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: N71382 Harrop Creek	**FIRE YEAR: 2017**	**DATE OF REPORT:** 2 Oct 2017

AUTHOR: Sarah Crookshanks

REPORT PREPARED FOR: Selkirk Resource District and Southeast Fire Centre

FIRE SIZE, LOCATION, AND LAND STATUS: 3117 ha. Fire is located in the headwaters of Harrop, Narrows and Midge Creeks, 18 km NE from Nelson. Crown land.

VALUES AT RISK: Houses on Harrop and Narrow Creek fans; water intakes on Harrop Creek (50 water licences) and Narrows Creek (50 water licences); Harrop-Procter Rd

WATERSHEDS AFFECTED:	TOTAL AREA	AREA BURNED	BURN SEVERITY (% of burned area)
Harrop Creek	4240 ha	1172 ha (28%)	26% H, 48% M, 26%L
Midge Creek	26370 ha	868 ha (3%)	40% H, 47% M, 13% L
Narrows Creek	2210 ha	232 ha (10%)	18% H, 44% M, 38% L
Slater Creek Face	1780 ha	35 ha (2%)	9% H, 43% M, 49% L

SUMMARY OF HAZARDS AND RISKS:

<u>Hazards</u>: The most significant hazards are potential water quality impacts on Narrows and Harrop Creek as well as possible flood impacts to Harrop Creek.

<u>Risks</u>:

	HAZARD [1]	RISK [2]
1. A debris flow impacting houses on Harrop Creek fan	L	L
2. Damage to water intakes on Harrop Creek from a debris flow or flood	L	M
3. Water quality impacts to domestic water users on Harrop Creek	M	H
4. Flooding impacting houses/infrastructure on the Harrop Creek fan	L	M
5. Debris flow impacting houses on Narrows Creek fan	L	L
6. Damage to water intakes on Narrows Creek from a debris flow or flood	L	M
7. Water quality impacts to domestic water users on Narrows Creek	L	M
8. Flooding impacting houses/infrastructure on the Narrows Creek fan	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:
Water users on Harrop and Narrows Creek and residents on the fans should be advised of the potential water quality impacts and flooding risk.

POTENTIAL MITIGATION:
No potential mitigation recommended.

COMMENTS:

- There is a moderate likelihood of ongoing periodic water quality (turbidity) impacts to water users on Harrop Creek due to the erosion of exposed mineral soil in burned areas, erosion of sediment from the fire guards, and debris flows from higher up in the watershed.
- Snowmelt-dominated peak flow events in Harrop Creek may be elevated due to the fire.

SIGNATURE:	**ATTACHMENTS:**
Sarah Crookshanks, P.Geo.	See attached memo, map and photos.

Post-Wildfire Natural Hazards Risk Analysis, Fire N71382, Harrop Creek

Sarah Crookshanks, MFLNRO, 2 October 2017

Introduction and methods

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

The Harrop Creek fire burned approximately 3117 ha of land in the headwaters of Harrop Creek, Midge Creek and Narrows Creek. The fire was initiated by lightning and was discovered on July 27, 2017. 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).

On September 21, 2017 an initial assessment of the fire was completed by Sarah Crookshanks (MFLNRO) and Peter Jordan (SNT Geotechnical Ltd.) accompanied by Erik Leslie (Harrop Community Forest). This involved a traverse across the burned area from the end of the East Harrop road to Mill Lake on foot and an inspection of the fan apex. An overview flight was undertaken by Sarah Crookshanks on September 27, 2017.

Burned area observations

Figure 1 is a map of the fire area spanning the Harrop Creek, Narrows Creek and Midge Creek watersheds. This map also shows the Burned Area Reflectance Classification (BARC) map produced by comparing Landsat-8 imagery from before and after the fire. The BARC post-fire imagery dates from September 2, 2017. This was the latest imagery available at the time of writing this report, and while the fire continued to be active for several more weeks, the effects on the BARC map are likely quite minimal given the fire characteristics (Will Burt, MFLNRO, personal communication). The field sampling and observations of burn severity along the Mill Lake trail and from the air indicate that the BARC map appears to be a fairly accurate representation of burn severity and no calibration was needed.

The fire occupies 28% of the Harrop Creek watershed area, 10% of the Narrows Creek watershed and only 2 to 3% of the Slater and Midge Creek watersheds. Given the location of the elements at risk (on Harrop and Narrows Creek fans) and percent of burned area in each watershed, this analysis will focus on primarily the Harrop Creek watershed, with some consideration of the Narrows Creek watershed as well.

