CLIMATE RESILIENT BUSINESS GUIDE

Future-proofing your business
for a changing climate

CHANGE FOR CLIMATE

Edmonton

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ALL ONE SKY FOUNDATION is a not-for-profit, charitable organization established to help vulnerable populations at the crossroads of energy and climate change. We do this through education, research and community-led programs, focusing our efforts on adaptation to climate change and energy poverty. Our vision is a society in which ALL people can afford the energy they require to live in warm, comfortable homes, in communities that are resilient and adaptive to a changing climate.

Table of Contents

Note: Text in **blue bold** are words listed in the Key Vocabulary section.

1. Introduction: Why build resilience?

With rising temperatures, changing rainfall patterns and more severe weather events being observed, it's clear our climate is changing.

As a result of **climate change**, many businesses have already suffered intense weather-related impacts. And these trends are anticipated to persist. Weather and climate conditions can:

- Damage physical assets and infrastructure
- Present health and safety **risks** to employees
- Reduce productivity
- Interrupt transport logistics and raw materials supply
- Disrupt power, fuel and water supply
- Hinder access to markets and reduce sales
- Increase the cost of doing business
- Create other direct and indirect impacts

Further, businesses depend on the prosperity of their communities – communities that provide them with their supplies, workforce, sales and more. Equally, prosperous communities depend on successful and stable businesses for goods, services and livelihoods. We all become vulnerable when our economic base is damaged or disrupted by extreme weather events.

Climate change requires us all to manage the physical risks that come with changing weather patterns and build resilience to minimize disruptions.

Where this guide comes from

The Climate Resilient Edmonton: Adaptation Strategy and Action Plan (ASAP), released in November 2018, was developed to help build resilience and adapt the community, infrastructure and services to the impacts of climate change. Actions in the Plan, aimed at improving wider community resilience to climate impacts, also have indirect benefits for Edmonton's businesses when it comes to reducing the risks of disruption.

The goal of this Climate Resilient Business Guide and the accompanying **online Climate Resilient Business (CRB) Tool** is to build knowledge and provide practical guidance to help Edmonton's businesses manage the physical risks (see Box 1) associated with climate change.[1] This includes:

- Enhancing the resilience of **fixed assets (i.e. buildings)** to climate-related risks.
- Ensuring safe and productive future working conditions for **employees**.
- Minimizing the consequences of **supply chain** disruptions.

Benefits of resilience for businesses

Building resilience to the physical risks of climate change ensures your business will experience the benefits, such as:

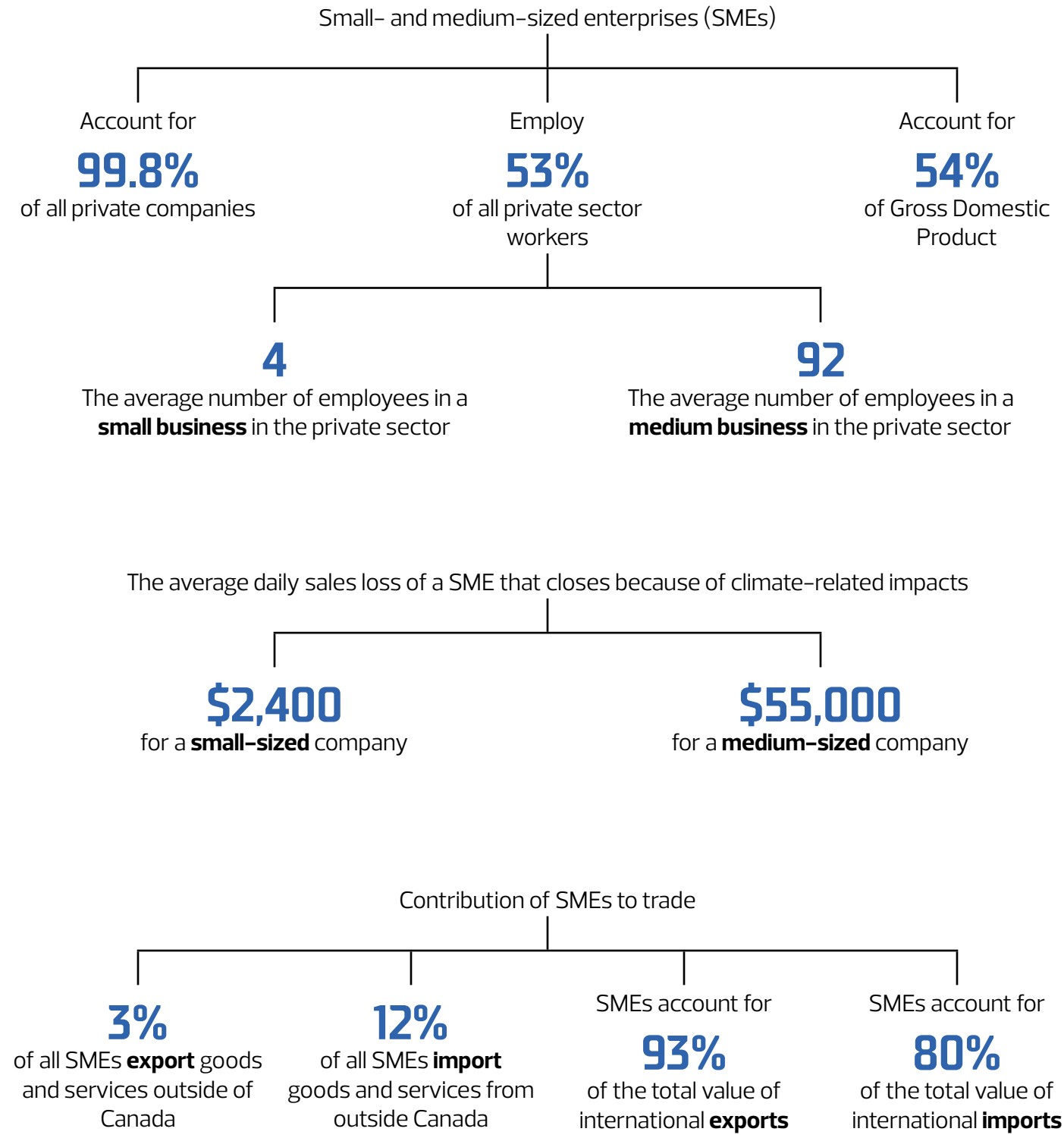
- The ability to better manage and avoid downtime.
- Reduce operating and recovery costs.
- Maintain or increase your profits.

Who this guide is for

More specifically, both this Guide and the accompanying online CRB Tool are **designed to support business owners and managers in Edmonton's small- and medium-sized enterprises (SMEs)**.[2]

Why? Because SMEs are the backbone of the local economy (as shown in Figure 1). But most are unprepared for the risks presented by the changing climate.

Figure 1: Small- and medium-sized businesses are the backbone of the local economy in Edmonton



Box 1: Physical risks versus Traditional risks to business due to climate change[3]

Physical Risks
associated with climate-related physical changes

Transitional Risks
associated with transition to a lower-carbon economy

Climate-related physical risks result from the biophysical impacts of climate change that are either event-driven (acute physical risks) or that arise from longer-term shifts in climatic patterns (chronic physical risks).

Acute risks tend to be associated with short duration events that typically last minutes, hours, days, or weeks. These will generally occur irrespective of climate change—though their frequency, intensity, or distribution may alter because of climate change. Examples include windstorms, heavy rainfall events, freezing precipitation events, wildfire, and temperature extremes.

Chronic (slow-onset) stresses, in contrast, are caused entirely by climate change, with impacts unfolding gradually, building up over longer time frames—decades or more. Examples of chronic (slow onset) impacts include warming trends in air and surface water temperatures and ecosystem shifts, which could lead to reduced water availability, habitat and biodiversity loss and changes in soil productivity.

Limiting further climate change will require changes to energy systems, other GHG emitting activities, and throughout the economy. Businesses will need to adjust their day-to-day decisions. The risks that accompany the adjustment to a low-carbon future are called climate-related transition risks. These risks can arise through a variety of channels, including changes in government policies, innovation and changes in the affordability of existing technologies, and changes in business and consumer sentiment towards lower carbon places to invest, work and live.

Deliberate action to mitigate and adapt to climate change can also produce climate-related opportunities for businesses.

Reducing emissions of heat-trapping greenhouse gases (GHGs) is critical to avoiding the worst (i.e. 'dangerous') effects of climate change and not exceeding technical, ecological and economic limits to (climate) adaptation. This process of reducing GHG emissions is known as (climate) **mitigation**.

The process of adjusting to the actual or anticipated climate and its impacts on business assets, employees, supply chains and markets, is referred to as (climate) **adaptation**. Both, climate mitigation and adaptation are necessary to help businesses build climate resilience and manage climate-related physical and transitional risks to acceptable levels.

Although efforts to reduce emissions and limit future climate change are very much needed, this Guide is focused solely on helping businesses adapt to climate-related physical risks.[4]

1.1 Organization of the Guide

This Guide is structured around a **'business function'** approach.

The approach was developed to assess climate change risks to business and industry as part of the 2017 and 2021 United Kingdom Climate Change Risk Assessments.

It starts by asking the question: ''What is needed to make a typical business work?''

In response to this question, **six business functions were identified**, applicable across any business or sector. Businesses need a **site** from which to operate. They then acquire and use **capital** and depend on **employees** to transform intermediate goods — procured through **supply chains** — into finished products and services. Finally, they choose how these finished products and services are **distributed** to **consumers** and across markets.

These functions are listed below, along with the questions that need to be asked to better understand the risks for **your business**, as a starting point to identify your next steps (adapted from Surminski et al., 2017).[5]

Site(s)

What are the implications of climate change for your site and buildings, equipment, data and inventories?

Access to capital

What are the implications of climate change for access to equity capital, loans and insurance, as well as relationships with investors and lenders?

Employees

What are the implications of climate change for your employees with respect to their indoor and outdoor working environment, and their commute to and from work?

Supply chains

What are the implications of climate change for the availability, quality, price and transport of raw materials and other intermediate goods acquired upstream of your site, including utilities? Would new climate policies adopted within the supply chain affect the availability of goods?

Distribution networks

What are the implications of climate change for business and consumer interactions downstream of your site, including the ways in which finished products and services are delivered to your customers and markets?

Consumers

What are the implications of climate change for the quality and price of, and demand for, finished products and services, as well as consumer behaviour and preferences?

How these business functions relate to one another is illustrated in the **left-hand side** of Figure 2. Key climate-related *impacts* on each business function are listed on the **right-hand side** of the figure.

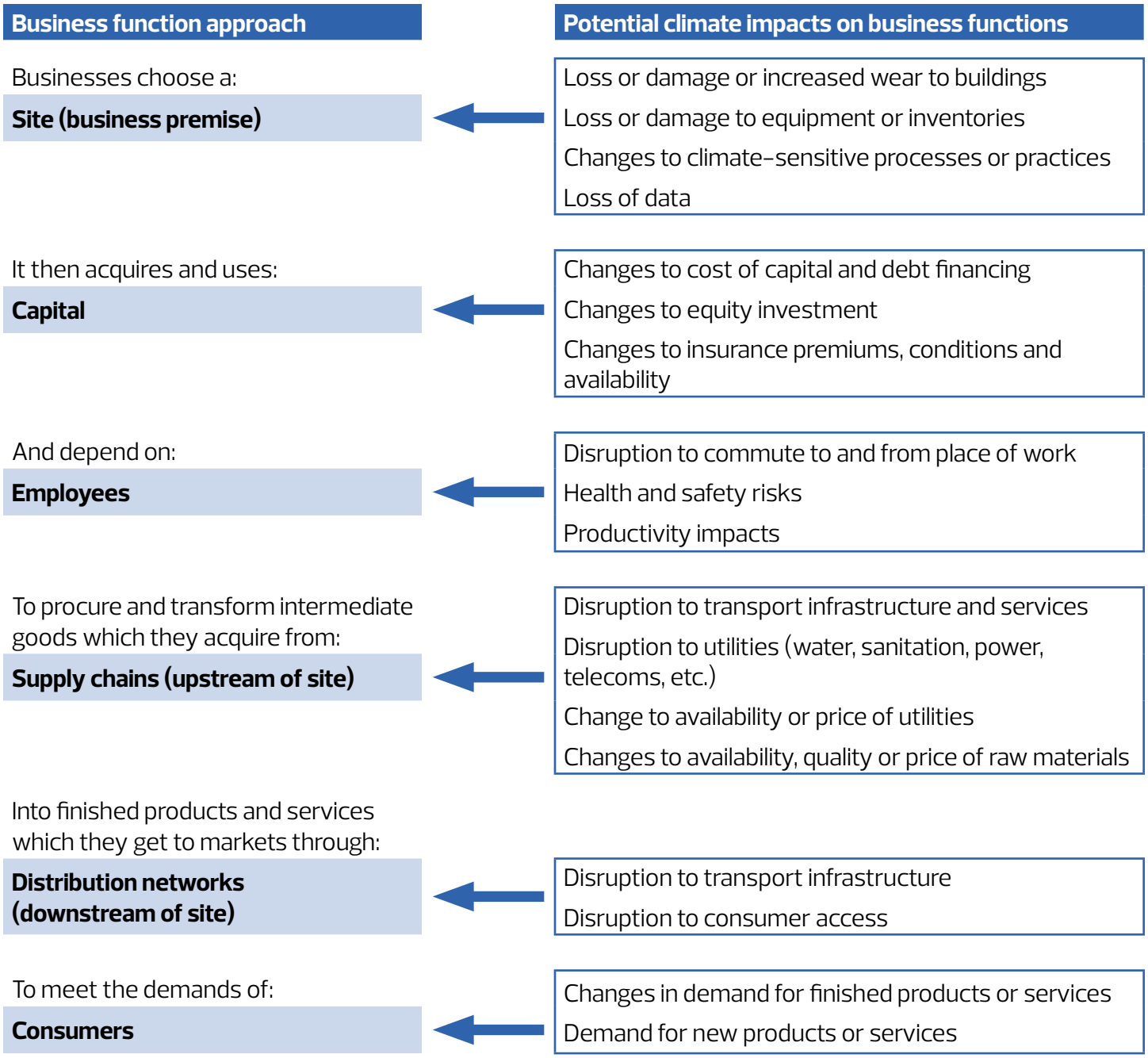
For example, if you consider employees, changing climate conditions could increase the risk of disruption to, or even prevent, your employees from getting to work. It could increase the risk of injuries, illness, and in rare cases, fatalities, as well as reduce the overall productivity of your employees.

Detailed practical support to help you understand and manage the risks across the following four business functions can be found in the following sections of this Guide:

1. **Site** [go to Section 3 of the Guide]
2. **Employees** [go to Section 4]
3. **Supply chains** [go to Section 5]
4. **Distribution networks**[6] [go to Section 5]

If you wish to increase your understanding of projected climate changes across Canadian municipalities and/or internationally, Section 2 summarizes the latest evidence.

Figure 2: Business functions and potential climate–related impacts



Source: Adapted from Surminski et al. (2017)

2. Projected climate changes and impacts

While Earth's climate has changed throughout the history of the planet (due primarily to very small variations in Earth's orbit that change the amount of solar energy our planet receives) the current rate of change is unprecedented. The earth's temperature has risen by over 1°C since the late 1800s, and most of the warming has occurred in the past 35 years.[7] This warming trend is projected to continue throughout the next century and is effectively irreversible.

This section provides a high-level summary of climate projections and impacts for the Edmonton area, then Alberta, Canada and internationally. With today's global supply chains, climate changes anywhere in the world can affect your business in Edmonton.

2.1 Edmonton

Weather records from the Edmonton area show the mean annual temperature has increased about 1.5°C over the past century (or 0.15°C per decade) . This rate is about 60 per cent faster than the observed global rate of surface warming over the same period.[8] Winter temperatures have increased even more substantially, by 3.0°C over the past century (or 0.3 °C per decade).

Over the last 50 years the rate of annual warming is over double the average rate observed over the past century, with mean annual temperature increasing at 0.34°C per decade.

Climate change projections for Edmonton can be found at **edmonton.ca/climatealmanac**, under ''Temperatures''. But in general, Edmonton can expect to see the following changes in climate in the coming decades:

- Hotter summers, with an increase in average temperatures, hot days and heat waves.
- Warmer winters, with fewer cold days, fewer freeze-thaw cycles and less snow.
- More precipitation overall, including more extreme precipitation events (e.g., with larger volumes of rain falling in a single event relative to what Edmonton normally experiences).
- Drier summers, caused by higher temperatures, coupled with virtually no change in summer precipitation, but significant evapotranspiration (evaporation and water transfer from plants into the atmosphere).
- More extreme weather overall.

Table 1 below summarizes projected climate changes for the Edmonton region under a 'very high' scenario (referred to as **RCP**8.5).[9] Projections are provided for two time periods:

- The 2050s (a 30-year average of an indicator over the period 2041 to 2070)[10] and
- The 2080s (a 30-year average of an indicator over the period 2071 to 2100).

All projections show a change in each climate indicator relative to a baseline period (defined by the 30-year average of the indicator over 1981 to 2010). For each time span, projected values are shown as median, 10th and 90th percentile.

After Table 1, a glossary of the terms used here is provided in Box 2.

Table 1: Summary of climate projections for Edmonton under a 'very high' climate change scenario[11]

Climate Indicator	Baseline (1981 to 2010)	Projected value by 2050s			Projected value by 2080s		
							
Mean annual temperature (˚C)	3.1	5.2	**6.4**	7.7	7.2	**8.7**	10.2
Hottest day (˚C)	31.1	33.3	**35.0**	36.1	34.6	**37.4**	39.9
Days above 30˚C (days)	4	10	**20**	26	22	**43**	55
Coldest day (˚C)	-35.4	-31.8	**-29.9**	-26.9	-27.9	**-25.4**	-22.4
Freeze-thaw cycles	87	65	**72**	88	56	**61**	72
Frost-free season (days)	131	148	**161**	180	158	**181**	196
Growing degree days (degree days)	1,509	1,849	**2,134**	2,339	2,202	**2,646**	2,895
Total annual precipitation (mm)	459	467	**498**	537	462	**507**	559
Maximum 1-day precipitation (mm)	34	33	**36**	42	32	**36**	42
Maximum 5-day precipitation (mm)	63	61	**67**	82	61	**69**	80

Box 2: Definitions of climate variables in Table 1 and Table 2

Mean annual temperature. The average daily temperature of the year.

Hottest day. The highest maximum temperature in the selected time period.

Days above 30°C. The number of days with a maximum temperature greater than 30°C.

Coldest day. The lowest nighttime temperature in the selected time period.

Freeze–thaw cycles. When the daily maximum temperature is higher than 0°C and the daily minimum temperature is less than or equal to –1°C.

