

Post-wildfire Natural Hazard & Risk Assessment: The Twin Two wildfire (V30941), near Pemberton, BC



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V1 October 9, 2026

Table of Contents

The Twin Two Wildfire (V30941).....	1
Terrain Hazard and Risk Assessment	1
Independent Review	3
Geomorphic Overview	4
The Study Area	4
Debris Avalanches and Debris Flows.....	4
Rockfall Hazard	6
Landslide Landscapes, Runout and Geomorphic Cascades	6
Basin Steepness and Geomorphic Domain.....	7
Alluvial Fans.....	8
Climate.....	10
Hydrology	11
Annual Hydrograph.....	11
Peak Flow Estimates	11
Dam Break Floods.....	13
Logging history.....	14
Fire History	17
The Twin Two Fire (V30941).....	18
Fire Weather	18
Burn Severity	22
Elements at Risk.....	25
BC Hydro Towers.....	25
In-SHUCK-ch FSR.....	27
Major Crossings	27
Minor Crossings	28
Twin One Recreation Site (#218).....	29
Water Infrastructure.....	29
Water Quality.....	30
Residences	31
Water Survey Canada Lake Level Gauge.....	32
Spiritual Sites.....	33
Conclusions	33
Recommendations	33
Watershed Scale.....	33
BC Hydro Towers.....	33
In-SHUCK-ch FSR Major and Minor crossings	34
Twin One Recreation Site.....	34
Residences on Twin One fan	34
Intake on Twin Two Creek	34
Residences on Twin Two Creek Fan	34
Water Quality.....	34
Water Survey Canada Lake Level Gauge.....	35
Spiritual Sites.....	35
Behavioural Safety Precautions	35
References	35
Closure	37

List of Appendices

Appendix 1. Annotated photos of the Twin Two (V30941) post-wildfire watershed condition.

Appendix 2. Field burn severity plot spreadsheet.

Appendix 3. Annotated photos of domestic water infrastructure.

List of Figures

Figure 1. Twin Two Fire (V30941). Fire perimeter, BARC classification, burn intensity field plots, subbasins & morphomeric analyses.

Figure 2. Rockslides in the Joffre and Mount Matier alpine area: ~2016, 0.1 M m³, Mt Slalok rockfall; ~2012, 0.5 M m³, Mt Taylor rockfall; May 19-20, 2019 5 M m³ rockslide from the north face of Joffre Peak; July 5, 2025 400,000 m³ rockfall onto Matier glacier.

Figure 3. Twin Two Fire (V30941).Twin One & Twin Two alluvial fans, fan hazard polygons & elements at risk.

Figure 4. Temperature and Precipitation Graph for 1991 to 2020 Canadian Climate Normals for Pemberton, BC (ID 1086082; 50°18'20.326" N, 122°44'02.720" W; 204 m asl).

Figure 5. Annual hydrograph for Pemberton Creek based on monthly average discharges.

Figure 6. Channel long profiles and selected valley side cross sections for Twin One and Twin Two Creeks (see Figure 1 for cross section locations). Topographic profiles were extracted from the Google Earth topographic profile tool.

Figure 7. Previously harvested terrain within the Twin Two wildfire (V30941) perimeter.

Figure 8. Historic wildfire around Lillooet Lake 1922-2024. See Table 12 for Fire IDs.

Figure 9. Monthly climate Normals (1991-2020) versus monthly records for 2026 from Pemberton Airport (1086082).

Figure 10. The Twin Two Wildfire, on the afternoon of July 23, 2026 when the fire moved explosively into Twin One Creek. Source BC Wildfire Service.

Figure 11. Observed daily weather for Pemberton airport, July 1-August 31, 2026. Also showing observed daily fire growth from July 17-August 26, 2026 (Table 13). 30-30-30 refers to the critical threshold condition for wildfire on days where maximum temperatures (max T) exceed 30 °C, minimum relative humidity (RH) drops below 30%, and wind gusts exceed 30 km/h.

Figure 12. Twin Two (V30941) Fire progression, July 17 to August 26, 2026. Increasing lighter shades indicates growth. Successive fire perimeters provided by the BC Wildfire Service. **A.** July 17-July 22 AM. Lightning start on the ridge crest and slow spread toward Twin Two Creek. **B.** July 22 AM to July 25 PM. Explosive growth in Twin Two and then Twin One Creeks. **C.** July 25 PM to July 31 PM. Growth on the NW and SW flanks. **D.** July 31 PM to Aug 26. Smoldering growth.

Figure 13. Twin Two fire (V30941) fire perimeter, BARC classification, BC Hydro towers and angle of reach from hypothetical landslide initiation site to BC Hydro towers.

List of Tables

Table 1. Qualitative descriptions of post-wildfire hazard likelihood, hazard criteria, and related quantitative probabilities. Ratings are modified from Land Management Handbook 56 (Wise et al., 2004) and EGBC Landslide Assessment Guidelines (2023).

Table 2. Qualitative descriptions of the likelihood of spatial interaction and related quantitative probabilities. Ratings are modified from Land Management Handbook 56 (Wise et al., 2004).

Table 3: Matrix of post-wildfire natural hazard partial risk

Table 4. Watershed morphometrics, ruggedness and preliminary estimate of geomorphic domain.

Table 5. Pre-2002 instantaneous peak flow for Pemberton Creek at the gauge (32 km²).

Table 6. Peak instantaneous discharge for Pemberton, Twin One and Twin Two Creeks based on regional power function presented by NHC (2018).

Table 7. Peak discharge estimates for Pemberton Creek based on regional analysis and adjusted for climate change (source NHC 2018).

- Table 8.** Twin One Creek (64.3 km²) hydrology based on regional analysis using Pemberton Creek (08MG025; 30.5 km²; 1987-2024).
- Table 9.** Twin Two Creek (20.1 km²) hydrology based on regional analysis using Pemberton Creek (08MG025; 30.5 km²; 1987-2024).
- Table 10.** Hypothetical landslide dam breach scenarios for Twin One and Twin Two Creeks.
- Table 11.** Cutblock information available on iMapBC for Twin One Creek.
- Table 12.** Historic wildfire polygons on Lillooet Lake (1922-2025).
- Table 13.** Fire area and growth from fire perimeters provided by the BC Wildfire Service.
- Table 14.** Comparison of Field burn severity and BARC classification: grey - sites with same classification; yellow - sites on/near polygon boundary with similar classification; orange - sites with different classification. Boxed shows consistency of Moderate plus High classification.
- Table 15.** Burnt area as a percentage of total watershed area, and parsed by burn severity class.
- Table 16.** Watershed area parsed by burn severity class and slope class, expressed as percentage.
- Table 17.** Post-wildfire debris avalanche and debris flow hazard affecting BC Hydro towers downslope of Twin Two wildfire (V30941). Post-wildfire, hazard (P_H), based on %cover of M+H (%) burn intensity on 50-90% slopes (see Tables 1-3). See Figure 13 for ID locations.
- Table 18.** Bridge opening required for extreme flood events on Twin One and Twin Two Creeks.
- Table 19.** Post-wildfire risk to major crossings (Figure 1). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and $P_{S/H}$ is spatial impact rating (see Tables 1-3).
- Table 20.** Post-wildfire risk to minor crossings (Figure 1). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and $P_{S/H}$ is spatial impact rating (see Tables 1-3).
- Table 21.** Post-wildfire risk to Twin One Recreation Site (Figure 3). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and $P_{S/H}$ is spatial impact rating (see Tables 1-3).
- Table 22.** Post-wildfire risk to Domestic Water Intake structures (Figure 3). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and $P_{S/H}$ is spatial impact rating (see Tables 1-3).
- Table 23.** Parcel details for properties on Twin One and Twin Two Creek fans.
- Table 24.** Start and end points (UTM grid reference, NAD83, Zone; m)
- Table 25.** Post-wildfire risk to Residential Lots (Figure 3). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and $P_{S/H}$ is spatial impact rating (see Tables 1-3).
- Table 26.** The location of identified spiritual sites, Twin Two wildfire (V30941).

The Twin Two Wildfire (V30941)

The Twin Two wildfire (V30941) affected 3772 hectares (ha) on the north shore of Lillooet Lake, near Pemberton BC (Figure 1). Post-wildfire hazards (debris flood, debris flow) potentially affect several elements at risk bordering the shoreline of Lillooet Lake. This report was prepared to identify imminent natural hazard threats arising from the wildfire, to identify the associated risks, and to establish immediate response plans. The methodology follows Land Management Handbook 69: Post-wildfire natural hazards risk analysis in British Columbia (Hope et al 2015). The scope of work follows a **Level 3** reconnaissance assessment that involves extensive fieldwork, partial risk estimates for identified elements at risk, and conceptual risk mitigation measures as required.

Terrain Hazard and Risk Assessment

A hazard is a phenomenon with the potential to cause harm. Consequence is the measure of the harm caused, and is a product of factors, including whether a given hazard will reach a site, whether elements at risk (e.g., houses/people) will be present when the site is affected by the hazard, how vulnerable the elements at risk are to the hazard affecting the site, and the value of the elements at risk or the number of persons exposed. The product of the factors Hazard and Consequence equals Risk.

No activity is free of risk, and the concept of safety embodies risk tolerance. In Canada and BC there is no legislated guidance for risk tolerance to geohazards, and the term “safe” has not been defined. In considering risk tolerance, an important concept is that risk of loss of life from natural hazards should not add substantially to those that one is typically subject to (e.g., driving, health, recreation, etc) combined. For reference, the risk of death and injury from driving in Canada is approximately 1:10,000 and 1:1000 per annum, respectively (Transport Canada, 2011). The Forest and Range Practices Act refers to risk when it states that there should be no material adverse impact to soils, visual quality, timber, forage, water, fish, wildlife, biodiversity, recreation, and cultural resources. However, “material adverse impact” has not been defined in the Act or elsewhere.

Terrain reports typically provide *partial landslide risk* analysis, identifying potential hazards in a landscape, and estimating whether there will be impact at an identified element at risk. This report follows the methodology outlined by Hope et al (2015). The post-wildfire hazard (Table 1) and consequence (Table 2) are described qualitatively, and the risk is outlined in a matrix (Table 3).

Table 1. Qualitative descriptions of post-wildfire hazard likelihood, hazard criteria, and related quantitative probabilities. Ratings are modified from Land Management Handbook 56 (Wise et al., 2004) and EGBC Landslide Assessment Guidelines (2023).

Hazard Likelihood (P(H))	Description	Hazard Criteria	Annual Probability Range and Return Frequency	Five Year Cumulative Probability
Very High	An event is expected to occur over a 5-year period.	- Most of the catchment has burned with a significant proportion burned at moderate and/or high severity. - Evidence of pre-fire terrain instability within stream channels, on fans or face units. - Post fire instability observed on similar terrain nearby.	>0.20 (>1:5)	>67%
High	An event is probable under adverse conditions.	- Most of the catchment has burned with a significant proportion (i.e., >50%) of terrain conducive to post-wildfire natural hazard initiation burned at moderate and/or high severity. - Indicators of pre-fire terrain instability within stream channels, on fans or face units.	0.01 - 0.2 (1:100 to 1:5)	5 – 67%
Moderate	An event could occur under adverse conditions- it's not probable, but possible over a several year period.	- More than 20% of the terrain conducive to post-wildfire natural hazards in the catchment area was burned with moderate and/or high severity. - Historic geomorphic indicators of instability are present.	0.002 - 0.01 (1:500 to 1:100)	1 – 5%
Low	An event could occur under very adverse conditions - it's considered very unlikely to occur over a several year period.	- Only a limited proportion of the catchment was burned during the fire. - Few or no signs of pre-fire instability are present within stream channels, on fans, or face units.	0.0004 - 0.002 (1:2,500 – 1:500)	0.2 – 1%
Very Low	An event will not occur; or is conceivable though considered exceptionally unlikely to occur over a several year period.	- A limited proportion/none of the catchment was burned during the fire. - No terrain instability indicators are present.	<0.0004 (<1:2,500)	<0.2%

Table 2. Qualitative descriptions of the likelihood of spatial interaction and related quantitative probabilities. Ratings are modified from Land Management Handbook 56 (Wise et al., 2004).

Likelihood of Spatial Impact	Description	Criteria	Probability Range
High Likelihood	The element at risk will be impacted by the hazard.	The element at risk is within or immediately adjacent to a stream channel, at the apex of a fan, or at the foot of a face unit slope, and there are no natural or artificial barriers preventing the hazardous event from impacting the element.	> 0.5
Moderate Likelihood	It is possible that the element at risk will be impacted by the hazard.	- The element at risk is located outside the zone of direct impact, but within a zone of potential impact based on the geomorphic processes associated with the specific hazard. - There are no natural or artificial barriers preventing the hazardous event from impacting the element.	0.5 - 0.1
Low Likelihood	It is unlikely that the element at risk will be impacted by the hazard.	The element at risk at the distal end of a runout zone for the specific hazard. Natural or artificial barriers exist that are anticipated to prevent the hazardous event from impacting the element.	<0.1

Table 3: Matrix of post-wildfire natural hazard partial risk.

Hazard Likelihood P(HA) (Table 1)	Spatial Impact Likelihood (P(S:H)) (Table 2)		
	High	Moderate	Low
Very High	Very High	Very High	High
High	Very High	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Very Low
Very Low	Low	Very Low	Very Low

Independent Review

As Post-wildfire Natural Hazard and Risk Assessment (PWNHRA) is a reactive emergency assessment conducted rapidly as soon as conditions permit post-wildfire, there is little time for external independent review. While PWNHRA may assess natural-hazard scenarios with potentially severe consequences, including loss of life, the professional activity is undertaken as part of an emergency response using an established and conventional methodology, with a well-

defined scope and conceptual-level recommendations, and is therefore not considered high-risk professional work.¹ David Kallai, P.Geo., (Facet Geoscience Inc.) participated in the field assessment, and conducted an “internal” review of the final report.

Geomorphic Overview

The Study Area

The fire perimeter extends along the shoreline of Lillooet Lake for a distance of about 6.5 km from Cataline Creek south to the Lizzie Creek. The lower boundary follows the east boundary of the Lillooet Lake FSR and the upper boundary crests the valley sidewall slope at ~2000 m asl, with the fire extending up the drainages of Twin One and Twin Two Creeks. About 30% of each watershed is within the fire boundary (Figure 1).

