



Fairmont Hot Springs Hazard Guidance Project

Prepared by BGC Engineering Inc. and Pinna Sustainability Inc.
for:

Regional District of East Kootenay



October 21, 2025

Project 1127007



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Regional District of East Kootenay
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Attention: Karen MacLeod, MCIP, RPP, Planning Manager

Fairmont Hot Springs Hazard Guidance Project

Please find the final report attached. We appreciate the opportunity to collaborate with you on this challenging and interesting project.

Should you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely,

BGC Engineering Inc.
per:

Brett Eaton, Ph.D., P.Geo.
Principal Geoscientist

SUMMARY

The Regional District of East Kootenay (RDEK) engaged BGC Engineering Inc. and Pinna Sustainability Inc. to provide hazard guidance for Fairmont Hot Springs, focusing on Cold Spring Creek and Fairmont Creek. The project builds on prior studies, provides interim policy options, and supports long-term bylaw and planning decisions.

Objectives and Scope

The project aimed to:

- Update land-use tools (OCP, Development Permit Areas, bylaws) with current hazard and risk information.
- Strengthen public awareness of geohazards and climate impacts.
- Build staff capacity to interpret hazard and risk information for policy and planning.

Work included reviewing existing studies, engaging with First Nations and the community, developing a direction for interim land-use policy, and preparing educational materials.

Current Understanding of Geohazard Risk

The primary hazards of concern are debris floods and debris flows. While debris floods occur more frequently, debris flows are larger and more destructive. On Cold Spring Creek, the construction of a debris basin in 2025 significantly reduced the hazard by containing events with return periods of up to 1,000 years. In contrast, hazards remain considerable on Fairmont Creek, where large debris flows could overtop berms and impact resort infrastructure, golf courses, residential parcels, and Highway 93/95. Hazard mapping categorizes both creek fans into four zones – Very High, High, Moderate, and Low – based on the annual probability of life loss (Annual PDI). These zones provide a consistent and transparent basis for land-use policy.

Hazard zones for Cold Spring Creek and Fairmont Creek.

Hazard Zone	Risk Index (Annual PDI)	Implications for Development (based on policy recommendations)
Very High	>1:1,000	Only limited, low-intensity land uses permitted (e.g., non-habitable accessory buildings, agricultural uses, outdoor recreational facilities, wildlife corridors)
High	1:10,000 to 1:1,000	
Moderate	1:100,000 to 1:10,000	Risk assessments required for all new and existing developments. Development may be approved with mitigation measures (avoidance, resistance, resilience).
Low	<1:100,000	Most development is tolerable and usually will not require a risk assessment

Policy Review & Framework Options

The policy review examined three frameworks currently in use across British Columbia and Alberta:

1. **Hazard Threshold:** decisions based on probability of a hazard occurring
2. **Risk Threshold:** decisions based on estimated life-loss risk, which is compared to formal risk tolerance criteria adopted by the community
3. **Combined Framework:** uses hazard mapping to define areas within which decisions are based on estimated life-loss risk and risk tolerance criteria.

Local governments in BC apply these frameworks through a range of regulatory and policy tools, including but not limited to Official Community Plans, Development Permit Areas, zoning bylaws, Qualified Professional reports, floodplain management bylaw, covenants, and education initiatives.

On February 14, 2025, the RDEK Board resolved to direct the development of policy options utilizing a Combined Framework (Resolution 52133).

Interim Policy Recommendations

BGC and Pinna recommend the following policies:

Recommendation 1 – OCP Amendments: Update hazard mapping in Schedule I using the 2025 Hazard mapping. Incorporate hazard zones and related development approval policies for Low, Moderate, High, and Very High hazard zones.

Recommendation 2 – Risk Tolerance Policy: Include formal risk tolerance criteria for the Fairmont Hot Springs area, either as a standalone policy or referenced in OCP sections and/or DPA guidelines.

Recommendation 3 – DPAs & Guidelines: Add DPA(s) for debris flow hazards covering both creeks, aligned with mapped fan extents, requiring development permits for new development or modifications within these areas. Allow development that does not increase risk (e.g., additions to existing buildings, renovations, decks, minor landscaping). Avoid using structural mitigation at the community level to encourage densification in hazard areas.

Recommendation 4 – Development Policies by Hazard Zones: Develop a formal policy for Cold Spring and Fairmont Creek DPAs using a combined hazard-risk framework based on formal risk tolerance criteria for the community. Reference this policy in both OCP hazard sections and DPA guidelines to guide development approvals.

TABLE OF REVISIONS

Date	Revision	Remarks
September 15, 2025	0	Draft issued for client review.
October 10, 2025	1	Draft issued for client review.
October 21, 2025	A	Final

CREDITS AND ACKNOWLEDGEMENTS

BGC and Pinna would like to acknowledge the following individuals for their contributions to this report:

- Jack Park, P.Eng.
- Kris Holm, P.Geo.
- Sophia Zubrycky, P.Eng.

In addition, BGC acknowledges the contributions and collaboration of RDEK staff to the project work presented in this report:

- Justin Cook, Planner II
- Karen MacLeod, MCIP, RPP, Planning Manager
- Loree Duczek, Communications Manager
- Michele Bates, General Manager, Development & Protective Services.

This work has been supported through the Union of BC Municipalities Disaster Risk Reduction – Climate Adaptation (DRR-CA) Grant.

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LIST OF ACRONYMS & ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BC MOTT	British Columbia Ministry of Transportation and Transit
BGC	BGC Engineering Inc.
DPA	Development Permit Area
EDMA	Emergency and Disaster Management Act
EGBC	Engineers and Geoscientists British Columbia
FVRD	Fraser Valley Regional District
LGA	Local Government Act
LUB	Land Use Bylaw
MDP	Municipal Development Plan
OCP	Official Community Plan
PDI	Probability of Death of an Individual
Pinna	Pinna Sustainability Inc.
QP	Qualified Professional
RDEK	Regional District of East Kootenay

1.0 INTRODUCTION

The Regional District of East Kootenay (RDEK) is developing policies related to natural hazards in the unincorporated community of Fairmont Hot Springs, BC, specifically those associated with Fairmont Creek and Cold Spring Creek. RDEK retained BGC Engineering Inc. (BGC) and its subcontractor, Pinna Sustainability Inc. (Pinna), to provide recommendations for the Fairmont Hot Springs Hazard Guidance Project. This work is provided under Contract No. CDL 0747, dated June 17, 2024. Fairmont Hot Springs is situated on the coalesced alluvial fans of Cold Spring and Fairmont Creeks (Figure 1-1).

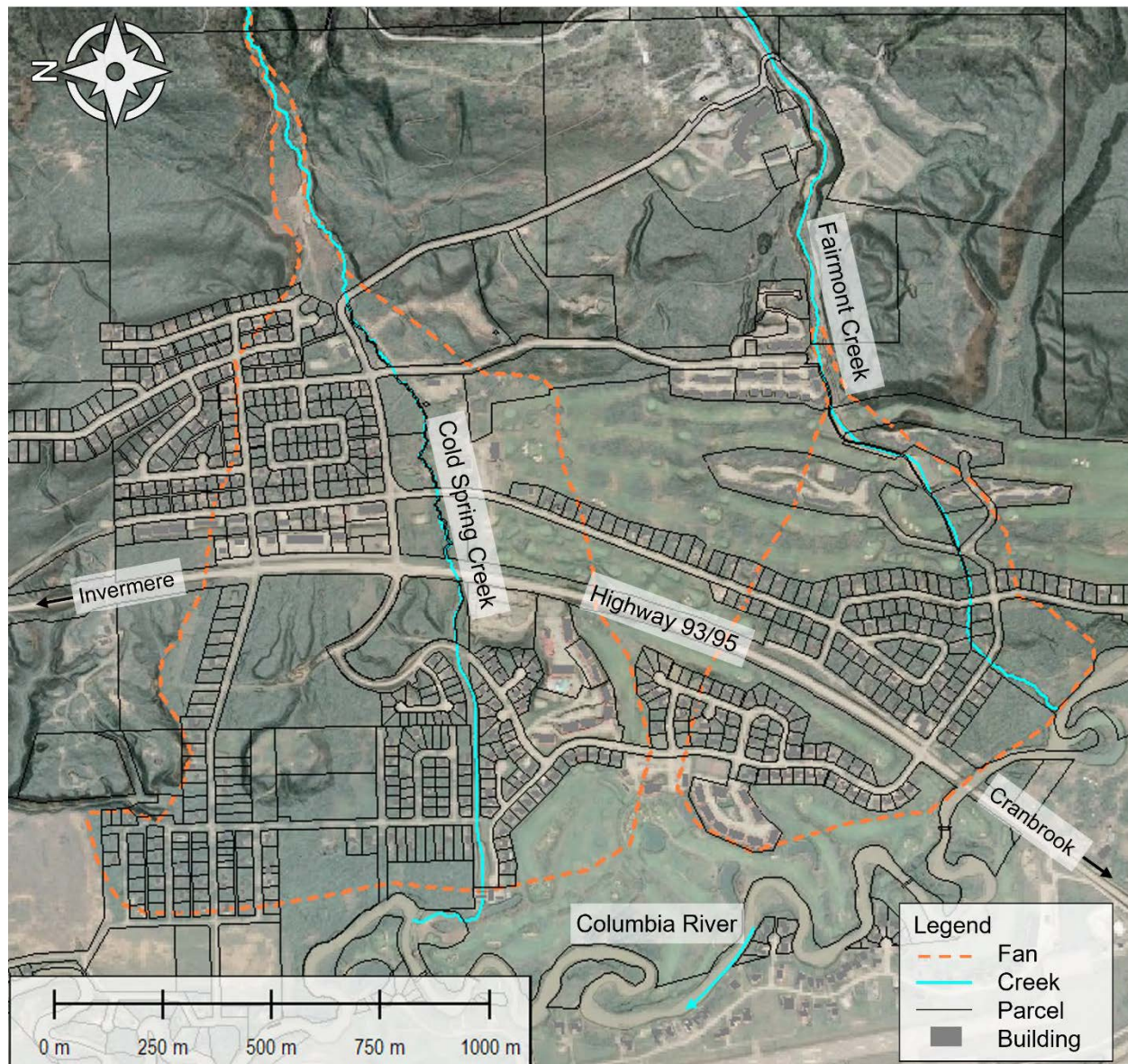


Figure 1-1 Overview of Cold Spring and Fairmont fans. The background imagery is a combination of 2018 lidar hillshade and 2023 imagery.

1.1 Objectives and Scope of Work

The RDEK's decision-making process for land use and development relies on policies that, while not legally binding, direct their decisions and actions, and bylaws that represent a legal instrument to make decisions enforceable under authority granted by provincial or territorial legislation.

Project objectives support both policy and bylaw development by the RDEK. Specifically, the RDEK has defined two key needs as follows:

- Guide RDEK's **land use decision-making process** by preparing information proposed for integration into the Official Community Plan, development permit areas (DPA), and modification of bylaws to reflect updated information about floodplain setbacks and flood construction levels.
- Increase **community education and awareness** through engagement that increases understanding of geohazard risks, sets expectations about limitations of structural mitigation to reduce risk, conveys implications of climate change on risk, and communicates how communities can adapt to build climate resilience.

The scope of work included:

- Review of existing hazard studies, policies, and bylaws, including understanding the current processes the RDEK Staff manage.
- Community engagement with stakeholders and First Nations, including a public workshop.
- Provide options for interim land use policy.
- Propose interim policy and recommended next steps.
- Development of educational material on hazard awareness.

1.2 Study Team

The study team and contributors are listed below, and the primary authors and reviewers are listed in Table 1-1.

- Brett Eaton, Ph.D., P.Geo., Principal Geoscientist
- Tamsin Mills, M.Sc., R.P.P., Senior Planner
- Jack Park, B.A.Sc., P.Eng., GIT, Geological Engineer.

Table 1-1 Study team.

Project Manager		Brett Eaton	
Technical Reviewer		Kris Holm	
Section		Primary Author(s)	Peer Reviewer(s)
1.0	Introduction	Jack Park	Brett Eaton
2.0	Community Engagement	Jack Park	Brett Eaton
3.1	Hazard & Risk Concepts	Jack Park	Brett Eaton
3.2	Hydrogeomorphic Hazards	Jack Park	Brett Eaton
3.3	Existing Hazards	Jack Park	Brett Eaton
3.4	Current Understanding of Geohazard Risk	Jack Park	Brett Eaton
3.5	Existing Policy & Bylaws	Tamsin Mills	Brett Eaton
4.0	Policy & Bylaw Considerations	Brett Eaton; Tamsin Mills	N/A
5.0	Recommendations	Brett Eaton; Tamsin Mills	N/A

2.0 COMMUNITY ENGAGEMENT

2.1 First Nations Engagement

The project team and the RDEK Staff met virtually with representatives from the Shuswap Band and the ʔAkisq̓nuk First Nation during the project. Concerns from both groups were related to the downstream effects of the Columbia River due to debris flow events and the construction of the debris barrier on Cold Spring Creek. The study of the downstream effect of the Columbia River was not part of the scope of this work. Both First Nations were updated on the project through email communications and virtual meetings and were invited to participate in the public workshop.

2.2 Public Workshop

On October 30, 2024, a virtual public workshop was hosted by the study team. The promotion of the workshop was done through RDEK's Communications Department. The workshop invitation was open to all residents of Fairmont Hot Springs, its businesses, and representatives from the Shuswap Band and the ʔAkisq̓nuk First Nation. The workshop, built on previous engagements with the community to discuss the hazards associated with Cold Spring Creek and Fairmont Creek, further provided information on the steep creek hazards in the community, presented a general understanding of risk tolerance concepts, and shared examples of how hazard policies are implemented in similar jurisdictions in western Canada.

The workshop included presentations and survey questions for participants to respond to on the following four topics:

1. **Debris Flows & Debris Floods**
Overview of steep creek hazards, what they are, how they get triggered, and visual examples of how they behave. Highlight the risk management process and its application at Fairmont Hot Springs.
2. **Fairmont Hot Springs – Steep Creek History**
Known historical accounts of events on Cold Spring and Fairmont Creeks since 2012.
3. **Risk Tolerance**
Understanding risk tolerance and how it translates in simple statistical terms (i.e. what are the odds?).
4. **Policy Consideration**
Examples of different risk management approaches, existing RDEK guidelines, and available planning tools related to hazard zones.

Table 2-1 summarizes the responses from the survey questions provided during and following the community engagement.

Table 2-1 Summary of community engagement responses.

Question		Response Summary
1	What has been your experience with debris flows and debris floods?	Most respondents had little to no direct personal experience, although many had witnessed the impacts locally (in Fairmont Hot Springs and Canmore) or through their work (in emergency services, resort rehabilitation, and consulting). Several noted only second-hand awareness or training. A few observed effects on creeks, sediment buildup, and local floods. Overall, experiences ranged from none to indirect observations to professional involvement in past events.
2	What concerns you the most about future events?	Key concerns centred on climate change increasing frequency and intensity, potential damage to property, infrastructure, and lives, and the economic impacts (property values, taxes, insurance, and affordability of mitigation). Respondents also worried about preparedness, adequacy of mitigation efforts, changes to the creek, and the safety of residents and visitors. Several noted uncertainty around how risk is assessed given changing conditions.
3	What was your previous understanding of the hazard history?	Understanding among the respondents varied. Some were already aware of past events through residents, news, or prior knowledge, while others admitted limited or no awareness. A few gained better understanding through updates or newsletters. Several noted awareness without full context (magnitude, frequency, long-term risks).
4a & 4b	Has your understanding of the hazard history changed after today's presentation? How so?	Mixed responses among the respondents. About half said yes, their understanding deepened, often noting surprise at the number or scale of past events and debris volumes. Others said no, but still gained perspective, appreciated graphics, or confirmed what they already knew. A few asked for more detailed data on event volume ranges and trends.
5	What is your current level of comfort knowing the risk of the hazard?	Responses were highly mixed: • Extremely uncomfortable – 3 respondents • Uncomfortable – 1 respondent • Neither comfortable nor uncomfortable – 4 respondents • Comfortable – 2 respondents • Extremely comfortable – 2 respondents

Question		Response Summary
6	What would make the risk acceptable?	Suggestions included: • Effective mitigation infrastructure and maintenance • Emergency preparedness and communication • Clear policies and insurance frameworks • Monitoring creeks, keeping culverts clear • Shared funding (not solely local residents' burden) • Understanding event probabilities and consequences (e.g., 1-in-100-year floods) • Some also acknowledged full risk elimination is impossible, so proportional and practical responses are needed.
7	What would you like the region to consider when developing policy to reduce risk to property, buildings, and people?	Themes included: • Climate change impacts and long-term resilience • Stricter land-use planning (limit or deny development in high-risk zones, stronger OCP policies) • Resident engagement and communication • Funding support from higher governments • Insurance availability and affordability • Stronger mitigation requirements for developers • Integration of technical studies (geotechnical, hydrological) into planning
8	How do you currently or foresee keeping yourself and your property safe?	Some rely on not being in the hazard zone, while others take steps such as floodproofing their property, clearing debris, ensuring proper drainage, and keeping sandbags ready. A few emphasized the importance of staying informed, maintaining situational awareness, and fostering ongoing communication. Some expressed uncertainty about what more they could do,

The workshop was recorded and made available following the live workshop for those who were not available to attend.