Frost free season. The number of days between the date of the last spring frost and the date of the first fall frost, equivalent to the number of consecutive days during the 'summer' without any minimum temperatures below 0°C.

Growing degree days. A measure of whether climate conditions are warm enough to support plant and insect growth. When the daily average temperature is warmer than the threshold temperature (the lowest possible temperature at which plants or insects grow), growing degree days are accumulated. For Edmonton, the chart shows the number of degree days accumulated above a threshold temperature of 5°C.

Total precipitation. The total amount of precipitation accumulated in the selected time period.

Maximum 1–day precipitation. The largest precipitation total that falls in a single day in the selected time period.

Maximum 5–day precipitation. The maximum total precipitation that falls over a consecutive 5–day period.

Wet days >=10 mm. The number of days where at least 10 mm of precipitation (rain and snow combined) falls in the selected time period.

Maximum number of consecutive dry days. The longest spell of days where less than 1mm of precipitation falls daily.

2.2 Alberta

Similar to Edmonton, the climate across Alberta has changed and will continue to change. Alberta is projected to become less colder than today, with an increase in total precipitation during winter and spring. There will be considerably fewer cold days, higher maximum temperatures and heavier rainfall events. With warmer temperatures, evapotranspiration (overall water transfer from soil and plants) will increase, resulting in soil moisture deficits, leading to the **likelihood** of frequent and intense summer droughts in the south of the province.[12]

Projected values for a selection of climate variables in three regions of the province are provided in Table 2. As with Table 1, the 1981 to 2020 baseline period is used and 'very high' (RCP 8.5) climate change scenarios for the 2050s and 2080s.

Table 2: Summary of climate projections for Edmonton under a 'very high' climate change scenario[13]

Climate Indicator	Central			North			South		
	Baseline	2050s	2080s	Baseline	2050s	2080s	Baseline	2050s	2080s
Mean annual temperature (˚C)	3.1	6.4	8.7	-1.6	2.0	4.5	5.7	9.0	11.1
Hottest day (˚C)	31.1	35.0	37.4	29.6	32.8	35.4	36.0	40.2	42.8
Coldest day (˚C)	-35.4	-29.9	-25.4	-42.7	-36.2	-32.2	-34.0	-28.8	-25.1
Frost-free season (days)	131	161	181	111	136	153	141	166	182
Total annual precipitation (mm)	459	498	507	399	433	468	332	361	369
Wet days >= 10 mm (days)	10	11	12	5	7	8	7	7	8
Maximum 1-day precipitation (mm)	34	36	36	26	29	30	28	30	32
Maximum number of consecutive dry days (days)	29	27	28	25	24	23	34	34	34

The economic, social and environmental consequences of flooding, drought and wildfire in the last decade are already unprecedented in Alberta, where 6 of the 10 most costly weather-related disasters on record in Canada have occurred.[14] With projected changes in temperatures and precipitation patterns, the frequency and severity of these extreme weather events is expected to increase. Indeed, it has been shown that climate change increased both the likelihood of the 2016 Fort McMurray wildfire and the extreme precipitation that resulted in the 2013 flooding in southern Alberta.[15]

The distribution of water resources is also anticipated to shift, reducing productivity in the agriculture, forestry, energy and mining sectors. At the same time, *crop production in Alberta may benefit* from warmer temperatures and a longer growing season, *if* other challenges presented by climate change can be adequately managed by producers, such as the availability of water and the potential increase in pests and disease.

2.3 Canada

On average, all regions of Canada have warmed at twice the global rate.[16] The mean annual temperature in Canada has increased by about 1.7˚C since the mid-1900s, with the Prairies and the North experiencing higher levels of warming. Canada is anticipated to continue warming at twice the global rate in the future.

Temperature trends

Temperatures have risen the most during winter months. Consistent with an overall rise in mean temperature, temperatures during extreme heat periods have become even hotter. In the future, extreme heat will become more frequent, intense and longer, increasing drought and wildfire risks, and amplifying health risks to the public and the workforce.

Precipitation trends

Annual precipitation has been increasing in all regions of Canada and is projected to increase over the remainder of the century. While winter precipitation has increased, the proportion falling as snow has decreased. With further projected warming, the trend towards less snowfall and more rainfall in winter is expected to continue. As a result, snowfall accumulation and snow cover are projected to decline.

In summer months, rainfall is expected to decrease in parts of southern Canada. However, with more convective energy in the atmosphere observed as a result of warming, extreme rainfall amounts accumulating over 24 hours or less are projected to increase, leading to a higher risk of localized flooding in urban areas.

Impact of rising temperatures and changing precipitation patterns

Rising temperatures and changing precipitation patterns will affect the seasonal availability of freshwater, increasing the risk of water supply shortages during summer in some parts of Canada, despite overall increases in precipitation.

At the same time, warmer temperatures, earlier snowmelt and increased winter rainfall will increase the risk of snowmelt- and rain-on-snow related floods in parts of Canada. Seasonal changes in river flows and freshwater availability — whether too much or too little — are projected to continue, increasing the risk of inland flooding and drought.

The oceans surrounding Canada have warmed, become more acidic and less oxygenated. These trends are anticipated to continue and intensify. Such changes adversely affect the health of marine ecosystems, with consequences for the economic sectors that depend upon the goods and services they provide.

Sea level around Canada's Atlantic and Pacific coastlines and the Beaufort coast in the Arctic has risen and is projected to continue rising. Along these coasts, the threat of flooding and erosion from high water-level events and storm surge is expected to increase, along with the risk of damage to coastal buildings and infrastructure, like warehouses and ports. In 2019, about 37 per cent of goods imported to Canada were transported by water. About 19 per cent of all goods *exported* to international markets went by water.[17]

These impacts directly or indirectly affect almost all sectors and value chains of Canada's economy.[18]

2.4 Internationally

In 2017, five per cent of surveyed small and medium enterprises in Edmonton sold (exported) goods and services outside of Canada.[19] The main export destinations were the United States, Europe and Asia. Smaller markets included Central and South America and Mexico.

About 12 to 15 per cent of Edmonton's small and medium enterprises *directly* imported goods or services from outside Canada to be used in the production of goods or were resold as is.[20] Just over five per cent of enterprises had products manufactured at a site outside of Canada. It's worth noting however that even suppliers in Canada have supply chains that extend beyond Canada's borders. Just over 16 per cent of all intermediary resources purchased by Alberta businesses to create goods and services were sourced from outside of Canada.[21]

Table 3 highlights key impacts of climate change on communities in different regions of the world (that could in turn increase the risk of both upstream and downstream supply chain disruptions for your business).[22]

Table 3: Summary of observed regional impacts and risks to communities due to climate change

Impacts on:	Water availability and food production				Health		Cities and infrastructure			
Community Systems:	Water scarcity, water quality, drought	Crop production	Livestock health and productivity	Fisheries and aquaculture yields	Infectious (water- and vector-borne) diseases	Heat, nutrition, labour productivity, harm from wildfire	Inland (river and urban) flooding and damages	Sea level rise, storm surge, cyclones, damages in coastal areas	Storm damage to infrastructure	Damage to key economic sectors
Africa	–	–	–	–	–	–	–	–	–	–
Asia	±	±	–	–	–	–	–	–	–	–
Australasia	±	–	±	–	–	–	–	–	–	–
Latin America	±	–	±	–	–	–	–	–	–	–
Europe	±	±	–	±	–	–	–	–	–	–
North America	±	±	–	±	–	–	–	–	–	–

Legend

+ beneficial climate-related impact

– adverse climate-related impact

± both beneficial and adverse impacts have been attributed to climate change within each region.

For example, crop production in parts of northern Europe have benefited from climate change, while crop production in southern Europe around the Mediterranean has been adversely impacted by climate change.

The colours of the symbols indicate confidence in the contribution of climate change to the observed impacts:

- red: high or very high confidence
- orange: medium confidence
- green: low confidence

Key climate-sensitive economic sectors include: agriculture, forestry, fisheries, energy, mining, oil and gas extraction, utilities, construction, recreation and tourism, and transportation.

Source: Adapted from Figure SPM.2 (page 12) in IPCC (2022)[23]

3. Site

This section summarizes potential impacts of climate change and resilience measures you can take related to your **business site**.

Your site (or business premise) refers to:

- Your building structure or envelope.
- Mechanical, electrical, and water and waste systems.
- The comfort conditions created by your internal environment.

If a building is damaged, for example, by an extreme weather event, it is likely that equipment and inventories will also be damaged. This includes computers and servers that store data, as well as stocks of raw materials, finished products, merchandise and emergency supplies. Equipment stored outside is likely to be damaged directly by extreme weather. The land around your business site may also be affected, including exterior structures and landscaping.

3.1 Understanding climate-related risks to your site

3.1.1 Impacts to buildings

Impacts to buildings can result in a wide range of consequences for your business, including:

- Costs to repair damaged buildings and structures.
- Disruption of services, including lost revenue, from business closure.
- Injury to or death of building occupants, as well as any psychological impacts or trauma from experiencing and surviving a natural disaster.

Building damage can result from a wide range of climate-related weather: high winds, extreme heat, flooding, snow and ice, hail, wildfire, as well as long-term weather changes.

What does that damage look like? Below is a summary by **hazard**.

3.1.1.1 High winds

High winds from severe weather events can cause:

- **Structural damage** including blow-off or collapse of the roof structure, collapse of exterior load-bearing walls, or collapse of major portions of or the entire building, which primarily occurs during strong and violent tornadoes. When wind enters a building through a broken window, door, or roof section, the wind pushes on the walls and roof of the building from the inside. Buildings are generally not designed to resist forces acting on both the inside and the outside walls.
- **Roof damage** (lifting, peeling and blowing off), which is the most common type of wind damage. Extreme winds can also cause blowing debris to penetrate roofs.
- **Damage to windows and window glazing**, typically caused by wind-borne debris. Blown-off windows allow rain and debris to enter the building, causing further damage.
- **Exterior doors to be blown off.** Large sectional or rolling doors are particularly vulnerable. Blown-off doors can allow rain and debris to enter the building, causing further damage, and tumbling doors can cause additional damage or injuries.
- **Wall coverings and soffits to be damaged.** Extreme winds can also cause blowing debris to penetrate siding.
- **Collapse of non-load-bearing exterior walls**, which is common during tornadoes but less common during high winds..

3.1.1.2 Extreme heat

Edmonton's temperatures are increasing, and local temperatures are expected to continue to get hotter. Extreme heat can make the interior of your

building unbearable and uncomfortable, and can lead to:

- Lethargy
- Reduced productivity
- Heat-related illnesses
- In extreme cases, fatalities.

High temperatures and large variations in temperature can also damage building materials (e.g., roofing and siding) over time, causing buckling, bowing, cracking, and sometimes breakage. Some chemical processes are accelerated by an increase in temperature, which can degrade and damage concrete, asphalt and steel structures over time.

Extreme heat risks to buildings can also include electrical system overload and interruption due to increased use of ventilation and air conditioning systems.

3.1.1.3 Flooding

Flooding has the potential to inundate buildings, causing moisture damage and water accumulation in basements and below-grade areas.

3.1.1.4 Snow and ice storms

Snow accumulation beyond what original building designs can handle can result in structural failure or collapse because of but not limited to[24]:

- **Unbalanced snow loads:** When snow accumulates at different depths in different locations on a roof due to drifting and sliding snow, it can potentially overload the roof structure.
- **Rain-on-snow load:** Heavy rainfall on top of snow may cause snow to melt and become further saturated, significantly increasing the load on the roof structure.
- **Snowmelt between snow events:** If the roof drainage system is blocked, improperly designed or maintained, then ice dams may form, overloading the eaves and reducing the ability of sloped roofs to shed snow. On flat or low slope roof systems, snowmelt may accumulate in and overload low areas on roofs.
- **Roof geometry:** Roofs with geometric irregularities and obstructions collect snow drifts in an unbalanced pattern. These roof geometries include flat roofs with parapets, stepped roofs, saw-tooth roofs and roofs with obstructions such as equipment or chimneys.
- **Ice dams:** An ice dam is a ridge of ice that develops at the edge of a roof or around drains that prevents snow or water from melting off the roof. Ice dams can damage downspouts and gutters and affect the structural integrity of the roof. Ice dams are one of the most common sources of roof damage in Canada.

Heavy snowfall and ice build-up can also lead to interior water damage, as snow or ice melts and seeps into the building

3.1.1.5 Hail

Large hailstones can cause extensive damage to roof coverings, siding, windows, doors and exterior equipment such as vehicles. An assessment of a 2016 hailstorm in Texas showed how the following roofing system types performed[25]:

- Built-up roofing with aggregate-surface generally performs well.
- Flat roofs with modified bitumen membrane (shingles) can be severely damaged, particularly when not supported by a high compressive strength substrate.
- Steep-slope roofs with asphalt shingles generally perform well, except when exposed to hail larger than 1.25 inches (32 mm). In this case, asphalt shingle roofs can sustain significant damage, particularly on the windward side, with granular loss, punctures and occasional fractures in the underlying sheathing. Less-supported ridge, hip and valley shingles are more severely damaged.
- Sprayed Polyurethane Foam (SPF) roof systems perform poorly and are severely damaged.
- Flat metal roofs can be severely damaged with large dents and distortion of seams.

- Single-ply membranes had potential for severe damage, particularly when not supported by a high compressive strength substrate.
- Cedar shake and shingles on steep-slope roofs can sustain splits in the shingles, impact marks and broken shingles, when exposed to large hail (>32 mm).
- Metal roofing on steep slopes generally performs well, with only some possible denting.

3.1.1.6 Wildfire

Although building type and designs vary widely, the following building components are the most susceptible to damage during wildfires:

- **Roofs** because they are easily ignited by airborne embers and firebrands (pieces of burning wood). Combustible debris can also accumulate on the roof or in gutters.
- **Exterior walls that are not constructed of fire-resistant materials** are easily ignited by nearby flames, radiant heat and airborne embers.
- **Vents and openings for utilities** and other purposes that allow hot gases and embers to intrude, causing fire to ignite within the building. Openings also allow smoke to enter and cause smoke damage.
- **Door, window and skylight assemblies that are not constructed of fire-resistant materials.** Gaps around doors and breaking glass in doors, windows and skylights may allow hot gases and embers to intrude, causing fire to ignite within the building.
- **Ramps, decks and other attached structures, if constructed of combustible materials**, provide fuel for flames that can spread to the building.
- **Foundations constructed of wood** or other combustible materials can easily ignite.
- **Heating, ventilation and air conditioning systems and equipment** are easily damaged and may allow hot gases and embers to enter the building where equipment penetrates the building's exterior..

3.1.1.7 Drought

Drought can wreak havoc on structures. In extreme drought scenarios, the drying out of soils can lead to:

- Soil shrinkage, causing **building settlement**
- Premature **drying or deterioration of caulking, roofing and exposed membranes**, which can lead to air and water leakage or
- **Excessive shrinkage of wood or wood siding**, affecting the performance of the building envelope.

3.1.1.8 Chronic climate changes

Long-term changes in climate can also eventually cause premature degradation in building structures from wind-driven rain, freeze-thaw cycles, frost penetration, wetting and drying, wind-driven abrasive materials, solar and ultraviolet (UV) radiation and atmospheric chemical deposition on materials.

Specific examples of the most affected building elements include:

- Frost decay of masonry
- Concrete carbonation (from increased atmospheric CO_2)
- Corrosion of embedded metals in concrete (from increased carbonation and chlorination rates)
- Degradation of wood products (from increases in temperature and rainfall)
- Corrosion of metals
- Solar radiation on plastic

3.1.2 Impacts to land around your buildings and site

The land around a building or site can also be negatively affected by long-term climate changes, resulting in higher repair costs and disrupted services. Land damage includes damage to trees, shrubs and landscaping from high winds, extreme

heat, snow and ice accumulation, wildfires, flooding, or drought.

Overall, increasing temperatures and drier conditions will change the composition of forests and ecosystems in and around Edmonton. The changes in climate projected in Edmonton will be more favourable for Mixed Grassland ecosystems, but less favourable for the Parkland ecosystem that currently exists. This shift will change the type of trees that are suitable, the tree pests and diseases we encounter, and the diversity of wildlife species that reside in this area.

3.1.3 Impacts to equipment

Equipment stored outdoors in unprotected areas is most likely to be directly damaged by extreme weather. Exposed assets may include vehicles, benches, picnic tables, garbage cans and outdoor storage facilities.

However, materials inside damaged buildings may also be at risk. This includes computers and servers that store data, and inventories of supplies and materials.

3.1.4 Impacts to building occupants

See Section 4 – Employees.

3.2 Building resilience and adapting your site for climate change

Building resilience for your business is about reducing your **vulnerability** to changing climate and extreme weather events, maintaining services and protecting the long-term value of your assets.

3.2.1 Buildings

3.2.1.1 High winds

Planning and Design

- Use climate projections to **calculate wind loads and wind resistance** and design, detail and specify the structural system, building envelope, and exterior-mounted mechanical, electrical, and communications equipment to meet the factored design loads.
- Plan and site buildings to **avoid wind tunnel effects**.

Structural

- **Simple roof designs.** Building irregularities, such as corners, bay windows, stairway towers and chimneys can cause localized turbulence and wind speed-up, which increases wind loads. A simple roof design with fewer obstructions and irregularities is less susceptible.
- **Steep-sloped roofs** are less vulnerable to wind damage.
- Buildings should have a secure **"continuous vertical load path"**. A continuous vertical load path requires that major structural systems – including roofs, walls and upper and lower stories – are well connected, and that the entire structure is securely connected to the foundation.
- Incorporate a **safe room or storm shelter** in the design of new buildings.
- **Aerodynamically efficient structures** reduce deflection and resonance, including curved corners, minimized eave overhangs, dynamic

stabilization systems and better foundation design.

- Interior **non-load-bearing masonry walls** next to occupied areas should be designed to accommodate loads exerted by a design wind event. Note: design wind speed is an engineering calculation that involves wind speeds, pressures, topography, building height and more.

Building Envelope

- Install **wind-resistant roof covering**[26] and follow **installation best practices** outlined in the Insurance Institute for Business and Home Safety – Commercial Wind Standard.
- Protect the **mechanical fasteners and plates** that secure insulation boards on low-sloped roof covers by placing them below an adhered cover board and roof cover.
- Supplement impact-resistant roof coverings with **roof underlayment** installed over the entire roof deck, prior to installation of the roof cover.
- Use **plywood** instead of oriented strand board (OSB) for roof sheathing.
- Install **impact-resistant cladding material** such as steel, fibre cement, Cementitious stucco, brick or concrete.
- Install **impact-resistant skylights**[27]. Skylights and their attachments should be designed and detailed to withstand high wind speeds and provide resistance to lifting.
- Install **impact-resistant windows and doors**, including garage, overhead and entry doors
- Install **safety film** on window and door glass. Window safety films make windows shatter-proof, holding glass fragments in place if the window is damaged. The film should be 4 mm thick minimum.
- Install **storm shutters** or have them readily available for application during a storm.
- Ensure growth on **green roofs** is less than 8 inches (20 cm) in depth.
- Design **gutter systems** including gutters, straps, brackets, joints, fasteners and roof flanges to be wind resistant.[28]

Mechanical Systems

- Design and install **roof-mounted structures and equipment** to withstand high wind speeds and check for engineering standards.

