TOWN OF OPHIR

Box 683 • Ophir, CO 81426

NOTICE OF THE REGULAR MEETING OF THE GENERAL ASSEMBLY

TOWN OF OPHIR, CO 81426

TUESDAY 7:00 PM, July 23, 2024

OPHIR TOWN HALL 36 PORPHYRY ST.

Join Zoom Meeting

Meeting ID: 867 0143 8435 Passcode: 373146

+16699006833,,86701438435#,,,,*373146# US (San Jose)

AGENDA

1. CALL TO ORDER
2. APPROVAL OF AGENDA
3. MEETING MINUTES APPROVAL for June 18, 2024
4. BUSINESS ITEMS
    a. Executive session for a conference with Town Attorney to receive legal advice, specifically regarding potential claims asserted against the Town by Joseph Waller
5. STAFF REPORTS
    a. Town Manager
        i. Continued exemption for Jason Rogers from Town of Ophir water bills in recognition of his 15 years of service to the TVFD and Ophir.
        ii. Assorted thank yous for recent volunteerism to Ophir: Sydney Roop- landscaping around Town Hall, Claudia Cain- weekend plant watering, Peter Israel for road planter flowers, Sean McNamara for replacement flowers after Yukon planter took its first hit from passing vehicle
        iii. Ophir P&Z Commission still looking for 2 regular members and 2 alternates
        iv. Loss of Ken Page as Ophir Water Commissioner- need to repopulate the Water Commission?
    b. Other
6. NEW BUSINESS
7. ADJOURN

General Assembly Meeting Memorandum

To: Ophir General Assembly

From: John Wontrobski, Ophir Town Manager

Date: July 19, 2024 for July 23, 2024 GA meeting

4a. Ophir Town Attorney David McConaughy will be present via Zoom to update the General Assembly on the status of the Waller lawsuit and answer any questions the GA may have. For background, I have added to the packet a recently published paper, entitled, “Urban Avalanche Risk Management in North America- A Review of Select Jurisdictions,” which presents a summary of urban avalanche risk mitigation measures from select North American jurisdictions, and highlights some of the challenges with the implementation of urban avalanche risk mitigation measures. It also discusses differing criteria used for avalanche hazard zoning and their effect on the resulting avalanche hazard maps.

DRAFT MINUTES OF THE REGULAR MEETING OF THE GENERAL ASSEMBLY
TOWN OF OPHIR, CO 81426
TUESDAY JUNE 18TH, 2024 7:00 PM

Voting Members: Teri Steinberg, Jerry Oyama, Allyn Hart, Andy Ward, Ben Foster, Eric Beerman, Tyler Schultz, Phil Hayden, Amy Ward, Leigh Sullivan, Janice Gerona, Todd Rutledge, Lisa Rutledge, Miles Heiner, Mark Rosenthal

Non-Voting Members: John Wontrobski, Geneva Shaunette, David McConaughy

1. CALL TO ORDER
Andy Ward calls the meeting to order at 7:05pm

2. APPROVAL OF AGENDA
Andy adds Geneva's presentation to the agenda.
Todd motions to approve, Janice seconds
Motion passes unanimously via voice vote.

3. ADOPTION AND SIGNATURE OF MEETING MINUTES for May 21st General Assembly
Tyler motions to approve, Amy seconds.
Motion passes unanimously via voice vote.

4. BUSINESS ITEMS
A) Geneva Shaunette presents to the GA. She is running in the democratic primary for an open County Commissioner seat against Anne Brown.

Q&A follows.

B) Appointment of David McConaughy as Town of Ophir Attorney.

Eric Beerman asks whose interests David would be advocating for.
David responds it would be his duty to represent the whole Town of Ophir (aka ”the client”), not any one staff member or special interest. David’s opinions would be offered when asked.
Eric is concerned about David’s opinion on the GA form of government in regards to his advice to the Ophir Charter Committee.
David clarifies he is only describing the potential difficulties of a GA vs. a more conventional form of government.
Phil asks if there is any conflict of interest because David was previously hired by town as Special Council in an Ophir land dispute.
David states he is representing the town in both instances, so there would be no conflict.
David notes Newcastle and Delta both hold meetings on the third Tuesday of the month as well, so consultations would have to be scheduled accordingly
Teri asks when the GA should engage his services
David responds most town clients collect legal issues which need legal guidance and put them on an agenda when David can attend, either in person or via Zoom.

Janice motions to approve, Todd seconds.
Motion passes unanimously via voice vote.

