Clarke Geoscience Ltd.

POST-WILDFIRE NATURAL HAZARDS RISK ANALYSIS OF THE 2023 CRATER CREEK WILDFIRE (K52125)

Crater Creek Wildfire (August 15, 2023) (Photo from: BC Wildfire Service)

Dated:	June 17, 2025
Presented To:	Ministry of Forests – BC Wildfire Service
Attention:	Mr. Trevor Bohay & Mr. Gareth Wells
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Executive Summary

Clarke Geoscience Ltd. (CGL) was retained by the Ministry of Forests – BC Wildfire Service (MOF-BCWS) to complete a detailed Post-Wildfire Natural Hazard Risk Analysis (PWNHRA) for areas affected by the 2023 Crater Creek Wildfire (K52125). The Crater Creek Wildfire burned a total area of approximately 465 km^2, affecting areas within the jurisdictions of the Lower Similkameen Indian Band (LSIB), the Regional District of Okanagan – Similkameen (RDOS) – Electoral Areas B & G, and provincial Crown Lands.

The study approach generally follows *Land Management Handbook (LMH) No. 69 – Post-Wildfire Natural Hazards Risk Analysis in British Columbia* (Hope et al., 2015). The report intends to assist the MOF-BCWS in informing owners, other agencies and jurisdictions, and stakeholders of high-risk sites that may require immediate mitigative action to address post-wildfire natural hazard risks, or to direct more detailed assessments where required.

Post-wildfire natural hazards are associated with the loss of forest cover and the development of water repellent soils and include:

- hydrologic effects associated with greater snow accumulation and faster, and earlier, snow melt, decreased infiltration, increased soil erosion, higher peak flows, and sediment bulking of streams. Example natural hazards include **clear water flood, debris flood, and sediment-laden flows**.
- geomorphic effects associated with increased soil erosion due to exposed mineral soils, loss of root stabilization, concentration of runoff along open slopes and within steep gullies, and thermal expansion of rock due to intense heating. Example natural hazards include **landslides, debris flow, and rockfall**.

Post-Wildfire Natural Hazards Risk Analysis Results

The study area was divided into catchments within the Ashnola River watershed and catchments within the Lower Similkameen River valley. The hazard ratings assigned each catchment area describe the qualitative likelihood for post-wildfire natural hazards. Each catchment was classified by dominant hydrogeomorphic process, and a hazard rating was based on criteria that include percentage burned, percentage burned at moderate and high severity, proportion of terrain burned that is conducive to natural hazard initiation, and evidence of past instability along the stream channel or fan area. The hazard assessment was completed using desktop, imagery, GIS analysis, and field observations.

Elements at Risk were defined as infrastructure and roads, structures and residences on IR lands and private lands, domestic water intakes, and other sensitive features. The risk analysis process required an estimated likelihood of impact to the site/location occupied by the identified Elements at Risk (referred to as "spatial likelihood").

Partial risk levels for the Elements at Risk were derived by combining the hazard rating with the spatial likelihood rating according to a risk matrix.

A summary of partial risk analysis results is presented in the following Table 1, below. Recommendations for risk mitigation were presented in Section 8 of the report and were organized by catchment area.

Table 1: Summary of Post-Wildfire Natural Hazard Risk Analysis Results – 2023 Crater Creek Wildfire

Map #	Watershed/Sub-Basin/Face Unit		Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process (P(H))	Spatial Likelihood (P(S:H))			Highest Level of Partial Risk (P(HA))
					Public (or Resource) Road & Infrastructure	Private Property or Structures on IR Lands	Other (specify)	
Map 002	Similkameen River Watershed	Paul Creek	Flood	Low to Mod	Moderate	Moderate	-	Moderate
Map 002	Similkameen River Watershed	Rattlesnake Creek	Debris Flood	High	High (Paul Creek Rd)	-	-	Very High
Map 002	Similkameen River Watershed	Similkameen Sub-Basin 1	Debris Flow	Low	Low	-	-	Very Low
Map 002	Similkameen River Watershed	Similkameen Sub-Basin 2	Debris Flow	Moderate	Moderate	-	-	Moderate
Map 003	Similkameen River Watershed	Face Unit East of Ashnola	Rockfall	Moderate	Low	High	Moderate (reservoir)	High
Map 003	Similkameen River Watershed	Bullock Creek	Debris Flood	Low	High (Ash R Rd)	Low	Low (gas pipeline)	Moderate
Map 003	Similkameen River Watershed	Watershed 2	Debris Flood	Moderate	High (River Rd)	Moderate	Low (gas pipeline)	High
Map 003	Similkameen River Watershed	Barrington Creek	Debris Flood	Moderate	High (River Rd)	Moderate	-	High
Map 004	Similkameen River Watershed	Susap Creek	Flood	High	Moderate (Chopaka Rd)	Moderate	-	High
Map 005	Similkameen River Watershed	Snehumption Creek	Flood	Moderate	Moderate (Chopaka Rd)	Moderate	-	Moderate
Map 002	Ashnola River Watershed	Ashnola Face Unit 1	Rockfall & Debris Flow	High	High (Ash R Rd)	Moderate	-	Very High
Map 002	Ashnola River Watershed	Red Bridge Creek	Debris Flood	High	High (Crater FSR)	-	-	Very High
Map 006	Ashnola River Watershed	Ashnola Face Unit 2	Landslide & Debris Flow & Sediment-Laden Flow	High	High (Ash R Rd & Crater FSR)	-	Low (rec sites)	Very High
Map 006	Ashnola River Watershed	Webster Creek	Debris Flood	High	High (Ewart Ck Rd)	High	-	Very High
Map 007	Ashnola River Watershed	Ewart Creek	Flood & Channel Instability & Bank Erosion	Moderate (flood) & High (bank erosion)	Mod to Low (Ewart Ck Rd & Trailhead)-	-	Moderate (WSC Stn.)	High
Map 007	Ashnola River Watershed	Ashnola Face Unit 3	Landslide & Debris Flow & Sediment-Laden Flow	High to Very High	High (Ash R Rd)	Moderate to High	Low (Rec Sites)	Very High
Map 007	Ashnola River Watershed	Ashnola Face Unit 4	Landslide & Debris Flow & Sediment-Laden Flow	High	High (Lakeview Rd)	-	High (Cathedral Base Camp)	Very High
Map 007	Ashnola River Watershed	Lakeview Creek	Landslide & Debris Flow & Sediment-Laden Flow (valley side slopes)	High	High (Lakeview Rd)	-	Low (Lodge/Camp)	Very High
Map 001	Ashnola River Watershed	Ashnola River (cumulative)	Flood, Channel Instability and Bank Erosion	Moderate	High (Ash R Rd site-specific)	Moderate	Moderate (rec sites)	High

Territorial Acknowledgement

The area affected by the 2023 Crater Creek Wildfire is located within the unceded traditional territory of the Lower Similkameen Indian Band (LSIB). Members of LSIB are the (sməlqmíxʷ) people of the (sukʷnaʔqinx) Okanagan Nation, who are the original inhabitants of the Similkameen Valley.

The Ashnola River watershed was declared an Indigenous Protected and Conserved Area (IPCA) in 2022. This designation recognizes that the local indigenous government has a primary role in protecting and conserving ecosystems through indigenous laws, governance and knowledge systems.

The post-wildfire natural hazard risk analysis acknowledges that the LSIB has a relationship to the land that is integral to their culture and the maintenance of their community, governance and economy.

sməlqmixʷ Place Names

- Ashnola River Watershed - nʔaysnúlaʔxʷ
- Similkameen River Watershed - nmǝlqitkʷ

> The nʔaysnúlaʔxʷ is an essential watershed. Its waters are iʔ siwłkʷ sq̓aq̓łus iʔ təmxʷúlaʔxʷ (veins of the land), providing cold, pure siwłkʷ (water) for the təmxʷúlaʔxʷ (land) and tmixʷ (the life force within all four sacred ecosystems) in a time of climate change, uncertainty, increasing water scarcity, and threats from industry and development.

Source: Declaration of the Ashnola sməlqmíx Protected and Conserved Area (2022)

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1. Introduction

Clarke Geoscience Ltd. (CGL) was retained by the Ministry of Forests – BC Wildfire Service (MOF-BCWS) to complete a Detailed Post-Wildfire Natural Hazard Risk Analysis (PWNHRA) for areas affected by the 2023 Crater Creek Wildfire (K52125).

Work was authorized by the MOF-BCWS and is defined in the Consulting and General Services Contract CS25WHQ0131. The scope of work is defined in Schedule A – Services of that contract.

The intended use of the report is to provide information to assist the MOF-BCWS in informing owners, other agencies and jurisdictions, and stakeholders of high-risk sites that may require immediate mitigative action to address risks, or where more detailed assessments may be required. The following report uses terms and language that are technical in nature and are not necessarily intended for a general audience. For assistance, a glossary of technical terms is provided.

1.1 Project Background & Cultural Significance of Study Area

The Crater Creek Wildfire (Fire K52125) was a lightning-caused fire that was first reported on July 22, 2023. The Wildfire of Note[1] persisted until it was declared “held” on October 26, 2023, and burned a total area of 46,504 ha (~465 km^2). The wildfire affected residents in the Ashnola River and Similkameen River valleys including the following jurisdictions:

- RDOS Electoral Areas G and B;
- Reserve Lands and traditional territory of the Lower Similkameen Indian Band (LSIB) including Ashnola 10 IR, Lower Similkameen 2 IR, Range 13 IR, and Chopaka 7 & 8 IR; and,
- provincial Crown Land.

The wildfire perimeter and location southwest of Keremeos, BC, are shown on Figure 1-1 and on Map 001 (see Appendix B).

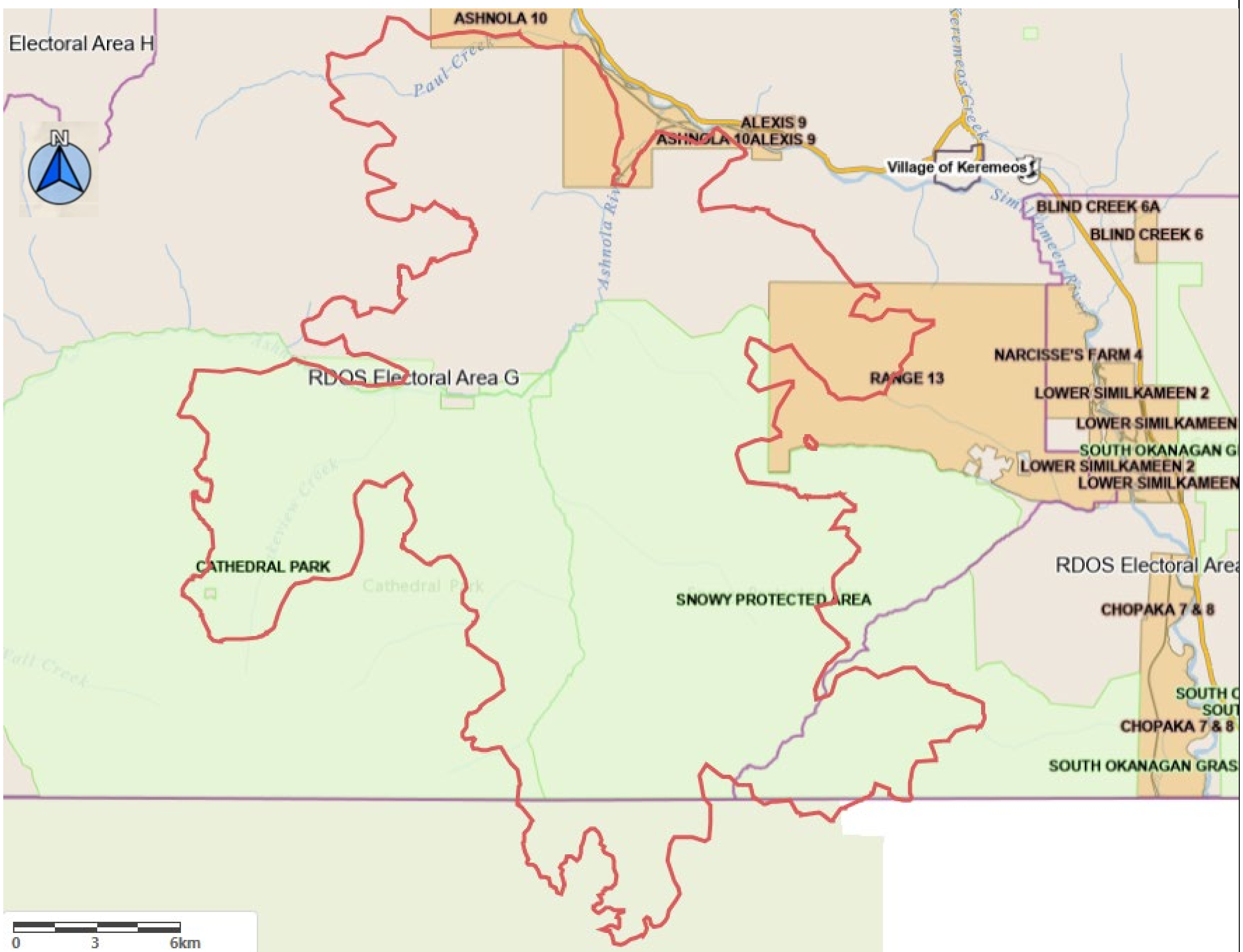
The Ashnola River Watershed (nʔaysnúlaʔxʷ) is a culturally significant area for the sməlqmíxʷ peoples. The watershed is an Indigenous Protected and Conserved Area (IPCA) with specific goals and objectives with regards to governance.

The Ashnola River watershed has experienced numerous historic wildfires, and the north-western side of the watershed has experienced historic forestry development activities (described in Section 4.5). The eastern part of the watershed has not experienced the same level of land development due to the protection offered by Cathedral Provincial Park and by the Snowy Protected Area.

It is understood that the Ashnola Watershed has provided, and continues to provide, lands that have special importance to the sməlqmíxʷ; lands that have historic range use activity, hunting and gathering, and healing.

[1] A Wildfire of Note is determined to be of significant public interest and may pose a threat to public safety, communities or critical infrastructure.

The nʔaysnúlaʔxʷ is one of the last pristine stream systems in sməlqmíxʷ territory, providing pure, cold water in the face of climate change, water scarcity, and other threats[2].



Source: iMAP BC

Figure 1-1: Location of Study Area
(with 2023 Crater Creek Wildfire Perimeter, IR Lands, and Protected Lands shown)

1.2 Project Objectives and Scope of Work

Post-wildfire natural hazard risks are associated with ***hydrologic effects*** such as faster runoff, lower infiltration, higher peak flows, and ***geomorphic effects*** such as increased soil erosion, landslides and debris flow, and sediment transport. In larger watersheds, the risk scenario is dominated by hydrologic effects, while smaller, steeper sub-basins and face units are more likely to be affected by geomorphic effects.

[2] Source: Declaration of the Ashnola sməlqmíx Protected and Conserved Area (LSIB, 2022)

The primary objective of this detailed PWNHRA is to identify the Elements at Risk from potential post-wildfire hazards, elaborate on the hazards and risks to these Elements, identify the need for risk mitigation, and provide conceptual risk mitigation options.

With respect to scale, the detailed PWNHRA builds upon the reconnaissance-level PWNHRA that was completed by the MOF-BCWS shortly after the fire was held (see Section 1.3). However, the analysis is still relatively high-level, so more detailed investigation would be required to determine site-level risks and corresponding risk mitigation measures (i.e., prescribing road repairs, stream crossing upgrades, or designing protective risk mitigation structures).

1.3 Reconnaissance PWNHRA Report (MOF-BCWS, 2023) and Preliminary Results Memo (CGL, 2024)

A reconnaissance-level PWNHRA report was prepared for the Crater Creek Wildfire (K52125) by G. Wells, P.Geo., Geomorphologist for the Thompson-Okanagan Region on behalf of the District Manager of the Kamloops Fire Centre – Penticton Zone on November 29, 2023. The report is available on the MOF-BCWS Post-Wildfire Reports portal (URL: https://pwnhr-bcgov03.hub.arcgis.com/pages/assessments-explorer).

The reconnaissance-level report was prepared shortly after the wildfire was declared “held” and was based on a desktop analysis, a helicopter overview flight, and limited fieldwork. The analysis identified moderate to very high-risk sites, which largely dictated the scope of work for the detailed PWNHRA.

A preliminary results memo was prepared by CGL at the completion of field work for this detailed PWNHRA. The memo, dated September 12, 2024, was also posted on the MOF-BCWS Post-Wildfire Reports portal (URL: https://pwnhr-bcgov03.hub.arcgis.com/pages/assessments-explorer). The purpose of the memo was to provide early identification and communication of potential risks to begin planning for risk mitigation.

1.4 Study Area Watersheds, Sub-Basins, and Face Units

The 2023 Crater Creek Wildfire affected watersheds and sub-basins draining into the lower Ashnola River, and upper elevation headwater areas of the watersheds and sub-basins draining into the lower Similkameen River valley. The wildfire extended into the United States of America (the USA) to the south. The eastern perimeter of the Crater Creek Wildfire roughly aligns with the western perimeter of the 2018 Snowy Mountain Wildfire (K51238), which burned watersheds draining into the lower Similkameen River valley. Small areas of overlap indicate locations where the more recent fire burned areas that were previously unburned or burned at low severity.

The study area is sub-divided into affected sub-basins of the Ashnola River watershed, and sub-basins of the Similkameen River. Open slope areas located between the sub-basins are called “face units”. The project study area includes those sub-basins and face unit areas identified as being at risk by the Ministry of Forests, and in consultation with the LSIB. The watersheds, sub-basins and face units included in the study are shown on Map 001 and listed in Table 1-1 below. Corresponding maps, enclosed in Appendix B, are indicated.

Table 1-1: List of Study Area Watersheds, Sub-Basins, and Face Units

Map #	Watershed/Sub-Basin/Face Unit		Area (km^2)
Map 002	**Similkameen River Watershed**	Paul Creek	109.6
		Rattlesnake Creek	8.3
		Similkameen Sub-Basin 1	1.9
		Similkameen Sub-Basin 2	2.1
Map 003		Face Unit East of Ashnola	3.7
		Bullock Creek	8.9
		Watershed 2	9.8
		Barrington Creek	17.8
Map 004		Susap Creek	77.3
Map 005		Snehumption Creek	85.3
Map 002	**Ashnola River Watershed**	Ashnola Face Unit 1	4.5
		Red Bridge Creek	19.4
Map 006		Ashnola Face Unit 2	15.6
		Webster Creek	7.4
Map 007		Ewart Creek	251.6
		Ashnola Face Unit 3	4.2
		Ashnola Face Unit 4	13.4
		Lakeview Creek	61.7
Map 001		Lower Ashnola River (downstream of fire perimeter)	466.7

2. Study Tasks & Risk Analysis Approach

The study approach generally follows that which is outlined in *Land Management Handbook (LMH) No. 69 – Post-Wildfire Natural Hazards Risk Analysis in British Columbia* (Hope, et al., 2015). In addition, further clarification on study tasks and the risk analysis approach was provided in the MOF Contract, Schedule A – Services, and by communication with MOF-BCWS (G. Wells, personal communication, 2025).

2.1 Study Tasks & Methods

The study approach is comprised of the following tasks:

Task 1: Preparation for field work, including background information review and base map preparation. In advance of completing the field work pertinent background information was gathered and reviewed. Publicly available information was reviewed to characterize area topography, terrain, bedrock, and hydrology. Of relevance was the detailed PWNHRA completed for the 2018 Snowy Mountain Wildfire (K51238) by Westrek Geotechnical Services Ltd. (2018).

Task 2: Collect GIS-Derived Watershed Parameters for the Hazard Assessment. This task is a desktop GIS-based screening assessment of the watershed areas to determine the dominant hydrogeomorphic process and to direct field efforts to high hazard areas.

Task 3: Aerial reconnaissance and ground-based field assessment of the slopes, creek banks, and fan areas within the areas potentially affected by the effects of wildfire. A helicopter overview flight documenting conditions at higher elevations was completed on August 1, 2024, by J. Clarke, P.Geo., of CGL, accompanied by B. Scott, of Ecora Engineering and Environmental Ltd. (Ecora) and K. Louie, Natural Resource Team Lead of the LSIB. Ground-based (foot and vehicle) field assessment was completed between July 29 and Aug. 1, 2024, by J. Clarke, P.Geo., accompanied by B. Scott and members of the LSIB Natural Resources Field Crew (Rick Kruger and RJ Edward). Photos and field notes were collected using a tablet on georeferenced maps. Field and aerial observations were used to confirm and correlate vegetation burn severity and soil burn severity ratings.

Field observations obtained while completing other related assessments in and near the study area provided additional complementary supplemental information. These related projects included:

- Detailed inspection of the Crater Lake Forest Service Road (FSR) within the fire perimeter, and detailed inspection of Ashnola River FSR outside the fire perimeter, on behalf of the Ministry of Forests – Okanagan Shuswap Natural Resource District (OSNRD);
- Detailed inspection and road repair prescriptions for Lakeview Road, Cathedral Park, on behalf of Ministry of Environment and Climate Change Strategy - BC Parks;
- Regional Similkameen Baseline Geohazard Study, on behalf of the USIB and LSIB. Project funded through the Disaster Risk Reduction – Community Emergency Preparedness Fund (team member for Ecora, in progress); and,
- Post-Wildfire Natural Hazard Risk Analysis Update of Shoudy Creek Watershed, on behalf of the MOF-BCWS (in progress).

The field observations are considered in context with other background information to assess the likelihood of post-wildfire natural hazards, and to further identify the spatial likelihood of impact to identified Elements at Risk.

Task 4: Conduct a natural hazard assessment and partial risk analysis. This task is comprised of a qualitative hazard assessment to determine the likelihood of post-wildfire natural hazards (see Section 2.2 below). The partial risk analysis, as outlined in the LMH 69 (2015), is presented in greater detailed below (see Section 2.3 below). Partial risk analysis does not quantify the degree of impact (i.e., vulnerability), rather, it is a combination of the likelihood of an event occurring, and the likelihood of that event reaching or otherwise affecting a specified Element at Risk. The approach identifies high priority sites/areas which may require response/repair and distinguishes them from lower priority sites that can be addressed at a later time.

Task 5: Develop concept-level mitigative strategies to address high risk sites. Recommended measures to reduce risk are identified.

Task 6: Prepare a Report. This report accompanies maps provided in Appendix B. Partial risk analysis Report Cards, along with select photographs that document post-wildfire natural hazard conditions, are provided within the body of the report for each sub-basin area.

2.2 Natural Hazard Assessment

The natural hazard assessment is the first phase of the PWNHRA process. The hazard criteria were developed with reference to post-wildfire hazard research, LMH 69 (2015), and included within Schedule A - Services. The hazard assessment criteria (Table 2-1) estimate the likelihood for post-wildfire natural hazards such as debris flow, debris flood, or post-wildfire peak flow effects. Field-based investigation was completed to verify and provide more detail, particularly with reference to vegetation and soil burn severity observations and with reference to the field indicators of instability along the stream channel or across the fan area.

Table 2-1: Post-Wildfire Natural Hazard Assessment Criteria Utilized for the Crater Creek PWNHRA

	Criteria		
Description	**High Hazard Level**	**Moderate Hazard Level**	**Low Hazard Level**
Total Area (%) Burned	>75%	>30%	<30%
Area (%) Burned at Moderate & High Burn Severity	>50%	>20%	<20%
Area (%) Burned of Wildfire Affected Terrain Conducive to Post-Wildfire Natural Hazard Initiation (>50% slope class)	>50% mod/high burn severity on >50% slopes	>20%	<20%
Evidence of Previous Instability in Channel or on Fan (through imagery or field review)	Yes, incl. recent activity	Only historic (overgrown) activity	None visible, ancient

The hazard criteria are based on:

- the total percentage of the watershed burned;
- the percentage that burned at moderate and high vegetation burn severity; a condition that represents a complete loss of forest and understory.
- the area burned at moderate and high burn severity that is also situated on terrain conducive to natural hazard initiation. For the purposes of this assignment, in the absence of comprehensive terrain stability mapping, this was interpreted to be terrain greater than 50% slope.
- evidence of previous instability along the stream channel or across the fan area. It assumes that if a watershed exhibits a historic hydrologic or geomorphic response process, then there is a higher likelihood that it will respond in a post-wildfire condition.

The USGS Burned Area Emergency Response (BAER) teams utilize a similar screening approach for emergency assessments of post-wildfire debris flow hazards[3]. The USGS uses catchment morphometrics, burn severity, soil properties, and rainfall characteristics to estimate the probability and volume of debris flows that may occur in response to a design storm event. Results for US wildfires are presented on the Post-Fire Debris Flow Hazard Assessment Viewer[4].

2.3 Partial Risk Analysis Approach

The post-wildfire risk analysis approach, outlined in LMH #69 (2015) and adapted for this project, is a qualitative partial risk analysis. The approach and definitions of technical terminology are derived from LMH #56 (Wise, et al., 2004) and a detailed description of the risk analysis approach is provided in Appendix A.

In summary, partial risk is defined as the probability of a specific hazardous event affecting an Element at Risk, and it can be expressed as:

$$P(HA) = P(H) \times P(S{:}H)$$

where:

$P(HA)$ is the partial risk

$P(H)$ is the likelihood of a hazardous event occurring

$P(S{:}H)$ is the spatial likelihood that the hazardous event will reach the element at risk.

Qualitative ratings (i.e., low, moderate, and high) are used to describe hazard levels and the spatial likelihood level. These ratings, and the criteria used to assign each rating, are provided in Appendix A (Tables A1 and A2). The hazard and spatial likelihood ratings are combined in a risk matrix (see Table 2-2) to determine partial risk.

Table 2-2: Qualitative Partial Risk Matrix

Partial Risk P(HA): the probability that a specific hazard will occur and the probability of it impacting a site occupied by a specific Element at Risk (i.e., P(HA) = P(H) x P(S:H))		**Spatial Impact Likelihood P(S:H) – the probability (likelihood) that the hazard will reach or otherwise impact the site occupied by an Element at Risk**		
		High	**Moderate**	**Low**
Hazard P(H) – the annual probability (likelihood) of occurrence of a post-wildfire natural hazard (i.e. landslide, debris flow)	**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

[3] https://burnseverity.cr.usgs.gov/products/baer

[4] https://usgs.maps.arcgis.com/apps/dashboards/c09fa874362e48a9afe79432f2efe6fe

The outcome of the partial risk analysis, above, is an assigned risk level. Five possible outcomes, or risk levels, range from very low to very high. Assigned risk levels provide a relative risk rating, which can be used to prioritize sites, and each level has associated management implications for risk mitigation (see Table 2-3). These risk levels broadly assume a threshold level of acceptability or tolerance. This is completely dependent upon regulatory requirements or perspective of the end user.

Table 2-3: Implications of Qualitative Partial Risk Ratings

Partial Risk Rating	Evaluation
Very High	Unacceptable risk typically requiring site-specific detailed investigation, planning and implementation of mitigative treatments recommended to reduce the partial risk to a more acceptable level. May be very expensive or impractical. Consider avoidance.
High	Usually unacceptable and typically requiring site-specific detailed investigation, planning and implementation of mitigative treatment recommended to reduce the partial risk to a more acceptable level.
Moderate	This risk may or may not be tolerable, depending on the risk acceptability criteria of the stakeholder or decision maker. The risk may be accepted and monitored. Treatment plans may be developed to reduce the hazard. Additional investigation and planning for treatment or mitigation options may be pursued.
Low	Usually acceptable, treatment or additional investigation may still be pursued at the discretion of the stakeholder or decision maker.
Very Low	Acceptable.

3. Background Information on Post-Wildfire Effects on Hydrology and Geomorphology

The following sections provide general information regarding post-wildfire effects based on scientific literature and includes documented post-wildfire response experience in the southern interior of BC (Jordan and Covert, 2009; Jordan, 2016). Historic post-wildfire impacts from the 2018 Snowy Mountain Wildfire and in the year following the 2023 Crater Creek Wildfire, are discussed in Section 4.6.1 of this report.

3.1 Typical Post-Wildfire Hydrogeomorphic Responses

Wildfire has the potential to affect hydrologic and geomorphic processes in a watershed. High vegetation burn severity wildfire consumes the forest canopy and underlying soils. Normally, these function to intercept precipitation, moderate infiltration, and protect mineral soils from erosion. With wildfire, there is an immediate decrease in evapotranspiration and infiltration, and exposed mineral soils become subject to surface erosion. These effects are reflected in soils with a corresponding high soil burn severity rating and which may also be exacerbated by wildfire-induced soil-water repellency[5].

Soil-water repellency occurs at, or just below, the soil surface and is caused when intense heat from wildfire burns plant material that releases waxy substances that coat soil particles. It is a characteristic that develops

[5] Soil-water repellency, also referred to as hydrophobicity, describes soils that repel water.

more strongly on areas burned at moderate to high vegetation burn severity. The development of repellency is also a function of antecedent soil moisture (dry soils more likely to develop repellent character) and thickness of the forest floor duff layer (thicker organic layers provide insulation against heat from the wildfire) (DeBano, 1981). Soil texture also influences the development of soil-water repellency. Very coarse-textured angular sediments such as colluvium are less likely to become water repellent after severe wildfire.

The hydrogeomorphic processes that are most affected by the effects of wildfire are listed below:

Hydrologic Hazards - Flooding, debris floods, and sediment-laden floods are hydrologic processes associated with the loss of vegetation and soil by wildfire, and by the development of soil-water repellency due to high burn severity wildfire. Effects include:

- Faster runoff and greater volume of runoff due to the loss of interception and transpiration by vegetation, and by the reduced infiltration into wildfire-affected soils. The presence of water repellent soils (see Section 3.3) causes irregular wetting, preferential flow paths in the soil matrix, reduces rainfall infiltration rates, and leads to enhanced overland flow (Doerr and Moody, 2004).

- Sediment-bulking of a stream occurs with increasing sediment inputs from tributaries, side slopes or within-channel mobilization. With increasing sediment, the hydrologic process will transition to a geomorphic process (i.e., debris flow). Additionally, woody debris generated by fallen burned timber may cause debris jams in stream channels, which can disrupt flow and sediment transfer rates.

- In snow-dominated watersheds, wildfire results in greater snow accumulation, earlier onset of snow melt, and increased rates of snow melt. Thus, in a transitional watershed that occupies a wide range of elevations, wildfire at higher elevations has a more pronounced effect on snowmelt generated peak flows.

- The effect on peak flows is proportional to the area burned at moderate to high burn severity. In watersheds that have been subject to high vegetation burn severity wildfire, particularly those with steep terrain, peak flows can be flashier and orders of magnitude higher (Neary, et al., 2011).

- Post-wildfire hydrologic response will be greater in smaller catchment areas due to the short time of runoff concentration and synchronization of runoff during intense convective rain events. Hydrologic changes in larger watersheds may be less pronounced/obvious due to the desynchronization of widespread regional rainfall events and snowmelt runoff from diverse aspects, elevations, and slope types.

Geomorphic Hazards - Landslides, rockfall, debris flows, and soil erosion are geomorphic (hillslope stability) processes associated with the loss of vegetation and soil runoff effects due to wildfire and water repellent soils along slopes within the study area. Effects include:

- Increased likelihood of open slope landslides (slumps, debris slides, debris avalanches) and channelized landslides (debris flows). Stability impacts will be most apparent on steep (>50%) slopes and along steep debris-flow prone gullies.

- Accelerated soil erosion due to exposed mineral soils.

- Thermal expansion of rocks due to intense heating that may destabilize exposed bedrock.
- Burned trees that remain standing are a potential safety hazard, and when the trees fall, they may destabilize the slope and expose soils to erosion.

While snow avalanches are not specifically considered for this study, there is an increased likelihood for snow avalanches associated with the loss of forest cover by wildfire. These effects are more likely to occur in areas that already experience snow avalanche activity. The loss of trees and the associated understory reduces the anchoring and surface roughness effect for the snowpack, which can result in avalanches occurring with greater likelihood[6]. Loss of trees can also alter the local snow climate, increasing the likelihood for sensitive snow layers (i.e., sun or wind crusts) to develop in areas where they previously did not occur.

The presence of danger trees associated with burned areas is not considered for this study but is an important public safety factor.

3.2 Post-Wildfire Debris Flow Trigger Mechanisms

Post-wildfire debris flows are a targeted post-wildfire response process because they can be potentially dangerous to life and property. Debris flows are classified as (saturated) landslides that move quickly, are capable of transporting bouldery debris, and often occur without advance warning. Debris floods, in comparison, are classified as floods that transport large volumes of sediment and woody debris. In larger catchments, debris flows on small steep tributary channels may transition to a debris flood as the event moves downstream within the mainstem channel.

In Jordan and Covert (2009) and Jordan (2016), post-wildfire debris flow events were found to have been triggered by spring snowmelt, by short-duration high-intensity rainstorms in the summer, and by long duration low-intensity fall rainstorms. The specific initiation mechanisms are described as:

- Runoff-Triggered Debris Flows - the most common debris flow initiation mechanism is by runoff, caused by erosion of channel bed and banks, and progressive bulking of sediment within the channel, caused by a critically high discharge; and,
- Landslide-Triggered Debris Flows – these types of debris flows are caused when a landslide enters a steep channel. This was found to be the most common debris flow trigger mechanism in unburned forested landscapes in the West Kootenay region of the Southern Interior.

Much of the post-wildfire natural hazard research comes from the Pacific Northwest of the US, and California, where post-wildfire debris flow events are more common[7]. In the Southern Interior of BC there are fewer documented events. This may be attributed to more stable pre-fire terrain conditions, or that events are occurring in remote areas, or possibly due to a historically fire-conditioned landscape. More recently, it is widely accepted that BC is experiencing higher precipitation intensities more frequently due to climate change, and normally moist soils are now drier due to prolonged periods of drought (see Section 7.6 for climate change discussion). Drier soils and forests contribute to higher burn severities, which also affects debris flow likelihood.

[6] See Avalanche Canada URL: https://avalanche.ca/blogs/wildfire-avalanches
[7] USGS Post-Wildfire Emergency Assessment of Post-Fire Debris-Flow Hazards URL: https://landslides.usgs.gov/hazards/postfire_debrisflow/

Research from the USGS[8] indicates that the 2 to 5 year, 15-minute storm is the storm most likely to generate debris flows. The closest precipitation intensity-duration-frequency (IDF) data is available for the Oliver STP Station (#1125766; 1973-2007), however data for the 15-minute storm is not available. The station does provide the 2 to 5 year 1-hour storm data which has an intensity of 9 to 13 mm/hr.

Using the IDF-CC web-based tool to model IDF curves under a changing climate, the modeled conditions for an ungauged location at Keremeos are summarized as follows (Simonovic, et al., 2015):

15-min, 2-to-5-year precipitation intensity using Historical IDF Data	= 21 to 34 mm/hr
15-min, 2-to-5-year precipitation intensity using 2015 to 2100 Multi-model ensemble (SSP3.70 – RCP8.5[9] for IDF under Climate Change	= 24 to 39 mm/hr

Real-time precipitation data is useful for monitoring and can be used to develop a warning system for rainfall-triggered debris flow and flooding events. The Pacific Climate Impacts Consortium (PCIC) provides meteorological data from various sources through a BC Station Data Portal[10]. A complete search for suitable and available data variables and data was not completed for this study, but would be required for the development of a weather-based warning system.

