Town of CANMORE

Climate Emergency Action Plan

Adaptation Opportunities Assessment Summary Report

March 2024

Territory Acknowledgement

The Town of Canmore is located within the Treaty 7 region of Southern Alberta. In the spirit of respect, reciprocity, and truth, we honour and acknowledge the Canmore area, known as “Chuwapchipchiyan Kudi Bi” (translated in Stoney Nakoda as “shooting at the willows”), and the traditional Treaty 7 territory and oral practices of the Îyârhe Nakoda (Stoney Nakoda), comprised of the Bearspaw First Nation, the Chiniki First Nation, and the Goodstoney First Nation; the Tsuut’ina First Nation; and the Blackfoot Confederacy, comprised of the Siksika, the Piikani, and the Kainai. We acknowledge that this land is also home to the Rocky View Métis District 4 within the Battle River Territory. We acknowledge all Nations who live, work, and play on and help us steward this land and honour and celebrate this territory. We commit to working to live in right relations and to advance Truth and Reconciliation.

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Purpose of Document

This document is intended to supplement Canmore's Climate Risk and Vulnerability Assessment (CRVA) Report. This report summarizes the opportunities for adaptation to reduce the vulnerability of people and assets within Canmore to the climate hazards outlined in the CRVA. This report uses an RCP 8.5 future climate scenario to assess future climate impacts and uses the same population and land-use/development assumptions as the CRVA. Adaptation actions, both modelled and non-modelled, illustrate the potential to reduce the risk of damages to buildings and infrastructure, as well as the risk of injury and death, but they do not encompass all possible opportunities to reduce this risk. Further information on the climate scenarios, hazard identification, and risk and vulnerability assessment are found in the CRVA.

Climate Change Adaptation

Adaptation Vision Statement

The Town of Canmore is working to reduce and prepare for the changing threats from climate change, and it is taking action to ensure the people of Canmore are safe and prepared for future climate events, the natural environment is protected, and the economy of Canmore thrives into the future.

Work to adapt to climate change and increase resilience across the town and the community will begin immediately, with work prioritized based on the potential consequences of inaction, community need, infrastructure opportunities, and resource availability.

Climate Action Themes

Canmore is working to address climate change mitigation and adaptation simultaneously. By choosing this approach, the Town can maximize efficiency in efforts while also identifying and avoiding any potential maladaptive actions before they occur. Centering equity in all decision-making for both mitigation and adaptation actions ensures that those most vulnerable to climate change impacts are prioritized. Actions to reduce GHG emissions, improve energy efficiency, and increase climate preparedness and resilience are combined in Canmore's Climate Emergency Action Plan (CEAP). The CEAP themes are as follows:

1. Municipal Leadership
2. Resilient, Efficient Buildings
3. Clean Resilient Energy
4. Safe and Protected Natural Spaces
5. Emergency Preparedness for All
6. Rethinking Transportation and Mobility
7. Reliable and Resilient Waste, Water, and Wastewater Management

Action taken to improve climate adaptation and community resilience will be measured against the 2022 base year used for modelling in both the mitigation and adaptation work for the CEAP.

Table 1. Climate action themes.

Theme		Action Areas
1	Municipal Leadership	Internal Leadership Community Involvement
2	Resilient, Efficient Buildings	Municipal Climate Leadership Efficient and Resilient New Buildings Efficient and Resilient Residential Retrofits Efficient and Resilient Commercial and Institutional Retrofits
3	Clean, Resilient Energy	Renewable, Reliable Electricity Emergency Energy Management Reducing Energy Poverty
4	Safe and Protected Natural Spaces	Protected Forests and Urban Trees Protected Freshwater
5	Emergency Preparedness for All	Wildfire Management Flooding and Steep Creek Hazard Management Water Security Community and Visitor Safety
6	Rethinking Transportation and Mobility	Electric Vehicles for All Active Mobility Across Canmore Low-Carbon Transit
7	Efficient Waste, Water, and Wastewater Management	Water Conservation and Management Waste Reduction

Using these themes and action areas, a complete list of actions to implement the CEAP has been developed. These actions, as well as the supporting partners, the timeline for implementation, the costs and resource needs, the equity considerations, and other details, are found in the CEAP Implementation Strategy.

Climate Hazards

Climate Hazards Summary

While a full climate risk and vulnerability assessment can be found in the CRVA document, a short summary is included below to provide context on the prioritization of climate hazards in this analysis.

To understand the risk from climate hazards, three components are assessed:

- **The hazard threat —** What is the extent of the threat? How frequently does it occur?How will it change over time?
- **The vulnerability —** What is the adaptive capacity of the system? What are the sensitivity and susceptibility of the system to the hazard?
- **The consequence —** What are the direct and indirect consequences of the hazard to the system?

The risk score is the result of all three components combined. A summary of this work (Table 2) shows that wildfire, steep creeks, and riverine flooding pose the largest risk to Canmore and the community. Ecoregion changes, especially to forested areas, pose a moderate risk to Canmore, while extreme heat and drought are minor risks.

High winds, freezing rain and ice accumulation, extreme cold, and snow accumulation are anticipated to pose an insignificant risk to Canmore and the community, primarily because climate indicators for these risks are expected to remain consistent with current conditions or decrease in severity.

This risk assessment allows for the prioritization of actions to reduce Canmore's climate risk and protect the community.

Table 2. Risk assessment scores for climate hazards in Canmore.

Rank	Hazard	Hazard Threat	Vulnerability	Consequence	Risk
1	Ecoregion Changes	2.2	0.7	2.5	1.67
2	Wildfire	2.1	0.9	4.5	3.90
3	Steep Creeks	1.5	0.7	4.0	2.93
4	Extreme Heat	1.3	0.4	2.0	0.80
5	Riverine Flooding	1.1	0.7	4.0	2.67
6	High Winds	1.0	0.3	1.5	0.50
7	Freezing Rain/Ice Accumulation	0.9	0.2	1.5	0.30
8	Dry Weather Conditions/Drought	0.8	0.4	1.5	0.60
9	Extreme Cold/ Cold Snaps	0.8	0.3	1.0	0.27
10	Snow Accumulation	0.8	0.2	1.0	0.20

Quantitative and Qualitative Modelling of Hazards

Quantitative modelling of the hazards and the potential adaptation interventions to reduce risk is not appropriate for all hazards. The following parameters are assessed when classifying a hazard as suitable for quantitative or qualitative modelling:

- **Historical risk** associated with the hazard for the community;
- **Anticipated risk** of the hazard in the future for the community;
- **Spatial variance** in the interaction between the hazard and potentially affected assets; and
- **Data availability** of the hazard parameters.

The analytical approach is also informed by the Climate Risk and Vulnerability Assessment, where the highest risks to Canmore are identified. Hazards that are anticipated to pose an insignificant risk in the future are not assessed in detail. The hazards assessed for Canmore, as well as the type of analysis and the rationale for this decision, are shown in Table 3.

Table 3. Hazard scope and definitions.

Hazard	Definition	Hazard Risk	Assessment Type	Rationale
Ecoregion Changes	Shifts in the species composition, or type of ecosystem or ecoregion found in the area. The focus of this is on invasive species and diseases, as well as stresses to the forest ecosystem.	Moderate	Qualitative	Data are not available to track the potential shifts in ecoregion or the spread of new species at the Canmore scale. Regional shifts can be tracked, but these are harder to scale down to the level of a town. Impacts from ecoregion changes are included in wildfire, as the primary concern is with stresses to forest ecosystems.
Wildfire and Smoke	Wildfire is the unplanned spread of fire caused by natural events or human activity. Smoke from wildfires can affect locations far away from the actual fire. Canmore is a valley, and smoke can become trapped in the valley, resulting in health problems and impacts to recreation and visitors.	High	Qualitative	The wildfire risk is elevated across all of Canmore, so specific high-risk areas cannot be isolated in the analysis. The value of assets at risk from fire in the present day and in the future can be assessed based on the elevated fire risk across the town. Smoke from wildfires cannot be tracked spatially at the scale of the town, so this is assessed qualitatively.

Hazard	Definition	Hazard Risk	Assessment Type	Rationale
Steep Creeks	Debris flows and debris floods, also known as steep creek flooding, occur when large precipitation events in mountainous areas cause flows to entrain an abundant quantity of sediment and debris. These floods can be unpredictable and dangerous, causing extensive damage downstream.	High	Quantitative[1]	Detailed assessments of the risk and potential damages from steep creek flooding were completed by BGC Engineering. These studies form the basis of the quantitative assessment of risk, but spatial data from these analyses were not available to include in spatial modelling here.
Extreme Heat	Extreme heat is a period of high heat. For the purposes of this analysis, we are specifically looking at the effect of such conditions as they relate to heat stress and the effect of periods of high heat on Canmore's residents.	Minor	Quantitative	Data are readily available to assess the spatial variation of high heat across Canmore.

[1] The quantitative analysis for steep creek flooding was completed by BGC Engineering between 2014 and 2018.

Hazard	Definition	Hazard Risk	Assessment Type	Rationale
Riverine Flooding	Riverine flooding occurs when there is excessive rainfall over an extended time period, which causes rivers or creeks to overflow.	High	Quantitative	The geographic extent of flooding across Canmore is highly variable, and data are available on flood depth, return intervals of floods, and the assets found within floodplains.
Dry Weather Conditions/ Drought	Extended warm periods can result in droughts. Stresses to surface and subterranean water supplies threaten potable water availability.	Minor	Qualitative	The impacts of droughts have low spatial variability, and data are not available to assess this in detail.
Not Included				
High Winds	Strong winds result from shifting atmospheric pressures, and they can damage trees, buildings, electrical infrastructure, and other assets.	Insignificant	Not Included	This hazard is not expected to have a significant impact on Canmore nor is it expected to change from current conditions.

Hazard	Definition	Hazard Risk	Assessment Type	Rationale
Freezing Rain/Ice Accumulation	Winter storms that occur with temperatures around the freezing point can result in freezing rain and the accumulation of ice on surfaces, trees, and other infrastructure.	Insignificant	Not Included	This hazard is not expected to have a significant impact on Canmore nor is it expected to change from current conditions.
Extreme Cold/ Cold Snaps	Periods of extreme cold or periods with a rapid drop in temperature outside of the normal temperatures expected for a given time.	Insignificant	Not Included	This hazard is not expected to have a significant impact on Canmore nor is it expected to change from current conditions.
Snow Accumulation	Snow accumulation refers to the gradual buildup of snow on the ground over a specific period, such as hours or days.	Insignificant	Not Included	This hazard is not expected to have a significant impact on Canmore nor is it expected to change from current conditions.

