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Terrain Specialists

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January 10, 2024
File: Tis24001

Memo: Natural Hazards affecting 6991 Highway 99 (PID 028-270-304), Tisdale Developments Ltd. (Figure 1).

Assessment Trigger

According to a letter received by Tisdale Developments Ltd. (TDL) from Village of Pemberton, TDL has been requested to provide a "geotechnical slope stability study" and an “existing and proposed slope analysis” for the Tisdale Property in the Pemberton Industrial Park (Figure 1).

Cordilleran reviewed the Village of Pemberton official community plan (OCP) and associated maps (Appendix 1). OCP Section 7.2 Development Permit No. 2 – Natural Hazards expresses the objective to “protect people and buildings, structures and other development from natural hazardous conditions, notably flooding, unstable slopes and wildland fire; and to mitigate or rehabilitate hazardous conditions where possible.” The OCP Section 7.2 references Map L, Land Constraints. It is noted that Map L does not highlight the property. Thus, there is no clear guidance from the Village of Pemberton defining what the concerns at the site are and what needs to be addressed in the report.

The Subject Property & Zoning

The subject property is a ~10.6 hectare parcel. About 7.1 hectares are located within the Village of Pemberton carrying M-2 zoning, while the remainder is within the Squamish-Lillooet Regional District (SLRD) carrying $RR1_{RM}$ zoning (Figure 1). The allowable uses in these zones are presented in detail by Cunningham & Rivard Appraisals (Vancouver) Ltd. (2023), and the reader is directed to that report, or the original zoning bylaws, for details. The Village of Pemberton M-2 zoning allows for a range of light industrial uses, but no residential use; whereas, the SLRD $RR1_{RM}$ zoning does allow for residential uses as well as a range of industrial and other uses. However, the site's lack of standard services adversely impacts the feasibility of developing habitable structures on the SLRD portion of the property.

Note that this report is prepared considering the Village of Pemberton’s jurisdiction, namely the 7.1 hectare portion zoned M-2 (non-residential).