5. STAFF REPORTS
A) Town Manager John Wontrobski
John recounts Ophir Days events and lauds their success.
Spring road maintenance is finished.
Town’s truck has had its transmission fixed.
Town’s backhoe has a seized wheel, could be time to replace the backhoe if the wheel cannot be fixed. It is nearing the end of its life cycle.

Thanks to Yukon for the town planters.
Thanks to Peter Israel for planting flowers in the planters.
John is working with Brian Morgan on an as-built diagram for the town fiber internet network
Clear Networks is adding fiber on Ilium Road and has been asked if they would like to offer competition to the sole internet provider in Ophir. They have not given an answer yet.
Waller land dispute - no progress and will come to GA with an agenda item when appropriate.
Town water system - no update.

Eric requests that GA minutes be sent out earlier between meetings, as opposed to in the GA packet.
Todd asks if we should ask David if releasing draft minutes can be done.
John notes we will try and get draft minutes out sooner, most likely via email.

B) Mayor Andy Ward
Andy asks for a motion to approve Joan May to be Mayor Pro Tem
Janice motions to approve, with the clerk to ensure Joan is a qualified elector. Phil seconds.
Motion passes unanimously via voice vote.

Andy and John met with Paul Machado and Dick Unruh to talk about Ophir history. Town would like to have a day celebrating the history and notable Ophirites, most likely in September, 2024

6. NEW BUSINESS
Andy mentions a home solar pilot program with Miles Heiner. He is hoping to install solar on three homes in Ophir this summer, with interest for more next year. Some homeowners may be installing panels themselves to save on costs.

Tyler notes that this is a good time to deal with the broken town equipment since it is most used in the winter for snow removal. Should it be on the agenda? Town needs to upgrade its plowing equipment. John notes it will probably be discussed at the next GA.

7. ADJOURN
Andy Ward motions to adjourn @ 8:25pm

Minutes prepared by Ben Foster, Town Clerk
Audio and video recordings of all General Assembly Meetings are available to the public. Please contact the Town Clerk if you would like a copy of this month's audio of the meeting minutes.

URBAN AVALANCHE RISK MANAGEMENT IN NORTH AMERICA – A REVIEW OF SELECT JURISDICTIONS

Chris Argue[1]*, Dan Rohn[1] and Alan Jones[1]

[1]*Dynamic Avalanche Consulting Ltd., Revelstoke, BC, Canada*

ABSTRACT: Many urban areas in North America are affected by snow avalanche hazards that threaten residential structures, urban roads, civic infrastructure, and pedestrian areas. A key challenge faced by jurisdictions that manage urban avalanche risk is the determination of an appropriate balance between the rights of individual landowners to use their property and the need to protect the public from avalanche risk. North American jurisdictions have landed at very different points along this spectrum.

Avalanche hazard maps play an important role in urban avalanche risk management, often they are the basis for land development policy. Avalanche hazard maps delineate the area affected by avalanches and are typically divided into zones representing areas of higher and lower hazard, which allow land managers to mandate specific conditions for new development and modification of existing structures. Jurisdictions have established different criteria for determining such hazard zones.

This paper presents a summary of urban avalanche risk mitigation measures from select North American jurisdictions, and highlights some of the challenges with the implementation of urban avalanche risk mitigation measures. It also discusses differing criteria used for avalanche hazard zoning and their effect on the resulting avalanche hazard maps.

KEYWORDS: Avalanche, risk, hazard, land-use, zoning, occupied structure.

1. INTRODUCTION

Many urban areas in North America are affected by snow avalanche hazards that threaten residential structures, urban roads, civic infrastructure, and pedestrian areas. European alpine countries have a long history of managing urban avalanche risk, with centuries of experience in some areas. In Europe, a variety of long-term and short-term measures are used to manage this risk, including avalanche hazard zoning that sets policy for development, and extensive direct mitigation measures such as snowpack supporting structures, runout zone defenses, and structurally reinforced buildings. Much of the science and methodology used for avalanche hazard zone mapping for land development is based on European experience. However, legal and regulatory environments are different in North America, as are societal expectations of risk tolerance and intervention. This often results in different practices compared to European nations.

In North America, public opinion is often divided around land development restrictions to manage urban avalanche risk (and other natural hazards). Proponents of development restrictions consider urban avalanche risk to be a matter of public safety and that the land managers (e.g., municipal governments) have a moral responsibility to protect the public, in particular future owners, tenants, and others who may be unaware of the risk.

Opponents of land-use restrictions believe that such restrictions are in violation of individual property rights, particularly in some jurisdictions in the United States (US). This highlights a critical aspect for consideration during the development and implementation of land development policy related to avalanche hazard; that is, balancing individual property rights with the need to provide public safety. Jurisdictions in North America have landed at very different points along the spectrum of individual rights versus restrictions for public safety.