Adaptation Opportunities and Impacts

Climate adaptation actions focus on reducing the risk associated with climate change. This can include actions to reduce the exposure to threats such as extreme heat, debris flows in steep creeks, or wildfire and smoke, which can cause serious harm, or even death. It also includes actions to reduce the damages associated with hazards like flooding and fire by protecting buildings and assets from these hazards now and into the future. These actions also work to increase the community's preparedness prior to and during a climate emergency and to increase the adaptive capacity of the community, the Town, and the essential services and assets across Canmore.

The actions and interventions were developed through engagement activities with town staff, subject matter experts, the business community, local non-governmental organizations, and the public, as well as through reviews of best practices and climate planning in other jurisdictions. A summary of the actions to adapt to climate hazards that pose a high, moderate, or low risk to Canmore are found in Appendix 1.

Ecoregion Changes

Summary of Interventions

Category	Impacts	Interventions
Changes to hazard due to climate change	• Stresses to ecosystem health from increased heat and precipitation changes, particularly forested areas. • Increased presence of invasive species, including pest species like the mountain pine beetle and vectors of diseases. • Decreased biodiversity. • Increased climate hazard potential.	

Category	Impacts	Interventions
Infrastructure/ Critical Infrastructure	• Increased stress on forest ecosystems, which can increase vulnerability to climate hazards such as landslides, flooding, and wildfire, which all pose substantial risk to infrastructure.	• Establish forest monitoring and management programs to track pests and invasive species. • Ensure FireSmarting of buildings and vegetation to reduce fire risk.
Services	• Impacts changing the regulatory functions of the natural environment will put more stress on human systems (e.g., increased need for air conditioning if the cooling effect of local plants is reduced).	• Update the Urban Forest Management Plan to include climate considerations such as species selection, tree management, and Urban Heat Island Effect (UHEI).
People	• Invasive insects and increased insect populations, such as mosquitoes, pose a nuisance risk as well as a vector-borne disease risk.	• Develop internal working groups to monitor the spread of invasive species and vectors of disease. • Educate the community about the identification of vectors and how to protect themselves from disease. • Encourage citizen science programming to monitor ecosystem health and the spread of invasive species.
Environment	• Ecosystem biodiversity may deteriorate, with negative outcomes for ecosystem functions, including cooling and flood mitigation. • Spread of species like the mountain pine beetle.	• Ensure the Urban Forest Management Plan includes climate considerations for tree planting and other activities, including species selection, tree management activities, and pest monitoring. • Monitor and manage the spread of forest pest species.
Economy	• Disruptions to the visitor industry from forest fires, forest death, and spread of vector-borne disease.	• Work with the visitor industry to share education materials on the identification of disease vectors and how to protect oneself from disease.

Context

Climate change, specifically warmer temperatures and shifts in precipitation patterns, affects forests in a number of ways, resulting in ecoregion changes. As the temperature warms, species adapted for cooler temperatures may no longer be able to thrive in their current locations and will be driven northward, and to higher elevations. Depending on their ability and the speed at which they can shift their location, some species may not be able to adapt quickly enough to persist in the face of the shifting environmental conditions. These shifts in environmental conditions can bring pest species to new locations where they previously have not been found. Additionally, these changing conditions can stress ecosystems, reducing their ability to defend against pests. Many pest species infect stressed or damaged trees, and shifting climatic conditions can contribute to the rapid growth of ecosystem-wide infections.

Invasive species typically do not have specialized food or habitat needs, making them adaptable to various environments. They also lack predators in their introduced environments and are often better able to exploit disturbances than their native competitors. Climate change impacts (such as hotter temperatures, wildfires, droughts, etc.) will produce more disturbances, and thus, may further facilitate the establishment and spread of invasive species.[2] Species will migrate as climate change impacts make geographies more hospitable for them.

Human activities (e.g., development, transportation infrastructure, altering land uses, agriculture, etc.) alter, degrade, and fragment habitat. This can make it challenging for flora and fauna species to move elsewhere in response to climate-related disturbances. Human responses to natural disasters can also exacerbate the impacts of climate change. For example, extensive tree salvage harvest following insect infestations can create hotter microclimates that encourage wildfire, and overgrazing and trampling change the plant community in grasslands and forest understory, destroying the biological crust and opening soil to invasive plants.[3] Human activities can compound the effects of climate change for invasive species introduction.

[2] "Invasive Species." *U.S. Climate Resilience Toolkit*, 6 Aug. 2021, https://toolkit.climate.gov/topics/ecosystem-vulnerability/invasive-species.

[3] Government of British Columbia. "Adapting Forest and Range Management to Climate Change in the Skeena Region:" *Adapting to Climate Change*, https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nrs-climate-change

Infrastructure/Critical Infrastructure and Services

Monitoring the forest ecosystem for the presence and spread of invasive species and pest species will allow Canmore and other groups to develop management strategies to reduce the potential damages to the forests from these threats. Coordinating this work across the region and with all levels of government will improve the ability to identify and track the spread of pests and new species and allow for the development of regional management strategies, expanding beyond the jurisdiction of Canmore itself.

Managing the forest to remove sick and injured trees and other invasive species will improve its overall health. Healthy forests pose less wildfire risks and increase the stability of steep slopes.

The urban forest provides shade and cooling, while also adding to Canmore's beauty. To reduce wildfire risk, climate considerations such as FireSmarting and the selection of climate-tolerant tree species for new plantings should be integrated into the forest management plan.

Human Health and Safety

Canmore should establish internal working groups with representatives from multiple municipal departments to address the threat of the spread of invasive species and vectors of disease (such as ticks and mosquitoes). These working groups will share information and expertise to provide early identification of potential threats to human health and develop strategies to reduce their impact on the environment and on public health.

Education programming can help community members understand how to identify disease vectors and other species of concern and how to protect themselves from the diseases carried by these species. Empowering individuals with this knowledge ensures that the public can become active participants in safeguarding their own health, as well as the health and integrity of the local ecosystems.

Citizen science allows community members to contribute to data collection and analysis on the spread of invasive species, fostering a deeper connection between the public and their environment. This participatory approach enhances scientific knowledge and raises awareness about environmental stewardship, creating a more informed and proactive community in the fight against ecological threats.

Environment

Integrating climate considerations into the Urban Forest Management Plan ensures that the urban forest in Canmore will be healthy and strong long into the future. For example, selecting tree species that are resilient to climate extremes and the shifting ecoregion conditions promotes the survival of the urban tree canopy as a whole. Actively monitoring and managing the urban forest will allow the Town to easily adapt its management strategies in the face of shifting conditions and community needs.

Additionally, managing the forest surrounding Canmore, particularly for the spread of forest pests and diseases, will help protect healthy trees and reduce the risk of fires and landslides.

Economy

The natural beauty of Canmore and the surrounding area form the backbone of the town's visitor economy. Including the town's industry and visitors in the identification of pests and invasive species, as well as disease vectors and their associated diseases, ensures that both Canmore and its visitors are protected.

Wildfire and Smoke

Summary of Impacts

Category	Impact	Interventions
Changes to hazard due to climate change	• Drier landscape from warmer weather. • Longer fire season. • Increased fuel from dead trees weakened by invasive species and heat stress.	

Category	Impact	Interventions
Infrastructure/ Critical Infrastructure	• Disruption to the transportation network. • Disruption to electricity grid infrastructure.	• Develop and update community-wide evacuation route planning, particularly for neighbourhoods with limited road access. • Clear vegetation around power lines and utility poles. • Integrate FireSmarting into new construction and retrofits to infrastructure, including fire-resistant building materials. • Ensure pumping stations and lift stations have back-up power supplies.
Services	• Increased strain on emergency services. • Contaminated drinking water. • Increased strain on medical systems from poor air quality from smoke.	• Update the Wildfire Mitigation Strategy with climate considerations, including fire frequency and severity, and how changing climate conditions affect hazards contributing to fire risk, like precipitation changes and the spread of invasive species. • Develop a regional wildfire management working group to coordinate FireSmarting, grants, and other fire management priorities and activities across the region. • Complete regular testing of the wildfire incident preparedness plan. • Continuously review community-wide evacuation plans and routes, focusing on neighbourhoods with vulnerable populations and challenging access to designated emergency routes. Support these plans with regular communication, including translation into multiple languages. • Continue fuel management in high-risk areas. • Identify clean-air shelters that can be used during evacuations or poor-air-quality events.

Category	Impact	Interventions
People	• All of Canmore is at an elevated risk of wildfire. • Health concerns from poor air quality from smoke.	• Develop programs and incentives for property owners to implement Fire Smarting, including the potential of offering a Town service to collect material from households. Regularly monitor for continued compliance. • Require new buildings to follow FireSmart design guidelines for construction materials and landscaping. • Deploy the Smoke Emergency Response Plan.
Environment	• Decreased tree canopy. • Soil erosion. • Air quality.	• Practice fuel management, including pest monitoring and management.
Economy	• Decreased visitor economy. • Unhealthy working conditions due to air quality. • Reduced productivity from extended periods of poor air quality.	• Update the Municipal Emergency Management Plan to more specifically address the potential impacts of climate-related emergencies on visitors and the tourism sector. Continue to collaborate with Tourism Canmore Kananaskis and other representatives from the tourism sector on emergency and overall preparedness. • Provide public awareness campaigns to educate visitors about wildfire risks, safety precautions, and emergency procedures. • Provide comprehensive training to outdoor workers on wildfire safety.

Context

Wildfire risk is high across all of Canmore. The town is situated in a forested valley surrounded by intact forests and grasslands. Both of these environments are susceptible to fire, and fire risk is impacted by a variety of climate conditions. Warmer temperatures, changes to precipitation, and the spread of invasive species all contribute to an elevated fire risk. Careful monitoring and management of natural spaces, as well as the built environment, are essential to protect the health and safety of the community, as well as the natural systems in the region.

Smoke from wildfires outside of Canmore can drift into the community, resulting in increased air pollution, extended periods of poor air quality, and health concerns for those exposed to the smoke.

Financial Impacts

No area of Canmore is removed from the risk of wildfire. As the community grows, especially on the outskirts, more buildings will be located in areas of high and extreme wildfire threat.