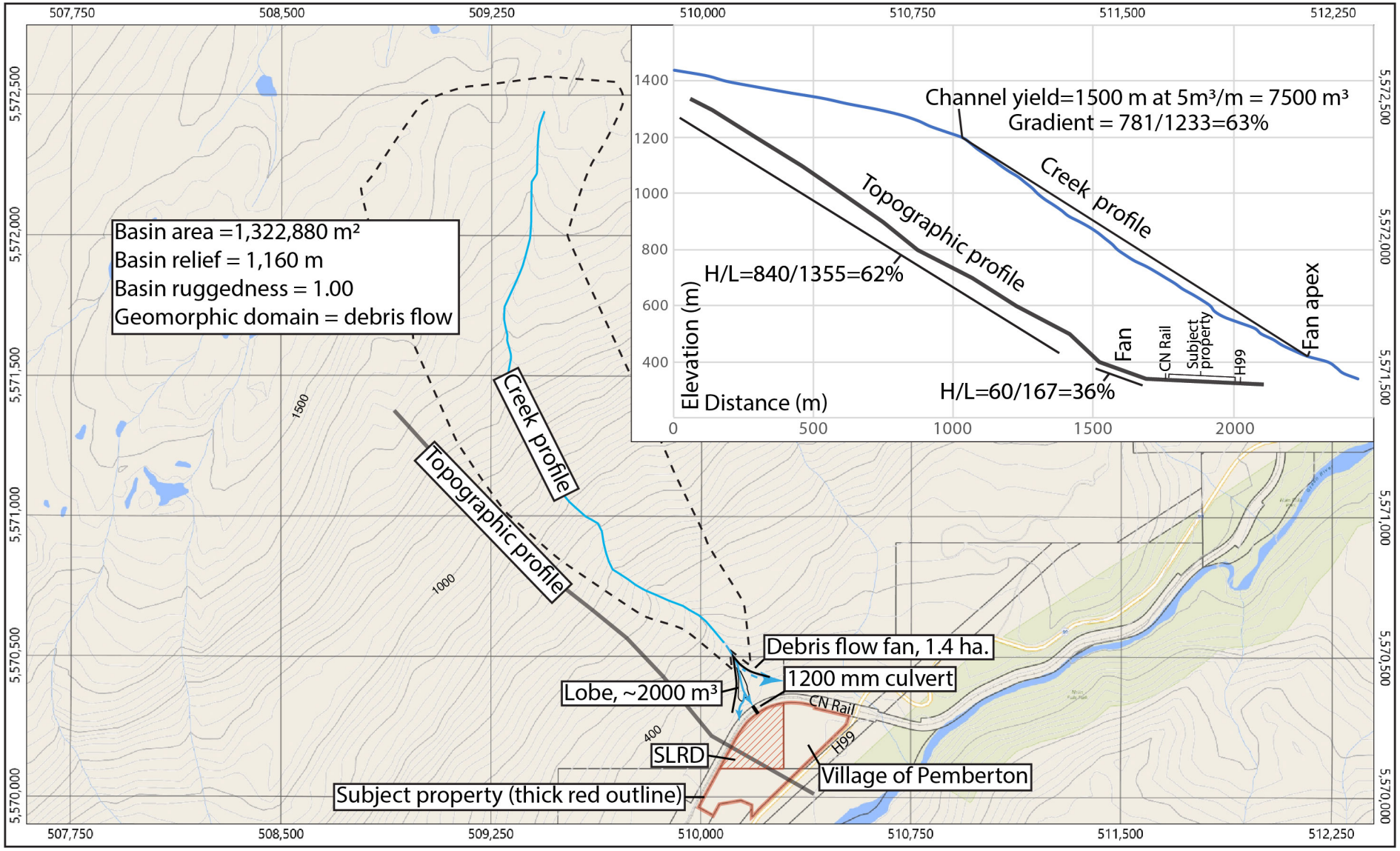

Figure 1. Terrain analysis, 6991 Highway 99, Pemberton Industrial Park, near Pemberton, BC. Red hachured portion is SLRD jurisdiction.

Elements at Risk and Landslide Safety

The site is being used as a storage area for vehicles, RVs, boats and similar items. There is no residential use on the land. The Village of Pemberton, and the SLRD for that matter, do not have an adopted policy for landslide risk safety. Landslide risk policies Cordilleran is aware of (Cave 1993; MoTI 2015, etc) are concerned with loss of life, not loss of goods.

Scope and Study Type

This memo has been prepared to fulfill the need for a landslide assessment (EGBC 2023). Herein, Cordilleran reports on potential landslide hazards affecting the subject property; we do not discuss the geotechnical stability of the ground underlying the subject property.

Given there is no existing or proposed residential use, M-2 zoning forbids residential use, and the existing use consists of storage of goods only, the situation is deemed low risk. As such, this study consists of a Class 0 landslide assessment (EGBC 2023; Appendix B). It is based on desktop review; previous field visits to the subject property to report on flooding issues (Cordilleran 2015) and drainage management (Cordilleran 2023); and on Cordilleran's 30-years of professional experience conducting terrain assessments in the Sea-to-Sky Corridor and throughout BC.

Landform Description

The project area is located on the distal margin of the Rutherford Creek alluvial fan. The site is a machine-modified, smooth, gently northeast-sloping surface, consisting of a blanket fan gravel overlying a clay/silt of deglacial lacustrine origin.

From the fan apex upstream of H99 downstream to its confluence with Green River, Rutherford Creek is deeply incised in the fan body. It is judged that the fan is a relict feature deposited during the early post glacial period.

In Cordilleran's opinion there is no risk of flooding or debris from Rutherford Creek affecting the subject property. Similarly, the site is elevated well above (>10 m) Green River, and there is no risk of Green River flooding affecting the subject property.

The hillslope to the west rises from ~330 m elevation at the subject property to 1560 m elevation at the ridge crest. The hillslope is underlain by hard diorite intrusive rocks. Based on review of aerial imagery on Google Earth, the bedrock is cut by a series of widely spaced joints traversing the slope, leading to a pattern of outcrop and intervening talus. There may be a thin veneer of morainal sediment in topographic lows. The overall slope gradient is between 50-70% (Figure 1).