Niemczyk (1984) provided a summary of counties and municipalities in the US with avalanche hazard regulations, which was expanded in Mears (1992). This paper, in a similar manner, provides a review of current urban avalanche risk management practices in several jurisdictions in North America.

2. URBAN AVALANCHE RISK MANAGEMENT

2.1 Avalanche Hazard Mitigation Measures

A wide range of avalanche mitigation measures are employed by jurisdictions in North America.

* *Corresponding author address:*
Chris Argue, Dynamic Avalanche Consulting Ltd., Box 2845, Revelstoke, BC, Canada, V0E 2S0;
tel: +1 250-837-4466
email: chris.argue@dynamicavalanche.com

These are categorized in the Technical Aspects of Snow Avalanche Risk Management [Canadian Avalanche Association (CAA), 2016] either as long-term or short-term measures. Long-term measures are defined as those which are effective over several years and are typically applied during the planning stage (i.e., prior to development). Short-term measures are those which are effective for hours up to a single winter and are applied during the operational stage (i.e., post-development).

Measures are further categorized by the strategy for intervening in the avalanche process, either direct or indirect. Direct measures modify the avalanche hazard by altering the terrain and/or snowpack. Indirect measures modify the exposure and/or vulnerability of the element at risk. Examples of measures in each of the four categories are listed in Table 1.

Table 1. Examples of long- and short-term avalanche risk mitigation measures (adapted from CAA, 2016).

	Long-term
Indirect	Location planning *(e.g., positioning structures to reduce exposure or hazard)* Land-use zoning *(e.g., bylaws related to permissible development activities)*
Direct	Starting zone defences *(e.g., snowpack support structures, bench cuts)* Runout zone defences *(e.g., diversion berm, stopping wall)* Structural design standards *(e.g., structures designed for avalanche impact)*

	Short-term
Indirect	Hazard communication *(e.g., hazard bulletin, warning system)* Access restriction *(e.g., closure, evacuation)*
Direct	Artificial triggering *(e.g., explosive avalanche control)*

Long-term, indirect measures by location planning and land development policy are usually preferred for occupied structures, such as residential dwellings. Long-term, direct measures (e.g., avalanche defense structures) can also be considered depending on the level of risk and acceptability to the jurisdiction, but site-specific evaluation is required to determine their effectiveness before implementation.

In locations where sufficient risk reduction cannot be achieved through long-term measures, short-term measures may serve as an alternative. For example, area closures and evacuation of occupied structures during periods of elevated hazard. Short-term measures rely on accurate avalanche hazard assessment and forecasting for successful implementation, which have inherent uncertainty and residual risk since predictions rely on human judgement. Application of short-term measures tends to result in a more conservative approach (e.g., several evacuations with no avalanche occurring), and may result in evacuation policies becoming ineffective over the long-term if they are not consistently implemented by the jurisdiction and willingly accepted by stakeholders and the public. In some cases, only partial acceptance by the public (e.g., some residents evacuate, and some choose to remain) can result in increased risk and introduce potential liability (Kellam, 2012).

2.2 *Avalanche Hazard Zoning*

Land development policy typically incorporates avalanche hazard maps that delineate areas affected by avalanches. These areas are often divided into three hazard zones representing high, moderate and low hazard areas. These zones are determined by avalanche frequency and impact pressure (i.e., magnitude), and are usually termed the Red (high hazard), Blue (moderate hazard) and White (low hazard) zones (e.g., Mears, 1992; CAA, 2016). This allows jurisdictions to establish development policies based on the degree of hazard. Some jurisdictions use a single avalanche hazard zone and therefore do not distinguish between areas of higher and lower hazard.

In Canada and the US, there is no federal or provincial/state legislation that explicitly specifies the acceptable level of avalanche hazard, or risk, for land development (Jamieson, 2018). Instead, it is regional or municipal governments that determine zoning definitions and their application to land development.

Two guidelines were published in Canada since 2002 (CAA, 2002 and 2016) that describe best practices for hazard zoning methods, and these have been applied in many jurisdictions in Canada. However, at least one jurisdiction in Canada has developed their own definitions for avalanche hazard zones [Fraser Valley Regional District (FVRD), 2020], which has evolved from their need to address multiple geohazards in the district, such as flooding, rockfall, and landslides (Cave et al., 1993). The FVRD definitions predate the CAA (2002 and 2016) guidelines.

