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Project No.: 0409004

Graham Daneluz, MCIP, RPP
Fraser Valley Regional District
45950 Cheam Avenue
Chilliwack, BC V2P 1N6

Dear Mr. Daneluz,

Re: Clarification on Hazards and Risks: Timber Camp Linears

1.0 INTRODUCTION

The Fraser Valley Regional District (FVRD) retained BGC Engineering Inc. (BGC) to carry out a landslide hazard assessment. It focused on estimating probability of occurrence, runout, and encounter probability at specific locations on the valley floor from potential rock avalanches originating at the informally named Timber Camp Linears (TCL). BGC understands that this landslide hazard assessment was requested to help guide land use in areas potentially affected by rock avalanche runout. BGC's findings are summarized in their February 1, 2018 report (BGC, 2018)[1].

In subsequent discussions between the FVRD and the BC Ministry of Transportation and Infrastructure (MoTI) it was decided that the FVRD will provide a letter to the public in which key elements of the BGC (2018) report are summarized in a language easily understood by the public. BGC was asked by the FVRD on March 7, 2018 to aid in the preparation of the letter to the public.

This work is being carried out under the existing Consulting Services Agreement (dated November 23, 2016) between BGC and FVRD.

This current letter responds to specific questions posed by the FVRD, which are paraphrased here for clarity. BGC kindly requests an opportunity to review the finalized letter by FVRD for scientific correctness, before it is issued to the public.

[1] BGC, 2018. Bridal Falls Landslide Hazard Assessment – Timber Camp Linears – Revision 1. Report submitted to Fraser Valley Regional District on February 2, 2018.

1. *Can the probability of a rock avalanche be expressed also in a probability of non-occurrence over a variety of time frames?*

The probability of non-occurrence is simply 1.0 minus the probability of occurrence.

Hazards are often described using an annual probability, which is the occurrence probability in a one-year time period. For example, a 200-year return period flood, has an annual probability of occurrence of 1:200, or 0.005. To express this as a percentage, one multiplies the 0.005 by 100. Thus, a 1:200-year return period means a 0.5% chance of the event occurring in any given year. The probability of this flood not occurring in a given year would be 99.5%, which is 1.0 (1.0 = 100%) minus 0.5%.

Rock avalanche encounter probabilities can be expressed in the same way. BGC's best estimate annual probability of a rock avalanche is 1:9,000 or 0.00011. This implies a 0.011% chance of occurrence in any given year. The probability of a rock avalanche not occurring in a given year would be 99.99%, which is 1.0 minus 0.011%.

The probability of a rock avalanche occurring can also expressed as the chance of it happening in the next X years. This is useful for land use planning where one is interested in the occurrence probability (or non-occurrence probability) over the life of the development. For example, we may wish to estimate the chance of a rock avalanche occurring in the next 100 years. This can be calculated by the following formula:

$$P_n = 1 - (1 - F)^n$$

In that formula, the *n* would be replaced by 100 (years) for this example, which means the probability of the rock avalanche occurring within the next 100 years. The F is annual probability which is 1:9,000 or 0.00011. Using the above formula, we find that there is a 1% chance of a rock avalanche occurring at the TCL site in the next 100 years. Table 1 summarizes probabilities of occurrence and non-occurrence for several scenarios.

Table 1. Probability of occurrence and non-occurrence summary.

		200-year flood	**Rock avalanche initiating from TCL**
Annual probability →		1:200 = 0.005 = 0.5%	1:9,000 = 0.00011 = 0.011%
Time Period			
50 years	Occurrence	22%	1%
	Non-occurrence	78%	99%
100 years	Occurrence	39%	1%
	Non-occurrence	61%	99%
200 years	Occurrence	63%	2%
	Non-occurrence	37%	98%
500 years	Occurrence	92%	5%
	Non-occurrence	8%	95%

It should be noted that this calculation is only correct if it can be shown that there are no long-term changes or trends in the magnitude of floods or activity of the deformed rock mass. For example, if a future site investigation finds that tension cracks had started to open in the vicinity of the Timber Creek Linears, the probability of occurrence would need to be re-assessed.

2. *How can we express to the public that there is no imminent risk?*

Upon visiting the TCL in the field, BGC noted various signs that could be associated with large scale slope deformation, however none suggest imminent slope collapse. No features associated with active deformations were observed. For example, BGC did not observed open tension cracks, deformed or damaged trees, bulging toe slope, or evidence of frequent rock fall, which would indicate ongoing movement. Therefore, BGC concluded that, at the time of field investigations in 2017, there appears to be no imminent risk of rock avalanche occurrence.

Most, but not all, large rock slope failures are preceded by observable deformations. Typically, these slope movements are initially gradual followed by rapid acceleration until slope collapse. This means, that when monitored with the appropriate instrumentation arrays (plus its regular maintenance and data downloads and processing), a lead time (varying between hours and months depending on specifics of the monitoring system and slope failure mechanism) could be provided to warn potentially affected population. Even with a robust monitoring system in place, the exact time of the failure cannot be predicted.

It is possible, however, that an earthquake could suddenly release a rock avalanche with little or no lead time. We speculate that such an earthquake would need to have a large magnitude or have its epicenter near the TCL, but too little is known to be sure about the potential trigger by an earthquake.

2.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of Fraser Valley Regional District. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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Yours sincerely,

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MJ/MAB/sjk