Kemp Creek Fire, N70171
Post-Wildfire Risk Analysis

Prepared for BC Ministry of Forests and Range:
Kootenay Lake Forest District, Southern Interior Forest Region,
and Southeast Fire Centre

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Summary

Kemp Creek is the community watershed for the village of Kaslo. The Kemp Creek fire of 2007 covers about 20% of the watershed, and about 9% of the watershed is affected by high or moderate vegetation burn severity.

Severe soil burn severity and water repellency exist in much of the burned area. There is a moderate likelihood of increased turbidity in the creek, which would probably occur during summer or fall rainstorms. The likelihood of a debris flow which could damage or destroy the water intake is considered low. These hazards result in moderate risks to the water quality and supply and are likely to persist for about 3 to 5 years.

The following recommendations are made:

1. Information on the post-wildfire hazards and risks should be communicated to stakeholders, which in this case is primarily the village of Kaslo, but also the forest licensee, the regional district, and nearby landowners.

2. The village of Kaslo should be aware of increased risks to its water quality, water supply, and water intake structure, and consider options to manage these risks, during the period of several years when post-wildfire effects may exist.

3. Water quality on Kemp Creek should be monitored for several years, or until substantial recovery of hydrologic processes in the watershed has occurred.

Introduction and Objectives

The Kemp Creek Fire (number N70171) started in mid-July, 2007, and burned an area of about 200 ha in the Kemp Creek watershed, about 5 km southwest of Kaslo. The fire perimeter did not increase beyond early August, but the fire actively burned for several more weeks. The area within the fire boundary is quite mountainous and rugged.

Forest Sciences and Engineering staff of the Southern Interior Forest Region have developed a procedure for analysing post-wildfire risks, in particular those risks caused by flooding, erosion, and landslides. A number of large wildfires occurred this season in the West Kootenays, including several high-risk fires near communities and highways, and risk analyses have been conducted on them. The general objectives of these risk analyses are:

- identify the consequences at risk;
- review relevant information on the affected area;
- identify and map watersheds affected by the fire;
- prepare a preliminary burn severity map;
- assess soil burn severity, and identify areas of water repellent soils;
- assess the potential for increased overland flow and soil erosion in the burned area;
- evaluate the potential for increased runoff, and increased peak flows and sediment transport;
- evaluate the potential for landslides, debris flows, and other natural hazards in and below the burned area;
- inspect roads and other development in and below the burned area, which might contribute to flood, erosion, and landslide hazards;
- conduct a risk analysis, and identify specific hazards that could affect the elements at risk;
- make recommendations.

Further information on the analysis procedure, and on the causes of post-wildfire hazards, is given in Dobson Engineering Ltd (2006), Jordan et al (2006), and Curran et al (2006). *Risk analysis* is "the systematic use of information to identify hazards and to estimate the chance for, and severity of, injury or loss to individuals or populations, property, the environment, or other things of value" (Wise et al, 2004). Risk analysis (unlike *risk assessment*) does not include determining whether a risk is acceptable or tolerable.

The Kemp Creek Fire was identified as being relatively low-risk compared to some other fires in the region, and therefore a less detailed analysis was done.

Methods

An aerial reconnaissance of the fire was made on August 15, and high-elevation aerial photographs taken for use in preparing a vegetation burn severity map. The map is included in this report (Figure 2). The following classification is used (after Curran et al, 2006):
– High – trees blackened and dead, needles consumed, understory consumed;
– Moderate – Trees burned and dead, needles remain, understory mostly burned;
– Low – Canopy and trunks partially burned, understory lightly or patchily burned.

On Sept. 20, the writer spent one day on the ground in the fire, accompanied by R Munter and D Karassowitsch who were representing the Kaslo Community Forest (the licensee for the area). We traversed a slope in the northeast part of the fire to determine soil burn severity (location A on Figure 1). We also inspected the creek channel in the vicinity of the water intake, and the alluvial fan of Kemp Creek.