There are no national or state guidelines available in the US, so jurisdictions have developed their own definitions for hazard zones (e.g., Mears, 1992; Scroggin and Batatian, 2004; Kors-Olthof et al., 2022). In the authors' experience, most US jurisdictions that employ avalanche hazard zoning use either three classes of hazard (Red/High, Blue/Moderate, White/Low) or a single zone, such as the Town of Vail (2020).

CAA (2016) provides recommended development according to hazard zone for the three-class system (Table 2). For jurisdictions that use a single avalanche hazard zone, a Professional Engineer is often

Table 2. Hazard zone definitions and corresponding recommended activities in Canada (CAA, 2016).

Hazard Zone	***Definition***	***Recommended Activities***
White (Low hazard)	An area with an estimated avalanche return period of > 300 years, or impact pressures < 1 kPa with a return period of > 30 years.	Construction of occupied structures is normally permitted.
Blue (Moderate hazard)	An area which lies between the Red and White Zones where the impact pressure divided by the return period is < 0.1 kPa/year for return periods between 30 and 300 years, and impact pressures ≥ 3 kPa. The Blue Zone also includes areas where impact pressures are between 1 and 3 kPa with return periods of > 30 years.	Construction of occupied structures may be permitted with specific conditions.
Red (High hazard)	An area where the return period is < 30 years and/or impact pressures are ≥ 30 kPa, or where the impact pressure divided by the return period is > 0.1 kPa/year for return periods between 30 and 300 years.	Construction of occupied structures should not be permitted.

Table 3. Hazard zone definitions proposed for Juneau, Alaska, USA (Kors-Olthof et al., 2022).

Hazard Zone	***Definition***
Low hazard (White Zone)	Return period greater than 300 years OR Impact pressures less than 20 lbs/ft^2 (1 kPa) with a return period greater than 30 years.
Moderate hazard (Blue Zone)	Return period between 30 and 300 years AND Impact pressure less than 600 lbs/ft^2 (30 kPa).
Severe hazard (Red Zone)	Return period less than 30 years AND/OR Impact pressure greater than or equal to 600 lbs/ft^2 (30 kPa).

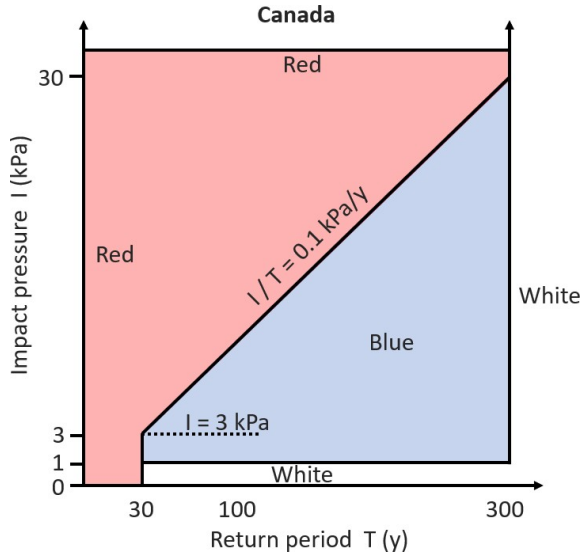

Figure 1. Hazard zones for occupied structures in Canada. (CAA, 2016).

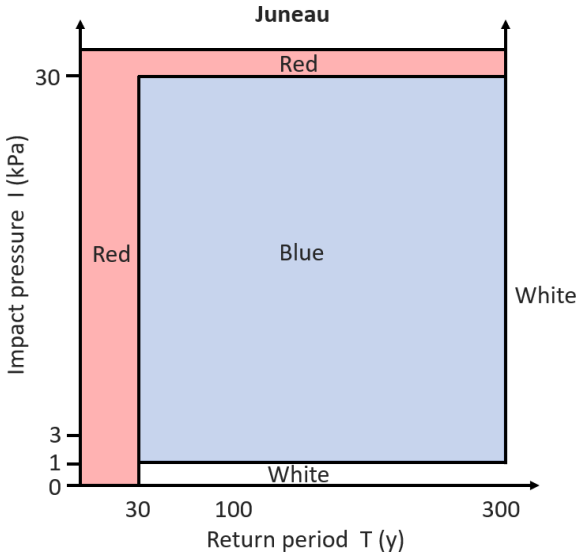

Figure 2. Hazard zones proposed for occupied structures in Juneau, AK. (Kors-Olthof et al., 2022).

required to prepare a site-specific study to guide development and provide recommendations for mitigation of avalanche hazard.

Avalanche hazard zoning for occupied structures in North America is based upon European methods. Hazard zones are determined by a combined estimate of magnitude (as impact pressure) and frequency (in years). In Canada, the most widely used definitions are those provided in CAA (2016) (Table 2).