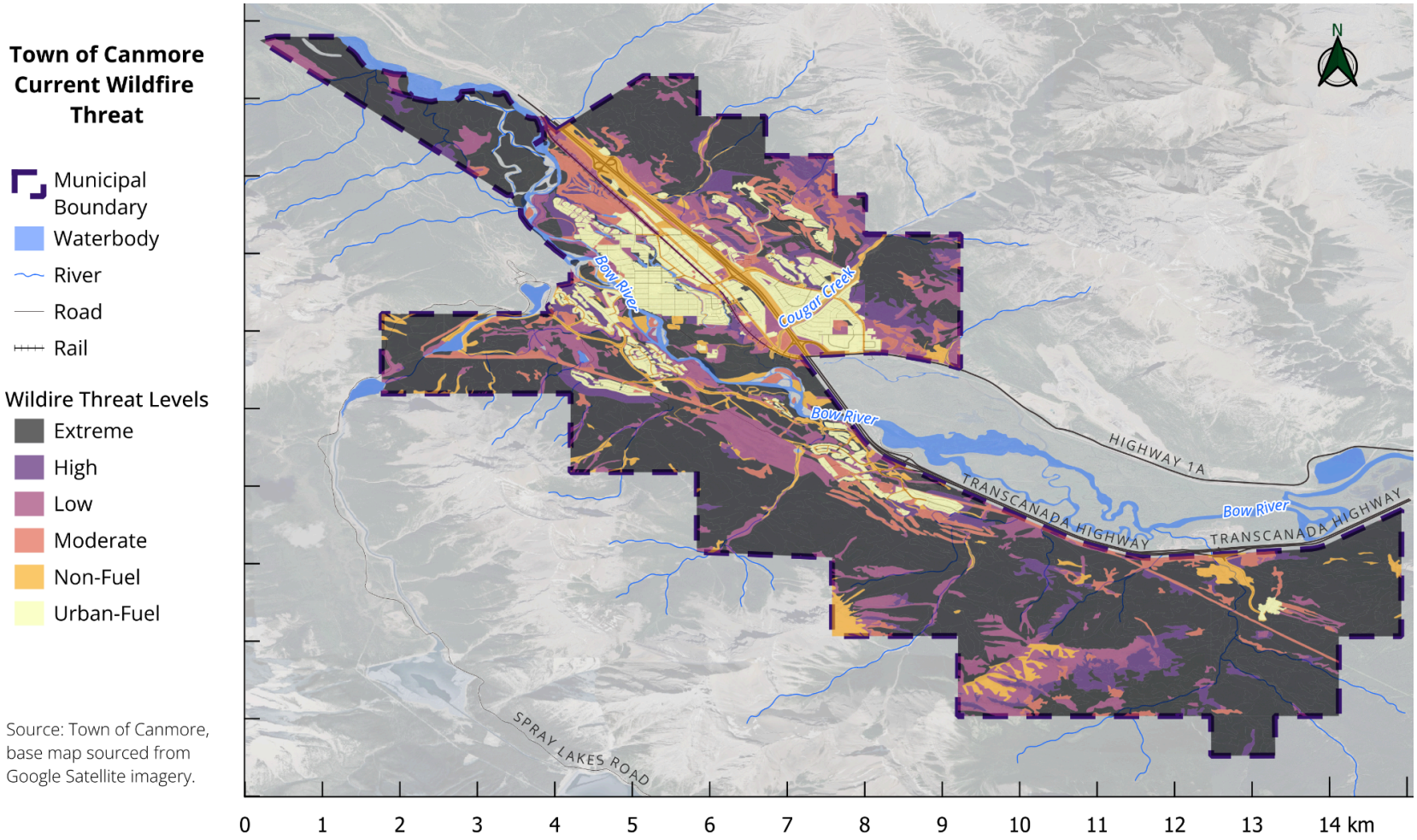


Figure 1. Present-day wildfire threat levels for Canmore.[4]

[4] Modified from: Walkinshaw, Stew, 2020. Wildfire Risk Assessment. Three Sisters Mountain Village. Montane Forest Management Ltd.

Fires can easily destroy whole homes and businesses, resulting in the need for demolition and total reconstruction. Currently, residential buildings and associated properties are worth over $8.5 billion dollars, and non-residential buildings and properties are worth $2.7 billion.[5] By 2070, based on growth alone, and without consideration of inflation or increases in property values, residential buildings are worth over $15.5 billion dollars, and non-residential buildings and properties are worth over $3.1 billion dollars.

Implementing building and landscape modifications according to FireSmart guidelines is a highly effective approach to protecting communities from the dangers of wildfires. Research shows that structural modifications alone can reduce wildfire risk by up to 40%, and when structural modifications are combined with landscape modifications, the risk reduction potential increases significantly to about 75%.[6]

Widespread adoption of these modifications within communities can yield substantial financial benefits (Table 5). Implementing structural FireSmarting reduces the 2070 residential damages to $9.3 billion, and structural and vegetation FireSmarting can reduce damages to $3.8 billion. Non-residential buildings follow a similar trend, with potential damages decreasing from $3.1 billion to $1.9 billion with structural FireSmarting, and $780 million with structural and vegetation FireSmarting. Thus, the potential for financial gains through reduced property damage and losses is considerable.

Although structural modifications to existing buildings can be costly and difficult to implement on a large scale, new buildings designed following FireSmart guidelines for fire resistant construction materials and landscape considerations would incur smaller cost premiums. As Canmore grows and adds new homes and businesses, there is a considerable opportunity to reduce wildfire risk by requiring new buildings to follow such guidelines. Similarly, existing buildings undergoing major renovations, such as deep energy retrofits, also present a timing opportunity for coupling fire-resistant measures with planned modifications.

[5] Property values obtained from the 2023 Tax Assessment values from the Town of Canmore.
[6] National Association of Insurance Commissioners. 2020. Application of Wildfire Mitigation to Insured Property Exposure. Retrieved from: https://content.naic.org/sites/default/files/cipr_report_wildfire_mitigation.pdf

Table 5. Value of buildings and properties in 2070, with potential damages from wildfire with different levels of FireSmarting.

	2070 value of buildings + land	2070 potential damages with with structure FireSmart	Value of avoided damages from structure FireSmart	2070 potential damages with structure and vegetation FireSmart	Value of avoided damages from structure and vegetation FireSmart
Residential buildings + land	$15.55 Billion	$9.330 Billion	$6.220 Billion	$3.890 Billion	$11.660 Billion
Non-residential buildings + land	$3.110 Billion	$1.865 Billion	$1.240 Billion	$777 Million	$2.33 Billion

Infrastructure/Critical Infrastructure and Services

The Town takes a central role in coordinating emergency responses to climate hazards, including wildfire. This work includes reducing the risk of wildfire, planning and coordinating during emergencies, and working with the community after an emergency event.

To reduce the risk of wildfires, Canmore should update the Wildfire Mitigation Strategy to include climate considerations, such as changes to the frequency and intensity of fires, long-term forest health, and water availability, and the integration of other climate hazards in fire management. By developing a regional fire management working group, Canmore can coordinate fire risk reduction activities across the entire region, increasing the impact and success of these activities. Continuing fuel management in high-risk areas, integrating FireSmarting of buildings and vegetation across the town, and clearing vegetation around power lines and utility poles will help reduce the likelihood, impact, and spread of wildfires.

The Town must be prepared for a wildfire, ensuring that emergency services have adequate training and resources and that community-wide evacuation strategies identify areas with limited road access. Emergency response plans should be clearly communicated with the public so the community is prepared for potential evacuations and knows the location of clean-air shelters that can be used as needed.

Human Health and Safety

Canmore's Smoke Emergency Response Plan outlines activities and roles and responsibilities, as well as activities designed to protect the community from smoke and other poor-air-quality events. Deploying the Smoke Emergency Response Plan and ensuring it is regularly updated is essential to protecting Canmore from fires that happen outside of the town but still impact the area.

FireSmarting buildings can greatly reduce the risk of damages from fire and can help improve indoor air quality during smoke events. Developing bylaws that require FireSmarting and continued compliance with these regulations will help protect the community of Canmore.

Environment

Continuing fuel management, pest monitoring, and forest health monitoring will be instrumental in reducing the wildfire risk to Canmore and the surrounding areas, and a greater impact can be produced by coordinating these activities between all levels of government..

Economy

The visitor industry must be included in the development and deployment of wildfire preparedness and risk-reduction strategies. Providing fire safety training to members of the visitor industry, particularly those working closely with visitors in the outdoors, will reduce the likelihood of accidental fires. Similarly, education campaigns directed at visitors will help keep them safe if a wildfire occurs.

Steep Creeks

Summary of Impacts

Category	Impact	Interventions
Changes to hazard due to climate change	• Increased total precipitation annually and seasonally in spring and fall. • Higher average temperatures in winter and spring affect peak flows and timing of spring freshet.	
Infrastructure/ Critical Infrastructure	• Potential damages to electrical infrastructure. • Potential damages to other critical service buildings, including the hospital, RCMP building, and municipal government buildings. • Damage to and disruption of roads.	• Work with Engineering, Public Works, and Protective Services to map redundancy in the road network. • Continue to identify and maintain locations within the community to serve as short-term shelters for evacuees during emergency events.
Services	• Increased need for emergency shelters. • Support for repairs and clean-up after flooding.	• Continue to fund and implement measures to mitigate steep creek debris flow and continue to monitor slopes for additional threats to downstream areas. • Ensure that watershed-level hazard and risk assessments are continually updated to align with advances in flood mitigation measures and climate change science and modelling. • Work with Engineering, Public Works, and Emergency Management to prioritize movement of essential services during an emergency. • Continuously review community-wide evacuation plans and routes, focusing on neighbourhoods with vulnerable populations and challenging access to designated emergency routes.

Category	Impact	Interventions
People	• Risk of death or injury from debris flows/floods. • Disruption and displacement from debris flows/floods.	• Adhere to land-use bylaws to keep development out of high- risk areas, and update restrictions for development in steep creek flood zones to align with ongoing updates to debris flow/flood projections. • Work with Protective Services, Communications, and Engineering to prepare and coordinate emergency response plans and education for existing vulnerable locations.
Environment	• Damage to forests and other ecosystems from debris flows/floods. • Increased sedimentation in downstream water bodies.	• Work with Engineering, Public Works, and Emergency Management to plan debris removal and environmental recovery.
Economy	• Potential damages to homes, businesses, roads, and other infrastructure. • Loss of visitor industry in affected areas.	• Work with Business Development, Public Works, Protective Services, and impacted businesses to plan and prepare for and provide education about steep creek flooding and debris flows.