Relevant information on the area was reviewed, including air photos, the bedrock geology map, and terrain stability maps and report (Wells and Wallace, 1999).

Description of the Kemp Creek Watershed

The Kemp Creek watershed drains an area of 12 km^2 in the Selkirk Mountains, and enters the lower Kaslo River 4 km above Kaslo. The watershed is mountainous and rugged. Alpine and subalpine terrain covers about 1/3 of the watershed, and annual runoff is dominated by snowmelt from this area. There is no streamflow data available (other than some miscellaneous measurements from 1929-30). The watershed is in the ESSFwc, ICHmw, and AT biogeoclimatic zones. Figure 1 gives an overview of the watershed and the fire location.

Geology in the watershed is complex, with a variety of rock types including Slocan Group (argillite, phyllite, limestone) which is the most abundant, and weathers easily to produce fine colluvium and silt loam soil. Kaslo volcanics, Nelson granite, and Milford Group (schist, limestone) are also present.

The terrain map (Wells and Wallace, 1999) shows that in most of the watershed, including the area of the fire,
colluvium and rock are the most abundant materials, with some glacial till in areas of gentler slope. Soil textures are mostly silt loam, and soil drainage is typically well to moderately well drained, with some seepage areas. About half the area of the fire is mapped as class IV (potentially unstable) and V (unstable), and most of the area has high surface erosion potential. Observations on our field traverse were in agreement with these interpretations.

Snow avalanche tracks and small debris flow gullies are widespread in the middle part of the watershed. The alluvial fan of Kemp Creek consists mostly of debris flow deposits, and large debris flows apparently flow infrequently (every few centuries) down the creek to the fan. (Debris flow hazard is discussed further below.)

There has been no recent logging and little other development in the watershed. An old mine road, now only passable on foot, climbs the ridge on the east side, and there are some overgrown skid trails from old selective logging at the bottom of this ridge.

The table below gives some summary data on the watershed and burn characteristics.

Watershed area	1186 ha	
Elevation range	960 – 2440 m	
H60 elevation (approx.)	1850 m	
Melton ratio [1]	0.43	
average slope of lower channel , forks to fan	25%	
average slope of alluvial fan	24%	
Burn area	233 ha	20% of watershed
High severity burn	42 ha	3.5% "
Moderate severity burn	65 ha	5.5% "
Low severity burn or unburned	126 ha	11% "

1 Melton Ratio = relief / √ area. It is an index of average watershed slope. A study by Wilford et al (2004) in northwestern B.C. concluded that watersheds subject to debris flows and debris floods typically had Melton ratios of >0.6 and 0.3-0.6 respectively.

Resources at Risk

Kemp Creek is the community watershed for the village of Kaslo. The resource at risk from the fire is the water supply for the village. This includes three elements: the water intake, continuity of the water supply, and water quality. The water intake is in the creek channel about 300 m above the fan, in a narrow canyon, and could be damaged or destroyed if a debris flow, or a flood with high debris load, descended the creek. The severity of damage, and other factors such as reservoir storage and the ease of repair or replacement, would affect the length of time water supply is interrupted. Water quality could also be affected if a smaller debris flow or significant soil erosion were to occur in the watershed.

Natural Hazards, and Effects of the Burn on Hazards

It is well established through research and experience that wildfire can result in significant changes to watershed hydrology and geomorphology. These can include:

- Combustion of the forest floor produces hydrophobic compounds which accumulate below the surface, resulting in a water repellent layer which inhibits infiltration and can produce overland flow during heavy rainfall;
- Loss of litter and duff by burning removes the water storage capacity which normally exists on the forest floor;
- The interception capacity of the forest canopy and understory shrub layer is removed;
- The vegetation and forest floor layers which protect the soil from raindrop energy are removed, exposing the underlying mineral soil to erosion;
- Loss of the forest vegetation results in less evapotranspiration, increased snow accumulation, and potentially higher groundwater levels.