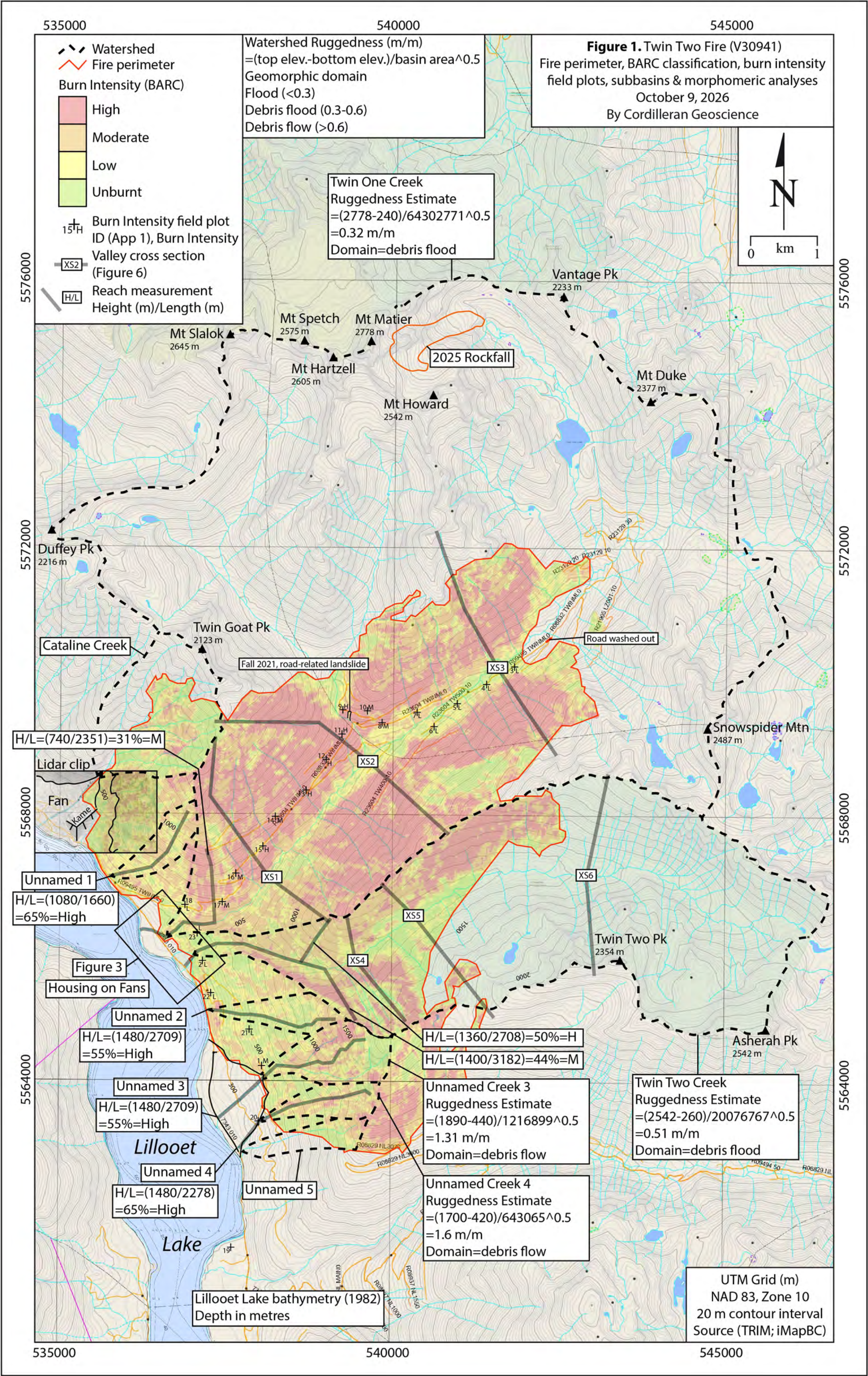
The entire area was glaciated, leaving rounded ridges and U-shaped valleys. Valley sidewalls are typically steep and rocky, with veneers of colluvium and till, while valley bottoms contain thick deposits of glacial sediment, forming a valley fill. Post-glacial sediments consist of rockfall and debris slide colluvium on mid and lower slopes and floodplain sediments along the river valleys. Bedrock in the study area consists of competent intrusive rocks (granodiorite/diorite) of the Coast Plutonic Complex. The zonal soil in the region is the podzol (Valentine et al 1986). Rainfall leaches soil, leading to a dark orange, strongly oxidized soil profile.

Debris Avalanches and Debris Flows

Landslides in the study area involve fragmental bedrock, organic debris, and mineral sediment. A typical failure is triggered by rockfall from a bluff, by windthrow of large trees on a steep slope, or by release of a weathered soil veneer. The failure plane is typically >60%, but sometimes as low as 40%. Headscarp dimensions are typically 10-50 m wide by 0.5-1.0 m thick. This initial slip then impacts timber downslope clearing a swath through the forest. Landslide types may be differentiated as open slope, gullied (headwall, sidewall, channel), road-related, or single track versus multiple track events (Fannin and Rollerson 1993). Regional storms with severe localised precipitation cells may trigger numerous events (Guthrie and Evans 2004).

Post-wildfire failure potential will be greatest in steep terrain with 60-120% slope, and overlain by a veneer/blanket of till/colluvium (e.g., Rollerson et al 2001, 2005). Natural factors that contribute to the failure rate are wetter climate, higher frequency of extreme rainfall, gullied or escarpment landforms, increasing soil moisture, aspect, and fine-grained sediments (Rollerson et al 2001). Post-wildfire factors contributing to instability are hydrophobicity causing rapid runoff, enhanced slope erosion and in-channel debris flows, loss of evapotranspiration and greater peak discharges, loss of root cohesion, and poor road/fire break design and construction (altered drainage, poor road fillslope construction). After a wildfire the landslide hazard may become elevated above the long-term background rate. This period of elevated hazard is greatest in the first 5 years following fire, and then diminishes to background as vegetation re-establishes. The background rate is not fully re-established until there is mature forest cover with a well-developed root system.

¹ <https://www.egbc.ca/getmedia/ef5d5b68-115d-4d5c-80b8-b47d278823f6/EGBC-Documented-Indep-Rev-of-HRPAW-V1-0.pdf.aspx>



Rockfall Hazard

Rockfall hazards span the range from individual blocks (m^3) to landslide volumes with millions of cubic metres (M m^3). Within the fire boundary, there will be a very high post-wildfire hazard for local, small-scale fragmental rockfall hazard on steep rocky terrain, and moderately steep slopes veneered by angular colluvium. In the alpine areas of the Matier-Joffre massif (Figure 2), outside the fire boundary, large scale (10^4 - 10^6 m^3) rockfall presently (last 16 years) exhibits very high frequency (1/4-years), with potential impacts to proglacial lakes (e.g., Twin One):

- Mt Taylor 2010-2013, 0.5 M m^3 , Friele (2025)
- Mt Slalok, 2016-2017, 0.1 M m^3 , Friele (2025)
- Joffre 2019, 5 Mm^3 , Friele et al (2020)
- Matier 2026, $40,000 \text{ m}^3$, Friele (2025)

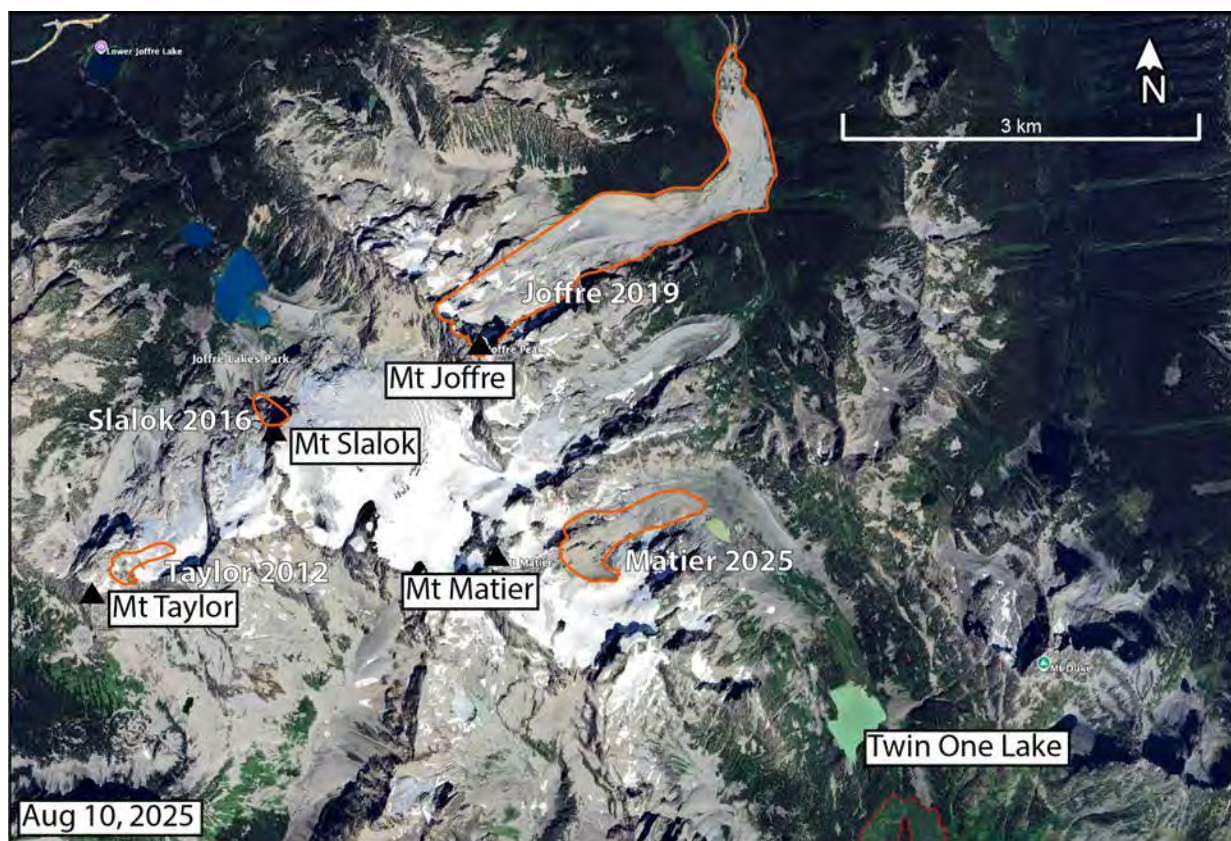


Figure 2. Rockslides in the Joffre and Mount Matier alpine area: ~2016, 0.1 M m^3 , Mt Slalok rockfall; ~2012, 0.5 M m^3 , Mt Taylor rockfall; May 19-20, 2019 5 M m^3 rockslide from the north face of Joffre Peak; July 5, 2025 $400,000 \text{ m}^3$ rockfall onto Matier glacier.

Landslide Landscapes, Runout and Geomorphic Cascades

Hillslope hazards (rockfall, debris avalanche, debris flow) occurring within Twin One and Twin Two watersheds may have direct impacts to lakes and stream channels, with associated influence on stream peak flow discharge. These hillslope hazards do not directly affect elements at risk on Twin One and Twin Two fans (private and crown parcels, domestic intakes, Twin One Recreation Site, FSR bridges, BC Hydro towers, spiritual sites, lake level gauge). However, landslide damming, followed by outburst flood is a typical flood generating mechanism in steep

watersheds (Jakob and Jordan 2001), and landslides within the watersheds will have an *indirect* effect on channel processes that occur on the alluvial fans downstream at the watershed mouth. In contrast, on the face unit above Lillooet Lake, hillslope hazards may *directly* affect elements at risk located along the lake shoreline (FSR minor crossings, BC Hydro towers).

Debris avalanches and debris flows will typically travel to the base of slope, with the deposition zone being a 50-200 m wide belt of terrain less than 30% slope (Fannin and Rollerson 1993). Travel angle, H/L, or ratio of total drop to total horizontal length of the landslide is widely used to characterise travel distance (Corominas 1996), and this measure can be used in terrain hazard mapping as a first order estimate of potential impact areas.

A large sample of landslide travel angles were collected by the author from the Coast Mountains. The resulting travel angles were grouped into categories with H/L>50% a high probability of direct impact, H/L=30-50% a moderate probability of direct impact and H/L<30% a low probability of direct impact.

Basin Steepness and Geomorphic Domain

We have delineated a total of eight watersheds intersecting the length of the FSR below the fire boundary (Figure 1). These include Cataline Creek, Twin One and Twin Two Creeks, and five unnamed subbasins. The steeper, or more rugged, a watershed is, the more intense the channel processes may be. Based on Melton's ruggedness screening (Melton 1965), the Twin One and Twin Two watersheds are classified as debris flood² basins (Table 4). Both creeks are hanging valleys with steep slopes feeding steep confined channels near the watershed mouths. It is possible that debris avalanches or debris flows off the steep sidewall slopes could enter the channel and propagate as debris flow.³ However, these would likely become diluted, reaching the fan apex as debris floods. In contrast, subbasins on the valley sidewalls above the lake (i.e., the face units) are steep, and channels there are debris flow prone (Cataline, Unnamed 1-5; Table 4).

Table 4. Watershed morphometrics, ruggedness and preliminary estimate of geomorphic domain

Watershed	Highest point (m asl)	Fan apex (m asl)	Watershed area (km ²)	Ruggedness (m/m)	Geomorphic domain
Cataline	2123	520	3.0	0.92	Debris flow
Twin One	2778	240	64.3	0.32	Debris flood
Twin Two	2542	260	20.1	0.51	Debris flood
Unnamed 1	1440	240	0.7	1.52	Debris flow
Unnamed 2	1520	240	0.8	1.53	Debris flow
Unnamed 3	1890	440	1.2	1.31	Debris flow
Unnamed 4	1700	420	0.6	1.6	Debris flow
Unnamed 5	1480	240	0.5	1.6	Debris flow

² **Debris floods** are water floods with coarse bedload transport in steep mountain channels (typically 5 to 27 gradients) bulked (20-47 by volume) with mineral and organic sediment, such that the channel bed is mobile. Debris floods are transitional between clearwater floods (<20 sediment by volume) and dense, viscous debris flows.

³ **Debris flows** are fast-moving (often >10 m/s), destructive saturated mixtures of loose soil, rock and organic debris flowing down a stream channel. The material acts like flowing concrete or a wet avalanche rather than a normal river flood.

Alluvial Fans

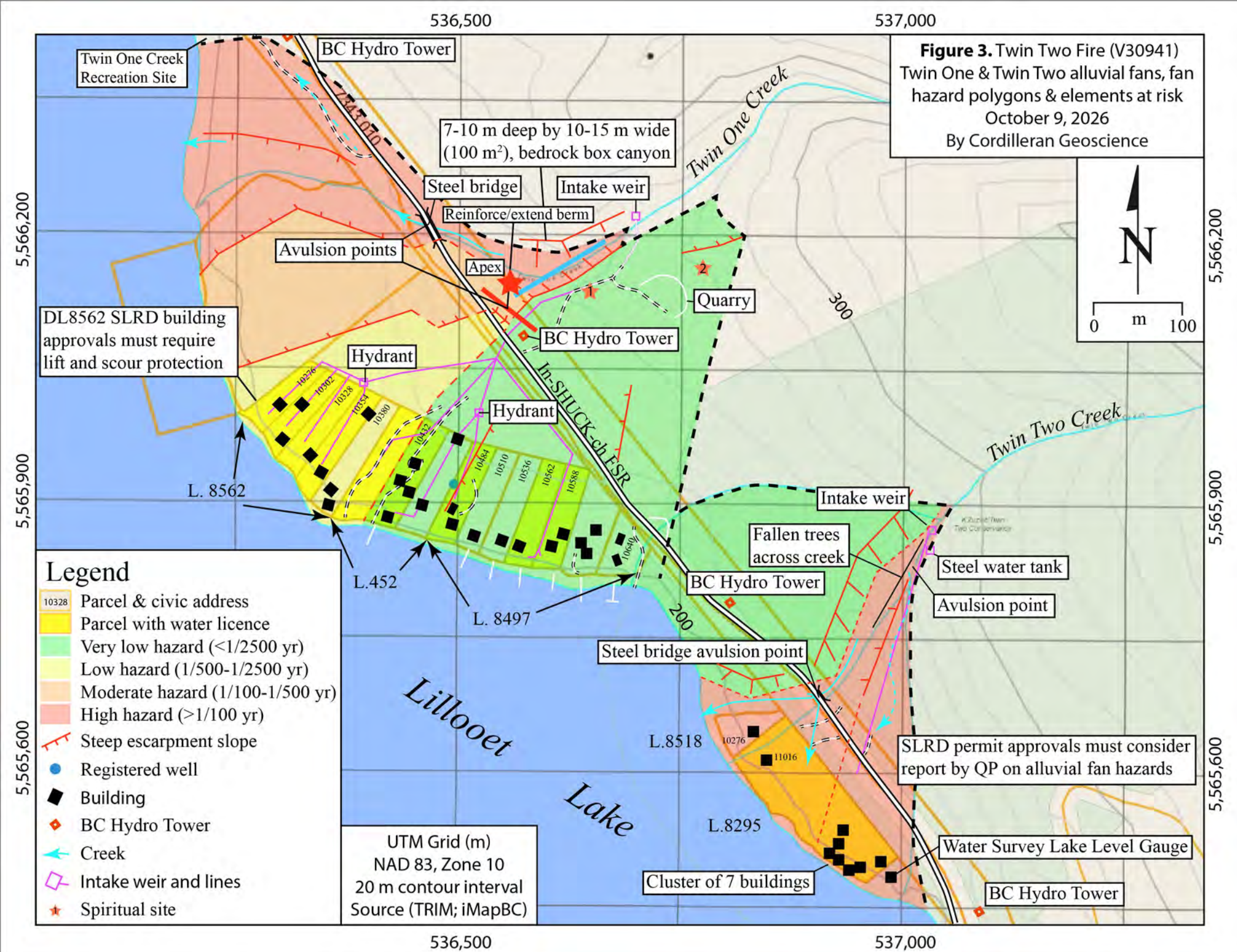
Twin One and Twin Two Creeks have built alluvial fans at their valley mouths. The fan apices stand at ~280 m asl, they impinge on Lillooet Lake (~195-200 m asl), and their subaqueous extent is poorly defined by existing lake bathymetry (Figure 1). The Twin One fan covers an area of ~23 ha and Twin Two fan covers an area of ~10 ha. Fan gradients range from 6-20%. Surface materials consist of very coarse boulder gravel, with surface lobes 2-3 m tall containing boulders 1-3 m diameter. Debris floods transporting these materials would be extremely destructive.