Context

Flooding along steep creeks in mountainous areas behaves differently than riverine flooding. The combination of intense precipitation and loose sediment along streambeds can produce fast-moving flows with entrained debris, including mud, soil, rocks, boulders, and trees, making it more hazardous than riverine flooding.

Between 2014 and 2019, Canmore commissioned BGC Engineering to assess the hazards and risks associated with debris flows and debris floods on the town's steep creeks. The assessments included an evaluation of potential damages to buildings and infrastructure, as well as an evaluation of the risk to the lives of people located within the buildings. The assessments also included recommendations to reduce the risks associated with debris flows/floods along the town's creeks. The following creeks were included in the assessments:

- Stone Creek;
- Pigeon Creek;
- Stoneworks Creek;
- Three Sisters Creek;
- Echo Canyon Creek;
- Cougar Creek; and
- X, Y, and Z creeks.

Financial Impacts

Mitigating the hazard of steep creeks can help reduce damages and loss of life. Between 2014 and 2019, BGC Engineering completed modelling of debris flows and debris floods in Canmore's steep creeks to assess the risks posed to people and buildings.

The direct building damage costs estimated by BGC for the different creeks is shown in Table 6. Several different return periods were assessed and are also shown in Table 6. The estimated average annualized damage costs are shown in the last column, and they consider all return periods and building damage costs. All values shown in the table are based on the base case without any steep creek mitigation. A typical objective of steep creek mitigation is reducing the economic risks associated with steep creek hazards.

Table 6. Summary of damages and impacts of steep creek hazards for different return periods.

Return Period	30–100 yr		100–300 yr		300–1,000 yr		1,000–3,000 yr		Annualized Costs
Creek	# parcels affected	Building damages ($M)	# parcels affected	Buildings damages ($M)	# parcels affected	Buildings damages ($M)	# parcels affected	Buildings damages ($M)	
Stone	8	$10.3	11	$19.5	17	$20.4	22	$25.7	**$300,000/yr**
Stoneworks	46	$7.8	46	$8.7	52	$13.6	56	$25.8	**$790,000/yr**
Three Sisters	213	$31.4	239	$37.4	257	$39.3	264	$40.3	**$1,100,000/yr**
Cougar	37	$8	39	$10	707	$106	875	$129	**$700,000/yr**

For example, on Cougar Creek the estimated direct building damage costs range from $8 million for the 30–100-year scenario to about $129 million for the 1000–3000-year unmitigated scenario. For comparison, the 2014 total assessed building value for the entire fan was about $376 million. The estimated average annualized building damage cost is $700,000, which considers all return periods and associated building damage costs.

BGC Engineering's creek-specific reports completed for the Town of Canmore provide further details on the risks associated with steep creek hazards.

Human Health and Safety

BGC Engineering assessed the risk of loss of life for each creek, which is shown as the number of fatalities in Table 7. All values shown in the table are based on the base case without any steep creek mitigation.

The primary way to avoid further economic and loss-of-life risks is to avoid exposure to steep creek hazards. The Land-Use Bylaw places strict restrictions on development in steep creek hazard areas, including prohibiting developments in high-hazard areas. Additionally, implementing emergency response plans for each creek will help further reduce risks to the community.

Table 7. Risk of loss of life for unmitigated creeks as an estimated number of fatalities for each return period assessed.

Creek	30–100-yr	100–300-yr	300–1000-yr	1000–3000-yr
Stone	<1	2	3	4
Stoneworks	0	0	2	3
Three Sisters	0	0	≤1	≤1
Cougar	<1	5	42	57

Infrastructure/Critical Infrastructure and Services

The Town of Canmore can work to reduce the risk of damages, injury, or death from debris flows by continuing to fund and implement debris flow mitigation measures and by continuing to monitor steep slopes for additional threats to downstream areas.

Mitigated scenario modelling has not been completed for all creeks, and a further exploration of potential mitigation actions and the impacts these will have on damages and loss of life should be explored.

The Town should also continue to take a leadership role in the coordination of evacuations during high-risk weather conditions, establishing emergency management plans to identify safe routes and secondary access points for emergency services and evacuation, and communicating with the community about emergency preparedness. The Town should complete and regularly test a steep creek evacuation plan.

Environment

To promote slope stability and reduce the risk of landslides or debris flows, forest monitoring and management in upstream areas is essential. A healthy and intact forest will help reduce erosion and increase the stability of the slope in severe precipitation events.

The Town can work with park services and other land managers to continue debris removal and to develop environmental recovery plans.

Economy

Businesses located within the higher-risk areas for steep creek flooding and debris flows can participate in the development of emergency management plans and can help educate visitors and the community about safety precautions for steep creeks and debris flows.

Extreme Heat

Summary of Impacts

Category	Impact	Interventions
Changes to hazard due to climate change	• Higher average temperatures. • More heat waves. • Hotter nights.	
Infrastructure/ Critical Infrastructure	• Increased importance of grid stability. • Deterioration of and disruption to roads. • Decreased hours available for road and other infrastructure repairs.	• Work with the utility to improve grid resilience. • Develop a heat stress policy for all outdoor workers.
Services	• Increased peak electricity demand. • Increase in hospitalizations. • Increased demand for cooling centres.	• Deploy the Extreme Heat Emergency Response Plan. • Retrofit municipal buildings for energy efficiency and added space cooling. • Add cooling centres to high- risk areas. • Inform the Town's outdoor workers about heat-related illnesses and how to prevent and manage them.
People	• Increased risk of heat-related health impacts and diseases. • Increased demands on health services, with added stresses to healthcare workers and emergency services.	• Increase tree canopy coverage. Incentivize developers to include net-zero building standards such as thermal insulation, roof reflectance, air conditioning, and shading. • Use building retrofits to improve building insulation, and add space cooling with heat pumps.
Environment	• Decreased air quality. • Tree canopy loss. • Changes in water availability from glacial and snowpack melt. • Heat stress on vegetation and changes in species composition as the climate warms. • Changes in water quality from algal blooms and reduction in dissolved oxygen in warmer waters.	• Reduce the number of gas- and diesel-powered vehicles on roads. • Increase tree canopy and green spaces. • Plant heat-resistant tree species.

Category	Impact	Interventions
Economy	• Increased energy costs for households, businesses, and institutions for space cooling. • Loss of productivity due to heat-related illnesses. • Reduction in visitors due to long-term impacts to glaciers and mountain snowsports.	• Develop visitor heat risk management guidelines.

Context

Increasing annual average temperatures, as well as higher maximum temperatures, means that heat is going to affect Canmore more and more over the coming century. Canmore's geography protects the town from the most extreme heat, with the compounding effects of shading from the surrounding mountains, nighttime cooling from chilled air settling in the valley, and wind patterns bringing cool air into the town. As the climate changes, increasing global temperatures will impact the community in a variety of ways. Canmore can expect warmer summers and longer periods above freezing. Increased heat impacts the changes in snowpack at elevation and increases the potential for warmer winters. Canmore's drinking water comes from surface and groundwater sources, and changes in precipitation and snowpack can alter the recharge and quality of these water sources. A longer growing season and warmer winters impact biodiversity and natural spaces, resulting in changes in species composition in forests and waterways, and can result in the spread of invasive species.

Infrastructure/Critical Infrastructure and Services

Canmore's Extreme Heat Emergency Response Plan is the first line of defence in preparing for and responding to extreme heat events. The Town should work to ensure this plan is updated regularly and that all those involved in its deployment are prepared.

The Town can help protect vulnerable members of the community by establishing cooling centres, particularly in high-risk areas or in locations with higher concentrations of vulnerable people and outdoor workers. Municipal buildings can be retrofitted for energy efficiency, with space cooling, and can act as short-term refuges from high heat.

Human Health and Safety

While temperatures are not anticipated to reach the extremes shown in other locations across the country, high temperatures pose a risk to human health and safety, nonetheless. Ensuring that outdoor workers are informed about the signs of and dangers associated with heat-related illnesses and how to prevent and manage them helps protect those who will experience the most extreme temperatures during the daytime.

Elevated nighttime temperatures that follow hot days are strongly linked with negative health impacts from heat events because people lack the ability to cool off overnight.[7] Vulnerability to health impacts from heat are exacerbated by age (older than 65 years) and by lower incomes.[8] Those without the ability to escape the heat through the use of air conditioning or improved building quality are more likely to feel the negative effects of high temperatures.

To reduce the risk from these hot nighttime conditions, new buildings should be highly efficient and well insulated and have space cooling provided by energy-efficient heat pumps. Existing buildings should be retrofitted to improve efficiency and provide space cooling.

Environment

Increasing the urban tree canopy and ensuring that the urban forest is healthy and intact will provide shade and cooling for denser areas. By planting heat-resistant trees that are suited for future climate conditions, the urban canopy will be healthy in the long term, contributing to the overall livability of Canmore.

Gas- and diesel-powered vehicles produce heat, and by converting to electric vehicles for personal use, transit, and other transportation needs, the latent heat will be removed from the more urbanized areas of Canmore.

Economy

To ensure visitor safety during heat events, the visitor industry will need to partner with the Town and other relevant groups to develop and implement heat risk management guidelines. Additionally, ensuring that outdoor workers in the visitor industry are educated about the risks and signs of heat-related illnesses will help protect these vulnerable employees during heat events.

[7] Murage P, Hajat S, Kovats RS. Effect of night-time temperatures on cause and age-specific mortality in London. Environ Epidemiol. 2017 Dec;1(2):e005. doi: 10.1097/EE9.0000000000000005. Epub 2017 Dec 13. PMID: 33195962; PMCID: PMC7608908.

[8] Environment and Climate Change Canada, 2020. MSC Heat Warning Criteria. Warning issued when 2 or more consecutive days of daytime maximum temperatures are expected to reach 31°C or warmer and nighttime minimum temperatures are expected to fall to 20°C or warmer.