2.3 Educational Material

BGC and Pinna developed a series of infographics to inform the public about existing hazards at Fairmont Hot Springs and various risk management strategies. The following infographics are included in Appendix A:

- Debris Flood Hazard.
- Protect Yourself From Debris Floods.
- Debris Flow Hazard.
- Protect Yourself From Debris Flows.
- Debris-Flow & Debris-Flood Hazards Risk Management Options.

3.0 BACKGROUND

BGC understands that RDEK wishes to develop policies and update their bylaws to better manage risks associated with geohazards in Fairmont Hot Springs. Several key concepts need to be defined at the outset.

3.1 Hazard and Risk Concepts

Disaster risk refers to the potential for loss resulting from a future event. Two parts are needed to describe a disaster risk:

- **Consequence**, which describes characteristics (e.g., size, count, type) of what is lost or damaged.
- **Probability** of that consequence occurring.

Quantitatively, risk is the product of the adverse consequence (e.g., number of lives lost, economic loss, days of service disruption) and the probability of that consequence occurring. Most disasters cause multiple consequences; therefore, the total disaster risk is the sum of each possible consequence times its probability of occurrence:

$$Risk = \sum (Consequence \times Probability)$$

Both parts of disaster risk are a function of the interactions between the hazard, exposure, and vulnerability (Figure 3-1):

- **Hazard**, which is any process or phenomenon that threatens people and the things that people care about. A hazard is described by the process type, the potential size or intensity of a hazard event, and the probability of that hazard event occurring.
- **Exposure** describes what could be impacted by a given hazard scenario, like the number of people, the number of buildings, or the economic value of businesses. It is derived from maps that overlay the location of assets with the extents of a hazard zone.
- **Vulnerability** describes the proportion of loss, probability of loss, and/or the ability to recover, given impact by a specific hazard scenario. It depends on the physical and social characteristics of the exposed people, communities, and assets, and the intensity of the hazard.

The key point is that all three components must exist for there to be a potential loss (i.e., disaster risk). For example, a flood only poses a risk to a community if the community has people and assets in the flood's path (i.e., exposure) and the flood is deep enough relative to the elements at risk to cause damage (i.e., vulnerability).

Although all three components must exist for there to be potential loss, many decisions about disaster risk can be made without a detailed assessment of all three components. Using hazard or risk **thresholds** can further simplify yes/no-type decisions, such as issuing a permit or requiring further actions. For example, actions may be triggered by knowing that a hazard or risk exceeds some level, without having to know the exact degree of hazard or risk.

Resiliency is another closely related concept that is relevant to this report. It describes the ability of a system, person, community, or society to resist, respond, and recover from the

effects of a hazard. Vulnerability is one aspect of resiliency. In reaction to hazards, resilience may refer to the technical capacity to withstand and recover, or the social and emotional strength needed to cope with trauma and stress. In a proactive sense, resiliency may refer to policy and governance that support long-term adaptation or to community actions that reduce vulnerability, exposure, or hazard.

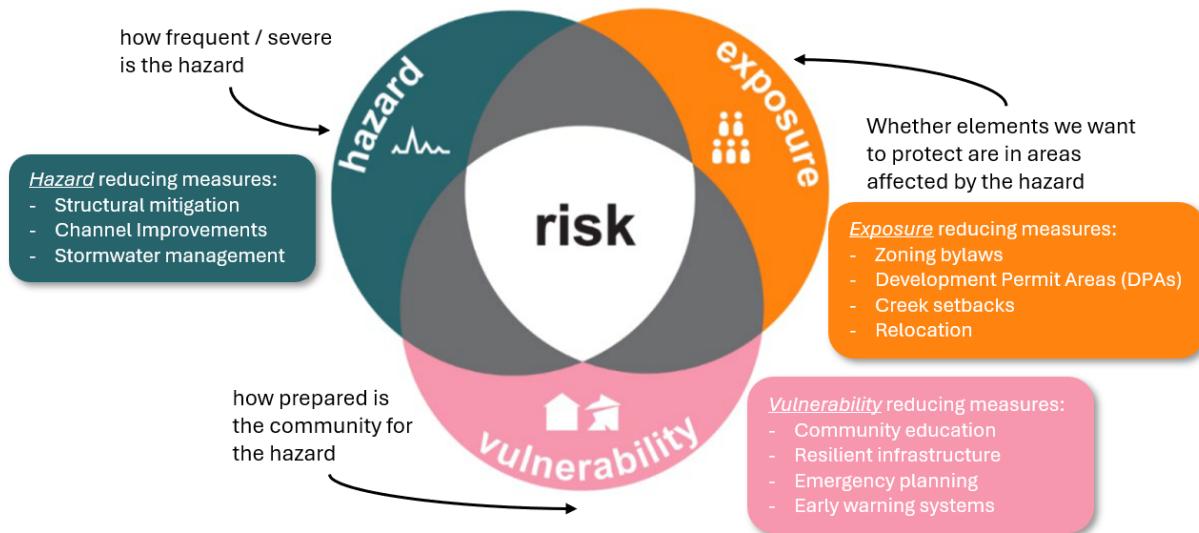


Figure 3-1 An illustration of how risk occurs at the intersection of hazard, exposure, and vulnerability, and examples of risk reduction measures in each category.

There are two types of risks to consider when developing policy:

- **Individual risk** is the probability of death for an individual who lives or works in the hazard zones. Individual risk enables us to compare the risks we face in hazard zones with those in our daily lives.
- **Group risk** is the probability that multiple lives will be lost during a given event. Group risk helps community and emergency planners better contemplate risk to the neighbourhood/community.

When managing the effects of many small hazard events that affect a few elements at a time, approaches based on the individual risk may be sufficient. When managing the effects of a large event with the potential for numerous fatalities and extensive damage, the group risk should also be taken into consideration.

Risk evaluation means comparing the estimated level of individual or group risk against thresholds to determine if the estimated level of risk will be tolerated. While informed by science, risk tolerance is ultimately a social decision. Regulatory decisions based on risk thresholds can be binary, such as whether a proposed development is considered “safe for the use intended” and a permit should be issued. For planning decisions, risk thresholds can also inform priorities. For example, there may be increasing justification for risk control actions above a threshold and decreasing justification below the threshold. Appendix D describes risk thresholds previously set by other jurisdictions in British Columbia and Alberta.

The geohazards relevant to this report are those driven by flooding and the transport and deposition of sediment in steep creeks. These are referred to as **hydrogeomorphic hazards** and are described in the next section.

3.2 Hydrogeomorphic Hazards

Hydrogeomorphic hazards are natural hazards that involve the mobilization, transport, and deposition of mixtures of water and debris or sediment (Figure 3-2). Hydrogeomorphic hazards include floods, debris floods and debris flows. Debris flows and debris floods are typically the most damaging types of hazards².

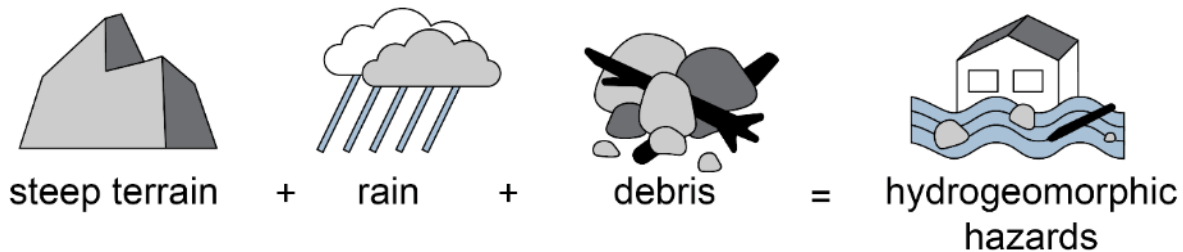


Figure 3-2 Main factors contributing to hydrogeomorphic hazards.

Hydrogeomorphic hazards occur in a continuum, as shown in Figure 3-3. Floods carry fine sediment in suspension and transport larger sediment along the channel bed. Debris floods occur when large volumes of water in a creek or river entrain the gravel, cobbles and boulders on the channel bed. Debris flows involve higher sediment concentrations than debris floods with boulders and large woody debris mixed into the flow³.

² Hydrogeomorphic hazards typically occur in steep streams (i.e., streams with gradients greater than about 5% or 3 degrees) with small watersheds (usually less than 100 km² in area) in mountainous terrain and are most often triggered during intense and/or long rainfall events. Hydrogeomorphic hazards are sometimes triggered by snowmelt and are more likely to occur following forest fires.

³ Debris floods can generally be classified into three types, based on the conditions that trigger them (Church & Jakob, 2020). Type 1 debris floods are initiated from rainfall or snowmelt-generated streamflow that is sufficiently powerful to deeply erode the channel bed. Type 2 debris floods are generated from diluted debris flows. Type 3 debris floods are generated by natural or human-made dam breaches. Both Type 1 and Type 2 debris floods are likely to occur in Cold Spring and Fairmont Creeks.

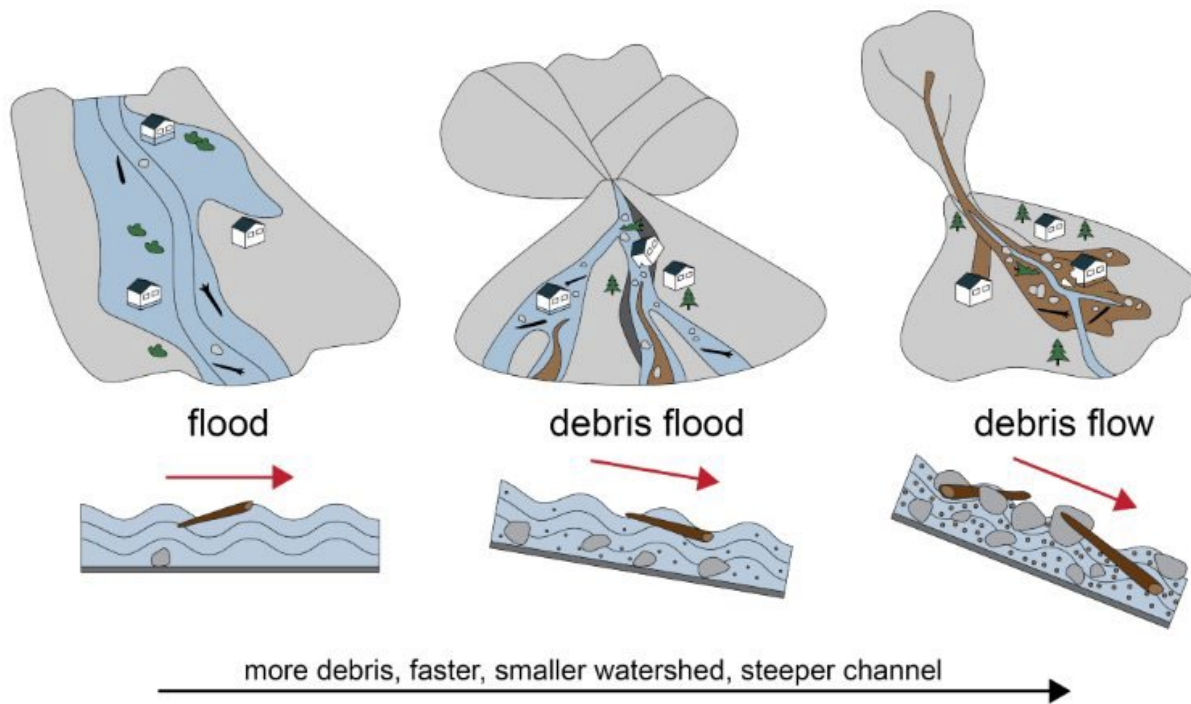


Figure 3-3 Hydrogeomorphic processes spectrum. BGC-created figure.

Debris flows have higher sediment concentrations than debris floods and can approach consistencies similar to wet concrete. As with debris floods, the range of impacts can vary depending on the event's intensity and duration, as well as the proximity of elements at risk to the active channel. Debris flows are typically faster and more intense than debris floods and have substantially higher flow depths, resulting in higher peak flows and impact forces. They are particularly threatening to life and property.

The effects of the hydrogeomorphic hazards described above vary with their magnitude and duration. These hazards can be relatively harmless if of short duration and low magnitude. Events with longer duration and/or higher magnitude can be damaging, particularly when they cause bank erosion and other adverse changes to the stream channel. The largest events can be catastrophic, causing major damage to infrastructure and buildings, including the collapse of buildings and bridge foundations, culvert blockages, exposure and damage to utilities, and erosion of road surfaces. While relatively rare, injuries and/or fatalities can occur when people unexpectedly encounter or fail to escape the areas impacted by these events.

3.3 Existing Hazards

The RDEK has undertaken various assessments and inspections related to hydrogeomorphic hazards in Cold Spring Creek and Fairmont Creek. Previous studies, including the annual

inspection reports, can be found under the Fairmont Debris Flow Mitigation⁴ page on RDEK's website. Two key reports that pertain to policy guidance are listed under Table 3-1.

Table 3-1 Assessment reports for Cold Spring Creek and Fairmont Creek.

Report	Date	Organization
Fairmont Creek Hazard & Risk Assessment (Interim Draft)	July 4, 2025	BGC
Cold Spring Creek Residual Hazard Map	July 30, 2025	BGC

3.3.1 Cold Spring Creek

The Cold Spring Creek fan includes both active and inactive zones⁵. Based on various kinds of field data⁶, BGC understands that debris floods and debris flows shape the fan. Historic channel shifts, trenching data, and geomorphic features confirm that both debris floods and debris flows formed the Cold Spring Creek fan. Debris floods are expected to occur relatively frequently (i.e., associated with 5 to 100-year return periods⁷), and could transport as much as 5,000 m³ of sediment. Debris flows on Cold Spring Creek are expected to be larger (i.e., transport volumes approaching 100,000 m³ are possible) and more hazardous, but they are less common (i.e., associated with 100-year return periods and above). Damaging debris flood events are known to have occurred on Cold Spring Creek in 2012, 2013, and 2020⁸. BGC's *Cold Spring Creek Hazard Assessment* report (September 25, 2020) includes details of the historical record and the latest understanding of the hazard on the fan.

A sediment basin has been constructed on Cold Spring Creek that should trap a large fraction of the material transported by even the largest debris flows, which has reduced the hazard on Cold Spring Creek. BGC (*Cold Spring Creek Residual Hazard Map*, July 30, 2025) estimates the basin storage capacity to be 84,000 m³, which should fully mitigate hydrogeomorphic hazards for return periods less than 1000 years, and reduce the hazard for debris flows with return periods above 1000 years.

3.3.2 Fairmont Creek

Fairmont Creek geohazards have been studied since the 1980s in response to ongoing development on the fan. Based on BGC's *Fairmont Creek Hazard & Risk Assessment* (July 4, 2025; interim draft), debris floods are likely to occur frequently in Fairmont Creek (i.e., 10-to-

⁴ <https://engage.rdek.bc.ca/debris>

⁵ Inactive zone refers to "paleofan" areas, which are not affected by contemporary debris floods and debris flows.

⁶ The average channel gradient above the fans is about 30%, which is sufficient for sustained debris flow transport. Large, subangular boulders are found at the surface around the fans that are likely to have been transported by past debris flows. BGC also observed historical deposits, levees, debris lobes, and high-water marks well above typical creek levels.

⁷ A return period is a statistical estimate of how often an event of a certain magnitude is likely to occur. A return period of 100 years does not mean the event will only happen once every 100 years. Multiple events of that magnitude can occur in close succession.

⁸ The debris flood that occurred in Cold Spring Creek on May 31, 2020 (the same day as a much larger event on Fairmont Creek) appears to have deposited about 2,000 m³ of sediment at the apex of the fan, and another 1,000 to 2,000 m³ of sediment further down the fan.

100-year return periods) and the largest debris floods could transport almost 30,000 m³ of sediment. Debris flows are less frequent (i.e., 100-year return periods and above) but may be much larger than the largest debris flood (i.e., transport volumes above 150,000 m³ are possible). The first well-documented debris flow event⁹ occurred in 2012, and a large debris flood¹⁰ occurred in 2020. Since then, various studies and mitigation efforts have been conducted. BGC's *Fairmont Creek Hazard and Risk Assessment Report* (July 4, 2025; interim draft) includes details of the historical records and the latest understanding of the hazard on the fan.

3.4 Current Understanding of Geohazard Risk

Risk depends on the nature of the geohazard, whether the hazard reaches nearby development, and how much damage could be caused by the geohazard reaching the development. This section presents our current understanding of the risk in Fairmont Hot Springs due to hydrogeomorphic hazards in Cold Spring and Fairmont Creeks. A detailed explanation of how risk is assessed is provided in the *Fairmont Creek Hazard and Risk Assessment Report* (BGC, July 4, 2025; interim draft; Section 4.5).

3.4.1 Cold Spring Creek

The Cold Spring Creek fan includes homes, businesses, and community buildings. Many of these are single-family homes with a mix of year-round and seasonal occupancy. The fan also includes Highway 93/95 and local roads. A major concern is the potential for large debris flows, expected every 100 to 1,000 years, that could cause multiple deaths and property damage and losses. In 2025, the RDEK completed construction of a debris flow barrier that could contain hydrogeomorphic events with return periods less than 1,000 years, significantly reducing the hazard associated with larger but less frequent events¹¹. BGC's modelling of the residual risk following debris basin completion on Cold Spring Creek (BGC, July 30, 2025) shows that all but the largest debris flows should be fully contained by the debris basin, reducing the risk of life loss¹² at all the existing structures on the fan to a relatively low value (i.e., less than one chance in 100,000 for any given year).