The table below summarizes some watershed statistics for Harrop and Narrows Creeks.

	Harrop Creek	Narrows Creek
Watershed area	4240 ha	2210 ha
Elevation range	640 m to 2320 m	650 m to 2340 m
Relief ratio*	0.25	0.36
Burn area [% of watershed]	1172 ha [28%]	232 ha [10%]
High	304 ha [7%]	41 ha [2%]
Moderate	560 ha [13%]	102 ha [5%]

*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.

The BARC mapping in Figure 1 and aerial photos of the fire (Figure 2 through 6) indicate that the vegetation burn severity is quite patchy throughout the fire area. The riparian zones along the bottom of the valleys were generally left unburnt or have low burn severity. Five burn severity plots were completed along the Mill Lake trail on September 21. The soil burn severity was generally equivalent to the vegetation burn severity. Water repellency was observed at most plots, but it was quite patchy with areas of no repellency observed at each plot.

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.

The majority of the Harrop watershed is underlain by the granitic rocks of the Nelson Batholith. Moving towards the west into Narrows Creek, the bedrock geology transitions to the metasedimentary rocks of the Slocan, Kaslo and Lardeau Groups as well as the Milford Formation. These metasedimentary rocks may be more prone to erosion and landslides than the granitic rocks in the Harrop watershed. The ablation till that overlays the bedrock in the area tends to be sandy with low proportion of coarse fragment and tends to be susceptible to gully erosion (Carver, 2006).

Several residents were interviewed as part of the watershed assessment of Harrop Creek (Carver, 2006) and recollected several big floods, most notably 1948, 1972 and 1974. The three bridges across Harrop Creek were apparently washed out in the seventies floods and a major deposit was established in Kootenay Lake at the mouth of the creek. No avulsion of the creek channel on the fan was reported during these events. A flood event was reported in June 1974 on Narrows Creek as well (NHC, 1990).

Harrop Creek has been monitored seasonally (for some or all of April through September) by the Water Survey of Canada (WSC) for 25 years over the period of 1922-1994. The creek typically peaks end of May or early June. The maximum daily discharge recorded during this period was 10.9 m^3/s on 15 June 1974. The next highest maximum daily value recorded was 5.8 m^3/s in 1986. Narrows Creek was also gauged seasonally by the WSC for 12 years from 1921-1950. The maximum daily discharge recorded was 7.16 m^3/s on June 19, 1950.

Post-fire changes in streamflow volume and timing are generally greater the more extensive the burn and the higher the soil and vegetation burn severity. In Harrop Creek, the burned area is quite patchy in terms of both vegetation and soil severity, which minimizes the connectivity of flow paths between areas of bare ground and/or water repellent soils. Even in the high burn severity area around Mill Lake, the water repellency was not particularly strong or spatially uniform. Therefore, in Harrop Creek the burned area may have only a minimal impact on the storm flow response to intense rainfall events.

In terms of the spring freshet response, changes to the vegetation canopy have the most significant impact on the hydrological response. Twenty percent of the Harrop Creek watershed has high or moderate vegetation burn severity. Of the watershed area above the H60 elevation (1600 m), approximately 40% is burned and 30% is of high or moderate burn severity. The H60 elevation refers to the snowline elevation when the upper 60% of the basin area is still covered with snow. Vegetation removal in the area above the H60 elevation is generally understood to have a greater influence on peak flows due to changes in snow accumulation and snowmelt processes. Given the spatial distribution of the burned area (i.e. concentrated in the higher elevation area of the watershed), it is possible that the snowmelt-dominated peak flow events in Harrop Creek may be somewhat elevated due to the wildfire.

The watershed assessment of Harrop Creek (Carver, 2006) identifies several debris flow paths within the watershed based on terrain mapping undertaken in the nineties (Wallace et al. 1998). The debris flow paths are along the steeper tributaries to the main channel. Given that the average channel gradient of Harrop Creek below the central confluence of the east and west forks ranges from 6.6% to 10.1%, it is unlikely that any debris flow initiating within the steeper tributaries would be transported to the lower channel reaches and onto the fan. Channel gradients under 10% are generally not considered steep enough to transport debris flows.