NHC (1990) provide a preliminary or reconnaissance level evaluation of hazards from debris torrents, channel avulsions or other flooding events for land parcels on Indian Arm, Lillooet Lake and Harrison Lake. From review of airphotos, they concluded Twin One Creek has been confined to the north side of the fan since 1948. In contrast, Twin Two Creek had avulsed at least every 15 years during the historic air photo record. On Twin One Creek, they described flooding and erosion along the existing channel that occurred during the regional storm of August 30, 1991. Based on hydrologic and hydraulic analysis, they determined that during peak flow events, flood depths are expected to be ~2.5 m deep with velocities of 5 m/s.

Twin One Recreation Site is located on the northern portion of the Twin One alluvial fan. Baumann (2001) reported 4 m freeboard on the right bank above the active channel of Twin One Creek at the recreation site and concluded that geologic hazards at the recreation site are restricted to potential channel avulsion and associated flooding with return periods at or above ~1/50 per annum. Channel blockage at the FSR bridge was identified as a potential avulsion trigger. No evidence for debris flow, snow avalanche or rock slide activity was evident at the recreation site. Baumann (2001) recommended signage that would alert recreation users to the increased flood hazard during periods of heavy rain or runoff, and suggesting they vacate the area if unusual conditions persist.

NHC (1999) provided a more detailed follow up assessment for Twin One and Twin Two fans. They concluded that the northern six residential parcels on Twin One fan could be affected by avulsion at the bend above the FSR bridge crossing. The other parcels would only be affected by an avulsion upstream of the waterfall, with flow that travels down the road from the log sort yard, which is considered a very unlikely scenario as this would require complete blockage or infilling of the 10 m wide by 10 m deep bedrock canyon that exists between the intake and the sharp north bend above the FSR (Figure 3). For new development proposals, they recommended floodproofing consisting of lift and scour protection for houses on the low hazard lots; the remaining lots were considered free of fan hazard affecting. On Twin Two fan, they concluded that District Lot 8518 is particularly vulnerable to channel avulsion, though protected from moderate flooding in the existing channel.

Based on our field review, both Twin One and Twin Two alluvial fans have higher, inactive fan sectors, with the active fan incised into the raised surfaces supporting large boulder lobes (Figure 3). This is a common feature of alluvial fans in formerly glaciated landscapes, reflecting the rapid decline in sediment supply during deglaciation 11,000 years ago until ~7000 years ago (Church and Ryder 1972).



As sediment supply diminished, Twin One Creek became incised and it swung progressively northward. Today the active fan area (High debris flood hazard) underlies the Twin One Recreation Site. Starting from the southern abutment of the Twin One Creek FSR bridge and moving west there is a 4-m tall escarpment slope that defines the south edge of the active fan (Figure 3). The average fan surface gradient on the active fan is ~9%. Starting from the sharp right bend on the channel just above the FSR, there is a second well defined escarpment trending westward that marks the next fan surface (Moderate debris flood hazard). South of this second escarpment, the remainder of the fan is likely a product of paraglacial activity, and the modern hazard is deemed Low to Very Low. Gradient on this part of the fan is 12-14%.

Twin Two Creek has a raised fan surface on the north side, and the incised active fan on the south side of the fan. At the fan apex near the domestic water intake, the left (south) channel bank is ~1 m above the seasonal active channel margin (i.e., the natural boundary). From this point down to the Lillooet Lake FSR the freeboard on the left (south) bank gradually increases to ~5 m. In this reach there is an abundant amount of fallen trees laying across the channel. Downstream of the FSR re is 2.5 m freeboard on the left bank of the channel.

Climate

Based on climate Normals (30-year period of record with high quality data) for Pemberton airport (ID 1086082; Figure 4), the climate in Pemberton is classified as Mediterranean:

- Summers are warm, sunny, and relatively dry, with daytime temperatures often peaking in the high 20s (°C).
- Winters are cool and wet with regular rain and seasonal snowfall. The area lies in the transition zone between the wet coast and the drier interior.

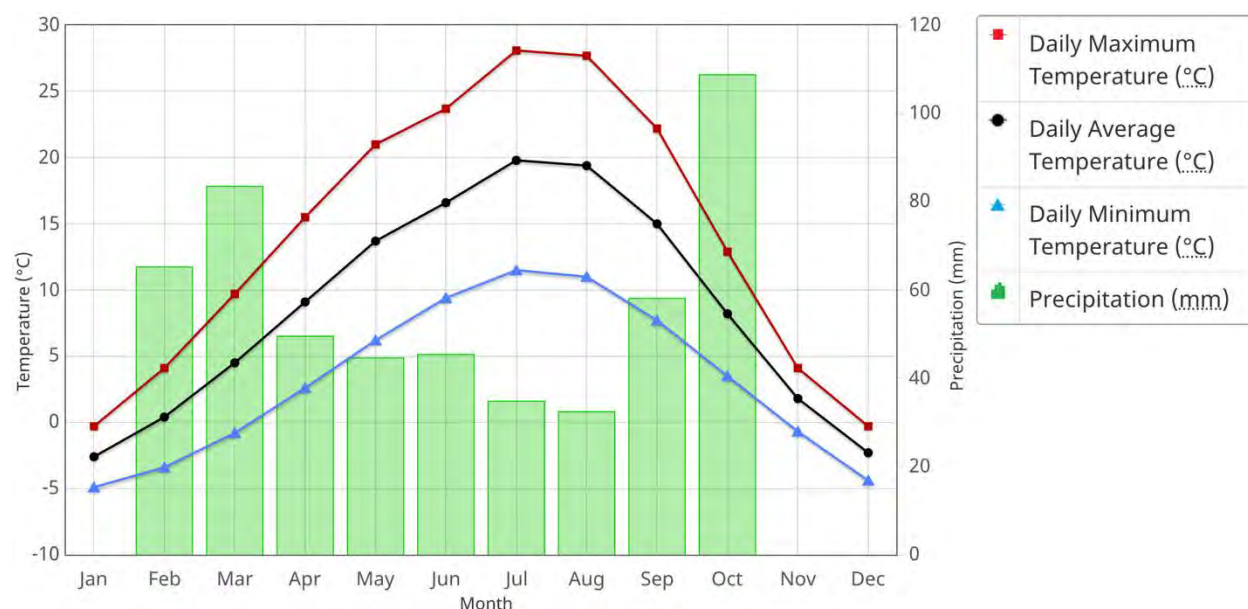


Figure 4. Temperature and Precipitation Graph for 1991 to 2020 Canadian Climate Normals for Pemberton, BC (ID 1086082; 50°18'20.326" N, 122°44'02.720" W; 204 m asl).

Hydrology

Annual Hydrograph

Twin One and Twin Two Creeks are ungauged streams and peak flow estimates are based on comparison with gauged streams from similar size and hydrologic regime. Based on watershed size and proximity, Pemberton Creek (30.5 km²) is the most representative gauged stream, and here we review flood frequency estimates for Pemberton Creek as a basis for extrapolating to the Twin Two study area. Pemberton Creek has a snowmelt dominated flood regime, with a sustained snowmelt freshet peaking from May-July and with instantaneous rainfall peaks in the fall, peaking in October (Figure 5).

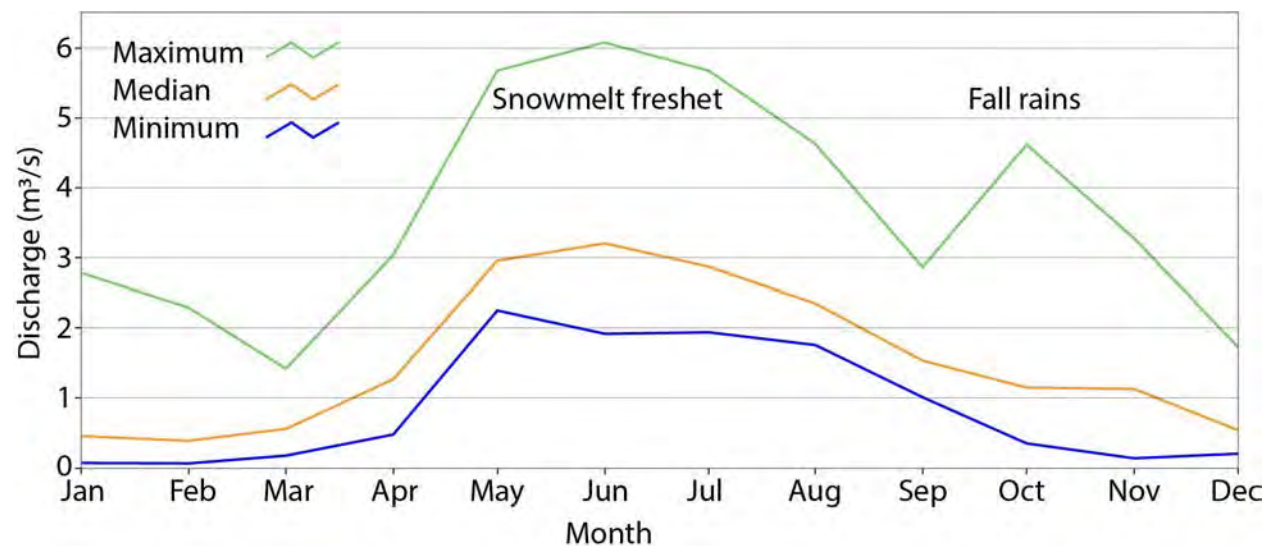


Figure 5. Annual hydrograph for Pemberton Creek based on monthly average discharges.

Peak Flow Estimates

Pre-2002 estimates of the 200-year flood (Q_{200}) for Pemberton Creek suffered from few data points. They were often tied to Green River as an index station, and estimates were on the high side (i.e., too much maritime influence), ranging from 50-100 m³/s (Table 5).

Table 5. Pre-2002 instantaneous peak flow for Pemberton Creek at the gauge (32 km²).

Instantaneous discharge	Cameron 1991	Baumann 2000	NHC 2001	KWL 2002
200 yr	86.1	92	80	46

More recently, NHC (2018) has conducted a regional analysis of all gauged streams within similar climate and has produced the following power function for peak discharge (Q) of any given frequency, n , where

$$Q_n = a * A_b^b$$

with the exponents a and b given in Table 6.

Table 6. Peak instantaneous discharge for Pemberton, Twin One and Twin Two Creeks based on regional power function presented by NHC (2018).

Return Interval (yr)	Exceedance probability	a	b	Peak discharge (m ³ /s)		
				Pemberton	Twin One	Twin Two
2	0.5	0.571	0.857	10.7	20.2	7.5
50	0.02	1.477	0.839	26.0	48.6	18.3
100	0.01	1.762	0.834	30.5	*56.8	21.5
200	0.005	2.098	0.829	35.7	66.2	25.2

*this is equivalent to an estimate of 60 m³/s provided by Greg Dohm (pers comm; Sept 10, 2026)

The resulting 200-year discharge for Pemberton Creek is 36 m³/s. In their final analysis of 200-year flood peaks to include in their Lillooet River flood hydrograph, they chose the values in Table 7 for Pemberton Creek (30 km²). Note +CC indicate estimates increased by 20% to account for climate change. Their 200 yr estimate ranges from 37-44 m³/s.

Table 7. Peak discharge estimates for Pemberton Creek based on regional analysis and adjusted for climate change (source NHC 2018). +CC indicates adjusted value for climate change.

Model reach	50 yr	50 yr +CC	100 yr	100 yr +CC	200 yr	200 yr +CC
Pemberton Creek	32	38	35	41	37	44

We conducted flood frequency analysis of Pemberton Creek using Gumbel Extreme Value distribution and data from 1987-2024 (Tables 8, 9). Our result for the 200-year instantaneous peak, 52 m³/s, falls between the older higher estimates from earlier studies, and the lower result reported by NHC (2018). As such, we use our values as suitably conservative estimates. We have scaled our estimates of Pemberton Creek to the study area watersheds using a power function developed by the author (Tables 8, 9). This gives the 200-year peak discharges for Twin One and Twin Two Creeks as 93.8 m³/s and 37.4 m³/s, respectively.

Table 8. Twin One Creek (64.3 km²) hydrology based on regional analysis using Pemberton Creek (08MG025; 30.5 km²; 1987-2024).

Return interval (yrs)	Pemberton Creek peak instantaneous discharge (m ³ /s)	Twin One estimated peak discharge (m ³ /s)	*Required cross section area (V=2.5)
2	19	33.4	17.4
50	42	76.7	39.9
100	47	85.3	44.3
200	52	93.8	48.8

*Required cross sectional area assumes a velocity of 2.5 m/s. This is conservative, as use of a larger velocity (4-5 m/s) will require a smaller opening.

Table 9. Twin Two Creek (20.1 km²) hydrology based on regional analysis using Pemberton Creek (08MG025; 30.5 km²; 1987-2024).

Return interval (yrs)	Pemberton Creek peak instantaneous discharge (m ³ /s)	Twin Two estimated peak discharge (m ³ /s)	*Required cross section area (V=2.5)
2	19	13.3	6.9
50	42	30.6	15.9
100	47	34.0	17.7
200	52	37.4	19.5

*Required cross sectional area assumes a velocity of 2.5 m/s. This is conservative, as use of a larger velocity (4-5 m/s) will require a smaller opening.

Dam Break Floods

Landslides occurring within Twin One or Twin Two Creeks could directly impact the channel and cause blockages. Temporary blockage and rapid dam breach may produce extreme instantaneous peak discharge. Where channels are steep, then impoundments will be small volume and outbursts inconsequential; but where gradient is less, then impoundments may extend for longer distance upstream providing larger volumes for release during a breach. As such we have selected three locations on Twin One and one location on Twin Two Creeks to estimate potential landslide induced floods peaks (Figure 6).

Instantaneous peak discharges for dambreak floods were estimated using an empirical equation developed from breach of natural and constructed dams (Walder and O'Connor 1997; Table 10). The equation estimates peak discharge from impounded lake volume (Vol), whereby

$$Q_{\text{peak}} = 0.045 * (\text{Vol})^{0.66}$$

Using channel long profiles and valley cross sections from Google Earth imagery (Figure 6), we have assumed 10 m and 20 m tall landslide barriers, calculated impounded cross-sectional areas and upstream impoundment lengths, and have estimated impoundment volume (Table 10). On Twin One Creek, the values for a 10 m barrier are of a similar order of magnitude to 100-year and 200-year peak flow estimates. Rapid breach of 20 m tall barriers would exceed the peak discharge of extreme hydrologic floods by 3-4 times (Table 10). On Twin Two Creek even the 10 m tall barrier could greatly exceed the hydrologic peak flow (Table 10).