Riverine Flooding

Summary of Interventions

Category	Impact	Interventions
Changes to hazard due to climate change	• Increased total precipitation annually and seasonally in spring and fall. • Higher average temperatures in winter and spring affect peak flows and timing of spring freshet.	
Infrastructure/ Critical Infrastructure	• The wastewater treatment plant and some of the pumping stations for drinking water are located within the Bow River floodplain. • Other critical infrastructure buildings and operations centres are located outside of floodplains. • Emergency service demand will be elevated during flooding because of the number of private homes and businesses located within the floodplains.	• Increase flood protection infrastructure for the wastewater treatment plant. • Prevent new construction of critical infrastructure in flood zones. • Equip all pump stations and lift stations with back-up power plans and supply to ensure reliable access to water and sanitary services during extreme weather events.
Services	• Municipal buildings and other essential services are located outside of floodplains.	• Continuously review community-wide evacuation plans and routes, focusing on neighbourhoods with vulnerable populations and challenging access to designated emergency routes. Support these plans with regular communication, including translation into multiple languages. • Identify emergency shelters for flood evacuation use.

Category	Impact	Interventions
People	• Currently, over 3,100 people are at risk of being impacted by a very rare flood event (200–500 year event). • By 2070, over 4,200 people are at risk of being impacted by a very rare flood event. • The majority of the buildings located within floodplains are residential or private businesses.	• As provincial flood mapping is updated, consider additional measures to restrict new development and increase minimum floor elevation levels in Bow River floodplains aligned with more severe flood return periods. • Incentivize and promote flood-proofing for existing buildings in the Bow River floodplains. • Work with community partners to determine which facilities in Canmore should be defined as "critical infrastructure" during emergency events and ensure that these can continue to operate (e.g., generators and/or batteries for back-up power at the hospital). • Expand public safety communications to encourage flood and evacuation preparedness.
Environment	• River-adjacent lands could experience soil erosion. • Flood events may cause the release of chemical contaminants such as paint solvents, fertilizer, and hydrocarbons, as well as physical debris, into the environment.	• Update the Bow River Flood Response Plan to include water quality and environmental impacts due to a potential uncontrolled release of contamination resulting from flood damage to the wastewater treatment plant. • Establish guidelines and regulations for the use of pesticides, particularly in areas where groundwater is vulnerable.
Economy	• Financial impact of potential structure damage, content damage, and business disruption during a rare flood event (50–100-year event) is estimated to be $225 million currently and $463 million in 2070.	• Restrict development in floodplains to reduce the exposure to floodwaters. • Build new construction above current Flood Construction Levels. • Work with Town Communications and tourism industry leaders to develop multilingual communications about climate hazards and emergencies.

Context

Riverine flooding refers to flooding that happens when rivers, streams, and other water bodies overflow, spilling out onto the surrounding area. This type of flooding often occurs during the spring freshet or during periods of prolonged, intense precipitation. The increase in total precipitation in the future, as well as the increase in volume of precipitation over short periods of time, increases the potential for future riverine flooding.

Climate change is bringing larger storms and reducing our ability to predict their severity and the resultant flooding. Buildings, homes, roads, and other infrastructure located within flood zones are at risk of damage during floods. Access to essential services is also at risk during floods and during recovery periods. Flooding in Canmore often coincides with the spring freshet and the melting of the snowpack, but it can also occur from rainfall-driven storm events in the upper Bow River watershed.

Floods are categorized by return periods, which reference the statistical probability of a flood of a given severity to occur each year. A 1-in-100-year (or 100-year) return period flood has a 1/100, or 1%, chance of occurring in any given year. A 1-in-10-year return period flood has a 10% chance of occurring in any given year, and a 1-in-500-year event has a 0.5% chance of occurring in a given year. Flooding data in Canmore covered a range of return periods, from two to 1500 years, with data availability varying by water body. To compare flood risk across Canmore, return periods are grouped into four categories. These categories are defined based on how often a person with a lifespan of 85 years can expect to experience a flood event of a specific magnitude.

Category	Description	Return Periods
Nuisance	Events occurring often in a lifetime	5-year, 10-year
Frequent	Events that may occur several times in a lifetime	20-year
Rare	Events that may occur once or twice in a lifetime	50-year, 100-year
Very Rare	Events that may occur once, if at all, in a lifetime	200-year, 350-year

Climate change impacts on flooding extent were incorporated into the provincial flooding data for the Bow River used for this project. Note that areas that flood during a less-severe flood will also flood during more severe floods. For instance, an area flooding during a Rare flooding event will also flood in a Very Rare event, and an area flooded in a Nuisance event will also flood in Frequent, Rare, and Very Rare events.

Financial Impacts

Damages from floods depend on the severity of the flood and the value of the assets within the flooded area. Reducing the damages associated with flooding on the Bow River has been modelled by implementing two actions. The first action is to raise the Flood Construction Level (FCL) for new buildings by 0.5 m. Most of the new development within the Bow River floodplain is infill development in areas already partially developed. By raising the FCL, these new buildings are elevated relative to existing buildings, reducing the depth of floodwaters within these buildings.

Additionally, to protect existing buildings within the floodplains, flood-proofing measures can be added to protect against damages from flood waters entering a home or building. In this analysis we have assumed dry flood-proofing measures can prevent flood waters of up to 1 m from entering a building.[9] Dry flood-proofing measures include improving the waterproof membrane around the house, using watertight doors and windows, and adding flood walls around the property. The costs of implementing these flood-proofing measures are not included in this analysis.

Table 8. Flood damages for the Business-as-Planned (BAP) Scenario compared with the damages avoided by implementing the modelled actions in the Adapted Scenario (AS).

	Nuisance	Frequent	Rare	Very Rare
BAP 2070 Damages	$77,300,000	$109,300,000	$180,300,000	$283,000,000
Damage avoided by FCL increase of 0.5 m	$3,600,000	$4,200,000	$3,000,000	$5,200,000
Damage avoided by flood-proofing existing buildings	$69,725,228	$93,800,000	$133,300,000	$200,500,000
Total damage avoided	$73,325,228	$98,000,000	$136,300,000	$205,700,000
% reduced	95%	90%	76%	73%

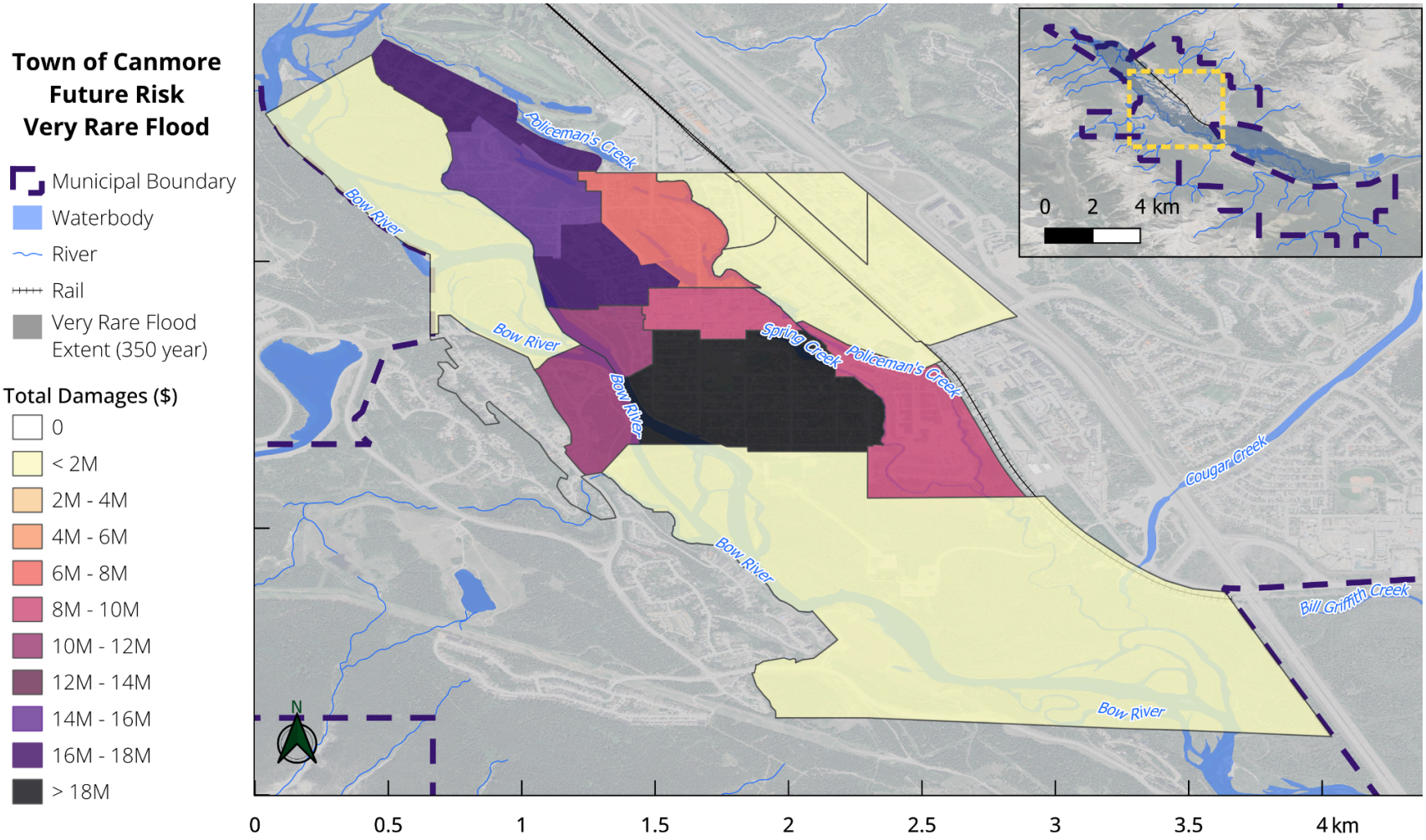
By implementing these two actions, the damages from Nuisance floods can be reduced by up to 95% and the damages from Very Rare floods by up to 73%.

[9] Aerts, Jeroen C. J. H. 2018. "A Review of Cost Estimates for Flood Adaptation" *Water* 10, no. 11: 1646. https://doi.org/10.3390/w10111646

The effect of these two actions on the geographic extent of flood damages is shown by comparing Figure 2 with the flood damages from a Very Rare flood in the 2070 BAP Scenario and Figure 3 with the flood damages from the same flood with the two actions implemented.