The fire has increased the debris flow hazard particularly in the Headwaters 1 sub-basin of Harrop Creek (see Figure 1 for location and photo in Figure 5). The burn severity on the upper slopes of this drainage is not uniform, but patches of moderate to high burn severity are located in the headwaters of what appear to be several debris-flow prone channels. Aerial photos from a helicopter and the high-resolution satellite imagery confirm that there are patches of high burn severity and high connectivity to the channel. The LiDAR hillshade imagery for this area reveals several features that provide evidence for historical slope instability within this drainage. A debris flow event in this sub-basin would most likely have water quality impacts downstream, but is unlikely to continue to be transported to the fan given the channel gradients (as discussed in the previous paragraph).

The post-fire debris flow hazard in Harrop Creek is mitigated by not only the low main channel gradient below the confluence of the East and West forks, but also the u-shape of the valley and the patchiness of the burn severity, which reduce the slope-channel connectivity. Therefore, the overall post-fire debris flow hazard for the Harrop Creek watershed as a whole is estimated to be low.

In Narrows Creek, the average channel gradient is 15%. Because of the low proportion of the watershed that was burned, there is a low likelihood of any hydrological effects due to the fire. Some of the steep tributaries on the west side of the creek have moderate to high burn severities, and as a result may have an increased likelihood in debris flows or avalanches. However, it is much more likely that these events will result in episodic water quality impacts rather than a direct public safety impact to residents on the fan (see discussion on fan morphology below).

Debris flow and flood risks on the Harrop Creek and Narrow Creek fans

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 Harrop Creek lower channel and fan was undertaken on September 21. The Harrop fan has a surface area of 1.8 km^2 and an average gradient of 4.5% (9% at the apex). The channel is incised by 2.5 m at the fan apex and no potential avulsion points were identified near the fan apex. The channel is confined by boulder debris levees that terminate in lobes 350-400 m downstream of the apex. Below these deposits, the creek is entirely fluvial in character and the fan is too flat to sustain debris transport to the lower portions of the fan (NHC, 1990). Therefore, the main hazard on the Harrop Creek fan beyond the fan apex is a flood event associated with snowmelt or heavy rains. Abandoned flood channels are apparent on the LiDAR hillshade image (Figure 7). As such, the likelihood of a debris flow affecting properties on the fan is low and the likelihood of a flood event impacting infrastructure or properties on the fan is moderate.

The Narrows Creek fan has a surface area of 1.1 km^2, with an average gradient of 6.5% (11% at the apex). However, for several kilometers upstream of the apex, the channel gradient is relatively low (~8%), which is an area of possible debris flow deposition and mitigates the debris flow/flood risk on the fan. Given the proportion of the watershed that is burned, the incremental risk of a flood or a flooding-caused avulsion is low. For further details on the flood risk on the Narrows Creek fan please refer to the Alluvial Fan Hazard Assessment report (NHC, 1990).

Water intakes and water quality

Water licence data show 50 water licences on Harrop Creek, of which 40 are for domestic use. On Narrows Creek, there are also 50 water licences of which 32 are for domestic use.

In Harrop Creek there is a moderate likelihood of ongoing periodic water quality (turbidity) effects due to erosion of exposed mineral soil in burned areas, erosion of sediment from the fire guards, and debris flows. The u-shape of the Harrop Creek valley, the lack of burned area along the valley bottom and the patchiness of the soil burn severity minimize the likelihood that exposed mineral soil will reach the main channel. Large avalanche paths created last winter may grow in size as well, although most depositional areas appear to be above the main creek channel. Past experience from fires in the West Kootenays indicates that these turbidity effects are usually minor in nature and of short duration.

In Narrows Creek there is also a moderate likelihood of ongoing periodic water quality (turbidity effects). The steep tributaries along the west side of the creek have a high connectivity to the main channel, so exposed mineral soil may be delivered directly to the channel either during rainstorms or snowmelt events or from avalanche debris. However, the low proportion of burned area within the watershed mitigates this potential impact.

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.

Recommendations

1. Residents of the Harrop and Narrows Creek fans and water users on both creeks should be provided a copy of this report.

Acknowledgements

Will Burt (MFLNRO, Nelson) prepared the BARC data and provided GIS support. LiDAR data was provided by Tom Dool at RDCK. Erik Leslie with Harrop Procter Community Forest provided local knowledge and field assistance.

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(Original Signed and Sealed by:)

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Reviewed by:

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Figure 1. Burned Area Reflectance Classification map of the Harrop Creek fire showing estimated burn severity derived Landsat 8 satellite images taken before and after the majority of the fire had stopped burning. The post-fire imagery is from September 2, 2017.