In the US, there is less consistency in hazard zone definitions across jurisdictions. However, where three-class systems are used, definitions are often similar to CAA (2016) with three notable differences:

1. For the upper limit of the Blue Zone (moderate hazard), CAA (2016) applies a threshold based on a linear ratio of impact pressure and return period (Figure 1) while US methods apply a constant impact pressure for return periods greater than the threshold (Figure 2).

2. The return period thresholds for the upper limit of the Blue Zone (moderate hazard) varies in the US, typically between 25 and 30 years.
3. The return period threshold for the lower limit of the Blue Zone (moderate hazard) varies in the US, typically between 150 and 300 years.

As a result of these differences, the US hazard zones tend to be less conservative than those determined using the CAA (2016) guidelines, shown by the larger Blue Zone in Figure 2 (Juneau) compared to Figure 1 (Canada).

2.3.1 *Limitations of Hazard Zoning*

Avalanche hazard zoning methods commonly used in North America follow a hazard-based encounter probability approach (McClung, 2005). While useful to inform a risk management response, these methods generalize consequence and do not include an assessment of the exposure (e.g., temporal, number of people,) or vulnerability (e.g., type of structure) for specific elements at risk. This is an important limitation of these methods. For example, an industrial building with occasional occupancy may not warrant the same degree of protection as a high-density apartment complex or new subdivision with critical infrastructure (e.g., hospital or school) (EGBC, 2023). Hazard-based methods are useful to identify the need for further risk assessment, and this should be considered when setting policies based on hazard zones. For example, allowing development in the Blue Zone (moderate hazard) subject to conditions, such as a site-specific risk assessment and structural design standards, is likely appropriate. A risk assessment accounts for exposure, vulnerability, and ultimately, the consequences (e.g., probability of death, economic cost). This allows for a comparison to other societal risks to inform tolerable risk and facilitates prioritizing mitigation at the highest risk sites.

Table 4. Definitions of key terms for long-term and short-term measures commonly used for urban avalanche risk management (after Niemczyk, 1984 and Mears, 1992).

Long-Term Measures	Zoning areas	Zoning areas are established according to the degree of hazard. Areas with the highest hazard are subject to more development restrictions compared to areas with lower hazard.
	Prohibited Use	Prohibits the development of land in areas with avalanche hazards.
	Restricted Use	Allows some development in avalanche hazard areas, subject to conditions. Conditions may define timing of occupancy (e.g., non-winter), type of use (residence, short-term or long-term rental, unoccupied structures only), number of occupants.
	Non-Conforming Use	A structure or portion thereof that may have previously been lawfully located in an area with avalanche hazards but does not comply with the current requirement(s) (e.g., bylaws, ordinances).
	Permit Requirement	Requires a specific type of permit for development in an avalanche hazard area.
	Direct Mitigation	Mitigation measures (e.g., berms, snowpack support structures, protection forest) that are applied to reduce the hazard to properties and structures.
	Design Standards	The design and/or placement of structures that reduces the vulnerability of structures and thus risk to occupants.
	Land Buyback, Lease Termination	Land manager employs a strategy to acquire property and structures to prevent future development.
	Re-location of structures	Land manager employs a strategy to re-locate structures outside of hazard areas.
Short-term Measures	Restricted access	Prevents or discourages public use of avalanche hazard areas, which may or may not be enforced.
	Risk Communication – Recurring	Provides information to landowners/occupants about the current avalanche hazard throughout the winter. Means of communication could include a regular (e.g., daily) hazard advisory, signage, electronic media (e.g., websites, email, text, social media, etc.).
	Risk Communication – Warning	Warnings are issued to landowners/occupants of structures in the hazard area when the hazard reaches a specified threshold.
	Evacuation - Voluntary	Evacuation of occupied structures is recommended but not mandatory.
	Evacuation - Enforced	Evacuation of occupied structures is mandatory and enforced by the land manager or designated authority.
	Temporary Curfew	Restrictions of outdoor travel (i.e., shelter-in-place) during periods of elevated avalanche hazard, may or may not be enforced.
	Artificial Triggering	Avalanches are released by artificial means (e.g., explosive control) to reduce the hazard.

2.3 Avalanche Risk Management Components

Terms have previously been assigned to long-term and short-term mitigation measures commonly used for urban avalanche risk management (Mears, 1980 and 1992; Niemczyk, 1984; CAA, 2016). These terms are defined in Table 4 and are used in this paper to present measures used in select North American jurisdictions.