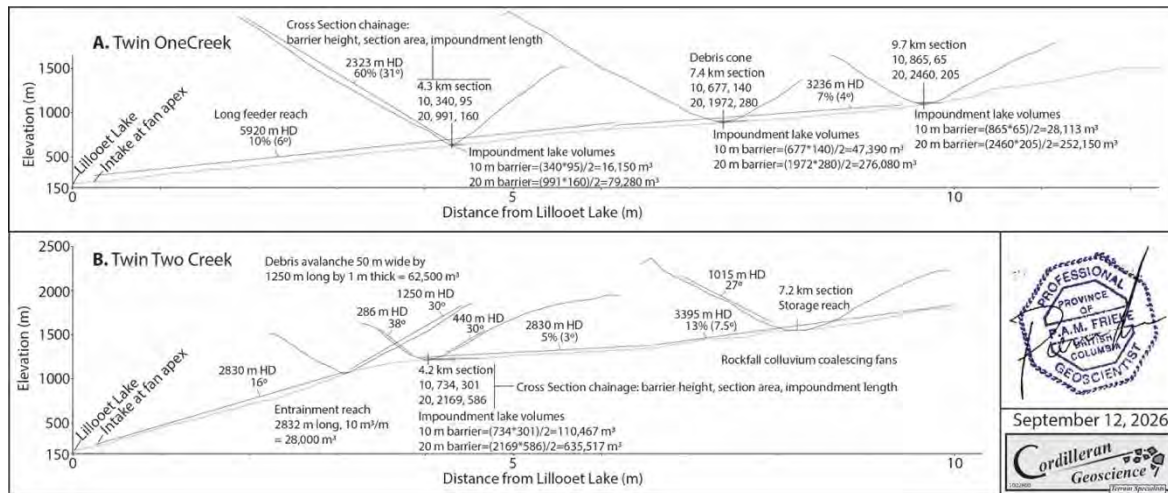


Figure 6. Channel long profiles and selected valley side cross sections for Twin One and Twin Two Creeks (see Figure 1 for cross section locations). Topographic profiles were extracted from the Google Earth topographic profile tool.

Table 10. Hypothetical landslide dam breach scenarios for Twin One and Twin Two Creeks.

River chainage (km)	Barrier height (m)	Channel cross section area (m ²)	Impoundment length (m)	Impoundment volume (m ³)	*Peak discharge (Q _{peak} , m ³ /s)
Twin One 4.3	10	340	95	16150	27
Twin One 4.3	20	991	160	79280	77
Twin One 7.4	10	677	140	47390	55
Twin One 7.4	20	1972	280	276080	176
Twin One 9.7	10	865	65	28113	39
Twin One 9.7	20	2460	205	252150	165
Twin Two 4.2	10	734	301	110467	96
Twin Two 4.2	20	2169	586	635517	304

*Walder and O'Connor (1997): $Q_{peak} = 0.045 * (Vol)^{0.66}$

Logging history

Twin One Creek has been logged starting in the 1980s; whereas Twin Two Creek has remained unlogged and in 2012 was protected within the K'Zuzail Conservancy area. iMapBC does not provide records of the earliest roads or cutblocks in Twin One Creek. There is only record of blocks planned and harvested since 2013 (Table 11). Most of the blocks logged since 2013 were field reviewed prior to logging by terrain stability assessments (TSAs) prepared by Cordilleran (see references).

Based on review of Google Earth, we have mapped blocks visible on the available 1985, 2010, 2013 and 2025 imagery (Figure 7). On 1985 imagery, there are cutblocks along the Lillooet Lake FSR that appear older (154 ha), and there is a new road into Twin One as far as Twin Goat Creek, with a series of fresh cutblocks (122 ha), and a fire in and extending above one of them (V30004; start date 1985-06-07). On the 2010 imagery, there was extensive logging right to the back end of Twin One Creek (400 ha). On the 2013 imagery the cutblocks TW100 and TW500 are fresh (33 ha), and by 2025 most merchantable timber had been harvested (75 ha).

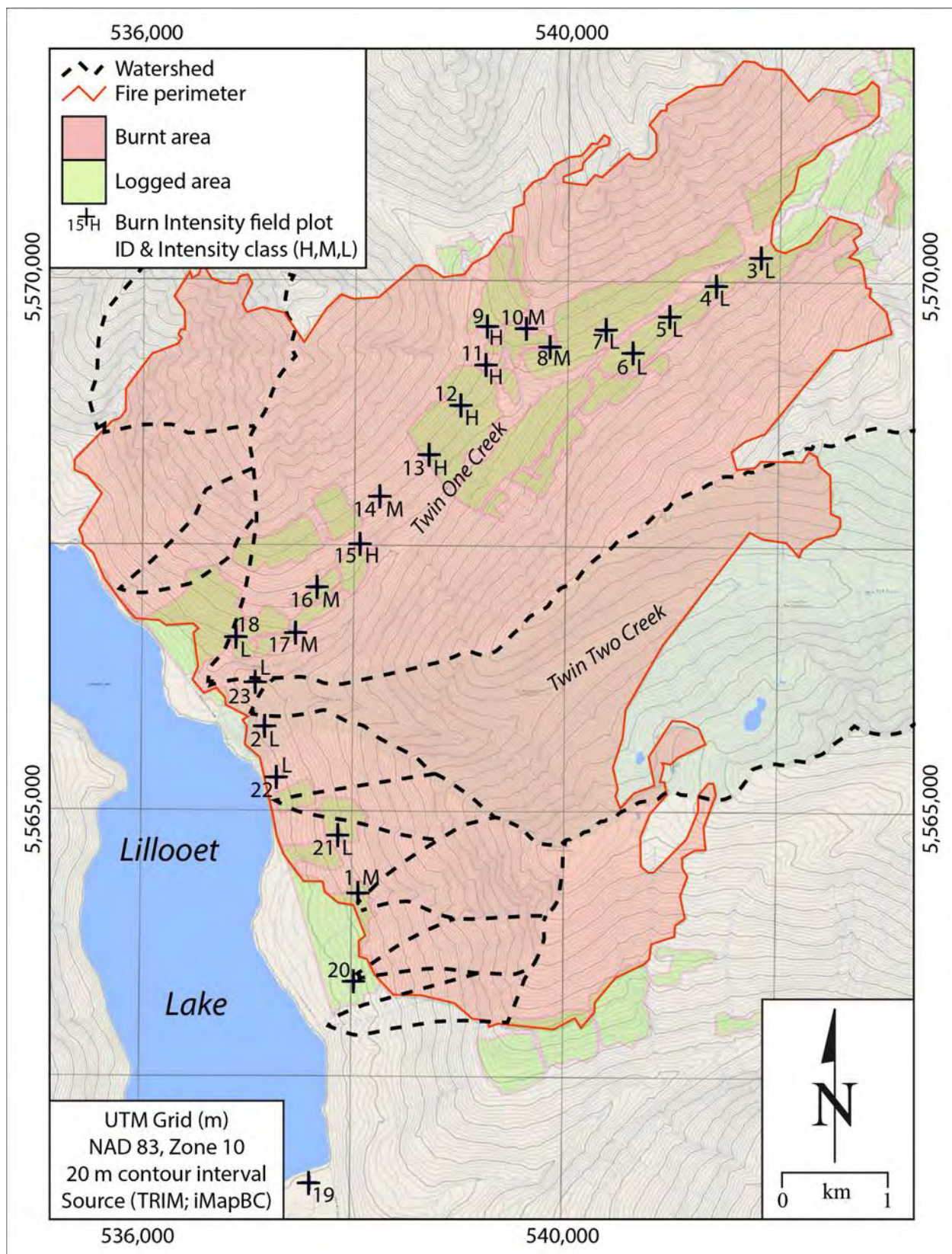


Figure 7. Previously harvested terrain within the Twin Two wildfire (V30941) perimeter.

The total area of harvested terrain within the boundaries of Twin Two fire is ~505 ha, of a total fire area of 3772 ha, or 13%. Most of the burnt unlogged original forest existed on steep upper slope positions, on very rocky terrain.

Table 11. Cutblock information available on iMapBC for Twin One Creek. Note that the available information on file is incomplete, lacking logging history from 1980-2013.

Cutting Permit	Block	Disturbance period	Area (ha)	TSA
CP11	TW100	2013-2014	13.9	Cordilleran, July 24, 2013
CP11	TW200	2013-2015	19.0	Cordilleran, July 24, 2013
CP6	TW300	2014-2015	13.3	Cordilleran, January 8, 2014
CP6	TW400	2014-2015	9.8	Cordilleran, January 8, 2014
CP6	TW500	2015	18.7	Cordilleran, January 8, 2014
CP10	TWH400	2015	3.0	
CP10	TWH401	2015	3.2	
CP10	TWH700	2015	1.8	
CP10	TWH800	2015	1.1	Cordilleran, January 20, 2016
?	LZ001	2021	22.9	Cordilleran, December 15, 2017
?	LZ002	2021	8.7	Cordilleran, December 15, 2017
?	LZ003	2021	4.5	Cordilleran, December 15, 2017
?	LZ004	2021	1.3	
?	LZ006	2021	8.3	
?	LZ007	2022	8.8	Cordilleran January 20, 2016

There are resource roads in Twin One Creek that are identified on maps but have no permit status. These roads are not maintained or inspected, and their condition is unknown. These roads are termed non-status roads (NSRs). The Ministry of Forest's policy is to assess NSRs when an issue becomes known as a possible safety/environmental problem.

On the north side of Twin One Creek, there are several NSRs that have not been deactivated (no water control, or fillslope pullback). Wildfire burns out old wood that may have supported road fillslopes, and increased slope ravelling on cutslopes may block ditches and cause water misalignment. Both these factors could lead to the potential for road-related instability, with direct landslide impact to Twin One Creek and associated geomorphic flood effects downstream. At two locations in Twin One Creek, we noted post-logging (pre-wildfire) road washouts related to water misalignment on old roads (Figure 1).

Fire History

Table 12 lists historical fires recorded in the BC wildfire archive (<https://app.geo.ca/en-ca/map-browser/record/22c7cb44-1463-48f7-8e47-88857f207702>; Figure 8). Historical fires on Lillooet Lake (1922-2025) range from 3.2-821 hectares. One historic wildfire is recorded in the area of the Twin Two fire boundary. This is V30004 (76.1 ha), started July 17, 1985, and identified as a human caused fire, likely logging-related as it consumed a clearcut and upslope terrain. At 3772 hectares, the 2026-07-17, Twin Two fire (V30941) is an order of magnitude larger than the largest of any of the historical fires listed. The total area of all previous fires combined (5620 ha) is only 50% larger than the Twin Two fire.

Table 12. Historic wildfire polygons on Lillooet Lake (1922-2025).

Date	Area (ha)	Trigger	Location	Fire #
1922-07-14	633	Human	Southeast end of Lillooet Lake	1922-469
1922-07-29	821	Lightening	North Lizzie headwaters	1922-634
1928-07-15	483	Human	Northeast end Lillooet Lake	1928-142
1933-08-11	531	Lightening	Strawberry Point	1933-115
1950-08-26	239	Lightening	North Lizzie mid valley	V00318
1954-07-29	27	Human	Southeast end of Lillooet Lake	V00084
1967-09-01	406	Lightening	Lillooet Lake FSR km4	V00400
1975-07-09	37	Lightening	Lizzie Ck mid valley	VR0427
1985-06-07	76	Human	Twin One mid valley	V30004
1985-07-15	800	Lightening	Southwest end of Lillooet Lake	V30016
1985-07-30	30	Lightening	Ure Ck near mouth	V30040
1992-05-17	20	Human	Southwest end of Lillooet Lake	V30003
1992-05-17	67	Human	Southwest end of Lillooet Lake	V30003
2018-05-03	8.4	Human	Joffre Creek, 5km on Duffey	V30103
2010-07-31	43	Lightening	Kakila Ck upper	V30734
2013-07-07	35	Lightening	Southeast end of Lillooet Lake	V30216
2016	1.4	Lightening	Southeast end Lillooet Lake	V30251
2020-04-08	1.8	Human	Northeast end Lillooet Lake	V30030
2020-08-16	368	Lightening	Strawberry Point	V31179
2020-08-17	34	Lightening	McCulloch Ck headwaters	V31176
2020-08-17	16	Lightening	Southwest end of Lillooet Lake	V31182
2024-07-22	3.2	Human	Lizzie Ck fan	V31395
2024-08-06	405	Lightening	Ure Ck mid valley	V31860
2025-08-29	534	Lightening	Bastion Peak	V31708
Sum	5619.8			

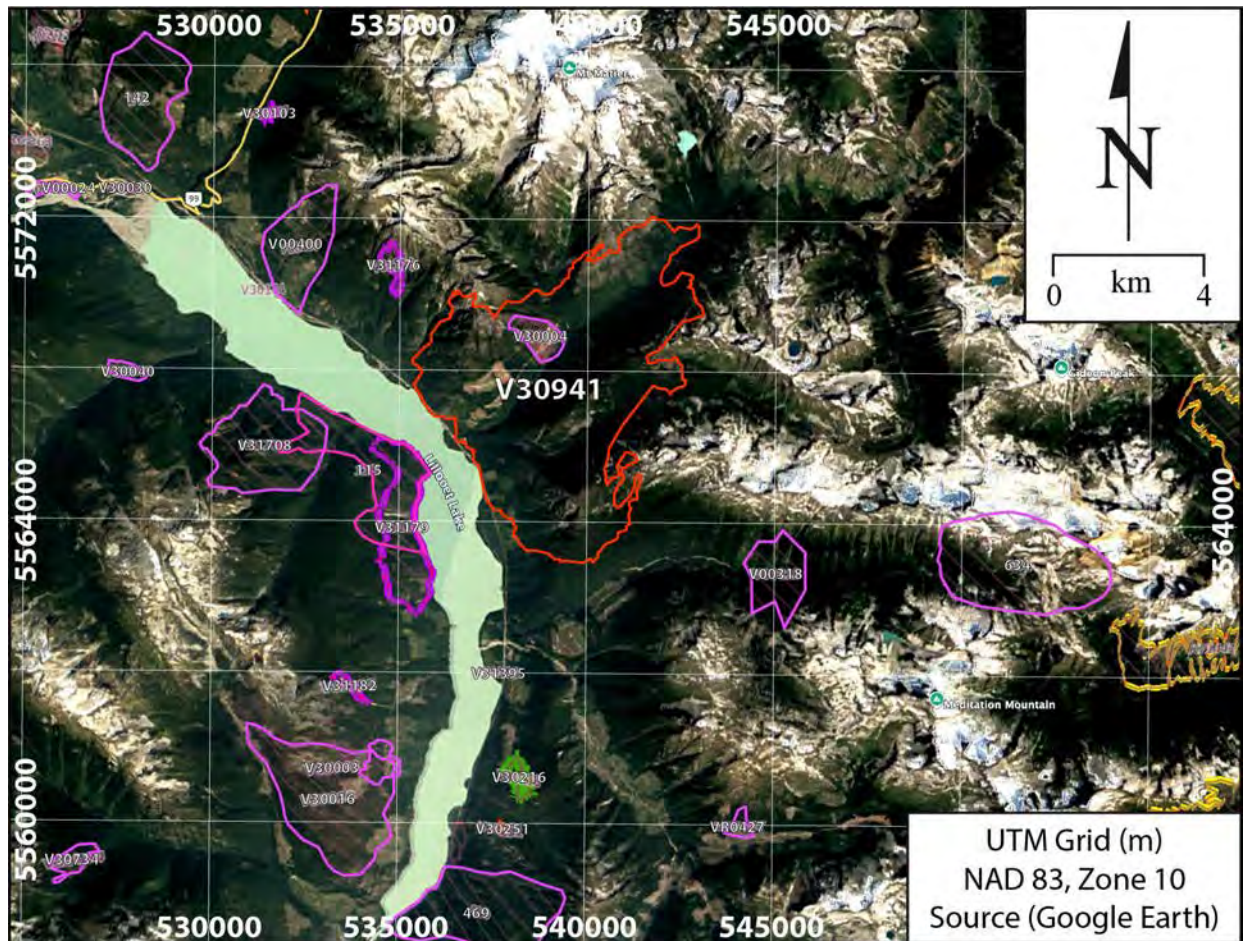


Figure 8. Historic wildfire around Lillooet Lake spanning 1922-2024. See Table 12 for Fire IDs.

