MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS,

POST-WILDFIRE RISK ANALYSIS – PRELIMINARY REPORT

NOTE: The results given on this form are preliminary in nature and are intended to be a warning of potential hazards and risks. It is not a final risk analysis and further work may alter the conclusions. Please contact the author for more information.

FIRE: N71691 Morley Creek	**FIRE YEAR: 2017**	**DATE OF REPORT:** 28 August 2017

AUTHOR: Sarah Crookshanks

REPORT PREPARED FOR: Selkirk Resource District (Kootenay Lake FD), and Southeast Fire Centre

FIRE SIZE, LOCATION, AND LAND STATUS: 76 ha. Fire is located on the face between Sitkum and Kokanee Creeks, 16 km NE of Nelson. Crown land.

VALUES AT RISK: Houses on Morley Creek fan; water intakes on Morley Creek (35 water licences); Highway 3A

WATERSHEDS AFFECTED:	**TOTAL AREA**	**AREA BURNED**	**BURN SEVERITY (% of burned area)**
Morley Creek	108 ha	46 ha (43%)	38% H, 62% M
Morley-Sitkum Face	110 ha	8.9 ha (8%)	Moderate
Morley-Kokanee Face	252 ha	6.1 ha (2%)	33% H, 67% M
Kokanee Creek	9500 ha	14.5 ha (<1%)	35% H, 65% M
Sitkum Creek tributary (Bourke Creek)	132 ha	0.4 ha (<1%)	Moderate

**Note: All burn severity calculations are approximate until better data is available

SUMMARY OF HAZARDS AND RISKS:	HAZARD [1]	RISK [2]
Hazards: The most significant hazards are debris flows and water quality impacts in Morley Creek.		
Risks:		
1. Risk of a debris flow impacting houses on Morley Creek fan – there is a low likelihood that it would reach the houses on the fan since the channel is incised.	M	L
2. Risk of damage to water intakes on Morley Creek from a debris flow or flood	M	H
3. Risk of water quality impacts to domestic water users on Morley Creek	H	H
4. Risk of an avulsion causing flooding of Highway 3A and surrounding properties	L	M

1. Hazard = P(H), the probability of occurrence of a hazardous event
2. Risk = Partial risk P(HA) = P(H) × the probability of it reaching or affecting an element at risk

FURTHER ACTIONS:
Residents on the Morley Creek fan and water users of Morley Creek should be advised of the risks from potential debris flows and floods.

POTENTIAL MITIGATION:
1. Mulch treatments of high burn severity areas in Morley Creek watershed might reduce the hazard of debris flows from high-intensity rainstorms, but would not be effective at reducing hazard during spring snowmelt.
2. There is a possibility that a debris flow will occur and cause an avulsion at a dirt access road near the apex of the fan [49.60712, -117.16373] on Lot 8214. This could be prevented by building a small berm at this location to prevent the creek from being diverted down this road.
3. Water quality impacts could be mitigated by improving filtration on water systems.

COMMENTS:
- Debris flows have occurred historically in Morley Creek. Deposits were observed along the fan area; however, these deposits appear to be many hundreds of years old.
- Due to the high burn severity, strong water repellency and exposed mineral soil in the headwaters of Morley Creek, the debris flow hazard in the channel has been elevated.
- A BCWS employee documented a debris flood in the channel of the western headwater channel of Morley Creek that was likely initiated following a rainstorm on August 13. If a more significant rainstorm were to occur this fall, a bigger debris flood or flow is likely.
- There is a high likelihood of ongoing periodic water quality effects due to the large area of exposed mineral soil in the headwaters of Morley Creek and the high connectivity between the burn area and the headwater channels.

SIGNATURE:	**ATTACHMENTS:**
Sarah Crookshanks, P.Geo.	See attached memo, map and photos. An update to this report will be provided when more accurate burn severity and rainfall data are available.

Post-Wildfire Natural Hazards Risk Analysis, Fire N71691, Morley Creek

Sarah Crookshanks, MFLNRO, 28 August 2017

Introduction and methods

This memo provides additional information that is intended to supplement the initial preliminary report summary form (attached).