3.3 Water Repellent Soils and Expected Duration of Post-Wildfire Effects

Development of water repellent soils within wildfire-affected areas is described in Section 3.1. This condition is not necessarily unique to wildfire, however, together with the loss of forest cover, it has the greatest influence on the likelihood of post-wildfire natural hazard occurrence.

Research on the persistence of wildfire-induced water repellent soils indicates that it is a phenomenon that decreases with depth and is spatially highly variable. The persistence is site specific, dependent upon the strength and extent of hydrophobic chemicals in the soil, the structure of soil minerology, and the physical and biological factors affecting the breakdown of these chemicals. MacDonald and Huffman (2004) showed rapid deterioration of soil-water repellency after 1 year, while others found that conditions may persist for up to 6 years (DeBano, 1981).

Repellency tends to decrease when soils have prolonged contact with moisture. As such, this characteristic will become reduced with prolonged rain and spring snowmelt. Once wet, water repellent soils are not repellent again until they dry out. Once dry, they can reoccur in subsequent dry seasons for several years (Curran, et al., 2006).

In the short-term, research has found that post-wildfire effects on hydrology increase in the first two to three years following wildfire and then decrease in time after that (Hope, et al., 2015). Degraff et al. (2015) indicate

[8] United States Geological Survey, Emergency Assessment of Post-Wildfire Debris-Flow Hazards (URL: https://www.usgs.gov/programs/landslide-hazards/science/emergency-assessment-post-fire-debris-flow-hazards)
[9] RCP8.5 is the Representative Concentration Pathway that provides a future concentration scenario leading to the most severe climate change impacts.
[10] PCIC BC Station Data Portal URL: https://services.pacificclimate.org/met-data-portal-pcds/app/

that the great majority of post-wildfire debris flows in the western US region occur within the first 12 to 18 months after a wildfire.

Longer-term hydrologic effects at a watershed scale are typically associated with changes to the spring snowmelt hydrograph (i.e., greater snow accumulation, faster snow melt, rain on snow events, etc.). These effects are expected to persist beyond 5 years until vegetation in the watershed approaches a state of recovery, or when the structure of the new forest approaches a pre-wildfire condition, which could be several decades post wildfire (Hope, et al., 2015; Jordan, 2015).

For the wildfire-affected slopes in the study area, short-term effects on hydrology and slope stability, are typically triggered by short-duration high-intensity rainfall events. These effects will be the greatest from the first year to about 5 years post-wildfire.

4. Study Area Characteristics

Study area characteristics that are relevant to the study are provided at an overview level in the following Sections and focus on pre-wildfire conditions and conditions that influence post-wildfire natural hazard initiation.

4.1 Physiography

The study area lies within the south-east corner of the Cascade Mountain physiographic region (Church and Ryder, 2010). South of the Similkameen River valley, Cathedral Provincial Park, Snowy Protected Area, and surrounding mountains are characterized by steep slopes and interconnected ridgelines radiating from three primary mountain peaks (i.e., Crater Mountain, Grimface Mountain and Snowy Mountain). Ewart Creek watershed is the largest watershed in the study area (252 km^2).

The downslope boundary of the study area is at the Similkameen River (elev. varies 360 to 450 m a.s.l.). The wildfire extended upslope into the headwaters of Ewart Creek and Snehumption Creek, including Grimface Mountain, Snowy Mountain, as well as the steep ridgelines connecting them (elev. ~2,600 m a.s.l.). The total elevational relief of the study area is ~1,300 to 2,000 m.

Table 4-1 provides a physiographic summary and Melton Ratio[11] classification of the study area sub-basins, but not for the face units. The Melton Ratio and the morphometric parameters that are used to derive the Melton Ratio provide insight to the dominant hydrogeomorphic process occurring within each area (Wilford, et al., 2004) (Church and Jakob, 2020).

Melton Ratio is plotted against watershed length in Figure 4-1, as per Wilford, et al. (2004). The classification is used as a screening tool during initial stages of the assessment. Generally, the classification indicates that larger watersheds are mostly prone to floods, while smaller, steeper sub-basins are prone to a mixture of debris flood and debris flow processes, indicating increasing potential for damages due to sediment/debris bulking. Depending on sediment supply and sediment transport potential, sub-basins within the larger watershed, or small sub-basins located within face unit areas are potentially subject to debris flow and/or sediment-laden

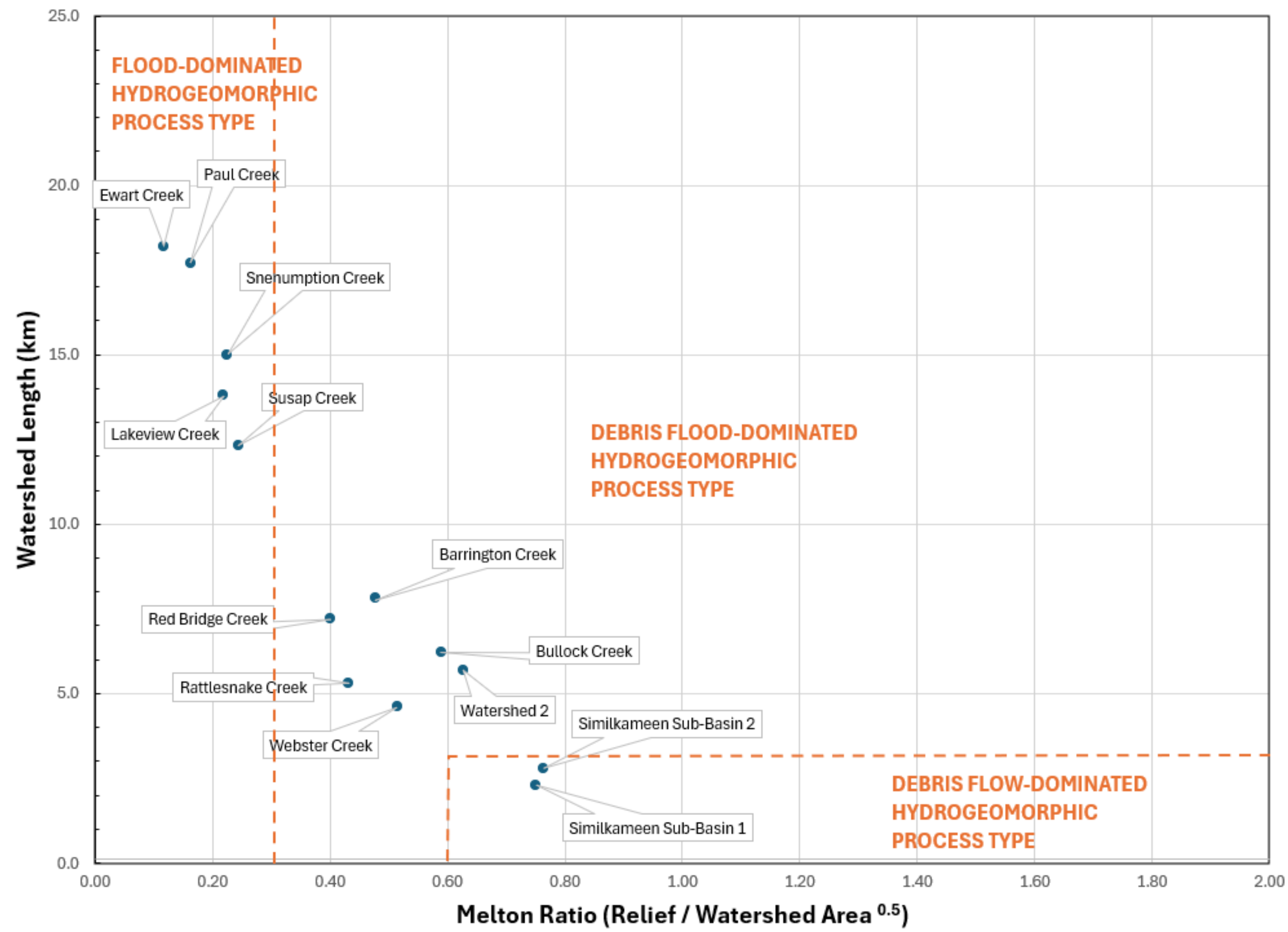
[11] The Melton Ratio is a measure of watershed "ruggedness" and is calculated as the watershed relief (m) divided by the square root of watershed area (m^2) (Melton, 1957; Wilford et al., 2004).

flooding. For watersheds with plateau (more gently sloped) headwater areas, such as Red Bridge Creek for example, the Melton Ratio can underestimate debris flow potential.

The physiographic characterization of each watershed provides a sense of pre-wildfire condition. The dominant hydrogeomorphic process would apply regardless of wildfire.

Table 4-1: Dominant Hydrogeomorphic Process at Study Area Watersheds and Sub-Basins

Watershed/Sub-Basin/Face Unit		Melton Ratio	Length of Catchment (km)	Dominant Hydrogeomorphic Process
Similkameen River Watershed	Paul Creek	0.16	17.7	Flood
	Rattlesnake Creek	0.43	5.3	Debris Flood
	Similkameen Sub-Basin 1	0.75	2.3	Debris Flow
	Similkameen Sub-Basin 2	0.76	2.8	Debris Flow
	Face Unit East of Ashnola	-	-	Rockfall
	Bullock Creek	0.59	6.2	Debris Flood
	Watershed 2	0.63	5.7	Debris Flood
	Barrington Creek	0.48	7.8	Debris Flood
	Susap Creek	0.24	12.3	Flood
	Snehumption Creek	0.23	15.0	Flood
Ashnola River Watershed	Ashnola Face Unit 1	-	-	Rockfall & Debris Flow
	Red Bridge Creek	0.40	7.2	Debris Flood
	Ashnola Face Unit 2	-	-	Landslide & Debris Flow & Sediment-Laden Flow
	Webster Creek	0.51	4.6	Debris Flood
	Ewart Creek	0.12	18.2	Flood
	Ashnola Face Unit 3	-	-	Landslide & Debris Flow & Sediment-Laden Flow
	Ashnola Face Unit 4	-	-	Landslide & Debris Flow & Sediment-Laden Flow
	Lakeview Creek	0.22	13.8	Flood
	Ashnola River (cumulative)	-	-	Flood



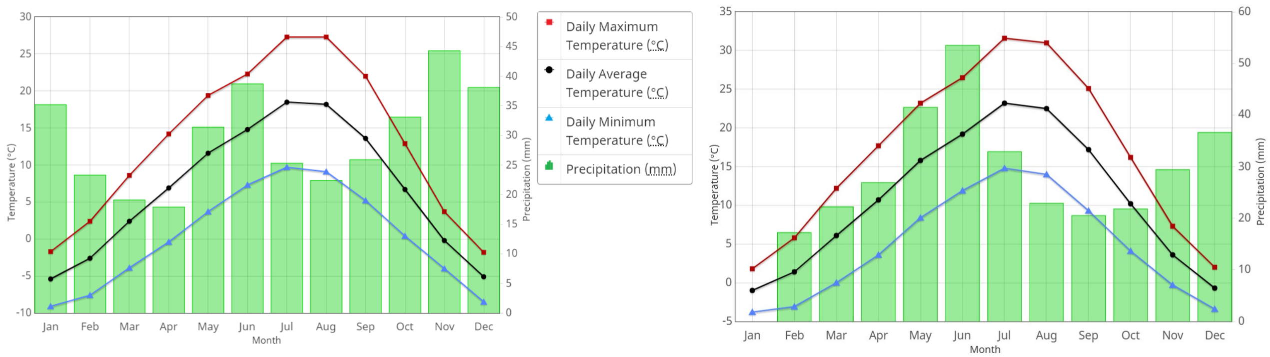
Note: Classification as per Wilford, et al. (2004). Process boundaries are approximate. Hybrid watersheds include those where flood, debris floods, and debris flow processes may occur at different frequencies and magnitudes.

Figure 4-1: Classification of Dominant Hydrogeomorphic Process Types for Study Area Watersheds

4.2 Climate (Precipitation and Biogeoclimatic Zones)

4.2.1 Temperature and Precipitation

The Similkameen Valley is a dry and comparatively warm portion of the BC Southern Interior. Canadian Climate Normals data (1991-2020) is presented for Princeton, located ~55 km NW of the study area, and for Osoyoos, located ~34 km SE of the study area. The datasets, shown in Figure 4-2, show relatively consistent monthly precipitation, typically ranging between 20 and 50 mm a month, throughout the year. Both datasets show similar trends and, by extension, are applicable to the study area. Precipitation in the winter months falls as snow. The data show average monthly temperatures ranging from -2 to -5° C in January to 18 to 23° C in July.



Source: Environment Canada[12] data for Princeton Station (#1123970) and for Osoyoos Station (#1125852)

Figure 4-2: Temperature and Precipitation Climate Normals (1991-2020)

Active manual snowpack data is available for the Lost Horse Mountain Station (#2G04; 1960-2024), which is located immediately north of the Paul Creek catchment. The records show a typical snowpack of up to 150 to 300 mm (snow water equivalent) that peaks in May. Manual snowpack data at the Mount Kobau Station (#2F12; 1966-2024), located east of the Similkameen valley opposite of Susap Creek, showed that there is up to 200 to 400 mm of snowpack in May. These data are useful because they dictate the timing and magnitude of the spring hydrograph in local area streams. The Lost Horse Mountain Station and Mount Kobau Station are at approximately 1,940 m and 1,810 m elevation, respectively. The study area extends up to approximately 2,600 m a.s.l. elevation, so snowpack within the site could potentially exceed these observations.

For flood forecasting purposes, the May 1 Snow Survey and Water Supply Bulletin from the BC River Forecast Centre[13] is the most applicable for spring snow data and flood forecast details.

4.2.2 Biogeoclimatic Zones in the Study Area

Biogeoclimatic zones are a regional climate-based ecosystem classification that defined as “a geographic area having similar patterns of energy flow, vegetation and soils as a result of a broadly homogeneous climate” (BC MOF, 2021). Biogeoclimatic zones within the study area are shown in Figure 4-3.

The Ashnola River valley and lower slopes of the Similkameen River valley within the study area lie within the Okanagan variant of the very dry hot Interior Douglas-fir (IDF xh1) biogeoclimatic zone and transition upward into to the Thompson variant of the dry cool Interior Douglas-fir (IDFdk1) biogeoclimatic zone. A thin band of the Similkameen variant of the very dry cool Montane Spruce (MSxk1) biogeoclimatic zone above ~1,500 m a.s.l. elevation, transitions to the Similkameen variant of the very dry cold Engelmann Spruce – Subalpine Fire (ESSFxc1) biogeoclimatic zone at approximately 1,700 m a.s.l. elevation, with alpine mountain peak areas (above ~2,000 m a.s.l. elevation) mapped as the Interior Mountain-heather alpine (IMAun) biogeoclimatic zone.

The 2023 Crater Creek Wildfire predominantly affected forests located within the ESSFxc1 biogeoclimatic zone, which generally lies between ~1,700 and 2,000 m elevation. This biogeoclimatic zone and elevation range are

[12] https://climate.weather.gc.ca/climate_normals/
[13] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/river-forecast-centre/snow-survey-water-supply-bulletin

characterized as a disturbance-driven ecosystem defined by, but does not consistently require, regular wildfire occurrence.

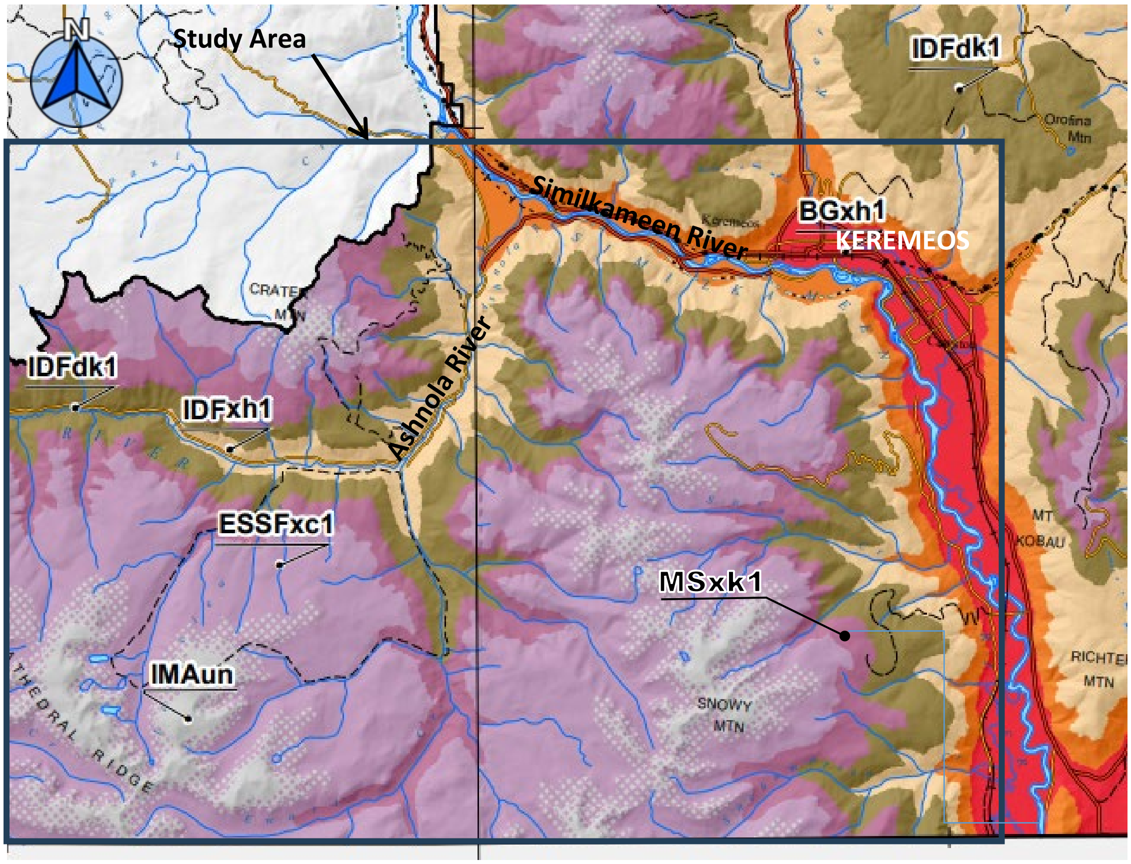


Figure 4-3: Biogeoclimatic Zones within the Study Area (MOF, 2021)

The study area has a Natural Disturbance Type (NDT) that is described as ecosystems with frequent stand-initiating events (NDT3) with lower elevation areas as having frequent stand-maintaining fires (NDT4). For stand-types within areas mapped as NDT4, there is value in maintaining frequent low intensity wildfires rather than suppressing wildfire to the point of experiencing more infrequent high intensity wildfire events.

In a 2008 Fire Management Plan, completed for Cathedral Provincial Park (i.e., Lakeview Creek watershed), forest health issues were determined to contribute to a High to Extreme potential fire behaviour condition (Davies, et al., 2008). The stand conditions in Lakeview Creek watershed, and potentially in adjacent watersheds, may help to explain the large extent and high severity of the 2018 Snowy Mountain and 2023 Crater Creek Wildfires.

4.3 Hydrology

Characterizing hydrology for the larger streams and rivers in the study area helps to understand what factors influence peak flows and the timing of peak flows. The most relevant hydrologic data, including real-time hydrometric monitoring, is available for Ashnola River from the Water Survey of Canada hydrometric station “Ashnola River near Keremeos” (Station #08NL004; Period of record 1914-current). This station is located just upstream from the confluence with the Similkameen River at the Paul Creek Road bridge crossing (see Map 002).

There is also historical, and real-time, hydrometric data for Ewart Creek near Cathedral Park (WSC Station #08NL076) for the period 1998-current (see Map 007), and a hydrometric station of the Similkameen River near Nighthawk (WSC Station #08NL022) located downstream of Keremeos for the period 1928-2018. The two stations located in the Ashnola River watershed provide extremely valuable and relevant flow data for areas affected by the Crater Creek Wildfire.

Historical flow data for the Ashnola River (see Figure 4-4) indicate that, on average, peak flows typically occur in early-June (mean maximum daily flow ~40 m^3/s) and are attributed to snowmelt. Figure 4-4 also shows flow conditions in 2024, the year following the Crater Creek fire. Flows in the spring of 2024 peaked on May 13th at 49.5 m^3/s, which is slightly earlier and higher than average (but well within variability). There is insufficient data to determine a post-wildfire trend correlate and more information on snowpack and temperature data is required.

The 2023 Crater Creek Wildfire extended into the higher elevation areas (i.e. snow accumulation zone) of Cathedral Provincial Park and the Snowy Protected Area. Loss of forest within the snow accumulation zone is more likely to result in increased snow accumulation (i.e. higher water yield) and faster snow melt resulting in an earlier peak flow and a higher peak flow in the spring. At any time of the year, the hydrograph responds to rainfall events, so in wildfire-affected areas the hydrograph tends to be flashier, with sharp streamflow peaks.

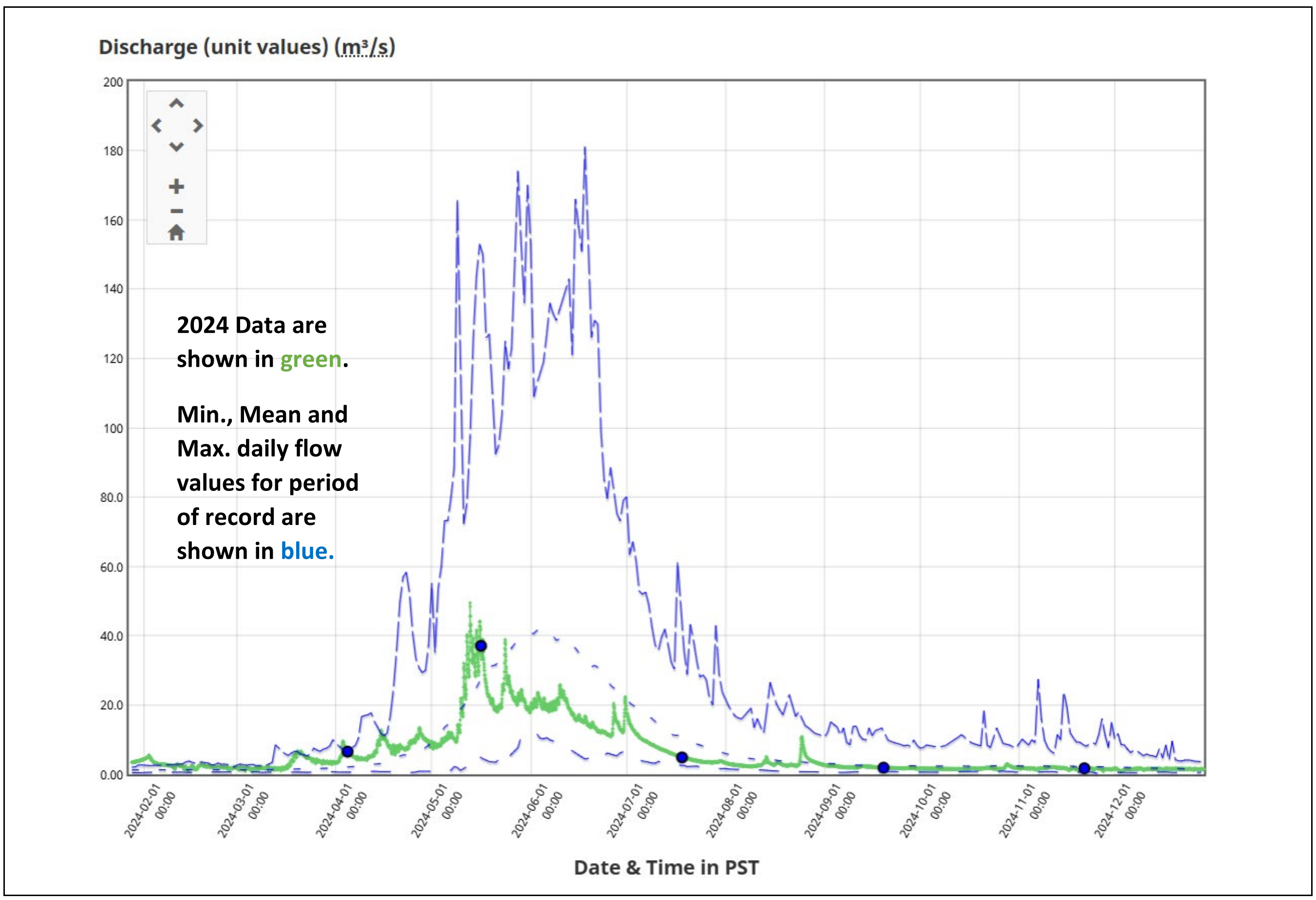


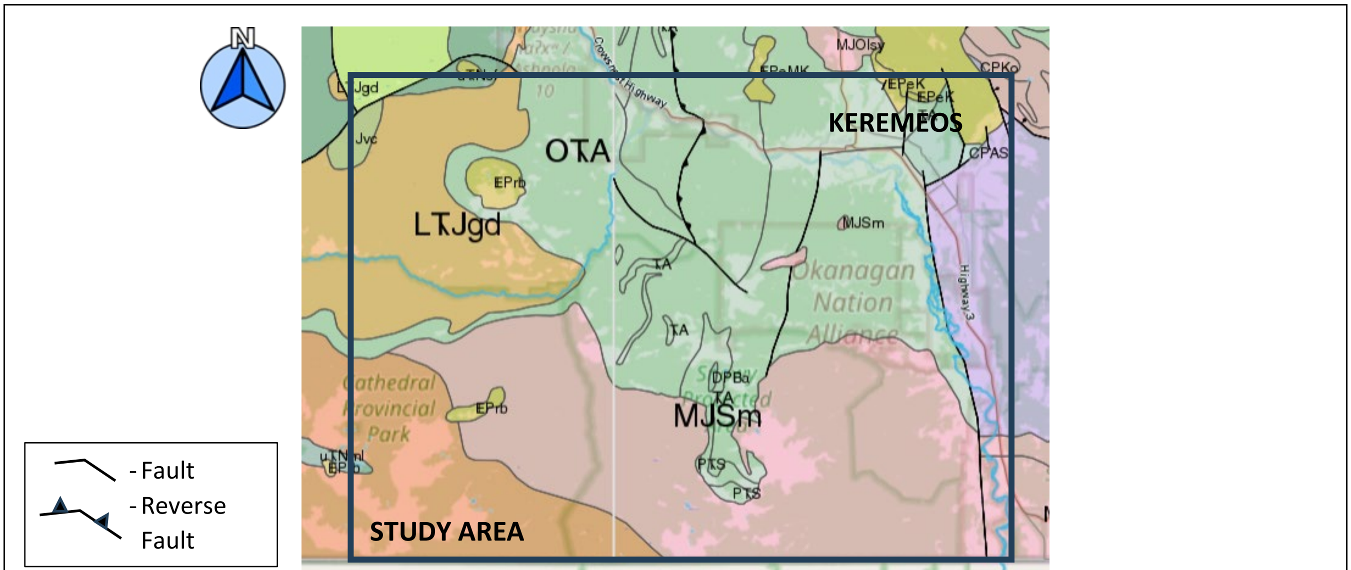
Figure 4-4: Streamflow at Ashnola River Near Keremeos (WSC #08NL004) (Period 1947-current)

4.4 Bedrock Geology & Surficial Geology

Bedrock geology mapping within the study area is compiled by the BC Ministry of Energy Mines and Petroleum Resources (MapPlace 2) and is shown in Figure 4-5.

The regional geology mapping shows that the bedrock geology is generally composed of volcanic, marine sedimentary and low-grade igneous bedrock. The mapped rock types include basalt, diorite, andesite, granodiorite, argillite, sandstone, siltstone, and greenschist. The slopes above the central and upper Ashnola River are typically volcanic while those adjacent to the Similkameen Valley are predominantly marine sedimentary or intrusive igneous.

Regional fault mapping on MapPlace 2 shows one key set of faults within the study area, with a north-south orientation east of Keremeos, near Barrington Creek and east of Bullock Creek. The fault near Barrington Creek is a reverse fault dipping east, the movement of the other faults is unknown. Andesitic volcanic peaks include some of the highest mountain peaks in the study area including Crater Mountain, Snowy Mountain, and Grimface Mountain.



Strat Unit: OTrA	Strat Name: Apex Mountain Complex	Rock Type: marine sedimentary and volcanic rocks
Strat Unit: LTrJgd		Rock Type: granodioritic intrusive rocks
Strat Unit: EPrb	Strat Name: Princeton Group	Rock Type: andesitic volcanic rocks
Strat Unit: MJSm	Strat Name: Similkameen Batholith	Rock Type: granodioritic intrusive rocks

Figure 4-5: Bedrock Geology within the Study Area (MapPlace2; BC EMPR)

Surficial materials within the study area reflect the processes associated with the most recent glaciation, which ended approximately 10,000 years ago (Fraser Glaciation). The glacial history of the study area is described in Church and Ryder (2010) and the distribution and character of surficial materials is mapped at an overview level by Fulton (1995).

The 1:5,000,000 scale Surficial Materials of Canada Map by Fulton (1995) indicates that the surficial geology of the Similkameen region is mostly made up of glacial sediments (veneer and blanket) and postglacial colluvium deposits. This is consistent with Hills and Matthews (1979) who noted the entire area was covered during previous two glaciations and surficial soils consist predominantly of till with some glaciofluvial deposits flanking the Ashnola River valley and localized landslide or rock glacier deposits present on Crater Mountain.

At the height of the last glaciation, the upland plateau areas were covered with ice and this ice retreated in situ, down-wasting on the plateau, leaving behind a mantle of heterogenous sediments (i.e., till or glacial drift) over bedrock[14], varying in thickness. During deglaciation, glacial meltwater flowed down into the presumably ice-filled Similkameen Valley (and potentially the lower Ashnola River valley). Glaciolacustrine sediments (clay and silt) may be present along the lower Ashnola valley side slopes.

Very large (i.e., over-sized) alluvial fans and raised glaciofluvial terraces characterize many of the larger catchments within the study area. Thick terraces flank the Lower Ashnola River, exposing stratified sands, gravels and boulders. Along one section of the Ashnola River (Face Unit 3 across from Ewart Creek Road), erosion along the exposed terrace scarp, which may potentially contain sediments of glaciolacustrine origin, has led to the formation of sediment pillars, or hoodoos.

The alluvial fans in the study area are easily recognized as there is sparse tree cover and mostly grasslands along the lower slopes. The fans could be interpreted as contemporary landforms, constructed from active alluvial sedimentation, however, these large fan features reflect a glaciofluvial environment and are paleo-fans. In Church and Ryder (1972), paleo-fans were found to represent rapid sedimentation conditions during a post-glacial (i.e., paraglacial) period of heightened sediment movement. Present day conditions are attributed to current rates of erosion and deposition, and, in certain situations, these fans become incised by modern streams but remain stable.

More contemporary fluvial sediments, comprised of sand, gravel and sometimes boulders, are associated with alluvial fans identified where tributary streams enter a larger valley. Where steep valley side slopes flank a valley, surficial materials derived from rockfall and/or debris flow processes are characterized as unsorted colluvium along talus slopes or talus aprons (where multiple talus fans converge along the toe of a slope).

4.5 Historic Land Disturbance

4.5.1 Past Wildfire History

Historic (i.e., post-1930) wildfires are mapped within the study area (iMap BC) and are shown on Figure 4-6. The mapping illustrates the high frequency of past wildfires in the study area. Historic wildfires have, however, tended to be much smaller in size than the recent 2018 Cool Creek Wildfire, the 2018 Snowy Mountain or the 2023 Crater Creek Wildfires.

The 2018 Snowy Mountain Wildfire (K51238) was a large (192 km^2) wildfire affecting the watersheds draining east to Range 13 IR and Chopaka 7 & 8 IR. This fire limited the eastern extent of the 2023 Crater Creek Wildfire. Other larger historic wildfires include the 2018 Cool Creek Wildfire (K62690; 136 km^2) located to the west of the study area.

[14] The composition and texture of till generally reflects that of the underlying bedrock.

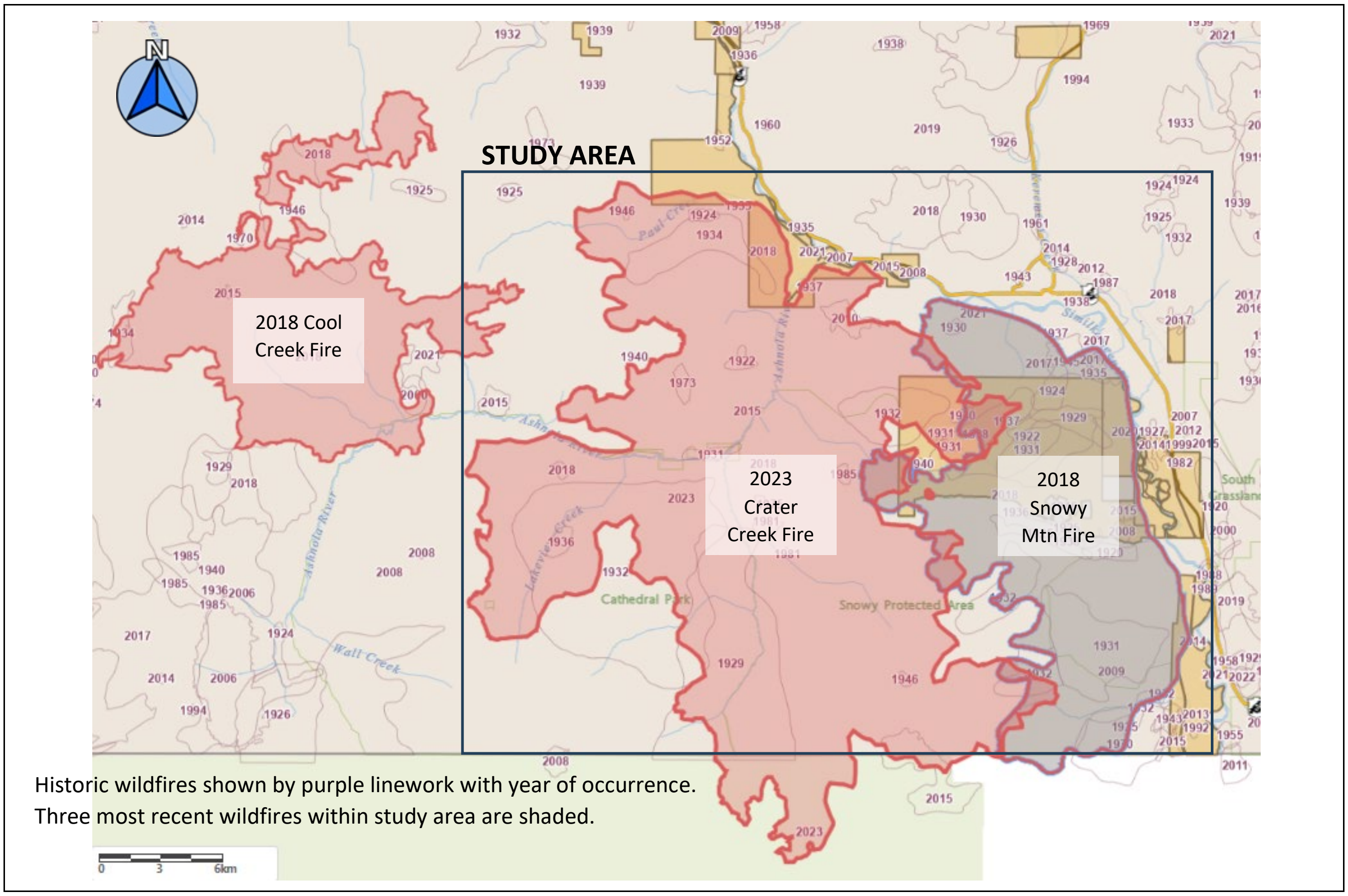


Figure 4-6: Historic Wildfires within and near the Study Area (source: iMAP BC)

4.5.2 Logging History

The protected areas of Cathedral Provincial Park (established in 1968) and the Snowy Protected Area (designated in 2001) are largely undeveloped and there has been limited logging. There is further protection of lands within the Ashnola River Watershed as it was designated an Indigenous (sməlqmíx) Protected and Conserved Area (IPCA) in 2022.