3. NORTH AMERICAN CASE STUDIES

Seven jurisdictions were selected in Canada and the US which provide a variety of examples of measures applied to urban avalanche risk management. Each jurisdiction's policies, bylaws and/or municipal codes were reviewed, and in some cases municipal staff were contacted to provide additional detail. Long-term and short-term measures used in these jurisdictions are summarized in Table 5. Four of the seven jurisdictions are discussed in additional detail below.

In addition to the jurisdictions discussed in greater detail in this paper, there are many other jurisdictions in North America that manage urban avalanche risk, and some additional locations are listed below. This list is not intended to be comprehensive but will serve to provide additional reference for interested parties.

Canada

- Blanc-Sablon, QC
- Fernie, BC
- Kangiqsualujjuaq, QC
- St. John's, NL (Outer Battery neighborhood)
- Telegraph Creek, BC
- Waterton, AB

United States

- Cordova, AK
- Blaine Country, ID
- Missoula, MT
- Morgan County, ID
- Nevada County, CA
- Ophir, CO
- Placer County, CA (Palisades Tahoe)
- Salt Lake County, UT
- San Juan County, CO

Table 5. Summary of measures used for urban avalanche risk management in select jurisdictions in North America (after Niemczyk, 1984 and Mears, 1992).

		Long-Term Measures									Short-Term Measures						
Location	Existing structures within hazard area(s)	Zoning areas	Prohibited Use	Restricted Use	Non-Conforming Use	Permit Requirements	Direct Mitigation	Design Standards	Land Buyback, Lease termination, Structure relocation		Restricted Access	Risk Communication - Recurring	Risk Communication - Warning	Evacuation - Voluntary	Evacuation - Enforced	Temporary Curfew	Artificial Triggering
District of Sparwood, BC	✗	✓	✓	✓	✗	✓	✓[1,3]	✓	✗		✗	✗	✗	✗	✗	✗	✗
District of Stewart, BC	✓	✓	✓	✓	✓	✓	✓[1]	✓	✗		✓	✓	✓	✓	✗	✗	✓
Fraser Valley Regional District, BC	✓	✓	✓	✓	✓	✓	✓[1]	✓	✗		✗	✗	✗	✗	✗	✗	✗
Alta, UT	✓	✗	✗	✓	✓	✓	✓	✓	✗		✓	✗	✓	✗	✓	✓	✓
Juneau, AK	✓	✓	✗	✓	✓	✓	✓[1]	✓	✗		✗	✓	✓	✓	✗	✗	✗
Ketchum, ID	✓	✓	✓	✓	✓	✓	✓	✓	✗		✓[2]	✗	✓	✗	✗	✗	✗
Vail, CO	✓	✓	✓	✓	✓	✓	✓	✓	✗		✗	✗	✗	✗	✗	✗	✗

Notes: 1: Permitted, but not in use at present. 2: Restrictions do not apply to local traffic (e.g., landowners, tenants). 3: Not preferred due to maintenance concerns.

3.1 District Of Sparwood, BC, Canada

The District of Sparwood (Sparwood) defines "hazard lands for landside, flood and avalanche risks, which are designated as Hazard Development Permit Area" (District of Sparwood, 2015). The hazard area does not differentiate between areas of high and moderate hazard (i.e., Red and Blue Zones). No development is permitted within designated avalanche hazard areas unless a study is completed by a qualified Professional Engineer. The study must define the limits of an avalanche flow path, including a delineation of dense and powder flow extents, and can prescribe applicable development design criteria that will protect life and property.

Development within a hazard area may be prohibited or development permits may be issued for a hazard

area with conditions. The permit may alter or supplement a bylaw related to subdivision servicing requirements or land use designation requirements (e.g., use or density).

Sparwood prefers, and is more likely to approve, structural design standards over privately owned direct mitigation measures. Sparwood has no means to ensure that privately owned direct mitigation measures are correctly maintained to ensure effectiveness, either by current or future property owners. Sparwood described experience with privately owned flood control mitigation measures that over time were compromised due to poor maintenance, or in some cases removed entirely. They stated that direct measures are preferred in cases where they are publicly owned and can thus be managed and maintained by the district for public protection.

3.2 District Of Stewart, BC, Canada

The District of Stewart (Stewart) had modern avalanche hazard zoning (Campbell et al., 2019) completed using CAA (2016) guidelines. Stewart has several structures located in hazard zones, including 133 undeveloped single-family residential lots in the Red Zone. In the Blue Zone there are 494 single-family residential lots, one multi-family residential lot, 152 commercial lots, a recreation center, and a school. Other elements at risk identified within hazard areas in Stewart include pedestrian areas, transmission lines, and port and airport infrastructure (Campbell et al., 2019; Hordowick and Johnson, 2023).