⁹ The debris flow that occurred in Fairmont Creek on July 15, 2012, was triggered by a localized convective rainstorm. It delivered an estimated 65,000 m³ of material to the fan, blocking a road culvert and impacting water intake structures on Fairmont Creek. It also inundated roads and residential buildings on the fan.

¹⁰ The debris flood that occurred in Fairmont Creek on May 31, 2020, was triggered by rainfall combined with snowmelt. It transported approximately 20,000 m³ of sediment, filling three weirs designed to trap sediment upstream of the fan apex, resulting in bank erosion and channel incision on the fan. It deposited about 8,000 m³ on the fan surface.

¹¹ The initial risk assessment and post-mitigation residual hazard map are presented in BGC's reports Cold Spring Creek Fan Debris-Flow Quantitative Risk Assessment (March 12, 2021) and Cold Spring Creek Residual Hazard Map (July 30, 2025).

¹² Modelling by BGC (March 12, 2020) without any mitigation in place suggests that 144 buildings on the Cold Spring Creek fan would be at relatively high risk of life-loss (i.e., greater than one chance in 10,000, annually) as a result of debris flows.

3.4.2 Fairmont Creek

The Fairmont Creek fan features the namesake hot spring and a significant portion of the Fairmont Hot Springs Resort (FHSR) infrastructure. It also intersects three golf courses (Creekside, Mountainside and Riverside Golf Courses) and residential homes. For the *Fairmont Creek Hazard and Risk Assessment* (BGC, July 4, 2025; interim draft), the life-loss risk for individuals and groups within buildings, as well as economic risk, was assessed. BGC's modelling suggests that small events (i.e., return periods of 10 to 30 years) debris floods will remain confined within the existing channel in the upper and middle parts of the fan, but could cause flooding of a campground and residential development near the creek mouth. For larger events (i.e., 100-to-300-year return periods), debris flows are likely to overtop several of the berms along the creek, impacting roads, Highway 93/95 and single-family residential parcels downstream of the Mountainside Golf Course. Even larger events will affect more of the fan, and produce larger flow depths, higher flow velocities and greater potential for damage.

The modelling from the *Fairmont Creek Hazard and Risk Assessment* (BGC, July 4, 2025; interim draft) suggests that 76 parcels on the Fairmont Creek fan could be impacted by hydrogeomorphic hazards. Of those, 44 parcels are associated a relatively low annual risk of life loss (i.e., less than one chance in 100,000 for a given year), and 23 parcels are associated with a relatively high risk of life loss (i.e., more than one chance in 10,000 for a given year); the remaining nine parcels are associated with intermediate risk of life loss¹³.

A risk index approach is described in the following sub-section that was used to formally define hazard zones in the Fairmont area corresponding to Very High, High, Moderate, and Low Risk of individual life loss for residents of a typical detached wood-frame building. Details of the mapping methodology are provided in the *Fairmont Creek Hazard and Risk Assessment* (BGC, July 4, 2025; interim draft). These zones are being presented and discussed because they can be incorporated into policies and bylaws for land use management in the project areas.

3.4.3 Hazard Zones

The *Cold Spring Creek Residual Hazard Map* (BGC, July 30, 2025) and the hazard map included in the *Fairmont Creek Hazard and Risk Assessment* (BGC, July 4, 2025; interim draft) show hazard zones¹⁴ defined using an annual life loss risk to an individual (referred to as the probability of death of an individual, or PDI¹⁵). Table 3-2 summarizes the proposed hazard zones for Fairmont Hot Springs. Because these hazard zone classes are based on an index that reflects the typical risk tolerance criteria used elsewhere in BC for geohazard management, they

¹³ BGC's July 4, 2025, report for Fairmont Creek is in its interim draft stage. RDEK should review its final report when it is available and update any necessary information. The mapping provided in the interim draft report is not anticipated to change.

¹⁴ The hazard zones were interpreted based on lidar topography, geomorphic interpretation, and the PDI based on the results from the various hazard scenarios that BGC modelled.

¹⁵ The PDI is calculated using a standard risk equation and numerical model results assuming each location on the fan is fully occupied with a typical detached wood-frame building (Cold Spring Creek Residual Hazard Map, BGC, July 30, 2025).

are suitable for defining areas subject to the same land use development policies, as recommended in Section 5.0 of this report.

- “Low” hazard zones are areas where both redevelopment and proposed development would generally be tolerable¹⁶ (i.e., the risk is likely to be tolerable for most kinds of development).
- “Moderate” zones are areas where proposed development may or may not fall within the tolerable risk zone, depending on the nature of the development (e.g., building type, location, and intensity of use), the potential hazard mitigation measures¹⁷ that would be applied, and the nature of the hazard. Existing development is generally tolerable within the “moderate” zone.
- “High” and “Very High” hazard zones are areas where redevelopment and proposed development would generally be subject to intolerable risk.

Table 3-2 Hazard zones for Cold Spring Creek and Fairmont Creek.

Hazard Zone	Risk Index ^{1,2} (Annual PDI)	Comparable Annual Risks of Fatality (PDI)
Very High	>1:1,000	Being 40 years old in the USA from all causes (1:500).
High	1:10,000 to 1:1,000	COVID-19 in 2020 (1:1,000); Car accident (1:10,000).
Moderate	1:100,000 to 1:10,000	Gun violence in USA (1:25,000); General anesthesia per instance (1:100,000).
Low	<1:100,000	Drowning in a bathtub (1:1,000,000).

Notes:

1. Risk level assumes a fully occupied, detached, wood-frame building and does not account for site-specific building characteristics or mitigation.
2. Risk tolerance thresholds reflect Annual PDI. However, the total risk increases every subsequent year you are exposed to the hazard (i.e., your risk of fatality from skydiving is greater when you jump twice, versus just once).

3.5 Existing Policy and Bylaws

3.5.1 Demographics

In the 1960s and 1970s, the Fairmont Hot Springs resort underwent expansion, incorporating a golf course and ski hill. This growth continued into the 1980s and 1990s, with further development of the resort and community. The 2021 census counted 781 year-round residents occupying about 50% of the total private dwellings (count 694), reflecting the significant number

¹⁶ In the “low” hazard zone, risk to development is likely to be tolerable, but would not be classified as acceptable following standard risk frameworks used in Canada (Porter & Morgenstern, 2013, Macciotta & Lefsrud, 2018). The “low” hazard areas remain hazardous and there is the potential for life loss and economic loss in them. Care should be taken to avoid unnecessary densification in all mapped hazard zones.

¹⁷ Examples of mitigation works that could be applied to reduce risk include: siting buildings in areas with low hazard; implementing flood construction levels through raising buildings on fill above ground level and/or adding raised concrete perimeter foundations; designing building structures to withstand impact loading; designing the locations of building openings (windows, doors) on sides of the structure not directly exposed to hazards; and designing a building layout so the areas most frequently occupied are on upper floors or the downstream side of the building.

of seasonal residents. In 2021, over 80% of the homes housing permanent residents were single detached houses. Fairmont Hot Springs is home to a large proportion of older adults, with individuals aged 60 years or older comprising 35% of the population.

3.5.2 Provincial Legislation and Guidance

In BC, assessment and regulation of development in areas affected by natural hazards are covered under various acts, statutes, and guidelines.

- The BC **Local Government Act** (RSBC 2015) requires that Official Community Plans (OCPs)¹⁸ contain statements and map designations respecting restrictions on the use of land that is subject to hazardous conditions (Section 473).
 - The LGA also allows for the designation of development permit areas (DPAs) for the protection of development from hazardous conditions. DPA guidelines establish the conditions for DPAs.
 - Zoning powers under the Local Government Act (s. 458) also provide a tool to specify land use and density, thereby limiting development, and can also incorporate setbacks and flood construction levels.
 - Section 524 of the Local Government Act allows local governments to designate land as a flood plain and, by bylaw, specify setbacks and flood construction levels. Section 524 also states that a local government may grant a bylaw exemption if the exemption is consistent with provincial guidelines or if a report exists that is certified by a Qualified Professional (QP), which states that the land may be used safely for the intended use.
- Section 56 of the **Community Charter** (SBC 2003), allows for a building inspector, on lands subject to hazardous conditions, to require a landowner to provide a QP report that the land may be used safely for the intended use.
- Under the **Land Title Act** (RSBC 1996), the Approving Authority¹⁹ has discretion to refuse subdivision or require a landowner to provide a QP report, and/or register a Covenant under Section 219 of the Land Title Act for lots created by the subdivision (s. 86(1)(c)(v)).
- Under the **Strata Property Act** (SBC 1998), a Bare Land Strata Plan can be refused at the discretion of the Approving Authority if the land could reasonably be subject to “flooding, erosion, land slip [landslide] or [snow] avalanche”. Such plans can potentially be approved if a QP report is provided and a Covenant under Section 219 of the Land Title Act is registered.

¹⁸ An OCP is a foundational planning document adopted by a municipality or regional district under Part 14 of the LGA that sets out the long-term vision, objectives, and policies for land use, development, and community services within a defined area. An OCP is adopted by bylaw through a council or board resolution. Once adopted, it becomes a statutory document guiding all future land use decisions. An OCP (1) establishes development policies, including those for hazard mitigation, climate resilience, and sustainability; (2) designates Development Permit Areas (DPAs) for regulating development in sensitive or hazardous zones; and (3) must be consistent with all bylaws and works undertaken by the local government.

¹⁹ In the RDEK, the approving officer is a Provincial Approving Officer, a government official appointed by the BC Ministry of Transportation and Transit for approving land subdivisions in areas outside municipal boundaries.

- Under the **Emergency and Disaster Management Act** EDMA (SBC 2023), the Province of BC has established a risk-based, all-hazards framework for emergency management across five phases: mitigation, preparedness, response, recovery, and continuous improvement. Detailed local-authority regulation is still pending under the Act but is expected to include requirements related to preparing risk assessments, emergency management plans, and business continuity plans.
- Development within a riparian area, or the construction of flood protection works within a riparian area, may require approvals under the:
 - BC Riparian Areas Protection Act (SBC 1997; provincial)
 - BC Water Sustainability Act (SBC 2014; provincial)
 - Fisheries Act (RSC 1985; federal)
 - BC Environmental Assessment Act (SBC 2018; provincial)
 - Canadian Environmental Assessment Act (2012; federal)
 - Canadian Navigable Waters Act (RSC 1958; federal).
- Local Governments must also consider applicable provincial standards and guidelines when developing bylaws and regulations. Those applicable to developing floodplain management include the BC **Flood Hazard Area Land Use Management Guidelines** (2004), and the **2018 Amendment Sections 3.5 and 3.6**. The guidelines state that development should be discouraged in areas where there may be a debris flow hazard. That consent to develop should only be granted if there is no other land available and an assessment by a QP indicates that the development may occur “safely”.

Measures or thresholds to define “safe” are not explicitly defined unless local jurisdictions have established risk tolerance criteria. QP’s carrying out assessments hold responsibilities under the **Professional Governance Act** (SBC 2018) and consider professional practice guidelines published by Engineers and Geoscientists BC (EGBC), as well as those of provincial or federal agencies²⁰.

3.5.3 Legislated Flood Assessments

Many of the acts and guidelines refer to a report certified by a QP that states the land is safe for the intended use. In the context of the hydrogeomorphic hazards associated with Cold Spring and Fairmont Creeks, these reports would be classified as Legislated Flood Assessment Reports, and governed by EGBC guidelines (2018), which state:

²⁰ Examples of relevant professional practice guidelines include the EGBC Professional Practice Guidelines for Legislated Flood Assessments in a Changing Climate (2018) and the EGBC Professional Practice Guidelines for Landslide Assessments in BC (2023). Flood Assessments in a Changing Climate (EGBC, 2018) and Guidelines for Landslide Assessments in BC (EGBC, 2023).

Flood Assessment Reports

“Conditions noted in the Flood Assessment Report that are necessary to render the land safe for the intended use are incorporated in a Covenant registered under Section 219 of the Land Title Act. Usually, the Flood Assessment Report itself is registered in the Covenant, making the document publicly available.” (EGBC, 2018, p. 92)

A Flood Assessment Report identifies the flood processes that could affect the property, identifies the elements at risk (both existing and future), and estimates the characteristics of the potential flood processes that could cause damage. In particular, the report must determine which of the hydrogeomorphic hazards (i.e., flood, debris flood, or debris flow) are likely to affect the property. The level of effort that is appropriate for a flood assessment depends largely on the size of the proposed development and the complexity/severity of the flood hazard (in particular, the risk of life loss). Table 3-3 describes the range of report types based on the development being assessed and the potential hazard. The three kinds of Flood Assessment Report (or in combination) are:

- **Flood Hazard Assessment**, focused on the physical aspects of flooding and their probability.
- **Flood Risk Assessment**, focused on potential impacts and consequences of flooding on human and built environments; requires local government to have an adopted formal risk tolerance criteria.
- **Flood Mitigation Assessment**, focused on developing and evaluating potential solutions to reduce or manage flood impacts.

Table 3-3 Typical flood hazard assessments for debris floods and debris flows.

Class	Development Type	Methods and Considerations	Typical Deliverables	Use Case
0	Renovations; expansions; new single house; new duplex house	• Site visit, qualitative assessment, no modelling • Identify very low hazard surfaces (inactive surfaces) • Consider watershed changes.	Letter report, memo with water levels, flow velocities	Loss of life very unlikely
1	Small subdivisions (3 to 10 single-family lots)	• All of the Class 0 methods • Qualitative description of process; preliminary estimates of process frequency & magnitude; mapping of hazard zones from field evidence.	Maps showing hazard zones; report with water levels, flow velocities	Possible loss of life, even for single homes; scoping-level studies for urban developments
2	Medium subdivisions (10 to 100 single-family lots)	• All of the Class 1 methods • Quantitative failure mode assessment, frequency & magnitude assessment, runout modelling, inundation mapping • Consideration of potential effects of climate change.	Maps with area inundated for design event, delineation of areas prone to bank erosion, and bed aggradation	Pre-feasibility studies for urban developments
3	Large subdivisions (>100 single-family lots)	• All of the Class 1 methods • Quantitative failure mode assessment, detailed frequency & magnitude assessment using absolute dating methods, breach and runout modelling for design events • Consideration of potential effects of climate change.	Frequency & magnitude graphs, mapping of inundation area, delineation of areas prone to bank erosion and bed aggradation	Feasibility studies for urban developments
4	Very Large subdivisions (new towns & townships)	• All of the Class 1 methods • Probabilistic failure mode assessment, geotechnical analysis of failure mechanisms, detailed frequency & magnitude assessment using all relevant dating methods, formulation of credible Hazard Scenarios, breach modelling and runout modelling • Consideration of potential effects of climate change.	Same as Class 3 with detailed reporting of geotechnical analyses, breach outflow hydrographs, model assumptions, hazard intensity maps for different scenarios and return periods	Input for quantitative risk assessment; pre-design studies for large urban developments; design-level studies for high-value industrial assets

Note: Adapted from Table D-2, p. 107, EGBC (2018). See the original table in EGBC (2018) for additional details and description.

3.5.4 Existing Relevant Policy and Regulation

RDEK Bylaw No. 2779²¹ is the Fairmont Hot Springs and Columbia Lake Area Official Community Plan. The goals of the OCP include encouraging the continued development of a high-quality, self-sufficient year-round resort community at Fairmont Hot Springs, while recognizing the risks of natural hazards such as flooding and debris flows, and the need to promote public safety through risk management to protect life and property.

The objectives for development in natural hazard areas include:

- Ensure public safety by discouraging development in unsuitable areas such as floodplains and areas subject to geotechnical hazards²² such as slope, erosion and landslip.
- Prevent or minimize the expenditure of public money in damage compensation or mitigation resulting from the development of lands subject to hazardous events or situations.
- Encourage engineering and construction of public infrastructure, such as roads, bridges, and drainage works, to be more resilient to increasingly frequent severe climatic events, such as flooding.
- Schedule I to the OCP identifies both flood hazard areas and alluvial fan hazard spatially. The alluvial fan mapping is outdated and superseded by more recent geohazard mapping work.

The Upper Columbia Valley Flood Management Bylaw No. 1034 (RDEK, 1993) applies in Electoral Area F and identifies flood construction levels and setbacks from watercourses that would apply to both Cold Spring Creek and Fairmont Creek.

The Zoning Bylaw No. 3255 (RDEK, 2023), dictates use and density across the Fairmont Hot Springs area, and the Fairmont Flood and Landslide Service Establishment Bylaw No. 1208 (RDEK, 1996), establishes a local service area to provide for the development of flood and debris flow hazard mitigation works.

Table 3-4 summarizes existing regulations and policies associated with development in natural hazard areas in Fairmont Hot Springs.

²¹ RDEK Fairmont Hot Springs & Columbia Lake Area Official Community Plan Bylaw No. 2779, 2017:
https://www.rdek.bc.ca/bylaws/ocp_zoning_landuse/ocp/fairmontocp

²² All hazard zones mapped for Cold Spring Creek and Fairmont Creek are remain subject to so level of geohazard, and care should be taken to ensure that classification as a low or moderate hazard does not incentivize densification of these hazard areas.

Table 3-4 Existing bylaws and policies for development in natural hazard areas in Fairmont Hot Springs.