Past forestry development (i.e., cut blocks and resource roads) and livestock range use is present on the north side of the Ashnola River. Current forest licensees operating within the study area include: Weyerhaeuser Company Ltd. (north of Ashnola River into the Paul Creek watershed), Lower Similkameen Community Forest (Ashnola River valley slopes), and Gorman Bros. Lumber Ltd. (eastern slopes of lower Similkameen River valley). Historic logging and range use activity took place within the Susap, Shoudy, and Snehumption Creek watersheds above (west of) the lower Similkameen River and within the eastern part of what is now the Snowy Protected Area.

There are numerous older roads and trails in the lower Similkameen River tributaries south of Keremeos that are associated with historic logging, livestock range use, or mining. These are now classified as legacy roads that are no longer being used for forestry/industrial purposes and are now lightly used by Off-Highway Vehicles (OHVs), dirt bikes, and other 4WD vehicles. Ongoing traditional cultural land use practices may continue to utilize the established trails and routes in this area.

In severely burned watersheds, with a high post-wildfire natural hazard, there is a greater likelihood for stability impacts along the legacy roads due to wildfire effects on runoff and stability. Efforts to deactivate and rehabilitate roads may be useful in mitigating further instability in high hazard areas (see mitigation recommendations in Section 8).

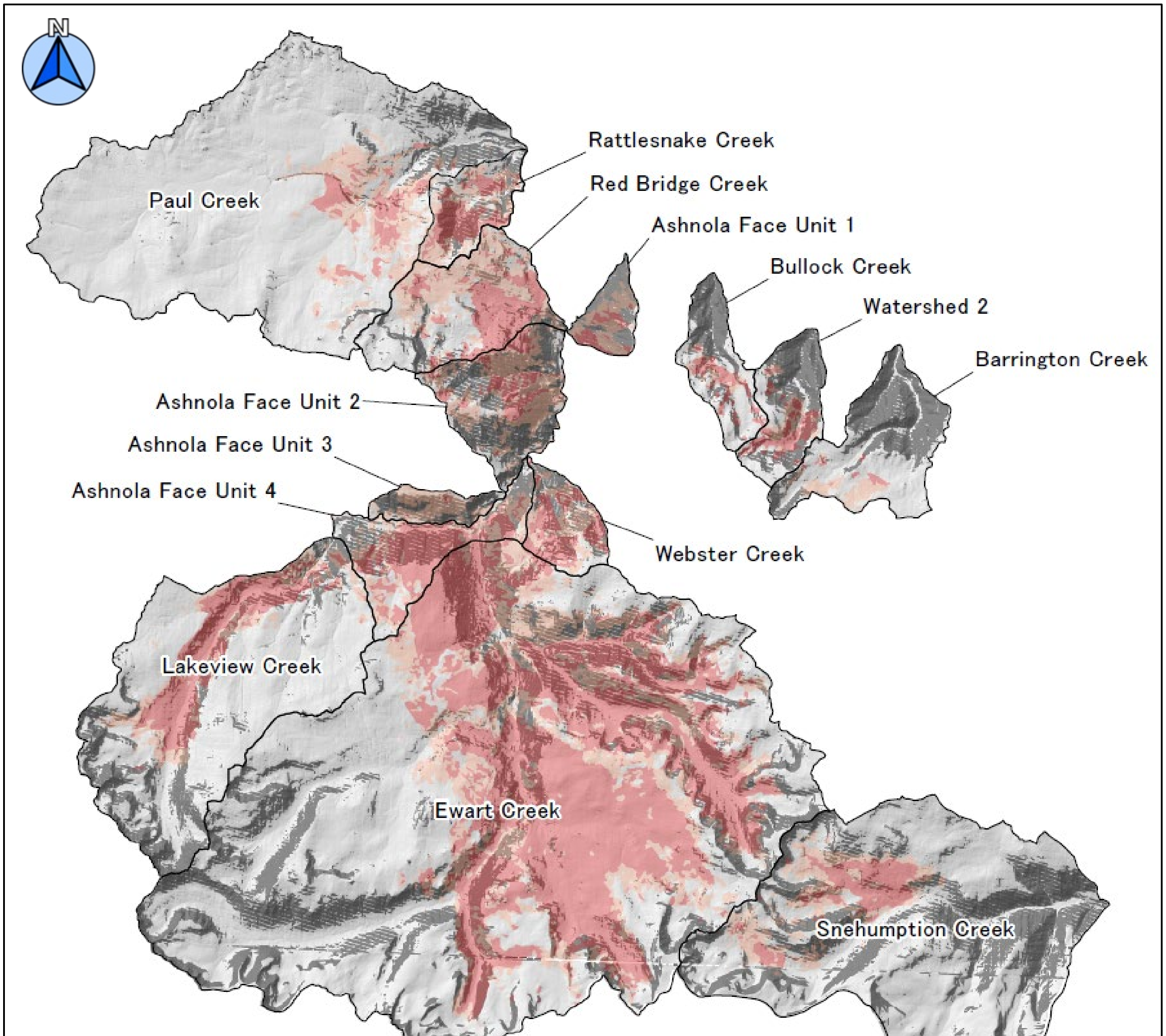
4.6 Geomorphology & Terrain Conducive to Natural Hazard Initiation

Terrestrial Ecosystem Mapping completed for Cathedral Provincial Park and reviewed on iMAPBC (data source is JMJ Holdings Inc, 2004) was found to confirm dominant surficial material classification, but did not include terrain stability classification.

Terrain stability mapping is not publicly available for most of the Crown Land portions of the study area. However, terrain stability mapping is available for a portion of the study area along the lower Similkameen River, including the Snehumption and Susap Creek watersheds draining into Chopaka 7 & 8 IR (data source is iMAP BC). For the mapped area, potentially-unstable and unstable terrain is mapped along the steep valley side slopes along mainstem channels, and steep gullied catchments of some of the small tributaries. The portion of the study area that is mapped is situated downslope or downstream from the area affected by the 2023 Crater Creek Wildfire. The affected upper elevation areas are generally more-stable and bedrock-controlled.

For the post-wildfire hazard assessment, slope classification combined with moderate and high burn severity, was used to identify terrain conducive to natural hazard initiation at an overview level for catchments burned in 2023 (see Figure 4-7). Slope class >50% slope, calculated using GIS on 1:20,000 raster topographic mapping is a surrogate value chosen to represent this kind of terrain. Records of past instability, a review of historical imagery, and field work were used to supplement and confirm the assessment of terrain conducive to natural hazard initiation.

A review of historic imagery available from GoogleEarth was also completed for this assessment to identify areas of previous slope or stream channel instability. The years of (sometimes partial) coverage include 2003, 2011, 2016, 2019, 2021, 2023. Historic air photos (prior to 2003) were not reviewed due to the large size of the study area. Rather, the above methods (Section 2.2) to identify potentially hazardous terrain were utilized for this assessment.



Moderate (orange) and High (red) burn severity and Slope Class >50% (dark grey). GIS-generated map based on TRIM data and Burn Severity Mapping

Figure 4-7: Terrain Conducive to Post-Wildfire Natural Hazard Initiation

4.6.1 Past Natural Hazard Events in the Study Area

There is no standardized, nor centralized, reporting of past natural hazard events in the study area. Documentation of past events is based on the imagery review, from previously completed natural hazard investigations, and from sources such as G. Wells, MOF, and anecdotal information from LSIB. The information presented here does not reference all possible sources and should not be considered a comprehensive inventory.

Post-wildfire natural hazard events that have occurred within (or near) the study area, are listed in Table 4-2. These events are noted on Maps 002 to 007 (Appendix B). In addition to the listed events, unusually high snowmelt conditions in the spring of 2018 (before the wildfires) led to high runoff conditions on major streams in the Okanagan region, including those within the study area. The November 2021 Atmospheric River precipitation event, combined with snow melt, led to flooding and bank erosion throughout south-western BC, including along the Similkameen River.

Table 4-2: Post-Wildfire Natural Hazard Events in the Study Area

Date	Hazard Type	Location	Description
Before July 2020 (GoogleEarth imagery)	Sediment-laden flood	Sintlehahten Creek	- Sediment-laden flooding within watershed impacted by 2018 Snowy Mtn Fire extended across fan, washed out North Chopaka Road, and into Similkameen River.
May 3, 2023	Debris flow	Roberts Creek	- Debris flow event on Roberts Creek, transitioning to sediment-laden flow, impacted residents in Chopaka 7 & 8 IR and road access across the fan. - Upper elevation areas of the watershed were burned by the 2018 Snowy Mountain Wildfire. - Report completed by G. Wells (2023) indicated that event was caused by rapid melt of mid-elevation snowpack and potential drainage concentration on old road/trail, which led to a landslide-triggered debris flow which travelled 4 km to the fan, transitioning to a sediment-laden flow.
Between May 4 and 12, 2023 (Sentinel imagery)	Sediment-laden flood	Shoudy Creek	- Sediment-laden flooding event on Shoudy Creek, impacted residents in Chopaka 7 & 8 IR and road access across the fan.
July 2, 2024 (LSIB comm. and field obs)	Sediment-laden flood	Red Bridge Creek	- Convective rain (localized event) led to washouts along the Crater FSR and sediment-laden flow along multiple channels into the Ashnola River.
Summer/Fall 2024 (GoogleEarth imagery & field obs.)	Debris flow	Swekust Creek	- Swekust Creek is located south of Lakeview Creek within 2023 Crater Creek fire perimeter. - Debris flow event caused temporary blockage of Ashnola River before deposit was removed by streamflow. Likely triggered by convective storm event.
Aug. 13, 2024 (LSIB comm. & field obs.)	Rockfall, erosion, sediment-laden flows & high runoff	Face Unit 3 flanking Ashnola River & Ewart Creek	- Rockfall, sloughing along Ashnola Road, and very muddy water in Ashnola River immediately downstream of Ewart Creek. - Event likely triggered by convective rain (localized) passing from west to east (impacted Calcite Creek (to the west) area first, then Ashnola, significant spike in stream flow detected on Ewart Creek)

5. Burn Severity Mapping

Vegetation burn severity was mapped by the BC Wildfire Service using the Burned Area Reflectance Classification (BARC) method using pre- and post-wildfire satellite imagery (Hope, et al., 2015). Soil burn severity is similarly classified but relies on field observations to determine the extent of consumption of the forest soils and ground fuels, and the extent and condition of exposed mineral soil. Soil burn severity refers to the relative measure of wildfire effects on soil properties that affect hydrologic function, such as loss of organic matter, root loss, altered mineral structure, ash depth, and reduced infiltration. Factors that influence soil burn severity include pre-fire forest floor properties and moisture content.

Definitions for vegetation and corresponding soil burn severity categories are from Hope, et al. (2015) and Parsons, et al. (2010) and are described in Table 5-1.

Table 5-1: Vegetation and Soil Burn Severity Class Descriptions

Burn Severity Class	Vegetation Burn Severity Class Description	Soil Burn Severity Class Description
High (red on map)	Trees are dead (black), needles, twigs, understory is completely burned.	Forest floor and near-surface roots consumed, mineral soil structure altered. Higher likelihood for water repellency effect on soil.
Moderate (orange on map)	Trees are dead (orange) but scorched needles remain on trees, understory is burned.	Litter is consumed, duff partly consumed or charred, mineral soil unaltered.
Low (green on map)	Canopy is mostly unburned, understory is lightly burned.	Litter is scorched or partly consumed, often with patchy forest floor burn.

Mapped vegetation burn severity for the 2023 Crater Creek Wildfire (see Map 001; Appendix B) indicates that there were extensive areas that burned at high severity. Areas mapped as high burn severity tended to have areas of dense forest cover, including areas within sheltered valleys (i.e., Lakeview Creek and Ewart Creek) or in areas with deeper soils that can support a denser forest. Burn severity was lower where forests were less dense due to shallow bedrock, steep ground, natural grasslands, or thinning.

Soil burn severity assessments were conducted throughout the study area during the field assessment to compare mapped vegetation burn severity with observed soil conditions; this information was used to correlate vegetation burn severity to soil burn severity. The field assessments also reviewed soil conditions for the development of water repellent (i.e., hydrophobic) soils. A total of 14 soil test pits were documented and locations are shown on enclosed maps (Appendix B)[15].

Field observations and soil test pit results are tabulated in Appendix C. To summarize, the results indicate that vegetation burn severity is judged to be well-correlated and representative of the soil burn severity. Some exceptions to the above include the following:

- Three (3) test pits showed that soil burn severity was lower than mapped vegetation burn severity. Two of these test pits were in the Red Bridge Creek watershed where the discrepancy could be explained by spatial resolution and variability at a site level scale.

[15] The total number of soil tests is less than specified in Schedule A – Services. Schedule A specified that for a >5,000 ha fire there should be >10 plots per vegetation burn severity class (>30 plots in total). Much of the study area that burned at high burn severity was inaccessible and helicopter landing was not possible.

- The testing in upper Snehumption Creek also downgraded soil burn severity in an area of shallow, moist soils within the sub-alpine headwaters.
- Within the lower elevation (i.e., IDF biogeoclimatic zone) Face Units of the Ashnola River valley, areas mapped at low vegetation burn severity were found to underestimate the soil burn severity and the impact on soils and terrain stability. In these areas it was observed that the fire consumed standing timber and left burn holes where roots were consumed. Where this occurred on steep slopes, this would potentially impact terrain stability.
- The results also showed moderate to strong water repellency at shallow (2 to 5 cm) soil depths within most areas mapped as high vegetation burn severity. Some variability was noted, perhaps due to degradation of repellency over the previous season. Weaker soil-water repellency was noted where soils were thin over rock and in areas with coarse-textured colluvial sediments despite burn severity.

6. Elements at Risk

Elements at Risk are defined as the population, building or engineering works, utilities, infrastructure in the area potentially affected by the hazards being assessed (Wise, et al., 2004). Other elements, such as cultural features, fish and fish habitat, and water quality are not specifically considered for this study.

The Crater Creek Wildfire affected lands within the LSIB traditional territory. The land holds special significance and value, providing cultural, archaeological, social, and economic resources. While specific sites are not identified on mapping, further engagement with LSIB is required for a more robust analysis of risk. Natural hazards along stream segments and slopes are identified, regardless of whether there are observed structures or dwellings.

Elements at Risk that are identified within the study area, and shown on accompanying Maps, include:

- Residences, structures, dwellings on public or private property or on Reserve Lands– the study area includes rural residential areas within Reserve Lands of the LSIB, and of the RDOS. Development density is sparse and may also include seasonal dwellings/cabins. Where "private property" is referenced in the report, the risk ratings are assigned to the specific property. On IR Lands "structures" are referenced in the report. Specific risk ratings for structures located on private property or on IR Land have a great deal of associated uncertainty necessitating knowledge regarding event magnitude, ability for drainage structures to handle events, and the runout characteristics of a design event. At the scale and scope of this project, this detailed analysis of risk is not possible, so risk ratings are broadly assigned to a fan area.
- Active domestic and irrigation water intakes mapped by GeoData BC are identified along streams within the study area (see Maps 002-007; Appendix B). No attempt was made to characterize intake infrastructure and use of water. Points of Diversion (PODs) located on a stream with a post-wildfire natural hazard is at risk of damage by high stream flows and/or sediment and debris transport. Water quality impacts due to ash, biological contaminants, and other substances are more likely due to the loss of vegetation buffer to the intake

- Transportation routes and associated major stream crossings (i.e., bridges and culverts) were identified and mapped. However, culverts on smaller streams were not identified. These include those under the jurisdiction and responsibility of the BC Ministry of Transportation and Transit (MOTT) but also for those located on Crown Land and within Reserve Lands and under the jurisdiction of LSIB.

Based on the results of this assessment, the level of post-wildfire flood risk may be extended to other features as they become known. For instance, the LSIB have expressed that water quality for fisheries and aquatic values is an Element at Risk. Water quality in the mainstem creeks and rivers, such as the Ashnola River and Similkameen River, is of high importance.

Where possible, the Elements at Risk are mapped on the Maps (Appendix B) and listed in Section 7.0 for each area of interest.

7. Detailed Post-Wildfire Natural Hazard Assessment and Partial Risk Analysis Results

The detailed PWNHRA results are summarized by watershed, sub-basin, or face unit area, which are listed in Section 1.4 and shown on accompanying Maps 002 to 007 (Appendix B). For each area, field observations and results of the hazard assessment are provided. Summary information and partial risk analysis results are summarized in a Report Card format and select photographs are provided.

Each area is presented as distinct sections within the report for ease of separation.

7.1 Ashnola 10 IR Lands (Lower Similkameen River Valley near Ashnola River)

7.1.1 Paul Creek Watershed & Rattlesnake Creek Sub-Basin

See Map 002 (Appendix B)

The Paul Creek watershed (110 km^2) was not originally included in the scope of work for the detailed PWNHRA. However, due to the extent of wildfire activity in the Rattlesnake Creek sub-basin and the presence of downstream Elements at Risk, we have chosen to include it in the risk analysis.

The Paul Creek watershed was not extensively burned (only 18% overall) and the area burned included the mid- to lower-elevation areas; areas below the snow-accumulation zone (see Photo 1). The larger watershed has a Melton Ratio of 0.16, characteristic of a watershed subject to clear-water flood hazard. The fire did, however, burn several steep valley side slope gullies that are directly connected to the channel (see Photo 2). There is a high potential for sediment delivery to the channel from these gullies. The tributary channels are steep enough to initiate and mobilize debris flows and debris floods, and downstream bulking of the stream channel may increase the likelihood for debris flood as it reaches the Similkameen Valley.

The fire extensively burned the Rattlesnake Creek sub-basin (83%), with almost 40% at high severity (see Photo 3). This level of burn severity represents a significant loss of forest and a high likelihood of fire-induced soil-water repellency. Approximately 25% of the area burned at moderate/high burn severity is located on slopes >50%. Therefore, there is a high likelihood for post-wildfire increases in runoff volume and flow, and an increased likelihood for sedimentation into and along the stream channel. The dominant hydrogeomorphic process in the sub-basin is debris flood (Melton Ratio 0.43).

Post-Wildfire Natural Hazards: There is a LOW likelihood for post-wildfire effects on the hydrology of Paul Creek. However, there is at least MODERATE likelihood of stream channel sediment bulking associated with valley side slope instability, which increases the hazard level on the fan area. There is a HIGH post-wildfire peak flow and debris flood hazard on Rattlesnake Creek (due to burned area and high percentage burned at high severity) and high sediment bulking potential from steep valley side slopes. There is a HIGH likelihood for post-wildfire landslide and debris flow from small steep tributaries that are directly connected to the mainstem channel of Rattlesnake Creek.

Spatial Likelihood of Impact and Partial Risk Analysis:

The Elements at Risk within this catchment include drainage structures along the Paul Creek Road (non-permitted resource road), including a bridge on Paul Creek (at ~2.5 km; see Photo 4), a 1000 mm diameter culvert on Rattlesnake Creek (at ~1.5 km; see Photo 6). Downstream on the fan, Paul Creek is traversed by the Ashnola 10 IR access road, with a newer looking bridge (Photo 8), and there is a residence located on the east side of Paul Creek (see Photo 1).

The wooden bridge on the Paul Creek Resource Road is currently not passable due to damages that may have incurred by machine access during the fire. The bridge sits high above Paul Creek, which has a boulder step-pool morphology consistent with a high gradient channel. The channel is fairly confined by valley side slopes and becomes more bedrock-controlled downstream through a lower canyon (see Photo 5). The spatial likelihood of impact to the bridge from high streamflow and/or high bedload transport is considered LOW. Thus, the partial risk of impact to the bridge is considered VERY LOW.

The 1000 mm diameter culvert on Rattlesnake Creek along the Paul Creek Resource Road has a HIGH spatial likelihood of impact from elevated streamflow and bedload transport. There is a short section of lower gradient channel upstream of the Paul Creek Resource Road that may become infilled prior to reaching the road (see Photo 7). The outlet of the culvert is partially plugged with debris. In its current condition the culvert may not have the capacity for increased flow. The culvert is also considered vulnerable to plugging by sediment in the event there is a debris flood event. The partial risk of impact to the culvert from elevated streamflow and high bedload transport is considered VERY HIGH.

The Paul Creek alluvial fan is deeply incised by the channel as it approaches the Similkameen River, and any evidence of past avulsion activity is downstream of the LSIB bridge that is located near the top of the fan. There are small-scale landslides on the valley side slopes upstream of the bridge. The natural hazard of concern is the delivery of sediment in debris flood, sediment-laden flow, or flood to the apex of the fan. The LSIB bridge on Paul Creek within Ashnola 10 IR is sited above the channel and is considered to have a MODERATE spatial likelihood of impact. The residence on the east side of the channel is setback 10 to 20 m from the slope break of the incised channel. With elevated stream flows and bedload transport, the incised fan side slopes may become undercut and potentially destabilize. Thus, the partial risk of impact to the LSIB bridge and to the residence is MODERATE.

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PAUL CREEK (and RATTLESNAKE CREEK SUB-BASIN) RISK ANALYSIS REPORT CARD

	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Paul Creek Watershed Total:	109.6	18	6.6	7.9	0.16	Flood	Low
Rattlesnake Creek Subbasin:	8.3	83	39.8	27.9	0.43	Debris Flood	High

Post-Wildfire Hazards:	There is a low likelihood for post-wildfire effects on the hydrology of Paul Creek. However, there is at least moderate likelihood of stream channel sediment bulking associated with valley sideslope instability. There is a high post-wildfire peak flow and debris flood hazard on Rattlesnake Creek (due to burned area and % at high severity) and high sediment bulking potential. There is a high likelihood for post-wildfire landslide and debris flow from small steep tributaries that are directly connected to the mainstem channel of Rattlesnake Creek. As a result, there is a high likelihood for increased instability across the downstream alluvial fan.

	Rattlesnake Creek	**Paul Creek**		
	Elements at Risk			
Dominant Process	**1000 mm diameter Resource Road Culvert on Rattlesnake Creek**	**Resource Road Bridge on Paul Creek**	**Downstream access road LSIB bridge on Ashnola 10 IR**	**Residence (adj. to fan) on Ashnola 10 IR**
	Hazard Level - Likelihood of Event P(H)			
Flood / Debris Flood	High	Low	Moderate - stream channel bulking and instability	
Debris Flow	-	-	-	-
Landslide/Rockfall	-	-	-	-
	Spatial Likelihood of Impact P(S:H)			
Flood / Debris Flood	High	Low	Moderate	Moderate
Debris Flow	-	-	-	-
Landslide/Rockfall	-	-	-	-
	Partial Risk P(HA) = P(H) x P(S:H)			
Flood / Debris Flood	**Very High**	Very Low	Moderate	Moderate
Debris Flow	-	-	-	-
Landslide/Rockfall	-	-	-	-

PHOTOS (Paul Creek Watershed and Rattlesnake Creek Sub-Basin)

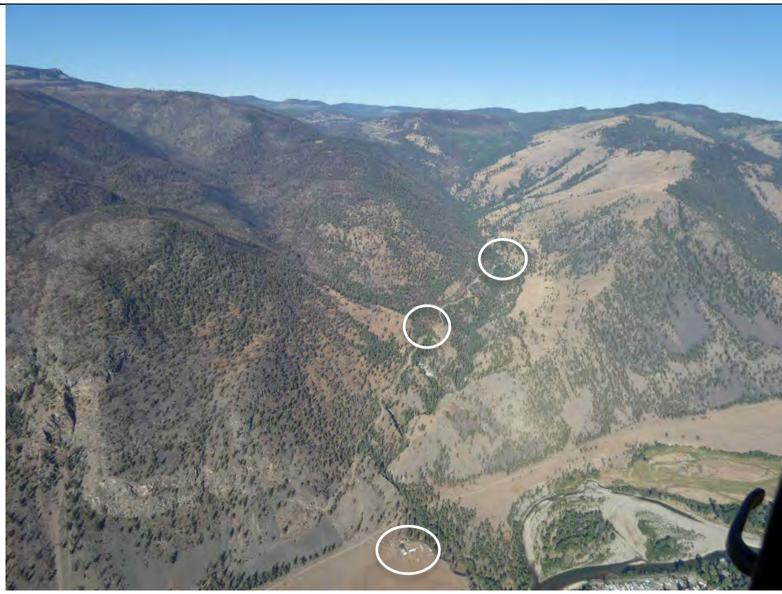

Photo 1: View of Paul Creek Watershed and Rattlesnake Creek Tributary from the Similkameen River. Note burned areas and forested alluvial fan area. Key stream crossings and residence in Ashnola 10 IR are circled.

Photo 2: Steep burned gullies along middle Paul Creek and view of upper watershed area that has been logged (incl. salvage logging of burned timber).

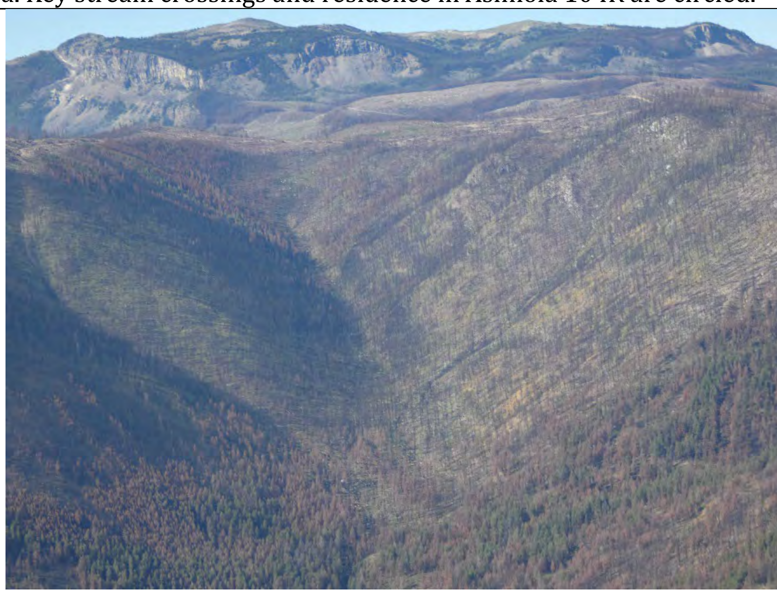

Photo 3: View of upper Rattlesnake Creek Tributary.

Photo 4: Bridge across Paul Creek (at ~2.5KM Paul Creek Road) is not passable.

Photo 5: Bedrock canyon of Lower Paul Creek, with view of Similkameen Valley

Photo 6: Culvert (1000 mm) inlet at Rattlesnake Creek crossing along Paul Creek Road. Outlet is partially obstructed by road grading sediment.

Photo 7: Rattlesnake Creek, view upstream from Paul Creek Road culvert. Evidence of livestock access to channel.

Photo 8: Bridge across Paul Creek at top of fan (access through Ashnola 10 IR in the Similkameen Valley)

7.1.2 Similkameen Sub-Basins 1 & 2 (west of the Ashnola River mouth) and Face Unit East of Ashnola River

See Map 002 (Appendix B)

Two small (~2 km^2) sub-basins above Ashnola 10 IR west of the Ashnola River are steep bedrock-controlled sub-basins within the lower Similkameen River valley (see Photo 1). The sub-basins were both extensively burned (78%) with a high proportion at moderate to high burn severity (>50%). Sub-basin 1 is undeveloped and has abundant talus material flanking steep bedrock side slopes and obscuring the channel. This sub-basin does not have a downslope fan (see Photo 6).

Upper elevation areas within Sub-basin 2 have historic forest harvest activity and resource roads (see Photo 2). Access into the area is from the Crater FSR (from Red Bridge Creek). Field observations in the upper sub-basin area indicates a low severity ground-based fire on moderate slopes (see Photo 3). Silty soils exhibit weak soil-water repellency in the burned area and there is evidence of shallow groundwater or seepage in the upper sub-basin. Loss of forest cover by wildfire in the upper sub-basin may result in increased peak flows.

The geohazards most likely to reach the sparsely forested fan area of Sub-basin 2 are rockfall and debris slide associated with the incised bedrock gullies closer to the fan area. Some of the trees on the fan are >100-years old but there is evidence of direct impact by rockfall. There are scattered boulders and cobbles across the fan and very shallow drainage swales indicating the presence of geohazards (see Photos 4 and 5). These hazards have the potential of reaching the downslope road. This hazard condition is relatively independent of the wildfire and represents a pre-existing hazard condition.

The Face Unit East of Ashnola River that is identified and described here is within Ashnola 10 IR in the Similkameen Valley and is situated between the Ashnola River (west of Tweddle Creek) and Bullock Creek (see Map 002). The slopes were not extensively burned and much of the area inspected along the toe of the slope burned at low burn severity (see Photo 7). The face unit is subject to frequent rockfall activity, as evidenced by the scattered boulder colluvium on the glaciofluvial terrace adjacent to the slope (see Photo 8). The talus slopes form an apron along the toe of the slopes and indicate pre-wildfire instability. The reconnaissance level PWNHRA (Wells, 2023) reports that rockfall activity increased after the fire. Although the forest cover on the bedrock slopes is thin, thermal fire effects and the loss of root strength may have an impact on bedrock stability.

Post-Wildfire Natural Hazards: The post-wildfire natural hazard level for Similkameen Sub-Basin 1 is rated LOW. There is a moderate likelihood that wildfire in the upper area of Similkameen Sub-Basin 2 has increased the likelihood for elevated peak flows and that this constitutes a MODERATE debris flow hazard. The geohazards most likely to reach the fan area are rockfall and debris slide associated with the incised bedrock gullies upslope of the fan.

For the Similkameen Face Unit East of the Ashnola and west of Bullock Creek, the post-wildfire rockfall hazard level is rated MODERATE, depending on the specific location on the slope, due to the fire-affected slopes that are conducive to rockfall initiation.

Spatial Likelihood of Impact and Partial Risk Analysis:

Paul Creek Road is an access road that traverses the toe of the slope below Similkameen Sub-Basins 1 and 2 through Ashnola 10 IR. The lack of any developed fan at Sub-Basin 1 indicates a LOW spatial likelihood and a

VERY LOW partial risk. Due to the position of the road at the distal end of runout along the Sub-Basin 2 fan, the spatial likelihood of impact to the road is considered MODERATE, resulting in a MODERATE partial risk.

The Ashnola River Road, located east of the river and along the Similkameen Valley slopes, is considered to lie beyond the influence of rockfall (beyond rockfall shadow zone) through the identified Face Unit East of Ashnola River. Therefore, the partial risk to this section of the road is rated LOW. The water reservoir servicing a nearby sub-division is located on a short slope at the western edge of the Face Unit, thus, the spatial likelihood of rockfall impact is rated MODERATE and the resultant partial risk of rockfall is rated MODERATE. The residence situated at the toe of the slope, west of Bullock Creek (at 455 Ashnola River Road), is considered to have a HIGH spatial likelihood of impact by rockfall and, therefore, has a HIGH partial risk rating.

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Post-Wildfire Natural Hazards Risk Analysis
2023 CRATER CREEK WILDFIRE (K52125)

SIMILKAMEEN SUB-BASINS 1 & 2 (west of Ashnola River mouth) & FACE UNIT East of Ashnola River - above Ashnola 10 IR RISK ANALYSIS REPORT CARD

	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Similkameen Sub-Basin 1:	1.95	78	21.1	37.6	0.79	Debris Flow	Low
Similkameen Sub-Basin 2:	2.05	78	28.4	35.3	0.66	Debris Flow	Moderate
Face Unit East of Ashnola River:	3.72	29	2.8	17	-	Rockfall	Moderate

Post-Wildfire Hazards:	Field observations in the headwaters of the Similkameen sub-catchment area indicates a low severity ground-based fire. Silty soils exhibit weak soil-water repellency in the burned area and there is evidence of shallow groundwater or seepage in the upper catchment. There is a moderate likelihood that wildfire in the upper catchment has had an impact on the hydrology and the potential for debris flow. The geohazards most likely to reach the fan area are rockfall and debris slide associated with the incised bedrock gullies upslope of the fan.
	The Similkameen Face Units east of the Ashnola River are subject to frequent (pre-wildfire) rockfall and rockslide activity. Due to the patchy and low severity wildfire on the rocky slopes, the likelihood of elevated post-wildfire rockfall activity is considered relatively low.

	Similkameen Sub-Basin 1	**Similkameen Sub-Basin 2**	**Similkameen Face Unit East of Ashnola River**			**All**
	Elements at Risk					
Dominant Process	**Downstream Access Road on LSIB Lands**	**Downstream Access Road on LSIB Lands**	**Ashnola River Road**	**Water Reservoir**	**Residence (455 Ashnola River Rd)**	**Buried gas pipeline**
	Hazard Level - Likelihood of Event P(H)					
Flood / Debris Flood	-	-	-			
Debris Flow	Low	Moderate	-			Moderate
Landslide/Rockfall	Low (pre-existing)	Moderate (pre-existing)	Moderate (pre-existing)			Moderate (pre-existing)
	Spatial Likelihood of Impact P(S:H)					
Flood / Debris Flood	-	-	-	-	-	
Debris Flow	Low	Moderate	-	-	-	Low
Landslide/Rockfall	Low	Moderate	Low	Moderate	High	Low
	Partial Risk P(HA) = P(H) x P(S:H)					
Flood / Debris Flood	-	-	-	-	-	
Debris Flow	Very Low	Moderate	-	-	-	Low
Landslide/Rockfall	Very Low	Moderate	Low	Moderate	**High**	Low

PHOTOS (Similkameen Sub-Catchments 1 & 2 and Face Unit E of Ashnola River)

Photo 1: View of Similkameen Sub-Catchments 1 & 2 from the Similkameen River. Note burned areas on plateau, incised bedrock channels & fan area of Sub-Catchment 1 (circled).

Photo 2: View of upper Sub-Catchment 2, previous harvesting and grassland areas draining to centre part of photo.

Photo 3: View downslope towards Similkameen Valley from upper Sub-Catchment 2. Note moderate slopes and patchy burn.

Photo 4: Large boulders on upper fan of Sub-Catchment 2. Forest is >100 years old.

Photo 5: Sub-Catchment 2 fan, view upslope. Scattered cobble and boulder-sized material, few larger rocks.

