Provincial Emergency Program

POST WILDFIRE HAZARD ASSESSMENTS

Springer and Sitkum Creek Fires

M09468A01

Klohn Crippen Berger

March 21, 2008

PROVINCIAL EMERGENCY PROGRAM
Emergency Management British Columbia
455 Boleskine Road
Victoria, British Columbia
V8Z 1E7

Jim Whyte, AScT
Director, Provincial Operations

Dear Mr. Whyte:

Post Wildfire Hazard Assessments - Springer and Sitkum Creek Fires

This report describes post wildfire flood, debris flood and debris flow hazard assessments carried out for the Springer and Sitkum Creek fires, in the West Kootenay region. The work carried out is consistent with our August 27, 2007 proposal. Engineering advice and assistance with public meetings and stakeholder meetings were also provided during the course of this assignment.

The report has been divided into the two fire areas: Springer Creek Fire N50372; and Sitkum Creek Fire N70347. This report and associated mapping will be provided digitally to the Provincial Emergency Program (PEP) and to the other agencies listed at the end of this report.

This report was prepared by Klohn Crippen Berger Ltd. (KCBL) for the Provincial Emergency Program (PEP), Emergency Management British Columbia. It reflects KCBL's best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. KCBL accepts no responsibility for damages, if any, suffered by any third party as a result of decisions or actions based on this report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Richard F. Rodman, P.Eng.
Project Manager

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Provincial Emergency Program

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Springer and Sitkum Creek Fires

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1. BACKGROUND

KCBL were retained by PEP to provide engineering advice and support with respect to the assessment of downslope hazards to the public from two wildfires that occurred during the summer of 2007: the Springer Creek Fire N50372; and Sitkum Creek Fire N70347.

As part of this contract, KCBL also provided assistance to the Regional District of Central Kootenay (RDCK) at public information meetings and with dissemination of technical information relating to post wildfire hazards. KCBL met with the Ministry of Forests and Range (MoF) and the Ministry of Transportation (MoT) on numerous occasions to discuss the hazards and assist with action plans to mitigate the hazards.

This report is intended to be used as a starting point for others assessing hazards downslope from these two wildfires. Hydrological recovery of the burned areas, status of MoF mitigation measures, and geomorphological and hydrological events that have occurred since the wildfires should be taken into consideration when assessing downslope hazards. New developments in analyses and understanding of wildfire hazards also need to be considered.

2. SPRINGER CREEK ASSESSMENT

2.1 Wildfire Impact

The 2007 Springer Creek Fire N50372 affected a series of creeks and drainages along the east side of Slocan Lake, from Springer Creek in the south to Enterprise Creek in the north (Drawing 1). The total area burned is approximately 23 km^2. Many of these watersheds have a history of debris flow and debris slide activity. Due to the wildfire effects on vegetation and soil, the likelihood of occurrence of these types of events is increased, especially in the next 3 to 5 years. Drawing 1 shows the extent of the fire and the burn severity. A description of burn severity and how it was mapped is contained in Nicol, D.R. (2007). The topography, burn severity, watershed boundaries and the locations of existing houses/foundations were provided by MoF. RDCK provided the cadastral mapping.

Mr. Rick Rodman, P.Eng. of KCBL, carried out a site visit with Mr. Doug Nicol, P.Eng., consultant to MoF, on September 21, 2007 and again with Mr. Rob Griffith, EIT, of KCBL, on February 22, 2008.. Areas adjacent to Highway 6 and the first 5 km of the Enterprise Creek Forest Service Road were visited. Photo 1 shows typical steep slopes upslope of Highway 6.

Photo 1 Looking upslope from Highway 6 into Allen Creek catchment (September 21, 2007)

The following background reports provide detailed descriptions of watersheds, burn severity, MoF risk assessments and proposed upslope mitigation measures:

- “Springer Creek Fire Post-Wildfire Risk Analysis”, Nicol, D. et al (2007);
- “Springer Fire N50372: Erosion Risk Mitigation Options and Hillslope Soil Mitigation Treatments Proposal”, Curran, M. (2007);
- “Springer Creek Fire Number N50372 Long Term Risk Analysis” Draft, Nicol, D. (2008); and
- “Landslide Study – Cape Horn Bluffs Area Detailed Report”, Curran, M. et al (1990).