Tool	Content	Comments
OCP Bylaw 2779	Development constraints for hazardous areas include: • The Upper Columbia Valley Floodplain Management Bylaw. • Terrain hazard assessments completed by Qualified Professionals (QP) for land development, excavation or infrastructure construction in the hazard areas identified on Schedule I. • Consideration of transfer or risk to downstream properties in hazard assessments. • Rezoning applications in hazard areas require hazard assessments with hazard mitigation measures and covenants. • OCP amendments and zoning amendments must show how the project can sufficiently mitigate any hazardous site conditions. • In hazard areas, applications to vary the minimum usable site area requirements in the zoning bylaw are generally not supported. • Buffers from hazardous areas are recommended for subdivision.	• Reliance on QP reporting. • Development variance permits should not vary flood regulations. • The floodplain management bylaw does not specifically address hydrogeomorphic hazards on Fairmont and Cold Spring Creeks.
OCP Bylaw 2779 – Schedule I: Flood Hazard	• Spatially identifies high-hazard areas. The alluvial fan areas of both Fairmont Creek and Cold Spring Creek are included in this designation.	• These mapped areas are out of date and are superseded by the work BGC has completed recently (July 4, 2025, interim draft; July 30, 2025).
Zoning Bylaw No. 3255, 2023	• Includes a range of uses and densities in the Fairmont Creek and Cold Spring Creek debris flow fan areas, ranging from parks and open space to resort employee housing and from single-family residential to medium-density zones.	• Exposing more people and infrastructure to the hazard increases risk. Residential uses may not be compatible with areas of higher hazard.
Fairmont Flood and Landslide Service Establishment Bylaw No. 1208, 1996	• Establishes a local service area to provide flood and debris flow control. Service taxes on property owners within the service area are collected to pay for flood and debris flow hazard mitigation.	• Residents have contributed to the mitigation measures. However, they may not understand that residual risk still needs to be managed through non-structural measures, such as land-use policy, awareness, and planning for event response.

Tool	Content	Comments
Upper Columbia Valley Flood Management Bylaw No. 1034, 1993	Fairmont Creek and Cold Spring Creek both qualify as “other watercourses” in the bylaw and have an associated flood construction level of 1.5 m and a setback of 15 m from the ordinary high-water mark (visible high-water mark).	- The bylaw focuses on clearwater flooding and not debris flow/flood. - The exemptions in the bylaw inform whether a QP report is required for development adjacent to both creeks.
Emergency Management Planning	- RDEK is currently working on a regional Hazard, Risk and Vulnerability Analysis (HRVA) with local communities and First Nations. Debris flow/flood should be included in the HRVA. - Event response planning and building public awareness around preparedness help reduce vulnerability to potential hazard events.	The Shuswap Band and the ?Akisq̓nuk First Nations are partners in emergency management.

3.5.5 Current Hazard Management Approach

Staff at RDEK are currently using the 2020 pre-mitigation debris flow hazard map from the *Cold Spring Creek Hazard Assessment* (BGC, September 25, 2020) to determine the requirement for a hazard assessment by a QP at the building permit application. An application in the high and medium hazard zones of the map requires a hazard assessment by a QP. Applications in the very low hazard zone do not.

Exemptions for hazard assessments are currently applied in accordance with the Upper Columbia Valley Flood Management Bylaw No. 1034 (RDEK, 1993). For example, an application for a renovation to an existing building or structure that does not involve an addition may not require a hazard assessment²³. Additions that would increase the size of the building by less than 25% of the floor area, with no added nonconformity to the setback, may also not require an assessment. Section 56 of the Community Charter gives a Building Inspector the authority, at their discretion, to request a report from a Qualified Professional certifying that the land is safe for the intended use, if the parcel of interest is located in a known hazard area.

On both Cold Spring and Fairmont Creeks, the Upper Columbia Valley Flood Management Bylaw No. 1034 (RDEK, 1993) is currently being applied.

The mitigation measures commonly recommended in required QP reports include building to flood construction elevations, restricting the removal of trees and brush along the streamside of the property and foundation protections. Building department staff ensures adherence to the recommendations outlined in the hazard assessment reports. Covenants are registered on title at the recommendation of the Qualified Professional and are common. Based on BGC's engagement with RDEK, BGC understands that the cost of retaining a QP or fulfilling their recommendations is not always clear to proponents, and that referencing previous reports helps RDEK staff engage early with proponents about these issues.

²³ Under the Section 56 of the Community Charter, a request for an assessment report is at the discretion of the Building Inspector.

4.0 POLICY AND BYLAW CONSIDERATIONS

By the request of the RDEK Staff, BGC provided a memorandum to the RDEK Board on January 16, 2025 (Appendix B) that highlights different approaches to land use in natural hazard areas. On February 13, 2025, BGC and Pinna presented to the Board, and on February 14, 2025, the RDEK Board resolved to direct the development of policy options utilizing a **combined hazard and risk-focused approach** (Resolution 52133; Appendix C).

The objective of this section is to provide the basis for the decision made by the RDEK Board and to relate hazards and risks to different policies and bylaw tools used by various jurisdictions for managing geohazards similar to those affecting the Fairmont Hot Springs area. The three frameworks that were presented to the RDEK Board are:

- Hazard Threshold Framework
- Risk Threshold Framework
- Combined Hazard-Risk Framework

In the context of the frameworks listed above, policy and bylaws are defined as:

- **Policy** refers to guiding principles or strategic directions adopted by governments or organizations. Policies are not enforceable on their own but inform the creation of bylaws and other regulatory tools²⁴.
- **Bylaws** are legal instruments enacted by local governments under provincial legislation such as the LGA or the Community Charter. They are enforceable and binding, and typically regulate specific aspects of land use, construction, and hazard mitigation.²⁵

4.1 Hazard Threshold Framework

This section provides background on hazard management approaches that address risk by considering the probability of a hazard occurring and using prescriptive rules to govern development in areas where the hazard probability exceeds an established threshold value. In this context, the consequence of the hazard is not explicitly addressed. Detailed jurisdictional examples are provided in Appendix D.

The hazard threshold framework relates land use decisions to the probability of the hazard occurring or to the encounter probability. Engineering standards are an example of this approach, as they often employ a threshold hazard probability for design²⁶. The framework does

²⁴ Examples include: OCPs that outline long-term planning goals and hazard mitigation strategies; and Risk Management Policies that shape how hazards like floods, debris floods or debris flows are assessed and mitigated (these may include thresholds, technical guidelines, and community engagement strategies).

²⁵ Examples include: Zoning Bylaws that define permitted land uses, building density, setbacks, and restrictions in hazard-prone areas; Floodplain Management Bylaws that specify development restrictions and construction levels in flood-prone zones; Building Bylaws that govern construction standards and may require hazard assessments by QPs; and Bylaws that regulate development in hazard zones, often tied to OCPs.

²⁶ For example, in BC, clearwater flooding is typically managed by identifying the inundation extent of the 200-year flood and restricting development within the inundated area, as enacted through local bylaws (for example, the Upper Columbia Valley Floodplain Management Bylaw No. 1034, 1993, which applies to the Fairmont Hot Springs project area). This is an example of a hazard threshold framework for land use policy, as it considers only the extent of the hazard, not its consequences.

not explicitly consider the other components of risk (i.e., exposure and vulnerability, Figure 3-1), though risk can be implicitly incorporated by selecting different thresholds for different geohazards²⁷. A hazard threshold framework has also been used to develop land use policy in relation to landslides in BC²⁸. One major drawback to hazard threshold frameworks is that they cannot account for site-specific mitigation efforts that would reduce risk. For a detailed comparison of the advantages and disadvantages of each framework, see Appendix D.

4.2 Risk Threshold Framework

This section provides background on hazard management approaches that utilize risk tolerance criteria to determine safe development in hazard-prone areas. Detailed jurisdictional examples are provided in Appendix D.

The risk threshold framework relates land use decisions to risk tolerance criteria defined by the governing jurisdiction. Under this framework, hazard, exposure, and vulnerability are all explicitly evaluated to estimate the risk for development. Both individual and group risk can be considered using this framework²⁹, depending on the anticipated size of the hazard events and the likely number of fatalities associated with them.

There is no legislated guidance on risk tolerance to geohazards in BC, and the term “safe” has not been generally defined for application in natural hazard planning. In the absence of formally defined criteria, some local governments in BC³⁰ have adopted formal risk tolerance criteria to guide QPs when assessing whether a proposed development is safe for its intended use.

These risk tolerance criteria have typically been adapted from established frameworks (e.g., Porter & Morgenstern, 2013; Strouth & McDougall, 2022; Strouth, 2024) to reflect local community values and priorities. These frameworks provide a consistent basis for evaluating development applications and determining whether proposed developments (including land use,

²⁷ An example of this would be using a 1 in 200-year return period for clearwater flood hazard mapping, a 1 in 500-year return period for debris flood mapping, and a 1 in 1,000-year return period for debris flow mapping.

²⁸ In 1972, near Rubble Creek (north of Squamish), a proposed 126-lot subdivision application was rejected by the Province of British Columbia because a large landslide could potentially impact it. The developer appealed the decision to the BC Supreme Court. After hearing testimony from expert engineers and geologists, Justice Thomas Berger upheld the Province’s decision because there was a sufficient likelihood of a catastrophic landslide occurring and affecting the community (Berger, 1973). In his ruling, Justice Berger described “catastrophic” as a very large landslide that could potentially affect more than 100 residences and result in the loss of many lives. He described “sufficient likelihood” as an annual probability of occurrence of 1 in 10,000 (VanDine, 2018). This ruling, one of the first landslide hazard-based decisions in Canada, has been cited in numerous subsequent land-use decisions. In summary, the precedent policy established by the Berger decision is to reject large new developments in areas with a 1 in 10,000 (or greater) annual probability of being impacted by a catastrophic landslide. Because the ruling did not explicitly consider the consequence of the landslide for the potential subdivision, it cannot be interpreted as a risk-based threshold policy. BGC interprets this 1 in 10,000 annual probability to be a statement about the potential for the hazard to occur (i.e., it is an encounter probability).

²⁹ In general, individual risk helps protect the most exposed person, while group risk ensures that community-scale impacts are considered. Individual risk is most useful when assessing risk at a specific location, such as a residence or workplace, and is independent of the number of people present. Group risk evaluates the number of people who could be killed in a single event. It is essential for land-use planning (particularly for schools, subdivisions, or public infrastructure) and emergency preparedness. Group risk is especially valuable for prioritizing mitigation when multiple lives are at stake, such as in schools or densely populated residential zones.

³⁰ Including Cowichan Valley Regional District, District of Squamish, and District of North Vancouver (Appendix D)

building, infrastructure, and service provision) meet safety expectations. They also potentially support risk evaluation for existing structural risk control measures or setting risk-reduction targets for future measures (e.g., flood or steep creek debris retention or diversion structures).

4.3 Combined Hazard-Risk Framework

In the combined framework, hazard mapping can be used to define different hazard zones applicable to any proposed or existing development within the zone. Policies specific to those zones can then be used to determine whether further risk assessment is needed for development approval.

Several municipalities, including the Town of Canmore and the District of Squamish, have taken a combined hazard and risk approach and the details are included in Appendix D. In these frameworks, when a risk assessment is triggered, approval decisions are made with reference to risk tolerance criteria established by the community.

Hazard-based maps have an advantage over risk-based maps as a trigger to require actions because they can apply to any development within a hazard zone. They do not need to be updated when existing structures are modified in a way that alters their vulnerability, or when new development occurs that alters the exposure for a given hazard.

Risk-based assessments for existing and/or proposed development have an advantage over hazard-based assessments to determine if required actions will lead to development that is 'safe for the use intended'. They can take into account factors specific to the development and provide a way for proponents to communicate how risk will be controlled that can be checked by decision makers as part of the permitting process.

The approach that seems most appropriate for the Fairmont Hot Springs project area combines both hazard and risk approaches.

4.4 Tools Implemented in BC and Alberta

This section summarizes policy and bylaw tools used by various BC communities prone to steep creek hazards, most often including OCPs (enacted by an OCP Bylaw), DPAs (also enacted as part of the OCP Bylaw), floodplain management bylaws, and QP hazard assessments to protect people and property from steep creek hazards. Table 4-1 includes various jurisdictions in BC and Alberta, their adopted frameworks, key policies and bylaws, and examples of their applications.

Table 4-1 The applied frameworks by BC and Alberta jurisdictions and their implemented tools.

Location	Applied Framework	Key Policies & Bylaw	Specific Examples
Fraser Valley Regional District (FVRD)	Hazard Threshold	• OCP hazard maps & DPA for known fans; identifies the need for further study and construction of mitigation works underway. • Floodplain Bylaw 1669, 2002 includes a section on alluvial fans applying to all those mapped in the schedule and those that have not yet been identified. All development on alluvial fans must meet FCL and setbacks determined by a site-specific geohazard assessment by a QP while taking the floodplain bylaw regulations into account. • Community-specific Hazard Acceptability Thresholds. • A standardized Geohazard Assurance Statement for geotechnical professionals to sign off on for development approvals.	Hazard Acceptability Thresholds for Development Approvals: The FVRD has had acceptability thresholds in place since 1993, outlining the type of hazard, the type of development, and the possible remedial or protective measures required for each type of application. As the probability of the hazard and the significance of the development application increase, the development approval requirements increase. A Geohazard Assurance Statement helps staff standardize QP reporting and provide greater assurance.
Regional District of Central Kootenays (RDCK)	Hazard Threshold	• Floodplain Management Bylaw calls out non-standard flood and erosion areas (NSFEA) where supplementary measures are needed over and above the regulations in the bylaw. For some NSFEA, complete hazard assessments by QPs are required. • Municipalities within the region utilize a combination of tools to address clearwater and debris flow hazards, including DPA Bylaws that reference NSFEAs, Floodplain Bylaws, and Zoning Bylaws.	RDCK is currently reviewing and updating its floodplain management bylaw following an updated detailed study of alluvial fans in the region. The District is also working to develop a risk tolerance policy.
City of Kelowna	Hazard Threshold	• Hazardous Condition Areas DPA Bylaws. • Floodplain Bylaw No. 10515 sets creek-specific FCLs. • Mitigation measures such as debris basins built on major creeks.	Development shall be directed away from hazard zones; QP must demonstrate risk mitigation through recommendations.

Location	Applied Framework	Key Policies & Bylaw	Specific Examples
City of Coquitlam	Hazard Threshold	- Hazardous Lands DPA Bylaw; 15–30 m floodplain setbacks; no permit without QP; covenants required. - General section (s.519) in the Zoning Bylaw includes “Flood protection and slope control measures”.	Coquitlam offers a range of public-facing information for residents on “Living Near Steep Slopes,” which outlines the applicable policies, bulletins, and other relevant resources. While related to slope failure and landslide and not debris flow, the public information is comprehensive, linking policies together.
Cowichan Valley Regional District (CVRD)	Risk Threshold	- OCP Bylaw includes a Natural Hazard Area DPA with no development unless a QP demonstrates that it is safe for the intended use. - Floodplain Bylaw No. 1977 with 30 m setback. - Hazard Risk Tolerance Policy.	Hazard Risk Tolerance Policy: minor (renovations) and major (other applications). Minor – probability of death of an individual (PDI) not to exceed 1:10,000 per year, and group risk to plot in the ALARP zone. Major – PDI not to exceed 1:100,000 per year and reduced to as low as reasonably practicable. Group risk to fall within the ALARP or acceptable zones.
District of North Vancouver (DNV)	Risk Threshold	- Creek hazard DPA Bylaws minimize development in high debris flow/flood areas. FCLs are identified by a QP, who is to reference debris flow studies by DNV. DPA Bylaw guidelines include vegetation management, no increased hazard to neighbours, etc. Risk must be reduced to an “acceptable level” - Risk Tolerance Criteria.	Risk Tolerance Criteria were developed in 2009 by the District with a community task force. For a building permit with < 25% increase in gross floor area, 1:10,000 PDI/year + as low as reasonably practicable. For all other application types, it is 1:100,000 PDI/year.

Location	Applied Framework	Key Policies & Bylaw	Specific Examples
Columbia Shuswap Regional District (CSRD)	Risk Threshold	• OCP hazard mapping for active fans. • Steep Slope & Natural Hazard DPA Bylaws based on a Geohazard Risk Prioritization study. Guidelines require a QP study to determine site-specific recommendations. • Reports to be accompanied by a CSRD Geohazard Assurance Statement Form and meet EGBC Landslide Assessment Guidelines. • Floodplain Bylaw and floodplain designations in the Zoning Bylaw. Application Guide for Floodplain Exemptions. • The Building Permit Geohazard Information Policy (P-26) refers to categories from BGC hazard ratings, along with specific requirements.	Electoral Area E OCP DPA for Geohazard: An overview study identifies the boundaries of the DPA Bylaw area and provides direction on where more detailed studies are needed. The board may refuse to issue a DP where hazard frequency, as determined by a QP, exceeds the acceptability threshold for the proposed development, as determined by CSRD policy as it is developed and exists at the time.
Village of Zeballos	Risk Threshold	• Steep Creek Hazard DPA Bylaw in OCP.	New construction requires a QP report demonstrating that debris flow risk can be mitigated to the EGBC standard.
The Village of Lions Bay	Risk Threshold	• Village-wide Steep Creek & Slope Hazard DPA Bylaw. • Community evacuation signage mapped. • Sets Natural hazard Assessment Areas under section 473 (1) (d) of the Local Government Act.	DPA information includes risk tolerance criteria, where new development or subdivision/rezoning creating four or fewer parcels has a risk tolerance threshold of 1:10,000 PDI/yr + ALARP, and subdivision and rezoning creating five or more parcels must meet a threshold of 1:100,000 PDI/year. At a minimum, house foundations should be designed to withstand debris flood impacts.
District of Squamish	Combined Hazard-Risk Threshold	• OCP includes risk tolerance criteria and policies. • Natural Hazard Area DPA enacted as part of the OCP Bylaw. • Floodplain Management Bylaw. • Terms of reference for Natural Hazard and/or Risk Assessment.	New development must demonstrate safety through the QP report and mitigation. Risk tolerance criteria must be met at 1:10,000 PDI/year.

