EXECUTIVE SUMMARY

Debris-flow hazards result in risks to people and infrastructure located on Cold Spring Creek fan in the Regional District of East Kootenay (RDEK), BC. This work follows a detailed hazard assessment by BGC Engineering Inc. (BGC) (September 25, 2020) and aims to inform proposed mitigation works at and upstream of the Cold Spring Creek fan apex.

This report documents the baseline and mitigated debris-flow risk assessment. It supports risk reduction decision making by estimating life-loss risk from Cold Spring Creek debris flows. Secondary hazards, including flooding and bank erosion, are described but not quantified because loss of life risks associated with these hazards were deemed low in relation to risk tolerance limits for existing development.

The objective of the assessment is to estimate baseline and mitigated debris-flow risk and compare it to individual and group risk tolerance thresholds used by other jurisdictions in BC. Individual risk is an estimate of the annual probability of death due to a debris flow for the individual most at risk in each building. Group risk is an estimate of the potential number of fatalities that could occur in the specified debris-flow scenarios. Individual and group life loss risk were assessed only for occupants in buildings.

This risk assessment is based on geohazard scenarios. These scenarios were developed in the hazard analysis and include representative events that could credibly result in life-loss. The risks contributed by individual geohazard scenarios were summed to obtain estimates of the total risk of life-loss across all debris-flow scenarios.

For debris flows, the scenarios cover a range of return periods from 100 to > 1000 years, each representing events with a certain frequency, volume, and discharge.

A range of return periods and associated debris volumes were modelled numerically using FLO-2D to capture the range of potential debris-flow runout extents and impact intensities. The probability of each debris flow volume class was developed from a previously established frequency-magnitude relationship (BGC, September 25, 2020), and flow mobility probabilities were assigned based on some calibration of known and reconstructed events paired with professional judgement. BGC delineated areas with approximately similar life loss risk structured into levels > 10^{-3} (> 1000 Micromorts), 10^{-3} to 10^{-4} (>100 Micromorts) 10^{-4} to 10^{-5} (>10 Micromorts) and < 10^{-5} (<10 Micromorts). Transitions from one risk zone to another were purposely blurred to avoid the illusion of exactness that cannot be achieved given the uncertainties underlying the analytical methods. New standard buildings constructed within these zones will likely share similar risk values, unless they are constructed well above grade and are protected from debris-flow impact.

Life loss risk was calculated for each geohazard scenario by estimating the probability that the scenario occurs (scenario probability), impacts a building (spatial impact probability) when a person is present (temporal probability), with a destructive intensity resulting in loss of life (vulnerability). The scenario risk estimates were summed to determine the probability of a fatality at each building (individual risk), and the cumulative probability of expected fatalities for all buildings (group risk).

Using the risk tolerance criteria for life-loss referenced by other local governments in British Columbia (e.g., the District of North Vancouver, District of Squamish and Cowichan Valley Regional District) BGC identified that debris-flow individual and group risk are unacceptable for existing development on Cold Spring Creek fan. For the unmitigated base case, 86 parcels within existing development have intolerable individual risk (>1:10,000). Figure E-1 shows the results of the group risk assessment. Assessment of the specific debris-flow scenario results suggests that risk management strategies should focus on reducing risk from debris flows that range in size up to 64,000 to 96,000 m^3 total volume (100 to > 1000 return periods).

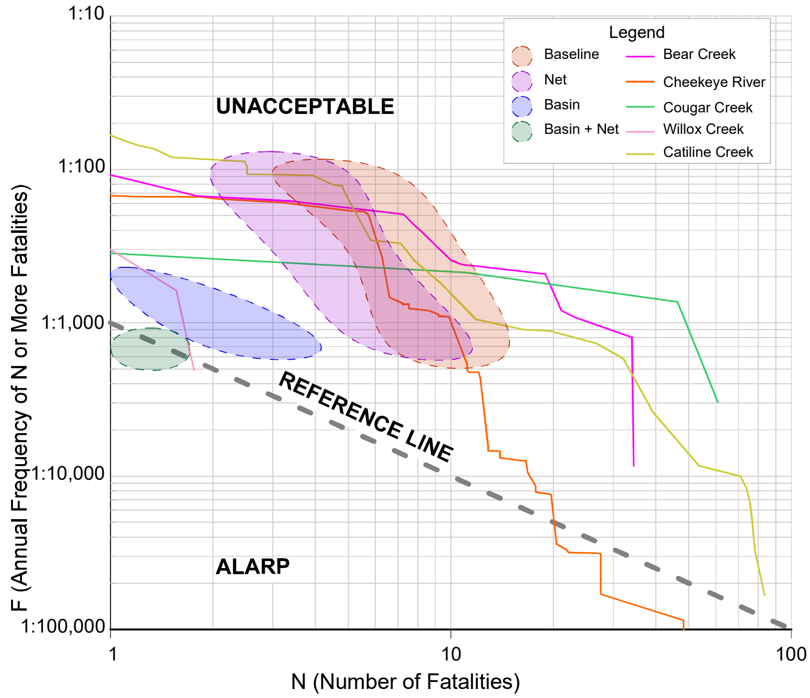

Figure E-1. Results of the group risk assessment for existing and proposed development, compared to group risk tolerance criteria used elsewhere in BC.

BGC also assessed economic losses associated with the different debris-flow scenarios for the unmitigated and mitigated cases. Those losses only pertain to building damage. They do not include building content, business losses and reconstruction costs of infrastructure, all of which would raise the total economic loss potential. Economic losses are summarized in Table E-1.

Both the life loss and economic risk estimates are similar to the highest developments on alluvial fans for which QRAs have been conducted in BC and Alberta. Therefore, a comprehensive debris-flow risk management plan including structural mitigation is warranted on Cold Spring Creek.

Table E-1. Economic losses for the different return periods for existing development and present occupancy. Ranges exemplify possible contents losses. Annualized losses are presented in brackets. All figures are rounded.

Return Period (years)	Expected Range of Economic Loss from Building Impact in Millions			
	Base Case	Debris Net	Debris Basin	Net and Basin
100 to 300	$20 to $30	$17 to $26	-	-
300 to 1000	$23 to $35	$21 to $32	$6 to $9	-
>1000	$29 to $44	$27 to $41	$15 to $23	$11 to $17
	Annualized Losses from Building Impact in Thousands			
100 to 300	$131 to $197	$113 to $170		
300 to 1000	$54 to $81	$48 to $72	$14 to $21	
>1000	$19 to $29	$18 to $27	$10 to $15	$7 to $11