The hydrologic changes include both short-term and long-term effects. The most severe effects are short-term, including flooding, erosion, and debris flows caused by surface soil hydrologic changes, including water repellency. Severity of effects depends on the extent of forest floor loss and water repellency, and also the extent of exposed mineral soil and depth of root kill. The short-term effects typically last for about 3 to 5 years. Long-term effects are similar to those of clearcutting. This risk analysis is primarily concerned with short-term effects.

Burn severity in the Kemp Creek fire

Figure 2 is a map of vegetation burn severity based on the aerial photographs (Photos 1 and 2 are examples). Our ground traverse in the northeastern tip of the fire covered an area mapped as low and moderate (we did not continue further up the slope into the high severity area due to danger from snags and falling rock). In the moderate vegetation burn severity area, the soil burn severity was rated high, although it was patchy in some areas, and water repellency was moderate to strong. Based on this very limited sample, and on experience at other fires (Springer and Sitkum), it is likely that all of the area mapped on Figure 2 as high, and much of the area mapped as moderate, will have severe soil burn severity, and moderate or strong water repellency.

Flooding

Peak streamflow in high-elevation watersheds in the region occurs during spring runoff. In Kemp Creek, the peak streamflow is dominated by snowmelt in the alpine-subalpine zone. The area of high and moderate burn severity covers 9% of the watershed. About half of the high and moderate burn is above the H60 elevation (where it would be expected to contribute to the snowmelt peak). This area is probably too small to have any measurable effect on spring streamflow.

It is possible that overland flow from severely burned areas could significantly increase the stream discharge during mid-summer or fall rainstorms. However, in an alpine-dominated watershed such as Kemp Creek, it is unlikely that discharge during these events would be as great as the typical spring snowmelt peak.

Soil erosion

Rainfall and overland flow in severely burned areas is likely to cause soil erosion. This will increase turbidity if eroded sediment reaches stream channels (which is likely), and is a water quality concern. The effect should last only for a few years, until surface soil recovers, the water repellency breaks down and vegetation becomes established.

Debris flows

Debris flows are often the most common and most hazardous type of event which can occur after a wildfire. A debris flow can be caused by overland flow generated on severely burned slopes above a gully or steep channel; if the flow is much greater than flows which the gully/channel normally experiences, a debris flow can result. A debris flow can also be caused by a landslide which enters a channel, and blocks the channel briefly and causes an outburst flood. There are several other initiating mechanisms, but these are the most likely in the type of terrain found in

Kemp Creek. Severe burn in areas of potentially unstable terrain will increase the likelihood of such events. The area which is probably most subject to increased debris flow hazard is the steep gully system in the west-central part of the burn (location B on Figure 1, and photo 1), which is an area mapped as unstable and which probably experiences frequent small debris flows. If debris flows occur in this area, and possibly other parts of the burn as well, they will enter Kemp Creek, adding suspended sediment and bedload (gravel) to the creek. It is less likely, but possible, that such events could cause a debris flow or debris flood which could reach the lower channel of the creek (see discussion below).

Under pre-fire conditions, probably most debris flows occurred in the spring and early summer. Under post-wildfire conditions, it is more likely that debris flows will occur in summer or fall, due to high-intensity rainstorms on dry soil in burned areas.

We inspected the lower channel of Kemp Creek from the water intake, down to the fan where it is traversed by the fire guard (locations C and D on Figure 1). From deposits at the apex of the fan, we concluded that the last large debris flow occurred several centuries ago, probably between about 200 and 500 years (older than the stand-replacing fire of about 100-150 years ago, but not old enough for development of a soil profile). On the lower part of the fan, where a good section is exposed by the fire guard, we saw many debris flow deposits, ranging from over 7000 years old (pre-Mazama ash) to about 400 years old. From this evidence, a rough estimate is that the return period of debris flows which reach the fan is about 200 to 500 years.