The Twin Two Fire (V30941)

Fire Weather

In Pemberton, starting in April the weather was hotter and much drier than normal (Figure 9). From July 14-16 daily maximum temperatures climbed above 30°C and daily minimum relative humidity dropped below 30% (Figure 11), presenting conditions ideal for the Twin Two fire start.

The Weather network issued a warning on July 15, 2026, that an active weather pattern would impact British Columbia on July 16, resulting in a significant risk of severe thunderstorms. The potential for large hail, heavy rainfall and strong winds across the South Coast and Interior regions was indicated.⁴

On July 18, 2026, CBC reported that up to July 15 there were only about 20 blazes in what had been a relatively quiet season, but as of July 18 there were about 115 fires burning, including

⁴ <https://www.theweathernetwork.com/en/news/weather/forecasts/thunderstorm-risk-spreads-across-b-c-risk-of-hail-rain-and-winds>

about 77 started on July 17. The B.C. Wildfire Service attributed the vast majority of the new fires to the 4,000 lightning strikes that hit the province that day.⁵ The Twin Two fire was attributed to lightning.

The progression of the wildfire was recorded by the BC Wildfire Service (Table 13; Figures 11, 12). The Twin Two fire started on the crest of the ridge between Twin One and Twin Two Creeks. From July 17-21, with temperature below 30°C and relative humidity above 30%, the fire grew slowly on the ridge crest. However, on July 22 the fire spread rapidly in response to daily temperatures reaching 38°C and relative humidity dropping to 20%; then, between July 23-25, the fire exploded (Figure 10), fanned by wind gusting to 30 km/h, it grew from 500 ha to 2600 ha in two days. From July 26-29, cooler weather and higher humidity damped fire progression. On July 31 a 30-30 cross over allowed one more surge. Through August, fire progression slowed, and the final perimeter was delineated on August 26. During field work from September 4-7 hot spots within the fire boundary were smoldering. By September 16, satellite imagery indicates the fire was completely out. Appendix 1 provides photographs of the areas burnt, taken from helicopter flight on September 7, 2026.

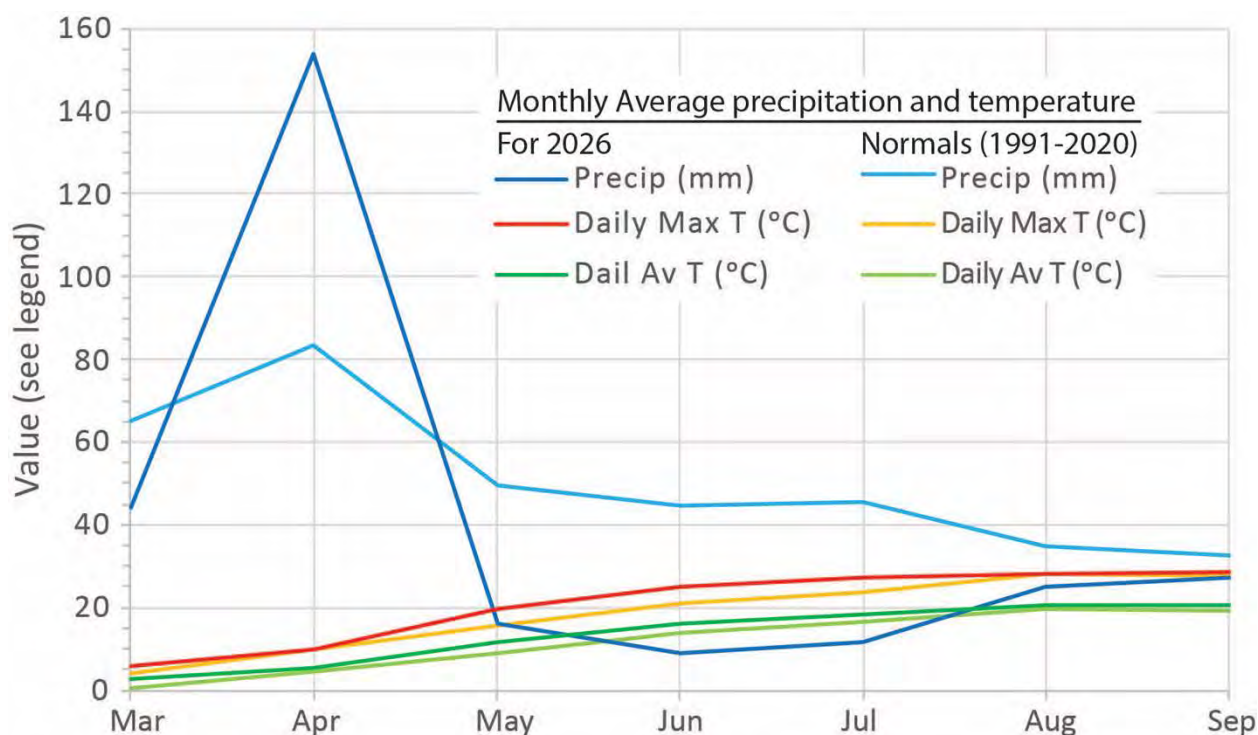


Figure 9. Monthly climate Normals (1991-2020) versus monthly records for 2026 from Pemberton Airport (1086082).

⁵ <https://www.cbc.ca/news/canada/british-columbia/bc-wildfires-lightning-9.7275420>

Table 13. Fire area and growth from fire perimeters provided by the BC Wildfire Service.

Date	Area (ha)	Daily growth (ha)	Comment
2026-07-17	0	0	First noted, lightening start on ridge between Twin One and Twin Two
2026-07-20	28	28	Growth on ridge between Twin One and Twin Two
2026-07-21 AM	76	49	Growth on ridge between Twin One and Twin Two
2026-07-22 10:00	245	169	Growth south onto north side of Twin Two
2026-07-22 PM	395	150	Further growth south, and extension east up Twin Two
2026-07-23 8:30	508	114	Growth downslope on north facing slope of Twin One
2026-07-24 16:30	1424	915	Major growth across Twin One up south face to ridge crest
2026-07-25 12:00	1491	67	Little growth overnight
2026-07-25 17:00	2575	1084	Major growth northeast up Twin One on both sides of creek, minor expansion in Twin Two
2026-07-29 AM	2712	137	Minor growth downslope on southwest toward FSR
2026-07-30 14:00	2814	102	Growth on northwest and southwest flanks
2026-07-31 19:00	3167	353	Growth to NW and SW onto the face above Lillooet Lake
2026-08-05 11:00	3400	232	Growth NW in Cataline and SW into North Lizzie
2026-08-17	3640	240	Slow growth on perimeter
2026-08-26	3773	133	Final perimeter



Figure 10. The Twin Two Wildfire, on the afternoon of July 23, 2026 when the fire moved explosively into Twin One Creek. Source BC Wildfire Service.

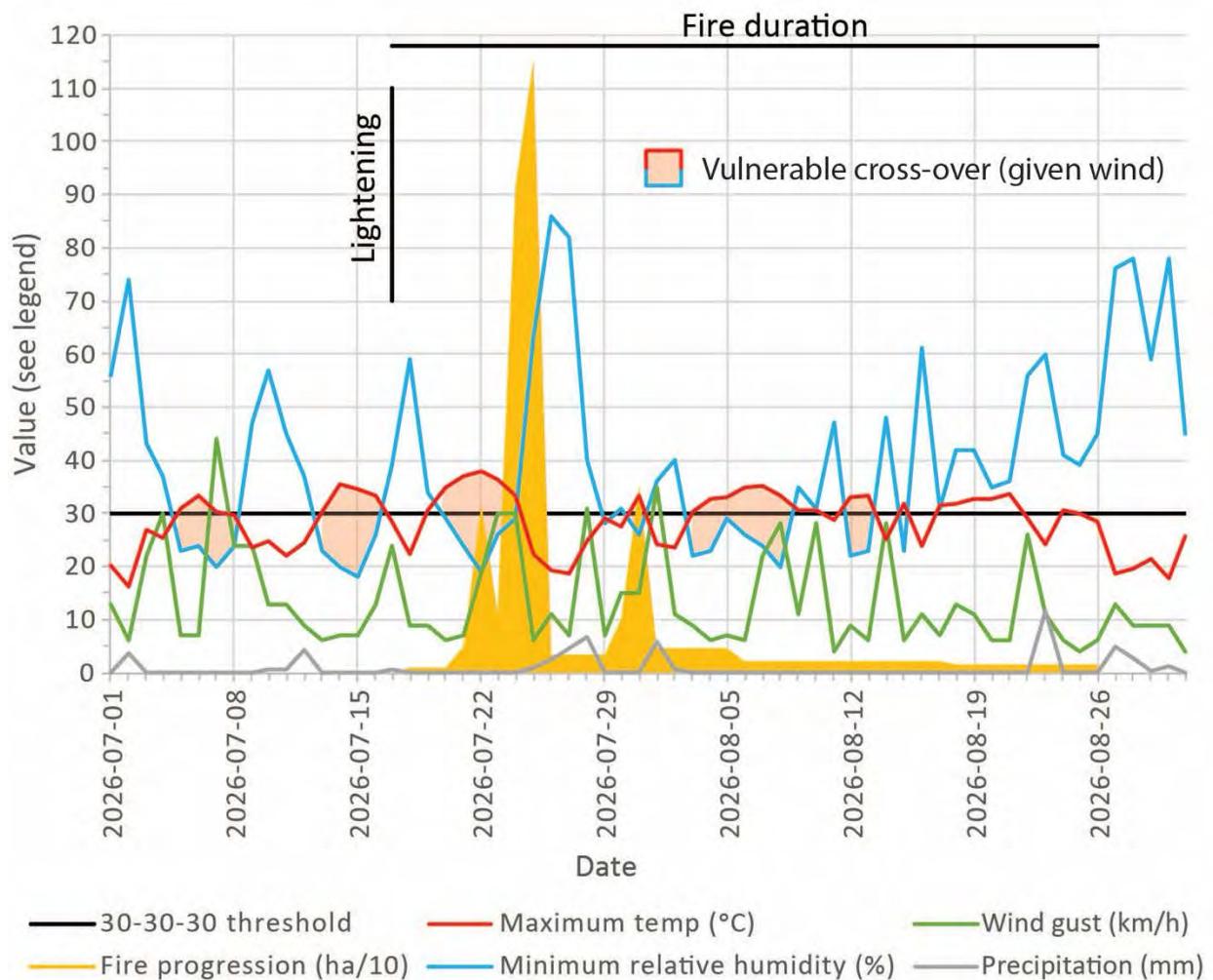


Figure 11. Observed daily weather for Pemberton airport, July 1-August 31, 2026. Also showing observed daily fire growth from July 17-August 26, 2026 (Table 13). 30-30-30 refers to the critical threshold condition for wildfire on days where maximum temperatures (max T) exceed 30 °C, minimum relative humidity (RH) drops below 30%, and wind gusts exceed 30 km/h. The fire was caused by lightening on July 17. Note the explosive growth starting July 22 when wind fanned the flames during a period of low humidity and high temperature.

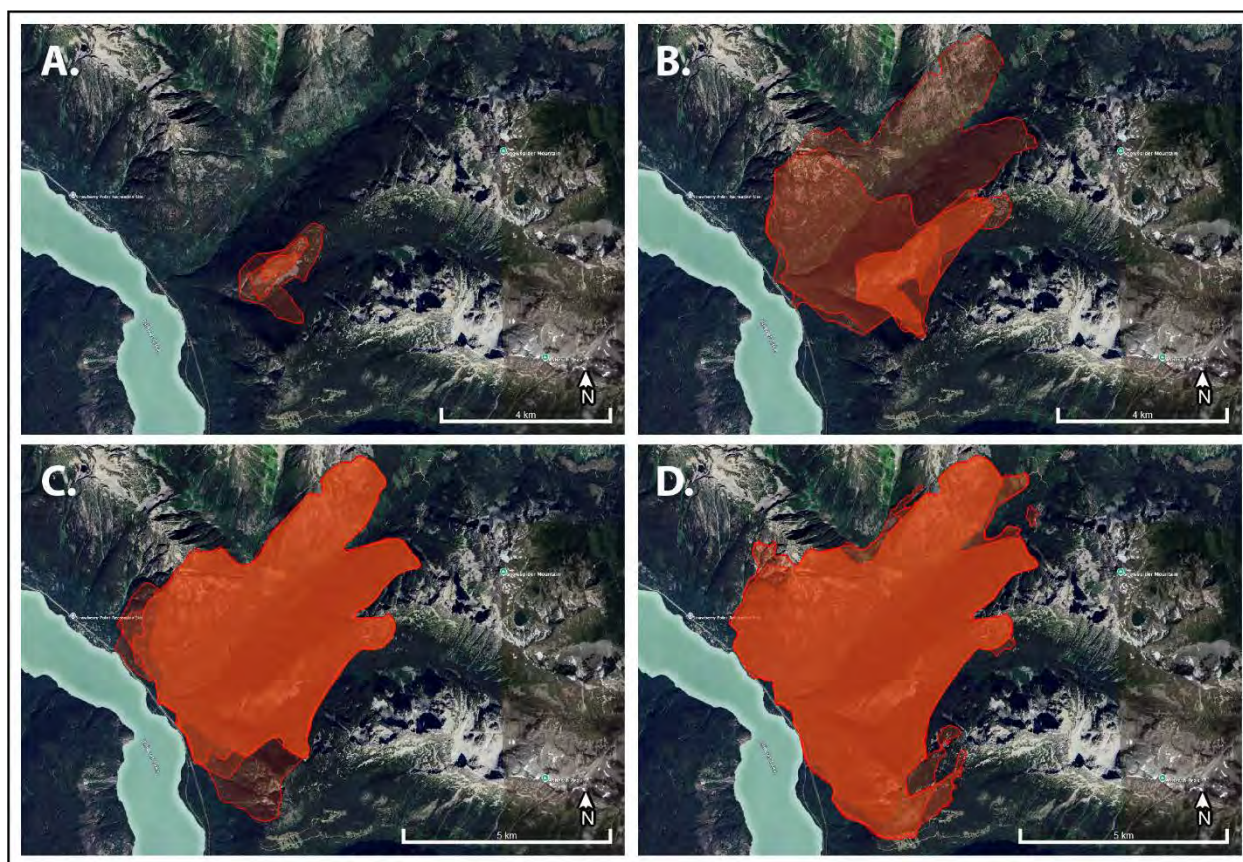


Figure 12. Twin Two (V30941) Fire progression, July 17 to August 26, 2026. Increasing lighter shades indicates growth. Successive fire perimeters provided by the BC Wildfire Service. **A.** July 17-July 22 AM. Lightning start on the ridge crest and slow spread toward Twin Two Creek. **B.** July 22 AM to July 25 PM. Explosive growth in Twin Two and then Twin One Creeks. **C.** July 25 PM to July 31 PM. Growth on the NW and SW flanks. **D.** July 31 PM to Aug 26. Smoldering growth.

Burn Severity

We collected data from 22 burn severity field plots between September 4-7, 2026 (Appendix 2). The Burned Area Reflectance Classification (BARC), or vegetation burn severity map, was provided by GeoBC on Sept 24th. Field plots recorded both vegetation and soil burn intensity, with water droplet drip tests to test for soil hydrophobicity. We found that vegetation and soil burn intensity field plots were generally well correlated. Whereas, field plots and BARC varied somewhat, primarily because many plots fell on BARC class boundaries, but overall, the combined Moderate plus High burn intensity is consistent across vegetation, soil and BARC classifications (Table 14). The Low and Unburned classes have the field observations showing more Low severity areas and BARC showing more unburned areas, and that is because the Low areas as classified in the field have intact canopy; in Western Red cedar areas these canopies may die back, but in Douglas Fir areas these trees will likely survive. Overall, as the Moderate plus High combined class is the value of primary interest, we did not adjust the BARC to match the field observations. Based on the BARC map, we have estimated the percent cover of each burn intensity class within the fire perimeter (Table 15).