Electrical systems

- Design and install **photovoltaic systems** to withstand high wind speeds and according to engineering standards.
- Install battery-operated **emergency lighting** in critical mechanical and electrical rooms, as well as in emergency exit stairwells for building evacuations, in the event that back-up generation equipment fails or malfunctions.
- Design all roof-mounted antennas, satellite dishes and other communication equipment and their connections for appropriate wind load requirements.
- Install wind resistant **roof-mounted lightning protection systems**.[29]
- Ensure systems are in place to provide **temporary back-up power** for disruptions in electrical power. Or provide **permanent back-up power**, switching gear and/or power hook-ups and infrastructure for temporary generators, to provide power for critical equipment.

3.2.1.2 Extreme heat

Planning and Design

- Provide **shaded external spaces** next to buildings for people to use during extreme heat events. These spaces should have access to power and water services.
- Orient buildings and massing to **self-shade** in summer and protect from extreme heat conditions.
- Design buildings for **passive survivability**. This means buildings should be able to maintain thermally safe conditions during a power outage that lasts four days during the peak

summertime and wintertime conditions projected for a typical year (in future climate scenarios).

Structural

- Use **external shading on walls** to intercept sunlight before it reaches the walls and glazing of the buildings. Shading devices can include horizontal overhangs or louvers for solar orientations, and vertical fins and egg-crate designs for other orientations.

Building Envelope

- Provide high levels of **insulation** in walls (including basement walls) and attics, especially in the outside walls where heat is most likely to be gained or lost. The Alberta Building Code (2019) outlines minimum levels of thermal insulation. Businesses can and should exceed these values where it is both practical and economical. Adding insulation during a renovation is an ideal time.
- Install **energy efficient windows** to reduce both heat loss and solar heat gain, particularly on east and west facades (see Box 3).
- Install **shading overhangs or operable shades** on all south-facing windows.
- Install **adjustable or retractable interior shading devices**, like roller or venetian blinds or curtains.
- Incorporate **glazing on windows** to reduce solar heat gain.
- Include **natural ventilation** options such as operable windows and specialized vents. Operable windows should be placed on opposite sides of the building, and/or at different heights, in each room or space to allow for natural ventilation.
- Design for **airtight construction** and controlled ventilation and solar heat gain to limit external air flow when even hotter conditions occur outside.
- Provide high levels of **internal thermal mass** and provisions for passive night-time flushing.

Box 3: Efficient window properites

Three key properties that define the energy efficiency of windows:

- The U-factor: the rate at which a window conducts non-solar heat flow. The lower the U-factor, the more energy efficient the window. [Range: 0.62–1.98]
- The solar heat gain coefficient (SHGC): the fraction of solar radiation admitted through a window. The lower the SHGC, the more effective the window is at blocking heat gain from the sun. [Range: 0.01–0.69]
- The energy rating (ER): This balances a window's U-Value with its SHGC and airtightness (another energy efficiency property). A higher energy rating indicates a more energy-efficient product.

- Install **high-reflectivity roofing materials** that have a high solar reflectance index value.[30]
- Install a **green or brown roof**.
- Establish a **cooling area refuge** (a room to go to during heat waves).

Mechanical Systems

- Design building cooling systems to handle an **increased cooling load over time** (i.e., adequate space in the mechanical room to install a larger system).
- Allow for **future flexibility in cooling systems** by providing space for future electrical, water, ductwork and radiant cooling to be added as needed.
- Install **air-source or ground-source heat pumps** – both of which are more efficient than standard air condition systems.
- Provide a **whole-building fan** for night flushing, with the capacity to power it with emergency backup power..

Electrical systems

- Design systems for **ties to renewable energy sources**/district energy solutions, such as solar thermal, wind, clean biomass/bio-digestion and/or micro-hydro.[31]
- Design for site-specific and building-based **renewable and efficient cooling systems** that incorporate renewable technologies, groundwater cooling loops or earth-tube cooling systems.

3.2.1.3 Flooding

The following actions apply to buildings within flood risk zones, including the 1:500-year flood inundation zone for the North Saskatchewan River and areas subject to stormwater or overland flooding.

Planning and Design

- **Avoid development within the 500-year floodplain** of the North Saskatchewan River, in flood-prone areas, or in high groundwater areas.
- **Use natural infrastructure, Low Impact Development (LID) measures** and grey infrastructure to retain, infiltrate, evaporate/transfer or filter runoff so that storm overflows are treated and runoff volumes are minimized.
- Avoid the need for **depressed (reverse slope) driveways**.
- Conduct detailed flood mapping and develop a **flood protection plan** for the site.

Structural

- Buildings that must be located in the 500-year floodplain or other flood-prone areas should have **no basements** and be built well above the flood construction level.
- Seal **cracks** in foundation walls and basement floors to reduce the risk of infiltration flooding/seepage.
- Apply **foundation drainage** and moisture protection approaches (e.g., weeping tile) to manage groundwater that has not been directed away from the building.

Building envelope

- Use **flood-damage-resistant building materials** for walls, ceilings, insulation, flooring, doors and cabinetry.[32]
- Use **pressure-moderated rainscreen walls** to shed water at the face with back-up drainage. For high-rise buildings, consider pressure-equalized rainscreen walls for exterior walls.
- Ensure **vapour permeable air barriers** allow for drainage and two-way drying via ventilation, evaporation or diffusion.
- Minimize water seepage into the building by sealing all **entry points** that are close to grade, including gaps between foundation walls and framing around windows and doors, gaps around piping, wiring and conduit penetrations in foundation walls and cracks in brickwork.
- In high flood areas, minimize moisture damage or facilitate disposal of materials and restoration by leaving basements and below-grade areas unfinished or with minimal materials, using **cleanable and moisture resistant materials or disposable materials**.[33]
- Avoid **lower-than-grade windows** in flood-prone areas.

Mechanical and Electrical Systems

For new buildings constructed in flood-prone areas:

- **Locate critical equipment and infrastructure above the 500-year floodplain** (HVAC, electrical transformers, switchgear and service panels, communication systems, fuel, etc.)
- If the critical equipment cannot be sufficiently elevated, **provide flood protection** such as flood gates, walls, doors and/or inflatable barriers to prevent water intrusion.
- Provide permanent **back-up power**, switching gear and/or power hook-ups and infrastructure for temporary generators to provide power for critical equipment.

For existing buildings in flood-prone areas[34]:

- Relocate the **main electrical panel** out of the basement and isolate circuits feeding electrical outlets and equipment in the basement, so that power can be restored quickly in the event of a flood.
- Install a **weather-proof service disconnect switch on the outside of the building** between the meter socket and the existing panel in the basement. This switch would have provisions for disconnecting the existing panel.
- Install an **electrical service panel in an outbuilding**, if one exists, to feed the building as a sub-panel. Receptacles within the outbuilding could supply power for restoration, while the building remains de-energized.
- Equip fuel supply lines with **float-operated automatic shut-off valves**.

Water and Wastewater

- **Sanitary disconnect.** Eavestroughs, downspouts, foundation drains, and sump pumps should not be directly or indirectly connected to, or directed to sanitary or combined sewer systems.
- Install **backflow prevention devices** on below-grade plumbing fixtures and equipment to protect your premises from backflow from public sewers. All backflow prevention devices should be installed in accordance with the manufacturer's recommendations and the Plumbing Regulations. Backflow prevention devices are required under the National Plumbing Code, adopted by regulation in Alberta.
- **Eavestroughs and downspouts** should be installed to discharge water well away from the building, ideally at least two metres away from the foundation. Water should discharge to a lower point in the landscape that can absorb the water, such as a rain garden or swale, or onto a splash pad that directs water away from the building and toward a permeable surface.

3.2.1.4 Snow and ice storms

Planning and design

- Provide **adequate entrance and exit for vehicles**, snow removal equipment and emergency vehicles to anticipate winter storm conditions.
- Prepare a **snow and ice storm response and removal plan** defining when snow removal should be initiated, how access will be provided for snow removal (i.e. to roof) if off-site snow removal is not possible.

Structural

- Harden the **roof system/structure** to prevent collapse by designing the snow loads to be greater than the Building Code design requirements.[35]
- **Simplify roof designs.** Building irregularities, such as corners, parapets, equipment, bay windows, stairway towers and chimneys collect snow drifts in an unbalanced pattern. A simple roof design with fewer obstructions and irregularities is less susceptible to snow and ice storms.
- Consider **steep-sloped roofs** which shed snow more easily.

Building Envelope

- Install **high-performance roofing materials** rated for higher-than-code snow loads and a waterproof membrane (ice and water barrier) where appropriate.
- Increase **roof and attic insulation** to protect against ice dam formation.
- Enhance **sealing** around ceiling fixture penetrations.

Electrical Systems

- Ensure systems are in place to provide **temporary back-up power** for disruptions in electrical power. Or provide **permanent back-up power**, switching gear and/or power hook-ups and infrastructure for temporary generators, to provide power for critical equipment.

3.2.1.5 Hail

Planning and Design

- Provide **undercover or covered parking spaces**, ideally for at least 75 per cent of total parking spaces.

Structural

- Consider **steep-sloped roofs**, which are less vulnerable to hail damage.

Building Envelope

- Install a **hail-impact-resistant** roof cover.[36]
- Protect the **mechanical fasteners and plates** that secure insulation boards on low-sloped roof covers by placing them below an adhered cover board and roof cover.
- Supplement hail-impact-resistant roof coverings with **roof underlayment** installed over the entire roof deck, as well as a self-adhering waterproofing underlayment (ice-and-water shield).
- Install impact-resistant **skylights**.[37]
- Use **hail-resistant cladding material** such as steel, fibre cement, Cementitious stucco, brick or concrete.
- Install **impact-resistant windows and doors**, including garage, overhead and entry doors.
- Install **safety film** on window and door glass. Window safety films make windows shatter-proof, holding glass fragments in place if the window is damaged. The film should be 4 mm thick minimum.

Mechanical Systems

- Install **hail guards** on all vulnerable components of roof-mounted equipment, including but not limited to air conditioner condenser fins and air intakes such as fans.

Electrical Systems

- Install **hail guards** on all vulnerable components of roof-mounted electrical equipment.
- Install **hail damage-resistant photovoltaic systems**.[38]

3.2.1.6 Wildfire

The following actions apply to buildings in wildfire risk zones (within 500 metres of a forested/wildland area).

Planning and Design

- Conduct a **hazard and exposure assessment** if there are wildland (vegetative) fuels that could sustain wildfire spread within 500 metres of your building. A hazard assessment will tell you the likelihood of a large, high-intensity wildfire occurring within 500 metres, as well as the potential for a structure to be impacted by fire sources, should a high-intensity fire occur nearby.
- Create a building-specific **wildfire response plan** that designates refuge areas, access and exit routes, and minimizes adverse effects on indoor air quality, with action plans to prohibit outdoor air intake and communicate with people inside to avoid opening doors and windows.

Structural

- **Avoid constructing ramps, decks and other attached exterior structures from combustible materials** or too close to heavily vegetated areas and steep slopes or gullies.
- **Foundation walls should be constructed of concrete or masonry.** If using insulated concrete forms (ICFs), follow the guidelines in the National Research Council Canada – Guide for Wildland-Urban Interface (WUI) Fires.
- **Protect the underside of open foundations** where building piers or piles, framing and subflooring are exposed, by using fire-resistant materials (fire-retardant-treated wood panels, fiber-cement panels, or metal panels), Type X gypsum board, and/or fire-resistant skirting around the perimeter of the building.

Building Envelope

- Use **non-combustible or ignition-resistant cladding** material for exterior walls, such as type X exterior gypsum, steel, masonry, cement board, Cementitious stucco or concrete.

Exterior Type X gypsum board can also be installed between the studs and wall covering to reduce the potential for heat transfer and spread of flames to the interior.

- Seal **openings and penetrations** in the exterior wall cladding and wall components to ensure no gaps greater than 3 mm.
- Use **fire-resistant roof covering materials** with a Class A classification, which could be made of metal, asphalt, clay or rubber.[39]
- Install a **fire-resistant underlayment** to prevent wildfire exposures from reaching the roof deck.
- Use **non-combustible flashing**.
- Use **non-combustible drip edges** and ensure they extend at least 75 mm up-slope from the edge of the roof.
- **Gutters and downspouts** should be non-combustible and fitted with corrosion-resistant, non-combustible screens or guards to prevent build-up of combustible materials
- **Eaves, soffits and roof projections** should use non-combustible material.
- **Service openings and vents** should be enclosed by materials tested to resist entry of embers and direct flame impingement, or screened with corrosion-resistant, non-combustible wire mesh with a maximum mesh aperture of 3 mm.[40]
- **Exterior doors** (including sectional and rolling doors) **and frames should be non-combustible** and have a fire-protection rating of not less than 30 minutes.[41]
- Windows, exterior door windows and skylight assemblies should include an outer pane of **tempered or heat-strengthened glass**.
- Window screens should be made of **corrosion-resistant, non-combustible wire mesh** with a maximum mesh aperture of 3 mm and supported by a metal frame.
- **Door and window shutters should be made of non-combustible material**, fixed to the building and non-removable, with no gaps greater than 3 mm, be manually operable, and protect the entire window assembly or door assembly. Window shutters can be permanent or temporary and include roll-down window covers.

Exterior elements

- **Decks, balconies, porches and other exterior building elements** should be constructed of non-combustible materials, such as stone, concrete or masonry.
- Enclose all **underfloor areas** with fire-resistant materials to prevent embers from penetrating the underside of the structure.
- **Openings in enclosed areas that are required for ventilation** should be screened with corrosion-resistant, non-combustible wire mesh with a maximum mesh aperture of 3 mm.

Mechanical systems

- Protect **exterior-mounted equipment with enclosures** constructed of fire-resistant or non-combustible materials.

Electrical systems

- Install **underground power supplies** to buildings wherever possible.
- Ensure systems are in place to provide **temporary back-up power** for disruptions in electrical power. Or provide **permanent back-up power**, switching gear and/or power hook-ups and infrastructure for temporary generators, to provide power for critical equipment.
- Shield **exposed electrical components** with metallic conduits or other fire-resistant materials such as flashing to reduce the possibility of damage.
- To mitigate electrical failures to critical equipment, install **transfer switches** that facilitate the use of a back-up generator.

Water and wastewater

- Ensure buildings have **adequate water supply** from an approved water source to suppress fire and protect structures.

- Install **automatic sprinkler systems** to prevent fire from spreading throughout the interior of a building.

3.2.1.7 Drought

Water and wastewater

- Reduce indoor water consumption by installing **low flow water fittings, fixtures and appliances**.

3.2.1.8 Chronic climate change

To enhance your building's resilience to hotter temperatures and broader ranges of annual and daily temperature changes:

- Use **dimensionally stable products** that have a lower coefficient of thermal expansion and will help to reduce overall dilation.
- Use products with **enhanced elasticity** that can resist repeated movement cycles (e.g., when considering jointing and sealing products).

To enhance your building's resilience to accelerated aging due to more prolonged periods of heat:

- Use products with **heightened resistance to heat aging and UV radiation** for exterior components that are directly exposed to solar radiation such as:
  - roofing, cladding, windows,
  - insulated glass units,
  - plastic fenestration components,
  - polymer-based waterproofing and sheathing membranes,
  - jointing and sealing products and
  - exterior paints and coatings.

To enhance the resilience of building walls and window and door frames to stronger, wind-driven rain loads:

- Use more **robust design approaches** to enhance your water drainage from surfaces and minimize the likelihood of water retention in intervening spaces (e.g., for wall assemblies, window design and installation).
- Use **products that are dimensionally stable** when wetted and have enhanced resistance to hydrolysis, i.e., degradation from contact with warm water (e.g., for insulation products that maintain thermal resistance at wall-window and wall-door interfaces, polymer-based waterproofing and sheathing membranes, jointing and sealing products).
- Use **metal product components with enhanced resistance to corrosion** after wetting (e.g., for roofing, cladding, window frames, window ties, brick ties).

3.2.2 Land

3.2.2.1 High winds

- Plant **coniferous (evergreen) trees** in a row on the prevailing wind side of buildings to provide wind protection.
- **Avoid planting trees too close** to buildings and primary access roads.

3.2.2.2 Extreme heat

- Provide **undercover and/or shaded parking** spaces, ideally for at least 75 per cent of total parking spaces.
- Maximize **parks, green spaces and vegetation** on your property.
- Install **high-reflectivity paving materials** (i.e., high solar reflectance index values), such as light concrete or white aggregate for roads and walkways.
- Use **green/open-grid pavement systems** for roads and walkways.
- Provide **evaporative cooling solutions** with fountains, misters and water features.
- Design enclosure systems with **exterior shading devices** to minimize solar heat gain during peak summer conditions.
- Use **vegetative cooling solutions** such as trees, shrubs and plant-based pergolas to shade buildings, surfaces, paved areas and playgrounds[42] (Box 4):

Box 4: Benefits of vegetated cooling

Shaded walls and surfaces may be 11 to 25˚C cooler than unshaded surfaces. Temperatures under a canopy of shade trees may be reduced 1 to 5˚C compared to open terrain and 11 to 17˚C compared to parking lots.

Each 10 per cent increase in tree canopy cover reduces maximum mid-day air temperatures by 1˚C.

  - Plant deciduous trees on the south, east and west sides of a building, with a minimum distance of twice the tree height away from the building.
  - Locate ground cover and shrubs around buildings, to lower air temperatures and reduce reflected sunlight.
  - Plant trees in courtyards, parking areas and next to walkways.

3.2.2.3 Flooding

- **Lot drainage** should direct water away from the building. This is the most effective means of protecting buildings from urban flooding.
- The **"backfill zone"** (within 2 metres of the wall) should have a five per cent slope, and a 1.5 per cent slope beyond that to ensure water drains away from the building.
- Incorporate **green infrastructure** at sites (bioswales, park areas, rain gardens, permeable pavement, box planters) to absorb rainwater and excessive moisture.
- Choose **plants for survival and water absorption capacity**.[43] Plant native vegetation where possible and choose plant varieties that thrive on your site conditions (climate, soil, water availability) and grow well together (based on water need). Consider plants that require less maintenance and water, are resistant to pests and can tolerate or absorb pollution.
- Ensure your **fences, landscaping and other property features** do not compromise the integrity of your lot grading and drainage.