Location	Applied Framework	Key Policies & Bylaw	Specific Examples
Town of Canmore	Combined Hazard-Risk Threshold	• MDP includes risk tolerance thresholds for both individual risk and group risk. • Land Use Bylaw (LUB) includes hazard zones and maps.	The MDP includes risk tolerance for new and existing developments: • New Development • Individual Risk (PDI) $\leq 1:100,000$ • Group Risk (PDI) $\leq 1:100,000$ (100 fatalities for an event) • Existing Development • Individual Risk (PDI) $\leq 1:10,000$ • Group Risk to be reduced as much as possible to the societal risk evaluation reference line, balanced with cost-benefit.

5.0 RECOMMENDATIONS

5.1 Interim Recommendations

The following section includes recommendations on integrating the steep creek hazard and risk assessments into the development interim policy³¹. Table 5-1 has been included for reference in the following recommendations. The recommendations provided in this section are provided from the perspective of planning and hazard risk management and should be considered subject to legal review.

Table 5-1 Hazard zones for Cold Spring Creek and Fairmont Creek.

Hazard Zone	Risk Index ^{1,2} (Annual PDI)	Zone-Specific Development Policy
Very High	>1:1,000	See Recommendation 4(c)
High	1:10,000 to 1:1,000	
Moderate	1:100,000 to 1:10,000	See Recommendation 4(b)
Low	<1:100,000	See Recommendation 4(a)

Notes:

1. Risk level assumes a fully occupied, detached, wood-frame building and does not account for site-specific building characteristics or mitigation.
2. Risk tolerance thresholds reflect Annual PDI. However, the total risk increases every subsequent year you are exposed to the hazard (i.e., your risk of fatality from skydiving is greater when you jump twice, versus just once).

BGC and Pinna recommend that RDEK undertake the following changes:

Recommendation 1: OCP Amendments

OCP Amendments should be made to the Fairmont Hot Springs and Columbia Lake Area Official Community Plan (Bylaw 2779):

- a. Hazard mapping (Schedule I) should be updated with the BGC mapping for both creeks:
- b. Cold Spring Creek Residual Hazard Map (BGC, July 30, 2025).
- c. Fairmont Creek Hazard & Risk Assessment (once the final report is available; interim draft issued by BGC on July 4, 2025).
- d. The hazard zones and related development approval policy should be added to the OCP section on natural hazards. For example, the approval policy related to Low, Moderate, High, and Very High zones is recommended below in Recommendation 4.
- e. Formal risk tolerance criteria should be included for the Fairmont Hot Springs area. This policy can be presented as a standalone policy (as per Cowichan Valley Regional District) or referenced in the OCP (District of Squamish, Town of Canmore) and/or in the DPA guidelines (District of Squamish and District of North Vancouver).
- f. The OCP should be amended to add a development permit area (DPA) for debris flow hazard that includes both creeks, or one for each creek, as RDEK prefers. DPA(s) should apply to the extent of the fans (i.e., all hazard zones) as mapped in the reports

³¹Interim policy in this report refers to the level of study conducted to provide the recommendations. Further studies to consider are included in Section 5.2.

Cold Spring Creek Residual Hazard Map (BGC, July 30, 2025) and *Fairmont Creek Hazard and Risk Assessment* (once the final report is available; interim draft issued by BGC on July 4, 2025).

Recommendation 2: Risk Tolerance Policy

A policy outlining the formal risk tolerance criteria for development in the Cold Spring Creek and Fairmont Creek DPAs should be developed. BGC and Pinna recommend that the RDEK adopt risk tolerance criteria that use a combined hazard-risk framework similar to that described in Section 4.3 and endorsed by the RDEK Board on February 14, 2025. The risk tolerance policy should be integrated into the OCP.

Recommendation 3: DPAs and Guidelines

DPAs and guidelines should be created with the following principles in mind:

- Allow development that does not increase risk (e.g. additions to existing buildings, renovations, decks, and minor landscaping).
- Avoid using structural mitigation at the community level to encourage unnecessary densification in hazard areas.

DPA should be created for each of the creeks:

a. Cold Spring Creek:

- i. Based on the 2025 post-mitigation hazard mapping, including areas protected by the debris barrier ('residual hazard areas'), within which development will require a development permit.
- ii. Guidelines should reference risk tolerance criteria and development approval policies.
- iii. Guidelines should also dictate that any construction, reconstruction, landscaping or site grading will conform to the best practices for design and construction in steep creek hazard areas (as described in Canmore's Engineering Design and Construction Guidelines (February 28, 2025), for example).

b. Fairmont Creek

- i. Based on the 2025 updated hazard assessment mapping, within which development will require a development permit.
- ii. Guidelines should reference risk tolerance criteria and development approval policies.
- iii. Guidelines should also dictate that any construction, reconstruction, landscaping or site grading will conform to the best practices for design and construction in steep creek hazard areas (as described in Canmore's Engineering Design and Construction Guidelines (February 28, 2025), for example).

Intention of the DPA

BGC and Pinna recommend that the development policies in the OCP conform with the general principle that development which does not increase risk should be allowed, including additions to existing buildings, repairs or renovations to an existing building, construction of additional stories above existing building (so long as it does not increase intensity of use), construction, repair, replacement of a deck, landscaping that does not alter site grades or increase hazard to other properties or buildings. BGC & Pinna also recommend that structural mitigations should not be used to promote unnecessary development and densification in a hazard area.

Recommendation 4: Development Policies by Hazard Zone

Development policies by different hazard zones should be implemented and applied to both Cold Spring Creek and Fairmont Creek.

a. Low Hazard Zone:

A policy for development in the “Low” hazard zones should be included in the OCP that outlines when RDEK will expect a steep creek risk assessment for both existing and new developments. BGC and Pinna recommend that RDEK not typically require a steep creek risk assessment in the “Low” hazard zone, but that it should explicitly reserve the right to require one for development under specified conditions related to the nature, size and socio-economic significance of the proposed development. RDEK should also seek legal review regarding limits of liability where steep creek risk assessments are not required, such as through the use of a save harmless covenant on title.

b. Moderate Hazard Zone:

A policy for development in the “Moderate” hazard should be developed for both existing and new developments. BGC and Pinna recommend that steep creek risk assessments be conducted for all development in “Moderate” hazard zones (as per EGBC, 2018), and that development approvals may be granted subject to hazard mitigation measures, including avoidance, resistance, and resilience measures, determined on a site-specific basis as part of the assessment, following the risk tolerance criteria policy for the DPAs. Any additions or renovations within the Moderate hazard zone should be subject to a site-specific risk assessment, depending on whether the proposed work materially increases risk. RDEK should establish clear criteria or thresholds to define the increase limit.

c. High & Very High Hazard Zones:

A policy for development in the “High” and “Very High” hazard zones should be developed for both existing and new developments. BGC and Pinna recommend that only a restricted set of land uses be permitted in these zones. For example, permitted uses could include:

- Non-habitable accessory buildings (non-dwelling unit)
- Agricultural uses

- Outdoor athletic and/or recreational facilities
 - Certain classes of home occupations (e.g., incidental and subordinate to the principal residential use)
 - Open space
 - Public utilities
 - Wildlife corridors
 - Wildlife habitat patches.
 - A review of land use designations and zoning in High- and Very-High-hazard zones is warranted to consider aligning them with recommended low-intensity uses. Generally, development in these areas should be limited without appropriate mitigation at community and site-specific levels.
- d. *Existing Non-Conforming Building in Medium to Very High Zones:*
A policy governing existing buildings in the DPAs that do not conform to the policies for the hazard zones should be developed. As per the BC Flood Hazard Area Land Use Management Guidelines (2004), where buildings are legally non-conforming with floodproofing requirements, it is acceptable to allow an addition, at the original non-conforming floor elevation, that would increase the size of the building or structure by less than 25% of the floor area existing at the time of the enactment of the new DPA, provided the degree of nonconformity regarding the setback is not increased.

5.2 Future Work

BGC recommends that RDEK pursue the following additional activities that align with project objectives:

1. Develop **guidelines for QPs** conducting hazard assessments (floods and steep creeks), which may include available resources (i.e., compilation of previous studies and maps) and a checklist of required submittals.
2. Define and develop **guidelines for development proposals for existing and new developments** in each hazard zone (i.e., thresholds for acceptable development based on floor area or building value for renovations and requirements for steep creek risk assessment).
3. Develop similar guidelines to Canmore's **Engineering Design and Construction Guidelines**. The objectives of these guidelines are:
 - To provide direction and guidance to support resilient development in hazard areas where development is permissible.
 - To guide small-scale on-site mitigation up to established thresholds.
 - To provide applicable measures for on-site mitigation, such as those listed in Appendix E.
 - To guide existing developments in identified hazard zones to reduce vulnerability.

4. Develop **policy tools for managing non-conforming buildings** in High and Very High hazard zones (i.e., buyout)³².
5. Continuation of the hazard early warning system.
6. Continuation of **public education** about the changes and importance of managing residual risk through non-structural measures.
7. Expanding the application of the policy approach to include other areas of the RDEK.

³² In April 2025, Canada updated the Disaster Financial Assistance Arrangement (DFAA) guidelines to limit disaster aid for assets in high-risk areas unless mitigation was in place beforehand. Assets built before April 1, 2025, are initially covered but will not be eligible after major damage without protection. High flood risk is set at the 1-in-200-year level (0.5% annual chance), and pluvial flood risk will be included in 2030.

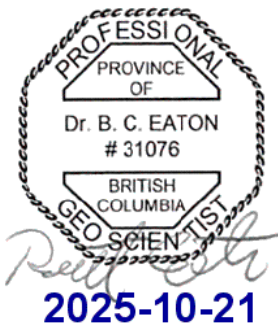
6.0 CLOSURE

This report contains sections under the supervision of different individuals as per Table 1-1.

We trust the above satisfies your requirements. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC Engineering Inc.
per:



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BE/KH/sf/th

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APPENDIX A

EDUCATIONAL MATERIAL



DEBRIS FLOODS

Floods that move large amounts of soil, rocks, and trees

Debris floods can be triggered by heavy rain, rain-on-snow events, and upstream hazards (debris flows, dam breaches)

Debris floods are more likely to occur after periods of prolonged rain or snowmelt, or in years following forest fires

Houses near mountain creeks are at greatest risk

Debris floods can occur over a long period of time (days) and can have several surges (pulses)

Debris floods can burst their banks and flood houses far from the channel

Debris floods can erode banks and undermine building foundations

Debris floods can sweep away or bury cars

Debris floods can destroy roads and bridges



PROTECT YOURSELF FROM DEBRIS FLOODS

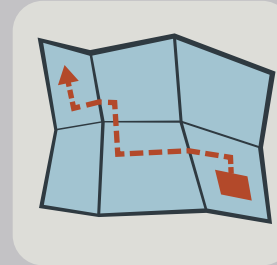
BEFORE

Stay informed



Keep updated with weather advisories, such as heavy rainfall warnings. Consult your local hazard map to learn where the flood hazard zones are located.

Prepare and plan



Prepare an emergency kit for your home, vehicle, and workplace. Know your local flood evacuation routes and emergency shelter locations.

Know the signs



Look/listen for an abrupt increase or decrease in water flow, unusually muddy water, and the sound of cracking trees and rolling boulders.

Protect your property



Store valuables in high places or water-tight containers. Consider flood-proofing measures, such as elevating the first floor, flood walls, erosion protection, sump pumps, etc.

DURING

DECISION: Evacuate



If it is safe to do so, take the flood evacuation route or go to higher ground. If you are able, shut off your gas/electricity and help others evacuate.

DECISION: Shelter



If you are unable or it is unsafe to evacuate, seek shelter on high ground. Avoid basements.

Build sandbag dikes



Sandbag dikes can prevent or lessen damage from overland flooding. Do not attempt to build if you are required to evacuate.

DO NOT go near the bank



Debris floods can quickly erode and undermine banks. If you are near the bank, you put yourself at risk of falling in and being swept away.

DO NOT cross bridges



Debris floods can erode bridge piers and cause bridges to collapse. Bridges affected by debris flooding must be avoided.

DO NOT cross flood waters



Moving water as little as 30 cm deep can quickly sweep you away. Do not attempt to drive or walk through water or debris.

AFTER

Obey road closures



Do not enter areas that are closed-off. There may be emergency repair efforts underway or flooded areas unsafe to the public.

Return only when safe



Do not return home until authorities say it is safe and they have cleared your home of structural, electrical, or other hazards.

Help each other



Floods are stressful and traumatic events. Offer and accept help if you are able. Communities are more resilient when they work together.

Clean up



If your home was flooded, dispose of mouldy items, open doors and windows, and scrub all washable surfaces with a household bleach solution.

NOTES

BGC Engineering Inc. (BGC) prepared this infographic with artwork by Sophia Zubrycky. This infographic depicts some measures that may help to lower but not eliminate certain kinds of risk associated with debris floods. Simply following the measures shown in this infographic does not make it safe to occupy areas at risk of debris floods. Even if the measures shown in this infographic are taken, debris floods may still cause serious personal injury (including death) or property damage. BGC provides no guarantee or warranty of any kind related to the information in this infographic. Persons and entities using or relying on this infographic do so at their own risk. BGC will not be responsible or liable for any loss or damage including any personal injury, death, or property damage that any person or entity may suffer or sustain as a result of the information in this document, or any use of or reliance on this document.

Information on flood preparedness is from PreparedBC's Flood Preparedness Guide.

Photo references:

[Top right] Wildfire. Photo: Shutterstock.

[Top left] Debris flood in Canmore, AB. Photo: THE CANADIAN PRESS/Jonathan Hayward.

[Middle right] Flood damaged homes along Cougar Creek in Canmore, AB. Photo: THE CANADIAN PRESS/Jeff McIntosh.

[Bottom left] Car swept away by debris on the Coquihalla Highway, Hope, BC. Photo: THE CANADIAN PRESS/Jonathan Hayward.

[Bottom right] Bridge damages from debris flood on Hwy. 1, Lytton, BC. Photo: TranBC.

DEBRIS FLOWS

A fast, flowing landslide comprised of mud, rocks, trees, and water

Debris flows are triggered by heavy bursts of rain or rain-on-snow events



Debris flows are more likely to occur after periods of prolonged rain or snowmelt, or in years following forest fires

Houses at the base of steep slopes with mountain creeks are at greatest risk



Debris flows begin in mountain creeks and grow in size as they travel down slope, usually in surges (pulses)

Debris can bury or destroy houses



Debris can flow faster than the fastest human can run

Debris can suddenly jump out of the channel

Debris can impact houses far from the channel



Debris can sweep away or crush cars



PROTECT YOURSELF FROM

DEBRIS FLOWS

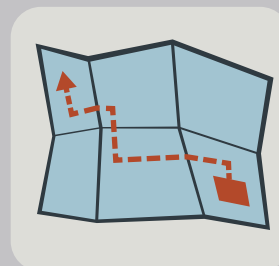
BEFORE

Stay informed



Keep updated with weather advisories, such as heavy rainfall warnings. Consult your local hazard map to learn where the slope hazard zones are located.

Prepare and plan



Prepare an emergency kit for your home, vehicle, and workplace. Plan a safe evacuation route and muster point. Know which rooms are safest if you have to shelter in place.

Know the signs



Look/listen for an abrupt increase or decrease in water flow, unusually muddy water, shaking ground, and a loud roar (sounds like a train or helicopter).

Safe home design



Put high occupancy rooms like bedrooms on the top floor and on the downhill side (away from slopes).

DURING

DECISION: evacuate



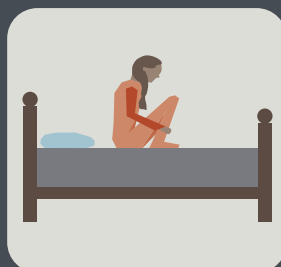
If you believe your life to be in imminent danger and you see a clear path to safety, evacuate. Get away and to higher ground as fast as you can.

DECISION: shelter



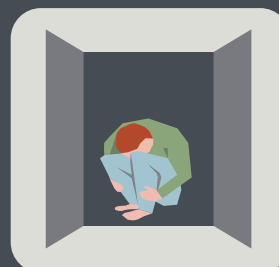
If it is unsafe to evacuate, shelter up and away. Climb to the top floor or on the roof. Shelter on the downhill side, away from the slope. Avoid basements.

Climb on top of furniture



Get on top of a bed or counter to avoid being swept away or buried. Do not hide behind or underneath heavy furniture as they can crush or pin you down.

Shelter in a closet



If you cannot escape vertically, small rooms like closets can offer additional protection from collapse if your home is buried.

DO NOT exit out of curiosity



Seek shelter instead of investigating the situation. Only go outside if you have to evacuate.

DO NOT cross flood waters



Moving water as little as 30 cm deep can quickly sweep you away. Do not attempt to drive or walk through water or debris.

AFTER

Assume more will come



Debris flows come in surges (pulses) and can continue for days. Subsequent pulses may be more severe than the previous.

Make noise if buried



Shout or tap on something so search and rescue can locate you faster.

If safe, help neighbours



Help evacuate your neighbours when it's safe to do so, and offer assistance to search and rescue personnel.