From the terrain map, it appears that the most likely source of large debris flows in the past was the unstable slope in the west part of the watershed, outside the fire area, although other unstable gully areas within the burn are also possible sources.

The burn, which has affected some areas of unstable terrain, has probably increased the likelihood of a large debris flow event which could reach the Kemp Creek fan. Since the burn covers a relatively small part of the watershed, the increase in hazard might be slight. It is possible, although it cannot be confirmed, that earlier large debris flows have occurred in response to past large wildfires. It is equally likely that they occurred due to extreme rainfall or snowmelt events, unrelated to wildfire.

<u>Debris floods</u>

A debris flood is a water flood carrying unusual quantities of gravel, boulders, and wood debris. It is unlike a debris flow in that the peak discharge is lower and the density (or sediment concentration) is lower, and debris floods are much less destructive than debris flows.

Kemp Creek is larger and less steep than most watersheds which typically are subject to debris flows in this region. Probably, it experiences debris floods more frequently than debris flows. The increase in the likelihood of erosion, small landslides, and small debris flows in the burned area means that additional coarse sediment could be introduced to the channel, and therefore the likelihood of debris floods will probably increase.

Snow avalanches

Much of the burned area is steep, and includes a number of snow avalanche tracks. In some areas, new avalanche tracks may form, and avalanches in existing tracks may be more frequent, due to removal of stabilizing vegetation and also due to a likely increase in snow accumulation. Avalanches in freshly burned areas may be quite dirty, compared to those in established tracks, and as avalanche debris melts in the spring, this could result in increased turbidity compared with pre-fire conditions.

Risk Analysis

Risk is the product of *hazard* (or probability of occurrence) and *consequence*. A simple qualitative scale of High-Moderate-Low is used for rating hazard, consequence, and risk. The principles of this type of risk analysis are summarized in Wise et al (2004), and further detail on its application to post-wildfire risks is given in the reports for other 2007 wildfires (Nicol et al, 2007; Jordan and Gluns, 2007).

The values or elements at risk are the water supply, water quality, and water intake infrastructure for the village of Kaslo.

A large debris flow in the lower channel of Kemp Creek would destroy the water intake. A debris flood also has the potential to damage or destroy the intake. The reservoir which is supplied by the intake is about 1 km to the northeast, in an area which is very unlikely to be affected by a debris flow or debris flood. The incremental (due to the fire) hazard of a debris flow in the Kemp Creek channel is considered to be low (unlikely to very unlikely, over the next three to five years). This hazard is probably somewhat higher, but not greatly so, than the pre-fire hazard. The consequence of a debris flow is probably moderate to high (destruction of or damage to the intake is not likely to cause a long-term loss of water supply, as presumably there is some storage capacity in the reservoir). The risk of a large debris flow or debris flood is therefore considered to be moderate.

Risks to water quality are primarily due to increases in turbidity which are possible due to post-wildfire erosion, or to small debris flows in the burned area. For the first several years, the probability of this (i.e. the hazard) is considered to be moderate, as the severely burned area is a small proportion (9%) of the watershed. The duration of increased turbidity would probably be brief. Although this is a community watershed, because the reduction in water quality would probably be short-term, the consequence is considered to be moderate; therefore the risk is moderate. The risk may not be greatly increased over pre-fire conditions, as there are a number of non-fire-related sediment sources in the watershed. However, increased turbidity is likely to occur during mid-summer or fall rainstorms, which is a time when high turbidity would be rare under pre-fire conditions. Risks to public health due to effects of the fire on chemical water quality are low.

Recommendations

It is not the purpose of this risk analysis to determine whether risks are acceptable, or if they should be mitigated, or which agencies should be responsible for risk management. The recommendations below are intended to draw attention to the most significant risks, promote awareness and discussion of risks, and suggest where further study or action is warranted.