A small watershed occupies the hillslope above the property (Figure 1). The watershed has an area of 1.3 km^2 and a relief of 1160 m, and an overall basin steepness (Ruggedness; Melton 1965) of 1.0. This result would indicate that the watershed may be

prone to debris flow activity (Millard et al. 2006). At the mouth of the watershed, there is a small alluvial fan, and based on field observation (Cordilleran 2023), the channel is unconfined, such that it is prone to lateral instability and channel avulsion. There is no record of debris flow activity on the channel, but it has shifted its position from directly upslope of the culvert under the CN Rail tracks, to a location about 50 m south along the right of way (Figure 1). The flow is then gathered by the CN Rail ditch, and routed to the original 1200 mm culvert.

Landslide Frequency-Magnitude

Debris slide/avalanche

Based on the overall slope steepness (moderately steep), surface expression (irregular to broken), and parent material (rock/talus), the potential for debris slides or debris avalanches from the open slope face to the west of the property occurring and then reaching the property is judged to be low (<1/500 per annum) to very low (<1/2500 per annum; Table 1).

Rockfall

Since there is no extensive rockfall talus slope encroaching onto or immediately bordering the west side of the property, and since there are no extensive tall cliffs directly above, the potential for rockfall affecting the property is judged to be very low (<1/2500 per annum; Table 1).

Table 1. Qualitative hazard frequency categories.

Qualitative frequency	Annual return interval (yrs)	Probability in 50 years	Comments
Very high	<20	>90%	Hazard is well within the lifetime of a person or typical structure. Fresh evidence is present.
High	20-100	40% - 90%	Hazard could happen within the lifetime of a person or structure. Events are identifiable from deposits and vegetation, but may not be fresh.
Moderate	100-500	10% - 40%	Hazard within a given lifetime is possible, but not likely. Evidence may not be easily noted.
Low	500-2500	2% - 10%	The hazard is of uncertain significance.
Very low	>2500	<2%	The occurrence of the hazard is remote.

Debris flow

As discussed above, the small watershed above and west of the property may be debris flow prone. Based on a simple channel yield estimate, assuming a yield of 5 m^3/m of channel length (Channel Type A, bedrock; Hungr et al 1984), the creek could yield a debris flow volume of 7500 m^3. This is a Class 3 debris flow with the potential to "destroy larger buildings, damage concrete structures, damage roads and pipelines, and block creeks (Table 2)." This volume is considered a maximum credible event, with a low frequency (<1/500 per annum). Smaller, Class 2 debris flows (<1000 m^3), with the potential to "bury cars, destroy small wooden buildings, break trees, block culverts, and

damage heavy machinery (Table 2)" would be expected to have a moderate frequency (1/100-1/500 per annum). The runout of small (Class 2; <1000 m^3) debris flows is known to be highly sensitive to topographic obstruction (Fell et al. 2005), and as a result small debris flows from the watershed west of the subject property would lose considerable energy on the alluvial fan, and would likely be intercepted by the railway berm before impacting the subject property.

Table 2. Landslide size class ratings describing impacts for each class (Jakob 2005).

Class	Volume (m^3)	Peak discharge (m^3/s)	Potential consequences
1	$<10^2$	<5	Very localized damage, known to have killed forestry workers in small gullies and damaged small buildings.
2	10^2-10^3	5-30	Bury cars, destroy small wooden buildings, break trees, block culverts, and damage heavy machinery.
3	10^3-10^4	30-200	Destroy larger buildings, damage concrete structures, damage roads and pipelines, and block creeks.
4	10^4-10^5	200-1500	Destroy camps, destroy sections of infrastructure corridor, damage bridges and block creeks.
5	10^5-10^6	1500-12,000	Destroy camps and forest up to 2km^2 in area, block creeks and small rivers.

Conclusions

Cordilleran has presented a Class 0 landslide assessment (EGBC 2023; Appendix B) for the subject property.

The hazard of openslope debris slides/avalanches and rockfall at the subject property is judged to be very low (<1/2500 per annum; Table 1).

We have identified a potential debris flow hazard affecting the west side of the subject property in the vicinity of the 1200 mm metal culvert conveying a small unnamed creek beneath the CN Rail grade onto the subject property (Figure 1). It is judged the hazard area extends along the CN Rail right of way a distance ~75 m north and south of the culvert. The hazard threat affecting the subject property is uncertain due to the fact that the landforms have been modified by the railway construction and by earth moving on the subject property.