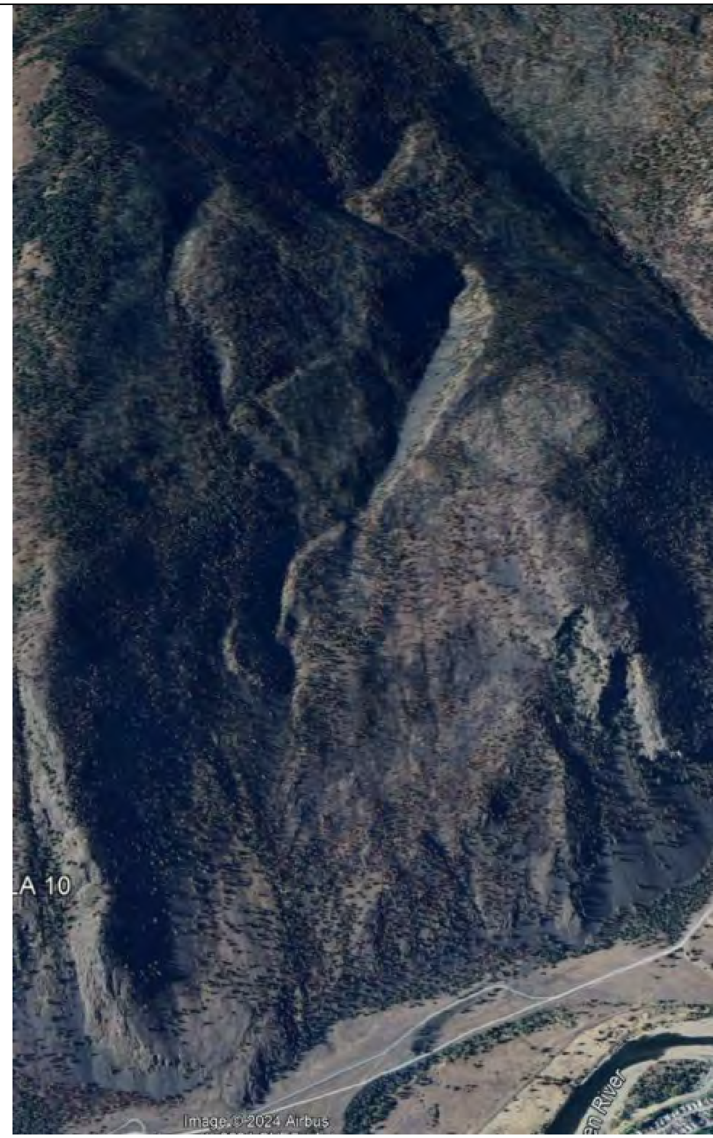

Photo 6: Oblique GoogleEarth image of Similkameen Sub-Catchment 1. Note abundant talus and lack of associated downslope fan (Low Hazard)

Photo 7: Similkameen Face Unit east of Ashnola River (west of Bullock Creek) outlined with residence at toe of slope circled.

Photo 8: Face Unit east of Ashnola River along the Similkameen (west of Tweddle Creek). View east showing extensive talus slopes below steep bedrock bluffs. Rockfall activity indicated by scattered boulders across glaciofluvial terrace along toe of slope.

Photo 9: View upslope to water reservoir for downslope sub-division (Element at Risk).

7.1.3 Bullock Creek Watershed

See Map 003 (Appendix B)

Bullock Creek is a steep, deeply incised and bedrock-controlled catchment (9 km^2) above the Similkameen Valley. It is also locally known as "Cold Spring Creek" (see Photo 1). The 2023 Crater Creek Wildfire burned 21% of the watershed and the area burned was located within the upper catchment (see Photo 2). The lower part of the watershed is sparsely vegetated with abundant talus deposits flanking the slopes. The dominant geomorphological processes occurring in the watershed are rockfall, rockslide and debris slide from the steep bedrock valley side slopes. There are some large-scale features of geologic instability.

The Bullock Creek fan is well-defined and sparsely forested (see Photo 3). The mainstem channel is incised within the larger (paleo) fan. There is evidence, however, of several avulsion channels extending from the fan apex across the fan but there is no contemporary evidence of debris flood activity (field access was limited due to private property). It is noted that there is ponding of Bullock Creek on the upstream side of Ashnola Road with evidence of beaver activity and partial blockage of the culvert. It is noted that soft soils are potentially affecting the road subgrade.

Post-Wildfire Natural Hazards: The influence of post-wildfire effects on the pre-existing hydrogeomorphic processes is likely to be very low in this catchment due to the characteristic subsurface flow of the mainstem channel through abundant colluvium. Elevated flows are unlikely to be detected. However, increased groundwater flows may occur further downslope. Overall, the post-wildfire natural hazard level is judged to be LOW.

Spatial Likelihood of Impact and Partial Risk Analysis:

Based on communication with a local resident, it is understood that the watershed and fan area contain sites of cultural significance. Downstream on the Bullock Creek alluvial fan, there are two residences within the Ashnola 10 IR (see Photos 3 & 4), a buried Fortis gas pipeline crossing (mid-fan), and Ashnola River Road traverses the distal edge of the fan (with a 4-foot (1,220 mm) diameter culvert crossing; see Photo 5). The overall partial risk to the identified Elements at Risk is considered VERY LOW to MODERATE (at the Ashnola River Road culvert).

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BULLOCK CREEK (aka Cold Spring Creek, locally) RISK ANALYSIS REPORT CARD

	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Bullock Creek:	8.86	21	14.8	4.7	0.59	Debris Flood	Low

Post-Wildfire Hazards:	The influence of post-wildfire effects on the pre-existing processes is likely to be insignificant in this catchment.

	Elements at Risk			
Dominant Process	**Residence 1 on the fan**	**Residence 2 on the fan**	**Ashnola Road & Culvert (4 ft diameter)**	**Buried Gas Pipeline**
	Hazard Level - Likelihood of Event P(H)			
Flood / Debris Flood	Low			
Debris Flow	-			
Landslide/Rockfall	Low			
	Spatial Likelihood of Impact P(S:H)			
Flood / Debris Flood	Low	Low	High	Low
Debris Flow	-	-	-	-
Landslide/Rockfall	Low	Low	Low	Low
	Partial Risk P(HA) = P(H) x P(S:H)			
Flood / Debris Flood	Very Low	Very Low	Moderate	Very Low
Debris Flow	-	-	-	-
Landslide/Rockfall	Very Low	Very Low	Very Low	Very Low

PHOTOS (Bullock Creek Watershed)

Photo 1: View of Bullock Creek Watershed (circled) upslope of Similkameen River. Residences are circled.

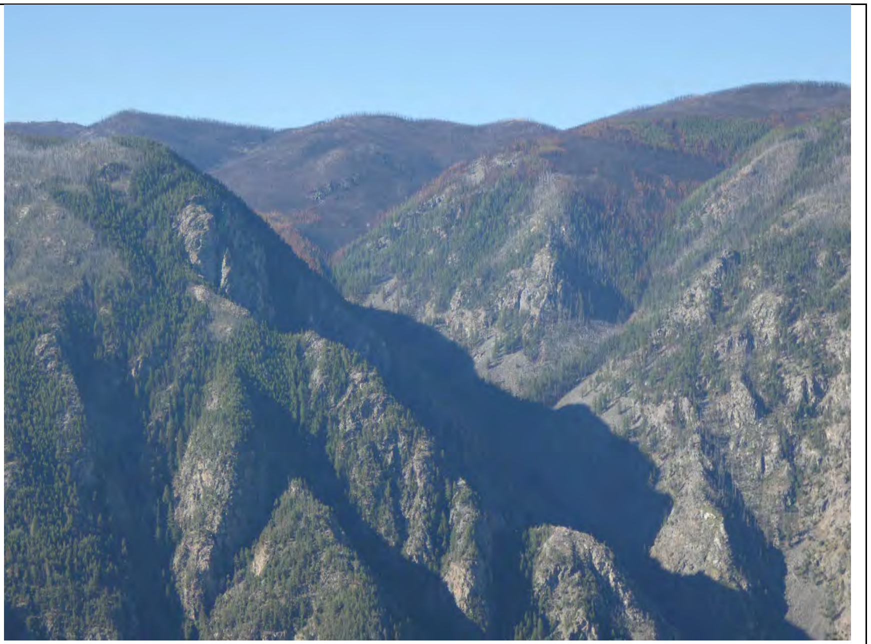

Photo 2: View of upper Bullock Creek Watershed, note burn area on upper slopes.

Photo 3: View of Bullock Creek fan area. Note two residences (circled), buried Fortis gas pipeline, and Ashnola Road with circled culvert.

Photo 4: View upslope of Ashnola Road with Bullock Creek canyon in background and residence in foreground.

Photos taken in August 2024

Photo 5: Culvert (4 ft (1220 mm) diam.) at Ashnola Road with upstream ponding associated with partial obstruction of flow.

7.2 RDOS Lands (Lower Similkameen River Valley across from Keremeos)

7.2.1 Watershed 2

See Map 003 (Appendix B)

Watershed 2[16] is a long, narrow catchment (10 km^2) located between Bullock Creek and Barrington Creek within the Similkameen River valley (see Photos 1 & 2). The stream channel is flanked by steep valley side slopes. The lower slopes of the catchment burned in the 2018 Snowy Mountain Wildfire (29% of total watershed area) and the upper slopes of the catchment burned in the 2023 Crater Creek Wildfire (29% of total watershed area). The cumulative watershed area that burned is 58%.

The Watershed 2 fan area is sparsely vegetated, with dense forest along the stream channel and with undeveloped grassland upslope of River Road (see Photos 3 & 4). Parts of the fan area are cultivated private property, with a private residence. There was no observed stream channel instability, nor any evidence of larger-scale debris flood activity across the fan (field access was limited due to private property).

Post-Wildfire Natural Hazards: Based on the cumulative area burned in 2018 and 2023 there is a high likelihood for post-wildfire changes in stream flow. Because the stream channel appears to flow subsurface through abundant talus deposits, and there is no historic evidence of debris flood activity, the post-wildfire flood hazard level is reduced to MODERATE.

Spatial Likelihood of Impact and Partial Risk Analysis:

Downstream on the Watershed 2 Creek alluvial fan, there are two residences within the Ashnola 10 IR, a buried Fortis gas pipeline crossing (mid-fan), and Ashnola River Road traverses the distal edge of the fan (with a 600 mm diameter culvert crossing). There is a MODERATE likelihood for a higher-than-usual peak flow to reach the fan and a MODERATE likelihood of impact to a single residence on the fan based on its proximity to the channel. The precise level of exposure to stream channel processes is unclear. The overall partial risk to one of the residences is MODERATE. Another residence located at the distal part of the fan is rated LOW partial risk, as is the buried Fortis gas pipeline.

The 600 mm diameter culvert on the creek at Ashnola River Road (see Photos 5 & 6) has a HIGH spatial likelihood of impact by elevated stream flows and is rated HIGH partial risk.

[16] Note: this watershed was referred to as Watershed 1 in the Reconnaissance PWNHRA. The watershed nomenclature was chosen to coincide with the 2018 Snowy Mountain PWNHRA report by Westrek (2018)

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WATERSHED 2 (between Bullock and Barrington Creek) RISK ANALYSIS REPORT CARD

* note that this unnamed watershed was referred to as Watershed 1 in the Reconnaissance Level PWNHRA

		2023 Crater Creek Wildfire			2018 Snowy Mtn Wildfire						
	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	% Burned	% High Burn Severity	% Mod Burn Severity	Cumulative % Burned	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Watershed 2 Creek:	9.8	29	19	8.1	29	2	15	58	0.62	Debris Flood	Moderate

Post-Wildfire Hazards:	Based on the cumulative area burned in 2018 and 2023 there is a high likelihood for post-wildfire changes in streamflow. Because the stream channel appears to be subsurface through abundant talus deposits, and there is no historic evidence of debris flood activity, the hazard level is reduced to moderate. There is a moderate likelihood for a higher-than-usual peak flow to reach the fan and a moderate likelihood of impact to a single residence on the fan based on its proximity to the channel. The precise level of exposure to stream channel processes is unclear. There is a 600 mm diameter culvert on River Road that is at risk from elevated peak flows.

	Elements at Risk			
Dominant Process	**Residence 1 located on the fan**	**Residence 2 located at distal part of fan**	**Ashnola River Road and 600 mm diam. Culvert**	**Buried Fortis Gas Pipeline**
	Hazard Level - Likelihood of Event P(H)			
Flood / Debris Flood	Moderate			
Debris Flow	-			
Landslide/Rockfall	-			
	Spatial Likelihood of Impact P(S:H)			
Flood / Debris Flood	Moderate	Low	High	Low
Debris Flow	-	-	-	-
Landslide/Rockfall	-	-	-	-
	Partial Risk P(HA) = P(H) x P(S:H)			
Flood / Debris Flood	Moderate	Low	**High**	Low
Debris Flow	-	-	-	-
Landslide/Rockfall	-	-	-	-

PHOTOS (Watershed 2)

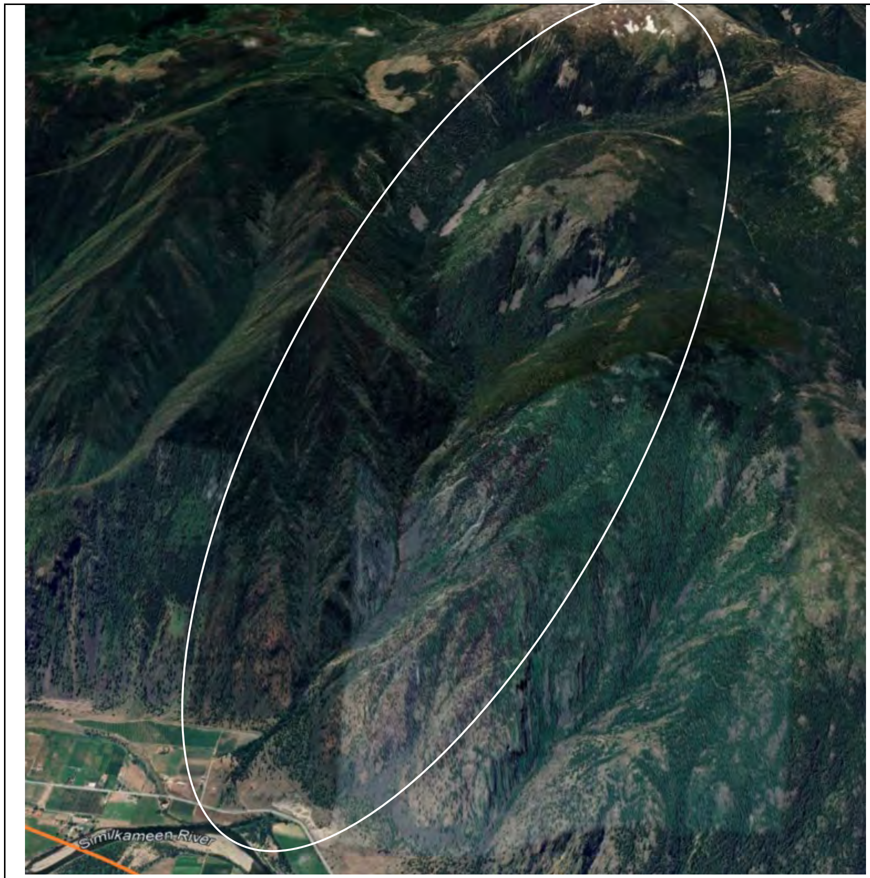 Photo 1: Oblique GoogleEarth image (2024) of Watershed 2 (circled) upslope of Similkameen River.	 Photo 2: Helicopter overview of upper Watershed 2 catchment.

	
Photo 3: GoogleEarth image of the Watershed 2 fan area. Residences (2) and culvert on River Road are circled.	Photo 4: View of Watershed 2 fan area and upslope watershed from River Road.

 Photo 5: 600 mm diameter culvert at River Road, inlet damaged but free flowing. Some evidence of scour along streambanks but very little bedload movement.	 Photo 6: Watershed 2 stream channel view upstream from River Road. Note gravel to small cobble sized substrate.

7.2.2 Barrington Creek

See Map 003 (Appendix B)

Barrington Creek watershed (17.8 km^2) was extensively (61%) burned in 2018, with 45% at moderate to high burn severity affecting the lower half of the watershed (see Photo 1). The upper part of the watershed burned in 2023 (11%) with some patchy overlap, burning some areas that were not completely burned in 2018. The cumulative area burned represents 72% of the watershed area. The upper part of the watershed is on a plateau and has experienced some forest harvest activity (likely salvage logging).

Post-Wildfire Natural Hazards: Several steep tributary channels in the upper part of the watershed show signs of post-2018 wildfire instability (see Photo 2). However, these do not appear to have initiated a debris flow or debris flood along the mainstem channel. Given the 5 years of post-wildfire recovery, the likelihood for further stability is beginning to decrease. Based on the area burned (72%) the likelihood for changes in hydrology is elevated but remains at a MODERATE level due to the lack of historic instability.

Spatial Likelihood of Impact and Partial Risk Analysis:

Barrington Creek becomes highly incised through a raised paleo fan as it flows through the downstream alluvial fan that extends downslope to the Similkameen River (see Photos 3 & 4). The fan area is cultivated, with a residence sited on Ashnola River Road. At the fan apex there is a concrete weir structure associated with a Point of Diversion (see Photo 5) and just downstream from the apex there is a buried Fortis gas pipeline crossing (see Photo 6). Barrington Creek reaches Ashnola River Road at the distal edge of the fan (with a 5-foot (1,524 mm) diameter culvert crossing; see Photo 7) before flowing into the Similkameen River.

The spatial likelihood of impact by debris flood to the residence located east of the channel along Ashnola River Road is rated MODERATE, with an overall partial risk of MODERATE. The spatial likelihood of impact to structure sited along the stream channel (i.e., water intake works & downstream culvert on Ashnola River Road) is HIGH, resulting in a HIGH partial risk. The partial risk at the buried Fortis gas pipeline is LOW.

Ministry of Forests - BC Wildfire Service
Post-Wildfire Natural Hazards Risk Analysis
2023 CRATER CREEK WILDFIRE (K52125)

BARRINGTON CREEK RISK ANALYSIS REPORT CARD

		2023 Crater Creek Wildfire			2018 Snowy Mtn Wildfire						
	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	% Burned	% High Burn Severity	% Mod Burn Severity	Cumulative % Burned	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Barrington Creek:	17.8	11	1.9	7.1	61	17	28	72	0.47	Debris Flood	Moderate

Post-Wildfire Hazards:	Several steep tributary channels in the upper part of the watershed show signs of post-wildfire instability. However, these do not appear to have initiated a debris flow or debris flood along the mainstem channel. Given the 5 years of post-wildfire recovery the likelihood for further stability is beginning to decrease. Based on the area burned (72%) the likelihood for changes in hydrology is elevated but remains at a moderate level due to the lack of historic activity.

	Elements at Risk			
Dominant Process	**Water License POD**	**Residence at River Rd**	**River Road and 5-ft diam. Culvert**	**Buried Fortis Gas Pipeline**

	Hazard Level - Likelihood of Event P(H)
Flood / Debris Flood	Moderate
Debris Flow	-
Landslide/Rockfall	-

	Spatial Likelihood of Impact P(S:H)			
Flood / Debris Flood	High	Moderate	High	Low
Debris Flow	-	-	-	-
Landslide/Rockfall	-	-	-	-

	Partial Risk P(HA) = P(H) x P(S:H)			
Flood / Debris Flood	**High**	Moderate	**High**	Low
Debris Flow	-	-	-	-
Landslide/Rockfall	-	-	-	-

PHOTOS (Barrington Creek Watershed)

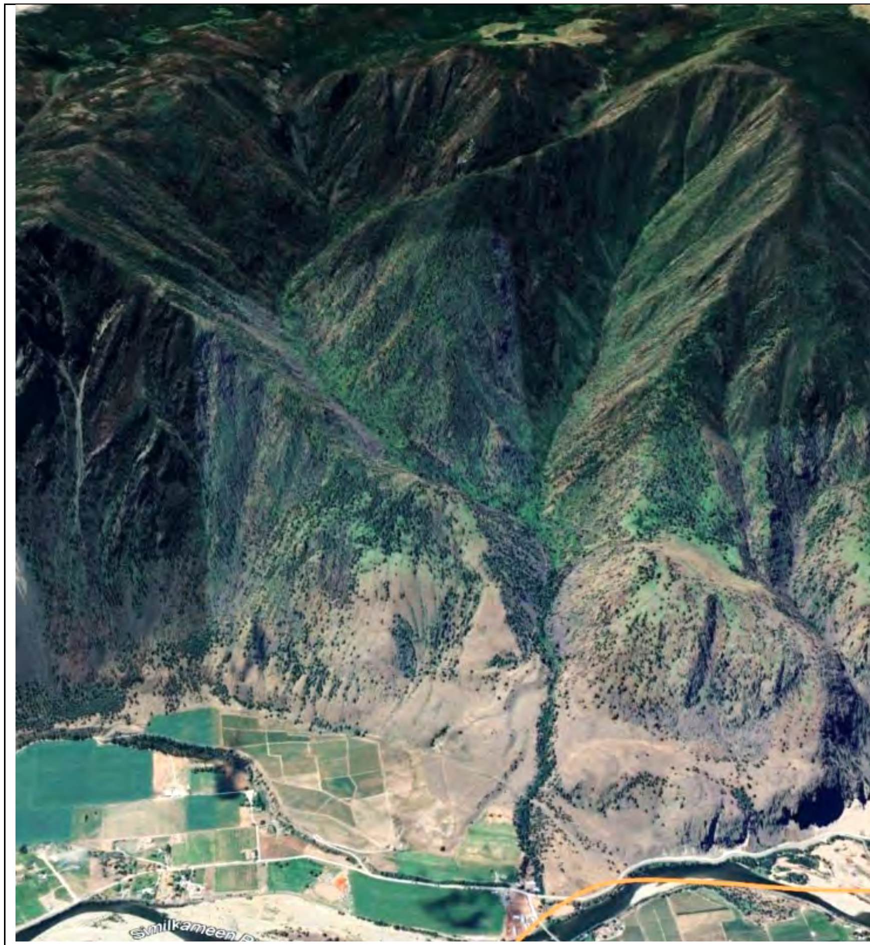

Photo 1: Oblique GoogleEarth image (2024) of Barrington Creek watershed upslope of Similkameen River.

Photo 2: Helicopter overview photo of upper Barrington Creek watershed (north tributary) with evidence of instability along steep valley side slopes (arrows indicate flow paths).

Photo 3: Helicopter overview of Barrington Creek fan area. Circles indicate residences, culvert on Ashnola River Road, and Fortis gas line crossing.

Photo 4: Thin, discontinuous layers of sands and gravels in trail cut on upper part of fan (terrace)

Photo 5: Barrington Creek POD weir. No accumulated sediment in upstream weir structure.

Photo 6: Buried Fortis gas pipeline under Barrington Creek.

Photos taken in August 2024

Photo 7: 5 ft (1,524 mm) diameter culvert encased in concrete at River Road is free flowing.

7.3 Lower Similkameen 2 IR Lands and Chopaka IR Lands (Lower Similkameen Valley)

7.3.1 Susap Creek

See Map 004 (Appendix B)

Susap Creek is a large watershed (77 km2) with two main tributary catchments; Hunter Creek and Coulthard Creek (see Photo 1). The watershed was extensively (55%) burned in 2018 by the Snowy Mtn Wildfire, with 52% at moderate to high burn severity. The 2023 wildfire affected a very small portion (2%) of the headwaters. The dominant hydrogeomorphic process in the watershed is flooding.

There are large-scale volcanic bedrock scarps within the headwaters that are unstable (see Photo 2). The middle to lower watershed has subdued slopes and abundant grassland areas (see Photo 1). There are few indications of terrain instability within this area, even where the slopes are traversed by old trails/resource roads. The bedrock-controlled incised lower reaches of Susap Creek show indications of small-scale rockfall activity.

The mainstem channel of Hunter Creek tributary (see Photo 3) and the lower half of the Coulthard Creek tributary channel were severely burned by the 2018 Snowy Mountain Wildfire. The lower reaches of Susap Creek were less affected by the previous wildfire. There is a large accumulation of sediment stored within a lower gradient channel reach upstream of the canyon above the fan area (see Photo 4). This may indicate past instability, and a lack of downstream transport due to a shallower gradient approaching the fan. The lower reaches of Susap Creek upslope of the fan are incised within a bedrock canyon (see Photo 5).

Susap Creek has a large alluvial fan, with a gradient ranging from 5 to 10% (see Photos 6 & 7). There are large boulders present on the fan and many historic avulsion channels (see Photo 8). The channel is relatively well confined at the apex but becomes less confined along the fan. There are numerous historic irrigation and water intake works present along the channel and the fan is considered culturally sensitive. There are numerous residences situated on the fan and Chopaka Road traverses the lower perimeter. There is a wooden bridge with concrete abutments on Chopaka Road at Susap Creek (see Photo 9).

Post-Wildfire Natural Hazards: Susap Creek watershed was burned by the 2018 Snowy Mountain Wildfire, and then minorly again in 2023. The watershed is still recovering from the 2018 wildfire and will continue to recover for many years until the forest recovers. Due to the loss of forest in the upper part of the watershed, there continues to be an increased likelihood of hydrologic effects. Higher peak flows may mobilize stored sediments within the channel, transporting water and sediment downstream to the fan. The post-wildfire natural hazard level for flooding and debris flood is rated HIGH.

Spatial Likelihood of Impact and Partial Risk Analysis:

The fan area is located within Lower Similkameen 2 IR Lands and is considered culturally sensitive. Because all residences located on the Susap alluvial fan are located at the distal end of the zone of impact, they are assigned the same MODERATE spatial likelihood of impact by flooding, with a corresponding HIGH partial risk. At ground-level the specific exposure to flood hazard may vary.

The Chopaka Road bridge crossing has good clearance above the channel on stable concrete abutments and is assigned a MODERATE spatial likelihood of impact, and a resultant HIGH partial risk. Any domestic water intake or irrigation works situated on the stream channel have a HIGH spatial likelihood of impact and a VERY HIGH partial risk from flooding.

Ministry of Forests - BC Wildfire Service
Post-Wildfire Natural Hazards Risk Analysis
2023 CRATER CREEK WILDFIRE (K52125)

SUSAP CREEK RISK ANALYSIS REPORT CARD

		2023 Crater Creek Wildfire			2018 Snowy Mtn Wildfire						
	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	% Burned	% High Burn Severity	% Mod Burn Severity	Cumulative % Burned	Melton Ratio	Dominant Hydrogeo-morphic Process	Wildfire Hazard Level for Dominant Process
Susap Creek Watershed Total:	77.3	2	0.2	0.8	55	18	34	56	0.24	Flood	High
Hunter Creek Sub-Basin:	18.2	5	1	2.9	70	26	34	76	0.41	Debris Flood	High
Coulthard Creek Sub-Basin:	17.7	0	0	0	48	7	25	48	0.43	Debris Flood	High

Post-Wildfire Hazards:	Susap Creek watershed was predominantly impacted by the 2018 Snowly Mountain Wildfire, and then very minorly again in 2023. The watershed is still recovering from the 2018 wildfire. Due to the loss of forest in the upper part of the watershed, there is an increased likelihood of hydrologic effects. Higher peak flows may mobilize stored sediments within the channel, transporting water and sediment downstream to the fan.

	Elements at Risk		
Dominant Process	**Residences on the Fan (Chopaka 7 & 8 IR)**	**Chopaka Road and Bridge Crossing**	**Irrigation and Water Intake Infrastructure on the Fan**
	Hazard Level - Likelihood of Event P(H)		
Flood / Debris Flood	High		
Debris Flow	-		
Landslide/Rockfall	-		
	Spatial Likelihood of Impact P(S:H)		
Flood / Debris Flood	Moderate	Moderate	High
Debris Flow	-	-	-
Landslide/Rockfall	-	-	-
	Partial Risk P(HA) = P(H) x P(S:H)		
Flood / Debris Flood	**High**	**High**	**Very High**
Debris Flow	-	-	-
Landslide/Rockfall	-	-	-

PHOTOS (Susap Creek Watershed)

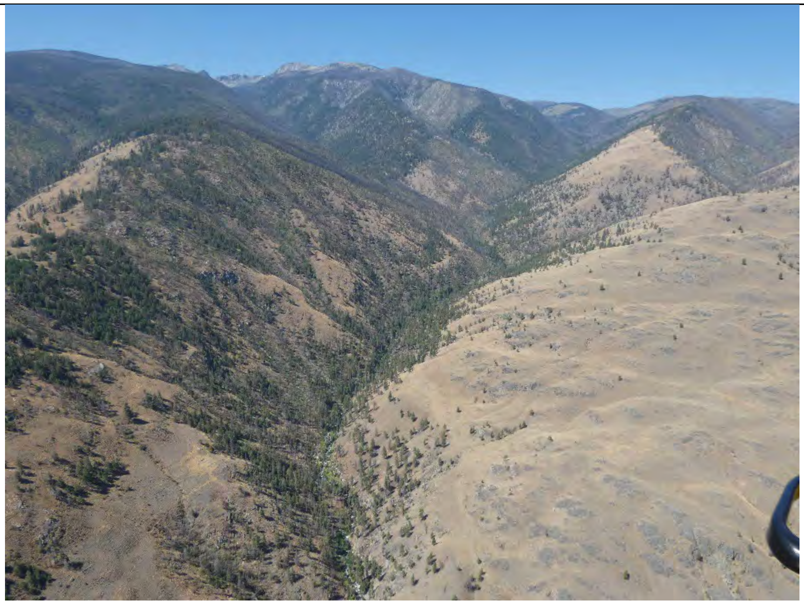

Photo 1: Helicopter overview photo of upper Susap Creek watershed. Note abundant grasslands in mid-watershed and burned headwater forest.

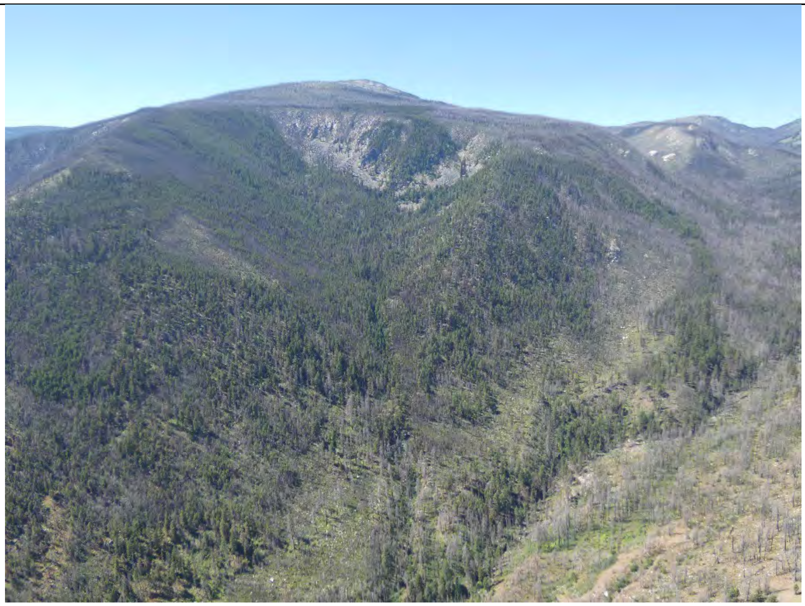

Photo 2: Headwaters of Susap Creek watershed at Snowy Mountain (Coulter Creek tributary) with volcanic bedrock scarp visible.

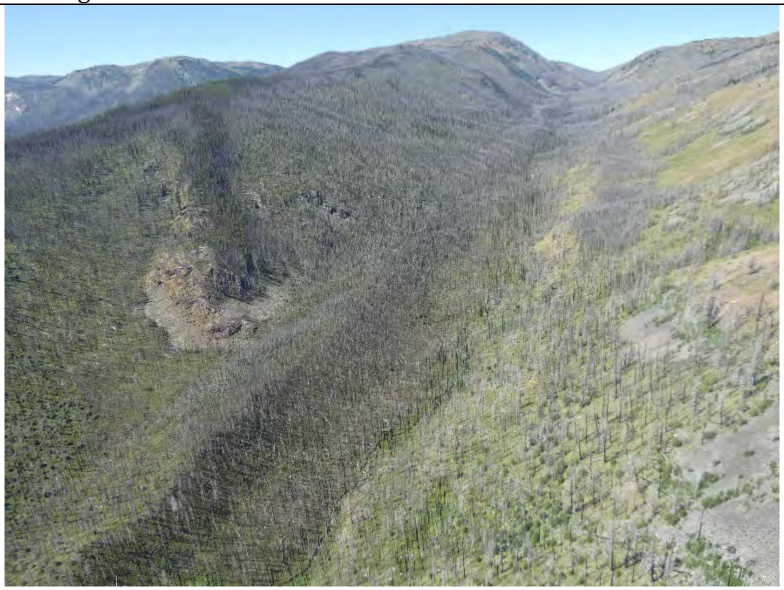

Photo 3: Helicopter overview of Hunter Creek sub-basin, burned in 2018 wildfire. Note burned riparian forest and some level of vegetation recovery.

Photo 4: Zone of sediment deposition (indicated with circle) within the mainstem Susap Creek channel at, and downstream of, the confluence of Coulthard Creek.

Photo 5: Bedrock-controlled incised lower reaches of Susap Creek, above the fan.

Photo 6: View of Susap Creek alluvial fan within the Similkameen River valley.

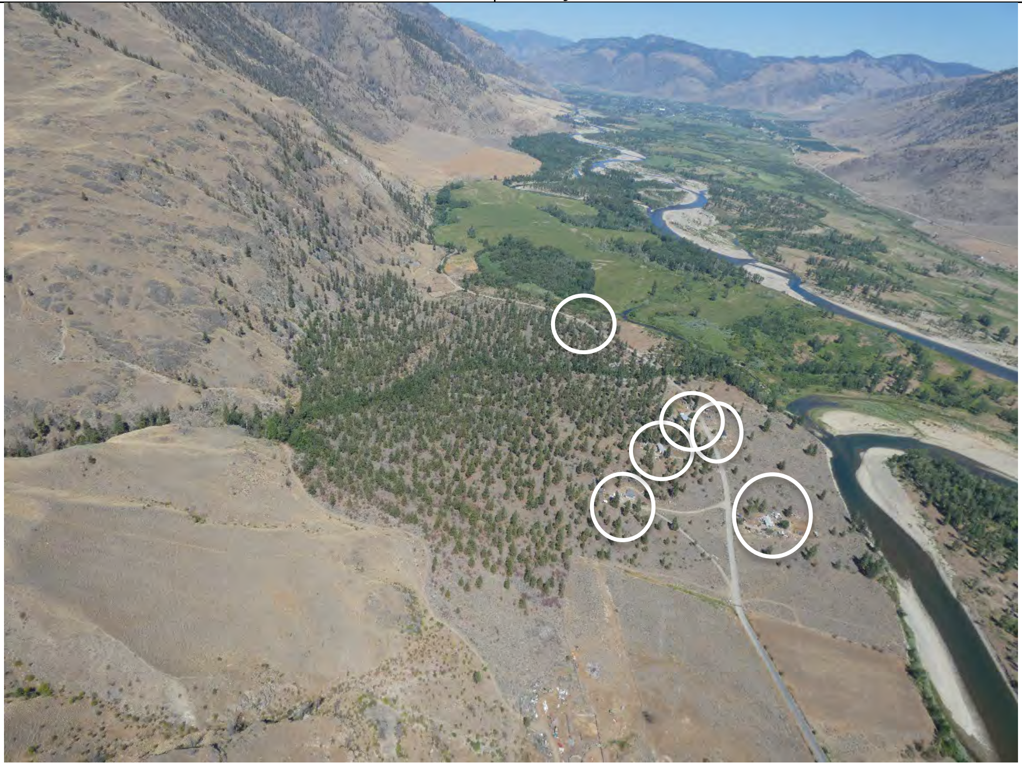

Photo 7: View north showing Susap Creek fan area. Note residences (circled) and Chopaka Road.

Photo 8: Avulsion channel (dry) on Susap Creek alluvial fan visible from Chopaka Road.