Obey closures



Evacuation orders and road closures must be taken seriously. Only return when local authorities declare it safe to do so.

NOTES

BGC Engineering Inc. (BGC) prepared this infographic with artwork by Sophia Zubrycky. This infographic depicts some measures that may help to lower but not eliminate certain kinds of risk associated with debris flows. Simply following the measures shown in this infographic does not make it safe to occupy areas at risk of debris flows. Even if the measures shown in this infographic are taken, debris flows may still cause serious personal injury (including death) or property damage. BGC provides no guarantee or warranty of any kind related to the information in this infographic. Persons and entities using or relying on this infographic do so at their own risk. BGC will not be responsible or liable for any loss or damage including any personal injury, death, or property damage that any person or entity may suffer or sustain as a result of the information in this document, or any use of or reliance on this document.

Information on life loss risk reduction in case of debris flow impact is informed by Pollock, W., and Wartman, J. (2020) Human Vulnerability to Landslides. GeoHealth, 4, e2020GH000287. <https://doi.org/10.1029/2020GH000287>.

Photo references:

[Top right] Wildfire. Photo: Shutterstock.

[Middle left] Debris flow at Cataline Creek, BC. Photo: BGC.

[Middle right] Debris flow at Wilcox Creek, BC. Photo: BGC.

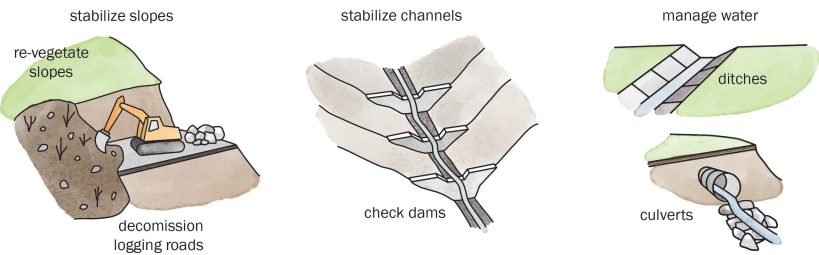
[Bottom left] Debris flow in the Austrian Alps. Photo: Shutterstock.

[Bottom right] Car swept away by debris on the Coquihalla Highway, Hope, BC. Photo: THE CANADIAN PRESS/Jonathan Hayward.

DEBRIS-FLOW & DEBRIS-FLOOD HAZARDS

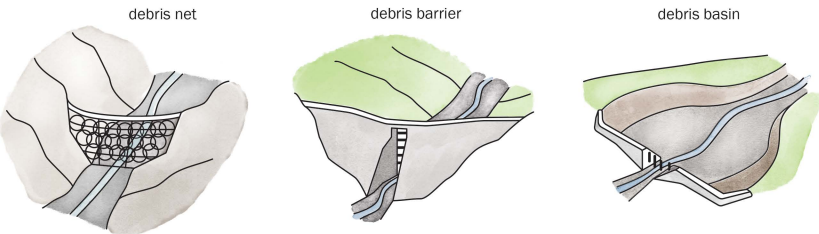
RISK MANAGEMENT OPTIONS

This graphic provides an overview of risk management options for debris-flow and debris-flood hazards. Selection of the appropriate risk management solutions depends on the unique site characteristics and risk reduction objectives. Often, multiple options are combined, working together to manage risk.



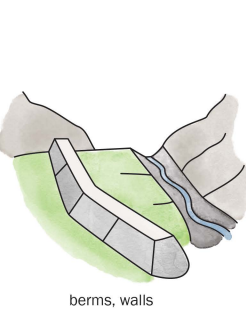
① reduce source sediment supply

Managing the sediment supply in the watershed can reduce the size and frequency of debris flows and debris floods. Strategies include efforts to stabilize slopes, stabilize channels, and manage water. For example, revegetation and decommissioning abandoned logging roads can restore natural drainage and slope stability disturbed by logging activities. Some of the challenges with this mitigation approach include access, practicality, and cost-effectiveness across large, unstable source areas.



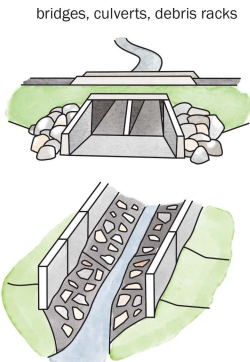
② retain / regulate debris

Structures that intercept debris can reduce the extent and intensity of debris-flow and debris-flood impacts downstream. There are many types of structures, such as flexible nets, barriers, and basins. These structures typically allow the passage of regular streamflow, but block or restrict the passage of larger events by storing debris and attenuating flow. These structures are designed and sized specific to each site and require regular maintenance and cleaning following an event. Erosion protection downstream of the structure is important.



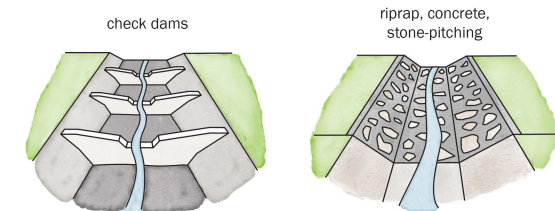
③ deflect flow

Engineered berms and walls can redirect flow away from elements at risk. These structures are often placed in locations where flow may leave the channel to direct flow back into the main channel or away from elements at risk. They can be constructed from earthfill, concrete, gabions, or other materials, and are engineered to withstand erosion and debris impact loads. Care must be taken in the design such that deflected flows do not transfer or increase risks to other areas.



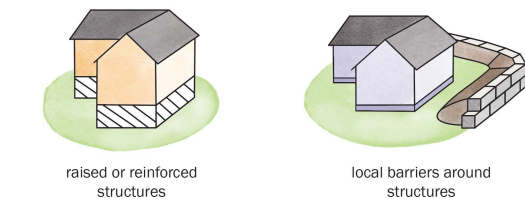
④ convey flow

Improving channel conveyance can reduce the likelihood that a debris flow or debris flood blocks or overtops the channel. This can be achieved by increasing the capacity of bridges and culverts, installing debris racks upstream of culverts to prevent clogging, deepening, steepening, and widening the channel through excavation, and building up walls or dikes along the channel. In some cases, bridges or culverts may be removed to reduce potential blockage points.



⑤ stabilize channels

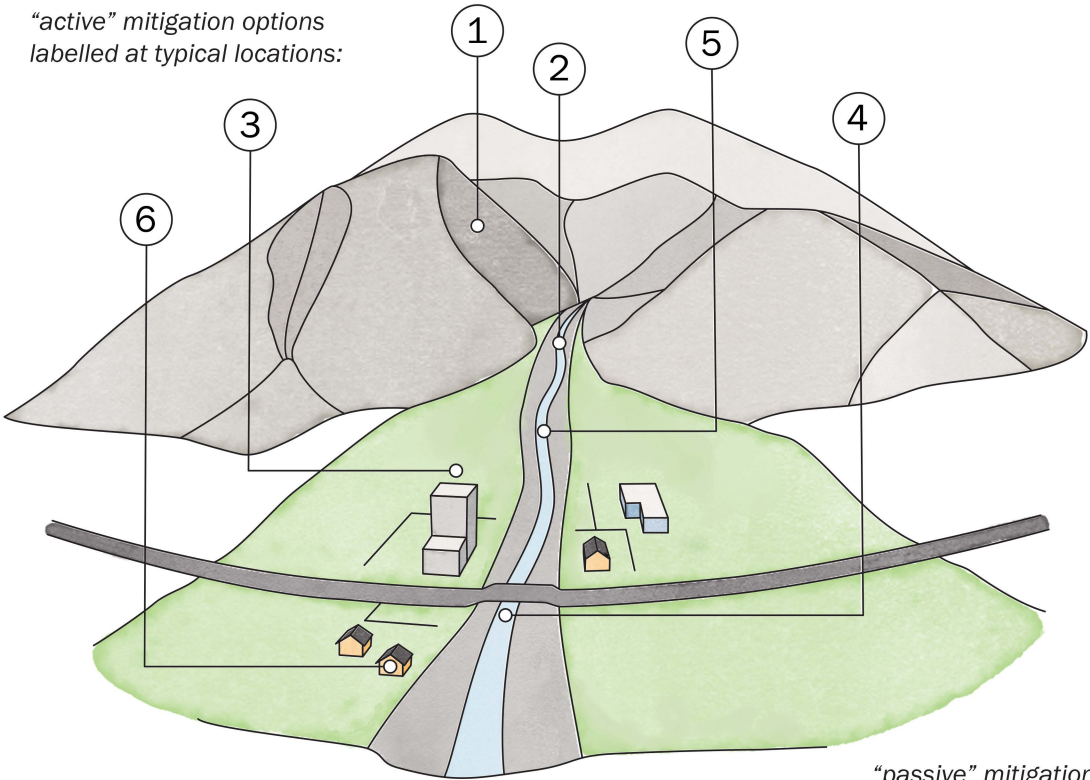
Stabilizing the channel can reduce the amount of bank erosion, channel incision, and debris entrainment that occurs during a debris flow or debris flood. This can reduce the total volume of the event and reduce damages to buildings and infrastructure adjacent to the channel. Typical armouring techniques include lining the channel with riprap, grouted riprap, concrete, and stone pitching. Check dams can also be used to reduce the channel gradient and stabilize the channel bed while providing temporary debris retention along the channel.



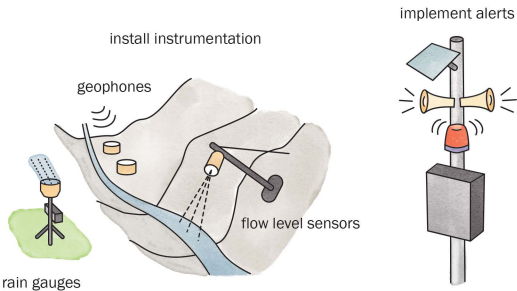
⑥ construct local protection

Local protection measures can decrease the vulnerability of structures where relocation is not an option. These measures typically involve modifying the building (e.g., reinforced walls, sacrificial berms, flood construction levels) or constructing small deflection structures on individual properties (e.g., berms, walls, nets) at the expense of individual property owners. Measures should be engineered to accommodate debris impact loads and avoid transferring or increasing risk to adjacent and downstream properties.

“active” mitigation options
labelled at typical locations:

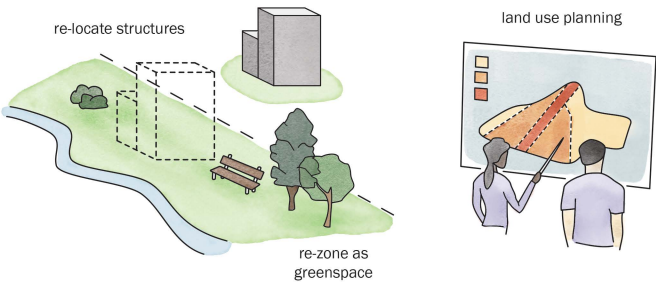


“passive” mitigation
options listed below:



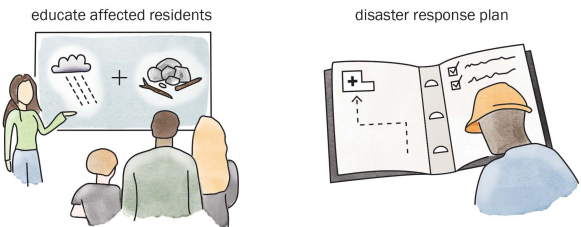
warning systems

Warning systems can alert a population of an impending debris flow or debris flood. Although they cannot prevent all damages, they may help get people and mobile equipment out of harm’s way. Warning systems can be alarm systems that trigger during an event (e.g., geophones, flow level sensors, cameras), or forecasting systems for advance warning based on measured or forecasted rainfall amounts. These systems must be paired with clearly defined triggering thresholds and response actions, with clear roles and responsibilities outlined for issuing alerts and maintaining instrumentation.



reduce exposure

Exposure can be reduced through relocating existing development or restricting future development in hazardous areas. Relocation is extremely effective at reducing risk, but it may not be a feasible or accepted approach in some locations. Land use plans that promote development in low-hazard areas and implementation of effective engineered mitigation measures in higher-hazard areas are a proactive way to reduce risk over time. These plans typically require hazard and risk assessments to guide hazard zonation and should be updated at regular intervals or with changed conditions.



prepare for emergency

Emergency preparedness can build resiliency by improving the ability to respond to debris flows and debris floods. Preparedness initiatives can include creating emergency response plans, running emergency training sessions or drills, and educational programs. Simple actions, such as establishing evacuation routes or learning the signs of an impending debris flow or debris flood, can reduce harm and even save lives.

APPENDIX B
JANUARY 16, 2025, MEMO TO RDEK BOARD





DRAFT



TECHNICAL MEMORANDUM

Date January 16, 2025

Project 1127007

To Justing Cook, Planner II
Regional District of East Kootenay

From Tamsin Mills, M.Sc., R.P.P. & Brett Eaton, Ph.D., P.Geo.

Local Government Approaches to Land Use in Natural Hazard Areas

1.0 INTRODUCTION

This memo presents a brief overview of the background, context, and nature of approaches taken to manage land use in areas subject to natural hazards. This memo is provided under Contract No. CDL 0747, dated June 17, 2024 and was requested by RDEK Staff for use in internal discussions that will guide the remaining work on this project. Where the memo cites provincial legislation and local bylaws, descriptions are limited to tools for restricting the use of land in natural hazard areas and are not exhaustive.

2.0 PROVINCIAL LEGISLATION AND GUIDANCE

In BC, assessment and regulation of development in areas affected by natural hazards is covered under various acts and guidelines. The BC **Local Government Act** (SBC 2015) requires that Official Community Plans (OCPs) contain statements and map designations respecting restrictions on the use of land that is subject to hazardous conditions (Sec 473). It also allows for OCPs to designate development permit areas (DPAs) for the protection of development from hazardous conditions. Section 56 of the **Community Charter** (SBC 2003) allows for a building inspector, on lands subject to hazardous conditions, to require a landowner to provide a report certified by a qualified professional (QP) that the land may be used safely for the use intended. Zoning powers under the *local Government Act* (s. 458) also provide a tool to zone or rezone to limit development. Other Provincial legislation relevant to restrictions on the use of hazardous land subject to hazardous conditions include the **Land Title Act** (RSBC 1996), under which the Approving Officer has discretion to refuse subdivision (s. 86(1)(c)(v)).

Local Governments must also consider applicable provincial standards and guidelines when developing bylaws and regulations; those applicable to developing floodplain management include the B.C. **Flood Hazard Area Land Use Management Guidelines**. The guidelines state that development should be discouraged in areas where there may be debris flow hazard and that consent to develop should only be granted if there is no other land available and an assessment by a QP indicates that the development may occur “safely”. Measures or thresholds

to define 'safe' are not explicitly defined. QP's carrying out assessments hold responsibilities under by the Engineers and Geoscientists Act (RSBC 1996) and consider professional practice guidelines published by Engineers and Geoscientists BC (EGBC), provincial or federal agencies. Examples of relevant professional practice guidelines include EGBC Guidelines for Flood Assessments in a Changing Climate (EGBC, 2018) and Guidelines for Landslide Assessments in BC (EGBC, 2023).

3.0 IMPORTANT CONCEPTS

Hazard: an event or situation with the potential to harm people, property or the environment. At Fairmont and Cold Spring Creeks, known hazards include debris flows¹ and floods. Hazards are often described by characteristics such as depth and velocity, for event magnitudes ranging from frequent, minor nuisance events to rare, catastrophic events.

Hazard Probability: The likelihood of an event of a certain magnitude occurring is often described by its 'return period', which is the average time between occurrences of such an event. For example, a 100-year flood (1:100 year flood) is expected to be exceeded once in a 100 year period, or twice every 200 years. This means there is a 1 in 100 chance (or 1% Annual Exceedance Probability, AEP) of it being exceeded in any given year, regardless of the last occurrence. Similarly, a 50-year event has a 2% AEP.

Risk Management: Considering risk is a common method of evaluating the safety of actions, including development. In British Columbia, management of the risks associated with debris flows (and other types of landslides) focusses on risk to life, rather than the economic risk associated with damage to infrastructure.

Risk to life: refers to the probability of death for an individual living or working within a hazard area. It can be compared to everyday risks such as a 1:100 chance of getting in a motor vehicle crash or a 1:1,000 risk of drowning. For debris flows, risk to life depends on whether a debris flow event occurs and reaches an inhabited structure, how deep and fast the debris flow is when contact is made, and the likelihood of structural failure causing a fatality. Larger debris flows, while less frequent, are deeper, faster and extend over larger areas, leading to greater loss of life when they occur. Risk to life therefore varies with the probability of a debris flow of a given magnitude and the resulting consequences to life. **Group Risk** refers to the probability of multiple fatalities in a debris flow hazard area, highlighting the impact on communities rather than just individuals.

4.0 PRECEDENTS

In 1972 a subdivision application near Squamish was rejected by the Province due to landslide hazard in the area. On appeal, the judge upheld the decision given there was sufficient

¹ In this document, the general term "debris flow" is used to encompass the full spectrum of steep stream hazards, including both debris floods and debris flows as defined by the mechanics of sediment movement during an event. Most steep streams that experience debris flows also experience debris floods, and debris flows can transition into debris floods during an event, so distinguishing between the two modes of transport is unnecessary from a hazard and risk perspective.

likelihood of a catastrophic landslide affecting more than 100 residences and resulting in loss of multiple lives. ‘Sufficient likelihood’ was described by the Judge as a return period of 1:10,000 years or AEP of 0.01%. Because catastrophic landslides have the potential to claim the lives of virtually everyone in the area affected by them, this 1:10,000 return period is analogous to a 1:10,000 risk to life in the affected area. The same is not true for hazards that are less likely to result in fatalities.