1. Information on the post-wildfire hazards and risks should be communicated to stakeholders, which in this case is primarily the village of Kaslo, and also the forest licensee, the regional district, and nearby landowners.

2. The village of Kaslo should be aware of increased risks to its water quality, water supply, and water intake structure, and consider options to manage these risks, during the period of several years when post-wildfire effects may exist.

3. Water quality on Kemp Creek should be monitored for several years, or until substantial recovery of hydrologic processes in the watershed has occurred.

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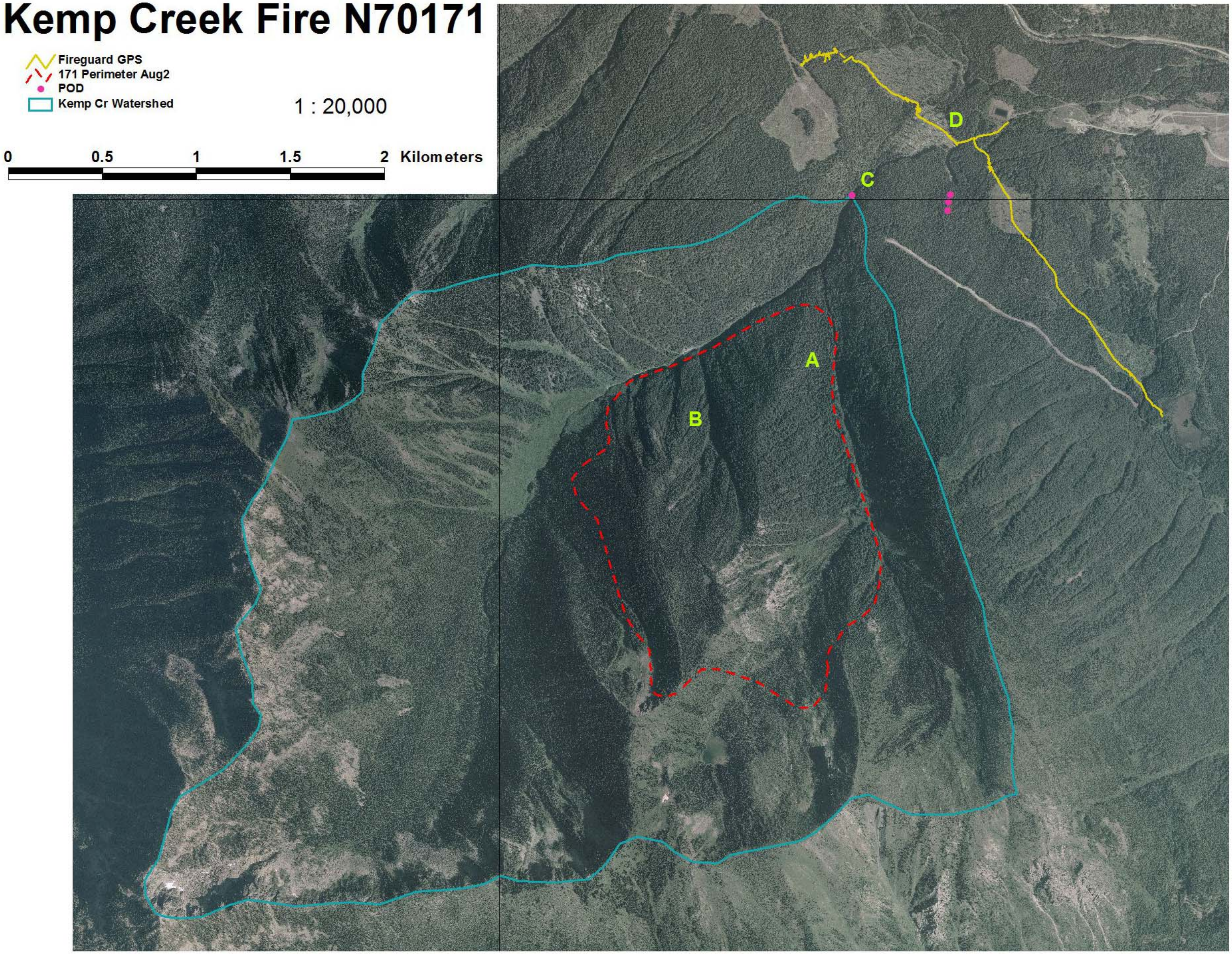