Photo 9: Wooden bridge (7.5 m long) with concrete abutments over Susap Creek at Chopaka Road.

7.3.2 Snehumption Creek Watershed

See Map 005 (Appendix B)

Snehumption Creek watershed is a large (88 km^2) watershed, a small portion of which is located within the USA. The watershed has alpine headwaters that include the summits of Snowy Mountain (~2,500 m a.s.l. elev.) and Armstrong Mountain (~2,500 m a.s.l. elev.). The headwaters include steep rocky ridgelines along several large tributary sub-basins that enter a broad u-shaped valley (see Photos 1 & 2). Side slopes in the mainstem valley are steep and directly connected to the channel. Mid to lower reaches become more incised before reaching the large alluvial fan within the Similkameen River valley.

The middle reaches of Snehumption Creek are flanked by steep, bedrock-controlled slopes with observed rockslide activity that delivers coarse talus material to the mainstem creek (see Photo 3). In the upper watershed there are numerous large-scale tributary gullies exhibiting instability and smaller-scale side slope instability within the valley bottom.

The Snehumption Creek alluvial fan is a large and mostly forested fan within Chopaka 7 & 8 IR within the Similkameen River valley (see Photo 4). There is evidence of irrigation and water intake infrastructure (trails) and there are abundant bouldery deposits on the fan surface, suggesting past-debris flood activity. However, the channel appears to be fairly well-incised and stable. There is at least one seasonal channel that may be associated with an upstream irrigation diversion (see Photo 9) but little evidence of historic channel avulsion.

Chopaka Road traverses the distal edge of the fan and there are numerous residences along the road (see Photos 5 & 6). There is a bridge on Chopaka Road across the mainstem creek and there are culverts along the road at the seasonal channel crossing (see Photos 6 and 10).

Post-Wildfire Natural Hazards: Wildfire activity in 2018 burned 28% of the watershed and in 2023, 16% of the watershed. Cumulatively, wildfire has affected almost half (44%) of the Snehumption Creek watershed. Much of this occurred at low burn severity. High burn severity was observed above approx. 1,500 m a.s.l. elevation, representing 9% of the total watershed area. While hydrologic effects associated with the loss of higher elevation forest will be most apparent in the spring due to a higher snow accumulation and faster melt in the spring, the overall likelihood for elevated post-wildfire peak flows is considered MODERATE.

Spatial Likelihood of Impact and Partial Risk Analysis:

The fan area is located within Chopaka 7 & 8 IR Lands and is considered culturally sensitive. Because all residences located on the Snehumption Creek alluvial fan are located at the distal end of the zone of impact, they are assigned the same MODERATE spatial likelihood of impact by flooding, with a corresponding MODERATE partial risk. At ground-level the specific exposure to flood hazard may vary.

The Chopaka Road bridge crossing is assigned a HIGH spatial likelihood of impact, and a HIGH partial risk. Any domestic water intake or irrigation works on the stream channel have a HIGH spatial likelihood of impact and a HIGH partial risk from flooding.

Ministry of Forests - BC Wildfire Service
Post-Wildfire Natural Hazards Risk Analysis
2023 CRATER CREEK WILDFIRE (K52125)

SNEHUMPTION CREEK RISK ANALYSIS REPORT CARD

		2023 Crater Creek Wildfire			2018 Snowy Mtn Wildfire						
	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	% Burned	% High Burn Severity	% Mod Burn Severity	Cumulative % Burned	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Snehumption Creek Watershed:	88.4	16	5.9	6.4	28	3	13	44	0.22	Flood	Moderate

* area calculations include Canada and US

Post-Wildfire Hazards:	Wildfire activity in 2018 and 2023 has cumulatively affected almost half of the Snehumption Creek watershed area. However, much of this was at low burn severity. High burn severity was observed in the upper watershed, above approx. 1,500 m elevation. Hydrologic effects associated with the loss of higher elevation forest is most apparent in the spring due to a higher snow accumulation and faster melt in the spring. Thus, the likelihood for post-wildfire peak flows is considered moderate to high.

	Elements at Risk		
Dominant Process	**Residences on the Fan (Chopaka 7 & 8 IR)**	**Chopaka Road**	**Irrigation and Water Intake Infrastructure on the Fan**

	Hazard Level - Likelihood of Event P(H)
Flood / Debris Flood	Moderate
Debris Flow	-
Landslide/Rockfall	-

	Spatial Likelihood of Impact P(S:H)		
Flood / Debris Flood	Moderate	Moderate	Moderate
Debris Flow	-	-	-
Landslide/Rockfall	-	-	-

	Partial Risk P(HA) = P(H) x P(S:H)		
Flood / Debris Flood	Moderate	Moderate	Moderate
Debris Flow	-	-	-
Landslide/Rockfall	-	-	-

PHOTOS (Snehumption Creek Watershed)

Photo 1: Helicopter overview photo of alpine headwaters of Snehumption Creek.

Photo 2: View upstream towards burned forested area within headwaters of Snehumption Creek.

Photo 3: Middle reaches of Snehumption Creek, showing connectivity with side slopes and abundant colluvium (talus) deposits and unstable rock gullies.

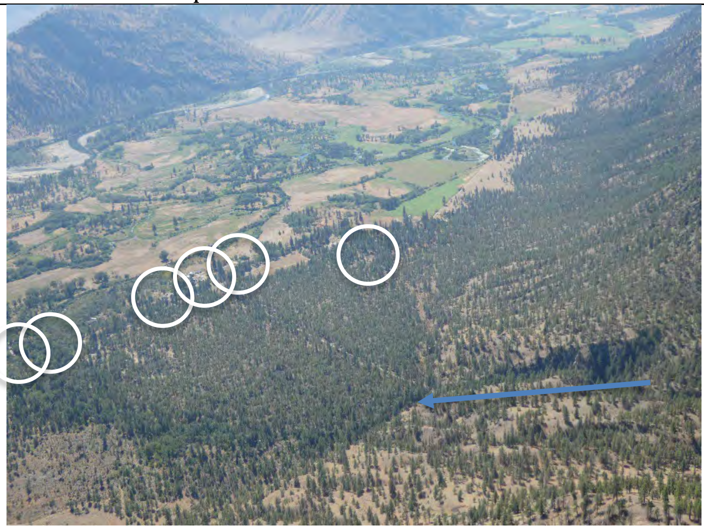

Photo 4: View of the Snehumption Creek alluvial fan located within the Similkameen River valley. Residences on the fan and along Chopaka Road are circled. Snehumption Creek is indicated with an arrow.


Photo 5: View of Snehumption Creek fan from Chopaka Road to the north .


Photo 6: View of 6.3 m long timber bridge over Snehumption Creek at Chopaka Road.


Photo 8: View upstream on Snehumption Creek from the Chopaka Road bridge. Relatively stable channel with cobble-boulder substrate and stable, vegetated streambanks.


Photo 9: Small (1.5 m wide) seasonal channel on the Snehumption Creek fan, potentially associated with upstream irrigation diversion.


Photo 10: Two culverts on Chopaka Road at the seasonal channel in Photo 9 (600 mm and 800 mm diameter culverts).

7.4 Lower Ashnola River Watershed

The Ashnola River watershed (nʔaysnúlaʔxʷ) is a very large watershed (1,054 km^2), of which less than half (467 km^2) was affected by the 2023 Crater Creek Wildfire. The portion of the watershed affected by the 2023 wildfire is separated out as the "Lower Ashnola River Watershed" (see Map 001; Appendix B).

For the purposes of the PWNHRA, several tributary sub-basins and face unit areas located within the fire perimeter are identified for more detailed analysis. The rationale for selecting the areas discussed below is related to identified Elements at Risk. Therefore, these areas include sub-basins that have associated fan areas with identified Elements at Risk and smaller tributaries and face units pose a risk to Ashnola River Road, private properties and/or recreation sites.

From a larger perspective, the watershed as a whole is also examined in Section 7.5. In particular, the cumulative effects of wildfire on the downstream alluvial fan are considered. The Ashnola River alluvial fan, delineated on Map 002, is part of the Ashnola 10 IR and hosts many important cultural activities of the LSIB, including the Snaʔsnulax'tn Campground and Pow-Wow Grounds.

7.4.1 Lower Ashnola River & Associated Face Units 1 to 4

See Map 002 & Map 006 & Map 007 (Appendix B)

Four face units are identified along the Lower Ashnola River. These face units include slope areas between identified catchments. Although smaller, these areas are still subject to potentially damaging post-wildfire natural hazards such as rockfall, landslide, and debris flow. Post-wildfire natural hazards and partial risk levels are described for each area in Table 7-1. Face units are shown on Maps 002, 006 and 007 and a Report Card, with accompanying photos is provided below.

For all Face Unit areas along the Ashnola River, the hazard level for post-wildfire hydrologic effects such as flooding, channel instability, and streambank erosion is rated MODERATE. Larger-scale watershed effects are discussed in more detail in Section 7.5.

Table 7-1: Description and Partial Risk Analysis of Lower Ashnola River Face Units 1 to 4

<table>
<tr><th>Lower Ashnola Face Unit#</th><th>Description</th><th>Post-Wildfire Natural Hazards</th><th>Elements at Risk</th><th>Spatial Likelihood of Impact to Elements at Risk</th><th>Partial Risk Level</th></tr>
<tr><td rowspan="3">Face Unit 1</td><td rowspan="3">Located on the east side of Lower Ashnola River, upslope of the alluvial fan area and north of Gillanders Creek. These slopes are very steep, rugged, highly fractured bedrock slopes that exhibit frequent pre-fire rockfall and small-scale rockslide activity.

There is also a small unnamed catchment along this section of the road which might pose a debris flow risk to the road.

See Photo 1.</td><td rowspan="3">The post-wildfire natural hazard level is rated HIGH for rockfall, small-scale rockslide and sediment-laden flows based on the degree of pre-existing instability and the loss of vegetation by wildfire.</td><td>Ashnola River Road is situated adjacent to the fan area within Ashnola 10 IR.</td><td>A ~910 m long section of road has HIGH spatial likelihood of impact.</td><td>VERY HIGH partial risk of impact by rockfall, small-scale rockslide, and sediment-laden flows.</td></tr>
<tr><td>The Sna?snulax'tn Campground area and Pow-Wow Grounds pavilion.</td><td>MODERATE spatial likelihood of impact to campground area.</td><td>MODERATE partial risk to campground and pow-wow grounds.</td></tr>
<tr><td>Two bridges (one on Paul Creek Road and another on Ashnola River Road at Red Bridge Creek (Bridges 1 & 2).</td><td>Bridges 1 & 2 are well sited and considered LOW spatial likelihood of impact by flood hazards on the Ashnola River.</td><td>LOW partial risk to Bridges 1 & 2.</td></tr>
<tr><td rowspan="3">Face Unit 2</td><td rowspan="3">Located on the west side of Lower Ashnola River, between Red Bridge Creek and Crater Creek. Within this face unit, upslope of Ashnola River Road, the Crater Creek FSR climbs to the upper part of the Red Bridge Creek sub-basin. Post-wildfire instability along the Crater Creek FSR has rendered the road impassible. The resource road was used for historic forest harvest activities. However, more recent harvest activities are now accessed from the north-east (via Sterling FSR).

There are two unnamed tributary sub-basins within this face unit. The</td><td rowspan="3">Observed instability is associated with elevated post-wildfire runoff and drainage interception at the FSR.

The steep slopes flanking the Ashnola River valley show evidence of pre- and post-fire instability associated with gully erosion and shallow instability & sediment-laden flows associated with high runoff. Chronic ravelling and</td><td>Crater Creek FSR and associated resource roads.</td><td>HIGH spatial likelihood of impact to resource roads.</td><td>VERY HIGH partial risk of impact to the resource roads within this face unit</td></tr>
<tr><td>Ashnola River Road.</td><td>HIGH spatial likelihood of impact to Ashnola River Road.</td><td>VERY HIGH partial risk of impact to sites along the Ashnola River Road within this Face Unit.</td></tr>
<tr><td>Three (3) Recreation Sites:
- Red Bridge Recreation Site,
- Tunnel Recreation Site,</td><td>Red Bridge Rec Site - LOW

Tunnel Rec Site - LOW

Horseshoe Canyon Rec Site – LOW</td><td>MODERATE partial risk of impact by geomorphic processes to the three (3) recreation</td></tr>
</table>

Lower Ashnola Face Unit#	Description	Post-Wildfire Natural Hazards	Elements at Risk	Spatial Likelihood of Impact to Elements at Risk	Partial Risk Level
	slopes forming the face unit, combined with the small tributary catchments, were extensively burned (74%). Slopes are characterized as over-steepened unconsolidated glaciofluvial sands and gravel sediment. Less visible, but still concerning from the risk perspective, are the unstable scarp slopes and gullies that drain the slopes above. See Photos 2 to 5.	erosion are observed along the lower parts of the slope immediately adjacent to the road. Natural hazard level is HIGH for geomorphic processes.	- Horseshoe Canyon Recreation Site		sites located in the valley bottom.
Face Unit 3	Located on the west side of Lower Ashnola River, between Crater Creek and Meausette Creek. Near the confluence of Ewart Creek, the Ashnola River flows through a tight bedrock canyon with a large, exposed slope of unconsolidated sediments above the road. East of Meausette Creek the valley slope has exposed bedrock scarp with expansive talus apron along the road. There are numerous sediment-laden flow paths along the slope, many of which reach the road. See Photos 6 to 8.	Observed post-wildfire sediment-laden runoff events have deposited sediment onto Ashnola River Road. Steep bedrock bluffs above the road are subject to rockfall and debris flow activity. Post-wildfire natural hazard level is HIGH to VERY HIGH	Ashnola River Road	Ashnola River Road – HIGH spatial likelihood of impact.	Partial risk is VERY HIGH for the Ashnola River Road for sediment-laden flow, rockfall and landslides.
			Private properties along Ashnola River Road, near Cathedral Park Base Camp (#2201 Ashnola River Road)	Private properties at MODERATE spatial likelihood for flood and rockfall but HIGH for sediment-laden flow.	VERY HIGH for private properties for sediment-laden flow and HIGH for landslide and rockfall.
			Ashnola River Recreation Site and Lakeview Trailhead Parking	Rec sites and trailhead parking – LOW	LOW partial risk to the valley bottom rec sites.
			Two (2) bridges: Bridge 4 (burned) and Bridge 5 (footbridge)	Bridge 5- LOW	MODERATE partial risk to foot bridge
Face Unit 4	Located on the east side of Lower Ashnola River, between Ewart Creek and Lakeview Creek.	Based on extent of burn (81%) and percentage burn at moderate to high	The Cathedral Park Base Camp is located below an unstable raised fan, with numerous	HIGH spatial likelihood for impact by debris flow,	Partial risk is VERY HIGH for park-related infrastructure

Lower Ashnola Face Unit#	Description	Post-Wildfire Natural Hazards	Elements at Risk	Spatial Likelihood of Impact to Elements at Risk	Partial Risk Level
	The east slopes and tributaries above the Ashnola River were severely burned. Flanking the river is a distinctive glaciofluvial terrace with steep scarp slopes that are dissected by landslides and gullies. Tributary fans are raised, extending across the terrace. See Photos 9 to 11.	severity (72%) the natural hazard level is HIGH for geomorphic processes. There are observed landslides and sediment-laden flood events along the face unit slopes.	sediment-laden flow channels that extend to the valley bottom.	sediment laden flow and landslide.	including the Base Camp
			<u>Lakeview Access Road</u>	HIGH spatial likelihood for impact.	Partial risk is VERY HIGH for the Lakeview Road access.

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ASHNOLA RIVER WATERSHED (nʔaysnúlaʔxʷ) and IDENTIFIED FACE UNITS PARTIAL RISK ANALYSIS REPORT CARD

	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Ashnola River Watershed:	1054*	26	16.6	6.6	0.22	Flood	Moderate
Lower Ashnola River (d/s of 2023 Crater Ck Wildfire Perimeter):	467	**50**	29.2	15.9			
Ashnola Face Unit 1 (e side north of Gillanders Ck):	10	**84**	30	42		Landslide & Debris Flow & Sediment-Laden Flow	**High**
Ashnola Face Unit 2 (w side btwn Red Bridge Ck & Crater Ck):	16	**74**	18	34			
Ashnola Face Unit 3 (w side btwn Crater Ck & Meausette Ck):	4	**80**	2	53			
Ashnola Face Unit 4 (e side btwn Ewart Ck & Lakeview Ck):	13	**81**	50	22			

* includes areas within Canada and USA

Post-Wildfire Hazards:	For the Ashnola River as a whole, 26% burn with 23% at moderate to high severity is anticipated to have a moderate hydrologic impact level. Increased peak flows are anticipated in the short-term (5-years), and the cumulative effects of sediment delivery from tributary catchments and face units has the potential to destabilize the channel on the fan. Wildfire within face units (1 to 4) has had an observed impact on geomorphic processes and the hazard level for sediment-laden flow, ravelling sediment/small-scale rock fall and debris slide activity, is anticipated to be moderate to high for these contributing areas.

	Ashnola River Fan & FACE UNIT 1			**FACE UNIT 2**			
	Elements at Risk						
Dominant Process	**Ashnola River Road & specific 910 m long section identified on Map 006.**	**Bridges 1 & 2 on Ashnola River**	**nʔaysnúlaʔxʷ Campground and Pow-Wow Grounds**	**Ashnola River Road**	**Crater FSR**	**Recreation Sites (Red Bridge, Tunnel & Horseshoe Canyon)**	**Bridge 3 (at Ewart Ck Rd)**
	Hazard Level - Likelihood of Event P(H)						
Flood / Debris Flood	Moderate						
Debris Flow & Sediment-Laden Flow	High	-	-	High	High	High	-
Rockfall & Landslides	High	-	-	High	High	High	-
	Spatial Likelihood of Impact P(S:H)						
Flood / Debris Flood	High (specific sites)	Low	Moderate	High (specific sites)	-	Moderate	Low
Debris Flow & Sediment-Laden Flow	High	-	-	High	High	Low	-
Rockfall & Landslides	High	-	-	High	High	Low	-
	Partial Risk P(HA) = P(H) x P(S:H)						
Flood / Debris Flood	**High**	Low	Moderate	**High**	-	Moderate	Low
Debris Flow & Sediment-Laden Flow	**Very High**	-	-	**Very High**	**Very High**	Moderate	-
Rockfall & Landslides	**Very High**	-	-	**Very High**	**Very High**	Moderate	-

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Post-Wildfire Natural Hazards Risk Analysis

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ASHNOLA RIVER WATERSHED (nʔaysnúlaʔxʷ) and IDENTIFIED FACE UNITS PARTIAL RISK ANALYSIS REPORT CARD

	FACE UNIT 3				FACE UNIT 4	
	Elements at Risk					
Dominant Process	**Ashnola River Road**	**Bridge 4 (to be replaced) & Bridge 5 on Ashnola River**	**Recreation Sites (Ashnola River & Lakeview Trailhead)**	**Private Properties (2201 Ashnola Rd, RDOS)**	**Ewart Creek Road**	**Cathedral Base Camp & Lakeview Road Access**
	Hazard Level - Likelihood of Event P(H)					
Flood / Debris Flood	Moderate					
Debris Flow & Sediment-Laden Flow	High to Very High	-	High to Very High	High to VH	High	High
Rockfall & Landslides	High	-	High	High	High	High
	Spatial Likelihood of Impact P(S:H)					
Flood / Debris Flood	High	Low	Low	Moderate	High	Low
Debris Flow & Sediment-Laden Flow	High	-	Low	High	High	High
Rockfall & Landslides	High	-	Low	Moderate	High	High
	Partial Risk P(HA) = P(H) x P(S:H)					
Flood / Debris Flood	**High**	Low	Low	Moderate	**High**	Low
Debris Flow & Sediment-Laden Flow	**Very High**	-	Moderate to H	**Very High**	**Very High**	**Very High**
Rockfall & Landslides	**Very High**	-	Moderate	**High**	**Very High**	**Very High**

PHOTOS (Lower Ashnola River & Associated Face Units)

Photo 1: Helicopter overview photo of **Ashnola Face Unit 1 (**East side of lower Ashnola River north of Gillanders Creek)

Photo 2: **Ashnola Face Unit 2** along Ashnola River between Red Bridge Creek and Unnamed Tributary (Crater FSR and old forest roads are visible).

Photo 3: **Ashnola Face Unit 2** slopes above Ashnola Road.

Photo 4: **Ashnola Face Unit 2** slopes above Ashnola Road**.** Note gullies subject to sediment-laden flows likely attributed to post-wildfire runoff.

Photo 5: **Ashnola Face Unit 2** near Ewart Creek Road bridge. View of west slopes above the Ashnola Road, which are potentially unstable unconsolidated over-steepened glacial drift deposits prone to ravelling (shallow debris slides and rockfall).

Photo 6: **Ashnola Face Unit 3** on the west side of Ashnola River. Photo at confluence of Ewart Creek. Note exposed and ravelling unconsolidated sediments above the road and tight, bedrock-controlled section of valley through which road and river are contained (circled).

Photo 7: **Ashnola Face Unit 3**, east of Meausette Creek. Evidence of multiple post-wildfire runoff flow paths along slopes above Ashnola Road (arrows). Structures/residences and Cathedral Park base camp circled.

Photo 8: **Ashnola Face Unit 3** (east of Photo 7 area) showing slopes above Ashnola Road on west side of Ashnola River.

Photo 9: **Ashnola Face Unit 4** along west slopes above Ashnola River north of the Cathedral Park Base Camp site. Residences along Ashnola Road opposite the river are shown (circled)

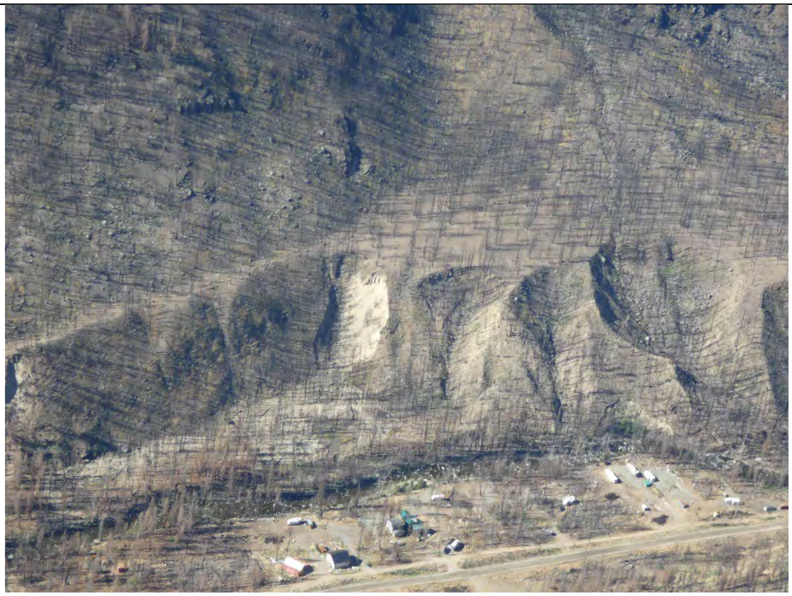

Photo 10: **Ashnola Face Unit 4** on the west side of Ashnola River. Residences along Ashnola Road opposite the river are visible.

Photo 11: **Ashnola Face Unit 4.** Structures/residences and Cathedral Park base camp are visible. Note, large raised fan associated with debris-flow prone catchment and gullied slopes along edge of terrace within the valley.

7.4.2 Red Bridge Creek Watershed

See Map 002 (Appendix B)

Red Bridge Creek watershed (19.4 km^2) was not originally included in the list of catchments to be included in the detailed PWNHRA due to the lack of identified Elements at Risk. However, a decision to include this catchment was made due to the presence of the Crater FSR, which provides access to LSIB Community Forest lands, and due to a high-level of observed post-wildfire natural hazard activity.

Red Bridge Creek has a relatively low gradient headwaters area, with considerable past forest harvesting activity (see Photo 1). The topography is indicative of an ancient large-scale rockslide within the volcanic rocks of Crater Mountain. The creek drains south, reaching steep bedrock-controlled slopes before entering the Ashnola River just downstream of Bridge 2. The south-facing mid-elevation slopes are steep and transition from forest (which burned at mod/high severity) to more sparsely vegetated grassland (see Photos 2 & 3). Approximately 2 km of the Crater FSR, with numerous switchbacks, climbs from the Ashnola River valley.

Post-Wildfire Natural Hazards: Due to the high percentage (68%) of the catchment burned, and the high percentage that burned at moderate to high severity (60%), there is an increased likelihood for hydrologic impacts associated with observed water repellent soils, elevated peak flows, and debris flood activity.

In July 2024, a localized rainstorm event resulted in extensive damage to the Crater FSR associated with sediment-laden runoff washing out several culverts along the road, sediment deposition on the road surface, and runoff interception by the road itself. Damages have made the road virtually impassible (see Photos 4 & 5). The MOF-OSNRD commissioned an inspection of the road and are aware of the need for improvements.

There is an increased likelihood for geomorphic impacts such as landslide and debris flow events along burned tributary side slopes and where logging debris (corduroy) is observed within stream channel crossings (see Photo 6 & 7). Due to the extent of high severity burn with observed high soil-water repellency (see Photo 8) the overall likelihood for post-wildfire natural hazards in the catchment is considered HIGH.

Spatial Likelihood of Impact and Partial Risk Analysis:

Elements at risk in the Red Bridge Creek watershed include the Crater FSR. The FSR crosses Red Bridge Creek at associated tributaries in several places. Overall, the FSR is assigned a HIGH spatial likelihood of impact, and a VERY HIGH partial risk.

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RED BRIDGE CREEK PARTIAL RISK ANALYSIS REPORT CARD

	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Red Bridge Creek:	19.4	68	30.1	29.7	0.4	Debris Flood	High

Post-Wildfire Hazards:	Due to the high percentage (68%) of the catchment burned, and the high percentage that burned at moderate to high severity, there is an increased likelihood for hydrologic impacts (water repellent soils, elevated peak flows, and debris flood). There is also an increased likelihood for geomorphic impacts such as landslides along burned side slopes.

	Elements at Risk
Dominant Process	**Crater Creek FSR**

	Hazard Level - Likelihood of Event P(H)
Flood / Debris Flood	High
Debris Flow	-
Landslide/Rockfall	High

	Spatial Likelihood of Impact P(S:H)
Flood / Debris Flood	High
Debris Flow	-
Landslide/Rockfall	High

	Partial Risk P(HA) = P(H) x P(S:H)
Flood / Debris Flood	**Very High**
Debris Flow	-
Landslide/Rockfall	**Very High**

PHOTOS (Red Bridge Creek Watershed)

Photo 1: Helicopter overview photo of headwaters of Red Bridge Creek looking east towards Ashnola Valley, showing burned areas, salvage logging.

Photo 2: View west into Red Bridge Creek catchment, showing grassland areas on south facing slopes. Note Crater FSR and logging within the middle reaches of the catchment.

Photo 3: View west from Ashnola River valley of wildfire-impacted lower Red Bridge Creek (right) and Unnamed Catchment (left).

Photo 4: View of the Crater FSR with numerous drainage-related washouts and failures into Red Bridge Creek.

Photo 5: Washout along Crater Creek FSR at Red Bridge Creek.

Photo 6: Corduroy stream crossing in area logged pre-wildfire (Red Bridge 1). Recommend rehabilitation of crossing due to anticipated increases in runoff.

Photo 7: Red Bridge Creek, view upstream at FSR road crossing (Red Bridge 4) with existing 1000 mm culvert. Note burned steep side slopes.

Photo 8: Area of high burn severity. Complete loss of organics and visible mineral soils. Lack of surface erosion on the low gradient slope area. High degree of water repellency soils in area.

7.4.3 Webster Creek Watershed (and portion of adjacent Face Unit slopes)

See Map 006 (Appendix B)

Webster Creek is a relatively small (7.2 km^2) watershed that has a Melton Ratio of 0.51, indicating that it may be subject to a combination of debris flow and debris flood processes. The catchment is well incised within steep, tightly connected valley side slopes with numerous indications of (pre-wildfire) instability, including shallow debris slides and scoured channels (see Photo 1). The watershed was extensively burned (80% of the total area) with a high proportion (73%) burned at moderate to high burn severity.

Webster Creek has a very large, raised paleo fan that has been down cut by the contemporary stream channel (see Photo 2). The modern fan at the base of the watershed is very small and lies within 15 m of the Ashnola River. The Ewart Creek Road traverses the lower part of the fan and there is a private residence located on the north side of the channel on the fan (see Photo 4). There are also 3 other private properties nearby, two are located below a face unit slope and one within the Ashnola River floodplain (see Photo 3). There is a 500 mm culvert on Ewart Creek Road that is partly obstructed with sediment (see Photo 5). There are (observed) domestic water intake works (PD56239) further upstream along the lower channel, providing domestic water to the nearby properties.

Post-Wildfire Natural Hazards: Based on the extent of wildfire and the degree of severity, there is an increased likelihood for post-wildfire effects on hydrology. Wildfire-affected terrain conducive to the initiation of natural hazards indicates that post-wildfire instability along valley side slopes will continue to deliver sediment to the channel. The potential for debris flood, and potentially debris flow activity is increased, depending on the occurrence of a hydrometeorological event. The post-wildfire natural hazard level along Webster Creek and the Webster Creek fan is rated HIGH for all hazard types. For the adjacent face units, the flood hazard on the Ashnola River is MODERATE and the landslide/rockfall hazard is rated MODERATE.

Spatial Likelihood of Impact and Partial Risk Analysis:

Elements at risk in the vicinity of Webster Creek include: the property on the Webster Creek fan (1621 Ewart Creek Road), the Ewart Creek Road, which provides access to four private parcels and to the Ewart Creek trailhead within the Snowy Protected Area, and the domestic water intake.

The spatial likelihood of impact to the structure located at 1621 Ewart Creek Road is considered HIGH due to the location on the contemporary fan and adjacency to the (relatively undersized) stream channel. Ewart Creek Road, and the partially obstructed 500 mm diameter culvert on Webster Creek has a HIGH spatial likelihood of impact. The domestic water intake on Webster Creek also has a HIGH spatial likelihood of impact. These three Elements have a corresponding VERY HIGH partial risk.

Other nearby properties are identified for the partial risk analysis. They include structures at 1609, 1612, and 1617 Ewart Creek Road. These properties are assessed as having a LOW partial risk of impact from post-wildfire processes occurring on the face unit slopes above. One property (#1612) is assessed as being at VERY HIGH partial risk of flooding from the Ashnola River, as it appears to be in a low-lying area adjacent to the river.

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WEBSTER CREEK PARTIAL RISK ANALYSIS REPORT CARD

	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Webster Creek:	7.4	80	46.4	26.9	0.51	Debris Flood	High

Post-Wildfire Hazards:	Based on the extent of wildfire and the degree of severity, there is an increased likelihood for post-wildfire effects on hydrology. Post-wildfire instability along valley side slopes will continue to deliver sediment to the channel. The potential for debris flood, and potentially debris flow activity is increased, depending on the occurrence of a hydrometeorological event. There is potential for event runout to Ewart Creek Road and the adjacent residence.

	Face Unit and Webster Creek Fan Area			
	Elements at Risk			
Dominant Process	**Residence on Fan (1621 Ewart Creek Road)**	**Ewart Creek Road**	**Other properties along Ewart Creek Rd (1609, 1612, 1617)**	**Domestic Water Intake (PD56239)**
	Hazard Level - Likelihood of Event P(H)			
Flood / Debris Flood	High	High	1612 - Moderate	High
Debris Flow	High	High	Moderate	High
Landslide/Rockfall	Moderate	Moderate	Moderate	High
	Spatial Likelihood of Impact P(S:H)			
Flood / Debris Flood	High	High	1612 - High	High
Debris Flow	High	High	Low	High
Landslide/Rockfall	Moderate	High	Low	High
	Partial Risk P(HA) = P(H) x P(S:H)			
Flood / Debris Flood	**1621 - Very High**	**Very High**	**1612 - Very High**	**Very High**
Debris Flow	**1621 - Very High**	**Very High**	Low	**Very High**
Landslide/Rockfall	Moderate	**High**	Low	**Very High**

PHOTOS (Webster Creek Watershed)

Photo 1: Helicopter overview photo of Webster Creek catchment, looking east.

Photo 2: Lower reaches of Webster Creek showing large, incised paleo-fan. Ewart Road bridge over Ashnola River is visible.

Photo 3: Webster Creek fan area at the Ashnola River. Visible are the Ewart Road bridge and Ewart Road along the east side of river. Ashnola Road is on the west side of river. Residences are circled.

Photo 4: Residence at base of slope adjacent to Webster Creek (1621 Ewart Creek Road)

Photo 5: Webster Creek at Eart Creek Road, 500 mm diameter culvert is partly lugged with sediment. Ashnola River is 15 m downstream.

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7.4.4 Ewart Creek Watershed

See Map 007 (Appendix B)

The Ewart Creek watershed is the largest tributary within the Ashnola River watershed (253 km^2). Its headwaters extend into the USA and include the mountainous summits of Snowy Mountain (2,585 m a.s.l. elev.), Armstrong Mountain (2,472 m a.s.l. elev.) and Haystack Mountain (2,400 m a.s.l. elev.). The watershed has a low Melton Ratio (0.12) indicating that the dominant hydro-geological process is flooding.

The Ewart Creek valley is a broad, wide-bottomed valley with relatively low connectivity with the adjacent valley side slopes. The connectivity and gradient increases with elevation into the tributary catchments. The watershed is relatively stable with some evidence of local instability along steep tributaries. There is an overall lack of exposed mineral soils and observed instability along the mainstem channel.

The 2023 Crater Creek Wildfire extended far into the headwaters of Ewart Creek (See Photo 1) and extensively burned the valley bottom along the mainstem stream channel (see Photos 2 to 4). The loss of riparian vegetation has a high likelihood of impacting stream channel stability, which may lead to bank erosion, and increased bedload mobilization and transport to downstream reaches. Ewart Creek does not have a large contemporary alluvial fan. Rather, the fan extends into the Ashnola River valley (see Photo 5). The large accumulation of sediment and debris at the mouth of Ewart Creek suggests that sediment (bedload) and woody debris transported downstream along Ewart Creek is deposited into the Ashnola River. There is some potential for at least temporary partial obstruction of the Ashnola River.

Post-Wildfire Natural Hazards: Overall, 46% of the watershed burned, with 43% at moderate to high burn severity. Based on the criteria for post-wildfire natural hazard, the watershed poses a MODERATE hazard associated with floods and debris floods. Destabilization of the channel and sediment delivery from contributing wildfire-affected tributaries may cause increased bedload transport that could erode streambanks and delivery sediment to the Ashnola River (see Photo 7). Due to the extent of burned and loss of riparian function, the post-wildfire natural hazard level associated with channel instability is rated HIGH.

On August 13, 2024, a storm event centered over the Ewart Creek watershed resulted in observed peak flow and water quality impacts downstream. Turbid (muddy) water was observed to enter the Ashnola River, and a flashy peak in streamflow was recorded at the Ewart Creek hydrometric station, and at the downstream Ashnola River hydrometric station.