3.2.2.4 Snow and ice storms

- Use **heated sidewalks and drives** to provide safe walking surfaces and access.
- Plant **native or adapted tree species** that can handle heavy snow that may occur earlier or later in the season when in full leaf.

3.2.2.5 Wildfire

- **Trim back vegetation** near power lines to maintain a minimum distance of five metres.
- **Remove hazardous trees** that are within a distance of 1.5 times the tree height of a power line.
- **Manage trees, shrubs and plants located within the power line right of way** to promote low flammability vegetation, with gaps between ground cover.
- Fences next to buildings should be constructed of **non-combustible materials**.
- Follow **FireSmart Guidelines** for vegetation management:
  - Plant fire-resistant trees and shrubs, which have moist, supple leaves, accumulate minimal dead vegetation, have water-like sap and a low amount of sap or resin material.[44]
  - Ensure low groundcover near buildings to mitigate fire risk.
  - Evergreen trees with cones and needles (conifer trees) are highly flammable and should not be located within 10 metres of your buildings. These include Spruce, Fir, Pine and Cedar.
  - Manage vegetation around buildings and facilities in accordance with FireSmart recommendations:
    - Within 1.5 metres: no combustible materials.

- 1.5 to 10 metres: fire-resistant zone, free of all materials that could easily ignite.
- 10 to 30 metres: thin and prune evergreen trees, regularly clean up fallen branches, dry grass and needles.
- 30 to 100 metres: look for opportunities to create fire breaks by creating space between trees and other flammable vegetation. Thin and prune trees and shrubs to reduce fire intensity.

3.2.2.6 Drought

- Incorporate **xeriscaping** into landscaping design and plant drought tolerant trees, shrubs and grasses.
- Install **lawn irrigation systems** to provide water efficiently to plants that need it to survive drought conditions and thrive.
- Incorporate a **rainwater collection system** (rain barrel or cistern) to use for non-potable water applications.
- Use **drought resilient groundcovers** such as tiered gardens, rock gardens, low water-use shrubs or flowering trees instead of grass lawn. These garden features use less water and act as wonderful filters and sponges to help absorb rainwater.
- Retain rainwater on site by incorporating **permeable surfaces and water retention systems** (rain gardens), to reduce runoff to the stormwater drainage system and water loss to your lawn and landscaping beds.

Chronic climate change

- Plant **climate resilient trees, shrubs and grasses** that will survive and thrive even in the climate conditions of the future.[45]

3.2.3 Equipment

High winds

- Securely anchor all **outdoor accessories and equipment** at and around your building(s) to avoid flying debris in windstorms.

Wildfire

- Use n**on-combustible materials for outdoor/ exterior equipment** such as benches, guard rails, signage, retaining walls, playground equipment, picnic tables and garbage cans.
- **Liquefied Petroleum (LP) gas tanks** located within 100 metres of a building should **rest upon a non-combustible surface** that extends not less than 1.5 metres outward in all directions from the perimeter of the tank. Any vegetation within 3 metres of the perimeter of LP gas tanks should be removed.
- Enclose **utility equipment and chemicals** in a fire- or heat-resistant building or enclosure.
- Where possible use fire-resistant materials for **water storage and distribution system equipment**, such as pipes, pumping stations, treatment facilities and wells.

4. Employees

Your employees are your most valuable resource. On average, adults in Alberta spend about half of their waking hours commuting or at work.[46] That makes their health and safety paramount to the success of your business.

Evidence for the negative consequences of climate change on human health is unequivocal.[47] and climate change may increase the risk to the health and safety of the workforce. Employees are often exposed to adverse environmental conditions for longer durations and intensities than the public. Workers are less able to avoid exposure especially if they work outdoors.

And just as the health of some population groups are more affected than others, certain groups of workers are more vulnerable to climate-related impacts because of where they work or the type of work they do.

Climate change can affect employees in two ways:

1. More severe or frequent hazards, such as storms, heat events, wildfires and air pollution – hazards that are likely already contributing to occupational injuries, illnesses and fatalities.[48]
2. Unprecedented or unanticipated occupational hazards, such as widening ranges of infectious disease vectors, like ticks and mosquitoes.

In this section you will find guidance to help you:

- Better understand how these climate-related impacts will affect your workforce, and the level of risk posed to your business (Section 4.1), and
- Identify actions to help you manage risks to acceptable levels (Section 4.2).

4.1 Understanding climate-related risks to your workforce

We start by identifying existing hazards to your workforce that will be made worse by climate change, as well as new hazards that climate change will create (i.e., the potential for tick- and mosquito-borne diseases to expand into the region).

4.1.1 Impacts of climate change on workforce hazards

The main climate-related occupational hazards are listed below.

4.1.1.1 Ambient air temperature

Climate change will lead to an increase in both average and extreme temperatures in Edmonton.

More extreme temperatures

In terms of temperature extremes, Edmonton is projected to see an additional 7 – 8 days with daily highs exceeding 30°C by the mid-2030s and an additional 22 – 23 days by the mid-2060s.

Exposure to moderate to high temperatures can cause acute heat stress (edema, rashes, cramps, exhaustion, heat stroke and hyperpyrexia (exceptionally high fever)) among workers[49], especially those in more physically strenuous jobs. Moderate to high temperatures can also worsen chronic conditions such as cardiovascular disease, respiratory disease, cerebrovascular disease and diabetes-related conditions.

Workplace temperatures and worker performance

Workplace temperatures also affect worker performance: **beyond certain temperatures, hourly productivity of workers declines**.[50] When an employee performs strenuous physical work the risk of overheating increases.[51]

Heat generated needs to be transferred to the external environment to avoid increases in the body's temperature. If the body is unable to dissipate the heat— because of prolonged exposure, or water or salt deficiencies—it begins

to cause dizziness, muscle cramps and fever. In extreme cases, prolonged exposure to high temperatures can worsen acute cardiovascular, respiratory, and cerebrovascular distress, which can be life threatening and hospitalization..

At lower temperatures, before these serious health effects occur, workers can experience diminished 'work ability''.[52] Temperature stress may affect workers in two ways:[53]

- It may cause direct physical or psychological discomfort.
- It may reduce productivity, altering the amount of effort exerted or the marginal return of that effort.

These two direct effects may adversely affect the number of hours that can be worked impacting productivity.[54] For example, workers at an outdoor industrial site in Ontario lost on average 22 hours each summer (equivalent to about 1% of annual work hours) as a result of taking breaks or stopping work due to heat stress.[55] In Edmonton, heat-related productivity losses for the local economy can be substantial, as shown in Box 5.

Workplace temperatures and accidents or injuries

Exposure to heat can also increase the risk of workplace accidents and injury. High temperatures can change worker capabilities, especially for strenuous tasks.

Box 5: Projected heat-related losses of labour productivity and economic output in Edmonton, attributable to climate change

By the 2050s, estimated losses from exposure of workers in 'high risk' sectors to high temperatures in Edmonton will amount to:

Sector	Work hours lost (000 hours per year)	Lost value added ($ 2020 M per year)
Agriculture	415	$ 0.8
Primary extractive industries	953	$ 24.0
Utilities	191	$ 6.7
Construction	1,767	$ 31.2
Manufacturing	1,775	$ 31.3
Transportation & warehousing	999	$ 17.3

Note: Projected lost value added by the 2050s is measured in constant 2020 dollars.

Source: Boyd et al. (2020)[56]

4.1.1.2 Extreme weather events

Climate change projections suggest the occurrence and severity of some extreme events will continue to rise through this century, with the potential to affect Edmonton directly or indirectly.

River and stormwater (urban) flooding, naturally occurring wildfires, drought, and severe windstorms may increase.[57] For other extreme weather events, such as heavy snowfalls, ice storms, hailstorms and lightning activity, there is the potential to cause considerable disruption and damage.

Extreme weather events can have multiple impacts on occupational health and safety, the most obvious being the potential for work related injuries and fatalities incurred during a weather event.

Indirect causes can also increase the likelihood of injuries or death. For example, outdoor workers speeding up to try to complete tasks before a storm may create unsafe conditions resulting in injuries.

During some extreme weather events, the risk of injuries and fatalities to employees will also be higher during commuting and may increase the risk of accidents for fatigued workers who must remain at the work site and put in extra hours until their replacements arrive.

4.1.1.3 Air quality

Changes in the climate will affect air quality indoors and outdoors, increasing the levels of outdoor air pollutants such as ground-level ozone (O_3)[58] and fine particulate matter (PM2.5)[59].

Increase in fine particulate matter (due to wildfires)

Wildfires are a major source of PM2.5 from natural sources—plants, wildfires and dust. The number and severity of fires in western North America is projected to increase driven by climate change. Because winds can transport PM2.5 great distances, air pollution from wildfires in British Columbia and the western United States can affect workers in Edmonton.

Poor air quality negatively affects respiratory and cardiovascular systems, and can cause premature deaths, hospital visits, acute respiratory symptoms (e.g., coughing, shortness of breath, and more), leading to lost workdays.

Keep Staff Aware with an Air Quality Health Index Lamp

To inform your staff about air quality and the Air Quality Health Index (AQHI), consider setting up an AQHI Light at your workplace. This free online tool available from the City of Edmonton connects a Wi-Fi enabled bulb to automatically change colour and reflect the current AQHI level for any community on the Alberta AQHI Map. To access a user-friendly tutorial on the type of bulb required and instructions on connecting it to your community's AQHI reading, visit **edmonton.ca/airquality**.

Increase in allergens

Changes in minimum and maximum temperatures, precipitation patterns, and increasing concentrations of atmospheric carbon dioxide (CO_2) brought on by climate change are also projected to increase levels of airborne allergens. These changes will influence the prevalence and severity of allergic disease. Higher pollen levels and longer pollen seasons can increase allergic sensitization and asthma attacks, affecting workforce productivity.

Airborne allergens can affect employees indoors or outdoors, or while travelling to and from work.

4.1.1.4 Biological threats

Climate change is projected to alter the seasonality, distribution, and prevalence of vectors and vector-borne diseases (diseases transmitted by the bite of an insect).

Vector-borne diseases from insects including ticks and mosquitoes can carry infectious viruses, bacteria and protozoa (a single cell microscopic animal) from one host (a rodent, bird or deer) to another (a person).

Climatic conditions—in particular, high and low temperature extremes and precipitation patterns—exert a significant influence on vector-borne disease numbers. This happens by altering the geographic range, size and density of the vector population, vector survival rates and activity, the abundance of pathogen-carrying animal hosts, and pathogen reproduction rates. Together, changes in these variables can increase the risk of the pathogen being transmitted to humans.

Lyme disease and West Nile virus

Although ticks and mosquitoes can transmit multiple infectious pathogens to humans, Lyme disease (tick-borne[60]) and West Nile virus (mosquito-borne[61]) are of the greatest concern. Both diseases can result in a range of symptoms, from headaches, fever, fatigue and gastrointestinal issues to serious effects on the nervous system. Even the milder acute symptoms may lead to workers being absent.

Other pathogens — food-borne and water-borne

Several food-borne pathogens are climate sensitive, such as *Campylobacter*, *Salmonella*, and *Escherichia coli* (*E. coli*). These pathogens favour warmer temperatures, so their occurrence is expected to increase with climate change. These food-borne pathogens can result in acute illness.

Water-related afflictions can be affected by changes to air and water temperature, heavy precipitation and runoff brought on by climate change. These changes can also affect the growth, survival and virulence of these pathogens (bacteria, viruses and protozoa, as well as toxins produced by certain harmful algae and cyanobacteria (i.e., blue-green algae). Most water-borne illnesses result in a range of symptoms from mild to severe.

Workers may acquire food- or water-borne illnesses through ingestion or direct contact with food or water contaminated by disease-causing pathogens or toxins.

4.1.1.5 UV radiation

Ultraviolet (UV) radiation levels at the earth's surface are projected to increase with climate change. This is primarily because of damage to the stratospheric ozone layer.[62] Despite the benefits of Vitamin D, exposure to UV radiation is still associated with the development of a number of different medical conditions.

Workers are at greatest risk when the sun's rays are at their highest intensity between the hours of 10 a.m. and 4 p.m. during the summer months. The heat that often occurs during these periods can make some workers remove clothing increasing skin exposure. Working in the vicinity of highly reflective surfaces such as snow, ice and light-coloured sand and concrete also increases potential UV exposure.

4.1.2 Defining levels of climate-related risks to your employees

Assessing the occupational health and safety, and productivity risks to your employees involves:

1. Identifying hazards and risk factors that can adversely affect your workforce (i.e., **risk identification**).
2. Analyzing and evaluating the risk against set criteria to determine its significance to your business (i.e., **risk analysis and evaluation**).
3. Outlining actions to either eliminate unacceptable, high priority hazards or manage their consequences to within acceptable levels (i.e., **risk control**).

There are many guides with detailed step-by-step instructions and templates for performing thorough risk assessments, and completing each of these three steps.[63]

Recommended: Consult Alberta Occupational Health and Safety (OHS) Legislation to ensure you

are fully aware of what is required for compliance. Visit **www.alberta.ca/occupational-health-safety.aspx** for legislation, education and resources.

In this next section, we identify some generic characteristics of the workforce that influence exposure levels to climate-related hazards. We then identify some simple practices to help smaller businesses get a better feel for the level of risk to their employees. The following may be useful as you review the Alberta OHS Legislation.

4.1.2.1 Workforce determinants of risk

The risk posed by different types of climate-related hazards depends on the type of work, the physical effort required, the season and the duration of work time, among other things. As an example, the range of risk factors influencing health and safety from exposure to high temperatures is shown in Figure 3.

Workers expected to be especially at risk include most outdoor workers including those working in: agriculture, construction, landscaping and land surveying, utility, recreation, natural resource extraction, transportation and the waste management and remediation sectors. First responders and other emergency and recovery workers are also at risk.

While the occupational risk posed to indoor workers by climate-related hazards might be lower, it is not insignificant. Several categories of indoor workers may be affected by high ambient air temperatures — especially those who work in warm spaces that are not air-conditioned, such as bakeries, manufacturing sites and warehouses.

Whether working indoors or outdoors, risks arising from exposure to high temperatures depends greatly on the intensity of the work and whether workers are acclimatized to the workloads and temperatures.

Finally, all employees are at risk of delays, accidents or illness, as a result of exposure to extreme weather events, high temperatures or poor air quality during their commute to and from work. The longer the commute, the higher the exposure to the hazard, and the higher the resulting risk.

Figure 3: Web of risk factors for occupational heat–related illness

Source: NIOSH (2016)[64]

4.1.2.2 Key questions to help you determine workforce risks[65]

To help you evaluate the level of potential climate-related risks facing your employees, consider the following questions (NOTE: responses do not account for heavier clothing or personal protective equipment (PPE). The type of clothing worn could increase – or decrease – a worker's risk of heat stress.

Outdoor Workers

What proportion of your employees work largely **outdoors** on a daily basis?		
< 25% (lower risk)	***25–50% (moderate risk)***	***> 50% (higher risk)***
Is the work performed outdoors physically demanding (e.g., construction and landscaping tasks, intermittent heavy lifting, pushing, pulling)? ***If yes, risk is increased***		
Do you schedule or modify work tasks to minimize the exposure of outdoor workers to heat and UV radiation – e.g., use a temperature-driven work-rest schedule or schedule tasks to avoid midday work in summer months? ***If yes, risk is reduced***		
Have employees been trained on the impacts of exposure to high temperatures, poor air quality and UV radiation, how to take precautions to protect themselves, and what to do if they or a co-worker exhibits signs of illness? ***If yes, risk is reduced***		
Do you have a Heat Acclimatization Plan for new employees or employees returning to work after an absence? (A Heat Acclimatization Plan gradually increases the intensity or duration of work performed in hot settings.) ***If yes, risk is reduced***		
Do you take air quality into account when scheduling outdoor work – e.g., by looking at forecasts for the local Air Quality Health Index (AQHI)? ***If yes, risk is reduced***		
Do outdoor workers spend time in grassy or wooded areas? Or work at dawn, dusk or the early evening, or in the vicinity of standing water between April and October? ***If yes, risk is increased***		
Do you educate and encourage employees to take necessary precautions to avoid being bitten by mosquitos or ticks? Do your employees know what to do if bitten by a tick, and the symptoms of Lyme disease? ***If yes, risk is reduced***		

Indoor Workers

What proportion of your **indoor** workforce perform physically demanding work on a daily basis (e.g., moderate to heavy lifting, pushing or pulling)?		
< 25% (lower risk)	***25–50% (moderate risk)***	***> 50% (higher risk)***
Do these employees work with, or close to radiant heat sources (equipment, processes or surfaces)? ***If yes, risk is increased***		
Are workspaces well ventilated (good air flow) with effective air-conditioning? ***If yes, risk is reduced***		
Do you schedule or modify work tasks to minimize the exposure of workers to heat – e.g., use a temperature-driven work-rest schedule recommended by industrial hygienists? ***If yes, risk is reduced***		
Have these employees been trained on how to avoid heat-related illness, how to recognize the symptoms of heat-related illness, and what to do if they or a co-worker exhibits signs of illness? ***If yes, risk is reduced***		
Do you have an Acclimatization Plan for new employees or employees returning to work after an absence? In general, acclimatized workers are at lower risk to high temperatures than unacclimatized workers. ***If yes, risk is reduced***		
Does your business have an emergency response plan that includes procedures to be taken by the business and workers in the event of severe weather? ***If yes, risk is reduced***		

Commuting Workers

What proportion of your workforce have **commutes** to or from work longer than 30 minutes?		
< 25% (lower risk)	***25–50% (moderate risk)***	***> 50% (higher risk)***
Do most employees commute to work using their personal vehicle or public transit? ***If yes, risk is increased***		
Does your business have an Inclement Weather Policy that outlines rules, expectations and operating procedures in the event of extreme weather? ***If yes, risk is reduced***		
Does your business have a work-from-home (or remote work) policy that allows employees to perform their usual job duties at an approved alternative location? ***If yes, risk is reduced***		

4.2 Building resilience and adapting your workforce for climate change

Multiple strategies are required to reduce the risks of occupational injuries, illnesses, fatalities and productivity losses from climate change.

NOTE: Section 4.2 provides a high-level summary. It is recommended that you visit the full-length guide found at: **edmonton.ca/climateresilience** for more detailed information. The interactive online assessment tool that accompanies these guides is another excellent resource, visit **climate resilient business.ca**.

4.2.1 Adaptation specific to climate-related occupational hazards

4.2.1.1 Ambient air temperature

There are three main approaches to managing heat-related impacts on your workforce:

- Engineered controls
- Administrative controls
- Personal protective equipment or behaviours.