Table 14. Comparison of Field burn severity and BARC classification: grey - sites with same classification; yellow - sites on/near polygon boundary with similar classification; orange - sites with different classification. Boxed shows consistency of Moderate plus High classification.

Plot ID	Veg Burn Intensity	Soil Burn Intensity	BARC
Plot 1	Mod	Moderate	Low/Moderate
Plot 2	Low	Low	Low
Plot 3	Low	Low	Unburnt
Plot 4	Low	Low	Low/Unburnt
Plot 5	Low	Low	Low/Unburnt
Plot 6	Low	Low	Low
Plot 7	Low	Low	Low/Moderate
Plot 8	Mod	Moderate	High/Moderate
Plot 9	High	High	High/Moderate
Plot 10	Mod	Moderate	High/Moderate
Plot 11	High	High	High
Plot 12	High	High	High
Plot 13	High	Moderate	High
Plot 14	Mod	Moderate	High/Moderate
Plot 15	High	High	High/Moderate
Plot 16	Mod	Moderate	High/Moderate
Plot 17	Mod	Moderate	Moderate
Plot 18	Low	Low	Low/Moderate
Plot 19	N/A	N/A	Out of Perimeter
Plot 20	N/A	N/A	Out of Perimeter
Plot 21	Low	Low	Unburnt
Plot 22	Low	Low	Low/Unburnt
Plot 23	Low	Low	Low

Furthermore, using the DEM from TRIM (source GeoGratis), we parsed each burn severity class by terrain slope class (<30%, 30-50%, 50-70%, 70-90%, >90% slope; Table 16). The slope classes are proxies for terrain types: slopes <30% may be gentle morainal areas, or are underlain by debris cones, fans and floodplains; slopes between 30-50% are typically underlain by thick morainal blankets; slopes between 50-70% may be underlain by morainal and colluvial blanket, often reflecting the topography of underlying bedrock; slopes between 70-90% may be underlain by morainal and colluvial veneers, reflecting the topography of underlying bedrock; while, slopes >90% are typically rocky with high rockfall hazard and scattered angular colluvium.

Table 15. Burnt area as a percentage of total watershed area, and parsed by burn severity class.

Watershed	Watershed Area (ha)	Percentage within fire perimeter	Breakdown within fire perimeter				P _H (Table 16)	
			H+M	Low	Unburnt			
Cataline	299	54	14.6	12.9	26.2	7	L	
Twin One	6426	31	24.5	3.4	2.9	17	M	
Twin Two	2014	31	20.8	5.0	5.6	14	M	
Unnamed 1	75	100	46.9	47.1	6.0	34	M	
Unnamed 2	80	100	20.9	35.5	43.6	13	L	
Unnamed 3	125	100	49.0	29.9	21.1	20	L	
Unnamed 4	58	100	58.2	26.2	15.5	42	M	
Unnamed 5	51	46	18.3	9.1	18.7	8	L	

Table 16. Watershed area parsed by burn severity class and slope class, expressed as percentage.

Watershed	Burn Severity Class	Slope class (slope)				
		<30	30-50	50-70	70-90	>90
Cataline	High + Moderate	0.04	0.30	2.73	4.56	7.00
	Low	0.01	0.09	1.75	5.00	6.03
	Unburnt	0.14	0.39	2.53	11.01	12.14
	Unburnt outside	0.32	1.77	8.99	19.16	16.05
Twin One	High + Moderate	0.49	2.59	8.10	9.28	3.99
	Low	0.26	0.78	1.20	0.83	0.39
	Unburnt	0.57	0.65	1.02	0.54	0.14
	Unburnt outside	8.45	14.28	19.63	14.00	12.83
Twin Two	High + Moderate	0.88	2.93	7.30	6.81	2.88
	Low	0.27	1.23	1.77	1.11	0.57
	Unburnt	0.96	1.77	1.93	0.75	0.17
	Unburnt outside	10.99	15.73	20.52	12.99	8.44
Unnamed 1	High + Moderate	0.00	4.01	15.91	17.90	9.10
	Low	0.07	4.51	17.10	17.25	8.20
	Unburnt	0.08	0.90	2.64	1.79	0.54
	Unburnt outside	0.00	0.00	0.00	0.00	0.00
Unnamed 2	High + Moderate	0.07	2.95	6.16	6.70	4.99
	Low	0.00	3.67	11.25	15.74	4.84
	Unburnt	0.07	12.94	13.55	13.87	3.21
	Unburnt outside	0.00	0.00	0.00	0.00	0.00
Unnamed 3	High + Moderate	0.07	1.21	5.86	14.57	27.30
	Low	0.05	1.28	6.00	6.51	16.01
	Unburnt	0.68	2.24	5.84	5.00	7.37
	Unburnt outside	0.00	0.00	0.00	0.00	0.00
Unnamed 4	High + Moderate	0.18	2.74	18.67	22.85	13.80
	Low	0.00	1.37	6.86	10.13	7.87
	Unburnt	0.34	0.71	2.61	7.24	4.61
	Unburnt outside	0.00	0.00	0.00	0.00	0.00
Unnamed 5	High + Moderate	0.05	1.72	1.91	6.52	8.09
	Low	0.00	0.00	1.09	4.67	3.36
	Unburnt	0.00	0.07	7.93	7.84	2.87
	Unburnt outside	6.51	20.42	23.36	3.60	0.00

On a watershed basis, the incremental post-wildfire hazard (P_H) is based on categories of the intersection of M+H (%) and 50-90% slopes (Table 16): <30% Low; 30-50% Moderate; >50% High. The summed P_H intersection values are provided in Table 15.

A high post-wildfire hazard (P_H) for debris avalanche and debris flow would occur on 70-90% slopes; with a Moderate to high hazard on 50-70% slopes (Table 16, orange, red highlights). There is a high rockfall hazard in the steep (>90% slope) rocky terrain.

Elements at Risk

At the direction of MoF (Tom Millard, MSc. P.Geo., South Coast Region), for the area potentially affected by the Twin Two wildfire, from the southern edge of Cataline Creek alluvial fan to the southern boundary of the wildfire, assess the partial risk from post-wildfire geohazards to:

- The In-SHUCK-ch FSR
- The BC Hydro electrical transmission infrastructure
- Residences/dwellings on the alluvial fans of Twin One and Twin Two Creeks
- Drinking water sources and drinking water infrastructure on Twin One and Twin Two alluvial fans
- Twin One Creek Recreation Site
- Spiritual sites

This list of elements at risk excludes those elements on the alluvial fan of Cataline Creek. This is because Cataline Creek (3 km²), although 54% burnt (1.6 km²) only 15% is Moderate and High burn severity (Table 15), and much of the area is steep and inaccessible (Table 16). More importantly, the Lillooet Lake Estates residential area is presently being protected from debris flow up to 100,000 m³ in volume by construction of a major berm and conveyance chute, a project valued at \$11.7 million (<https://www.slrld.bc.ca/inside-slrld/current-projects-initiatives/catiline-debris-flow-mitigation-service-project>). That project super-cedes the need for a post wildfire natural hazards risk assessment (PWNHRA).

BC Hydro Towers

Assessing the risk to BC Hydro towers is outlined below (Table 17):

- BC Hydro Towers were mapped using Google Earth (Figure 13). We assume a footprint of 25 m².
- We plotted fall line paths upslope from each footprint to the highest likely point of landslide initiation on the slope above (Figure 13), and a reach angle and probability of spatial affect was estimated from that line.
- Where topographic conditions affected the spatial impact, then that was noted. These might include obstructions, deflections, and accommodation widths on debris cones.
- The burn intensity pattern underlying the fall line path was visually reviewed and a post-wildfire hazard estimated. If the tower is on or near the outlet of a defined subbasin, then the hazard for that subbasin was used.

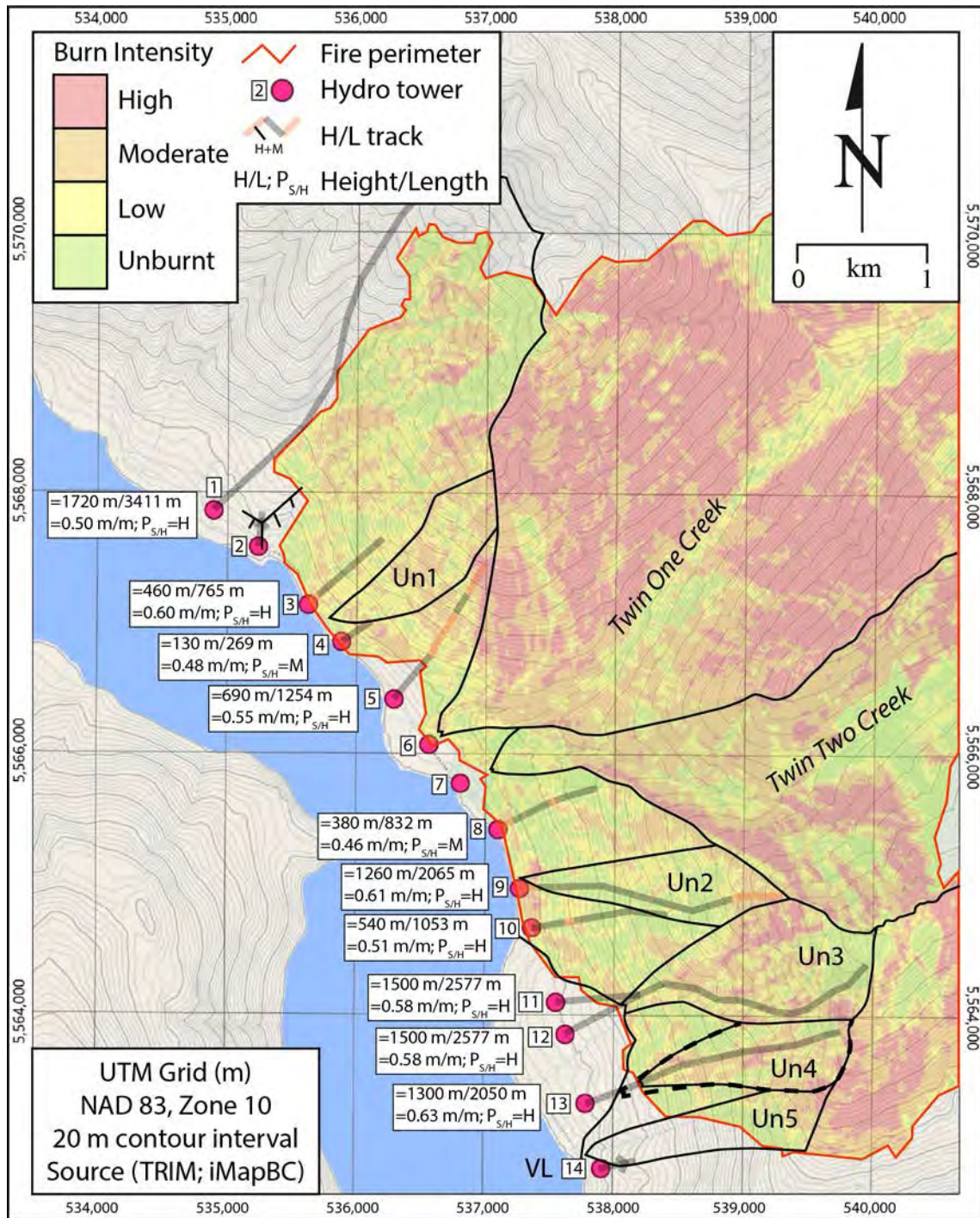


Figure 13. Twin Two fire (V30941) fire perimeter, BARC classification, BC Hydro towers and angle of reach from hypothetical landslide initiation site to BC Hydro towers.

Table 17. Post-wildfire debris avalanche and debris flow hazard affecting BC Hydro towers downslope of Twin Two wildfire (V30941). Post-wildfire, hazard (P_H), based on %cover of M+H (%) burn intensity on 50-90% slopes (see Tables 1-3). See Figure 13 for ID locations.

Tower	Landform	* P_H	$P_{S/H}$	Risk	Comment
1	Cataline	Low	N/A	N/A	Mitigated
2	Below kame	N/A	Very Low	N/A	Kame shields from burn upslope
3	Face	Low	High	Low	Short shedding slope, road-catch
4	Face	High	Moderate	Moderate	Short slope above, local rockfall
5	Face, T1 fan	High	High	High	Face presenting
6	T1 fan	Moderate	Moderate	Moderate	Raised fan. <i>Armour/extend berm</i>
7	T2 fan	Very Low	Very Low	V. Low	Raised fan, short slope above
8	Face	Low	Moderate	Low	..
9	Un2	Low	High	Moderate	..
10	Face	Low	High	Moderate	..
**11	Un3	Low	High * 1/20	Moderate	On debris cone 500 m wide
**12	Un3	Low	High * 1/20	Moderate	On debris cone 500 m wide
**13	Un4	Mod	High*1/12	Moderate	On debris cone 300 m wide
14	Face	Low	Low	Low	Very short splitter ridge

* P_H categories: <30% = Low; 30-50% = Moderate; >50% = High.

** For towers 11-13, located on a wide colluvial cone, the $P_{S/H}$ is diluted by the ratio of the width of the tower footprint to the width of the debris cone.

Only Tower 5 has high hazard, presenting as debris avalanche from a 1200 m long slope on the valley sidewall face. The uppermost steep and heavily burnt slopes are rocky with discontinuous coarse angular colluvium, and lack of soil may reduce hazard and risk somewhat. Towers 4, 6, 9-13 have Moderate risk. ***At Tower 6, the risk could be reduced by placing riprap armour on the upstream face of an adhoc gravel berm that has been placed to train the creek at the sharp right (north) bend above the FSR within the BC Hydro Right of Way.***

In-SHUCK-ch FSR

The In-SHUCK-ch FSR crosses through or lies below the fire perimeter for a 6.5 km distance extending from Cataline Creek south to a point 1.5 km north of the Lizzie Bay recreation site. Hazards affecting the road include floods on the major stream crossings, namely bridges on Twin One and Twin Two Creeks (Table 18), debris flows at smaller stream crossing sites (Table 19) and debris avalanches on face units above the road.

Major Crossings

Based on our hydrologic assessment of Twin One and Twin Two watersheds and the available opening at the crossing sites, it appears that there is sufficient clearance to pass the 100-year flood, and dam breach floods originating from temporary landslide blockages higher in the watershed. The possibility of debris flooding introduces greater uncertainty, as bulking of clearwater discharge with sediment could overwhelm the available openings; however, the degree of bulking is not readily estimated. Church and Jakob (2020) provide a classification for debris flood phenomenon: for debris floods initiated by meteorological floods, the bulking factor may be low, well below the uncertainty in the estimation of the peak flow itself; for debris floods triggered by dilution of debris flow, then bulking of 2-5 times the estimated peak discharge is

possible; at the outside of the range, debris floods generated by dambreak may bulk 2-100 times the estimated peak discharge.

Table 18. Bridge opening required for extreme flood events on Twin One and Twin Two Creeks.

Crossing	Crossing Structure	Existing opening (m ²)	100-200 yr flow (m ³ /s)	Required opening	
				*100-200 year (m ²)	**dam breach (m ²)
Twin One	Steel Bridge	60	84-94	44-46	11-22
Twin Two	Steel bridge	22.5	34-37	17-19	19-38

Notes: Assumes *Velocity between 2.5-5 m/s; **Barriers not exceeding 10 m tall.