Stewart is revising and adopting new development policies based on the avalanche hazard zoning completed in 2019. Stewart indicated that new development will be prohibited in the Red Zone and restricted in the Blue Zone (pers. comm., T. McKeown, District of Stewart, 2021). Restrictions under an Avalanche Hazard Area Development Permit are discussed in Hordowick and Johnson (2023). These include public notice by placing a covenant on the land title and submittal requirements including completion of a study by a Professional Engineer to determine avalanche magnitude (impact pressure) and frequency. Additionally, public services may be suspended during periods of high avalanche hazard.

Stewart has a memorandum of understanding (MOU) with the BC Ministry of Transportation and Infrastructure (BC MoTI, 2001), which operates an avalanche program for Highway 37A (Bear Pass), which provides the only road access to the townsite. The MOU outlines the provision of avalanche safety training and operational procedures for municipal employees, an avalanche rescue plan for the townsite, closure procedures for the Bypass Road, and references the townsite evacuation plan. The BC MoTI may perform avalanche control in paths affecting the townsite. They are also responsible for providing the recommendation to evacuate, while the implementation of the evacuation is the responsibility of Stewart, although to the authors' knowledge this has not been required to date.

3.3 City and Borough of Juneau, AK, USA

The City and Borough of Juneau (CBJ) has a well-documented history of avalanche hazards affecting urban areas. Generally, the municipal code aims to ensure development in avalanche areas minimizes the risk of loss of life or property (CBJ, 2006). CBJ designates avalanche areas as Severe, Moderate or Low which correspond respectively to the Red, Blue and White Zones. Numerous single-family residences are in the Severe hazard zone, and additional development (e.g., hotel, boat harbor) is located in either the Severe or Moderate hazard zone (Margreth and Schwitzer, 2011; Kors-Olthof et al., 2022). CBJ is in the process of adopting updated avalanche hazard mapping and revising development policies (Kors-Olthof et al., 2022). The current municipal code (CBJ, 2006) specifies conditions for development in avalanche hazard areas, such as:

- All subdivisions and developments greater than a single-family dwelling require a conditional use permit.
- In a Severe hazard zone, no development or renovation shall increase the density of that parcel, except that a single-family house may be constructed on a vacant lot.
- No subdivision shall be approved which creates a lot with insufficient building space outside a Severe hazard zone.
- Prior to issuing a conditional use permit, CBJ may require mitigating measures certified by a Professional Engineer.
- Developers who disagree with hazard boundaries may submit a site-specific study prepared by a qualified Professional Engineer.

CBJ allows the development of a single-family house on lots in Severe hazard areas to maintain individual property rights of landowners to use their property as a residence, and to avoid devaluing an individual's property. This has resulted in new residential development in obvious and severe avalanche hazard areas, even following adoption of avalanche hazard zone mapping.

CBJ employs one full-time avalanche forecaster, who provides a daily Urban Avalanche Advisory during the avalanche season (approximately November through April), which is published daily on the CBJ's website. CBJ will also periodically provide evacuation warnings to the public during periods of elevated hazard; however, these are not enforced and typically have only partial compliance from residents.

3.4 Ketchum, ID, USA

Divided public opinion over building restrictions has shaped Ketchum's policy related to urban avalanche hazard and land use (Mears, 1992; Kellam, 2012). The Ketchum municipal code defines an Avalanche Zone District as an area where potential avalanche hazard exists. It does not differentiate between areas of High and Moderate hazard (i.e., Red and Blue Zones). The purpose of the Avalanche Zone District is to give notice of hazard areas, protect public safety, prevent extraordinary expenditures, and allow for construction consistent with the City's zoning plan by informed persons. It also provides regulations to protect lessees, renters, and sub-tenants of the property within these zones. All related studies and reports are made publicly available.

Building permit applicants in the avalanche zone must accept full responsibility for building in the avalanche zone and indemnify the City. This is documented by an affidavit signed by the applicant.

The following are some of the notable restrictions and conditions on development in avalanche zones:

- A single-family residence can be built in the Avalanche Zone without any avalanche engineering studies and construction.
- Any building, except a single-family residence, will be designed for avalanche forces as set forth in the avalanche studies on file, or designed by a Professional Engineer.
- Avalanche defense structures, including buildings reinforced for avalanche loads, shall not deflect avalanches toward adjacent properties.
- All new and replaced utilities shall be installed underground. Service meters and shut-off valves shall be installed on the leeward side of buildings in a protected location.
- Any residence that has not been engineered to withstand avalanche forces shall not be leased, rented, or sublet from November 15 through April 15 of each year.
- Subdivision, including those for townhouses and condominium developments, within the Avalanche Zone District is permitted, provided no new public or private streets or flag lots are developed on parcels within the Avalanche Zone.
- A prospective buyer, lessee or tenant shall be provided with written notice upon first inquiry that the property and/or structure is located within the Avalanche Zone.
- During periods of avalanche danger, City services (e.g., fire, ambulance) may be suspended.