Figure 1. Orthophoto of Kemp Creek watershed (reduced). Points referred to in report: A – general location of field inspections; B – gullies subject to debris flows; C – water intake and lower channel of Kemp Creek; D – lower part of debris flow fan.

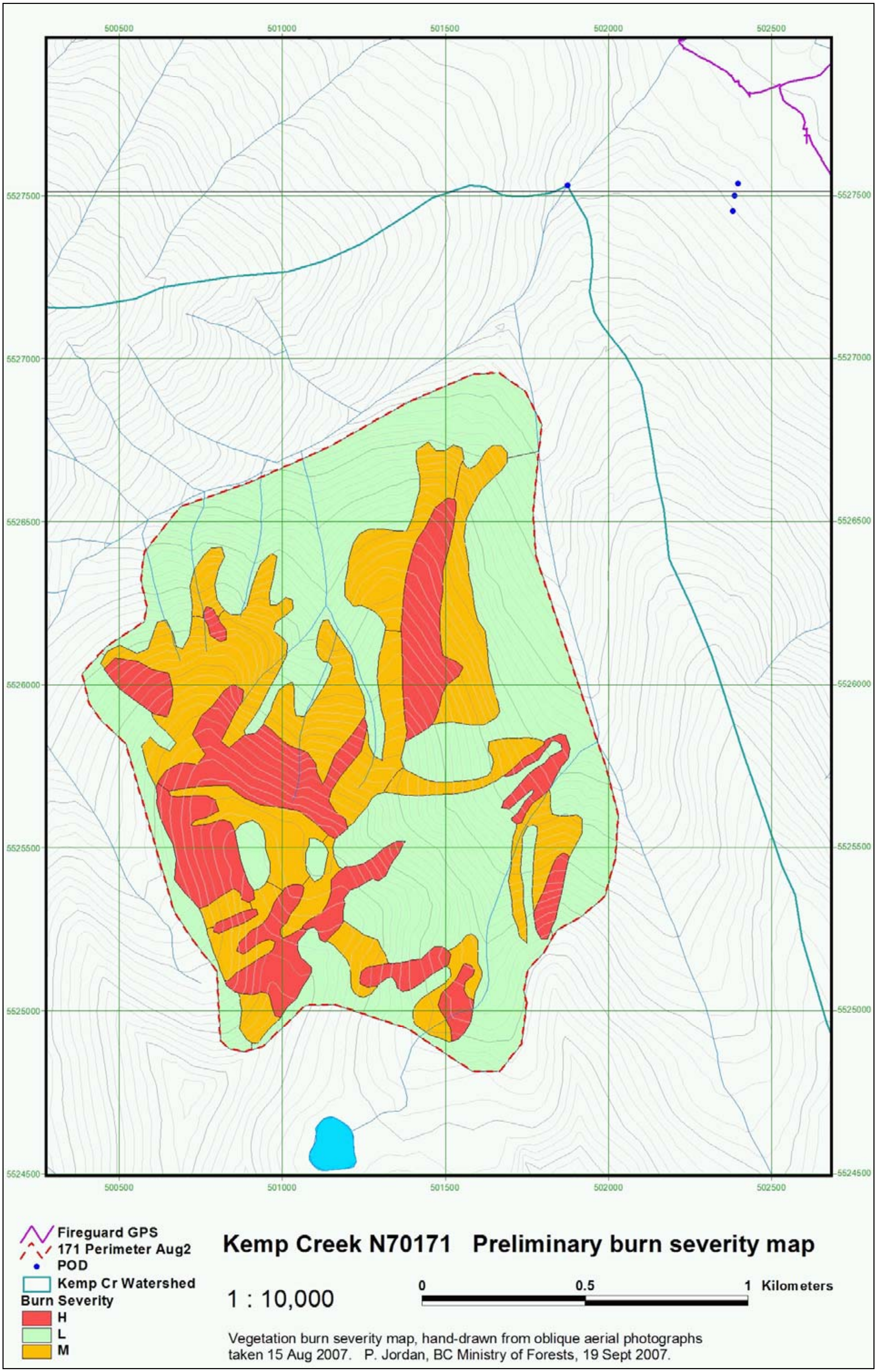