In Cordilleran's opinion, smaller debris flows (<~5000 m^3) likely deposit on the fan on crown land west of the subject property and debris may be contained by the CN Railway berm; these smaller events may have a moderate frequency (1/100-1/500 per annum; Table 1), but as indicated, do not affect the subject property. Larger events, with volumes of 5000-10,000 m^3 may overwhelm the CN Rail culvert and railway berm and cause sedimentation on the subject property, with direct impacts specifically restricted to that portion of the subject property under the jurisdiction of the SLRD (Figure 1); these maximum credible events are judged to have low frequency (<1/500 per annum;

Table 1). The potential for debris flow to directly affect the land under Village of Pemberton jurisdiction is very low (<1/2500 per annum) to negligible.

Risk Management

Risk management may include measures such as

i. Preventing access during periods of heavy rain, rain-on-snow or rapid snowmelt, within a ~75 m radius from the outlet of the 1200 mm culvert conveying the debris flow creek across the CN Rail right of way;

ii. Placing signage warning of the debris flow hazard within a ~75 m radius of the outlet of the 1200 mm culvert;

iii. If residential use, whether homes and camp facilities, are planned in future for SLRD lands zoned $RM1_{RM}$, then a more detailed assessment (Class 1; EGBC 2023, Appendix B) would be required to support development.

References

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Closure

This report was prepared for use by Paul Turner of Tisdale Developments Ltd., including distribution as required for purposes for which the report was commissioned. The report cannot be distributed to other third parties without prior written consent by Cordilleran Geoscience. The work has been carried out in accordance with generally accepted geoscience practice. Judgment has been applied in developing the conclusions stated herein. No other warranty is made, either expressed or implied to our clients, third parties, and any regulatory agencies affected by the conclusions.

Sincerely,

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Professional Geoscientist
EGBC Permit to Practice: 1002800

Appendix 1. Village of Pemberton DPA2

7.2 Development Area Permit No. 2 – Land Constraints

A Development Permit is required for areas which are hereby established and designated as DPA#2 within Map L for the purpose of the protection from natural hazards in accordance with Section 919.1(1) (b) of the Local Government Act.

7.2.1 Objectives

The Village of Pemberton has established DPA#2 – Land Constraints, in an effort to fulfill the following:

- Identify and protect people and buildings, structures and other development from natural hazardous conditions, notably flooding, unstable slopes and wildland fire; and
- Mitigate or rehabilitate hazardous conditions where possible.

7.2.2 Guidelines

The following Guidelines apply to all development proposed on lands within DPA#2, categorized as Slope, Flooding and Wildland Fire Hazards.

Slope Hazards:

a) All development in the slope hazard development permit area shall be required to submit a geotechnical report prepared by a qualified professional engineer.

b) Require certificates of approval on all construction works under the direct supervision of a qualified professional. Restrictive covenants may also be required to notify property owners of any specific conditions or concerns related to the geotechnical issues of the project.

c) Prohibit development on slopes greater than 40% except for public infrastructure installations including private driveways. Such installations shall still require the submission of a geotechnical report identifying mitigation measures to control soil, rock, and water erosion. Disturbed areas shall require revegetation with nature native plant material after the servicing work is completed.

Flood and Debris Hazards:

a) Provide professional reports and certification that ensures that the development meets the Flood Construction Level requirements for the Lillooet River and Pemberton Creek.

b) Provide professional reports and certification that ensures that the development will able to mitigate the impacts of debris flow of Pemberton Creek.

Wildland Fire Interface Hazards:

a) Require specific measures for fuel load management in areas designated in Map L-Wildland Fire Interface Hazard Areas to submit a pre-development fire risk assessment and fuels management strategy by a wildfire management specialist that considers FireSmart recommendations and OCP directives.

b) Wildland Fire Interface Hazard Areas shall extend to a minimum of 50.0 meters beyond the boundary of the proposed phase of development under construction, provided there is permission from the adjacent landowner.

c) Buildings and structures shall following any prescribed fire resistant design requirements as defined in the Building Code and Building Bylaw.