The BC Ministry of Transportation and Infrastructure’s past and current (2024) Subdivision Preliminary Layout Review requirements for Natural Hazard Assessments require that where a life-threatening event is known as a potential hazard to a building lot, the QP is to consider events having a probability of occurrence of 1 in 10,000 years and large-scale developments must also consider the total risk to the new development (Group Risk).

In 2013 a panel of risk experts was formed by the District of Squamish Council to provide opinions related to the Cheekye River debris flow hazard. The panel concluded that the 1:10,000- year event was the appropriate event for estimating the largest landslide that could affect the Cheekye Fan. The panel also recommended that staff consider the risk to existing buildings, not just new development, and that the evaluation of risk to life on the fan be determined for a full spectrum of event magnitudes and return periods because risk to individuals on various parts of the fan would be dominated by different events.

5.0 CURRENT APPROACHES IN BC AND ALBERTA

Both approaches presented below include a common reliance on QPs to provide professional reports that align with the provincial landslide assessment guidelines (EGBC, 2023). Local governments have developed tools to further support staff reliance on QPs, including assurance statements and terms of reference for QP studies.

5.1 Hazard-focussed approaches

Hazard-focused approaches relate land use decisions to the probability of the hazard occurring and reaching the area of interest. Hazard approaches do not explicitly translate the hazard of occurrence to a probability of life loss², but may imply a level of risk by adopting different criteria for hazard types with different levels of destructive potential. A debris flow hazard probability table for the Fraser Valley Regional District (Figure 5-1) indicates which of five approval categories the project falls in depending on the type of application and the hazard probability. Overview hazard studies inform the establishment of DPAs within which a study by a QP is required to ascertain the hazard probability, develop siting requirements, and plan mitigation measures as needed (per the table below right). Where there are known hazards but no DPAs, building inspectors request QP reports. Section 219 covenants (Land Title Act) are employed for all development in hazard-prone areas.

² For an example, see the **Fraser Valley Regional District (FVRD) Hazard Acceptability Thresholds for Development Approvals**.

Debris Flow/Debris Torrent

Debris flows and torrents are rapid, saturated flows of coarse debris and mud, damaged trees, stumps, and smaller organic material. These flows may be contained in steep creek channels or they may spread out on debris fan surfaces. Debris flows and torrents can be life-threatening and damage or destroy property.



Table 4

	1:50	1:50-1:200	1:200-1:500	1:500-1:10,000	<1:10,000
Minor Repair (<25%)	5	2	2	1	1
Major Repair (>25%)	5	4	2	1	1
Reconstruction	5	5	4	3	1
Extension	5	5	4	2	1
New Building	5	5	4	3	1
Subdivision (infill/extend)	5	5	5	4	1
Rezoning (for new community)	5	5	5	5	1

- 1 Approval without conditions relating to hazards.
- 2 Approval, without siting conditions or protective works conditions but with a covenant including "save harmless" conditions.
- 3 Approval, but with siting requirements to avoid the hazard, or with requirements for protective works to mitigate the hazard.
- 4 Approval as #3 above, but with a covenant including "save harmless" conditions as well as siting conditions, protective works or both.
- 5 Not approvable.

Figure 5-1 Debris flow hazard probability tables for the Fraser Valley Regional District

Advantages and disadvantages of the hazard-focused approach: Hazard probability has a strong precedent in engineering as they are often used in standards for design. Planners and professional engineers and geoscientists have familiarity with the approach and the tables provide process transparency for applicants.

The hazard-focussed approach concentrates on new development and does not directly promote the reduction of existing risk. The application types (minor repair, etc.) must be adjusted as new forms of development arise (i.e., accessory dwelling units). Applying different decision-making criteria to different hazards (e.g. more conservative criteria for more destructive hazards) lacks the flexibility of risk-focused approach that explicitly considers vulnerability. The approach may hamper creative, site-specific risk mitigation proposals as they would be invalidated by the rigid framework.

Key Point

Hazard-focused approaches place the full responsibility of determining what constitutes 'safe for the intended use' on the QP. Local government planners, who often lack the specialized expertise, must rely entirely on the QPs interpretation, with limited ability to assess or question it.

6.0 COMBINED HAZARD AND RISK APPROACHES

The City of Canmore, Alberta (Canmore) and District of Squamish (DoS) provide two examples of jurisdictions that combine hazard and risk approaches to inform land use decisions in hazard areas. Canmore experienced a significant debris flow on Cougar Creek in 2013, leading to the development of their development management approach. The DoS has been developing hazard and risk policies for over a decade, motivated by proposed major development in debris flow hazard areas on Cheekye River fan. While their approaches differ in detail, both local governments take a hazard approach to define zones of hazard on the fans and then establish risk tolerance criteria for management of development in the hazard area.

Both have similar risk tolerance criteria in their official plans:

- Group risk is within the As Low As Reasonably Practicable (ALARP) or acceptable range,
- For new development, the individual annual risk to life shall not exceed 1:100,000, and
- For existing development, the individual annual risk to life shall not exceed 1:10,000.

In both locations, the hazard mapping is based on the intensities (i.e., depths and velocities) and extents of events possible across return periods. The hazard area is divided into zones ranging from extreme- and high-hazard zones, to moderate- and low-hazard zones. Generally, the higher-hazard zones do not allow development, while moderate-hazard zones allow development if a risk assessment is undertaken and illustrates that the project can meet the established risk tolerance criteria (as above). In low-hazard zones, risk assessments may be required and development is permitted. Note that the decision trigger to require an assessment is hazard-focused, but the required assessment is risk-focused.

Advantages and disadvantages of the combined approach: the mapped hazard zones provide important information on the changing characteristics of hazard across the fan and enhance transparency, helping development applicants understanding of likely requirements. However, assessments typically require watershed scale analyses beyond a single homeowner's property. This can result in costly duplication of effort where independent applicants share similar assessment requirements. While this disadvantage can be addressed through watershed scale assessments at sufficient detail to enable QPs to focus subsequent work at a property level, applicants may still be challenged to find QPs with the appropriate risk assessment expertise. Shifting the burden to QPs to assess 'safe for the intended use' still requires capacity by the approving authority to incorporate, where possible, assessment deliverables into a maintained body of knowledge about a hazard area.

Key Point

In the combined approach, community-established risk tolerance criteria effectively define what is considered 'safe for the intended use', while risk assessments performed by QPs evaluate whether these standards are met through design of mitigation measures. This approach relieves the burden on planners to interpret QPs' assessments of 'safe for the intended use' and shifts the cost burden onto permit applicants. Setting up information management processes and tools will still be needed to enable new assessments to refine past work and maintain an up-to-date body of knowledge.

7.0 CLOSURE

We trust the above satisfies your requirements. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC Engineering Inc.
per:

Tamsin Mills, M.Sc., R.P.P.
Senior Associate, Pinna Sustainability

Brett Eaton, Ph.D., P.Geo.
Principal Geoscientist

Reviewed by:

Kris Holm, M.Sc., P.Geo.
Principal Geoscientist

bce/kh/rm/docrev

Attachment(s): Limitations
References

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APPENDIX C

RDEK HAZARD AND RISK MITIGATION APPROACHES IN FAIRMONT HOT SPRINGS (RESOLUTION 52133)





P 103 506

March 6, 2025

Brett Eaton, Principal Geoscientist
BCG Engineering Inc.
500 – 980 Howe Street
Vancouver BC V6Z 0C8

Via Email:
BEaton@bgcengineering.ca

Dear Mr. Eaton:

Re: Hazard and Risk Mitigation Approaches in Fairmont Hot Springs

Thank you for your presentation at the Electoral Area Services Committee meeting on February 13, 2025. The following day, the RDEK Board resolved to direct RDEK staff to develop policy options utilizing a combined hazard and risk focused approach.

If you have any questions please contact Justin Cook, Planner 2, at jcook@rdek.bc.ca or 250-489-2791.

Sincerely,

Nikki Bradshaw
Deputy Corporate Officer

cc: Jack Park, BGC Engineering Inc.
Tamsin Mills, Pinna Sustainability
Just Cook, Planner 2, RDEK
Karen MacLeod, Planning Supervisor, RDEK

Resolution 52133

APPENDIX D

JURISDICTIONAL EXAMPLES OF HAZARD MANAGEMENT FRAMEWORKS



D-1 COMPARISON OF HAZARD MANAGEMENT FRAMEWORKS

The three hazard management frameworks all have advantages and disadvantages relative to the others. These are summarized below:

- Table D-1 summarizes the advantages and disadvantages of the hazard threshold framework.
- Table D-2 summarizes the advantages and disadvantages of the risk threshold framework.
- Table D-3 summarizes the advantages and disadvantages of the combined hazard and risk framework.

Table D-1 Advantages and disadvantages of a hazard-focused framework.

Advantages	Disadvantages
• Precedent: There is strong precedent for using hazard threshold frameworks to develop prescriptive tables that determine what is permitted based on the hazard probability. Land-use decisions made based on these tables are consistent, and the tables are familiar to most professionals who have worked on land use in British Columbia. • Transparency: Tables can be developed for a wide variety of hazard types, and most types of development applications are included in the existing tables. Also, other types of hazards and development applications can be added, as needed. The tables are prescriptive, which facilitates clear documentation and justification for decisions. • Consistency and ease of use: All that is needed for application review are the development decision tables and maps of the hazard extent for the selected threshold encounter probability for each hazard type. Once the maps are available, all developers, land-use planners, engineers, and staff reference the same maps and tables. In contrast with a risk assessment, there are no other parameters to estimate, assume, or debate.	• Inflexibility: Site-specific factors that affect the hazard, exposure, or vulnerability to the hazard (e.g., mitigation measures, variations in hazard characteristics within a hazard type) are ignored, and there is no systematic process for incorporating these factors into decisions about variances or exemptions. Proponents are also unable to use vulnerability-reduction measures to demonstrate a development is safe for the use intended. • Existing risk is not reduced: Although the tables could help RDEK to slow population growth within the hazard zones, use of the tables does not explicitly promote or incentivize the reduction of existing risk. Detailed hazard studies may lead to area specific mitigation outcomes that reduce existing risk. • Not applicable to group risk: In some densely populated hazard areas, it is possible for individual risk to be tolerable, but societal (group) risk to be intolerable due to a probability of high consequences. Hazard-focused frameworks cannot support decisions requiring consideration of group risk.

Table D-2 Advantages and disadvantages of a risk threshold framework.

Advantages	Disadvantages
• Flexibility: The risk threshold framework is more flexible than the hazard acceptability framework, particularly where hazard avoidance is impractical. It allows development proponents to implement measures that reduce vulnerability and exposure (e.g., mitigation measures, non-structural measures) to meet the risk tolerance thresholds, and to demonstrate a favourable benefit-cost ratio. The framework is not limited to a predefined list of hazard types and can consider the total risk to development where multiple overlapping hazards exist. • Incentive to mitigate risk: Adoption of risk tolerance thresholds for development approvals creates incentives to reduce risk.	• Requires specialists to assess risk: Few registered professionals (e.g., engineers, geoscientists, or planners) in British Columbia are experienced in risk assessment. Therefore, specialists in risk assessment are needed, and these specialists can be challenging to find. It may be feasible to reduce this disadvantage in areas where existing detailed assessments are used to develop prescriptive policies (e.g., a rules-based framework that can be followed without additional risk analyses). • Inconsistency: It may be difficult to apply a risk threshold-based policy consistently. Risk assessments require several parameters to be estimated and justified. These parameters are always uncertain, and different risk analysts (even among experienced risk analysts) may assign different values to each parameter. It is possible to standardize risk parameters, as has been done for risk estimation in Switzerland (EconoMe, FOEN, 2023), to improve consistency, but this would be a very involved and costly undertaking for a local government. Inconsistency in risk estimates can lead to conflicts and inconsistencies in development approval decisions, as well as potential legal challenges.

Table D-3 Advantages and disadvantages of a combined hazard- and risk-focused framework.

Advantages	Disadvantages
• Hazard Understanding: Mapped hazard zones show how hazard characteristics change across the fan, giving applicants a clearer picture of risks. • Transparency: Hazard mapping helps development applicants understand likely requirements upfront. • Focussed Site-Specific Assessment: If watershed-scale assessments are available with sufficient detail, it allows QPs to concentrate on site-specific conditions. • Knowledge Build for Authorities: Shifting assessments from authorities to QPs enables approving authorities to compile assessments into a maintained knowledge base of hazard areas.	• Broader-Scale Analysis: Assessments often require watershed-scale studies beyond the boundaries of a single property. • Duplicated Effort: Independent applicants may repeat similar assessments, increasing overall effort unnecessarily. • Limited QP Availability: Similar to the risk threshold framework, applicants may struggle to find QPs with the necessary risk assessment expertise. • Capacity Demands on Authorities: Approving authorities still need the baseline understanding and resources to incorporate and manage applications.

D-2 HAZARD THRESHOLD FRAMEWORK

D.2.1. Ministry of Transportation and Transit

The BC Ministry of Transportation and Transit (MOTT; previously BC Ministry of Transportation and Infrastructure) is one example where a hazard threshold has been implemented. In 2009, MOTT produced a guidance document titled Subdivision Preliminary Layout Review. The policy document specifies a maximum tolerable hazard probability for various natural hazard types that could have life-threatening effects. Where life-threatening or catastrophic events are known to be a potential hazard to a building lot, QPs should consider events with an occurrence probability of 1 in 10,000 years. For large-scale developments, QPs must consider the same 1:10,000-year events and must also consider the total risk to the new development (Clague et al., 2014).

D.2.2. District of Squamish

The District of Squamish is an example of a location where an initial hazard threshold was established to evaluate the construction of a mitigation structure to protect existing and future development in the area. A panel of risk experts was formed by the District of Squamish Council in 2013 to provide opinions related to the Cheekeye River debris flow hazard, triggered by an application for OCP amendment. The panel opined on the volume and frequency of future landslides, the character and volume of the 10,000-year landslide and the possible effects of climate change on future landslides (Clague et al., 2014). The panel concluded that the 1:10,000-year landslide was the appropriate event for estimating the largest debris flow that could affect the Cheekeye Fan and that it could carry 5.5 million m³ of material. The panel recommended that, regardless of future development, existing development should be protected from large volume, low probability events and from small volume, high probability events. It was anticipated that events of different hazard probabilities would dominate risk to individuals on different parts of the fan, and the entire spectrum of events should therefore be considered.

The panel's policy recommendation was to consider up to a 10,000-year hazard scenario when considering the construction of a debris flow barrier. However, the District's development approvals are based on meeting risk tolerance thresholds, which are further described in Section .2 (Combined Hazard-Risk Threshold).

D.2.3. Fraser Valley Regional District

To improve our understanding of the Fraser Valley Regional District's (FVRD) implementation of hazard policies, we completed an interview with a staff planner during the project. In the early 1990s, the Fraser Valley Regional District³³ (FVRD) developed a series of tables with hazard probabilities per hazard type (often called "Cave Tables") to guide land use decisions (Cave et al., 1990; Cave, 1992). In 2020, the FVRD published the tables as Hazard Acceptability Thresholds for Development Approvals. The FVRD engaged with QPs in developing the tables.

³³ The Fraser Valley Regional District was called the Regional District of Fraser-Cheam at that time.

The tables include annual hazard probability categories against types of development, ranging from minor repair to subdivision and rezoning (see Figure -1 and Figure -2). A companion table, with levels 1 to 5, describes the development approval conditions. Together, these tables determine whether an application for a specific type of development would be approved, along with the conditions under which it would be approved, based on the hazard probability of the site. While the FVRD framework does not explicitly evaluate risk, risk concepts are implicitly incorporated through the creation of specific frameworks for different hazard types, where more destructive hazards are managed more conservatively. Within a given hazard type, the framework applies the same decision criteria irrespective of the destructiveness of the hazard.

1	Approval without conditions relating to hazards.
2	Approval, without siting conditions or protective works conditions but with a covenant including "save harmless" conditions.
3	Approval, but with siting requirements to avoid the hazard, or with requirements for protective works to mitigate the hazard.
4	Approval as #3 above, but with a covenant including "save harmless" conditions as well as siting conditions, protective works or both.
5	Not approvable.

Figure D-1 Responses to guide land-use decisions (FVRD, 2020; Cave et al., 1990; Cave, 1992).

Debris Flow/Debris Torrent

Debris flows and torrents are rapid, saturated flows of coarse debris and mud, damaged trees, stumps, and smaller organic material. These flows may be contained in steep creek channels or they may spread out on debris fan surfaces. Debris flows and torrents can be life-threatening and damage or destroy property.



Table 4

	1:50	1:50-1:200	1:200-1:500	1:500-1:10,000	<1:10,000
Minor Repair (<25%)	5	2	2	1	1
Major Repair (>25%)	5	4	2	1	1
Reconstruction	5	5	4	3	1
Extension	5	5	4	2	1
New Building	5	5	4	3	1
Subdivision (infill/extend)	5	5	5	4	1
Rezoning (for new community)	5	5	5	5	1

Figure D-2 Example hazard acceptability threshold used for development approval decisions in the FVRD (2020).