Spatial Likelihood of Impact and Partial Risk Analysis:

The watershed is largely protected as it lies within Cathedral Provincial Park and the Snowy Protected Area. As a result, there is very little development or infrastructure in the watershed. There are, however, recreation trails (including historic indigenous routes) and an established trailhead. Near the trailhead there is an active Water Survey of Canada hydrometric station which provide real-time flow data (see Photo 6) – a valuable resource for on-going monitoring purposes. Based on the LOW spatial likelihood of impact to the trailhead, the partial risk is rated MODERATE. Due to the streambank location of the hydrometric station, the spatial likelihood of impact is rated MODERATE and the partial risk of impact by stream bank erosion and channel instability is rated HIGH. As a major tributary, the cumulative post-wildfire effects on hydrology, channel stability, bank erosion, and downstream bedload transport, represent a VERY HIGH partial risk of impact to the Ashnola River.

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EWART CREEK PARTIAL RISK ANALYSIS REPORT CARD

	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Ewart Creek Watershed Total:	253	46	32.5	11	0.12	Flood	Moderate
Juniper Creek Sub-Basin:	57.2	64	41.7	18.3			
Mountain Goat Sub-Basin:	44.3	11	6	4.1			

* includes areas within Canada and USA

Post-Wildfire Hazards:	Based on the percent area burned (45%) within the watershed, there is a moderate to high likelihood for post-wildfire effects on hydrology. The sub-basin most affected is Juniper Creek. The predominant impact associated with wildfire effects is likely to be stream channel stability. Higher peak flows along the channel which has lost much of the riparian forest may result in stream channel instability, sedimentation and mobilization of sediment, resulting in aggradation of the channel and eventual transport and deposition at the mouth and into the Ashnola River.

	Elements at Risk	
Dominant Process	**Ewart Creek Road & Trailhead Camp**	**Water Survey of Canada Hydrometric Station (#08NL076)**

	Hazard Level - Likelihood of Event P(H)
Flood / Debris Flood	Moderate
Channel Instabilty & Bank Erosion	High
Debris Flow	-
Landslide/Rockfall	-

	Spatial Likelihood of Impact P(S:H)	
Flood / Debris Flood	Low	Moderate
Channel Instabilty & Bank Erosion	Moderate	Moderate
Debris Flow	-	-
Landslide/Rockfall	-	-

	Partial Risk P(HA) = P(H) x P(S:H)	
Flood / Debris Flood	Low	Moderate
Channel Instabilty & Bank Erosion	**High**	**High**
Debris Flow	-	-
Landslide/Rockfall	-	-

PHOTOS (Ewart Creek Watershed)

Photo 1: Helicopter overview photo of Ewart Creek headwaters near confluence with Mountain Goat Creek.

Photo 2: Middle reaches of Ewart Creek near Juniper Creek (on left side of photo).

Photo 3: Middle reaches of Ewart Creek mainstem valley.

Photo 4: Lower reaches of Ewart Creek mainstem valley

Photo 5: Confluence of Ewart Creek at the Ashnola River. Note raised fan deposits. Ashnola Road along bottom of photo. Ewart Creek Road is along base of slope next to Ewart Creek.

Photo 6: Water Survey of Canada hydrometric monitoring station near the mouth of Ewart Creek.

Photo 7: Lower Ewart Creek stream channel, view upstream near confluence.

7.4.5 Lakeview Creek Watershed

See Map 007 (Appendix B)

Lakeview Creek watershed is a large watershed (62 km^2) that is entirely contained within the Cathedral Provincial Park protected area. The 2023 wildfire was concentrated along the mainstem valley of Lakeview Creek, mostly downstream of the Cathedral Lakes Lodge, which is located on the shores of Quiniscoe Lake at 2,061 m a.s.l. (see Photos 1 to 3). The valley mainstem was also the most densely forested prior to the wildfire. The valley side slopes in the mid to upper watershed are partly connected to the mainstem creek, until reaching a steep canyon section (see Photo 4) along which the Lakeview Road is located. Below the Lakeview Road bridge, the channel down cuts through glacial drift deposits before reaching a bedrock canyon reach at the fan apex.

Post-Wildfire Natural Hazards: The total area burned in the watershed is substantial (25%) but unlikely to have a significant impact on peak stream flows on Lakeview Creek. A low proportion of the area burned at moderate to high severity is located on terrain conducive to the initiation of natural hazards and there is little evidence of pre-wildfire instability along the channel or fan area. This, the likelihood of post-wildfire natural hazards is rated MODERATE.

BC Parks commissioned a more detailed post-wildfire natural hazard assessment along Lakeview Road, the only vehicle access road into the Park. The results of the road assessment indicate that, due to the road location along the steeper burned valley side slopes, that the potential for interception and concentration of post-wildfire runoff and sediment delivery from the adjacent slopes, is HIGH. Evidence of post-wildfire drainage-related landslides below the road and sediment-laden flows from burned slopes above the road are observed (see Photos 4 to 7). The wildfire also burned small bridge structures along the road, and compromised road fill stability where trees and roots were burned (see Photo 8).

Spatial Likelihood of Impact and Partial Risk Analysis:

The Cathedral Park Lodge and Campground are located on the shores of Quiniscoe Lake and are relatively isolated from major slope processes (~200 m from nearest active slope). Although the site was not inspected in detail, there is an estimated LOW spatial likelihood of impact, and the partial risk to the Lodge area is rated VERY LOW.

The spatial likelihood of impact to the Lakeview Access Road is HIGH, resulting in a VERY HIGH partial risk of impact by geomorphic processes along the valley side slopes. The partial risk of impact to the bridge crossing on Lakeview Creek is rated MODERATE based on it being well sited above the creek.

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LAKEVIEW CREEK PARTIAL RISK ANALYSIS REPORT CARD

	Area (sq. km)	% Burned	% High Burn Severity	% Mod Burn Severity	Melton Ratio	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process
Lakeview Creek:	61.7	26	16.6	6.6	0.22	Flood	Moderate

Post-Wildfire Hazards:	The total area burned (25%) is substantial but unlikely to have a significant impact on overall streamflows on Lakeview Creek. The Cathedral Park Lodge and Campground are located on the shores of Quiniscoe Lake and relatively isolated from major slope processes (~200 m from nearest active slope), although the site was not inspected in detail. The area burned at high to moderate burn severity (23%) includes the moderately steep to steep valley sideslopes traversed by the Lakeview Creek access road. Post-wildfire hydrologic and geomorphic effects have a high potential to impact the road and the hillslope stability below the road.

	Elements at Risk		
Dominant Process	**Cathedral Lakes Lodge & Campground**	**Lakeview Access Road**	**Lakeview Road Bridge on Lakeview Creek**
	Hazard Level - Likelihood of Event P(H)		
Flood / Debris Flood	-	-	Moderate
Debris Flow & Sediment-Laden Flow	-	High	-
Landslides	Low	High	-
	Spatial Likelihood of Impact P(S:H)		
Flood / Debris Flood	-	-	Moderate
Debris Flow & Sediment-Laden Flow	-	High	-
Landslides	Low	High	-
	Partial Risk P(HA) = P(H) x P(S:H)		
Flood / Debris Flood	-	-	Moderate
Debris Flow & Sediment-Laden Flow	-	**Very High**	-
Landslides	Very Low	**Very High**	-

PHOTOS (Lakeview Creek Watershed)

Photo 1: Helicopter overview photo looking south into Lakeview Creek watershed from the Ashnola River (circled). Road on right is Ashnola Road and road on left on terrace is the Lakeview Road accessing Cathedral Park. Note steep, debris-flow prone burned tributaries on Ashnola River Face Unit 4 (arrows).

Photo 2: View south towards alpine headwaters of Lakeview Creek. Middle watershed areas along the mainstem channel were burned.

Photo 3: View north along Lakeview Creek with Lakeview Road access on the left side of valley.

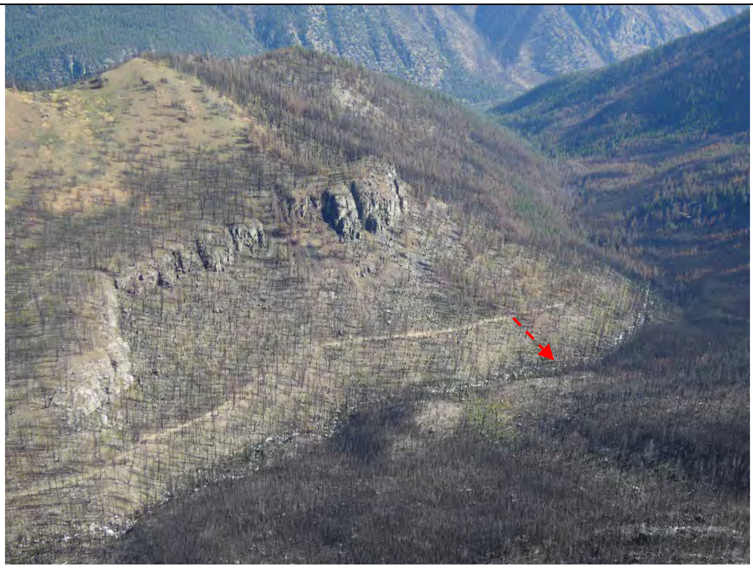

Photo 4: Section of Lakeview Road through steep canyon. Drainage-related landslide is indicated (arrow).

Photo 5: Fresh surface erosion on burned slopes intercepted at the road.

Photo 6: Scout Creek temporary bridge crossing along Lakeview Road (at ~12.5 km). One of two small bridge structures lost in the fire.

Photo 7: Example surface erosion associated with post-wildfire runoff onto Lakeview Road (~5.2 km).

Photo 8: Burn holes (arrows) and deformed trees indicate slope instability along the lower part of Lakeview Road (~1.4 km).

7.5 Cumulative Watershed Effects on the Ashnola River

A GIS indicator-based process for assessing cumulative watershed effects is presented by Lewis, et al. (2016). The process is not specifically used to assess post-wildfire effects. Rather, the process is focused on stream flow, sediment generation and delivery, and riparian function hazards associated with forest harvesting. Although considered outside the scope of work for this project, the approach could be adapted to evaluate cumulative post-wildfire effects on the Ashnola River.

Post-Wildfire Natural Hazards:

With respect to predicted changes in hydrology for the Ashnola River, an overview-level analysis was completed using one of the tools used by the USGS to predict post-wildfire peak flow effects[17]. Using this method, peak flow estimates derived by the Province of BC using the CLEVER model are adjusted based on the percentage (%) of the watershed burned, and the percentage (%) burned at high severity. The model assumes a much high runoff from areas that burned at high burn severity. The results indicate that:

- There may be up to 30% higher peak flows at all return periods in the first year following the fire; and,
- By Year 5, due to a decrease in soil-water repellency, the peak flow increase is estimated to be 9%.

Higher peak flows, combined with other post-wildfire effects such as sediment delivery and loss of riparian function, may lead to streambank erosion and aggradation. Sediment delivery from the contributing sub-basins and from valley side slopes, may impact water quality and fish habitat quality. While direct site-level impacts may occur, most of the effects will be cumulative.

Overall, based on the extent of wildfire, and the area that burned at moderate to high burn severity, the likelihood for post-wildfire effects on hydrology is rated MODERATE. There are no criteria for the hazard level associated with post-wildfire effects on stream channel stability. However, based on the observed contributions of sediment from Red Bridge Creek and Ewart Creek during peak flow events in the summer of 2024, the hazard level is rated at least MODERATE.

Spatial Likelihood of Impact and Partial Risk Analysis:

Elements at risk within the Lower Ashnola are considered for the various sub-basin catchments and face unit areas. These include the Ashnola River Road, recreation sites, several private properties, five (5) bridges, and the Ashnola River itself. The ultimate Element at Risk to be considered for the Ashnola River is the downstream alluvial fan area and those structures, features, and activities occurring on the fan.

The downstream alluvial fan extends into the floodplain of the Similkameen River. Floodplain mapping for the Similkameen River is available[18], dated 1995. The 1995 mapping does not extend upstream into the Ashnola River and includes the following text for the alluvial fan area:

> "Ashnola River Alluvial Fan – Flood depth indeterminant in this area. The entire fan area is subject to special flood hazards due to possible channel avulsion and erosion caused by channel accretion and/or debris jamming."

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[17] https://forest.moscowfsl.wsu.edu/BAERTOOLS/ROADTRT/Peakflow/USGS/Example/

[18] Similkameen River at Keremeos Floodplain Mapping, Environment Canada and BC Ministry of Environment. Drawing No. 91-23-7, 1:5000 scale.

More recent floodplain mapping of the Similkameen River was prepared for the RDOS, the Town of Princeton and the Village of Keremeos (Ecora, 2021). The updated mapping did not extend into the Ashnola River.

Ashnola 10 IR Lands, including the Sna?snulax'tn Campground and Pow-Wow grounds, are situated on the Ashnola River alluvial fan. There is also a residential sub-division (Ashnola Village) on the fan area. There is a flood protection dike located between the Ashnola River and the western side of the subdivision (iMAP BC, Dike #121, length 508 m, surveyed in 2003, under LSIB authority).

Because there is insufficient information relating to the floodplain elevations, processes that impact peak flow and streambank stability may increase the risk to those on the fan. The spatial likelihood of impact to the Elements located on the fan area is rated MODERATE, resulting in a MODERATE partial risk associated with flood hazards.

7.6 Climate Change Considerations

Considerations for a changing climate into the long-term (i.e., beyond mid-century) future are not considered in this report. It is the recent past climate and immediate (short-term) climate character (which include aspects of a changing climate) that are more relevant. It is the recent past climate conditions, including prolonged drought (lower winter snowpack and low summer precipitation) that may have exacerbated the wildfire conditions in the first place. Post-wildfire effects on hydrology are greatest in the first year following wildfire and are reduced (but not eliminated) in the following 3 to 5 years. While full hydrologic recovery does not occur until the forest recovers, which can take several decades. The preliminary hydrologic modelling results do not account for peak flow changes associated with the predicted effects of climate change.

For long-term consideration, the *Climate Projections for the Okanagan Region* document (RDNO, RDCO, RDOS and Pinna Sustainability, 2020), projected changes for the Central Okanagan for the 2050s (2040-2069) in comparison to a 1961-1990 baseline period. The results indicate the following:

- Total precipitation is expected to **increase by 10% to 13%** for the spring and autumn seasons, but summer precipitation expected to decrease (-14%).
- Of relevance to this study, the frequency of intense precipitation is expected to increase, as is the associated precipitation amount. Namely, the 1 in 20 wettest day of the year[19] is expected to **increase by 18%**, from an average of 33 mm to 39 mm.

Similar increases in precipitation are shown in model results examined using the PCIC Climate Explorer[20]. The maximum 1-day precipitation increases from the historical (1981-2010) to the modelled (2040-2069) by 8%. The 5-year annual maximum 1-day precipitation increases by 4%.

Changes in climate are already being experienced within the study area. These observed changes are considered in the post-wildfire hazard assessment. For example, localized precipitation events in the previous few years have resulted in debris flood and sediment-laden flows reaching fans of watersheds impacted by wildfire. The effects of intense, short-duration high intensity precipitation are anticipated in the near-future. Short-term provisions for a changing climate are incorporated in the recommendations for risk mitigation. Long-

[19] 1 in 20 wettest day is an indicator of extreme weather. The likelihood of a single-day rainfall of this magnitude occurring in any given year is 1 in 20, or 5% chance.

[20] Pacific Climate Impacts Consortium URL: services.pacificclimate.org/pcex

term provisions for a changing climate should be incorporated into future designs for culverts, drainage structures and road crossings.

7.7 Summary of Risk Analysis Results

The post-wildfire natural hazard assessment and risk analysis is presented for each watershed, sub-basin, and face unit area in the sections above.

Table 7-2 presents a summary of the hazard assessment, including the criteria used to derive the overall "likelihood for post-wildfire natural hazard event". A summary of partial risk analysis results is presented in Table 7-3.

Table 7-2: Hazard Assessment Results Summary (2023 Crater Creek Wildfire)

Hazard Criteria 1 and 2: Area (%) Burned and Area (%) Burned at Moderate & High Burn Severity → Hazard Criteria 3: Wildfire Affected Terrain Conducive to Post-Wildfire Natural Hazard Initiation → Hazard Criteria 4: Evidence of Previous Instability → HAZARD LEVEL

			2023 Crater Creek Wildfire				Cumulative Wildfire Effect: 2018 Snowy Mtn Wildfire & 2023 Crater Ck Wildfire						
				% Burn Severity				Cumulative % Burn Severity					
		Watershed/Sub-Basin/Face Unit	Total Area Burned (%)	Low	Mod	High	Cumulative Total Area Burned (%)	Low	Mod	High	% Area Burned* at Mod / High Burn Severity on Slopes >50% Gradient	Observed Instability in Field or on Imagery	Likelihood for a Post-Wildfire Natural Hazard Event
Map 002	Similkameen River Watershed	Paul Creek	18	4	8	7					2.5	no	Low
Map 002	Similkameen River Watershed	Rattlesnake Creek	83	15	28	40					25.8	no	High
Map 002	Similkameen River Watershed	Similkameen Sub-Basin 1	78	19	38	41					not calc.	no	Low
Map 002	Similkameen River Watershed	Similkameen Sub-Basin 2	78	14	35	58					not calc.	yes	Moderate
Map 003	Similkameen River Watershed	Face Unit East of Ashnola	29	9	17	3					not calc.	historic	Moderate
Map 003	Similkameen River Watershed	Bullock Creek	21	1	5	15					5.8	no	Low
Map 003	Similkameen River Watershed	Watershed 2	29	2	8	19	58	14	24	21	15.0	no	Moderate
Map 003	Similkameen River Watershed	Barrington Creek	11	2	7	2	72	17	36	19	0.7	no	Moderate
Map 004	Similkameen River Watershed	Susap Creek	2	1	1	0	56	3	35	19	not calc.	yes	High
Map 005	Similkameen River Watershed	Snehumption Creek	17	4	7	6	46	17	20	9	2.1	historic	Moderate
Map 002	Ashnola River Watershed	Lower Ashnola River	50	5	16	29					not calc.	yes	Moderate
Map 002	Ashnola River Watershed	Ashnola Face Unit 1	71	15	35	22					49.7	yes	High
Map 002	Ashnola River Watershed	Red Bridge Creek	68	8	30	30					6.3	yes	High
Map 006	Ashnola River Watershed	Ashnola Face Unit 2	74	21	34	18					33.2	yes	High
Map 006	Ashnola River Watershed	Webster Creek	80	7	27	46					29.7	yes	High
Map 007	Ashnola River Watershed	Ewart Creek	48	3	12	34					11.7	no	Moderate
Map 007	Ashnola River Watershed	Ashnola Face Unit 3	80	25	53	2					28.2	yes	High
Map 007	Ashnola River Watershed	Ashnola Face Unit 4	81	10	22	50					31.6	yes	High
Map 007	Ashnola River Watershed	Lakeview Creek	26	3	7	17					6.5	no	Moderate

* Calc. for 2023 Crater Fire Only

Hazard Criteria are discussed in Section 2.2 of report
- Moderate Rating
- High Rating

Table 7-3: Partial-Risk Analysis Results Summary (2023 Crater Creek Wildfire)

Map #	Watershed	Sub-Basin/Face Unit	Dominant Hydrogeomorphic Process	Post-Wildfire Hazard Level for Dominant Process (P(H))	Spatial Likelihood (P(S:H)): Public (or Resource) Road & Infrastructure	Spatial Likelihood (P(S:H)): Private Property or Structures on IR Lands	Spatial Likelihood (P(S:H)): Other (specify)	Highest Level of Partial Risk (P(HA))
Map 002	Similkameen River Watershed	Paul Creek	Flood	Low to Mod	Moderate	Moderate	-	Moderate
Map 002	Similkameen River Watershed	Rattlesnake Creek Sub-Basin	Debris Flood	High	High (Paul Ck Rd)	-	-	**Very High**
Map 002	Similkameen River Watershed	Similkameen Sub-Catchment 1	Debris Flow	Low	Low	-	-	Very Low
Map 002	Similkameen River Watershed	Similkameen Sub-Catchment 2	Debris Flow	Moderate	Moderate	-	-	Moderate
Map 003	Similkameen River Watershed	Face Unit E of Ashnola	Rockfall	Moderate	Low	High	Moderate (reservoir)	**High**
Map 003	Similkameen River Watershed	Bullock Creek	Debris Flood	Low	High (Ash R Rd)	Low	Low (gas pipeline)	Moderate
Map 003	Similkameen River Watershed	Watershed 2	Debris Flood	Moderate	High (River Rd)	Moderate	Low (gas pipeline)	**High**
Map 003	Similkameen River Watershed	Barrington Creek	Debris Flood	Moderate	High (River Rd)	Moderate	-	**High**
Map 004	Similkameen River Watershed	Susap Creek	Flood	High	Moderate (Chopaka Rd)	Moderate	-	**High**
Map 005	Similkameen River Watershed	Snehumption Creek	Flood	Moderate	Moderate (Chopaka Rd)	Moderate	-	Moderate
Map 002	Ashnola River Watershed	Ashnola Face Unit 1	Rockfall & Debris Flow	High	High (Ash R Rd)	Moderate	-	**Very High**
Map 002	Ashnola River Watershed	Red Bridge Creek	Debris Flood	High	High (Crater FSR)	-	-	**Very High**
Map 006	Ashnola River Watershed	Ashnola Face Unit 2	Landslide & Debris Flow & Sediment-Laden Flow	High	High (Ash R Rd & Crater FSR)	-	Low (rec sites)	**Very High**
Map 006	Ashnola River Watershed	Webster Creek	Debris Flood	High	High (Ewart Ck Rd)	High	-	**Very High**
Map 007	Ashnola River Watershed	Ewart Creek	Flood & Channel Instability & Bank Erosion	Moderate (flood) & High (bank erosion)	Mod to Low (Ewart Ck Rd & Trailhead)-	-	Moderate (WSC Stn.)	**High**
Map 007	Ashnola River Watershed	Ashnola Face Unit 3	Landslide & Debris Flow & Sediment-Laden Flow	High to Very High	High (Ash R Rd)	Moderate to High	Low (Rec Sites)	**Very High**
Map 007	Ashnola River Watershed	Ashnola Face Unit 4	Landslide & Debris Flow & Sediment-Laden Flow	High	High (Lakeview Rd)	-	High (Cathedral Base Camp)	**Very High**
Map 007	Ashnola River Watershed	Lakeview Creek	Landslide & Debris Flow & Sediment-Laden Flow (valley side slopes)	High	High (Lakeview Rd)	-	Low (Lodge/Camp)	**Very High**
Map 001	Ashnola River Watershed	Ashnola River (cumulative)	Flood, Channel Instability and Bank Erosion	Moderate	High (Ash R Rd site-specific)	Moderate	Moderate (rec sites)	**High**

8. Recommendations for Risk Mitigation

Recommendations for risk mitigation are provided for locations and areas that have been assigned a high or very high partial risk rating. Recommendations are both general and refer to specific sites, where possible. Based on the high-level nature of the post-wildfire risk analysis, not all hazards or risks can be identified for individual properties. However, use of this report can help guide where additional site-specific risk assessment may be warranted.

8.1 General Risk Mitigation Comments and Considerations

8.1.1 Structures located on Private Lands and IR Lands

Post-wildfire natural hazards were assessed for all areas impacted by the Crater Creek Wildfire, regardless of jurisdiction. Generally speaking, responsibilities for risk mitigation fall upon the private landowner, even though upslope hazards originate on Crown Land. Planning and funding project work on IR Lands falls within the jurisdiction of LSIB and Indigenous Services Canada (ISC).

Risk ratings were broadly assigned to identified Elements at Risk and to properties located on the fan. For structures located within the fan area, there is considerable uncertainty associated with the risk rating due to a lack of detailed understanding regarding potential event magnitude, unknown hydraulic capacity of drainage structures, and event runout characteristics.

Further, more detailed analysis is recommended to better characterize the risk to human safety on individual properties, or for specific residence sites, located on high hazard fans. More detailed analysis is required to design appropriate mitigation measures, such as barriers or berms, and to provide information on long-term monitoring and maintenance of such mitigation measures.

8.1.2 Water Points of Diversion (Domestic & Irrigation)

Domestic and irrigation water intake locations are identified along streams within the study area from iMAP BC (see Maps 002-007; Appendix B). Any structures that are located on a stream identified as having a high post-wildfire hazard level for flooding, debris flooding, or debris flow, are determined to be at high risk of impact. High hazard streams may be subject to high peak flows and bedload transport, which may damage infrastructure. Partial risk ratings for water intakes are not specifically listed on the summary table.

Impacts on water quality are more likely to occur on high hazard streams due to the effects of wildfire. For intake structures located on high hazard streams, it is recommended that protective structures be considered and/or alternative water sources be identified in the event of damages or conditions which render the water quality unacceptable for consumption.

It is recommended that water users inspect and monitor conditions at the intake and conduct water quality testing to detect post-wildfire changes. Besides turbidity and suspended sediment, post-wildfire impacts on water quality may include heavy metal concentrations and/or biological contamination from wildlife.

8.1.3 Watershed Management Activities

Salvage logging of burnt timber is often completed soon after the wildfire to maintain quality of the timber. Some salvage logging has already taken place in the upper part of the Rattlesnake Creek sub-basin of the Paul Creek watershed. It has already been more than one year since the wildfire, so it is unknown whether there are any further plans for salvage harvesting within the study area.

Additional care and attention is recommended if salvage harvesting is proposed in a high hazard catchment area, or where slopes are conducive to the initiation of post-wildfire natural hazards. For these areas, terrain stability assessments and hydrologic assessments are recommended prior to harvesting.

Terrain stability assessments would provide guidance to ensure that logging reduces the likelihood for harvest-related instability. Hydrologic assessments that include consideration for past harvesting (i.e., Equivalent Clearcut Area measurements), would evaluate potential cumulative hydrologic effects for the catchment area.

In addition, drainage structures (i.e., culverts and ditchlines) along resource roads (whether under permit or not) within fire salvage areas, and within areas harvested prior to the wildfire, should be inspected and maintained to ensure clear passage for runoff.

8.1.4 Fisheries and Aquatic Habitat Values

Wildfire impacts on water quality for fisheries and aquatic habitat values in the fire-affected watersheds are not well understood. Wildfire impacts on hydrology (i.e. peak flows and low flows) may affect in-stream values. Bedload transport and contributing source of sediment can lead to habitat degradation.

To further understand water quality impacts on fisheries and aquatic habitat values, it is recommended that a data gap analysis be undertaken to determine the availability of baseline water quality, fisheries, and aquatic habitat data. Then a strategy to monitor changes in water quality may be developed.

8.2 Increased Awareness of Post-Wildfire Hazards

In general, for the entire area affected by the Crater Creek Wildfire, increased education and awareness is recommended. Elevated risks are anticipated for the following 3 to 5 years, and potentially for decades until the forest fully recovers. Risks are elevated during the following periods:

- In the early spring (mid-March to mid-May) when rapid snowmelt occurs during early season warming or rain-on-snow events at lower elevation sites;
- In the late spring (early-May to late-June) during which elevated peak flows in the larger watersheds may be associated with snowmelt from higher elevation sites (due to warm temperatures and/or rain);
- in the summer (July to September), during localized, short-duration high-intensity convective rainstorms;
- in the mid- to late fall (mid-October to early December), during more prolonged periods of precipitation or rain-on-snow events; and,

- periods of freeze-thaw (late-November to late-March) during which rockfall hazards are most likely to occur.

Recommended measures to increase education and hazard awareness include:

- facilitate public and industry access to the Post-Wildfire Natural Hazard Risk Analysis report;
- install signage along public roads, such as Ashnola River Road and Chopaka Road, alerting residents and visitors of the potential for natural hazards (i.e., hazardous conditions during rain events; rockfall hazards during freeze-thaw periods; no stopping);
- provide public information bulletins on hazard recognition and how to respond (such as the BC government info-sheets);
- encourage property owners to inspect and maintain drainage structures to ensure clear passage for sediment-laden water and debris; and,
- provide emergency response information, including a single central contact number, to be called for all emergencies, or in the event of an observed hazard scenario. In areas without cell reception, alternate methods for emergency communication should be developed.

8.3 Recommendations for Risk Mitigation by Catchment Area

Risk mitigation measures are provided for high and very high-risk Elements at Risk and are organized by catchment area in Table 8-1.

Table 8-1: Recommendations for Risk Mitigation by Catchment Area

Catchment Area	Hazard Condition	Element at Risk	Recommendation for Risk Mitigation
Rattlesnake Creek Sub-Basin	High hazard for debris flood.	1,000 mm diameter culvert at Paul Creek Road has a partially obstructed outlet and may be undersized. Bridge on Paul Creek is damaged and in need of repair.	Clear debris from culvert inlet and outlet (short-term). Consider removal of culvert if resource road is not needed or upgrade to accommodate changed hydrology in catchment (long-term).
Face Unit East of Ashnola	High hazard for rockfall	Residence at 455 Ashnola River Road (Ashnola 10 IR)	Inform resident and recommend more detailed rockfall assessment for property.
Watershed 2	Moderate hazard for debris flood.	600 mm culvert at River Road, currently in good condition.	Monitor and maintain clear flow passage.
Barrington Creek	Moderate hazard for debris flood	4-foot (1,220 mm) diameter culvert at River Road, currently in good condition.	Monitor and maintain clear flow passage.
Susap Creek	High hazard for flood and debris flood.	Entire fan area is identified as high hazard and Elements at Risk located on the fan are rated very	More detailed hydrologic modeling to determine potential changes in flow, and geomorphologic assessment of

Catchment Area	Hazard Condition	Element at Risk	Recommendation for Risk Mitigation
		high risk. Fan area include multiple residences, Chopaka Road, bridge crossing (in good condition). Water intake infrastructure is also at risk.	channel stability across the fan area. Further work is needed to characterize flood risk to structures and infrastructure located on the fan.
Snehumption Creek	Moderate hazard for flood and debris flood.	Entire fan area is identified as moderate hazard and Elements at Risk located on the fan are rated high risk. Fan area include multiple residences, Chopaka Road, bridge crossing (in good condition). Water intake infrastructure is also at risk.	More detailed hydrologic modeling to determine potential changes in flow, and geomorphologic assessment of channel stability across the fan area. Further work is needed to characterize flood risk to structures and infrastructure located on the fan.
Red Bridge Creek	High hazard for debris flood.	There is observed instability along the Crater FSR. Historic resource roads and trails from past forest harvesting activities increase the post-wildfire natural hazard level.	Rehabilitate non-status forest roads including removal of drainage structures and unstable road fill. Drainage issues have been assessed along the Crater FSR by MOF.
Webster Creek	High hazard for debris flood.	At risk are a private residence at 1621 Ewart Creek Road (RDOS Area G), Ewart Creek Road (partly obstructed 500 mm culvert), and a domestic water intake.	Inform resident and recommend more detailed debris flood hazard assessment for the property. Construction of a small berm to deflect flows away from the residence may be possible along the water intake access trail. Monitor and ensure clear passage of the small culvert on Ewart Creek Road.
Ewart Creek	High hazard for bank erosion	At risk is Ewart Creek Road, the trailhead, and the WSC hydrometric station.	Install signage to inform road and trail users of bank erosion hazards. Inform WSC (Environment and Climate Change Canada) of potential hazards along Ewart Creek.
Lakeview Creek	High hazard for landslide, debris flow, and sediment-laden flow along valley side slopes.	At risk is the Lakeview Access Road into Cathedral Park.	BC Parks has already undertaken a more detailed assessment of Lakeview Road and in the process of securing funding for road repair work to mitigate risks. Further work may be required to mitigate risk at the Base Camp location.

8.4 Lower Ashnola River and Associated Face Units

Short-term and long-term mitigation measures are recommended for downstream reaches of the Ashnola River, which is subject to an elevated likelihood of peak flow-generated flood (and potentially debris flood if sediment-bulking is high) and/or channel instability (see Table 8-2). The interpreted risk to the Elements listed below varies, from MODERATE to VERY HIGH. These include:

- **Ashnola River Road** – approximate length of 16 kilometres closely follows the Ashnola River within a fairly well-confined valley bottom. The road is exposed to post-wildfire hazards generated from face unit slope above (landslide, rockfall, debris flow, and sediment-laden flow) and at major culvert sites at tributary crossings (flood, debris flood, and debris flow). At risk are several private properties (below Face Unit 3). Where the road lies near the Ashnola River, higher peak flows and increased sediment and debris transport may result in streambank erosion. Although not specifically identified, these sites are rated HIGH risk and mitigation measures are recommended (see Table 8-2).

  Ashnola River Road, is a public road from Keremeos to ~16 km, is maintained by AIM Roads Inc. on behalf of the BC MOTT. Beyond this point, beyond the 2023 Wildfire, the Ashnola River FSR is maintained by MOF-OSNRD (Vernon). It is also understood that Ashnola River Road is patrolled and monitored by LSIB Land Guardians who are stationed at the Campground. The Guardians are probably best suited to monitor conditions along the road and are able to flag hazardous sites as they become known. It is recommended that the Land Guardians be provided a copy of this report and consider a full-length traverse with a Qualified Professional to identify key sites that may require further attention.

  To address hazards identified along the first 16 km of the road, it is recommended that MOTT be provided a copy of this report and to liaise with the LSIB Land Guardians that have an ongoing presence along the road. For emergency purposes the roads contractor contact information is:

AIM Roads Inc. – Public Roads Contractor
24-hour hot line: 1-866-222-4204
X, Facebook, Instagram: @AimRoads
Website: https://aim-roads.ca/contact-us/

- **Ashnola 10 IR Lands** make up the entire alluvial fan area of the Ashnola River. There are numerous structures and culturally significant sites within the fan area, and little is known about flood risk. Existing floodplain mapping for the Similkameen River does not address flood hazards on the Ashnola River. Post-wildfire impacts on hydrology and increased sediment and debris transport may lead to decreased channel stability. This may lead to bank erosion and potentially stream channel avulsion (i.e., sudden change in channel pattern) and, as a result, Elements located on the fan area are rated MODERATE risk. Short-term mitigation measures are provided, and recommendations for further assessment are warranted to refine this risk rating (see Table 8-2). Identified Elements at Risk on the fan area include:
  - Bridge 1 at Paul Creek Road;
  - WSC Hydrometric Station (Ashnola River near Keremeos 08NL004);
  - Sna?snulax'tn Campground and Pow-Wow Grounds; and,
  - Ashnola Village Residential sub-division (which has existing flood protection as shown on GeoData BC).

Table 8-2: Risk Mitigation Recommendations for the Lower Ashnola River and Associated Face Units

Catchment Area	Hazard Condition	Site	Recommendations for Risk Mitigation
Lower Ashnola River	High hazard for debris flood and debris flow from tributary catchments.	Ashnola River Road (entire length, various sites)	Proactively maintain, clear, and upgrade (if possible) drainage structures (ditch lines and culverts) and increase frequency of inspection along Ashnola River Road. Install signage to alert road users of hazard conditions.
	High hazard for channel instability and bank erosion.	Ashnola River Road (entire length, various sites)	Identify sites along the road that are near the river and susceptible to bank erosion. Short-term - flag these sites to alert road users. Long-term – address bank and road fill stability.
	High hazard for channel instability and bank erosion	Ashnola River Floodplain (high burn severity sites)	Accelerate riparian recovery and improve riparian function along stream reaches impacted by wildfire through riparian restoration treatments including planting. Chosen sites should be within floodplain but set back from the active channel.
	Moderate hazard for increased peak flows and increased likelihood for channel aggradation, debris jams, and bank erosion.	Alluvial fan area (Ashnola 10 IR and WSC Station)	Undertake hydrologic analysis to determine post-wildfire design flows and hydraulic modelling across the alluvial fan area to determine flood extent and water depths for the design flow. Consider post-wildfire effects on hydrology and effects of a changing climate.
Ashnola Face Unit 1	High hazard for rockfall and debris flow.	Approx. 1 km long section north of Bridge 2.	Ensure that existing signage remains and that there are no pullouts to be used for stopping. Long-term consideration for rockfall protection measures.
Ashnola Face Unit 2	High hazard for landslide, debris flow, and sediment-laden flow from valley side slopes	Ashnola River Road	Proactively maintain, clear, and upgrade drainage structures (ditch lines and culverts) and increase frequency of inspection along Ashnola River Road.
Ashnola Face Unit 3	High hazard for landslide, debris flow, and sediment-laden flow from valley side slopes	At risk are several structures on private property at 2201 Ashnola River Road	Inform residents of hazards. Conduct further assessment to determine appropriate protective measures, which may include upgrades to roadside ditches and possible construction of a protective berm.
Ashnola Face Unit 4	High hazard for landslide and debris flow.	Unnamed tributary upslope of the Cathedral Park Base Camp is a high hazard catchment.	Road-related hazards were identified in a report to BC Parks. However, recommendations for road repair do not address the debris flow risk to Base Camp site. Further assessment is required to develop a mitigation strategy. In the short-term, recommend increased awareness during high-risk periods of time.