With 30% of each watershed burnt, with 14-18% of Moderate and High burn intensity situated on moderately steep (50-70%) to steep (70-90%) slopes flanking mainstem stream channel, the criteria indicate a Low debris flood hazard. However, the burnt area is concentrated at the mouth of the watersheds, where steep slopes feed steep feeder channel, and therefore we bump Twin One and Twin Two post-wildfire hazard up to (P_H) to Moderate. Given a Moderate debris flood hazard, there is a high chance major crossings would be affected (Table 19) as bridges confine the channel. If debris floods become sufficiently bulked by sediment, then the bridges could become washed out.

Table 19. Post-wildfire risk to major crossings (Figure 1). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and P_{S/H} is spatial impact rating (see Tables 1-3).

Crossing	Geodomain	M+H (%)	P _H	Element at		
				Risk	P _{S/H}	Risk
Twin One	Debris flood	17.4	*Moderate	FSR	High	High
Twin Two	Debris flood	14.1	*Moderate	FSR	High	High

* Bumped from Low to Moderate Hazard because the burnt terrain is concentrated close to front end of watershed, and with steep slopes looming above feeder channel, a direct landslide impact to channel may occur, and debris flood from diluted debris flow may reach fan apices.

The existing armour on both bridges is constructed of the largest boulders found in the channel. These are subround, and have been transported by flood events. The armour is in good condition on both abutments at both crossings. While intact and in good condition, the effectiveness is reduced by the shape and size of the material.

Minor Crossings

Five small drainages are mapped on the face unit above the In-SHUCK-ch FSR (Un1-5; Table 20). These all have small steep catchments and are classified as debris flow prone, with high reach angles (>50% slope) from potential start zones to the FSR. Percent cover of M+H burn intensity on steep (50-90%) slopes dictates the post wildfire hazard (P_H):

- Unnamed 1 has 34% cover of Moderate and High burn intensity on moderately steep (50-70%) and steep (70-90%) slopes, giving a High risk of debris flow affecting the FSR (Table 20).
- Unnamed 2 and Unnamed 5 have a lower proportion (8-13%) of watershed area affected by Moderate and High burn intensity on moderately steep (50-70%) and steep (70-90%) slopes, and the risk to the FSR is judged to be Low (Table 20).

- Unnamed 3 supports evidence of debris flow activity in last 5-10 years. The basin is ~20% covered by Moderate and High burn intensity on moderately steep (50-70%) and steep (70-90%) slopes. With evidence of debris flow, the risk to the FSR is High.
- Unnamed 4 has 42% coverage of Moderate and High burn intensity on moderately steep (50-70%) and steep (70-90%) slopes, with a High risk of debris flow affecting the FSR.

Minor crossings may be supplied with culverts (Un2, 3, 5) At Un2 the creek is intercepted by the FSR and diverted south 40 m before being dispersed by a 600 mm CMP. At Un3 there are 800 mm and a 1000 mm metal culverts separated by 55 m length along the FSR. Between them there is an abandoned channel. This indicates an unconfined channel on the debris cone at the mouth of Basin Un3. ***No stopping signs warning of debris flow hazard could be posted at minor crossings.***

Table 20. Post-wildfire risk to minor crossings (Figure 1). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and P_{S/H} is spatial impact rating (see Tables 1-3).

Crossing	Geodomain	M+H (%)	P _H	Element at		Risk
				Risk	P _{S/H}	
Un 1	Debris flow	34	Moderate	FSR	High	High
Un 2	Debris flow	13	Low	FSR	High	Moderate
Un 3	Debris flow	20	**High	FSR	High	Very High
Un 4	Debris flow	42	Moderate	FSR	High	High
Un 5	Debris flow	8	Low	FSR	High	Moderate

** Bumped up to High from Moderate with evidence of recent debris flow in this subbasin.

Twin One Recreation Site (#218)

Debris flooding involving substantial bulking during a dam breach flood could overwhelm the active channel and cause avulsion at the FSR bridge and subsequently affecting Rec Site 218. We judge the post-wildfire debris flood hazard at the recreation site to be Moderate (Table 21). However, there is also an open slope debris slide hazard (Tower 5, Figure 13) which must be accounted for. As such the hazard rating shown on Figure 3 is mapped as High. ***Temporary avoidance of the site, enacting a closure of the site for a one-year safety review is recommended. Signage warning of potential post-wildfire debris flood hazard during snowmelt or rainfall events is also indicated.***

Table 21. Post-wildfire risk to Twin One Recreation Site (Figure 3). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and P_{S/H} is spatial impact rating (see Tables 1-3).

Feature	Geodomain	M+H (%)	P _H	Element at		Risk
				Risk	P _{S/H}	
Fan	Debris flood	17	*Moderate	Rec Site 218	Moderate	Moderate
Tower 5	Debris slide	52	High	Rec Site 218	High	High

*Bumped up to Moderate by geomorphic hazard potential.

Water Infrastructure

There are community water intakes on Twin One and Twin Two Creeks, each located at the fan apex. Their position at the mouths of the creeks makes them highly vulnerable to impact from

the identified hazard affecting, which is debris flood. Debris floods may transport high volumes of sediment including large boulders. With Moderate hazard of debris flood and high spatial impact probability, the risk to intake structures is High (Table 22).

At Twin One the impact to the intake would likely consist of burial only, as there is no weir and the structure is inset in the left wall of the bedrock channel. Periodic cleaning of screens is likely the only post-wildfire maintenance issue. Some fine mineral sediment and organic washload may pass through the screens and enter the pipes. At Twin Two there is a sheet metal weir. This structure could become severely damaged by a debris flood event.

Water is conveyed to individual houses via buried pipes. On Twin One Creek, the pipes cross fan areas with Low to Very Low probability of experiencing overland flow, and the risk of erosion and damage to buried lines is Very Low. On Twin Two Creek, the buried line follows the access road. If the creek were to avulse onto the road surface, the line could become eroded. ***Mitigation of avulsion potential near the apex of Twin Two Creek could involve removal of all the trees that have fallen across the channel in the reach between the intake and the road. Should the intake weir become damaged consider replacement using an infiltration gallery design.***

Table 22. Post-wildfire risk to Domestic Water Intake structures (Figure 3). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and P_{S/H} is spatial impact rating (see Tables 1-3).

Intake	Geodomain	M+H (%)	P _H	Element at Risk	P _{S/H}	Risk
Twin One	Debris flood	18.2	*Moderate	Intake	High	High
Twin Two	Debris flood	14.9	*Moderate	Intake	High	High
Twin Two	Rockfall	Local H	Moderate	Intake access	High	High

*Bumped up to Moderate by geomorphic hazard potential.

Water Quality

The following is summarised from a global review of wildfire impacts on water quality by de Leon Rabago et al (2026).

“When comparing pre- and post-wildfire levels of sediment, nutrients, metals, organic carbon, ions and wildfire-fighting chemicals; contamination often intensified over time, particularly when storms or snowmelt washed stored ash and debris into rivers, with some increases, measured downstream at the domestic intake, persisting more than 14 years. Wildfire activity increased sediment, nutrients, heavy metals and polycyclic aromatic hydrocarbons—chemicals formed when vegetation and other materials burn. Smoke can also carry contaminants into unburned watersheds. Canada relies heavily on long-term fire retardants such as Phos-Chek. These products contain nutrients and trace metals that can fuel algal blooms and raise treatment costs. Water utilities’ ability to respond depends on fire intensity, duration, size, what burned, weather conditions and treatment system design. Not all systems have equal capacity to adapt, and smaller communities with limited budgets face greater risk from prolonged post-fire impacts. ***Communities need coordinated long-term water monitoring.***”

Health Link BC (<https://www.healthlinkbc.ca/healthlinkbc-files/wildfire-its-effects-drinking-water-quality>) summarises the potential impacts of wildfire on drinking water:

- Changes in the amount and timing of snowmelt and runoff from storms
- Changes in water quality (e.g. nitrate, ammonia, phosphate, total suspended solids, turbidity, temperature) from build-up of ash, soil erosion and fire debris
- Algal blooms in water sources. For more information on cyanobacteria blooms (blue-green algae), read [HealthLinkBC File #47 Cyanobacteria blooms \(blue-green algae\)](#)
- Changes in taste, colour and smell of drinking water
- If fire retardant is present, there may be a possible rise in soil and water chemical levels, such as: ammonium, phosphate, nitrate, and nitrite. Read [HealthLinkBC File #05a Nitrate in well water](#) and [Ministry of Environment and Climate Change Strategy: Water quality: Fire retardants used to fight wildfires](#)
- Chemical contamination of drinking water if pipes, meters, and wellheads are burned or exposed to heat. If pipes are damaged and leak, there is also potential for bacterial contamination.

These impacts can make it harder for the local water treatment system to work. They can also cause contamination of water after it's treated.

Residences

On Twin One alluvial fan, parcels (Table 23) designated Blks A-E, DL 8562 and Blk A, DL 452 are located on a fan sector with a Low potential for being affected by avulsion. These lots are located downslope of the sharp right (north) bend in the creek channel where the creek exists the bedrock box canyon between the apex and the FSR. This location is recognised as a weak point, and measures in the past have been undertaken to reduce erosion and avulsion at this point.

Table 23. Parcel details for properties on Twin One and Twin Two Creek fans.

ID	Civic (In- SHUCK- ch FSR)	Legal (Lillooet District)	Zoning	Owner	Water Licence ID	Well ID	Improvements
1	N/A	DL 8511	R1	Province	N/A		None
2	10276	Blk A, DL 8562	R1	Private	C070094		House
3	10302	Blk B, DL 8562	R1	Private	C069224		House & outbuilding
4	10328	Blk C, DL 8562	R1	Private	C069957		House
5	10354	Blk D, DL 8562	R1	Private	C069223		House & outbuilding
6	10380	Blk E, DL 8562	R1	Private	N/A		House & outbuilding
7	N/A	Blk A, DL 452	R1	Province	C124061		Storage yard
8	10432	Blk B, DL 452	R1	Private	C069226		House, 3 outbuildings
9	N/A	Blk C, DL 452	R1	Province	N/A		House, abandoned
10	10484	Blk A, DL 8497	R1	Private	C069222	35408	House, outbuilding
11	10510	Blk B, DL 8497	R1	Private	N/A		House
12	10536	Blk C, DL 8497	R1	Province	N/A		House
13	10562	Blk D, DL 8497	R1	Private	C069220		House
14	10588	Blk E, DL 8497	R1	Private	C069221		House, outbuilding
15	N/A	Blk F, DL 8497	R1	Province	N/A		2 houses, outbuilding
16	10640	Blk G, DL 8497	R1	Private	N/A		2 houses
17	N/A	DL 8518	R1	Private	N/A		House
18	11016	DL 8295	R1	Private	C118636		Lodge, 5 outbuildings

Presently, at the sharp northerly bend, just above the FSR, there is an adhoc berm lacking riprap armour to prevent erosion. ***This adhoc berm (Table 24) requires riprap facing on the east side to be resilient to erosion during a debris flood event. Extension of the berm to the southeast will protect tower and avulsion point, reducing risk to northern six parcels.***

Table 24. Start and end points (UTM grid reference, NAD83, Zone; m)

Deflection Berm (pit run gravel, no riprap armour)	Northing (m)	Easting (m)
At north end, from crest 2 m down to floodplain, then 1 m to creek	5566125	536539
At south end, berm ties into old scarp crest	5566106	536562
<i>Reinforce existing & extend berm to jcnctn with intake access road</i>	5566076	536588

On Twin One alluvial fan, Lots Blks B, C, DL452 and Blks A-G, DL8497 are located on a fan sector that is deemed relict surface, a product of paraglacial activity, and these parcels are judged to have a very low to negligible risk of being affected by debris flood processes.

At Twin Two Creek the residences are located on the active fan surface. There are several critical low freeboard areas on the fan, where potential avulsions could occur. These are near the apex, and at the FSR bridge, and downstream along the fan below the FSR. With Moderate debris flood hazard, and potential avulsion sites indicating a High avulsion and overland flooding hazard, the post-wildfire risk on Twin Two fan is judged to be High (Table 25). Due to its location downstream of the FSR and adjacent to the channel, the highest hazard is at the new home on DL815. On DL8295, the hazard to any given building (assume 25 m width) is reduced 17% by the width factor (150 m fan width), reducing the debris flood risk to any building to Moderate (Table 25).

Table 25. Post-wildfire risk to Residential Lots (Figure 3). M+H (%) indicates percentage of Moderate and High burn intensity on moderately steep and steep terrain. P_H is post-wildfire hazard rating and P_{S/H} is spatial impact rating (see Tables 1-3).

Fan Surface	Geodomain	M+H (%)	P _H	Element at Risk	P _{S/H}	Risk
Cataline	Debris flow	7	Low	LLE	Remedy	V. low
Twin One	Debris flood	17	*Moderate	Blks A-E, DL 8562, Blk A, DL 452	Low	Low
Twin One	Debris flood	17	*Moderate	Blks B, C, DL452, Blks A-G, DL8497	V. Low	V. Low
Twin Two	Debris flood	14	*Moderate	DL8518	High	High
Twin Two	Debris flood	14	*Moderate	DL8295	Mod	Mod

* Bumped up to Moderate from Low Hazard because the burnt terrain is concentrated close to front end of the watershed, and with steep slopes looming above the feeder channel.

Mitigation measures on Twin Two fan might include passive measures such as avoidance during periods of elevated hazard, or structural measures to reduce avulsion potential.

Water Survey Canada Lake Level Gauge

The water level gauge, Lillooet Lake near Pemberton (08MG020; 50°14'25" N, 122°28'52" W) consists of a small locked building at grade. The building could be damaged by debris flooding. ***The Water Survey of Canada (WSC) should be notified of a Moderate risk.***

Spiritual Sites

Two sites were identified in the Twin One Quarry bordering the intake access road. WP107, the chainsaw totem is of unknown significance; WP162 is a memorial plaque set in a stone monument. ***Care should be taken to safe-guard these sites from direct damage by movement of machinery.***

Table 26. The location of identified spiritual sites, Twin Two wildfire (V30941).

WP	Northing	Easting	Description
107	5566140	536646	Sacred site, flagged out, old chainsaw totem
162	5566165	536772	Stone memorial to Rev Thomas Lee York, 1940-1988

Conclusions

“The intersection of prolonged drought and extreme fire weather creates an "explosive" wildfire hazard by turning ecosystems into highly volatile fuel beds. When landscapes are deprived of moisture, wildfires transition from standard, predictable blazes into hyper-flammable, fast-moving compound disasters that defy traditional containment strategies” (Kim and Kim 2026).

The occurrence of the Twin Two (V30941) wildfire provides an excellent example of this phenomenon. Starting April 2026 and extending through August 2026, the weather in Pemberton was warmer and drier than the 30-year Normal; the fire was triggered by lightening on July 17, and was fanned by a 30-30-30 threshold cross-over leading to explosive growth between July 22-25, 2026. As weather cooled through August, the fire mellowed to a smolder on the flanks, with the final perimeter measured August 26, 2026. The Twin two Wildfire was an order of magnitude larger than any historic wildfire in a century of fire records around Lillooet Lake.

We have identified elements at risk, estimated post-wildfire risk, and below we have made conceptual recommendations to mitigate risk as appropriate. Elevated (P_H, Moderate to High) risk ratings (Tables 17, 19, 20, 21, 22, 25) serve to alert stakeholders of potential harms, and they may seek to make their own more detailed post-wildfire risk assessments.

Recommendations

Watershed Scale

- Deactivate firebreak trails. MoF should identify, assess and deactivate non-status roads within Twin One watershed and on the Lillooet Lake face. Permit holders should review post-wildfire road conditions and ensure appropriate maintenance and deactivation is carried out.

BC Hydro Towers

- The Hydro tower on the Twin One fan could be protected by armouring and extending the existing gravel berm (Table 24).

In-SHUCK-ch FSR Major and Minor crossings

- Instal no-stopping signs warning of debris flow hazard.
- Inspect condition after storm events.