The Morley Creek fire burned 75.9 ha of land on the face between Sitkum and Kokanee Creeks. The fire was initiated by lightning and was discovered on August 12. Most of the burned area fell within the Morley Creek drainage. At the request of the Southeast Fire Centre, a natural hazards risk analysis of the fire was completed following the procedures outlined in Land Management Handbook 69 (Hope et al., 2015). Since most of the burned area is concentrated within the Morley Creek watershed, this analysis will focus on the hazards within that watershed. The burned areas outside the Morley Creek are neither large nor severe enough to warrant further discussion at this time.

On August 22 an initial assessment of the fire was completed by Sarah Crookshanks (MFLNRO) and Peter Jordan (SNT Geotechnical Ltd.). This involved a flight over the fire area, followed by a traverse across the burn on foot. On August 24 the Morley Creek fan was inspected from above its apex down to the highway.

Burned area observations

Figure 1 is a map of the Morley Creek watershed and of the fire showing the burn severity mapped from photographs taken from a helicopter (e.g. Figure 2) and ground data. The fire occupies 43% of the watershed area. Of the burned area, 38% is high burn severity. ***The burn severity areas are very approximate and subject to review once satellite imagery is obtained***. The burn area is located in the headwater area of the watershed. The gullies that form the headwaters of Morley Creek steepen downslope away from the fire. The table below summarizes some of the watershed statistics for Morley Creek.

Watershed area	108 ha
Elevation range	580 m to 1800 m
Relief ratio*	1.2
Burn area [% of watershed]	46 ha [43%]
High	17.5 ha [16%]
Moderate	28.5 ha [26%]

*The Melton relief ratio is the elevation range divided by the square root of area. A relief ratio over 0.6 can indicate a watershed is susceptible to debris flows.

Ground observations of the burn severity showed high soil burn severity at most plots. All duff and organic matter were consumed in high burn severity zones, leaving grey ash and mineral soil exposed (Figure 3). Remnants of charred large woody debris were scattered throughout the burn area. Strongly water repellent soils were widespread and consistent, even where moderate vegetation burn severity was observed. Compared with other fires that have caused post-wildfire debris flows (e.g. the 2007 Springer fire), soil burn severity in this fire is somewhat higher.

Widespread rilling was observed on steep slopes throughout the burned area (Figure 4). It is assumed that they were produced during a rainfall event that occurred on August 13. A fire weather station installed at Harrop recorded a total of 21.6 mm that day with a max intensity of >14 mm in one hour.

Debris flow and flood hazards

Debris flows and floods following wildfires can occur in summer as a result of high-intensity rainfall on water-repellent soils (for example, the 2004 Kuskonook Creek debris flow which followed the 2003 fire). This hazard is greatest in the one to two years after the fire. Debris flows and floods can also occur during spring runoff as a result of rapid snowmelt in burned areas (for example, the debris flows in Middle Van Tuyl, South Van Tuyl, and Memphis Creeks which occurred in 2008, 2009, and 2010, following the 2007 Springer fire). This hazard is due to increased snow accumulation, more rapid snowmelt, and higher groundwater levels in burned areas, and can persist for many years until revegetation occurs.

Morley Creek appears to be susceptible to debris flows given the evidence of debris flow deposits and the morphology of the watershed. The channel slope from the headwaters to immediately upstream of the fan averages 45% with no distinct breaks in slope. This gradient is able to effectively transport debris flows. The nature of the deposits suggest that the most recent debris flow to have reached the lower channel or fan was many hundreds of years ago.

The current wildfire has increased the debris flow hazard in the Morley Creek watershed. The high burn severity area is centered in the steep gully headwall area of Morley Creek. The soils here are mostly strongly water repellent, and little to none of the forest floor organic layer remains. Therefore, there is a high hazard of booth flood and debris flow initiation as a result of a high-intensity, short-duration rainfall. A debris flow in response to rapid spring snowmelt is also possible given the lack of canopy in the upper watershed.

A BC Wildfire Service fire fighter documented a small debris flood event that occurred after a rainfall event that occurred on August 13 (Figure 5). A weather station installed at Harrop recorded a total of 21.6 mm that day with a max intensity of >14 mm per hour. Therefore, if a rainfall event with a similar or higher intensity (and/or duration) occurs within the next few years before vegetation has a chance to re-establish, then a similar or larger debris flood or flow event may be expected to occur.