In general, engineered controls are the most effective means to avoid heat-related illness and productivity losses, followed by administrative controls. However, despite their effectiveness, engineered controls can be practically impossible in an outdoor working environment. Personal protective equipment should be considered a last resort or be used as a supplementary control method.[66]

The good news is, there are some common strategies that you can employ to reduce the risks associated with higher temperatures in the workplace.[67]

Online Climate Resilient Business Tool

Take the **online assessment** or view the **detailed guide** to identify areas of risk specific to your business and get tailored information on the steps you can take when it comes to:

- Engineered controls to reduce the risk that can come with high temperatures
- Administrative controls
- Personal protective equipment or behaviours your employees can use and adopt.

4.2.1.2 Extreme weather events, air quality, biological threats, UV radiation

Beyond managing the risk of higher temperatures, there are also many steps you can employ to reduce the risks associated with extreme weather, air quality, insect-borne diseases and UV radiation. These can also be accessed in more detail by taking our online assessment.

Take the **online assessment** or view the **detailed guide** to identify areas of risk specific to your business and get tailored information on the steps you can take to manage risks to your employees when it comes to:

- Extreme weather events
- Air quality
- Biological threats (such as insect-borne diseases)
- UV radiation

4.2.2 Adaptation specific to climate-related occupational hazards

Regardless of approaches used, always ensure workers who show signs of heat-related illness are provided prompt medical attention.

4.2.2.1 Ambient air temperature

Below you will find some common strategies to reduce the risks associated with high temperatures in the workplace.

Eliminate or Substitute

- ✓ Review the measures identified in Section 3.2.1.2 to adapt your site for high and extreme temperatures, and make informed decisions:
  - Rethink if the work is necessary.
  - Consider postponing the work until temperatures are safer.
  - Consider moving the work location, if possible, to a cooler space outdoors or an indoor air conditioned space.

Engineered controls

- ✓ Adopt the measures identified in Section 3.2.1.2 to **adapt your site for high and extreme temperatures**, such as:
  - Installing external shading devices and technologies on walls and windows (especially south-facing walls).
  - Increasing insulation levels in walls (especially external walls) and ceiling spaces.
  - Installing partial or full green (vegetated) roofs or walls.
  - Using high albedo (reflective) surfaces (e.g., walls, roofs, paving) where possible.
  - Maximizing green space and vegetation on your site, such as strategically siting trees to provide shade, especially on work areas that receive direct sunlight in summer.
  - Upgrading the ventilation system to increase air flow and velocity through the building(s) and increase evaporative cooling.

- ✓ **Install and use air conditioning** to control the ambient air temperature.

  In some cases, the use of 'spot' air conditioning targeting specific areas or specific groups of workers can be a more cost-effective option than 'whole building' systems. Consider air-source or ground-source heat pumps — both of which are more efficient than standard air condition systems.

- ✓ **Change the location of work to cooler areas**, if possible.

  Can some tasks be performed in a well ventilated or air-conditioned space, or in parts of the building with less direct sunlight (e.g., the NE corner)? An example would be unloading and loading delivery vehicles inside a cooled warehouse, or under a carport or porch.

- ✓ Purchase and **use fans ('spot cooling')** to increase the speed of air movement.

  This improves the heat exchange between the skin surface and air, so long as the air temperature is lower than the skin temperature (about 35˚C). If the air temperature is above 35˚C, you need to reduce the air temperature and fan air speed by bringing in cooler air from the outside or by installing evaporative or refrigerative cooling (see above).

- ✓ **Decrease humidity levels** in the workplace by, for example, sealing leaks from steam values and steam lines and keeping surfaces like floors dry.

  Eliminating sources of water vapor can help reduce the vapor pressure in the air and increase the rate of sweat evaporation.

- ✓ **Reduce radiant heat exchange between workers and hot equipment**, as well as processes and surfaces that surround your employees. Examples include:
  - Lowering the process temperature (which may not be possible in some cases).
  - Relocating, insulating or cooling the heat source.
  - Installing 'line-of-sight' radiant reflective shielding between the heat source and workers.
  - Changing the emissivity of the hot surface by coating the material.

  Providing reflective shields to redirect radiant heat away from workers is often the most cost-effective solution.

- ✓ **Install local exhausts to remove hot air** and steam produced by equipment and vent it to the atmosphere.

- ✓ **Establish a cooling station(s)** where workers can rest in a shaded, ideally ventilated and air-conditioned space, like a portable tent, canopy or tarp, a large vehicle (e.g., a van) or nearby facility (e.g., a recreation centre or mall).

- ✓ **Provide for the proper hydration of employees** by providing cool (10 – 15˚C) water dispensers in convenient, visible locations close to work areas. For workers at remote locations, this might include providing large, insulated jugs that can be refilled with water and ice, for refilling personal water bottles.

Administrative controls

- ✓ Develop an **acclimatization plan**.

  In general, acclimatized workers are able to work in hotter work environments and for longer periods than unacclimatized workers. Acclimatization is the result of physiological adaptations (e.g., more efficient sweating and stable circulation) that occur through gradually more exposure to hot work environments.

  An acclimatization plan may include a schedule for new workers that might limit heat exposure to a maximum of 20 per cent on day 1, increasing by 10 to 20 per cent on each additional day. For employees returning to work after extended leave, but who have experience working in hot working conditions, exposure on day 1 might be limited to no more than 50 per cent, rising to 100 per cent by day 4 or 5.

- ✓ Develop and use a **formal work-rest schedule**, in line with the exposure guidelines recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) described on pages 39 and 40 of *Best Practice – Working Safely in the Heat and Cold*, by Work Safe Alberta.[68]

  Encourage employees to take their rest (water) breaks in shade (for outdoor workers) or in air-conditioned recovery areas, if available for indoor workers.[69]

- ✓ **Organize work to minimize the exposure of employees to heat** (an industrial hygienist may need to be consulted). Examples of what this looks like include:
  - Reducing the physical effort needed for tasks by lowering the pace of work (how fast the job is done) or the intensity of work (how 'hard' the job is), shortening the duration of work (how long it takes), or increasing the number of employees available to spread the workload.

- Scheduling high and very high intensity tasks for cooler parts of the day, such as early morning or early evening.
- **Rescheduling routine maintenance and repair work** to times when equipment and processes emitting radiant heat are shut down, or to cooler times of the year (especially routine outdoor tasks).

Lowering the intensity of work (for example, by using carts or mechanical lifting devices) will also help to reduce the risk of heat-related illness or productivity losses among your employees.

✓ **Educate and train employees about the potential hazards** of high temperatures and how to recognize and treat symptoms of heat-related illness in themselves and others.

- Training should also include making employees aware of how some prescribed medications, and pregnancy can affect their heat tolerance.

Encourage workers to immediately notify their supervisor if they have symptoms of heat-related illness. Ensure workers who show signs of heat-related illness are provided prompt medical attention.

Encourage workers to stay hydrated by drinking small amounts of water before they become thirsty. During moderate activity in moderately hot conditions, workers should drink about two glasses (1/2 litre) of water before starting work and about 1 cup every 15 – 20 minutes. Hydration is the most effective means of preventing heat-related illness. Suitable fluids include tap water, mineral water and fruit juices.

Encourage workers to eat regular meals and snacks to keep up body salt and electrolytes that may be lost through sweating (so long as workers are sufficiently hydrated).

✓ **Set up a buddy system**, if possible.

Workers and supervisors who are trained to recognize the early signs and symptoms of heat-related illnesses are assigned the responsibility for observing, at periodic intervals, one or more co-workers to determine whether they have any early symptoms of a heat-related illness. The buddy system can also be used to encourage workers to make use of water and available shade.

✓ **Monitor weather reports daily to inform how work is scheduled** and organized to minimize the exposure of employees to heat. Some businesses may go a step further and develop a formal Heat Alert Program for both on-site and off-site work.

✓ **Evaluate work practices continually** in response to changing climate, and make any necessary adjustments to existing engineered, administrative and personal controls. To get precise recommendations, you may wish to consult an industrial hygienist.

Personal controls and behaviours

✓ **Encourage workers to wear appropriate clothing** that is breathable, light-colored and loose-fitting. Good materials include silk, cotton and wool.

Cotton clothing can be soaked with water to aid cooling. Wool clothing deflects radiant heat away from the skin while allowing sweat to evaporate, especially in very hot conditions when the temperature exceeds 35˚C. Reflective clothing, such as safety vests, worn loosely, can also minimize heat stress.

Workers should also be encouraged to wear wide-brimmed hats, when possible. If working environments require hard hats, a piece of light-colored fabric can be attached to the back and sides to shield the neck from direct sunlight.

You may need to modify clothing requirements, when possible, to enable workers to make these adjustments.

✓ Workers can also be provided with and encouraged to wear:

- Specialized heat-protective clothing
- Temperature-controlled clothing (e.g., air-cooled suits, water-cooled suits, ice-cooled vests)
- Anti-radiant or reflective clothing, such as aprons or jackets or even full body suits.

Note: Anti-radiant or reflective clothing only protects a worker against radiant heat. It provides little or no protection from high temperatures unless combined with temperature-controlled clothing.

4.2.2.2 Extreme weather events

✓ **Develop an emergency response plan** that includes a hazard assessment and procedures for severe weather.

Even if you are the only employee of your business, Alberta's Occupational Health and Safety law requires an emergency response plan. [70] This means you must include severe weather in your list of identified potential emergencies and formulate procedures for dealing with it.

✓ **Train your emergency response team to take action** during severe weather.

All individuals identified in the emergency response plan should be trained in their roles. For example, the employee assigned responsibility for shutting off the gas supply needs to know where the shutoff valve is located and how to use it. Training should be frequently refreshed, especially if your business has a high rate of staff turnover.

Provide the emergency response plan and procedures to all employees. Make sure everyone knows who has been assigned specific responsibilities during severe weather.

Practice your emergency response plan. Conduct emergency drills, at least once per year, to increase employee confidence and understanding so that if a severe weather event hits, they will be able to follow the plan in a calm and efficient way. Practice will also help you identify gaps in the plan.

Make sure your plan is current—it should reflect your current site environment and business operations and incorporate lessons learned during drills.

✓ **Develop an inclement weather policy** for when bad weather causes disruption.

An inclement weather policy is a written document that outlines the rules, expectations and operating procedures that cover:

- How you will communicate a closure to employees — phone call, text, email, broadcasting system, etc.
- Your expectation that employees use caution while entering and leaving work in poor weather conditions.
- Your intention to monitor the weather forecast and any conditions that will trigger a closure (snowfall amount, temperature, electrical outage, loss of heat, declaration of weather emergency, etc.).
- Instructions that traveling employees are not to drive in unsafe conditions.
- Expectations about what happens in the event of closure, such as whether employees should work from home (this may take the form of a separate work-from-home policy).
- Compensation in the event of a severe weather scenario, keeping in mind relevant laws.

- How you will notify customers, clients or vendors of a closure — via notice on your website, voicemail message, email, etc.
- Expectations about what happens in the event of a mid-day closure, i.e., if employees are expected to leave immediately.

4.2.2.3 Air quality

✓ **Use the Air Quality Health Index (AQHI) to help make scheduling and task decisions.**[71] Consider:

Reducing the intensity of work tasks or rescheduling the work when the health risk is moderate (between 4 and 6 on the AQHI), especially if workers start experiencing symptoms.

Rescheduling the work when the health risk is high (7 or more on the AQHI).

Take into account micro-environments, where employees could be exposed to higher levels of air pollution, such as next to roadways or during peak traffic times.

To inform your staff about air quality and the Air Quality Health Index (AQHI), consider setting up an AQHI Light at your workplace. This free online tool available from the City of Edmonton connects a Wi-Fi enabled bulb to automatically change colour and reflect the current AQHI level for any community on the Alberta AQHI Map. To access a user-friendly tutorial on the type of bulb required and instructions on connecting it to your community's AQHI reading, visit **edmonton.ca/airquality**.

✓ **Educate workers on the symptoms of exposure to air pollutants**[72]:

Healthy workers may exhibit:

- Irritated eyes
- More mucus in the nose or throat
- Coughing
- Difficulty breathing especially when performing physical tasks.

Workers with *existing respiratory or cardiovascular illnesses* should be alerted to pay attention to symptoms that are specific to their medical condition and to not delay seeking medical attention if required.

✓ **Provide employees with personal protective equipment** — respirators (commonly referred to as a face mask) and train them on their use and fitting.

4.2.2.4 Biological threats

✓ Monitor government surveillance programs to see if there are Lyme disease and West Nile virus vectors in your work locations.[73]

Mosquito precautions

✓ If your site is next to or encompasses water bodies and grassed areas, consider:

- Implementing appropriate mosquito control measures on site, such as **removing or covering areas of standing water** (e.g., unused items that collect water, open rain barrels).

✓ Educate employees to **reduce the likelihood of being bitten by a mosquito** by:

- Wearing light-colored clothing, long-sleeved tops, long pants and socks, especially when working at dawn, dusk or in the early evening.
- Spraying clothing with an approved insect repellent, since mosquitoes can bite through thin clothing.

- Applying an approved insect repellent to exposed skin.

If your business entails working with or collecting dead birds, ensure employees use gloves, double bag specimens and wash their hands thoroughly afterwards.

Tick precautions

✓ Educate employees who are at risk of tick bites on **precautions they can take to protect themselves**, including:

- Wearing protective clothing, such as long-sleeved tops, long pants and closed toed shoes, to prevent ticks from attaching to the skin. Tops should fit tightly around the wrists and be tucked into pants, with socks pulled over the pant legs. In addition, light-coloured clothing makes it easier to find ticks.
- Applying approved insect repellents to both clothing and skin.
- Avoiding contact with low bushes and long grasses, if the work allows.
- Doing a whole-body check (armpits, in and around hair, navel, groin and behind the ears and knees) for ticks on and under clothing after work — inspecting the skin daily greatly reduces the risk of infection as ticks can take anywhere from several hours to two days to attach to the skin and feed.
- Showering or bathing within two hours of being at work to wash away loose ticks.
- Washing work clothes promptly and putting them in the dryer so the heat can help kill any remaining ticks.

✓ Educate employees at risk of tick bites on **proper procedures for removing ticks**:

- Use needle-nose tweezers to grasp the head and mouth parts of the tick as close to the skin as possible.
- Pull it straight out slowly to remove the whole tick without squashing, twisting, or crushing it (to avoid getting bacteria into the body).
- Wash the bite area with soap and water or disinfect it with alcohol-based hand sanitizer.
- Keep the tick for testing by placing it in a small, lidded container or zip lock bag, documenting the date. If any symptoms arise (see below), the tick should be taken to a doctor for testing.

✓ Educate employees who are at risk of tick bites (working in grassy or wooded areas) on the **symptoms of Lyme disease**—i.e., fatigue, fever and chills, headache, muscle and joint pain, swollen lymph nodes and skin rash (which may take the form of an expanding 'bulls-eye' known as erythema migrans). Workers with symptoms should see their doctor immediately to avoid more serious illness.[74]

✓ If your site is next to and encompasses wooded or grassy areas, take the following measures at your site to **reduce the presence of ticks**:

- Keep the grass mowed, and trim trees and shrubs.
- Remove leaf litter, brush and weeds at the edge of the site, and around structures.
- Consider using hard landscape items such as wood chips, mulch, stones, gravel, tile or metals.
- Create a buffer or barrier between the site and any adjacent woodlands (if relevant) to discourage deer and rodent activity.

Drinking water precautions

- ✓ If contaminated drinking water is a concern at your site, there are a variety of equipment and proven processes that you can install to remove bacteria, protozoa and viruses. These on-site methods include UV distillation, ozonation, filtration, and reverse osmosis.[75]

4.2.2.5 UV radiation

- ✓ Create **work schedules that minimize sun exposure**, if possible. For example, schedule outdoor tasks to avoid midday sun between 11 a.m. and 4 p.m. and rotate workers to reduce their UV exposure. Schedule breaks that allow workers to reapply sunscreen throughout their shifts.

5. Supply chains

Since the 1980s, supply chain management has promoted the benefits of low inventory, just-in-time delivery, single-sourcing and centralization. Many businesses have implemented this 'lean' approach successfully, achieving significant cost savings and productivity gains.

At the same time, sourcing, production and distribution operations have become increasingly globalized, creating complex webs of inter-related supply chains — all considered to be good business practice. By doing so, however, businesses have made their supply chains more vulnerable to different forms of disruption at a time when the risks of this happening are increasing. As discussed in Sections 2.3 and 2.4, the incidence and intensity of weather-related extreme events is increasing in Canada and globally. Unfortunately, businesses have traded higher efficiency for greater risk of disruptions.

As a business owner, you contend with supply chain risks as part of your routine operations. Supply chains need to be consistent and reliable so you can meet the demands of your customers and manage costs. Climate change, however, makes managing supply risks more challenging.

Rapid-onset, acute risks that cause supply disruption today — like extreme weather events — are expected to become more severe, frequent and widespread. Gradual, chronic risks — like sustained warming, changes to the timing of river flows, increasing winter rainfall and sea-level rise — will create new challenges. To better prepare for these challenges, businesses should consider integrating climate-related risks as part of their routine supply chain risk management strategy.

In this section you will find guidance to help you:

- Better understand how climate change and its consequences may affect your supply chains, and the level of risk posed to your business (Section 5.1).
- Identify actions to help you manage risks to acceptable levels (Section 5.2).