8.5 Develop a Weather-Based Early Warning System for Flood and Debris Flow

Elevated peak flows (flood and debris flood) associated with post-wildfire effects are anticipated on the larger watersheds located on the west side of the Lower Similkameen Valley, such as Susap Creek, and for larger watersheds and sub-basins along the Ashnola River. Elevated hazard levels for post-wildfire debris flow are anticipated for smaller sub-basins and within face unit areas. Debris flow hazards are particularly risky for residences, or for roads, that are located on the fan.

The rationale for a warning system is based on several damaging debris flow / debris flood events that have occurred since the 2018 Snowy Mountain Fire, and on the elevated potential likelihood for future damaging events.

Currently, regional intense rainfall warnings are available from Environment Canada[21]. This information is not specifically targeted to the study area and may not be able to provide data that can be relied upon to provide realistic alerts. In absence of a near-real time debris flow warning system based on rainfall thresholds, the provincial storm alerts provide general guidance.

Further work is required to better understand rainfall trigger thresholds for debris flow initiation and to advance this information to develop a locally relevant debris flow warning system.

[21] https://weather.gc.ca/mainmenu/alert_menu_e.html

9. Closure and Limitations

This report has been prepared by Clarke Geoscience Ltd. for the exclusive use of the Ministry of Forests, Emergency Management and Climate Readiness, Lower Similkameen Indian Band, and Regional District of Okanagan-Similkameen. Copies may be distributed to interested parties, including local residents. Any use of this report by a third-party is the responsibility of such, and no third party shall rely on this document. Use of the information contained within this report shall be at their own risk. CGL accepts no responsibility for damages, if any, suffered by any third party as a result of use, decisions made, or lack thereof, on this report. No other warranty is made, either expressed or implied.

The assessment has been carried out in accordance with generally accepted professional practices in BC. Professional judgment has been applied in the interpretations provided in this report. The conclusions and recommendations presented in this report are based on available information, limited field investigation, and professional opinion. Inherent variability in local precipitation, runoff, soil and vegetation burn severity, surface and subsurface soil conditions, may create unforeseen situations.

This report is subject to the CGL General Conditions and Terms of Use, presented in Appendix D.

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Appendix A Partial Risk Analysis Methodology

Appendix A – CGL Partial Risk Analysis Approach for Post-Wildfire Natural Hazards

The following describes the risk analysis approach used for post-wildfire natural hazards and provides definitions of the technical terms used. The approach is adopted from, and described in more detail in, Land Management Handbook No. 69 (Hope, et al., 2015), Land Management Handbook No. 56 (Wise et al., 2004), and the EGBC Landslide Assessment Guidelines (2023).

The term “partial risk” refers to the probability of a specific hazardous event affecting an element at risk. Partial risk analysis differs from a Total Risk analysis as it does not estimate the damages that may occur because of an impact (i.e., vulnerability). Partial risk assumes that any encounter is undesirable.

Partial risk is expressed as:

$$P(HA) = P(H) \times P(S{:}H) \times P(T{:}S)$$

where:
$P(HA)$ is the partial risk;
$P(H)$ is the likelihood of a hazardous event occurring;
$P(S{:}H)$ is the spatial likelihood that the hazardous event will reach the element at risk;
$P(T{:}S)$ is the temporal likelihood that the element at risk will be at the site if the hazard event occurs.

For fixed or stationary structures such as buildings and roads, the temporal probability [$P(T{:}S)$] is equal to 1 and the above equation is reduced to:

$$P(HA) = P(H) \times P(S{:}H)$$

Partial Risk = **Hazard** (likelihood of a hazardous event) x **Spatial Likelihood** (likelihood that event reaches and otherwise affects the Element at Risk)

Each component of risk is defined below.

Hazard P(H) – is defined as a process that has the potential to damage, harm, or cause other adverse effects to human health, property, the environment, or other things of value (CSA, 1997). With respect to post-wildfire natural hazards, these may include landslides, soil erosion, rockfall, debris flow, debris flood, sediment-laden flow, or other natural geological processes.

Hazard levels that pertain to specific hazardous events may be expressed in qualitative, or relative, terms. For the purposes of this project, qualitative descriptors and corresponding probability ranges for post-wildfire natural hazard likelihood (P(H)) are provided in Table A1 below. For each hazard level, there is corresponding annual probability of occurrence (Pa) and an associated return period in years (1/Pa).

Table A1: Natural Hazard Levels (Likelihood of a Hazardous Event) Defined

Hazard Level P(H)	Qualitative Description	Hazard Criteria	Annual Probability of Occurrence (Pa), or Return Period
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 (greater than 1 in 5 yr)
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.	0.01-0.20 (1 in 5 yr to 1 in 100 yr)
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 in 100 yr to 1 in 500 yr)
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 in 500 yr to 1 in 2,500 yr)
Very Low	An event will not occur; or is conceivable though considered exceptionally unlikely 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 (less than 1 in 2,500 yr)

from PWNHRA Contract Schedule A – Services, modified from Wise, et al., 2004; and EGBC, 2023

Spatial Likelihood P(S:H) – is defined as the likelihood that a specific hazardous event reaches and otherwise affects the identified Element at Risk. Relative levels of spatial likelihood are expressed in qualitative, or relative, terms as defined in Table A2 below.

Table A2: Spatial Likelihood Levels (Likelihood that the Hazardous Event Reaches or Affects the Specified Element at Risk) Defined

Spatial Likelihood Level P(S:H)	Probability Range	Qualitative Description (*from PWNHRA Contract Schedule A – Services, modified from Wise, et al., 2004*)
High	>0.5	It is probable that the Element at Risk will be impacted by the hazard. The Element is located within the zone of impact of the hazard being evaluated.
Moderate	0.5-0.1	It is possible that the Element at Risk will be impacted by the hazard. The Element at Risk is located at the distal end of the runout zone or zone of impact of the hazard being evaluated.
Low	<0.1	It is unlikely that the Element at Risk will be impacted by the hazard being evaluated.

Elements at Risk – are defined as the population, building or engineering works, utilities, infrastructure, water quality, and environmental features such as fish and fish habitat in the area potentially affected by the hazards being assessed.

Partial Risk P(HA)- is defined as the probability that a specific hazard, such as a landslide, debris flow, or rockfall event, will occur and the probability of it impacting a site occupied by a specific Element at Risk. Partial risk may be evaluated quantitatively using probabilities, or, as in the case for this assessment, qualitatively using relative ratings and a partial risk matrix (Table A3).

Table A3: Qualitative Post-Wildfire Natural Hazard Partial Risk Matrix

Partial Risk P(HA): the probability that a specific hazard will occur and the probability of it impacting a site occupied by a specific Element at Risk (i.e., P(HA) = P(H) x P(S:H))		**Spatial Impact Likelihood P(S:H) – the probability (likelihood) that the hazard will reach or otherwise impact the site occupied by an Element at Risk (see Table A2).**		
		High	**Moderate**	**Low**
P(H) – the annual probability (likelihood) of occurrence of a post-wildfire natural hazard (i.e. landslide, debris flow) (see Table A1)	**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

There are five possible outcomes, or partial risk levels, from the partial risk analysis (see Table A4). These risk levels do not imply a threshold level of risk acceptability or tolerance, as this may vary depending on the element being considered. General implications of the qualitative partial risk ratings are derived from LMH 69 (Hope, et al., 2015) and adapted from LMH 56 (Wise et al., 2004). Ultimately, risk acceptability is to be determined by the land manager or owner. This task is referred to as risk evaluation.

Table A4: Implications of Qualitative Partial Risk Ratings

Partial Risk Rating	**Evaluation** **(*from PWNHRA Contract Schedule A – Services*)**
Very High	Unacceptable risk typically requiring site-specific detailed investigation, planning and implementation of mitigative treatments recommended to reduce the partial risk to a more acceptable level. May be very expensive or impractical. Consider avoidance.
High	Usually unacceptable and typically requiring site-specific detailed investigation, planning and implementation of mitigative treatment recommended to reduce the partial risk to a more acceptable level.
Moderate	This risk may or may not be tolerable, depending on the risk acceptability criteria of the stakeholder or decision maker. The risk may be accepted and monitored. Treatment plans may be developed to reduce the hazard. Additional investigation and planning for treatment or mitigation options may be pursued.
Low	Usually acceptable, treatment or additional investigation may still be pursued at the discretion of the stakeholder or decision maker.
Very Low	Acceptable.

References:

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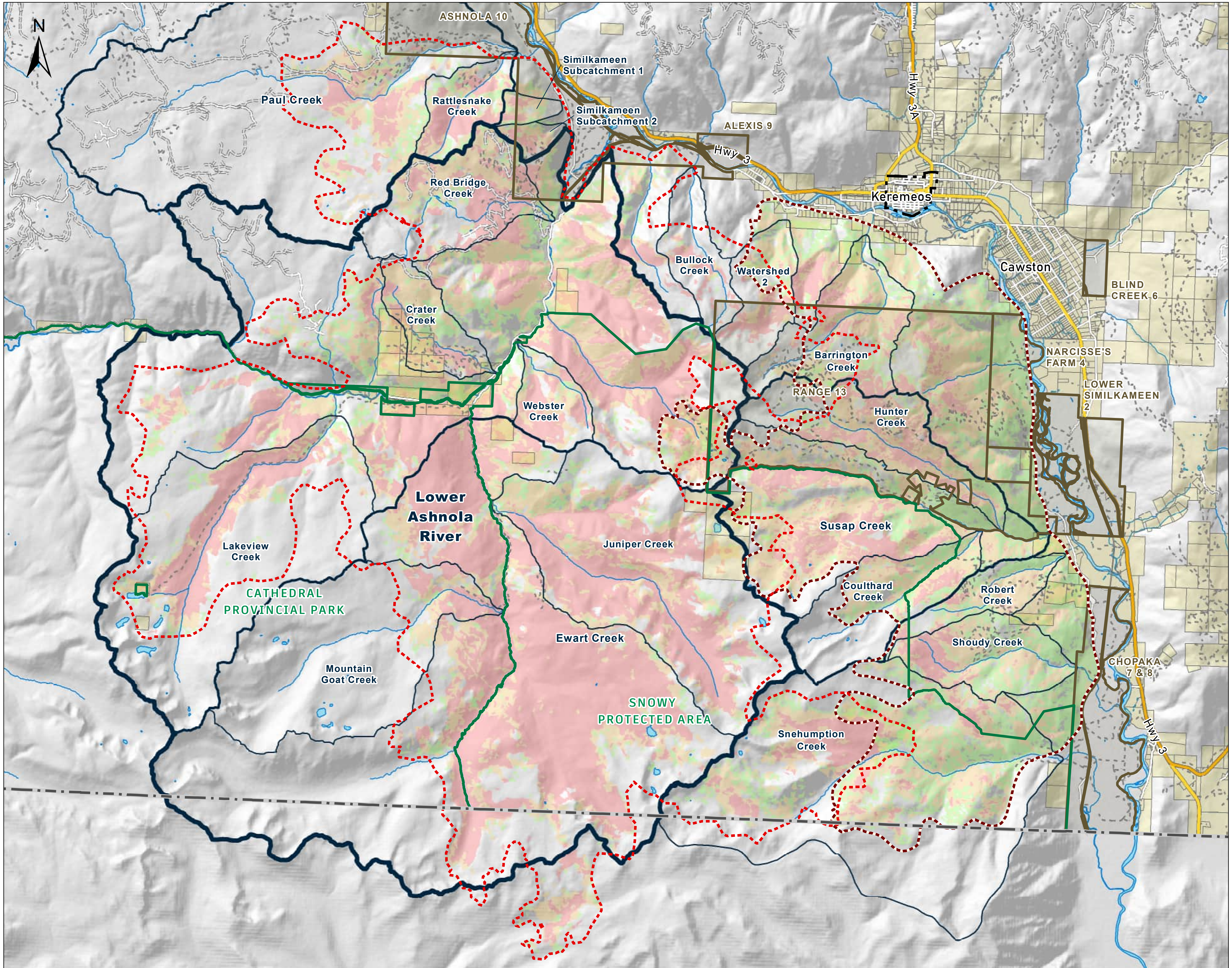
Appendix B Maps 001 to 007



LEGEND

- Municipality Boundary
- Park / Protected Area
- First Nations Reserve
- Cadastral Fabric (Private Land)
- 2023 Crater Creek Wildfire (K52125)
- 2018 Snowy Mountain Wildfire (K51238)
- Catchment / Sub-basin

Burn Severity (Source: BC Data Catalogue)

- High
- Medium
- Low

Roads (Source: Data BC Digital Roads Atlas)

- Highway / Major Road
- Arterial Road
- Local Road / Street
- Resource Road
- Forest Tenure Road (Active)
- Forest Tenure Road (Inactive)
- Skid / Trail / Unclassified

1,600 800 0 1,600 3,200
metres

Client: **MINISTRY OF FORESTS - BC WILDFIRE SERVICE**

Project: **POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS FOR THE 2023 CRATER CREEK WILDFIRE (K52125)**

Title: **STUDY AREA**

Scale: 1:135,000	NAD 1983 UTM Zone 11 U	Figure No.
Project No: 24-0103	Date: June 17, 2025	001

Clarke Geoscience Ltd.

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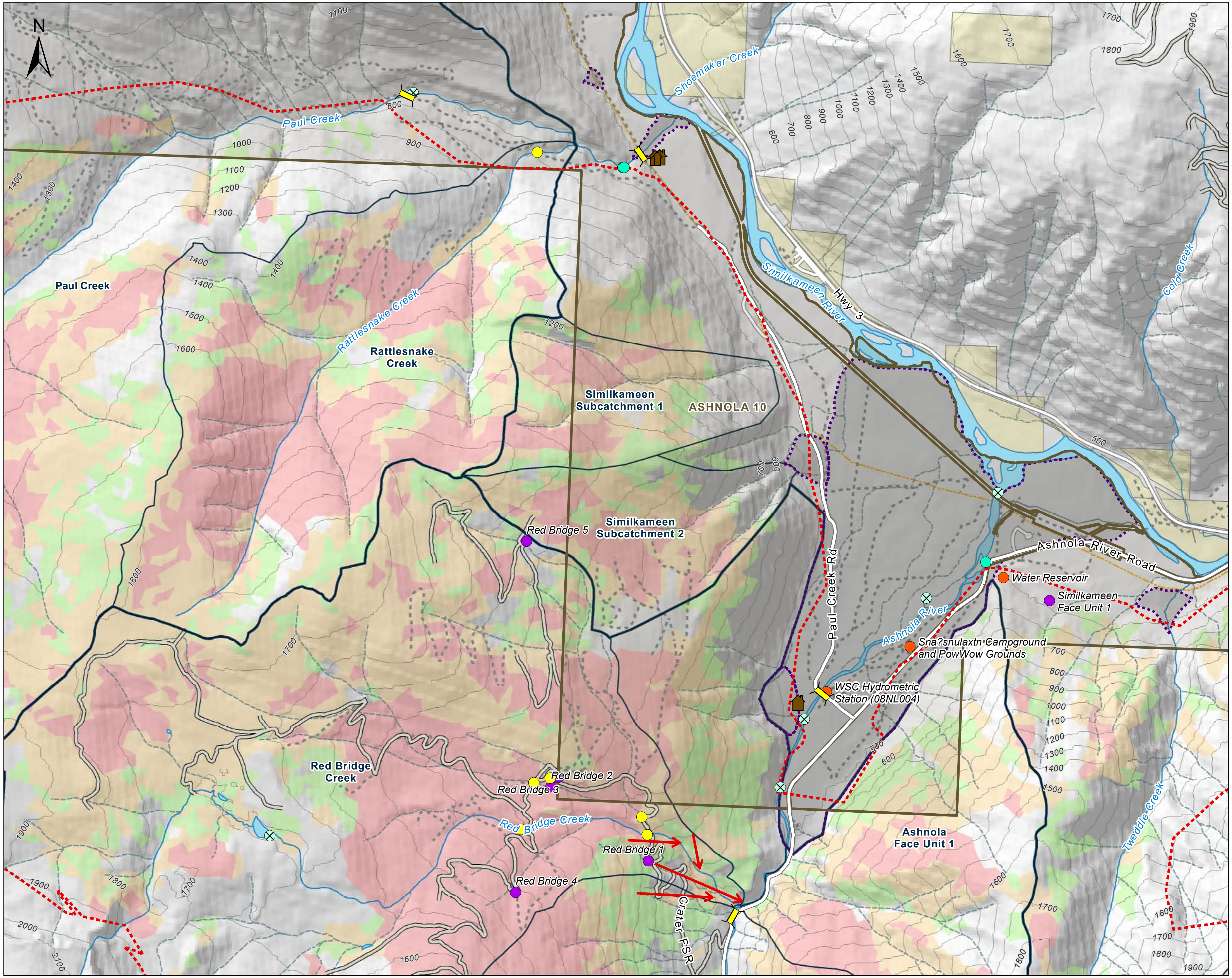


LEGEND

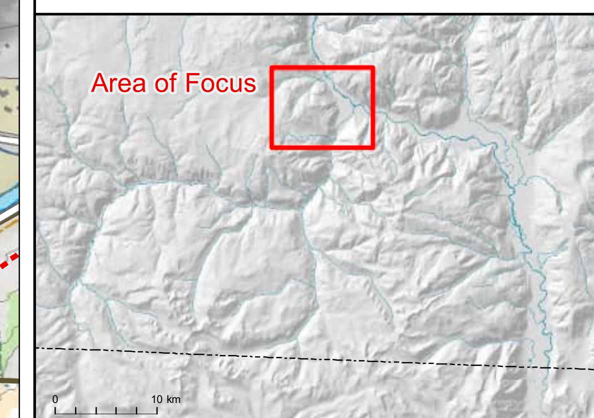
- First Nations Reserve
- Cadastral Fabric (Private Land)
- 2023 Crater Creek Wildfire (K52125)
- Catchment / Sub-basin
- Alluvial Fan
- Fortis Gas Pipeline
- Recent (post-2018 and post-2023) Post-Wildfire Hazard Events (Landslides, Debris Flows and Sediment-Laden Flooding)
- Structure
- Bridge
- Major Stream Crossing
- Point of Interest (Element at Risk)
- Soil Burn Test Pit
- Active Water Point of Diversion (POD) (Domestic)
- Active Water Point of Diversion (POD) (Other)

Vegetation Burn Severity (Source: BC Data Catalogue)

- High
- Medium
- Low

Roads (Source: Data BC Digital Roads Atlas)

- Highway / Road
- Resource Road / Trail
- Trail / Unclassified



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metres

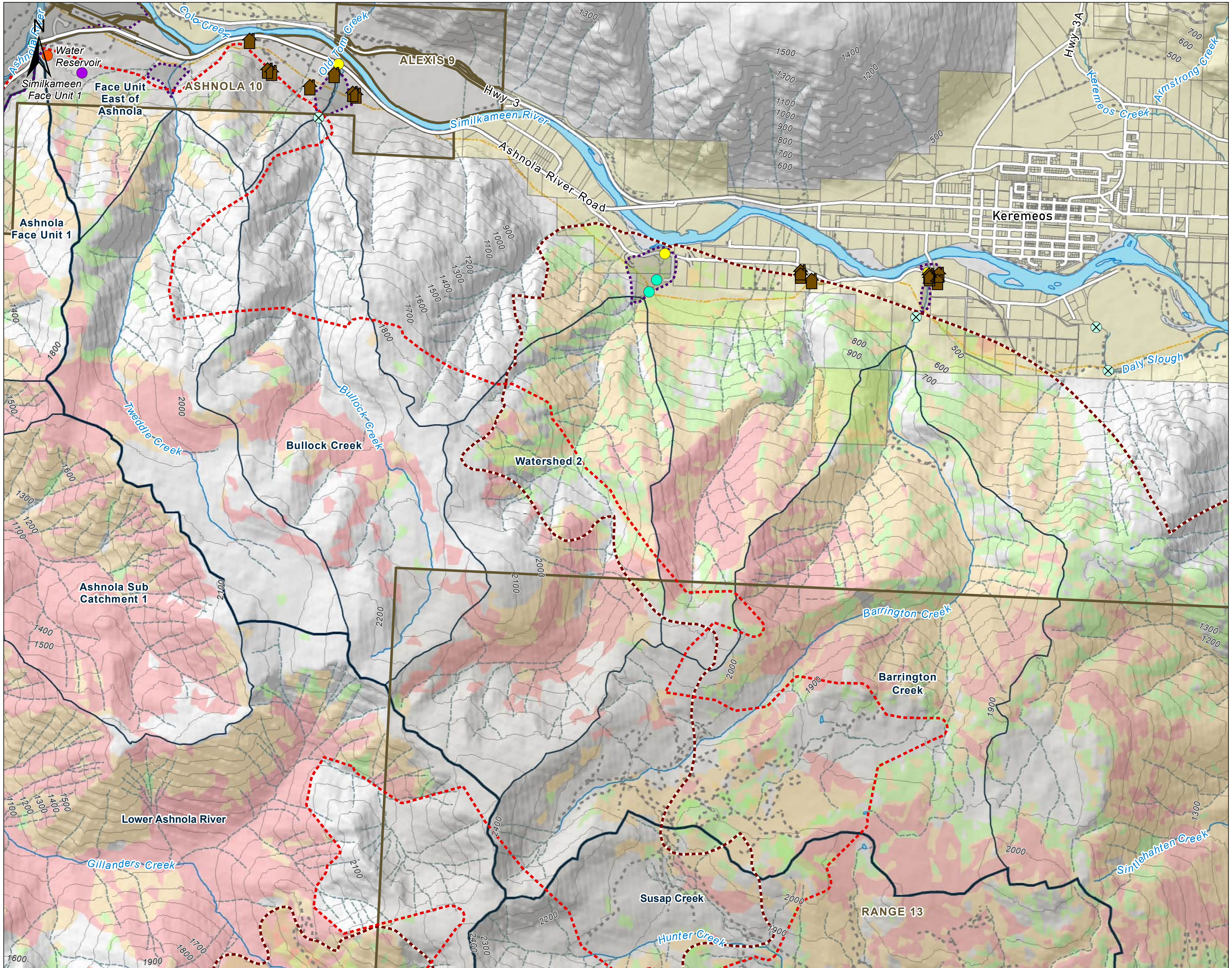
Client:
MINISTRY OF FORESTS - BC WILDFIRE SERVICE

Project:
POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS FOR THE 2023 CRATER CREEK WILDFIRE (K52125)

Title:
PAUL CREEK AND ASHNOLA RIVER FAN AREA

Scale: 1:30,000	NAD 1983 UTM Zone 11 U	Figure No. 002
Project No: 24-0103	Date: June 17, 2025	

CLARKE GEOSCIENCE LTD.



LEGEND

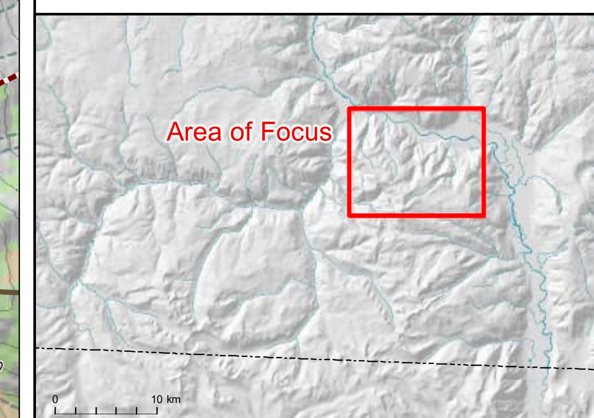
- First Nations Reserve
- Cadastral Fabric (Private Land)
- 2023 Crater Creek Wildfire (K52125)
- 2018 Snowy Mountain Wildfire (K51238)
- Catchment / Sub-basin
- Alluvial Fan
- Fortis Gas Pipeline
- Structure
- Major Stream Crossing
- Point of Interest (Element at Risk)
- Soil Burn Test Pit
- Active Water Point of Diversion (POD) (Domestic)
- Active Water Point of Diversion (POD) (Other)

Vegetation Burn Severity (Source: BC Data Catalogue)

- High
- Medium
- Low

Roads (Source: Data BC Digital Roads)

- Highway / Road
- Resource Road / Trail
- Trail / Unclassified



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metres

Client: **MINISTRY OF FORESTS - BC WILDFIRE SERVICE**

Project: **POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS FOR THE 2023 CRATER CREEK WILDFIRE (K52125)**

Title: **LOWER SIMILKAMEEN VALLEY BULLOCK CREEK - BARRINGTON CREEK**

Scale: 1:40,000 NAD 1983 UTM Zone 11 U

Figure No. 003

Project No: 24-0103 Date: June 17, 2025

Clarke Geoscience Ltd.

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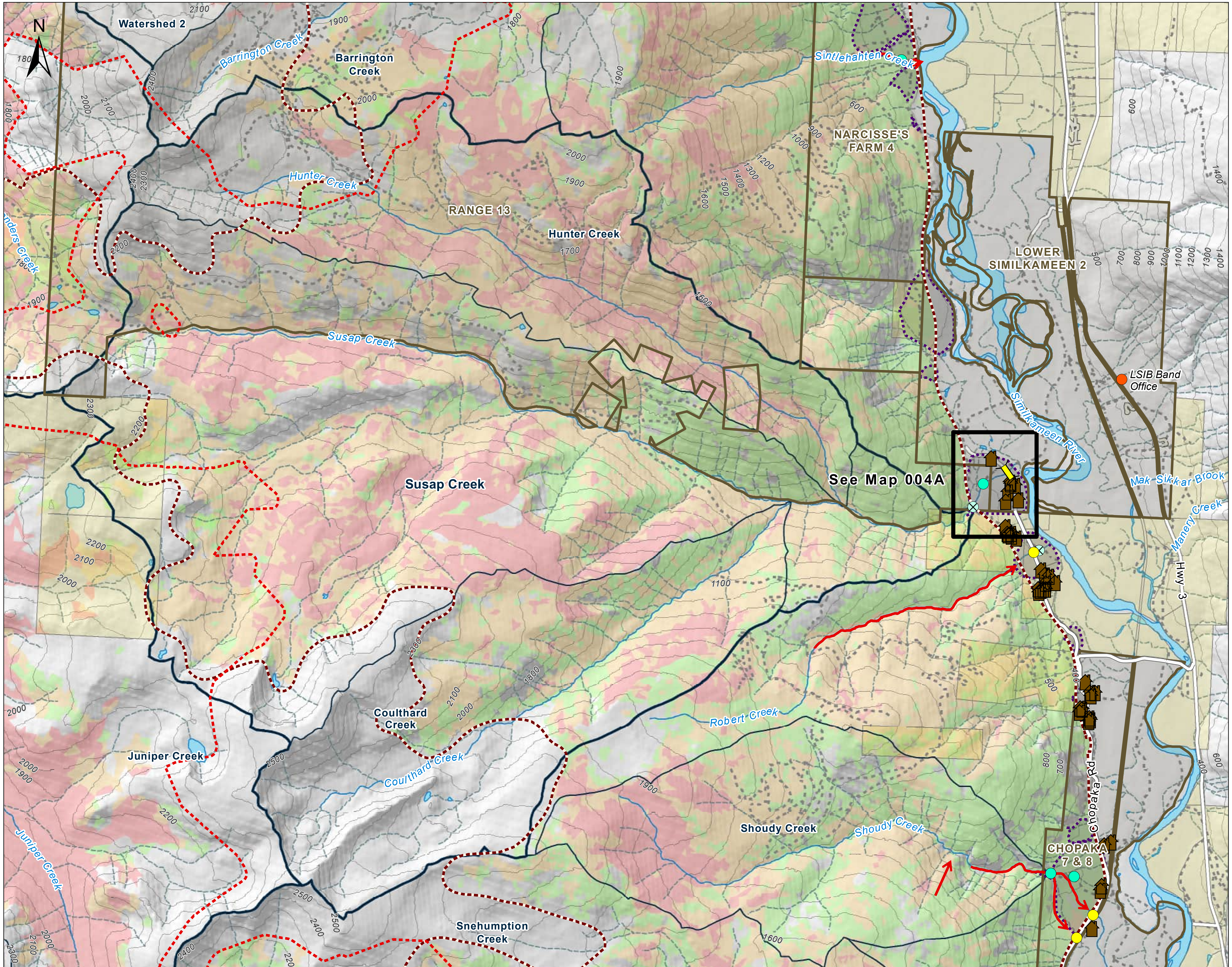

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LEGEND

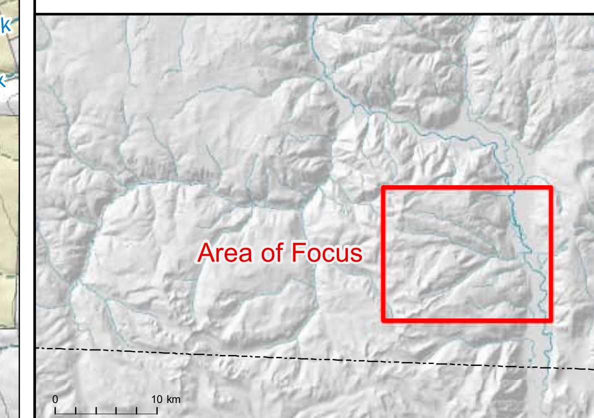
- First Nations Reserve
- Cadastral Fabric (Private Land)
- 2023 Crater Creek Wildfire (K52125)
- 2018 Snowy Mountain Wildfire (K51238)
- Catchment / Sub-basin
- Alluvial Fan
- Recent (post-2018 and post-2023) Post-Wildfire Hazard Events (Landslides, Debris Flows and Sediment-Laden Flooding)
- Structure
- Bridge
- Major Stream Crossing
- Point of Interest (Element at Risk)
- Active Water Point of Diversion (POD) (Domestic)
- Active Water Point of Diversion (POD) (Other)

Vegetation Burn Severity (Source: BC Data Catalogue)

- High
- Medium
- Low

Roads (Source: Data BC Digital Roads Atlas)

- Highway / Road
- Resource Road / Trail
- Trail / Unclassified



660 330 0 660 1,320
metres

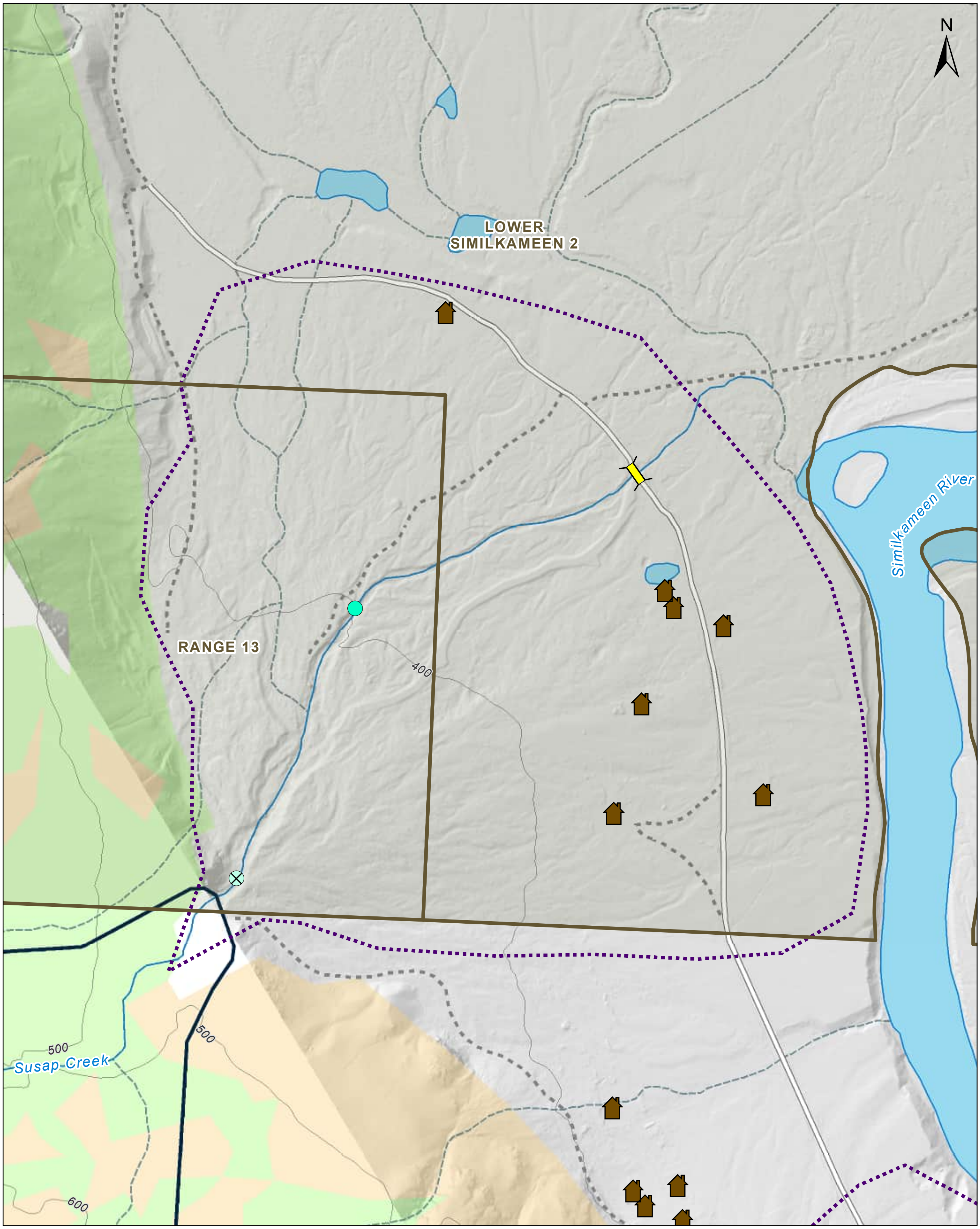
Client: **MINISTRY OF FORESTS - BC WILDFIRE SERVICE**

Project: **POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS FOR THE 2023 CRATER CREEK WILDFIRE (K52125)**

Title: **LOWER SIMILKAMEEN VALLEY SUSAP CREEK**

Scale: 1:50,000	NAD 1983 UTM Zone 11 U	Figure No. 004
Project No: 24-0103	Date: June 17, 2025	

Clarke Geoscience Ltd.