Twin One Recreation Site

- Temporary avoidance of the site, enacting a closure of the site for a one-year safety review.
- Place warning signage to alert users of post wildfire hazards.

Residences on Twin One fan

- Safety of resident parcels 10276, 10392, 10328, 10354, 10380 In-SHUCK-ch FSR (Table 23) would benefit from armoured and extended berm at the fan apex (Table 24). Building approvals should require lift and scour protection for Low hazard fans (WLAP 2004).

Intake on Twin Two Creek

- If damaged consider redesign to reduce exposure of weir and hide intake portal from direct debris impact. As at Twin One Creek, this might consist of an infiltration gallery design, rather than a highly vulnerable weir.
- Provide backup water storage or an alternative water source (Lillooet Lake).

Residences on Twin Two Creek Fan

- Immediate mitigation of avulsion potential near the apex of Twin Two Creek could involve removal of all the trees that have fallen across the channel in the reach between the intake and the road.
- Occupants should watch the weather and monitor local alerts from Environment Canada or provincial agencies before and consider temporary evacuation during alert rainfall events.
- Permit approvals for all buildings should be accompanied by legislated flood hazard reports prepared by a qualified professional (EGBC 2018).
- Consider structural mitigation measures to reduce debris flood hazard on both district lots. Such measures could include a retention basin, channel training and bank armoured, and/or deflection berms to direct debris floods away from structures. Any structural mitigation design would need to be guided by a detailed debris flood risk assessment, and would need to ensure that transfer of risk does not occur.

Water Quality

- Flush lines of fine organic and mineral sediment as required.
- It is recommended that residents continue to follow best practices regarding private drinking water safety, including regular monitoring and testing. More information can be found on Vancouver Coastal Health's website: <https://www.slrd.bc.ca/Wildfire-return-home/water-utilities-and-septic-systems-after-wildfire>.
- Report a drinking water concern at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/how-drinking-water-is-protected-in-bc/dwog_part_b_-_2_investigation_of_a_threat.pdf.
- For a period of at least 5-years, monitor regularly, especially post flood and snowmelt freshet, for post-wildfire contaminants.

Water Survey Canada Lake Level Gauge

- The Water Survey of Canada (WSC) should be notified of a Moderate debris flood risk affecting their Lillooet Lake gauge (08MG020) near Pemberton.

Spiritual Sites

- Care should be taken to safe-guard these sites from direct damage by movement of machinery.

Behavioural Safety Precautions

- Watch the Weather and monitor local alerts from Environment Canada or provincial agencies before and during storms.
- Avoid High-Risk Zones when it rains, including burned slopes, stream channels, floodplains, and alluvial fans.
- During flooding, do not linger near or cross channels or access intakes, as flash floods and debris flows move extremely rapidly.

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Closure

This report was prepared for use by MoF, 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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Appendix 1. Photos of the Twin Two fire, arranged north to south.



View north to Twin One Creek. Note the large fan at the mouth of Twin One Creek.



View east to face between Twin Two and Lizzie Creek. The point is underlain by a large colluvial cone.



View southwest down Cataline Creek to mitigation works under construction.



View south down Cataline Creek to mitigation works under construction.



View northeast to face south of Cataline Creek.



View east to face between Cataline Creek and Twin One Creek.



View east to Twin One fan, with Twin One and Twin Two Creeks.



View northeast to Cataline/Twin One face and up the lower reach of Twin One Creek.



View northeast up lower Twin One Creek



View north to face below Twin Goat Peak.



View north to face below Twin Goat Peak.



View northwest to face below Twin Goat Peak.



View north across Twin One Creek toward Mount Matier in the clouds.



View northwest up Twin Goat Creek.



View northwest to face east of Twin Goat Creek.



View north across face east of Twin Goat Creek.



View northwest to face east of Twin Goat Creek.



View northwest to face east of Twin Goat Creek.



View northeast from mid Twin One valley toward Mt Duke.



View northwest to face between Twin Goat Creek and Twin One Lake.



View northwest toward Matier in the clouds.



View southwest along the south side of Twin One Creek.



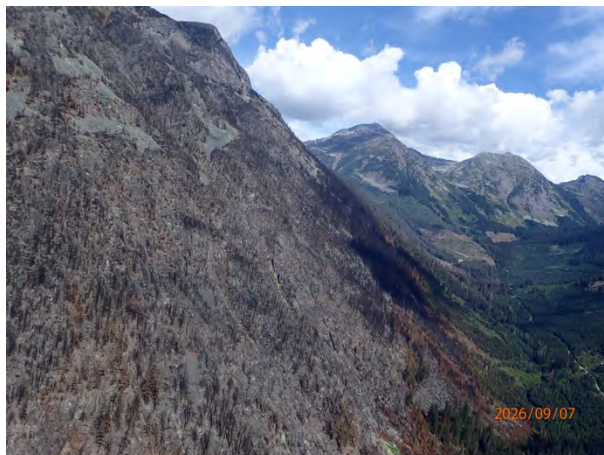
View southeast to Snowspider Mtn.



View southwest along the south side of Twin One Creek.



View southeast to Snowspider Mtn.



View northeast up Twin One Creek from Twin Goat over north valley side.



View northeast up Twin One Creek from Twin Goat over south valley side.



View southwest across Twin Goat down Twin One to Lillooet Lake.



View east from Twin Goat to Twin One Creek.



View north toward Mt Matier in the clouds.



View southeast across the south side of Twin One Creek.



View southeast across the south side of Twin One Creek.



View east across the south side of Twin One Creek.



View east across the south side of Twin One Creek.



View northeast up Twin One Creek from near the mouth toward mid valley.



View east up Twin Two Creek near the mouth.



View east up Twin Two Creek near the mouth.



View east up Twin Two Creek near the mouth.



View southeast up Twin Two Creek.



View northeast up Twin Two Creek.



View east up Twin Two Creek.



View east up Twin Two Creek.



View southwest down Twin Two Creek.



View southwest down Twin Two Creek.



View south to south side of Twin Two Creek near the mouth.



View southeast to south side of Twin Two Creek near the mouth.



View northeast to shoulder between the Lillooet lake valley sidewall face and Lizzie Creek.



View northwest to north slopes of Lizzie Creek.



View north to north slopes of Lizzie Creek.



View northeast to north slopes of Lizzie Creek.

Appendix 2. Twin Two wildfire (V30941), Burn Intensity Field Plots

Plot ID, Location and Terrain Attributes						Vegetation Burn Intensity					
Title	Northing	Easting	Slope (%)	Aspect (°)	Terrain	Forest	Canopy Cond.	Percent Ground Cover			Veg
								Grn under	Grn trees	Scorch trees	Burn Intensity
Plot 1	5564224	538058	30-35	220	dCc-Rd	D. fir 2nd grwth	Mostly dead	0	10	90	Mod
Plot 2	5565794	537162	25	265	rCv/Ra	D.fir/cedar	Mostly alive	0	50	50	Low
Plot 3	5570227	541821	55-60	335	Mb/xCv	Imm. plantation	Mostly alive	50	90	10	Low
Plot 4	5569962	541402	50	335	Mb/xCv	Imm. plantation	Mostly alive	20	90	10	Low
Plot 5	5569668	540963	30-45	320	Mb/xCv	Imm. plantation	Mostly alive	30	80	20	Low
Plot 6	5569325	540619	45	315	Mb/xCv	Imm. plantation	Mostly alive	50	100	0	Low
Plot 7	5569539	540361	45	165	xCbv	D.fir plantation	Mostly alive	0	30	70	Low
Plot 8	5569377	539835	40-55	165	Mb.rCv	Imm. plantation	Mostly dead	0	0	100	Mod
Plot 9	5569567	539242	20	175	dMb	Imm. plantation	Dead	0	0	100	High
Plot 10	5569552	539610	65-70	200	Rs/xCv	D. fir OG	Mostly dead	0	0	100	Mod
Plot 11	5569206	539230	45-50	135	dMb	mature WR cedar	Dead	0	0	100	High
Plot 12	5568824	538995	60-65	125	xCv/Rks	Imm. plantation	Dead	0	0	100	High
Plot 13	5568358	538700	65-70	135	xCv	Imm. plantation	Dead, some twigs	0	0	100	High
Plot 14	5567965	538239	55	150	xCv	D. fir 2nd grwth	Mostly dead	0	0	100	Mod
Plot 15	5567516	538056	50-60	145	xCv	D. fir OG	Dead	0	0	100	High
Plot 16	5567107	537653	45-55	160	Mb	D. fir 2nd grwth	Mostly dead	0	0	100	Mod
Plot 17	5566677	537450	40-45	220	Mb	D. fir OG	Mostly dead	0	0	100	Mod
Plot 18	5566634	536890	30-40	250	Mb	D. fir OG	Mostly alive	0	100	0	Low
Plot 19	5561494	537615	10	135	gFf	WR Cedar/D. fir OG	Unburnt site	N/A	N/A	N/A	N/A
Plot 20	5563393	538021	30	250	sdCa-Rd	D. fir 2nd grwth	Unburnt site	N/A	N/A	N/A	N/A
Plot 21	5564770	537867	25	270	Mb	WR Cedar/D. fir 2G	Unburned	0	50	50	Low
Plot 22	5565313	537282	60	215	Mb	WR Cedar/D. fir OG	Unburned	0	30	70	Low
Plot 23	5566211	537072	15-20	280	Mv	D. fir OG	Mostly alive	0	10	90	Low

Appendix 2. Twin Two wildfire (V30941), Burn Intensity Field Plots

Soil Burn Intensity

Litter	Duff	Wood debris small	Wood Large	Ash colour	Mineral Soil	Needle drop	Soil Chnge	Depth to Live roots (cm)	Soil Burn Intensity
Consumed	Mostly consumed	Consumed	Charred	Grey	<5	100	No	0-5	Moderate
Consumed	Mostly consumed	Partly consumed	Charred	Grey	5-40	100	No	0-5	Low
Scorched	Spottily consumed	Charred	Charred	Black	<5	60	No	0	Low
Consumed	Mostly consumed	Partly consumed	Charred	White	<5	30	No	0	Low
Mostly consumed	Spottily consumed	Charred	Charred	Black	<5	80	No	0-5	Low
Mostly consumed	Spottily consumed	Charred	Charred	Black	<5	<10	No	0-5	Low
Mostly consumed	Spottily consumed	Charred	Charred	Black	<5	70	No	0-5	Low
Scorched	Mostly consumed	Charred	Charred	Grey	5-40	0	No	0	Moderate
Consumed	Mostly consumed	Partly consumed	Some consumed	Grey	5-40	0	Minor	0	High
Consumed	Mostly consumed	Partly consumed	Charred	Black	5-40	40	No	0	Moderate
Consumed	Mostly consumed	Partly consumed	Many consumed	White	5-40	<5	Minor	0-5	High
Consumed	Mostly consumed	Partly consumed	Some consumed	Grey	5-40	0	Minor	0-5	High
Consumed	Mostly consumed	Partly consumed	Charred	Black	5-40	<5	Minor	0	Moderate
Consumed	Mostly consumed	Partly consumed	Charred	Black	5-40	<5	No	0-5	Moderate
Consumed	Mostly consumed	Partly consumed	Many consumed	Black	>40	40	Minor	0-5	High
Consumed	Mostly consumed	Partly consumed	Charred	Black	<5	95	No	0-5	Moderate
Consumed	Mostly consumed	Partly consumed	Some consumed	Grey	<5	100	No	0-5	Moderate
Consumed	Mostly consumed	Partly consumed	Charred	Grey	<5	95	No	0	Low
N/A	7-10 cm thick	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	7-10 cm thick	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scorched	Spottily consumed	Charred	Charred	White	5-40	15	Minor	0	Low
Mostly consumed	Mostly consumed	Partly consumed	Charred	White	<5	50	No	0-5	Low
Consumed	Mostly consumed	Partly consumed	Charred	Black	5-40	95	No	0-5	Low

Appendix 2. Twin Two wildfire (V30941), Burn Intensity Field Plots

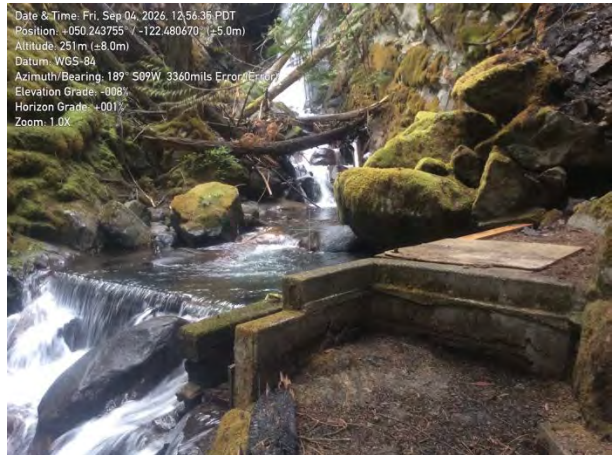
Drip Test Measurements

Overland Repelency												
Flow	Depth	none	weak	strong	Depth	none	weak	strong	Depth	none	weak	strong
N/A	3	20	..	80	7	80	..	20	..	..	..	..
N/A	3	100	..	..	..	..	..	..	..	..	..	..
N/A	4	100	..	..	..	..	..	..	..	..	..	..
N/A	2	80	..	20	5	100	..	..	..	..	..	..
N/A	3	100	..	..	..	..	..	..	..	..	..	..
N/A	3	100	..	..	..	..	..	..	..	..	..	..
N/A	5	80	..	20	10	90	..	10	..	..	..	..
N/A	3	0	40	60	10	0	70	30	15	0	90	10
N/A	8	0	0	100	15	40	..	60	..	..	..	..
N/A	3	80	..	20	5	100	..	..	..	..	..	..
N/A	3	0	0	100	8	20	..	80	..	..	..	..
N/A	5	20	..	80	10	30	..	70	..	..	..	..
N/A	5	100	..	..	10	100	..	..	..	..	..	..
N/A	5	60	..	40	10	80	20	..	..	..	..	..
N/A	3	10	..	90	5	70	..	30	..	..	..	..
N/A	5	60	..	40	10	80	..	20	15	100	..	..
N/A	5	70	..	30	10	80	..	20	..	..	..	..
N/A	3	100	..	..	..	..	..	..	..	..	..	..
N/A	3	..	..	100	5	10	..	90	..	..	..	..
N/A	3	80	..	20	10	80	20	..	..	..	..	..
N/A	5	70	..	30	10	80	..	20	..	..	..	..
N/A	5	70	..	30	10	80	10	10	15	100	..	..
N/A	5	80	..	20	10	90	..	10	..	..	..	..

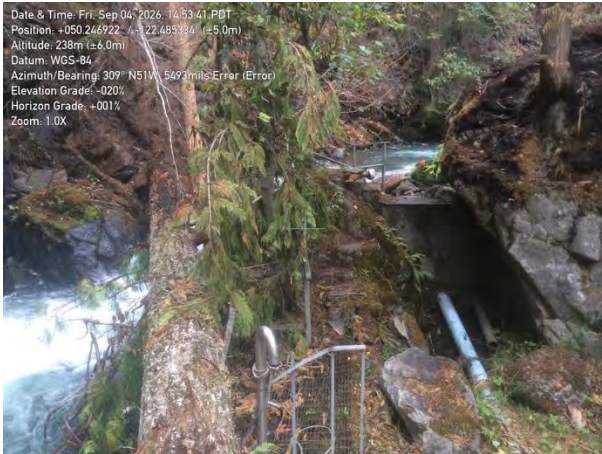
Appendix 3. Water intake infrastructure and hydrants.



Twin Two Intake, steel tank



Twin Two Intake, steel weir



Twin One Intake, recessed opening in left bank below fallen tree. Pipes are part of abandoned intake flume.



Twin One Intake, abandoned intake flume



Twin One hydrant station, site 1



Twin One hydrant station, site 2