Debris flow and flood risks on the Morley Creek fan

In simplest terms, *risk* is the product of *hazard* and *consequence*. For the purpose of post wildfire risk analyses, only *partial risk* is considered; this is the probability that a hazardous event (e.g. a debris flow) will occur and that it will reach or affect the site of the element at risk (e.g. a house or water intake). Other components of risk, such as spatial and temporal probability, and value or vulnerability of the elements at risk, are not considered. Subjective terms (low, moderate, high) are used to describe hazard and risk, based on generally accepted definitions used in British Columbia in other risk analysis studies and mapping projects. A simple qualitative risk matrix is used after Wise et al. (2004).

The field review of the Morley Creek lower channel and fan was undertaken on August 24. The upper fan slope angle is approximately 14%, which is typical of debris flow fans in the region, although the slope of the fan below the highway is closer to 11%. The channel is quite incised (2-5 m in height) until it reaches a private driveway approximately 40 m upslope from the highway. This incision will help confine any debris flows and floods to the channel area and minimize the likelihood of an avulsion.

Upstream of the fan apex and any elements at risk, there is a channel reach of approximately 180 m in length that is fairly flat (11% slope). This section of channel may serve as an area of deposition for any small debris flow that may occur, however a large debris flow could travel further. The channel then steepens to approximately 15% for approximately 130 m, before flattening out again below the highway. It appears likely that any debris flow would deposit most or all of its debris on the upper fan, and carry only flood deposits to the highway. The culvert under the private driveway and the highway ditch may be blocked by debris or sediment during a flood or debris flow event.

In the case of a large event, two points of possible avulsion were identified. One is at a dirt access road near the apex of the fan [49.60712, -117.16373] on Lot 8214. If a debris plug 1-2 m deep was deposited here, the water may be diverted down this road and cause damage downslope. This could be prevented by building a small berm at this location to prevent the creek from being diverted down this road.
The other possible point of avulsion is just upstream from the private driveway [49.606, -117.1627]. At this site, the creek has the potential to be diverted down towards the west and then along the driveway to the highway.

Water intakes and water quality

Water licence data show 35 water licences on Morley Creek, of which 31 are for domestic use. Anecdotal information from a water user suggests not all licensees are regularly using this water.

After the rainfall event of August 13, several water users reported fine black sediment that plugged up their intakes and caused water quality issues (Figure 6). This sediment appears to be composed of primarily organics (char/soot from the fire) with some fine particulate matter. This type of sediment has been observed in other watersheds in the West Kootenays following wildfires. This black sediment has been deposited throughout the lower channel of Morley Creek and will likely be remobilized during future high flow events.

There is also a high likelihood of ongoing periodic water quality (turbidity) effects due to the large area of exposed mineral soil in the headwaters of Morley Creek and the high connectivity between the burn area and the headwater channels. Past experience from fires in the West Kootenays indicates that these effects are usually minor in nature and of short duration. Water quality impacts could be improved by installing filtration on water systems.

Following wildfires, levels of nitrate and phosphate can be slightly elevated for several years, but have rarely been found to exceed water quality guidelines. Nitrate, ammonium, and phosphate can also be introduced from fire retardant, but these effects are of short duration, and have rarely been found to exceed water quality guidelines. These substances occur naturally in soil and water, and can increase in concentration due to vegetation and soil changes following wildfire.

Conclusions

1. Residents of the Morley Creek fan should be informed of the debris flow and flood risk that exists on the fan.

2. Residents should be alert to changes in streamflow or sediment in the creek. If extremely high levels of turbidity, or large quantities of ash or charred material, are observed in the creek during heavy rains or snowmelt, this could indicate that a debris flow may occur. Unusual stream behaviour, such as surging or pulsing flow, or a sudden drop in streamflow, could indicate that a debris flow is imminent.

3. Mulch treatments of high burn severity areas in Morley Creek watershed might reduce the hazard of debris flows from high-intensity rainstorms, but would not be effective at reducing hazard during spring snowmelt.