5.1 Understanding climate-related risks to your supply chains

5.1.1 Impacts of climate change on supply chains

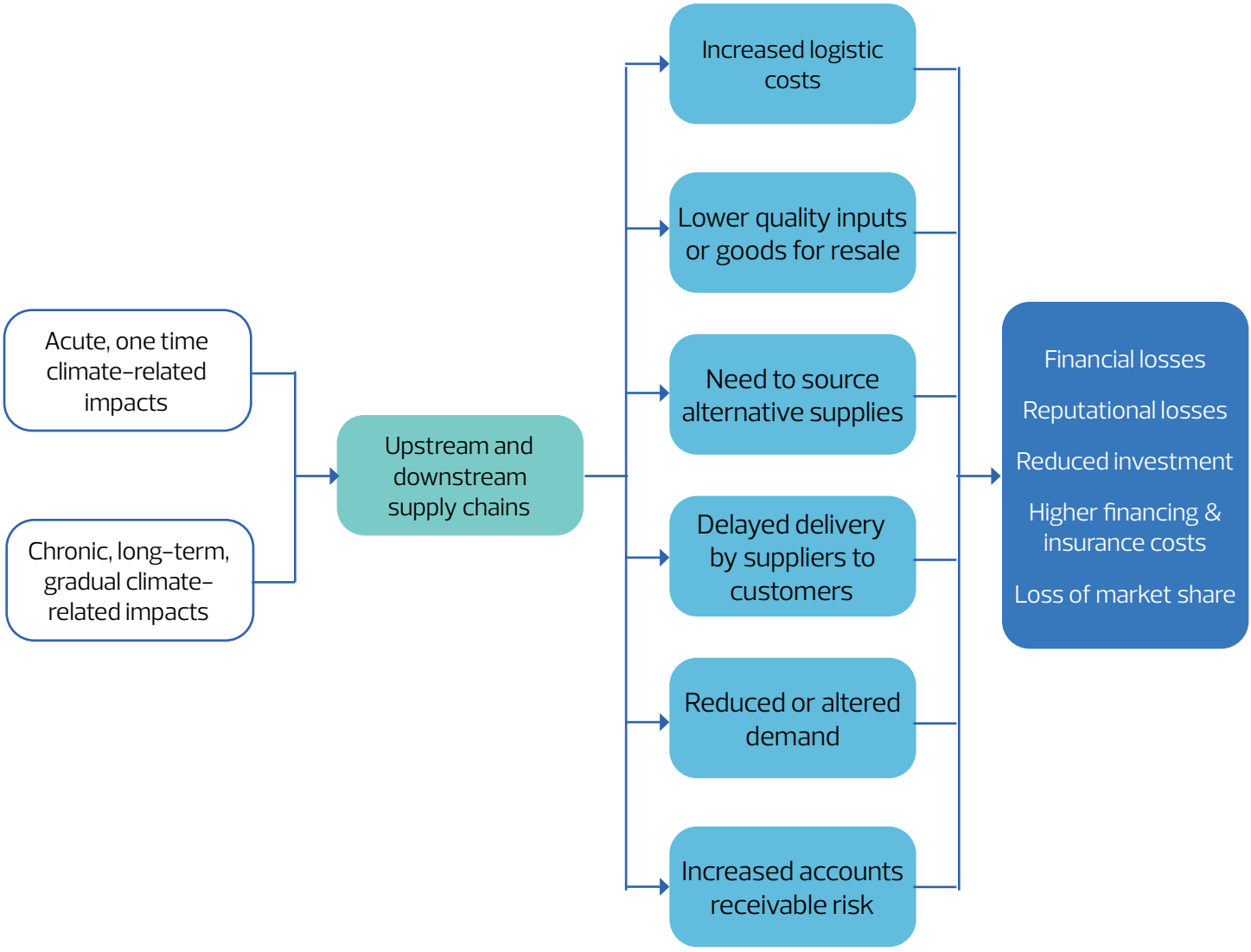
The potential impacts of climate change on supply chains — both upstream and downstream of your site of operations — are summarized in Figure 4.

Climate change will increase the frequency, intensity and spatial distribution of acute (one-time) supply chain disruptions caused by powerful storms, wildfires and floods that damage production facilities and infrastructure. Damaged infrastructure may in turn lead to cascading risks, such as disrupted energy, water, and communications and information technology (ICT) disruption.

Climate change will also create chronic (on-going) changes to supply chains and may give rise to new, not previously encountered risks. Gradually shifting temperature and precipitation patterns could affect, for example, the availability, quality and price of agricultural and other feedstocks, making it necessary to source alternative, potentially more expensive or lower quality, supplies. A sudden, unplanned transition to a new supplier may result in delays, in addition to increasing management costs.

Customer demand for goods and services could also be affected by chronic climate impacts — e.g., reduced demand for traditional winter recreation activities and warm outerwear as winters get warmer. Further, extreme weather events can restrict the ability of customers to access your site of business — which is what happened with the 2013 flooding in Calgary, when much of the road network in the vicinity of the Bow and Elbow Rivers closed. All of these supply chain issues will have an impact on your business' finances, ability to compete and reputation.

Figure 4: Risks to supply chains from climate change



5.1.2 Levels of risks to your supply chains

To help you measure the potential vulnerability of your upstream and downstream supply chains to climate change, a set of indices were created and subsequently used to define indicative risk levels (relatively low, medium, or high) for sectors and sub-sectors.

The results for 17 business sectors (defined by 2-digit North American Industry Classification System codes) are provided in Table 4.

Table 5 presents the results for over 220 business sub-sectors. The indices include the following components:

- Sector and sub-sector reliance on intermediate inputs
- Sector and sub-sector reliance on intermediate inputs from other Canadian provinces and territories and imported from outside Canada (international imports)
- Sector and sub-sector reliance on sales within Alberta and to other Canadian provinces and territory and international exports
- Sector and sub-sector reliance on indirect imports (i.e., on value added from imports by another Alberta sector)
- Sector and sub-sector reliance on indirect exports (i.e., value added to exports by another Alberta sector)
- Interprovincial transport data for Edmonton by commodity group (value of shipments, destination-origin distance, number of shipments, weight of shipments, tonne-kilometres, mode of transport)
- Projected climate-related damages to road and rail infrastructure, electricity generation and Transmission and Distribution (T & D) infrastructure, and commercial building stock, by Canadian province and territory
- Projected climate- related reductions in labour supply and productivity, by Canadian province and territory
- The country of origin for international (sector and sub-sector) imports to Canada
- The destination country for international (sector and sub-sector) exports from Canada
- The country-specific natural hazard risk index (INFORM Risk[76])
- The country-specific climate change adaptation index (ND-GAIN[77])

Table 4: Supply chain risks: summary sector level

Sector — summary level	Upstream risk level	Downstream risk level
Agriculture, forestry, hunting and fishing	Medium	High
Mining, quarrying, and oil and gas extraction	Medium	Medium
Utilities	Low	Low
Construction	High	Low
Manufacturing	Medium	Low
Wholesale trade	Medium	High
Retail trade	Low	Low
Transportation and warehousing	Low	High
Information and cultural industries	High	Medium
Finance, insurance and real estate	Low	Low
Professional, scientific and technical services	Medium	Low
Administrative support, waste management and remediation services	Low	Low
Educational services	Low	Low
Health care and social assistance	Low	Low
Arts, entertainment and recreation	Low	Medium
Accommodation and food services	Medium	Medium
Other services	Low	Medium

Table 5: Supply chain risks: detailed sector level

Sector — detailed level	Upstream risk level	Downstream risk level
Agriculture, forestry, hunting and fishing		
Crop production (except cannabis, greenhouse, nursery and floriculture production)	Medium	High
Greenhouse, nursery and floriculture production (except cannabis)	Medium	Medium
Cannabis production (licensed)	Medium	Low
Cannabis production (unlicensed)	Low	Low
Animal production (except aquaculture)	Low	Medium
Aquaculture	Medium	Medium
Forestry and logging	Medium	Low
Fishing, hunting and trapping	High	High
Support activities for crop and animal production	Medium	Low
Support activities for forestry	Medium	Medium
Mining, quarrying, and oil and gas extraction		
Oil and gas extraction (except oil sands)	Medium	High
Oil sands extraction	Medium	Medium
Coal mining	Low	Medium
Iron ore mining	Low	Low
Gold and silver ore mining	Medium	High
Copper, nickel, lead and zinc ore mining	Low	Low
Other metal ore mining	Low	Low
Stone mining and quarrying	Low	Low
Sand, gravel, clay, and ceramic and refractory minerals mining and quarrying	Low	Medium
Diamond mining	Low	Low
Other non-metallic mineral mining and quarrying (except diamond and potash)	Medium	Medium
Potash mining	Low	Low
Support activities for oil and gas extraction	Medium	Low
Support activities for mining	Medium	High
Utilities		
Electric power generation, transmission and distribution	Medium	Low
Natural gas distribution	Medium	Low
Water, sewage and other systems	Low	Low

Sector — detailed level	Upstream risk level	Downstream risk level
Construction		
Residential building construction	Medium	Low
Non-residential building construction	High	Low
Transportation engineering construction	Medium	Low
Oil and gas engineering construction	High	Low
Electric power engineering construction	High	Low
Communication engineering construction	High	Low
Other engineering construction	Medium	Low
Repair construction	High	Low
Other activities of the construction industry	High	Medium
Manufacturing		
Animal food manufacturing	Medium	High
Grain and oilseed milling	Medium	High
Sugar and confectionery product manufacturing	High	High
Fruit and vegetable preserving and specialty food manufacturing	Medium	High
Dairy product manufacturing	Medium	High
Meat product manufacturing	Low	High
Seafood product preparation and packaging	Medium	Medium
Bakeries and tortilla manufacturing	High	High
Other food manufacturing	High	High
Soft drink and ice manufacturing	High	High
Breweries	High	High
Wineries and distilleries	High	High
Tobacco manufacturing	Low	Low
Textile and textile product mills	High	High
Clothing and leather and allied product manufacturing	High	Medium
Sawmills and wood preservation	Medium	Medium
Veneer, plywood and engineered wood product manufacturing	Medium	High
Other wood product manufacturing	Medium	Medium
Pulp, paper and paperboard mills	Medium	High
Converted paper product manufacturing	High	Medium
Printing and related support activities	Medium	Medium
Petroleum refineries	Low	Medium
Petroleum and coal product manufacturing (except petroleum refineries)	Medium	Medium
Basic chemical manufacturing	Low	Medium
Resin, synthetic rubber, and artificial and synthetic fibres and filaments manufacturing	Medium	High
Pesticide, fertilizer and other agricultural chemical manufacturing	Medium	Medium

Sector — detailed level	Upstream risk level	Downstream risk level
Pharmaceutical and medicine manufacturing	High	Medium
Paint, coating and adhesive manufacturing	High	Medium
Soap, cleaning compound and toilet preparation manufacturing	High	Medium
Other chemical product manufacturing	High	Medium
Plastic product manufacturing	High	Medium
Rubber product manufacturing	High	Medium
Non-metallic mineral product manufacturing (except cement and concrete products)	Medium	High
Cement and concrete product manufacturing	Medium	Low
Iron and steel mills and ferro-alloy manufacturing	Medium	High
Steel product manufacturing from purchased steel	High	Medium
Alumina and aluminum production and processing	High	High
Non-ferrous metal (except aluminum) production and processing	High	High
Foundries	Medium	Medium
Forging and stamping	High	Medium
Cutlery, hand tools and other fabricated metal product manufacturing	High	Medium
Architectural and structural metals manufacturing	High	Medium
Boiler, tank and shipping container manufacturing	High	Medium
Hardware manufacturing	High	Medium
Spring and wire product manufacturing	High	High
Machine shops, turned product and screw, nut and bolt manufacturing	High	Medium
Coating, engraving, cold and heat treating and allied activities	High	Medium
Agricultural, construction and mining machinery manufacturing	High	Medium
Industrial machinery manufacturing	High	Medium
Commercial and service industry machinery manufacturing	High	Medium
Ventilation, heating, air-conditioning and commercial refrigeration equipment manufacturing	High	High
Metalworking machinery manufacturing	High	Medium
Engine, turbine and power transmission equipment manufacturing	High	High
Other general-purpose machinery manufacturing	High	High
Computer and peripheral equipment manufacturing	High	Medium
Communications equipment manufacturing	High	High
Other electronic product manufacturing	High	High
Semiconductor and other electronic component manufacturing	High	High
Electric lighting equipment manufacturing	High	High
Household appliance manufacturing	High	High
Electrical equipment manufacturing	High	High
Other electrical equipment and component manufacturing	High	High

Sector — detailed level	Upstream risk level	Downstream risk level
Automobile and light-duty motor vehicle manufacturing	High	Medium
Heavy-duty truck manufacturing	High	High
Motor vehicle body and trailer manufacturing	High	Medium
Motor vehicle gasoline engine and engine parts manufacturing	High	High
Motor vehicle electrical and electronic equipment manufacturing	High	High
Motor vehicle steering and suspension components (except spring) manufacturing	High	Medium
Motor vehicle brake system manufacturing	High	High
Motor vehicle transmission and power train parts manufacturing	High	High
Motor vehicle seating and interior trim manufacturing	High	High
Motor vehicle metal stamping	High	High
Other motor vehicle parts manufacturing	High	High
Aerospace product and parts manufacturing	High	High
Railroad rolling stock manufacturing	Low	Low
Ship and boat building	High	Medium
Other transportation equipment manufacturing	High	Medium
Household and institutional furniture and kitchen cabinet manufacturing	Medium	Medium
Office furniture (including fixtures) manufacturing	High	Medium
Other furniture-related product manufacturing	High	Medium
Medical equipment and supplies manufacturing	High	Medium
Other miscellaneous manufacturing	High	Medium
Wholesale trade		
Farm product merchant wholesalers	Medium	High
Petroleum and petroleum products merchant wholesalers	Medium	High
Food, beverage and tobacco merchant wholesalers	Medium	Medium
Personal and household goods merchant wholesalers	Medium	Medium
Motor vehicle and motor vehicle parts and accessories merchant wholesalers	Medium	Medium
Building material and supplies merchant wholesalers	Medium	Medium
Machinery, equipment and supplies merchant wholesalers	Medium	Medium
Miscellaneous merchant wholesalers	Medium	Medium
Business-to-business electronic markets, and agents and brokers	Medium	Medium
Retail trade		
Motor vehicle and parts dealers	Medium	Medium
Furniture and home furnishings stores	Medium	Medium
Electronics and appliance stores	Medium	Medium
Building material and garden equipment and supplies dealers	Medium	Low
Food and beverage stores	Medium	Low

Sector — detailed level	Upstream risk level	Downstream risk level
Health and personal care stores	Medium	Low
Gasoline stations	Medium	Medium
Clothing and clothing accessories stores	Medium	Medium
Sporting goods, hobby, book and music stores	Medium	Low
General merchandise stores	Medium	Low
Miscellaneous store retailers (except cannabis)	Low	Low
Cannabis stores (licensed)	Medium	Low
Cannabis stores (unlicensed)	Low	Low
Non-store retailers	Medium	Low
Transportation and warehousing		
Air transportation	Low	High
Rail transportation	Low	High
Water transportation	Low	High
Truck transportation	Medium	Medium
Urban transit systems	Low	Medium
Other transit and ground passenger transportation and scenic and sightseeing transportation	Low	Medium
Taxi and limousine service	Low	Medium
Crude oil and other pipeline transportation	Medium	High
Pipeline transportation of natural gas	Medium	High
Support activities for transportation	Low	Medium
Postal service	Low	Medium
Couriers and messengers	Low	Medium
Warehousing and storage	Medium	Medium
Information and cultural industries		
Newspaper publishers	Medium	Medium
Periodical, book and directory publishers	Medium	High
Software publishers	High	High
Motion picture and video industries (except exhibition)	High	Medium
Motion picture and video exhibition	High	Medium
Sound recording industries	High	Medium
Radio and television broadcasting	High	High
Pay and specialty television	High	Medium
Telecommunications	High	Medium
Data processing, hosting and related services	Medium	High
Other information services	Medium	Medium
Finance, insurance and real estate		
Monetary authorities – central bank	Medium	Low

Sector — detailed level	Upstream risk level	Downstream risk level
Banking and other depository credit intermediation	Medium	Medium
Local credit unions	Medium	Medium
Non-depository credit intermediation	Medium	Medium
Activities related to credit intermediation	Medium	Medium
Financial investment services, funds and other financial vehicles	Medium	Medium
Insurance carriers	Low	Medium
Agencies, brokerages and other insurance related activities	Medium	High
Lessors of real estate	Low	Medium
Offices of real estate agents and brokers and activities related to real estate	Low	Low
Owner-occupied dwellings	Low	Low
Automotive equipment rental and leasing	Low	Medium
Rental and leasing services (except automotive equipment)	Low	Medium
Lessors of non-financial intangible assets (except copyrighted works)	Medium	High
Professional, scientific and technical services		
Legal services	Medium	Medium
Accounting, tax preparation, bookkeeping and payroll services	Medium	Low
Architectural, engineering and related services	Medium	Medium
Specialized design services	Medium	Medium
Computer systems design and related services	Medium	Medium
Management, scientific and technical consulting services	Medium	Medium
Scientific research and development services	Medium	Medium
Advertising, public relations and related services	Medium	Low
Other professional, scientific and technical services	Medium	Medium
Administrative support, waste management and remediation services		
Holding companies	Medium	Low
Office administrative services	Medium	Medium
Facilities and other support services	Medium	Medium
Employment services	Medium	Medium
Business support services	Medium	Medium
Travel arrangement and reservation services	Medium	Medium
Investigation and security services	Medium	Medium
Services to buildings and dwellings	Medium	Low
Waste management and remediation services	Medium	Medium

Sector — detailed level	Upstream risk level	Downstream risk level
Educational services		
Elementary and secondary schools	Medium	Low
Community colleges and C.E.G.E.P.	Medium	Medium
Universities	Medium	Medium
Other educational services	Medium	Low
Health care and social assistance		
Offices of physicians	Medium	Low
Offices of dentists	Medium	Low
Miscellaneous ambulatory health care services	Medium	Medium
Hospitals	Medium	Low
Nursing and residential care facilities	Medium	Low
Social assistance	Medium	Low
Arts, entertainment and recreation		
Performing arts, spectator sports and related industries, and heritage institutions	Medium	Medium
Amusement and recreation industries	Medium	Medium
Gambling industries	Medium	Medium
Accommodation and food services		
Traveller accommodation	Medium	Medium
Recreational vehicle (RV) parks, recreational camps, and rooming and boarding houses	Medium	Medium
Food services and drinking places	Medium	Medium
Other services		
Automotive repair and maintenance	Medium	Medium
Repair and maintenance (except automotive)	Medium	High
Personal care services and other personal services	Medium	Medium
Funeral services	Medium	Low
Dry cleaning and laundry services	Medium	Medium
Business, professional and other membership organizations	Medium	Medium
Religious organizations	Medium	Low
Grant-making, civic and professional and similar organizations	Medium	Low
Other non-profit institutions serving households	Medium	Medium
Private households	Low	Low

In addition to the sector and sub-sector risk levels presented above, you could also consider the following questions to help you evaluate the level of climate-related risks facing your supply chains:

For upstream (supply) risks:
Does your business depend on climate-sensitive (e.g., agricultural products) material inputs that are not easily substituted? [An input is climate-sensitive if it is susceptible to damage or loss of quality from weather] ***If yes, risk is increased***
Are suppliers of critical material inputs clustered in the same location or region? [An input is critical if it would shut down operations if it were not available] ***If yes, risk is increased***
Do any of your critical supply chains depend on unique infrastructure, such as a single port or land or air route that is not easily substituted? ***If yes, risk is increased***
Do you rely on a single supplier for a critical material input? ***If yes, risk is increased***
Do you or any of your critical suppliers use Just-In-Time delivery processes (i.e., receive inputs only as they are required) or carry minimal inventory? ***If yes, risk is increased***
For downstream (demand) risks:
Does your business depend on the sales of climate-sensitive (e.g., agricultural products) products that are not easily substituted? ***If yes, risk is increased***
Are your main customers clustered in the same location or region? ***If yes, risk is increased***
Do any of your supply chains for moving goods to markets depend on unique infrastructure, such as a single port or land or air route that is not easily substituted? ***If yes, risk is increased***
Do you rely on a single customer for sales? ***If yes, risk is increased***
Do you sell goods that are time-sensitive for delivery? ***If yes, risk is increased***

For utilities disruption risks:
If a power outage would affect the phone, internet, or cable services, can your business operate without any of them? ***If no, risk is increased***
Can your business deliver products and services during a power, water or ICT outage? ***If no, risk is increased***
Can your business open, or employees work at your site of operations without any of the following systems that depend on power supply: heating, ventilation, and air conditioning, water heating and distribution, escalators or elevators, or lighting? ***If no, risk is increased***
Is your operations site and your inventory safe from water or temperature damage if environment control systems fail due to a power outage? ***If no, risk is increased***
Can you or employees access your site of operations without electricity, and will security and safety alarm systems operate as intended? ***If no, risk is increased***
Are you able to pay suppliers and employees, or receive payments from customers without electricity or functioning information and communication systems? ***If no, risk is increased***
Are utilities located in the basement? ***If yes, risk is increased***
Do you have back-up power or alternative water supply, or water storage on site? ***If no, risk is increased***
Is critical data regularly backed up and safely archived? ***If no, risk is increased***
Can your business open without production systems that depend on power, water or functioning information and communication systems – (e.g., assembly lines, machines, restaurant equipment)? ***If no, risk is increased***

5.2 Building resilience and adapting your supply chains for climate change

Simply put, a supply chain is considered resilient to the degree it can cope with (i.e., resist, absorb, accommodate or adapt to) a hazardous event, trend or disturbance and ensure a business can continue to operate.