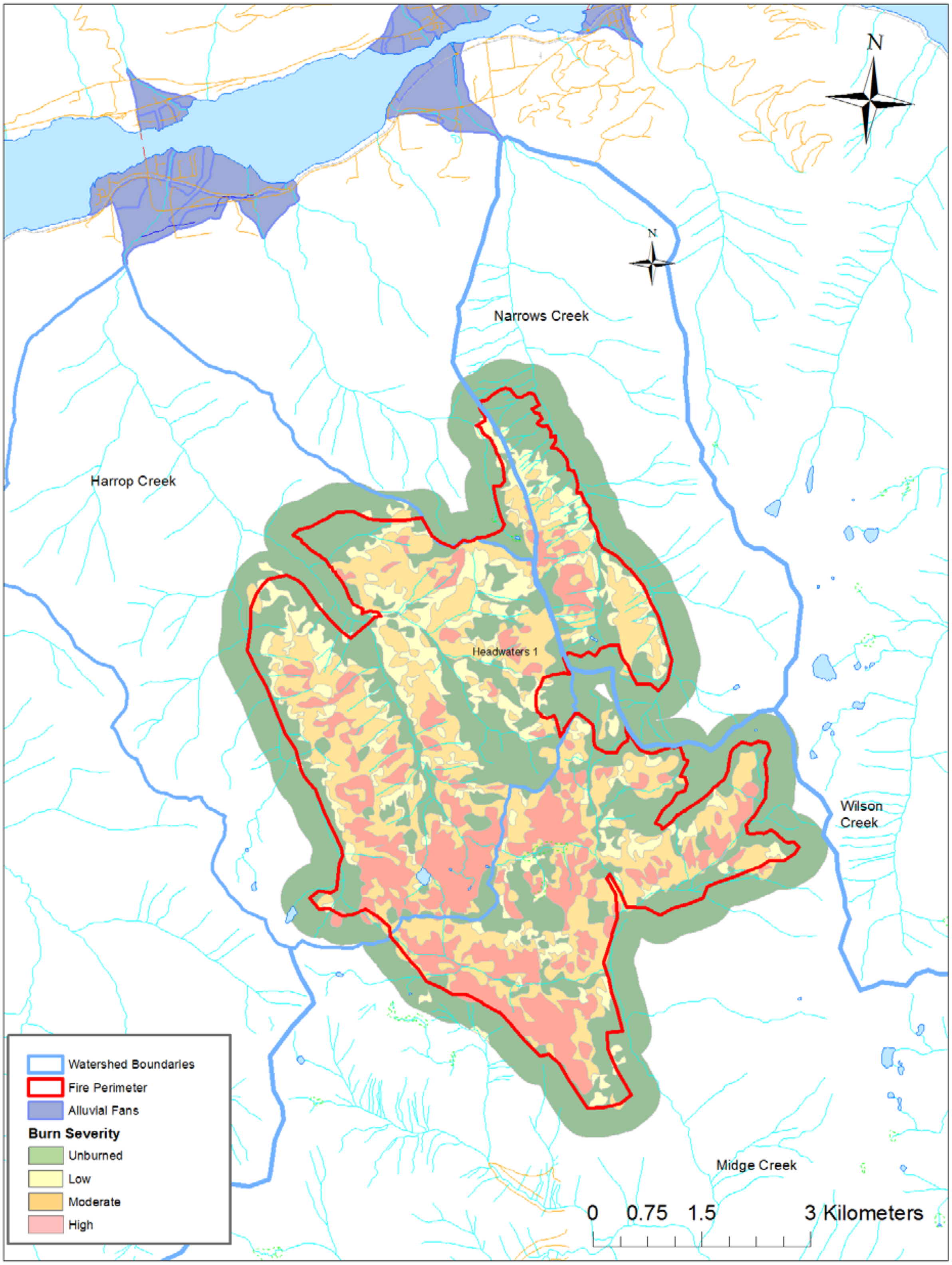

Figure 2. Overview photo of fire N71382 looking up Harrop Creek towards the south. This photo (and all subsequent photos) taken on September 27, 2017.

Figure 3. View downstream from Mill Lake.

Figure 4. Northwest view down the east fork of Harrop Creek. Note the avalanche paths from last winter.

Figure 5. View of Headwaters 1 sub-basin looking east.

Figure 6. View of the burned avalanche chutes along the east side of Narrows Creek.

Figure 7. LiDAR hillshade imagery of the Harrop Creek fan (LiDAR provided courtesy of RDCK).