Throughout the FVRD, bylaws have been used to create hazard DPAs based on the results of various overview hazard studies. Generally, the DPA guidelines describe the nature of the hazard and identify areas where further study by a QP would be required. Where required, a QP

completes a site-specific hazard assessment and proposes the approval rating level from 1 to 5. In specific areas of the region, the FVRD is completing more detailed hazard studies following OCP updates. In these areas, hazard mitigation will be prescribed in advance, with a QP study only needed if applicants disagree with the prescribed hazard mitigation measures. Where there are no DPAs, but the area is known to include hazards, the building department requires site-specific reports completed by QPs under Section 56 of the Community Charter and a covenant on title.

Guidelines in the DPA permit peer review of a QP study at the discretion of staff, with the cost covered by the applicant; however, this has been rarely applied. While staff at the FVRD do not assume the responsibilities of QPs, reviewing a typically high volume of reports in a given year helps FVRD staff compare the relative quality of each report they receive. They also rely on FVRD's Geohazard Assurance Statement for Development Approvals, which follows the Engineers and Geoscientists of BC's (EGBC) Professional Practice Guidelines on Legislated Flood Assessments in a Changing Climate in BC (EGBC, 2018) and Landslide Assessments in BC (EGBC, 2023).

FVRD staff described how they will be addressing challenges with the Hazard Acceptability tables in 2025. The categories of development (e.g., minor renovation, subdivision) are rigid and do not include changes to a parcel, such as the addition of an accessory dwelling unit. Land alteration, such as soil movement that does not accompany a development, is also not currently included.

D-3 RISK THRESHOLD FRAMEWORK

D.3.1. District of North Vancouver

In 2009, the District of North Vancouver (DNV) was the first local government in Canada to formally adopt and apply landslide risk tolerance thresholds for individual risk³⁴. The risk tolerance thresholds were used to make decisions about mitigation for relatively small landslides (i.e., those affecting one or a few homes) that could impact existing residential development.

Figure D-3 summarizes DNV risk tolerance criteria for different applications. The Factor of Safety (FoS) criteria shown in Figure D-3 apply to dwellings founded on potentially unstable terrain, and are not relevant to hydrogeomorphic hazards at Cold Spring Creek and Fairmont Creek.

Type of application	1:10,000 + ALARP	1:100,000	FOS>1.3 (static)	FOS>1.5 (static)
Building permit (<25% increase to gross floor area)	x		x	
Building permit (>25% increase to gross floor area and/or retaining wall >1.2m)		x		x
Rezoning		x		x
Subdivision		x		x
New development		x		x

Figure D-3 Risk tolerance criteria from the District of North Vancouver.

For minor redevelopment of an existing structure (i.e., <25% increase to gross floor area), the risk threshold is set at 1:10,000. For major redevelopment of an existing structure, the risk threshold is set at 1:100,000. This same threshold is also applied to rezoning, subdivision and new development proposals.

Both of these risk tolerance thresholds refer to individual life loss risk, not group risk. This is appropriate in the DNV context, given that the hazards in the DNV are likely to be relatively localized and will affect relatively few houses during any given event.

Anecdotally, the risk thresholds have been relatively straightforward to meet for existing development through economical mitigation measures such as drainage improvements and

³⁴ The District of North Vancouver did not adopt group risk tolerance thresholds.

removal of unstable fill slopes. For new development, the levels have been much harder to reach, resulting in the avoidance of landslide hazard zones for development. Significant work was undertaken with a community committee and QPs to develop risk tolerance thresholds in North Vancouver.

Although risk tolerance thresholds were defined for new development, the key decisions that led to the risk-based approach were about where and how much mitigation was required to protect existing homes.

D-4 COMBINED HAZARD-RISK THRESHOLD FRAMEWORK

D.4.1. Town of Canmore

In June 2013, heavy rainfall caused flooding on most rivers in southwest Alberta, including damaging debris flows and debris floods on multiple creeks in Canmore. Following immediate response and recovery efforts, Canmore commissioned detailed steep creek hazard mapping and risk assessment, updated policies and bylaws related to development in hazard lands, and constructed structural mitigation on select creeks. Canmore has built a 34-metre-high, water-retaining debris flood mitigation structure on Cougar Creek, which contains a developed fan with over 4,000 residents. Similar to RDEK and the District of Squamish, the mitigation structure is only one element of the comprehensive hazard strategy. Canmore's progress reflects over a decade of effort, with many millions of dollars invested in risk assessment and decision-making process development, and over \$100 million spent on structural mitigation projects.

Canmore's decision-making process for planning and development in hazard lands relies on three key documents that work together:

- **Municipal Development Plan (MDP):** long-term vision and policy direction for the community, including risk tolerance criteria for steep creek hazard areas.
- **Land Use Bylaw (LUB):** implements the MDP vision with legally enforceable rules for development, including steep creek hazard maps relevant for bylaw implementation according to risk tolerance criteria defined in the MDP.
- **Engineering Guidelines:** provide engineering design and construction guidelines for resilient development where permissible under the MDP and LUB.

Figure D-4 provides a flow chart describing how steep creek hazard maps and risk tolerance criteria are used in the development approval process. The steep creek hazard maps, which are hazard-based, define the necessary actions to be taken. The risk tolerance criteria are then used to determine if actions have met requirements. In other words, Canmore uses both hazard and risk thresholds in its decision-making process. A similar approach to that presented in the flow chart could be used throughout the RDEK to manage development on fans, which may or may not have suitable hazard mapping.

Canmore uses two kinds of hazard maps for decision-making:

- **Steep Creek 'study areas':** alluvial fan extents where detailed mapping does not yet exist. These define the likely extent of the hazard, but do not provide information about the intensity of the hazard within it.
- **Detailed hazard zone maps:** hazard maps with four zones: Extreme, High, Moderate, Low, and Residual. These define the extent of the hazard and rate the intensity of the hazard.



Figure D-4 Canmore steep creek development flowchart.

Methods to prepare Canmore's detailed hazard zone maps reflect work from about 2013 to 2018, and use a simplified approach compared to the more recent hazard mapping at Cold Spring or Fairmont Creeks (Section 3.4.3). The maps show the combined maximum credible flow intensities and extents for all studied return periods, and do not show hazard probability or

risk level³⁵ (in contrast, the Fairmont Hot Springs project area hazard maps are based on both flow intensity and hazard probability, enabling hazard zonation to more closely align with risk levels). The “residual” zone on the Canmore maps shows areas that have been protected by structural mitigation measures.

Hazard zones effectively distinguish decisions as ‘no’, ‘maybe’, or ‘yes’, consistent with the HSE (2001) risk framework. The Extreme/High hazard zone allows no new development, and expansion or intensification of existing development is limited to no material increase in hazard or risk. Lower relative land use intensities are defined for this zone. In the Moderate hazard zone, development can proceed where a risk assessment shows how risk tolerance criteria can be met, as described in the MDP. In the Low hazard zone, development may proceed according to Canmore’s engineering guidelines. However, staff may require a risk assessment where a proposed development may increase the level of group risk above the reference line or has significant economic loss potential.

The MDP defines risk tolerance criteria as follows, and group risk is evaluated based on a society risk evaluation tool (Figure D-5) defines a reference line of increasing and decreasing benefits of risk reduction:

For new development:

- The individual risk (PDI) shall not exceed 1:100,000 (this is consistent with the DNV’s risk threshold for new development).
- Group risk shall be at or below the reference line of Figure D-5. For comparison, the group risk at the reference line reaches 1:100,000 at 100 potential fatalities, meaning that so long as the anticipated number of fatalities for a single event is less than 100, the individual risk threshold of 1:100,000 effectively determines the risk threshold that needs to be met.

For existing development:

- The individual risk (PDI) shall not exceed 1:10,000 (this is consistent with DNV’s risk threshold for existing development).
- Group risk shall be reduced as much as possible to near the reference line of Figure D-5, considering the cost-benefit and cost-effectiveness of the mitigation. For comparison, the group risk along the reference line has a value of 1:10,000 for 10 potential fatalities.

³⁵ Holm et. al., 2018. Steep Creek Geohazard Risk and Risk Control Assessment in the Town of Canmore, Alberta.

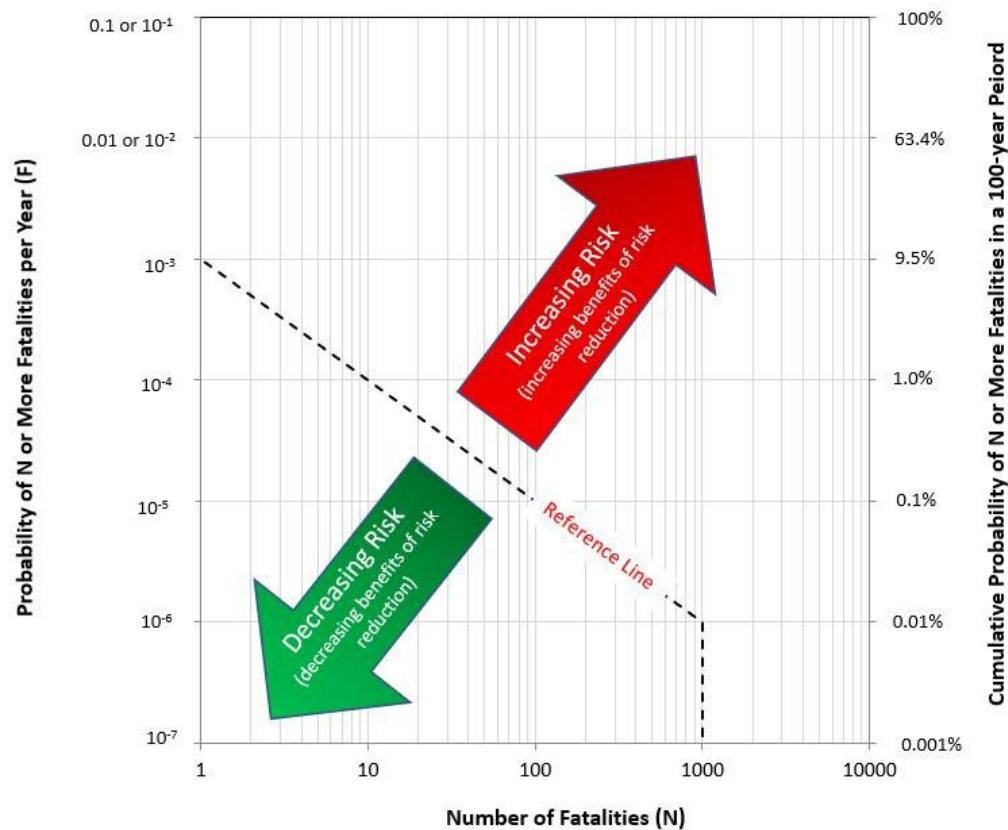


Figure D-5 Societal risk evaluation tool. Modified from Strouth et al. (2022).

D.4.2. District of Squamish

A combined hazard and risk framework is also used to manage development on a fan in Squamish, British Columbia. The Cheekeye Fan in Squamish is a desirable location for development; however, extensive studies have found that the fan is susceptible to rainfall and debris flows generated by rock avalanches from a nearby mountain. Debris flow event magnitudes are estimated at up to 5.5 Mm^3 for the upper-bound events. The local government adopted a life loss risk tolerance threshold that needed to be met as a condition for allowing new development on the fan. Currently, the District of Squamish employs various policy elements working together to address the debris flow hazard including OCP hazard policies, a Flood Hazard DPA in the OCP Bylaw that includes a section on debris flow hazard (OCP page 203), mapped hazard intensity categories (OCP Schedule D-1) with corresponding development stipulations, and a Terms of Reference for Natural Hazard and/or Risk Assessments³⁶.

Ahead of the 2010 Olympics, the Province and the Squamish Nation signed an agreement that granted the Nation development rights to a portion of land in Squamish, including part of the Cheekeye fan. Development of the area had previously been prohibited, as reflected by the land use designations in the OCP, due to a recognized debris flow hazard on the fan. In

³⁶ Terms of Reference for Natural Hazard and/or Risk Assessment:
<https://squamish.ca/assets/Planning-forms/20220912-Terms-of-reference-flood-hazard-assessments.pdf>

approximately 2014, a development partnership applied for an OCP amendment to change the land use from resource and recreational use to residential. Over the next decade, the District of Squamish undertook an expert review of the debris flow hazard and developed hazard-related policies and bylaws to protect existing and new development, as well as to guide the construction of a mitigation structure. Squamish issued interim development policies for the fan in 2014, which have now been incorporated into the updated OCP.

The OCP includes a set of risk tolerance criteria similar to those used by the Town of Canmore:

- Existing development: individual risk <1:10,000.
- New development: individual risk <1:100,000.
- Group risk shall be broadly acceptable or As Low As Reasonably Practicable (ALARP). Where group risk falls in ALARP, the risk assessment must demonstrate why the cost of further reducing the risk is disproportionate to the benefit.

A hazard-based approach was used to define different hazard levels on the Cheekeye fan. The mapping divides the Cheekeye Debris Flow hazard into 5 Zones (C1 to C5) using a composite of hazard intensity across all possible scenarios. Area-wide mitigation of the debris flow hazard is currently under construction, and the policies that apply to each of the hazard zones reflect the current hazard and risk, not the future mitigated hazard and risk on the fan. In the absence of area-wide mitigation, no subdivision, habitable space, or permanent structures are allowed in the two highest hazard categories (C1 and C2). No rezoning or subdivision that will create more than three lots is allowed in moderate hazard zones C3 and C4 until new hazard mapping and appropriate development controls are in place. In the low-hazard zone (C5), rezoning and subdivision creating more than three lots or building permits for more than three dwelling units are allowed with a QP report. Less intensive land uses (other than residential) are also permitted with a QP report.

Once the area-wide mitigation is in place, the OCP policies direct Council to amend the development controls (as above) in the OCP and update hazard mapping. Development will still need to meet OCP risk tolerance criteria.

The Squamish DPA 2 for Flood Hazard in the OCP Bylaw includes a section for Debris Flow Hazard Areas as mapped in Schedule D-1 of the OCP (C1 to C5 Zones). The Bylaw requires a risk assessment report prepared by a QP in accordance with the District's Terms of Reference for Natural Hazard and/or Risk Assessments. The determination of whether to do a quantitative or qualitative risk assessment is made by the QP in consultation with the District and EGBC Professional Practice Guidelines on Legislated Flood Assessments in a Changing Climate (August 28, 2018) and Landslide Assessments in British Columbia (March 1, 2023), and in consideration of the scale of the hazard and proposed development and site conditions. There are minimum requirements for the risk assessment, including that the QP certify that the risk tolerance criteria in the OCP have been met. A compliance and completion report, prepared by a QP, is required to certify that construction or development is in general conformance with the plans submitted with the development permit.

BGC completed the design of a debris-flow barrier for a land developer to meet the District of Squamish risk tolerance threshold. The barrier is designed to protect existing and new development in the Cheekeye debris flow hazard zone. Construction is currently underway, with design and construction costs exceeding \$100 million.

APPENDIX E

ON-SITE MITIGATION MEASURES FROM CANMORE

EDCG



Examples of on-site mitigation measures from the Canmore's Engineering Design and Construction Guidelines are included in Table E-1.

Table E-1 On-site mitigation measures from the Canmore EDCG.

Measure	Description	Reference Material
Minimum floor elevations	Established to ensure that the habitable space of a development is higher than the modelled flood levels.	Section 9, Pages 9-4 to 9-6, Figure. 9-1
Minimum building opening elevation	The concept is similar to the minimum floor elevation. Building openings refer to window wells, garage doors, door entrances, and the top of foundation walls.	Section 9, Page 9-4 to 9-6, Figure. 9-1
Driveways	Driveways sloping towards the building are discouraged	Section 9, Page 9-6
Raising the Lot	The development is not exposed to the hazard when raised above the modelled flood level.	Section 9, Pages 9-7 to 9-9, Table 9-2, Figure 9-3
Fuel Storage	Fuel storage containers, private pumping stations and any other external service installations with mechanical or electrical parts should be raised and secured at or above the minimum floor elevation.	Section 9, Page 9-9
Temporary flood protection	Preventing floodwater ingress into a building to minimize the impact of and to give occupants more time to relocate ground-floor contents.	Section 9, Pages 9-9 to 9-10
Grading & Drainage	Landscaping of a development site or property boundary to direct or divert floodwater away from buildings.	Section 9, Page 9-10
Basement & Below Grade Spaces	Due to the potential harm to building occupants, flood-proofing of spaces below the top of the foundation wall should be avoided. Walk-up basements, which feature a sunken entrance or dug-in stairs that extend from ground level down to the basement, should be avoided as an entry/exit point.	Section 9, Page 9-10
Foundation Design	The foundation design should consider the anticipated flood loads, potential debris impact loads, and scouring of foundation walls.	Section 9, Page 9-10, Table 9-3, Table 9-4

Measure	Description	Reference Material
Window Wells	The window well drainage system should minimize the likelihood of water accumulation in the well. The contact between the window well and the foundation should be sealed. The top of the window well should extend at least to the Minimum Building Opening Elevation. Grades around the window well must slope away at a minimum of 2%.	Section 9, Page 9-13
Waterproofing Measures	Waterproofing of foundation walls significantly increases the flood resistance of a building and can be adopted for buildings in steep creek hazard zones.	Section 9, Page 9-13 to 9-14
Flood-resilient building design	Flood-resilient buildings, also known as wet-proofing, are designed and constructed to minimize the impact of floodwater entering the building, thereby causing minimal permanent damage, maintaining structural integrity, and facilitating easier drying and cleaning.	Section 9, Page 9-14, Table 9-5