Below you will find guidance on how to increase the resilience of your supply chains and utilities to climate change.

5.2.1 Utilities

Actions you can take to mitigate the risk of utilities disruption include:

Power

- ✓ Ensuring systems are in place to provide temporary **back-up power** for disruptions in electrical power. Or provide permanent back-up power, switching gear and/or power hook-ups and infrastructure for temporary generators to provide power for critical equipment and systems.
- ✓ Make sure utility outages are included in your business's **emergency response plan** (see Section 4.2.1.2).
- ✓ Install **surge protection** on all important equipment.
- ✓ Install **emergency lighting, directional signage and exit signs that are independent of grid electricity**, and ensure these devices and batteries are properly maintained.
- ✓ Develop a **plan for turning off and disconnecting equipment** during a power outage.
- ✓ Develop an **ICT Resilience Plan** that includes:
  - Identifying the ICT systems (hardware and software) that your business relies on;
  - Documenting the steps to be taken in the event of outages and assigning responsibilities;
  - Ensuring your data is (frequently and completely) backed up and stored in at least two locations; and
  - Documenting all procedures to be followed during an outage, including a plan for recovering your data.

  Back-up options can include: external USB discs or hard drives and cloud storage services (e.g., Dropbox.com, Box.net, Microsoft OneDrive, Apple iCloud).

  Regardless of how you protect your data, make sure you **test it** — perform 'dry runs' regularly to ensure the whole process is functioning as intended.

Water

- ✓ Develop a Water Conservation Plan that includes:
  - A **water system profile** summarizing the service and operating characteristics of the system (annual supply, service connections, water demand, etc.), and includes an **inventory of existing resources and conditions**;
  - A **water demand forecast** identifying anticipated water demand in the future, and considers climate impacts among other factors that may affect total, average daily and maximum daily water demand (such as business growth or changes to business operations);
  - Identifying and evaluating **water conservation measures**, including the estimated costs to implement them, water savings and cost-effectiveness of each measure; and

- An **implementation strategy**, identifying how the conservation plan will be implemented, monitored and evaluated over time, how and when data will be collected, and when the plan will be updated or revised.

5.2.2 Suppliers and customers

Two main strategies can be used to manage supply chain risk: bridging and buffering.

Bridging involves strengthening the capacity of *your suppliers* to manage supply chain risks. **Buffering** involves protecting *your business* from 'failures' in your supply chains.

Bridging is the first line of defense, as you seek to minimize the chances that an acute or chronic climate-related disruption will even occur. *Buffering is your second line of defense*, as you seek to minimize the consequences for your business should supply chains be disrupted by climate events.

These strategies are not mutually exclusive. You can implement both for your business, although bridging strategies may only be available to medium-sized enterprises, given the need to work with and provide direct support to your upstream suppliers. Either way, your bridging and buffering strategies should be focused on the most critical supply chains, suppliers and customers — from a cost or revenue, time-sensitive and cause/effect perspective.

5.2.3 Bridging strategies

Bridging strategies help ensure your critical suppliers continue to function should a climate-related disruption occur and to rapidly recover to full operation despite the disruption.

Common bridging strategies include:

✓ **Collaborative risk management.** Engaging your most critical suppliers to manage risks cooperatively.

Up to this point, supply chain collaboration has been used to cut inventory costs and to smooth the flow of goods and services between businesses. But it can and should also be used to manage climate disruptions.

This can look like:

- Developing joint contingency plans to ensure operations continue in the event of supply chain failure or disruption, or to changes in demand orders.
- Sharing risk information to increase awareness of climate-related risks across supply chains (see also, ''ongoing monitoring of critical supply chains'' below).
- Going as far as involving your suppliers and customers in your procurement decisions.

It is unlikely that you can achieve collaboration with all of your suppliers. But you can prioritize your most critical supplies and suppliers. Have you identified them?

Failures and disruptions can also occur at any node in a supply chain. Knowing where your business is sourcing critical supplies or inputs from will help you assess the specific climate-related risks your key suppliers may face. Do you know where your critical suppliers are located? Do you know where critical raw materials are sourced?

The answers to these questions reveal where you should focus on collaboration.

✓ **Providing expertise or financial assistance.** Some businesses may be able to offer financial assistance — directly or through their partnering financial institution — to suppliers to enhance their resilience or to recover from a supply disruption.

Financial assistance can take several forms:

- Loans
- Gifts
- Price premiums
- Long-term contracts
- Joint ventures or co-ownership

Assisting your suppliers in this way not only helps to reduce supply chain risks, but it can also provide incentive for a supplier to put priority on your business and supply needs. Often, a supplier is not completely shut down after a climate-related event and is able to supply some customers during recovery. If your business has a legal or other formal relationship set up with the supplier, you are more likely to receive some of the limited supplies.

5.2.4 Buffering Strategies

Buffering strategies protect your business from the real consequences of failures in your supply chain.

Common buffering strategies are about building redundancies at critical points in supply chains. These can include:

✓ **A strategic inventory buffer.** Until recently, maintaining low inventory levels has been championed to reduce (carrying) costs. However, this does make operations more vulnerable to supply chain disruption.

A business can increase its resilience by carrying a sufficient inventory of *critical* inputs — a 'safety stock' — that would allow it to withstand interruption for an acceptable amount of time. A safety stock can take various forms, from materials and final products for market to equipment and infrastructure.

Of course, the carrying costs of an inventory buffer can be significant. These costs need to be balanced against the safety benefits (in terms of lost sales, recovery costs, and reputational damage) the inventory buffer brings. The idea is to 'right-size' the inventory. To maximize the safety benefits, the inventory buffer needs to target the most critical, unique and time-sensitive supplies or final products.

A good tip to consider in making this decision: carrying excess inventory can get expensive for high-value inputs/finished products that go out of date quickly. So, it will likely make more financial sense to apply this strategy only to low-value inputs/products that do not become obsolete.

When you increase inventory to carry safety stock, you now have to decide where the additional stock should be located. For medium-sized enterprises with more elaborate supply chains, safety stocks should ideally be located at critical points in the supply chain that are especially vulnerable to climate-related disruptions, where the gains from doing so are greatest.

This requires a highly visible supply chain (see 'good practices' below).

✓ A **capacity buffer.** You can develop excess or back-up capacity to either lower the impact of a supply chain disruption, or improve its ability to successfully recover from it, or to manage fluctuations in demand.

There are several ways this can be done:

- **Increase the number of accessible suppliers.** This is especially important for critical supplies that are sole sourced because it helps you spread the risk across multiple suppliers. Sourcing from multiple suppliers does add complexity and costs to your inventory management. To keep costs down, you can identify and pre-qualify potential suppliers, or even develop contractual arrangements that can be activated in emergencies. Or you can develop a rapid qualification protocol for suppliers of critical inputs, so they can be quickly contracted should the need arise.
- **Diversify the geographical locations of your critical suppliers.** Similar to addressing the risk of sole sourcing key supplies, the idea here is to spread (reduce) the risk of any single location being adversely affected by acute or chronic climate-related disruptions.
- **Source from multiple logistics providers or employ alternative modes of transport** and shift the allocation of freight between modes (also known as modal shift). For smaller businesses at the local level, modal shift could involve using a combination of trucks, motorcycles or bicycles to deliver finished products. If your business imports from overseas, you can look for logistic providers that are part of wider global networks and alliances. These alliances make it relatively easy to rapidly switch carriers in the event of disruption to any carrier's operations or base.
- **Identify a new supplier of a critical input(s).** This may be necessary if an existing critical supplier, or the region in which they operate and source raw materials and other inputs, is anticipated to become too risky and unsustainable. To do this, however, climate-related risks must be 'visible' and continuously monitored (see "good practices" below).
- In some cases, you may be able to **decrease product specificity**. For example, a good you produce may require a very specialized part from a single supplier, increasing your risks. It may be possible to adjust the design of the product to work with a generic part that is available from several geographically dispersed suppliers, and that still meets the demands of customers. A similar strategy involves designing many products to work with a single, common input, which can be sourced from several suppliers and locations.

✓ **A liability buffer.** There is uncertainty over how the courts may initially interpret liability resulting from failure to fulfill contractual arrangements because of *force majeure* — specifically, a climate-related event. A business can create a liability buffer by reviewing its current contracts with suppliers and customers and, if warranted, draft new contracts detailing specific liability for climate-related risks.

- ✓ **A lead time buffer.** Creating a time buffer involves *increasing awareness of potential supply chain failures and disruptions before they occur*, providing lead time to mitigate them. You can create a time buffer by implementing systems that (1) increase the visibility of suppliers and locations across critical supply chains and (2) cross-reference this information with projected climate-related risks for those locations (see 'good practices' below). Doing so will provide your business with sufficient lead time to take actions and build your resilience to anticipated disruptions.

  An effective time buffer is also good at *raising awareness with customers*. A customer's displeasure with delayed deliveries can be somewhat mitigated if you are able to communicate potential delays as soon as possible. This means you need time buffers upstream of your business and effective coordination between procurement and marketing or sales.

- ✓ **Promotion, dynamic pricing and assortment planning.** At the retail level, you can manage your revenue streams by enticing customers to purchase goods that are more readily available when the supply of alternative goods is disrupted. Similarly, you can use assortment planning to influence customer demand and the products they select. The choice of products on display, their location on shelves, and the number of facings for each product are all effective ways to encourage customers to purchase goods that are more widely available.

- ✓ **Create a climate resilience culture.** CCreate a culture that encourages employees to be aware of the risks that climate change can present to the business and to be motivated to manage those risks. If you have risk management systems already in place, this involves weaving ('mainstreaming') climate-related acute and chronic impacts into these systems. It also involves continuous monitoring to see advance warning of potential problems and take preventative actions (see ''monitoring'' below).

  Designate an individual or team with responsibility for engaging with all levels of the business (externally with upstream suppliers and downstream customers) to spread the message that managing the risk of supply chain failure or disruption requires the cooperation of all.

5.2.5 Good practices

In addition to bridging and buffering strategies, there are several general good practices that will enhance the resilience of your supply chains to climate-related risks. Like the bridging strategies, some of the good practices listed below will only be applicable to medium-sized enterprises.

✓ **Improve supply chain visibility.** Many supply chains suffer from poor visibility. With your business this may mean it's not clear to anyone what the status of upstream suppliers or downstream customers is, or what your flow and inventory levels look like. It can take weeks or months before problems come to light, when it may be too late to do anything about it.

Key questions that can help you map out your supply chains include:

- What are your critical supplies?
- Where are they sourced from?
- What logistics do they depend on to be delivered to your business?
- Who are your key customers? Where are they located?
- What logistics do you depend on to deliver finished goods and services to these customers?

You can further enhance visibility across your supply chain by obtaining information on typical inventory levels, delivery lead-times and supplier performance.

✓ **Ongoing monitoring of critical supply chains.** Monitoring your key supply chains helps you identify early signs of potential failures and disruption so that you can be more successful in adapting to them.

Monitoring considers both current and future risks. For example, you could monitor short-term and long-range weather forecasts for regions where critical suppliers and customers are located to keep abreast of imminent threats, instead of depending on the supplier or buyer to bring potential problems to attention. This provides you with a time buffer to initiate action (see 'time buffer' above). You could also routinely cross-reference the location of key suppliers and customers with the latest projected changes in the regional climate to identify potential future risks resulting from rising temperatures, sea-level rise and changes in extreme events. This again provides you with a time buffer to initiate action.

When monitoring risks, it is important to examine your entire supply chain. To spread risk, for example, you may be sourcing one critical input from four different Tier 1 suppliers. But what if those four suppliers themselves source a key input from a single Tier 2 supplier (hidden to you)? You will still be exposed to a single source failure, only at a higher level in the supply chain.

You can enhance collaboration with all of your supply chain partners and logistics providers by sharing your monitored risk information (see 'collaborative risk management' above).

✓ **Perform stress-tests.** Stress testing will help your business understand and prioritize climate-related supply chain risks. It involves developing and assessing 'what if' scenarios with employees, and analyzing critical supply chains, one node at a time. The starting point is ensuring you have a highly visible supply chain (see 'improve supply chain visibility' above).

Examples of the questions you can use for stress testing include:

- What if ... a supplier of a key input shuts down for a month?
- What if ... the capacity of critical supplies drops by 20 per cent overnight?
- What if ... demand goes up by 20 per cent for all products? For a key product?
- What of ... demand goes down by 20 per cent for all products? For a key product?
- What if ... deliveries of a key raw material or part are delayed by one month?
- What if ... customer orders are delayed by one month?
- What if ... a supplier is forced to increase the price of a key raw material or part by 20 per cent?
- What if ... logistics costs go up by 20 per cent overnight?
- What if ... a key customer withholds payments one month longer than normal?
- What if ... 20 per cent of accounts receivable payments are delayed by one month?

The numbers used should be large enough to have a significant impact on your business, but be small enough to be realistic.

Tip: Think of stress testing as a 'thought experiment' to help your business prepare for uncertain climate-related events. However, if desired you could consider attaching likelihoods to the 'what if' scenarios occurring.

Stress-testing helps you identify:

- Product and service lines at risk
- Key production sites and logistic nodes
- The suppliers and customers that pose the greatest risk to your business.

It helps you understand the implications for your sales, procurement costs, prices and revenues. It can also help you define your priorities for mitigating risks.

✓ **Insure against supply chain risks.** Most major insurance companies offer various coverages to provide some mitigation against the financial impacts of supply chain disruption.

There are two types of relevant insurance products:

- Business Interruption (BI) insurance
- Contingent Business Interruption (CBI) insurance

Business Interruption insurance covers events that happen at the site of business, such as a fire at your manufacturing plant. CBI insurance covers events that happen at a property owned by your suppliers or customers.

These forms of insurance would generally cover the costs of recovery but do not provide compensation for lost sales, loss of market share or loss of reputation. They also only cover events at your physical locations, but not events elsewhere across your supply chain.

New forms of insurance coverage are now starting to be offered that may address wider supply chain risks, like the failure of transport infrastructure. Talk with your insurance provider.

6. Key vocabulary

Adaptation (actions): Initiatives and measures to avoid or moderate harm to businesses, or to exploit beneficial opportunities, posed by current or anticipated climate change.

Adaptive capacity: A business's ability to implement actions to adapt to a changing situation.

Climate: Average weather of a place or region over a period of years, decades or longer.

Climate baseline period: The average weather conditions observed over a historical 30-year period in a given place or region, against which changes are measured.

Climate change: Refers to any persistent, long-term change in the climate over time (an increase or decrease in the mean, variability or extreme of a climatic variable, such as temperature or precipitation).

Climate extreme: The occurrence of a weather variable above (or below) a threshold near the upper (or lower) ends of the range of observed historical values at a particular place or time of year. Often used interchangeably with both extreme weather events and extreme climate events.

Climate Impact-drivers: Refers to physical climate conditions (e.g., means, events, extremes) that can have detrimental, beneficial, neutral impacts for a business, community or natural systems. Examples of climate impact-drivers include mean air temperature, extreme heat, mean precipitation, extreme rainfall and stormwater flooding, drought, severe windstorm, hail, heavy snowfall, ice storm, fire weather, etc. See also: Risk, Hazard and Impacts.

Climate variability: Variations above or below the average state of the climate (including the occurrence of extremes), whether as a result of natural variability or human activity.

Exposure: The presence of people, businesses, economic assets and infrastructure, and natural resources in places where they could be adversely affected by climate-impact-drivers.

Hazard: A source of harm to your business. In a climate change context, it refers to the potential occurrence of climate conditions (e.g., means, events, extremes) that may cause loss of life, injury, or other health impacts, reduced productivity, or damage and loss to property and infrastructure, and disruption to value chains. See also Climate Impact-drivers, Impacts and Risk.

IDF curves: Intensity-Duration-Frequency (IDF) curves relate rainfall intensity from short-duration events with the frequency of occurrence and are often used for urban drainage design.

Impacts: The consequences of a realized risk to a business, where risk results from the interactions of a climate impact-driver, exposure and vulnerability. Impacts refer to loss or damage to buildings, equipment, or inventories, loss of life, injuries, or other health effects to the workforce or customers, lost labour productivity, disruption to utilities, supply chains and access to markets, and changes to the availability, quality or price of raw materials, as well as changes in demand for finished products and services. Often used interchangeably with consequences. See also Climate Impact-driver, Exposure, Hazard, Risk, Vulnerability.

Likelihood: The chance of a specific outcome occurring.

Mitigation (actions): Initiatives and measures taken by businesses to reduce emissions or remove and store heat-trapping greenhouse gases.

Natural variability: Short-term changes that take place over months, seasons and years, due to variations in the interactions of the oceans and the atmosphere that occur. For example, in the Pacific Ocean during an El Niño event, as well as natural variations in the sun's radiation or volcanoes.

Representative Concentration Pathways (RCP): Scenarios that include time series of future emissions and concentrations of heat-trapping, greenhouse gases. The term "representative" indicates that each RCP represents only one of many possible scenarios that would lead to a specific range of global warming by the end of the century. RCP8.5 refers to a high-emissions scenario, while RCP4.5 refers to moderate emissions.

Resilience: The ability of a business to absorb disturbances while retaining the same basic structure and means of functioning, and its capacity to adjust to stress and change.