Figure 2. Preliminary map of vegetation burn severity (reduced).

Photo 1. View of Kemp Creek fire from the north, looking towards headwaters of Kemp creek. Gullies subject to debris flows are in centre left.

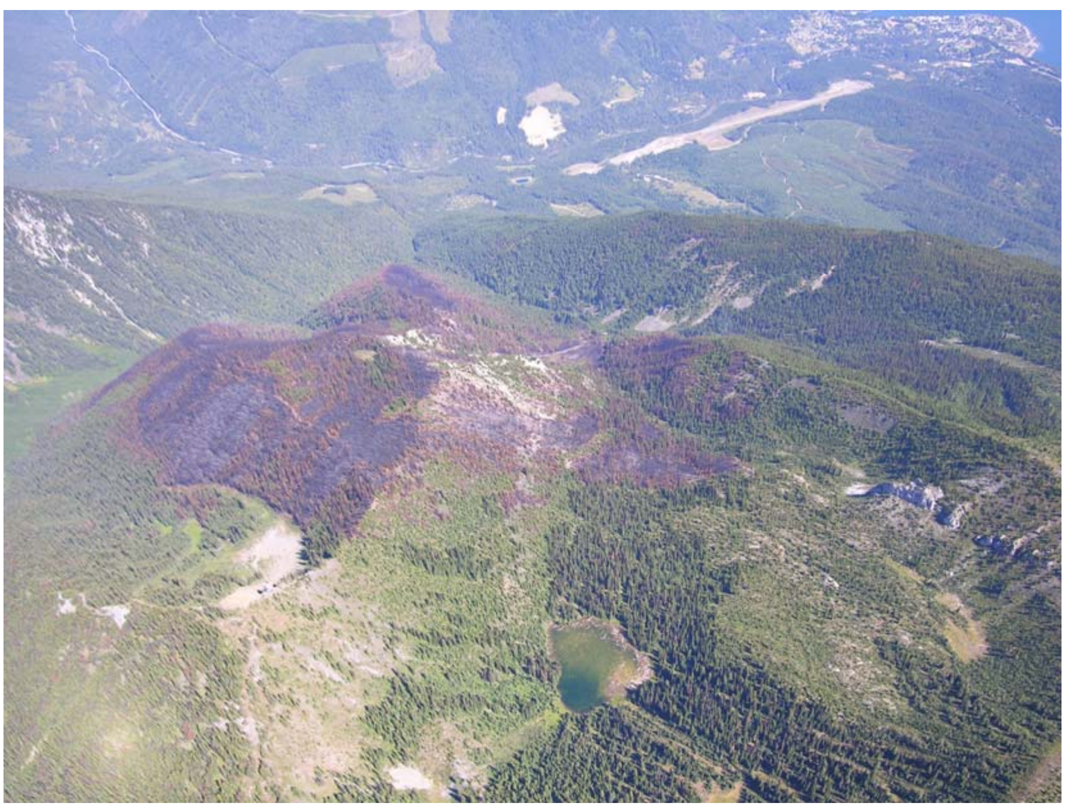

Photo 2. View across upper part of the fire, and down Kemp Creek towards Kaslo.