To inform property owners in the Avalanche Zone, the City of Ketchum mails avalanche awareness reminders prior to each winter. During periods of elevated avalanche hazard, the following tools are used to communicate the avalanche risk:

- Warning signs at neighborhood entrances.
- Phone and text messages.
- Road closures allowing local traffic only.

Ketchum has also implemented training for emergency responders, which has improved responses during urban avalanche events (Kellum, 2012).

3.5 Summary of North American Policies and Practices

There are two notable differences in policies between the jurisdictions reviewed. First, most jurisdictions in Canada do not permit new development in the Red Zone (high hazard), in accordance with the CAA (2016) guidelines. Several US jurisdictions permit development in the Red Zone, usually subject to conditions.

Secondly, Canadian guidelines suggest that development in the Blue Zone (moderate hazard) is not appropriate for the construction of "public structures such as residences" (CAA, 2016, page 63). However, many US and some Canadian jurisdictions (e.g., FVRD, Sparwood, Stewart) permit residential construction in the Blue Zone, subject to conditions. These two differences demonstrate a broad range in risk tolerance and in policy that strives to balance individual property rights against public safety.

Aside from these differences, there are many common policies applied by North American jurisdictions to manage urban avalanche risk, summarized below.

Commonly Applied Long-Term Measures

- Application of zoning areas, where the Red and Blue Zone are considered separately and are often subject to different development restrictions (most Canadian and some US jurisdictions).
- Requiring agreements which inform landowners and indemnify the jurisdiction.
- New development in Blue Zones is often permitted, subject to conditions, which include:
  - A study prepared by a qualified Professional Engineer defining expected impact pressures.
  - Structural design standards (i.e., structure designed for avalanche impacts).
- Rental of properties are subject to restrictions, including time of year when rental is permitted, requiring owner occupancy (e.g., Bed and Breakfast) and imposing upon landowners a "duty to warn" tenants.
- Direct mitigation is permitted subject to conditions, such as ensuring that hazard is not increased in adjacent properties.
- Structural design standards are generally preferred over direct mitigation (e.g., berm).
- Land buybacks or lease terminations are not used by the jurisdictions reviewed.

- Relocation has not been applied by the jurisdictions reviewed but has been used in in Blanc-Sablon, QC, Canada.

Commonly Applied Short-Term Measures

- Municipalities with structures in Red Zones provide warnings to landowners. Warnings are communicated by different means, but include websites, text messages and local signage.
- Evacuations during periods of elevated hazard are generally voluntary. The Town of Alta, UT, is the exception which enforces an outdoor travel prohibition (Interlodge closure) by municipal ordinance.
- Where warnings and evacuation recommendations are used, an avalanche program is operated, with a daily hazard monitoring program (e.g., Alta, UT; Juneau, AK; Stewart, BC).
- Artificial triggering is not typically used. Alta, UT and Stewart, BC are exceptions, but the principal reason is to protect roads, not occupied structures.

4. CONCLUSION

While land development in avalanche hazard areas has the potential to create public risk, many jurisdictions allow development in the interest of individual property rights and land scarcity. Given the demand and high value of properties in mountain communities, such development is likely justified assuming appropriate conditions for mitigation are specified. The case studies presented in this paper suggest that society is willing to tolerate some risk associated with land development in avalanche hazard areas.

The jurisdictions reviewed apply both long- and short-term mitigation measures, however, long-term measures such as location planning and land development policy are preferred. Structural design standards are usually the preferred direct measure in most jurisdictions. Another important component of land development in avalanche hazard areas is that of informed risk acceptance, and duty to warn future owners and tenants.

Avalanche hazard can vary from near-zero to high from one parcel of land to another. For this reason, the authors acknowledge the value of hazard zoning schemes with different levels (e.g., Red, Blue, and White) to appropriately manage development.

Current hazard zoning methods have an important limitation in that they do not consider the consequences of avalanche impact (i.e., exposure and vulnerability). Risk assessment, which evaluates consequences and allows comparison to other societal risks, is a useful next step in determining appropriate development activities and to inform mitigation priorities.

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