Return period (or interval): The average time interval between occurrences of an event (e.g., an extreme rainfall event) of a defined intensity or size.

Risk: The potential for adverse consequences for business assets, employees, value chains and communities, where the occurrence and magnitude of the consequences is uncertain. Risk results from the interaction of vulnerability (of an affected business), its exposure over time (to the climate impact-driver), as well as the nature and intensity of the climate conditions and their likelihood of occurrence. See also Climate Impact-driver, Hazard and Impacts.

Sensitivity: The degree to which a business is affected, either adversely or beneficially, by a climate impact-driver. See also Climate Impact-driver and Vulnerability.

Supply chain: The entire system of procurement, logistics, transformation and delivering a product or service, from the sourcing the raw materials through to the delivery of the finished product or service to customers. Sometimes used interchangeably with value chain.

Vulnerability: The degree to which a business (its assets, employees and value chain) is susceptible to, and unable to cope with, adverse effects of climate change. It is a function of character, intensity, frequency and duration of the climate impact-driver to which the business is exposed and the sensitivity and adaptive capacity of the business. See also Adaptive Capacity and Sensitivity.

Weather: The atmospheric conditions outside at any particular time and place, which can change quickly.

Endnotes

1 A similar tool is available for Edmonton's homeowners and builders that provides practical guidance on how to improve the climate resilience of homes in the city—the Climate Resilient Home (CRH) (**climateresilienthome.ca**).

2 Statistics Canada officially defines small- and medium-sized businesses as having less than 500 employees; a small-sized business employs less than 100 individuals while a medium-sized business employs 100 to 499 individuals.

3 Learn more: See the "Recommendations of the Task Force on Climate-related Financial Disclosures: Final Report" (**fsb-tcfd.org/recommendations**).

4 Learn more: Visit **edmonton.ca/climateresilience** for links to additional information.

5 Surminski, S., Style, D., Di Mauro, M., et al., 2016, UK Climate Change Risk Assessment Evidence Report: Chapter 6, Business and Industry. Report prepared for the Adaptation Sub-Committee of the Committee on Climate Change, London, UK.

6 The supply chains and distribution networks business functions are considered together in Section 5 because of the vulnerability of both functions to impacts on (sometimes the same) logistics and transport infrastructure.

7 NASA. Available at **climate.nasa.gov/evidence**. Accessed April 20, 2022.

8 Historical data obtained from Environment Canada's Adjusted and Homogenized Canadian Climate Data (AHCCD) from weather stations in the Edmonton Area. Cited in: City of Spruce Grove, Climate Resilience Express Action Plan. March 2018.

9 Projections of future climate change consider a range of plausible scenarios known as RCPs (Representative Concentration Pathways). RCP numbers (e.g., 8.5) refer to the median additional warming (in Watts per square metre) anticipated under each scenario by 2100.

10 To identify changing conditions across time, climate scientists work with 30-year averages to smooth out the effects of natural year-to-year variations in weather.

11 Projections obtained from **climatedata.ca** for the Edmonton Census Subdivision.

12 Learn more: see the Prairie Provinces chapter of Canada in a Changing Climate's Regional Perspectives Report (**changingclimate.ca/regional-perspectives/chapter/4-0**).

13 Projections obtained from **climatedata.ca** for the Edmonton Census Subdivision (Central), Medicine Hat Census Subdivision (South), and Mackenzie County Census Subdivision (North).

14 Boyd, R. and Markandya, A., 2021. Costs and Benefits of Climate Change Impacts and Adaptation; Chapter 6 in Canada in a Changing Climate: National Issues Report, (Eds.) F.J. Warren and N. Lulham; Government of Canada, Ottawa, Ontario.

15 Zhang, X., et al., 2019. Changes in Temperature and Precipitation Across Canada; Chapter 4 in Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario.

16 Learn more: See Canada's Changing Climate Report (**changingclimate.ca/CCCR2019**).

17 Jiang, K. and Scafffe, C., 2021. Canadian Supply Chain Logistics Vulnerability. Office of the Chief Economist, Global Affairs Canada.

18 Learn more: See the Sector Impacts and Adaptation chapter of Canada in a Changing Climate's National Issues Report (**changingclimate.ca/national-issues/chapter/7-0**).

19 Statistics Canada, 2018. Survey on Financing and Growth of Small and Medium Enterprises 2017, Data Tables. Centre for Special Business Projects, Statistics Canada, Ottawa, ON.

20 Ibid.

21 Statistics Canada, Provincial Symmetric Input-Output Tables, 2019.

22 Learn more: For Canada's trading partners (North America, Asia, Europe and Central and South America, Australasia and Africa), see the Climate Change Impacts and Risks Fact Sheets (**ipcc.ch/report/ar6/wg2/about/factsheets**).

23 IPCC, 2022. Summary for Policymakers [H.-O. Pörtner, et al. (eds.)]. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, et al.(eds.)]. Cambridge University Press. In Press.

24 Source: Federal Emergency Management Agency (n.d.). FEMA Snow Load Safety Guidance. FEMA P-957.

25 The Roofing Industry Committee on Weather Issues, Inc. (2017). Hailstorm investigation report. North Texas — April 11, 2016.

26 The American Society for Testing and Materials (ASTM) has standard test methods for roofing products and materials. Asphalt shingles rated as ASTM D7158(**astm.org/Standards/D7158.htm**) Class G or better are rated to withstand winds up to 200 kilometres per hour. The Standards Council of Canada is currently working on a Standard for High Wind Safety (CSA S520) (**scc.ca/en/standards/notices-of-intent/csa/high-wind-safety-for-low-rise-residential-and-small-buildings**), to provide guidance on wind resistant building design, materials, and techniques for low-rise residential and small buildings.

27 Impact-resistant skylights should meet the following standards (in accordance with the Insurance Institute for Business & Home Safety -Commercial Wind Standards): ASTM E1886 cyclic pressure test requirements and ASTM E1996 missile impact rated "B", "C", "D", or "E".

28 In accordance with ANSI/SPRI GD-1 2010 Structural Design Standard for Gutter Systems Used with Low-Slope Roofs or ANSI/SPRI GT-1 (2016) Test Standard for Gutter Systems.

29 Designed and installed for wind resistance in accordance with the Federal Emergency Management Agency (FEMA) Rooftop Attached Lightning Protections Systems in High-Wind.

30 Specific values and detailed information available through the LEED Heat Island Reduction Credit (**usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-hospitali-1?return=/credits**) and the Cool Roof Rating Council (**coolroofs.org**).

31 See: Green-e Renewable Energy Standard for Canada and the United States (**green-e.org/docs/energy/Green-e%20Standard%20US.pdf**).

32 Source: STANDATA Building Code Bulletin 06-BCB-009R1.

33 Ibid.

34 Ibid.

35 And/or, the design requirements in the American Society of Civil Engineers (ASCE) 7 – Minimum Design Loads and Associated Criteria for Buildings and Other Structures.

36 Hail impact-resistant roof cover should meet the following standards (in accordance with the Insurance Institute for Business & Home Safety -Commercial Wind Standards (hail considerations)):

- For low-sloped roofs (≤10° or less than 2/12 pitch):
  - FM Approval Standard 4470 with a Class 1-SH or 1-VSH
  - UL 2218 Class 4
- For steep-sloped roofs (>10° or greater than 2/12 pitch):
  - FM Approval Standard 4473 Class 4
  - UL 2218 Class 4

37 Impact-resistant skylights should meet the following standards (in accordance with the Insurance Institute for Business & Home Safety -Commercial Wind Standards (hail considerations)): ASTM E1886 cyclic pressure test requirements and ASTM E1996 missile impact rated "B", "C", "D", or "E". FM Approved per ANSI/FM 4431, with Severe Hail Rating.

38 Impact-resistant PV modules should meet the following standards (in accordance with the Insurance Institute for Business & Home Safety -Commercial Wind Standards (hail considerations)): Flexible PV modules that are FM Approved for hail or meet FM Approval Standard 4476 that includes a Severe Hail rating. Rigid PV modules that are FM Approved for hail or meet FM Approval Standard 4478 that includes a Class 4 rating. Rigid modules that meet UL 1703 Standards for Flat-Plate Photovoltaic Modules and Panels.

39 Class A materials are effective against severe test exposure, and afford a high degree of fire protection, in accordance with the Standards Council of Canada, CAN/ULC-S107:2019 Standard Methods of Fire Tests of Roof Coverings. 2019.

40 Material testing in accordance with the ASTM E 2886, "Standard Test Method for Evaluating the Ability of Exterior Vents to Resist the Entry of Embers and Direct Flame Impingement".

41 As determined in accordance with CAN/ULC-S104, "Standard Method for Fire Tests of Door Assemblies".

42 See: 2030 Palette. **2030palette.org/vegetative-cooling**.

43 The City of Edmonton Low Impact Development Best Management Practices Design Guide provides a list of recommended native vegetation and ornamental trees, shrubs and perennials appropriate for the Edmonton area.

44 The FireSmart Guide (**firesmartcanada.ca/wp-content/uploads/2019/10/FireSmart-Guide-to-Lanscaping.pdf**) to Landscaping provides a comprehensive list of tree species, including their hardiness zone, sun/shade preferences and water use requirements. From the Alberta FireSmart Homeowners Manual, deciduous (leafy) trees that are resistant to wildfire and include: Poplar, Birch, Aspen, Cottonwood, Maples, Alders, Ash and Cherry.

45 For a list of climatically suitable tree species in the Edmonton area, refer to the Edmonton Metropolitan Region Guide to Urban Forest Management in a Changing Climate (**allonesky.ca/regional-climate-adaptation-collaborative**).

46 Based on data in Statistics Canada Table 45-10-0014-01 and Table 14-10-0043-01 for persons aged 25-64 years.

47 Learn more: visit the Climate Change and Health: Health Effects site of the Government of Canada (**canada.ca/en/health-canada/services/climate-change-health.html**) or the U.S. Global Change Research Program's Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (**health2016.globalchange.gov**).

48 For context; between 2015 and 2019 there were 729 occupational fatalities in Alberta—50% caused by occupational illnesses, 31% by workplace accidents and 19% by motor vehicle accidents. Occupational illness mostly affected elderly workers. In 2019, there were 28,515 lost time claims in Alberta for work-related injuries or illnesses. Overexertion directly resulted in 1/5th of these incidents. Further information is available in the Government of Alberta's Workplace Injury, Disease and Fatality Statistics: Provincial Summary 2019 (**open.alberta.ca/publications/workplace-injury-disease-and-fatality-statistics-provincial-summary**).

49 Learn more: see ESDC (2018). Thermal stress in the workplace: Guideline 2018. Employment and Social Development Canada, Ottawa (**canada.ca/en/employment-social-development/services/health-safety/reports/thermal-stress-work-place.html**).

50 Dasgupta, S., et al. (2021). Effects of climate change on combined labour productivity and supply: an empirical, multi-model study. Lancet Planet Health, 5, 455-465; Zivin, J. and Neidell, M. (2014). Temperature and the allocation of time: implications for climate change. Journal of Labour Economics, 32, 1–26; and Dunne, J., Stouffer, R. and John, J. (2013). Reductions in labour capacity from heat stress under climate warming. Nature Climate Change, 3, 563–566.

51 ESDC (2018).

52 Kjellstrom, T., et al. (2015). Heat impacts on work, human performance and daily life. In: Climate Change and Public Health [Levy, B. and Patz, J., (eds.)], Oxford University Press, New York, 73–86.

53 Heal, G. and Park, J. (2016). Temperature stress and the direct impact of climate change: a review of an emerging literature. Review of Environmental Economics and Policy, 10 (2), 1-17.

54 Learn more: see ILO (2019). Working on a warmer planet: the impact of heat stress on labour productivity and decent work. International Labour Organization (ILO), Geneva, Switzerland; or Kjellstrom, T., et al. (2016). Heat, human performance, and occupational health: a key issue for the assessment of global climate change impacts. Annual Review of Public Health, 37, 97–112.

55 Vanos, J., et al. (2019). Workplace heat exposure, health protection, and economic impacts: a case study in Canada. American Journal of Industrial Medicine, 62 (12), 1024–1037.

56 Boyd, R., Eyzaguirre, J., Poulsen, F., Siegle, M., Thompson, A., Yamamoto, S., Alvaro. (2020). Costing climate change impacts on human health across Canada. Technical Report prepared by ESSA Technologies Ltd. for the Canadian Institute for Climate Choices, Ottawa.

57 Hot days and heat waves, which are discussed separately above, would fall within this category of extreme events.

58 Ground-level ozone (O_3) is a key component of smog. It is formed by chemical interactions between sunlight and pollutants, including nitrogen oxides and volatile organic compounds. O_3 levels are influenced by interactions between emissions of these compounds and meteorological conditions. In general, higher temperatures, sunnier skies, and lighter winds lead to higher O_3 levels. Climate change is anticipated to increase O_3 levels in the future, largely due to higher temperatures.

59 Particulate matter (PM) is a mixture of substances ("aerosols") in the atmosphere, including sulfate, nitrate, ammonium, organic carbon, and dust. PM smaller than 2.5 microns in diameter (PM2.5) is a particular concern—being associated with a range of serious health effects. Like O_3, PM2.5 concentrations depend in part on meteorological conditions, including precipitation patterns and humidity, fire weather and drought. Fire weather are conditions conducive to triggering and sustaining wildfires, including ambient air temperature, soil moisture, humidity, and wind.

60 Learn more: see Bouchard, C., Dibernardo, A., Koffi, J., Wood, H., Leighton, P. and Lindsay, L. (2019). Increased risk of tick-borne diseases with climate and environmental changes. CCDR, 45 (4), 81–89 (**doi.org/10.14745/ccdr.v45i04a02**).

61 Learn more: see Ludwig, A., Zheng, H., Vrbova, L., Drebot, M., Iranpour, M. and Lindsay, L. (2019). Increased risk of endemic mosquito-borne diseases in Canada due to climate change. CCDR, 45 (4), 90–97 (**doi.org/10.14745/ccdr.v45i04a03**).

62 The stratospheric ozone layer is a naturally occurring gas that filters the amount of the sun's UV radiation reaching the Earth's surface. Think of it as the Earth's sunscreen.

63 Learn more: visit the Canadian Centre for Occupational Health and Safety's online "Risk Assessment" guide (**ccohs.ca/oshanswers/hsprograms/risk_assessment.html**). Or see the Standards Council of Canada's Z1002 Occupational Health and Safety – Hazard Identification and Elimination and Risk Assessment and Control (CAN/CSA-Z1002-12 (R2017) (**csagroup.org/store**).

64 NIOSH (2016). NIOSH criteria for a recommended standard: occupational exposure to heat and hot environments. Jacklitsch, B., Williams, W., Musolin, K., Coca, A., Kim, J.-H., Turner, N. and Cincinnati, O. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 2016-106.

65 Key questions were drafted by the authors based on the literature and guidance reviewed for the development of Section 4; source material is referenced throughout the section.

66 ESDC (2018).

67 Learn more: see Alberta Government (2014), Best Practice – Working Safely in the Heat and Cold. Alberta Government, Edmonton (**ohs-pubstore.labour.alberta.ca/gs006**) or Work Safe B.C. (2007 update), Preventing Heat Stress at Work (**worksafebc.com/en/resources/health-safety/books-guides/preventing-heat-stress-at-work**). Also, visit the Canadian Centre for Occupational Health and Safety's "Fact Sheets" for "Hot Environments-Control Measures" (**ccohs.ca/oshanswers/phys_agents/heat_control.html**) and "Temperature Conditions-Hot" (**ccohs.ca/oshanswers/phys_agents/max_temp.html**).

68 For further details see ACGIH (2016). 2016 TLVs® and BEIs® – Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati: American Conference of Governmental Industrial Hygienists (ACGIH), p. 218.

69 See: Section 4.15 and Table 4-1 (and listed sources) of Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments, US Centre for Disease Control and Prevention, Technical Report, February 2016, B. Jacklitsch.

70 See Part 7: Emergency Preparedness and Response, Alberta Regulation 191/2021, Occupational Health and Safety Act for the required contents of a plan (**https://www.qp.alberta.ca/1266.cfm?page=2021_191.cfm&leg_type=Regs&isbncln=9780779826889&display=html**). Learn more: There are multiple guides to these ends. Consider, for example, the emergency response planning toolkit for the hospitality industry in Alberta (**https://open.alberta.ca/dataset/c61c5ea0-360d-4356-b6f1-ad5dcd70a2bf/resource/24b7ea6c-c16f-4134-ba5f-4d9e109267ea/download/lbr-emergency-response-planning-occupational-health-and-safety-tool-kit-for-hospitality-industry.pdf**), the preparedness and emergency response guide for thunderstorms, tornadoes and lightning developed by NOAA, the US Department for Homeland Security, and the American Red Cross (**https://www.weather.gov/media/owlie/ttl6-10.pdf**), or the Alberta Government's Hazard Assessment and Control: A Handbook for Alberta Employers and Workers (**https://open.alberta.ca/publications/9781460146835**). Also, look at pages 12-31 in the US Chamber of Commerce Foundation's Business Resilience 101 Workbook: Learn How to Protect Your Business Before Disaster Strikes (**https://www.uschamberfoundation.org/resilience-box/resilience-101-workbook-resources**).

71 Learn more: Visit the Government of Canada's Air Quality Health Index site (available at **https://www.canada.ca/en/environment-climate-change/services/air-quality-health-index.html**). The AQHI forecast values for Edmonton are available at: **https://weather.gc.ca/airquality/pages/abaq-001_e.html**.

72 Government of Canada, Health Risks of Air Pollution (**https://www.canada.ca/en/environment-climate-change/services/air-quality-health-index/health-risks.html#toc1**) (accessed 30-11-2021).

73 See the Mosquito-borne diseases national surveillance reports (available at **https://www.canada.ca/en/public-health/services/diseases/west-nile-virus/west-nile-virus-other-mosquito-borne-disease.html**) and the Surveillance of Lyme disease site (accessed at **https://www.canada.ca/en/public-health/services/diseases/lyme-disease/surveillance-lyme-disease.html**).

74 Learn more: Visit the Public Health Agency of Canada's online Lyme disease prevention toolkit (available at **https://www.canada.ca/en/public-health/services/publications/diseases-conditions/lyme-disease-prevention-toolkit.html**) or visit the U.S. National Institute for Occupational Safety and Health's Lyme Disease site (accessed at **https://www.cdc.gov/niosh/topics/lyme**).

75 CDC. Drinking Water: Guide to Drinking Water Treatment Technologies for Household Use (available at **http://www.cdc.gov/healthywater/drinking/home-water-treatment/household_water_treatment.html**).

76 See **drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk**. For the purpose of this Guide, the publicly available index was re-calculated to capture only natural hazards.

77 See **gain.nd.edu/our-work/country-index**.

Notes