smoke event and guideline 5, providing access to the drinking water fountain at the entrance are comparatively easy to implement. Easy implementation has a minimum dependency on other building elements such as the HVAC system, daylighting, artificial lighting, furniture layout, envelope design, serves and structures. Whereas, guideline 1, prioritizing clean air activation, guideline 2, providing dedicated refuge area, and guideline 4, increasing flexibility in the building design may require reducing the interdependencies of building elements for effective transformation based on the changing needs.

Therefore, it is important to identify the impact of the guideline implementations on the existing community centre functioning and to consider reducing the interdependencies of the building elements through meticulous building design and planning.

10. Recommendations for Community Centre Renewal Planning

Since the strategy for the renewal of 24 community centres is in an early development stage, it is crucial to consider the needs and requirements of the community during the wildfire smoke event. The Vancouver Board of Parks and Recreation plays a significant role in renewal strategy development, setting guidelines, coordinating project development and defining project briefs.

10.1 Recommendations

The following list is the set of recommendations that aims to inform the strategy development for the renewal of community centres.

- A. Include the needs and requirements of the community during the wildfire smoke event as a part of resilience planning for community centre renewal.
- B. Include clean air shelter adaptation in the project brief for new or existing community centre renewal plans.
- C. Increase the capacity and area configurations for indoor open to public spaces that do not accommodate any facility programs and have multifunctional characteristics.
- D. Consider establishing a universal signage system during the extreme weather events/emergency events that are applied to all the community centres for easy and quick recognition of essential refuge areas, toilets, drinking water and no entry zones in the building.
- E. Establish a system to record the community experience during the wildfire smoke event to identify and evaluate the needs and performance of each community centre.
- F. Consider including dedicated senior's centres in every community centre project brief as this demographic is among the highest health-risk population in extreme weather events and emergencies.

II. Conclusion and Way Forward

Developing guidelines and recommendations to adapt community clean air shelter is an important aspect of a broader strategy of community centre renewal plans, which aim to improve the community centres to better contribute to the overall health and wellbeing of the communities in Vancouver. The Vancouver Board of Parks and Recreation and the design team have a significant role to play in ensuring community safety and wellbeing through community facility planning and design. Their responsibilities include considering alternative ways of using existing infrastructure, utilizing existing resources, designing facilities for accessibility, resilience and wellbeing, and adapting to the changing needs of the community.

The existing community centres in Vancouver vary in recreational programs, spatial layout and function based on the demographics of the population in the neighbourhood, project funding, community needs and site constraints. The case study sample aimed at covering a broad range of recreational programs, facility conditions and neighbourhoods to include each aspect in the analysis.

The results of the analysis showed that some of the spatial requirements for a community clean air shelter were met, some needed to be upgraded, and half of them were not present in the community centres. Testing the applicability of the case studies, though Britannia and Roundhouse meet some of the spatial requirements, they cannot be used as CCAS unless the filtration system is upgraded to MERV 13 and above or HEPA filters. On the other hand, Hillcrest and Mount Pleasant have filtration systems with MERV 13 filter, which meets the minimum requirement and needs to be upgraded to HEPA filters during wildfire smoke event to be able to serve as CCAS. Hence, accommodating the spatial requirements for CCAS is significantly dependent on the filtration system of the community centres.

To accommodate the spatial requirements of CCAS, the community centres would potentially need to consider a minor upgrade, major renovation or replacement of the infrastructure based on the existing condition and planning for a particular community centre. The guidelines proposed are applicable to the existing community centres, which may require upgrades to serve as CCAS. Nevertheless, the principles can be applied to the new building project.

To adapt to the changing needs of the community during wildfire smoke events, a set of guidelines are proposed based on this research for existing community centres, which should be considered for each community centre's renewal design and planning.

The applicability of the guidelines is based on the different potential scenarios during the wildfire smoke event and the reduction of interdependencies of the building elements. This clearly highlights the context-specific design proposals and the importance of testing these guidelines on individual projects for effective building and facility functioning.

Since most of the community centres were built around the 1980s, airtightness has been identified as one of the major challenges in older buildings and larger volume spaces in delivering filtered air. Along with using the recommended air filtration system, airtightness and testing are equally important to maintain clean indoor air. If the air filtration, along with airtightness, is not considered, that could lead to increased energy usage and resource inefficiency. This highlights the important relationship between airtightness and low energy/low carbon design, which is an eminent piece in air filtration effectiveness and the climate change impact of the project. This aspect significantly aligns with the Building Step Code/regulatory directions and the green building rating systems tool, which emphasizes on the airtightness targets and testing for a building design project to achieve the low carbon emission targets set by the city.

11.1 Limitations

Some of the limitations of this research project are as follows:

The study does not include capacity calculation of the facility due to the complex nature of the project funding, changing community needs and building design restrictions. However, the Parks Board is underway researching this area and identifying the measure of building capacity for the community centres.

The guidelines and recommendations are based on a small sample of case studies. The sample was selected to be broadly representative of the 24 community centres in the Vancouver area.

The study does not include a building code analysis as this research aimed to address issues that go beyond the building codes and regulations, which investigates spatial requirements, layouts and proximities to meet the community needs during the wildfire smoke event.

The study does not include an in-depth analysis of the mechanical systems, structures and envelope of the building but briefly touches upon the relationship with spatial requirements.

11.2 Future Research Areas

The suggested future research areas would be as follows:

1. Testing the guidelines on a large sample set of community centres to identify the knowledge gaps.
2. Establishing a post-event evaluation protocol to document lessons learned or successes and challenges in the functioning of CCAS to inform planning and design principles in response to wildfire smoke events.
3. Researching how to reduce the interdependencies of the building elements, structure and services while performing spatial transformations like collapsing walls, moving furniture, space expansion and contraction, and changing the function of the rooms.
4. Conducting an assessment of the filtration system and performance to identify potential opportunities and challenges of the rooms in the existing community centres.
5. Libraries were identified as places where people could visit for lounging, which could serve as a CCAS in conjunction with community centres. Hence, it is important to research the potential and challenges of libraries which are located within the existing community centres.
6. Conducting a pilot study for a community centre on the implementation of CCAS during the upcoming wildfire smoke event in Vancouver to identify missing requirements, challenges and opportunities for public health protection and wellbeing.
7. Finally, conducting similar research for other extreme weather events like heat and cold to identify the overlapping and additional spatial requirements to serve as a community refuge area during extreme weather events in Vancouver.

Due to the depletion of resources, rapid climate change and ageing infrastructure, it is crucial to consider the impacts of wildfire smoke events on the communities in the planning and design of the community centres to be able to support and build a resilient environment for the people living in Vancouver. We need buildings and spaces that can adapt and transform effectively while responding to public health protection and wellbeing of the community.

The outcome of the analysis evidently highlights the need for upgrades required for community centres in Vancouver to serve as a community clean air shelter during the wildfire smoke events, which, if not considered, may impact the health and wellbeing of the community at large. Required filtration system, airtightness, building design flexibility, prioritizing clean air space activation, implementing universal wayfinding strategies, dedicating refuge area and providing immediate access to drinking water are the key aspects to establish a CCAS in a community centre. These guidelines and recommendations represent a planning and design challenge that can be incorporated during the typical building design process for renovation or new building project.

Meticulously understanding the needs of the community during extreme weather events, planning for renewal of existing infrastructure and designing for transformation will open new possibilities of space utilization. Therefore, this research hopes to instigate further discussion of these ideas and concepts into future design and planning of the community centres in Vancouver.

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