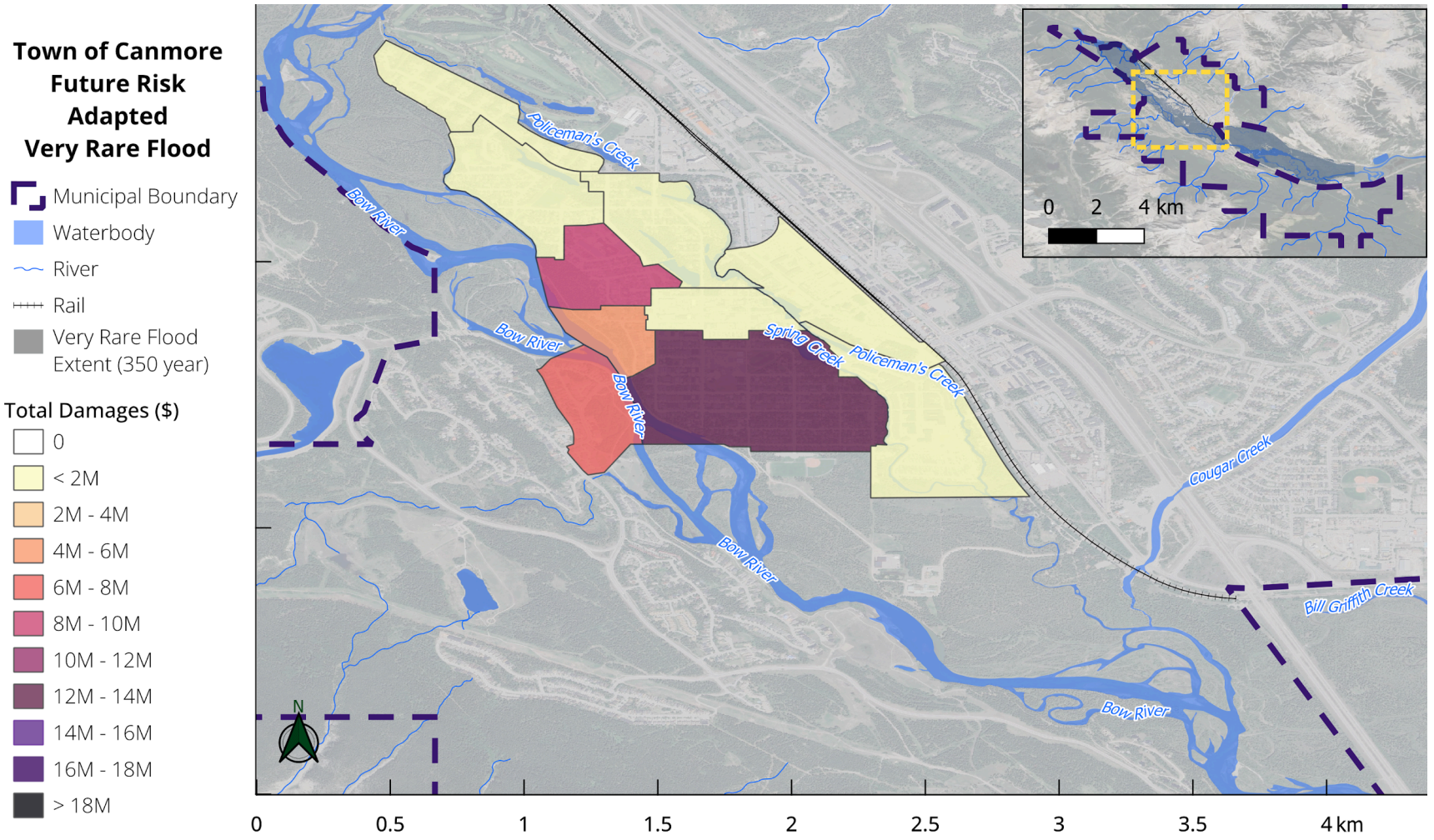
A comparison of the total annualized damages in the present day, in the 2070 BAP Scenario, and in the 2070 Adapted Scenario shows that by implementing flood-proofing measures on existing homes, future damages can be reduced below the levels of damages expected today, in spite of the increasing severity of floods due to climate change and the increase in the number of buildings within the floodplain due to infill development (Figure 4).

Figure 5 describes damages by structure, content, and disruption.



Source: Town of Canmore, extents from Government of Alberta Flood Mapping GIS Dataset, from Environmental Knowledge and Prediction Branch, Environment and Protected Areas. Base map sourced from Google Satellite imagery.

Figure 2. Flood damages from a Very Rare flood in the 2070 Business-as-Planned Scenario.



Source: Town of Canmore, extents from Government of Alberta Flood Mapping GIS Dataset, from Environmental Knowledge and Prediction Branch, Environment and Protected Areas. Base map sourced from Google Satellite imagery.

Figure 3. Flood damages from a Very Rare flood in the 2070 Adapted Scenario.

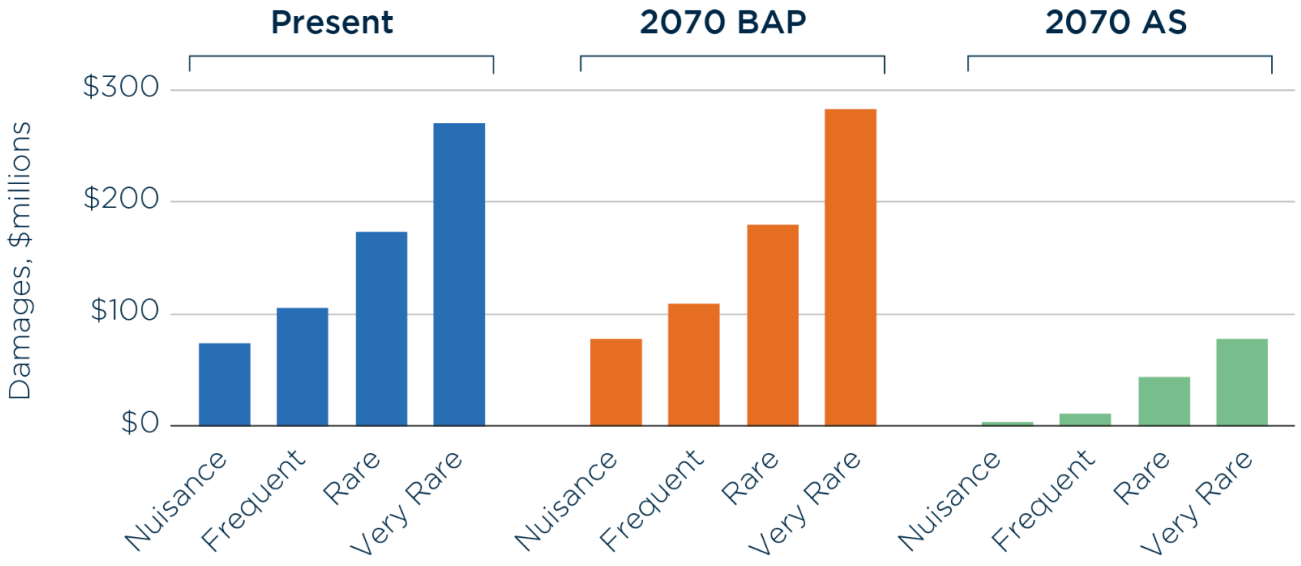


Figure 4. Total annual damages from flooding by return period for the present day ($ millions), the 2070 BAP Scenario, and the 2070 Adapted Scenario summed across the entirety of Canmore.

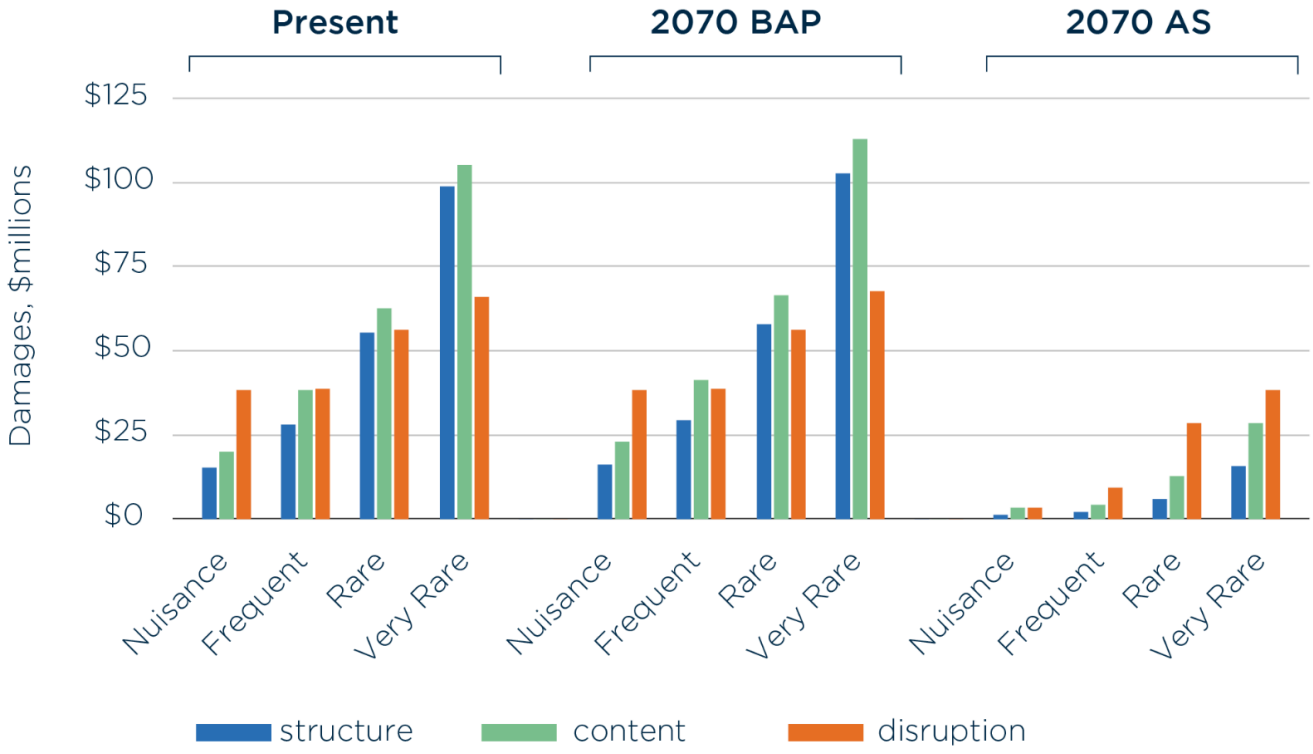


Figure 5. The potential total annual damages to structures and their contents and the potential disruptions to business and activities from flooding in the present day (left), in the 2070 BAP Scenario (centre), and in the 2070 Adapted Scenario (right) for the entirety of Canmore.