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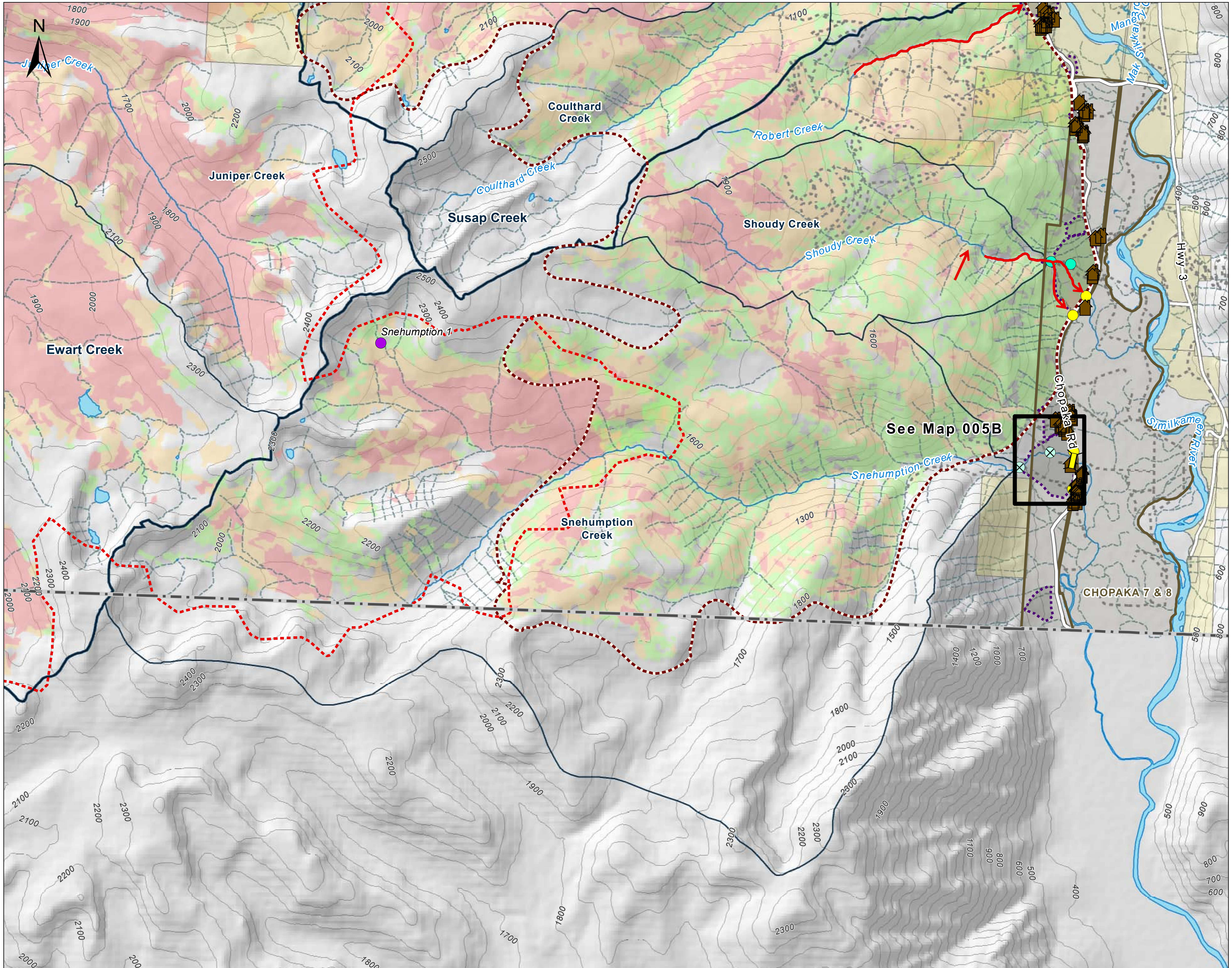
Alluvial Fan
Structure
Bridge
Active Water Point of Diversion (POD) (Domestic)
Active Water Point of Diversion (POD) (Other)

80 40 0 80 160
metres

Title:
SUSAP CREEK FAN AREA

Scale: 1:6,000
NAD 1983 UTM Zone 11 U
Project No: 24-0103
Date: June 17, 2025
Figure No.
004A



LEGEND

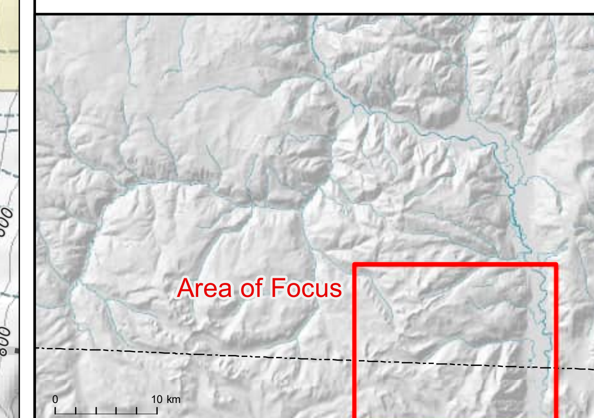
- First Nations Reserve
- Cadastral Fabric (Private Land)
- 2023 Crater Creek Wildfire (K52125)
- 2018 Snowy Mountain Wildfire (K51238)
- Catchment / Sub-basin
- Alluvial Fan
- Recent (post-2018 and post-2023) Post-Wildfire Hazard Events (Landslides, Debris Flows and Sediment-Laden Flooding)
- Structure
- Bridge
- Major Stream Crossing
- Soil Burn Test Pit
- Active Water Point of Diversion (POD) (Domestic)
- Active Water Point of Diversion (POD) (Other)

Vegetation Burn Severity (Source: BC Data Catalogue)

- High
- Medium
- Low

Roads (Source: Data BC Digital Roads Atlas)

- Highway / Road
- Resource Road / Trail
- Trail / Unclassified



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metres

Client:
MINISTRY OF FORESTS - BC WILDFIRE SERVICE

Project:
POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS FOR THE 2023 CRATER CREEK WILDFIRE (K52125)

Title:
LOWER SIMILKAMEEN VALLEY SHOUDY CREEK - SNEHUMPTION CREEK

Scale: 1:60,000	NAD 1983 UTM Zone 11 U	Figure No. 005
Project No: 24-0103	Date: June 17, 2025	

Clarke Geoscience Ltd.

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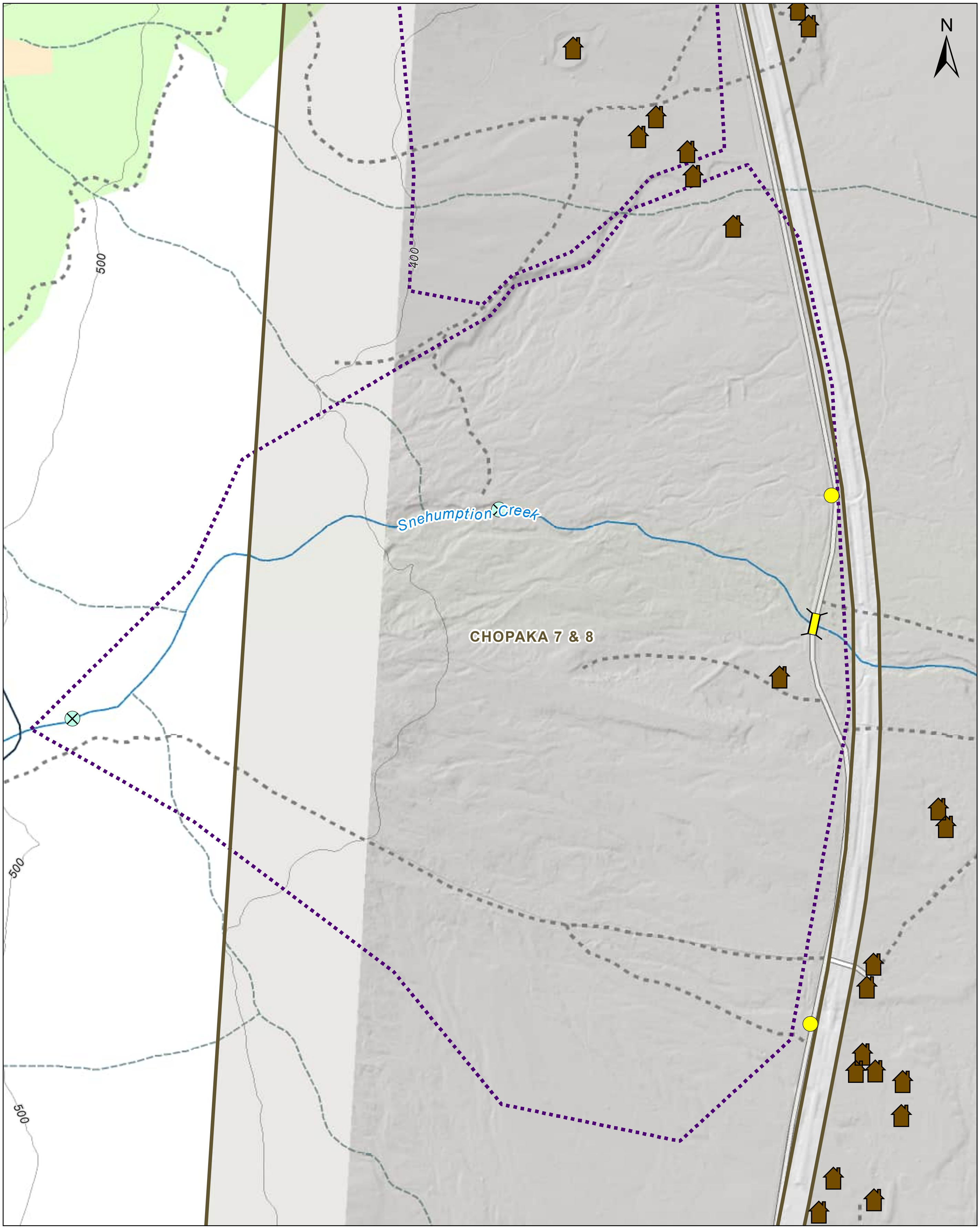

Alluvial Fan

Structure

Bridge

Major Stream Crossing

Active Water Point of Diversion (POD) (Other)

80 40 0 80 160
metres

Title:

SNEHUMPTION CREEK FAN AREA

Scale: 1:6,000	NAD 1983 UTM Zone 11 U	Figure No.
Project No: 24-0103	Date: June 17, 2025	005B

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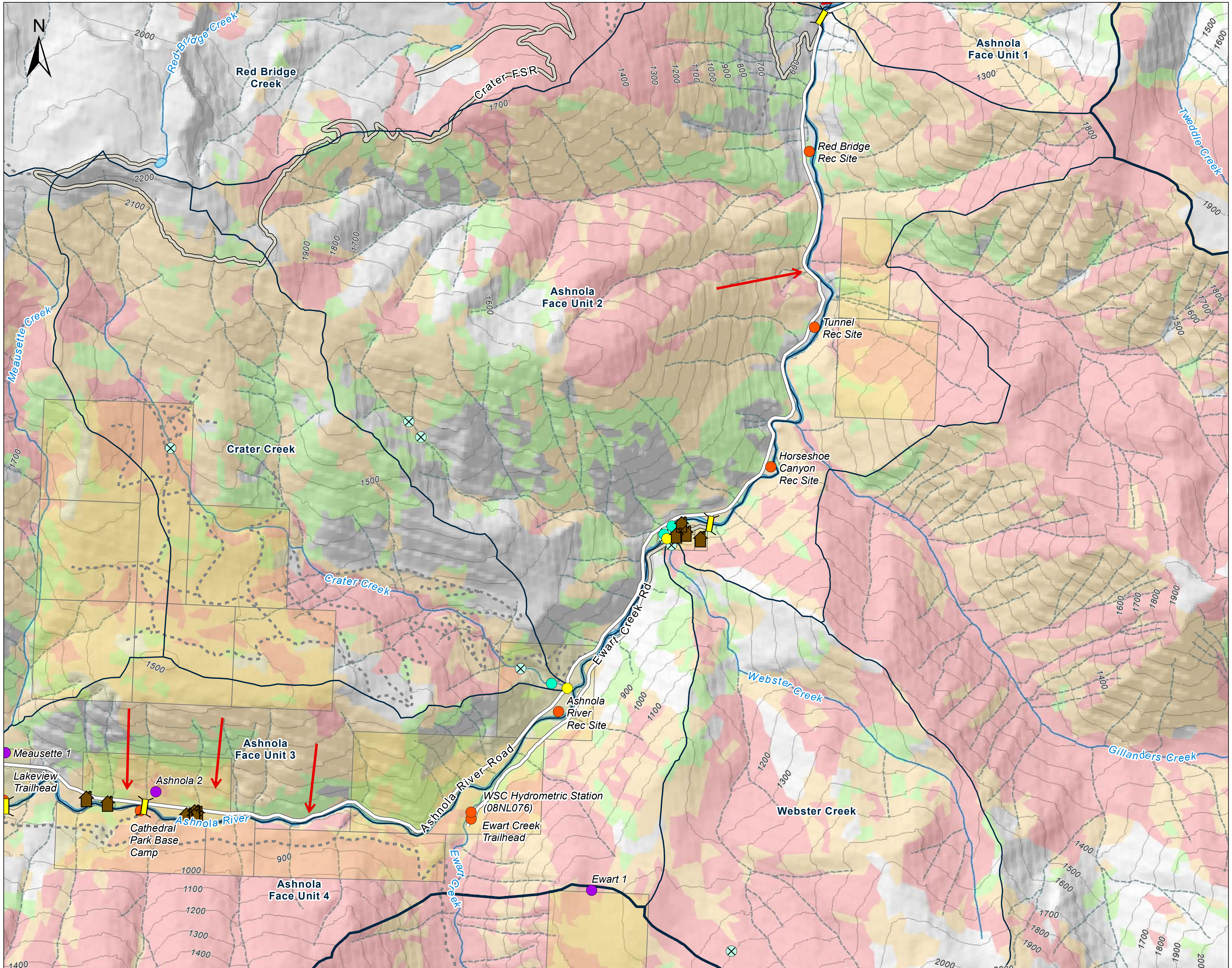

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LEGEND

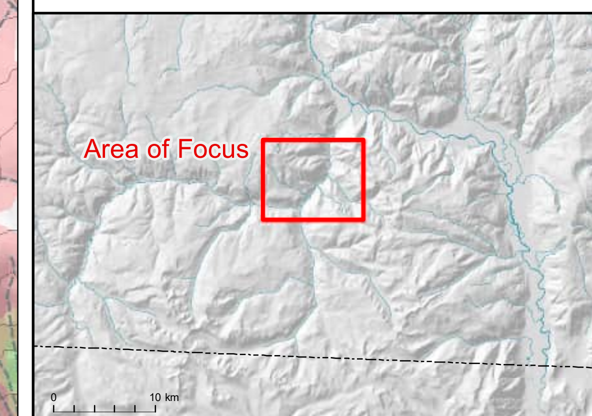
- Cadastral Fabric (Private Land)
- Catchment / Sub-basin
- Recent (post-2018 and post-2023) Post-Wildfire Hazard Events (Landslides, Debris Flows and Sediment-Laden Flooding)
- Structure
- Bridge
- Major Stream Crossing
- Point of Interest
- Soil Burn Test Pit
- Active Water Point of Diversion (POD) (Domestic)
- Active Water Point of Diversion (POD) (Other)

Vegetation Burn Severity (Source: BC Data Catalogue)

- High
- Medium
- Low

Roads (Source: Data BC Digital Roads Atlas)

- Highway / Road
- Resource Road / Trail
- Trail / Unclassified



400 200 0 400 800
metres

Client:
MINISTRY OF FORESTS - BC WILDFIRE SERVICE

Project:
POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS FOR THE 2023 CRATER CREEK WILDFIRE (K52125)

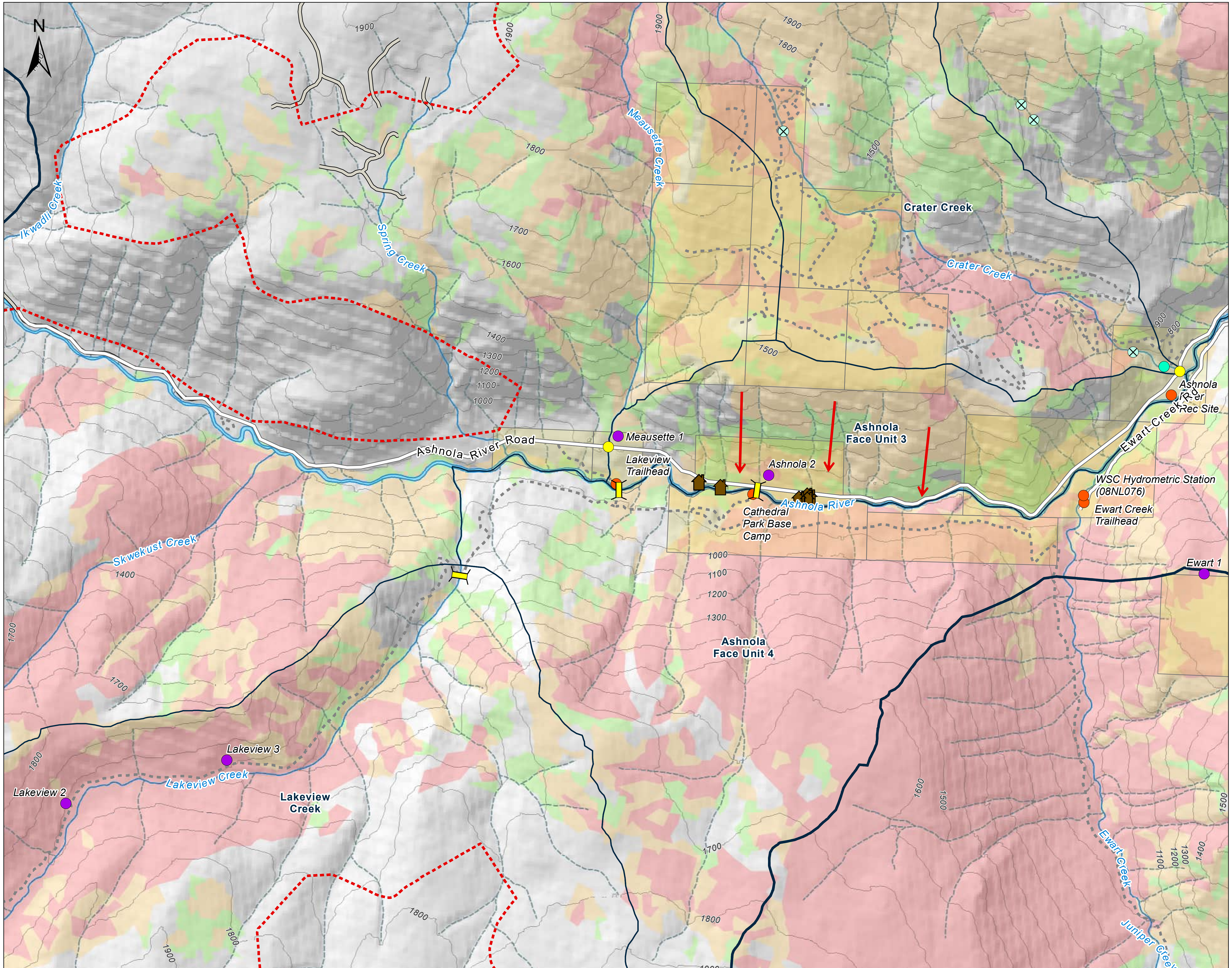
Title:
LOWER ASHNOLA RIVER

Scale: 1:30,000 NAD 1983 UTM Zone 11 U

Figure No. 006

Project No: 24-0103 Date: June 17, 2025

Clarke Geoscience Ltd.



LEGEND

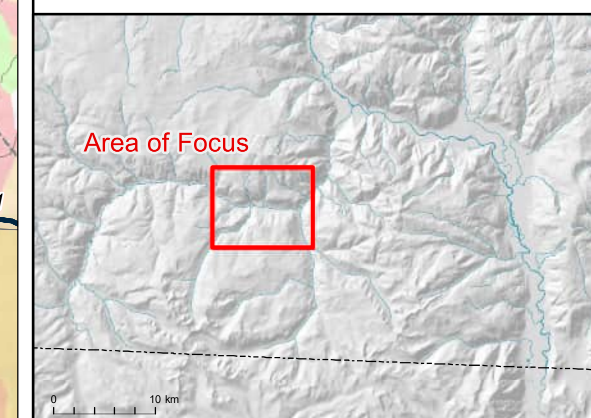
- Cadastral Fabric (Private Land)
- 2023 Crater Creek Wildfire (K52125)
- Catchment / Sub-basin
- Recent (post-2018 and post-2023) Post-Wildfire Hazard Events (Landslides, Debris Flows and Sediment-Laden Flooding)
- Structure
- Bridge
- Major Stream Crossing
- Point of Interest
- Soil Burn Test Pit
- Active Water Point of Diversion (POD) (Domestic)
- Active Water Point of Diversion (POD) (Other)

Vegetation Burn Severity (Source: BC Data Catalogue)

- High
- Medium
- Low

Roads (Source: Data BC Digital Roads Atlas)

- Highway / Road
- Resource Road / Trail
- Trail / Unclassified



400 200 0 400 800
metres

Client:
MINISTRY OF FORESTS - BC WILDFIRE SERVICE

Project:
POST-WILDFIRE NATURAL HAZARD RISK ANALYSIS FOR THE 2023 CRATER CREEK WILDFIRE (K52125)

Title:
MIDDLE ASHNOLA RIVER

Scale: 1:30,000	NAD 1983 UTM Zone 11 U	Figure No. 007
Project No: 24-0103	Date: June 17, 2025	

Clarke Geoscience Ltd.

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Appendix C Soil Burn Assessment Data

APPENIDX D: SOIL BURN SEVERITY ASSESSMENT DATA

Fire: **2023 Crater Creek Wildfire (K52125)** **Field Dates: July - Sept 2024**

Testpit ID	Elevation (m)	Up Slope (%)	Down Slope (%)	Aspect	Canopy Condition	% Cover Understory	% Green trees	% Brown trees	Vegetation Burn Severity (mapped & observed)	Litter	Duff	SWD
Red Bridge 1	815	70	60	SE	Mostly dead (needles remaining)	0	0	100	Low	Charred		Charred
Red Bridge 2	1105	12	11	SE	Dead (some twigs and cones)	5	0	30	High	Consumed	Consumed	Partly consumed
Red Bridge 3	1115	32	20	S	Mostly dead (needles remaining)	5	0	70	Moderate	Consumed	Consumed	Consumed
Red Bridge 4	1290	40	40	N	Mostly dead (needles remaining)	10	0	70	High	Consumed	Consumed	Consumed
Red Bridge 5	1326	20	28	SE	Mostly dead (needles remaining)	0	5	90	Low	Mostly consumed		Partly consumed
Meausette 1	950	22	15	SW	Mostly alive	5	60	30	Low	Charred		Partly consumed
Ashnola unburned 1	1150	28	15	S	Unburned	5	100	0				
Ashnola 2	836	30	28	S	Dead (trunk and branches only)	0	0	0	High	Consumed	Consumed	Consumed
Ewart 1	1300	22	3	N	Dead (trunk and branches only)	0	0	0	High	Consumed	Consumed	Consumed
Snehumption 1	2100	15	15	SE	Dead (some twigs and cones)	0	0	5	High	Consumed	Consumed	Consumed
Similkameen Face Unit 1	460	30	20	NE	Mostly dead (needles remaining)	5	20	80	Low	Charred	Spottily consumed	Charred
Lakeview 1	1920	35	45	SE	Dead (trunk and branches only)	0	0	0	High	Mostly consumed	Mostly consumed	Consumed
Lakeview 2	1600	35	38	NE	Dead (some twigs and cones)	0	0	0	High	Consumed	Consumed	Consumed
Lakeview 3	1530	33	55	SE	Dead (trunk and branches only)	0	0	0	High	Consumed	Spottily consumed	Consumed

APPENIDX D: SOIL BURN SEVERITY ASSESSMENT DATA

Testpit ID	LWD	Ash Color	Mineral Soil Exposure (%)	Change to Mineral Soil	Depth to Live Roots or Rhizomes	Soil Burn Severity	Size of Similar Area	Evidence of Runoff	Water Repellency	Trench Depth	Description
Red Bridge 1	Charred		>40	No	0-5cm	Low	>5ha	Rills	Weak 10 - 40s	3cm	cobbly gravelly fine to coarse SAND, minor silt
Red Bridge 2	Many consumed	Grey	>40	No	0-5cm	Moderate	>5ha	Needle deposits	Strong >40	3cm	
Red Bridge 3	Some consumed	Grey	>40	No	0-5cm	Moderate	1.5-2ha		Weak 10 - 40s	4cm	fine sandy SILT, trace clay
Red Bridge 4	Some consumed	Grey	5-40	No	0-5cm	Low	>5ha		Weak 10 - 40s	4cm	
Red Bridge 5	Charred		<5	No	0	Low	<0.5ha		Strong >40	2cm	fine sandy SILT, trace clay
Meausette 1	Many consumed	Black	<5	No	0	Moderate	<0.5ha		Strong >40	2-4cm	silty soils
Ashnola unburned 1					0		1.5-2ha		none <10s	4cm	
Ashnola 2	Many consumed		>40	No	0-5cm	High	2-5ha	Rills	Weak 10 - 40s	2cm	fine to coarse SAND, some gravels, some silt
Ewart 1	Many consumed	Grey	>40	No	>5cm	High	>5ha		None <10s	4cm	
Snehumption 1	Some consumed	Black	>40	No	0	Moderate	>5ha		Strong >40	3cm	gravelly silty SAND
Similkameen Face Unit 1	Some consumed		<5	No	0	Low	2-5ha		Weak 10 - 40s	2cm	
Lakeview 1	Many consumed		>40	no	>5cm	Moderate	>5ha		Strong >40	2 cm	
Lakeview 2	Many consumed	Grey	>40	No		High	2-5ha		Strong >40	2 cm	silty SAND
Lakeview 3	Many consumed		>40	No	>5cm	High	>5ha	Rills	Weak 10 - 40s	2cm	silty SAND

APPENIDX D: SOIL BURN SEVERITY ASSESSMENT DATA

Testpit ID	Notes
Red Bridge 1	Rills have a hard layer at the surface with loose soils underneath.
Red Bridge 2	More repellency at 4cm rather than 2cm. 2cm had weak water repellency.
Red Bridge 3	
Red Bridge 4	Veg regrowth. Ash soil is deep 150mm+
Red Bridge 5	
Meausette 1	Water repellency is highly variable weak to strong. Many medium to large roots burned below soil. Near burned roots its high, weak to none in other places.
Ashnola unburned 1	Unburned area for comparison. Site at base of talus slope.
Ashnola 2	
Ewart 1	
Snehumption 1	
Similkameen Face Unit 1	No to weak water repellency. Part of trench visibly beaded other parts drained in 12 sec.
Lakeview 1	Strong repellency for 25% trench length, otherwise weak
Lakeview 2	Strong repellency for 50% of trench length, veg regen obs
Lakeview 3	Erosion evidence of an intense localized rainstorm

Appendix D CGL General Conditions and Terms of Use

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Unless expressly agreed to in the Terms of Engagement agreement, CGL is not responsible for identifying, considering, or addressing environmental or regulatory issues associated with the project.

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Glossary of Technical Terms

Glossary of Technical Terms

(definitions obtained from Hope, et al. (2015), Wilford, et al. (2009), Pike, et al. (2010), DeBano (1981) , and Wise, et al. (2004))

Alluvial - Deposited by running water.

Alluvial Fan - A relatively flat to gently sloping landform composed of predominantly coarse-grained soils, shaped like an open fan or a segment of a cone, deposited by a stream where it flows from a narrow mountain valley onto a plain or broad valley, or wherever the stream gradient suddenly decreases.

Burn (or fire) severity - a general term that most commonly describes the combined effects of both flaming and smouldering. Burn severity, in broad terms and as applied in the British Columbia risk assessment procedure, refers to the effects of the fire on both the forest canopy and understory (vegetation burn severity) and on the forest floor and soil (soil burn severity). It provides vital information for soil erosion, hydrologic, and landslide assessment.

Catchment - A geographic area drained by a single major stream; consists of a drainage system comprised of streams and often natural or man-made lakes. See *Drainage Basin* or *Watershed.*

Colluvium - Loose, weathered material brought to the foot of a cliff or some other slope by gravity.

Consequence - the effect on human well-being, property, the environment, or other things of value; or a combination of these. Conceptually, the consequence is the change, loss, or damage to the elements at risk caused by the landslide.

Debris - An accumulation of unsorted fragments of soil, rock, and sometimes large organic material (e.g., tree limbs). Also used to describe organic material transported within streams.

Debris Flood – A type of flood process described as a hybrid between a flood and a debris flow. The event involves the transport of large volumes of sediment and woody debris down gully/stream systems by large volumes of water. Debris floods do not behave as coherent flows as the main constituent is water. Debris floods have sediment concentrations of 20–47% by volume and characteristically have significant sediment deposits beyond the channel.

Debris Flow – A type of fast-moving landslide that moves along a steep channel or gully. It is particularly dangerous to life and property because they move quickly, are capable of transporting bouldery debris, and often occur without advance warning.

Debris Flow Fan - A relatively steep sloping landform shaped like an open fan or a segment of a cone, deposited by a debris flow where it exits from a narrow mountain valley onto a plain or broad valley, or wherever the channel gradient suddenly decreases. Sometimes referred to as colluvial fan.

Debris Slide or Slump – A type of landslide described as displacement of soil or rock as an unbroken mass, or in a broken-up mass of material.

Debris Torrent - A term no longer used in British Columbia. See D*ebris Flow*.

Drainage Basin - Total land area draining to any point in a stream, as measured on a map, aerial photo, or other horizontal, two-dimensional projection. See *Catchment* or *Watershed*.

Elements at Risk – Features of social, environmental, and economic value (or simply elements) are humans, property, the environment, and other things of value, or some combination of these that are put at risk (adapted from CSA 1997).

Ephemeral Stream - A stream, whose channel is always above the water table, which flows briefly in direct response to precipitation, receiving no continued supply of water from snowmelt or springs. Also referred to as an intermittent stream.

Flood – Overland flow of water beyond its normal confines, over what is normally dry land. The most common type of flood in British Columbia is generated by rainfall and/or snow melt.

Geomorphic (Geomorphology) – Relating to the form of landscape or the processes occurring on the earth surface. Part of a discipline of science that aims to interpret landforms based on their origin and development.

Glaciofluvial - The processes, sediments, and landforms associated with glacial meltwater streams.

Glaciolacustrine - Pertaining to, or characterized by, glacial and lacustrine processes or conditions applied especially to deposits made in lakes.

Groundwater – Water that occurs below the ground surface within rock fractures and soil pore spaces.

Gully - A landform characterized as a steep-sided valley (or ravine) cut by concentrated runoff, mass movement, or a combination of both, occurring along a hillside composed of erodible sediments. A smaller-scale gully that is less incised (shallow) and often less-steep is referred to as a topographic swale.

Hazard - A source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to property, the environment, and other things of value; or some combination of these (CSA 1997). With respect to landslide risk management, the landslide is the source of potential harm—it is the hazard. A future landslide that has no harmful potential is not a hazard but is simply a natural geological or geomorphological process or feature.

Hydro-geomorphic processes – a technical word comprised of the combination of "hydrologic" and "geomorphic" to represent a range of both processes occurring in a watershed.

Hydrologic (Hydrology) – Relating to water and the effects of water on the land. The science that describes and analyzes water, its properties, its circulation, and its distribution over the Earth's surface in natural and disturbed environments.

IDF Curve (Rainfall Intensity–Duration Frequency) Curve - A curve showing the relationship between rainfall depth (or intensity) and storm duration for a given station for different return periods.

Landslide – a general term for the movement of a mass of rock, debris, or earth down a slope. Landslide types include debris flows, debris slides or slumps, and rockfall.

Likelihood - is used to provide a qualitative estimate of probability, referred to as a probability rating. Likelihood estimates are typically expressed using relative qualitative terms, such as *very low* to *very high* or *very unlikely* to *almost certain*.

Peak Flow – The greatest stream discharge recorded over a specified period of time, usually a year but often a season, or even a single event (as in storm peak flows).

Perennial Stream - Stream that flows all year round, regardless of weather conditions.

Probability of landslide occurrence is an estimate of the chance for a landslide to occur. An estimate of probability is expressed quantitatively, using a number between 0 (a landslide will not occur) and 1 (a landslide will certainly occur).

Rain-on-Snow Event - Rainstorms that result in large stream flows due to the combined effects of heavy rainfall and snowmelt runoff.

Return Period - The time to the recurrence of an event, from statistical analysis of data, based on the assumption that observations are equally spaced in time. A return period of 100 years means that, on average, an event of this magnitude or greater is not expected to occur more often than once in 100 years. It is calculated as the inverse of the probability of occurrence ($R = 1/p$).

Risk Analysis - The systematic use of information to identify hazards and estimate the probability and/or severity of injury or loss to people, property, the environment, or other things of value (CSA, 1997; Wise et al. 2004). A post-wildfire risk analysis usually describes, implicitly or explicitly, the change in hazard or risk due to the wildfire (the incremental hazard or risk), although the background or pre-existing risk is noted.

Risk - The chance of injury or loss as defined as a measure of the probability and the consequence of an adverse effect to health, property, the environment, or other things of value (adapted from CSA 1997).

Rock Fall - The relatively free falling or precipitous movement of a newly detached segment of bedrock of any size from a cliff or other steep slope; it is the fastest form of mass movement and is most frequent in mountain areas and during spring when there is repeated freezing and thawing of water in cracks in the rock.

Sediment-Laden Flow – A post-wildfire hydrologic response that occurs when surface water runoff becomes laden with sediment, made more available when protective organics are consumed. Rates of post-wildfire surface runoff may also be accelerated due to the loss of organics and the presence of water repellency, which limits infiltration into the ground

Soil burn severity - A relative measure that describes the effect of a fire on ground surface characteristics and soil conditions that affect soil hydrologic function.

Stakeholders - Any individual, group, or organization able to affect, be affected by, or believe they might be affected by, a decision or activity. Note that decision-makers are stakeholders (CSA 1997).

Surficial Geology - Geology of surficial deposits, including soils; the term is sometimes applied to the study of bedrock at or near the Earth's surface.

Terrain - A region of the Earth's surface considered as a physical feature, which can be described by relief, roughness, and surface material.

Terrain Stability - Slope stability from a regional perspective as opposed to the study of the stability of an individual slope.

Vegetation burn severity - is a relative measure that describes the effect of a fire on vegetative ecosystem properties.

Watershed - Also referred to as a drainage basin or catchment area. Watersheds are the natural landscape units from which hierarchical drainage networks are formed. Watershed boundaries typically are the height of land dividing two areas that are drained by different river systems.

Water Repellency – Soil-water repellency occurs at, or just below, the soil surface and is caused when intense heat from wildfire burns plant material that releases waxy substances that coat soil particles. It is a characteristic that develops more strongly on areas burned at moderate to high vegetation burn severity.

Watershed Assessment - A process for evaluating the cumulative impacts, over time and space, of all land use activities within a given watershed on variables such as stream flows, sediment regime, riparian health, and landscape and stream channel stability. The process can also be used to assess the potential impacts of proposed future land use activities.

Watershed Morphometrics – these are topographic measurements, completed by GIS analysis, of a watershed that are used to provide a first approximation of the dominant hydro-geomorphic processes.

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