References

Wise, M.P., Moore, G.D., and VanDine, D.F. (eds.) 2004. Landslide Risk Case Studies in Forest Development Planning and Operations. BC Ministry of Forests, Land Management Handbook 56.

Hope, G., Jordan, P., Winkler, R., Giles, T., Curran, M., Soneff, K., and Chapman, B. 2015. Post-wildfire natural hazards risk analysis in British Columbia. BC Ministry of Forests, Land Management Handbook 69.

(Original Signed and Sealed by:)

Sarah Crookshanks, MFLNRO

Reviewed by:

Peter Jordan, SNT Geotechnical Ltd.

Figure 1. Map of fire, showing preliminary burn severity (on next page). Scale 1:15,000. Burn severity polygons were drawn manually from photos taken from the air on 22 August 2017. A more accurate burn severity map will be prepared from satellite imagery when this is available.

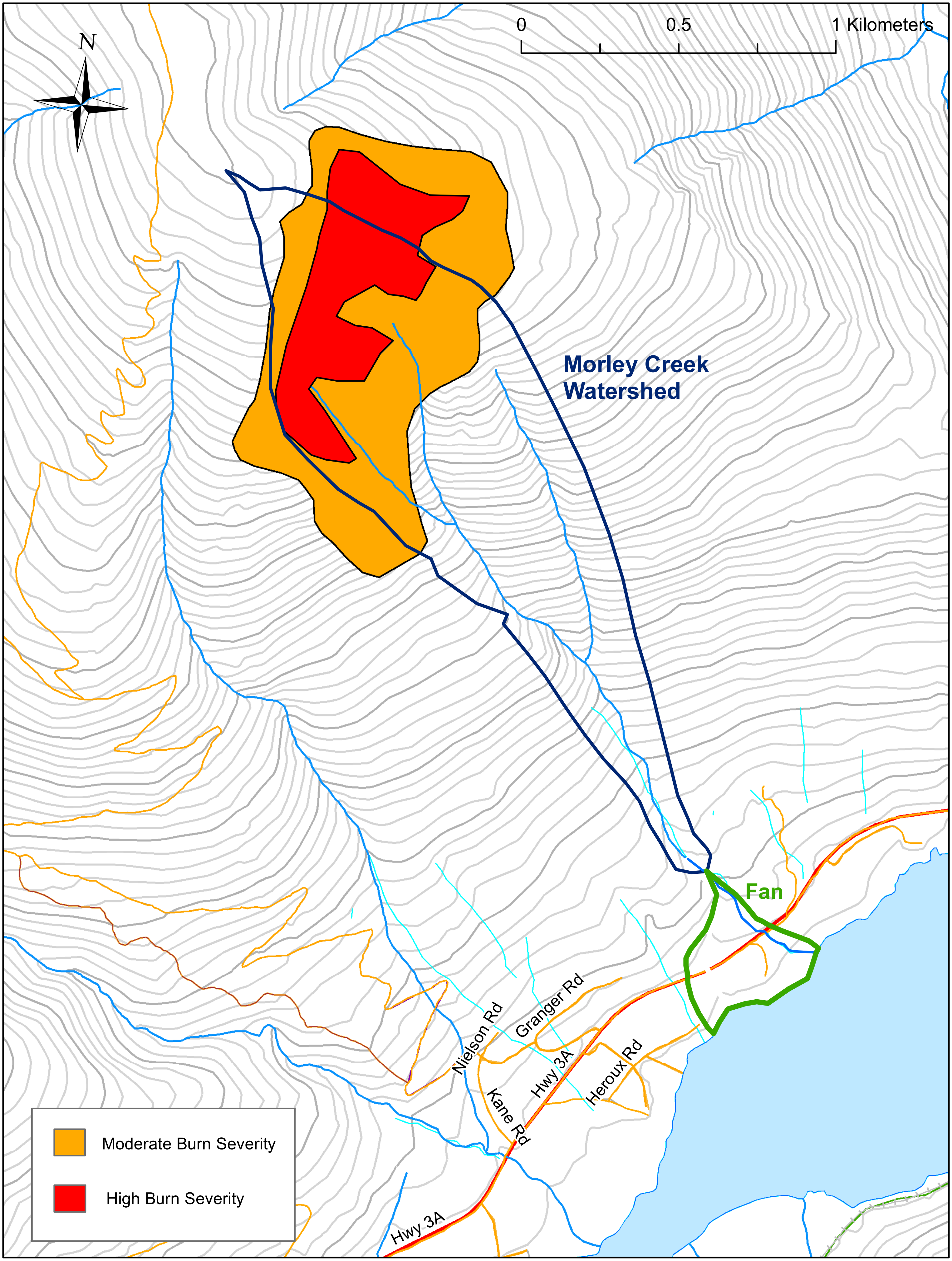
N
0
0.5
1 Kilometers
Morley Creek
Watershed
Fan
Granger Rd
Nielson Rd
Hwy 3A
Heroux Rd
Kane Rd
Hwy 3A
Moderate Burn Severity
High Burn Severity