Infrastructure/Critical Infrastructure and Services

Protecting the Wastewater Treatment Plant (WWTP) from flooding is the highest priority action to protect municipal critical infrastructure. The WWTP is located near the shoreline of the Bow River, within the existing 1-in-100-year floodplain. The WWTP, access roads, and supporting infrastructure are at risk of inundation during floods, and previous floods have rendered the WWTP an island within the river. The WWTP services the entire community of Canmore, and should the plant be damaged to the extent that it became inoperable, the town would have to be evacuated. Repairs could take many months and could cost tens to hundreds of millions of dollars, resulting in severe disruptions to the community and the area's economy. Less severe flooding to the WWTP could still result in contamination of the Bow River, requiring the evacuation of downstream neighbourhoods.

The Town is currently developing plans to complete flood-proofing of the WWTP and pumping stations, with a focus on constructing a protective berm around the plant and its supporting access roads and infrastructure. This work should be prioritized to ensure the safety of the town and to ensure that the WWTP can continue to operate safely and reliably in all conditions.

Including climate considerations in asset management and infrastructure planning will ensure that new construction and repairs are appropriately sized and designed for future conditions. Ensuring that a climate lens is used in the planning process will help reduce the need to replace or repair undersized or damaged assets before their planned end of life.

The Town also has a central role in coordinating emergency responses to flooding and ensuring that community members are safe and that emergency services are coordinated and prepared for rapid deployment during a flood. The Town can also ensure that municipal buildings are prepared for use as evacuation centres during floods.

Human Health and Safety

Increasing the FCL and flood-proof existing buildings can significantly reduce the number of people affected by flooding. Figure 6 compares the number of people affected (those living directly in locations that experience damages from floods) in the present day, in the 2070 BAP Scenario, and in the 2070 Adapted Scenario. By implementing the modelled actions, the number of people affected can be reduced well below current levels, even when accounting for population growth and the addition of new buildings.

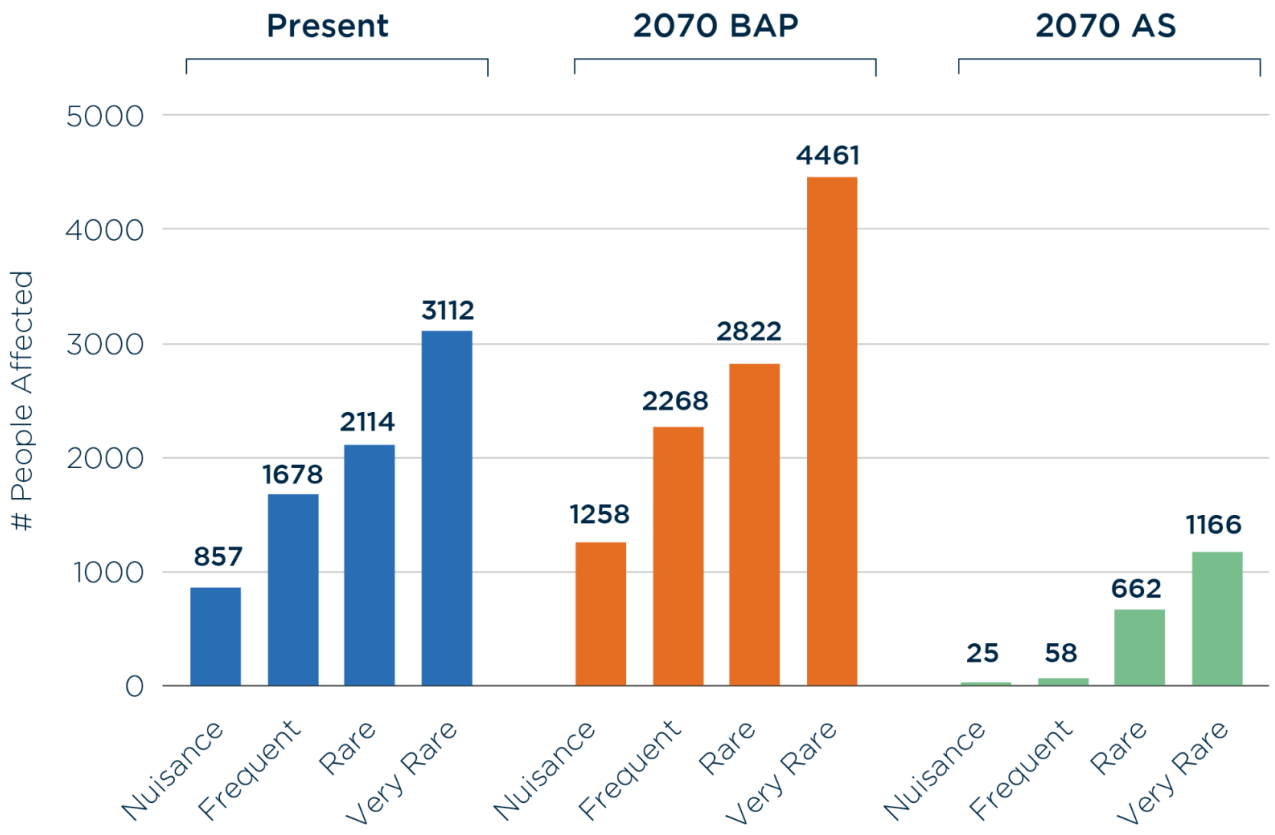


Figure 6. Total number of people affected by flooding for each return period in the present day (left), in the 2070 BAP Scenario (centre), and in the 2070 AS (right).

In addition to these measures to reduce the risk of damages to homes and businesses from floods and exposure to flooding, the community of Canmore should be prepared for emergency evacuation from floods. Education materials about emergency preparedness, evacuation protocols, and safe spaces will ensure that evacuations occur efficiently and safely.

Environment

Environmental damage from a flood at the WWTP should be included in the WWTP Emergency Response Plan. Water contamination could affect both surface water and groundwater in the event of a serious flood. Locations such as warehouses, storage facilities, and waste depositories that contain potentially dangerous contaminants and that are located within the floodplain should be monitored and maintained to prevent any potential contamination of floodwaters. Monitoring water quality after any flooding event can help identify contamination, as well as opportunities to mitigate it.

Economy

Damages from flooding can be costly and disruptive. Avoiding these damages is the most effective way to reduce impacts on Canmore's economy. This can include restricting development in future climate floodplains, flood-proofing existing buildings and infrastructure, and building new buildings with an increased FCL to elevate them.

Water Security

Summary of Interventions

Category	Impacts	Interventions
Changes to hazard due to climate change	• Higher average temperatures. • Changes in freeze–thaw cycles. • Changes in precipitation types and timing over the year.	
Infrastructure/ Critical Infrastructure	• Water supply sources, storage. • Water treatment processes can require additional resources.	• Increase flood protection infrastructure for the wastewater treatment plant. • Develop an Emergency Response Plan for the potential of wastewater treatment, drinking water treatment, and/or pumping operations being limited or ceased as a result of a flood or wildfire event. Ensure that hazard mitigation strategies are integrated into plans for lifecycle replacements and updates to facilities. • Ensure the water treatment plant and pumping/lift stations have reliable back-up energy sources and FireSmart construction.

Category	Impacts	Interventions
Services	• Disruption to emergency services due to shortages of water supply for catastrophic events (i.e., wildfire) during dry periods.	• Develop and deploy a leak-detection system for the municipal water supply. • Develop a comprehensive drought contingency plan that includes thresholds for triggering water restrictions and emergency water supply measures. • Establish a working group to coordinate approaches on water supply management across the region, integrating local expertise.
People	• Drinking water supply can be affected, with a higher probability for disruption to residential water supply and enforcement of water restrictions during dry periods.	• Establish a public education program about water conservation to encourage residents to reduce water consumption. • Develop a Source Water Protection Plan to holistically evaluate risks to Canmore's drinking water sources from climate impacts and recreational activities.
Environment	• Changes in soil during dry periods can reduce infiltration for groundwater sources. • Changes in the snowpack upstream can negatively impact source water.	• Include water quality and environmental damage to the Wastewater Treatment Plant Flood Emergency Response Plan. • Review and update the wellhead protection zone. • Establish comprehensive regulations governing the use of pesticides within the municipality, particularly in areas where groundwater is vulnerable.
Economy	• Water use restrictions for visitors can be challenging to implement and can impact the visitor industry. • Changes to water treatment processes can require additional costs.	• Develop and implement a water conservation strategy that identifies and targets the sectors with the highest water consumption.

Context

Increasing temperatures, as well as less predictable precipitation, pose a threat to water security for the town of Canmore. Fresh water is supplied by upstream snow melt, glacial runoff, and precipitation. Changes in any of these elements affect both the quality and the quantity of water available in natural systems and for municipal use.

The increase in precipitation, combined with more frequent severe precipitation events, leads to more dramatic fluctuations in water levels, with rapid influxes of surface runoff during rainfall events. These changes make it harder to use historic information to plan and manage freshwater resources into the future. A reduction in high-elevation snowpack or changes in the timing and types of precipitation change the recharge of aquifers and the flow in surface water systems. Canmore relies on both groundwater and surface water for drinking water, and changes to the flow regimes in either of these systems will impact the availability of fresh water for the community.

Infrastructure/Critical Infrastructure and Services

Protecting the WWTP from potential flood damages is critical to protecting freshwater resources in Canmore and downstream from the plant. Protecting pumping stations and lift stations from floods and establishing reliable back-up energy sources will ensure that the delivery of potable water and the treatment of wastewater are not interrupted.

Developing a leak-detection system for the municipal water supply system, as well as an underground utility life-cycle upgrade program, will help reduce water loss and waste from the system, reducing the costs for freshwater treatment.

Water demand reduction activities like using stormwater and greywater in buildings and using smart water-monitoring systems can help reduce the total water demand across Canmore and the costs associated with water treatment and delivery.

While the risk of extreme drought in Canmore is low, locations downstream from the town are much more vulnerable to drought conditions and water restrictions. Canmore can work with the region to develop a comprehensive drought contingency plan that includes emergency water supply measures and thresholds for triggering water use restrictions.

Human Health and Safety

Reducing water use across Canmore as a whole has a variety of benefits, from reducing the costs associated with water treatment and delivery, to reducing the energy use and the associated GHGs from water treatment activities. The public can play an essential role in water use reduction.