Figure 2. Overview of fire N71691. Photo taken on August 22, 2017.

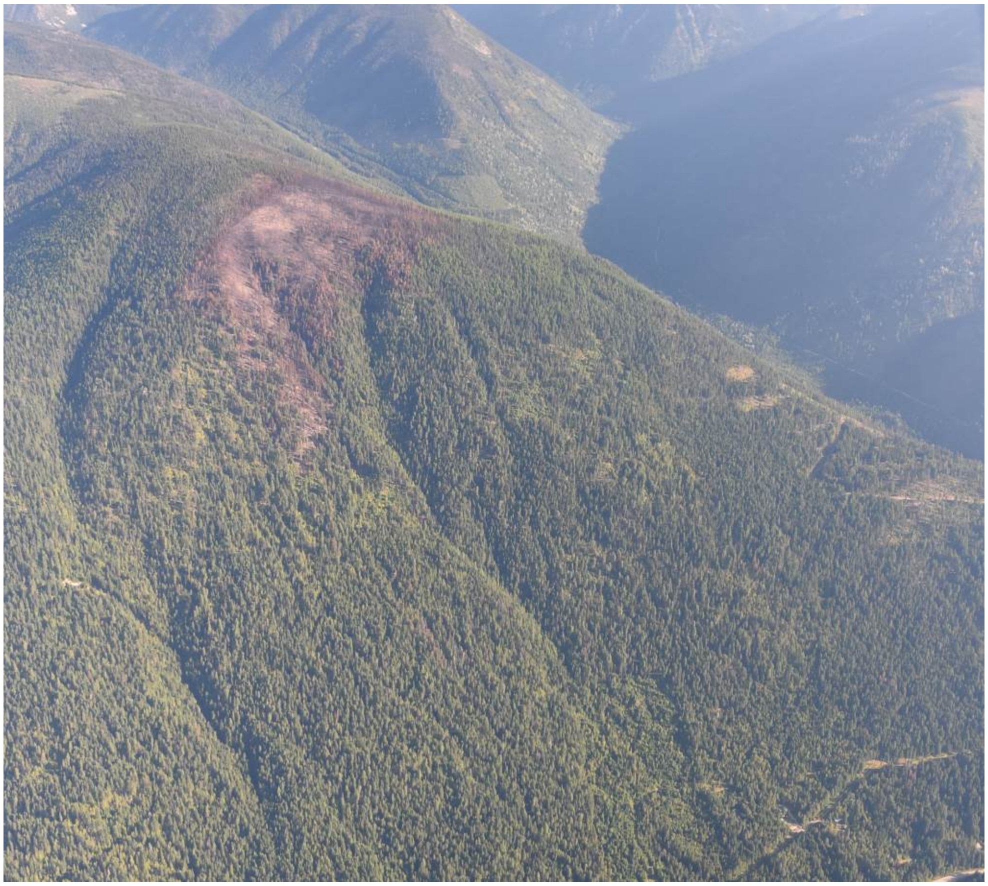

Figure 3. Aerial view of high burn severity area. Photo taken on August 22, 2017.

Figure 4. Widespread rilling was observed in the burn area.

Figure 5. A view of the western Morley Creek headwater channel after a debris flood event that likely occurred following a rainstorm on August 13 (photo by Nick Davis).

Figure 6. Black sediment deposited in the lower reaches of Morley Creek after the August 13 rainstorm.