Canmore's drinking water sources are vulnerable to contamination. Additionally, freshwater can become contaminated with sediment from floods, steep creek floods, or climate hazards like wildfires or sudden rainfall events. A holistic Source Water Protection Plan can include these considerations and can provide recommendations to protect drinking water by limiting recreation or other activities in sensitive areas.

Environment

In order to limit the risk of contamination and damages from a potential flood at the WWTP, water quality and environmental monitoring should be included in the WWTP Flood Emergency Response Plan. Additionally, the wellhead protection zones should be reviewed and updated to ensure they adequately protect these areas from contamination.

Establishing regulations to limit or eliminate the use of pesticides within the municipality, particularly in locations where the groundwater is vulnerable to infiltration and contamination, will help protect freshwater resources.

Economy

The visitor industry can play an important role in water conservation. A water conservation strategy specifically targeted at the commercial sector, with a focus on hotels, will help reduce total water use across Canmore.

Conclusion

Climate change adaptation needs to work in concert with GHG mitigation. Impacts from our changing climate are already being felt and will continue to increase due to wilder storms, less predictable weather, and increasing temperatures. Careful planning and decision-making today can prevent millions of dollars in damages in the future and protect the people, homes, businesses, infrastructure, and natural spaces in Canmore.

As a growing town that depends on visitors, Canmore faces development and land-use pressures that compete with the hazards posed by flooding and steep creeks. Ensuring that planning decisions consider future climate conditions and include risk reduction at their core reduces exposure to these hazards and reduces the damages associated with them.

Coordinating across the community to promote FireSmarting of all buildings and assets will help protect Canmore in the event of a wildfire. Canmore's forests are under threat from changing environmental conditions, invasive species, and pests. Managing these threats and working to protect the forest will reduce the likelihood of a catastrophic fire in Canmore. FireSmarting will reduce damages and can even be used to develop shelter-in-place refuges from wildfire.

Building retrofits for at-risk people within the community will ensure their safety and comfort during heat events, while also reducing energy consumption in those homes. Clearly communicating with the public about the facilities available for cooling off during these events will allow others to manage this hazard safely.

Finally, clear and open communication with the public about the ways to prepare for climate emergencies and the services available in major events will ensure as many people as possible are prepared and resilient in the face of these inevitable, serious events. By working with the community and the many knowledgeable and connected organizations within Canmore, the Town can be a leader in climate preparedness and resilience, making decisions today that will serve the community now and well into the future.

Appendix 1. Adaptation Interventions by Hazard

Table 1.1: Summary of adaptation interventions.

Interventions				
Infrastructure/ Critical Infrastructure	**Services**	**People**	**Environment**	**Economy**
Hazard: Ecoregion Changes				
• Forest monitoring and management programs to track pests and invasive species. • FireSmarting of buildings and vegetation to reduce fire risk.	• Update the Urban Forest Management Plan to include climate considerations like species selection, tree management, and UHEI.	• Develop internal working groups to monitor the spread of invasive species and vectors of disease. • Educate the community about identification of vectors and how to protect themselves from disease. • Encourage citizen science programming to monitor ecosystem health and the spread of invasive species.	• Ensure the Urban Forest Management Plan includes climate considerations for tree planting and other activities, including species selection, tree management activities, and pest monitoring. • Monitor and manage the spread of forest pest species.	• Work with the visitor industry to share education materials on identifying disease vectors and how to protect themselves from disease.

Interventions

Infrastructure/ Critical Infrastructure	Services	People	Environment	Economy
Hazard: Wildfire and Smoke				
• Develop and update community-wide evacuation route planning, particularly for neighbourhoods with limited road access. • Clear vegetation around power lines and utility poles. • Integrate FireSmarting into new construction and retrofits to infrastructure, including fire-resistant building materials. • Ensure pumping stations and lift stations have back-up power supplies.	• Update the Wildfire Mitigation Strategy with climate considerations, including fire frequency and severity and how changing climate conditions affect hazards contributing to fire risk, like precipitation changes and spread of invasive species. • Develop a regional wildfire management working group to coordinate FireSmarting, grants and other fire management priorities and activities across the region.	• Develop programs and incentives for property owners to implement Fire Smarting, including potentially offering a Town service to collect material from households. Regularly monitor for continued compliance. • Require new buildings to follow FireSmart design guidelines for construction materials and landscaping. • Deploy the Smoke Emergency Response Plan.	• Practice fuel management, including pest monitoring and management.	• Update the Municipal Emergency Management Plan to more specifically address the potential impacts of climate-related emergencies on visitors and the tourism sector. Continue to collaborate with Tourism Canmore Kananaskis and other representatives from the tourism sector on emergency and overall preparedness.

Interventions

Infrastructure/ Critical Infrastructure	Services	People	Environment	Economy
Hazard: Wildfire and Smoke				
	• Complete regular testing of the Wildfire Incident Preparedness Plan. • Continuously review community-wide evacuation plans and routes, with a focus on neighbourhoods with vulnerable populations and challenging access to designated emergency routes. Support these plans with regular communication, including translation into multiple languages. • Continue fuel management in high-risk areas. • Identify clean-air shelters that can be used during evacuations or poor-air-quality events.			• Create public awareness campaigns to educate visitors about wildfire risks, safety precautions, and emergency procedures. • Provide outdoor workers with comprehensive training on wildfire safety.

Interventions

Infrastructure/ Critical Infrastructure	Services	People	Environment	Economy
Hazard: Steep Creeks Flooding				
• Work with Engineering, Public Works, and Protective Services to map redundancy in the road network. • Continue to identify and maintain locations within the community to serve as short-term shelters for evacuees during emergency events.	• Continue to fund and implement steep creek debris flow mitigation measures and continue to monitor slopes for additional threats to downstream areas. • Ensure that watershed-level hazard and risk assessments are continually updated to align with advances in flood mitigation measures and climate change science and modelling. • Work with Engineering, Public Works, and Emergency Management to prioritize movement of essential services during an emergency.	• Adhere to land- use bylaws to keep development out of high-risk areas and update restrictions for development in steep creek flood zones to align with ongoing updates to debris flow/flood projections. • Work with Protective Services, Communications, and Engineering to prepare and coordinate emergency response plans and education for existing vulnerable locations.	• Work with Engineering, Public Works, and Emergency Management to plan debris removal and environmental recovery.	• Work with Business Development, Risk Management, Public Works, and impacted businesses to plan and prepare for and provide education about steep creek flooding and debris flows.

Interventions

Infrastructure/ Critical Infrastructure	Services	People	Environment	Economy
Hazard: Steep Creeks Flooding				
	• Continuously review community-wide evacuation plans and routes, focusing on neighbourhoods with vulnerable populations and challenging access to designated emergency routes.			
Hazard: Extreme Heat				
• Work with the utility to improve grid resilience. • Develop a heat stress policy for all outdoor workers.	• Deploy the Extreme Heat Emergency Response Plan. • Retrofit municipal buildings for energy efficiency and added space cooling. • Add cooling centres to high- risk areas. • Ensure the Town's outdoor workers are informed about heat-related illnesses and how to prevent and manage them.	• Increase tree canopy coverage and shade structures. • Incentivize developers to include net-zero building standards such as thermal insulation, roof reflectance, air conditioning, and shading. • Use building retrofits to improve building insulation, and add space cooling with heat pumps.	• Reduce the number of gas- and diesel-powered vehicles on roads. • Increase the tree canopy and green spaces. • Plant heat-resistant tree species.	• Develop visitor heat risk management guidelines.

Interventions

Infrastructure/ Critical Infrastructure	Services	People	Environment	Economy
Hazard: Riverine Flooding				
• Increase flood protection infrastructure for the wastewater treatment plant. • Prevent new construction of critical infrastructure in flood zones. • Equip all pump stations and lift stations with back-up power plans and supply to ensure reliable access to water and sanitary services during extreme weather events.	• Continuously review community-wide evacuation plans and routes, focusing on neighbourhoods with vulnerable populations and challenging access to designated emergency routes. Support these plans with regular communication, including translation into multiple languages. • Identify emergency shelters for flood evacuation use.	• As provincial flood mapping is updated, consider additional measures to restrict new development and increase minimum floor elevation levels in the Bow River floodplains aligned with more severe flood return periods. • Incentivize and promote flood-proofing for existing buildings in the Bow River flood- plains.	• Update the Bow River Flood Response Plan to include water quality and environmental impacts due to a potential uncontrolled release of contamination resulting from flood damage to the wastewater treatment plant. • Establish guidelines and regulations using pesticides, particularly in areas where groundwater is vulnerable.	• Restrict development in floodplains to reduce the exposure to floodwaters. • Build new construction above current Flood Construction Levels. • Work with Town Communications and tourism industry leaders to develop multilingual communications about climate hazards and emergencies.

Interventions				
Infrastructure/ Critical Infrastructure	**Services**	**People**	**Environment**	**Economy**
Hazard: Riverine Flooding				
		• Work with community partners to determine which facilities in Canmore should be defined as "critical infrastructure"during emergency events and ensure that these can continue to operate (e.g., generators and/or batteries for back-up power at the hospital). • Expand public safety communications to encourage flood and evacuation preparedness.		

Interventions

Infrastructure/ Critical Infrastructure	Services	People	Environment	Economy
Hazard: Water Security				
• Increase flood protection infrastructure for the wastewater treatment plant. • Develop an Emergency Response Plan for the potential of wastewater treatment, drinking water treatment, and/or pumping operations being limited or ceased as a result of a flood or wildfire event. Ensure that hazard mitigation strategies are integrated into plans for life- cycle replacements and updates to facilities. • Ensure the water treatment plant and pumping/lift stations have reliable back-up energy sources and FireSmart construction.	• Develop and deploy a leak-detection system for the municipal water supply. • Develop a comprehensive drought contingency plan that includes thresholds for triggering water restrictions and emergency water supply measures. • Establish a working group to coordinate approaches on water supply management across the region, integrating local expertise.	• Create a public education program about water conservation to encourage residents to reduce water consumption. • Develop a Source Water Protection Plan to holistically evaluate risks to Canmore's drinking water sources from climate impacts and recreational activities.	• Include water quality and environmental damage to the Wastewater Treatment Plant Flood Emergency Response Plan. • Review and update the wellhead protection zone. • Establish comprehensive regulations governing the use of pesticides within the municipality, particularly in areas where groundwater is vulnerable.	• Develop and implement a water conservation strategy that identifies and targets the sectors with the highest water consumption.


Town of
CANMORE