2.2 Affected Infrastructure

Highway 6 is the only north south land transportation route in the valley. MoT have been monitoring rockfall in the hazard area and will be assessing the potential for snow avalanche hazards. Slocan Lake provides an alternate water transportation route that would bypass the affected area. Telus has a fibre optic cable along the highway corridor. This cable serves an area which would have no alternate Telus communication lines should the fibre optic cable be damaged.

It is understood that there may be some private micro hydro facilities in the area. Their number and exact location is not known at this time. Neither BC Hydro nor FortisBC supply electrical power to the affected area.

2.3 Hazard Area Delineation

KCBL concurs with the recommendation in the 2008 draft report by D. Nicol that:

> "Before any proposed residential development is approved adjacent to the highway from drainage units R1 to R7 inclusive and extending up Enterprise Creek, it is recommended that a landslide assessment be conducted consistent with the guidelines produced by APEGBC [Association of Professional Engineers and Geoscientists of British Columbia] 2006, and that the professional conducting the assessment be familiar with the landslide history and the possible short term and long term effects of the recent fire. The RDCK and/or MoT may consider adopting a defined level of natural hazard safety."

Consistent with this recommendation, KCBL have identified, on Drawing 1, the hazard area within which the RDCK, MoT and Integrated Land Management Bureau (ILMB) should request a landslide assessment prior to allowing development. The RDCK refers to these areas as Non-Standard Flooding and Erosion Areas (NSFEAs). MoT reviews and approves subdivision applications; ILMB is responsible for reviewing plans for the management of Crown Land.

The delineation of the hazard area is based on burn severity, topography, limited site visits and short and long term partial risk analyses (Nicol, D. 2007 and 2008). A 30 to 50 m wide strip along both sides of all creeks, including Enterprise Creek down to Slocan Lake, has been included in the hazard area because of the possibility of upslope landslide activity that could result in creek blockage, debris flows and debris floods. Hazard areas adjacent to Highway 6 have been included because of the possibility of a landslide and/or debris flow or debris flood event being redirected and spilling over the highway. The resulting delineated hazard area, shown on Drawing 1, encompasses the areas described above and also includes additional areas.

The extent of the hazard area shown on Drawing 1 should be reviewed and modified as hydrological recovery of the burned areas takes place. This recovery may take up to 30 years after the wildfire.

Both private and Crown Land have been included in the delineated hazard area. The RDCK can implement the requirement for a landslide assessment on private property through its Floodplain Management Bylaw No. 1650. MoT can also implement this requirement on private land through its subdivision approvals process. The ILMB, are able to implement the requirement for a landslide assessment prior to issuance of development permits on Crown Land by placing this land under a “Land Act Reserve”.

Landslide assessments, which also includes debris flow, debris flood, debris slide and slope stability assessments, should be carried out by a qualified professional. Such assessments rely on the judgment of an experienced professional who should take into account the site specific geology and geomorphological and hydrological processes and the proposed development.

3. SITKUM CREEK ASSESSMENT

3.1 Background

Sitkum Creek is located on the north side of the West Arm of Kootenay Lake.

Prior to the 2007 Sitkum Creek wildfire, the Sitkum Creek fan had been identified by RDCK as a NSFAE area, requiring a hazard assessment prior to development.

The hazard delineation area was identified by Northwest Hydraulic Consultants Ltd. (nhc) and Thurber Consultants Ltd. (TCL), in their 1990 report entitled “Alluvial Fan Hazard Assessment, Regional District of Central Kootenay Electoral Area E & F”. Figure 1 shows the delineated NSFEA areas from the nhc/TCL report. The Klohn Crippen Ltd. 1998 report entitled “Terrain Stability Inventory, Alluvial and Debris Torrent Fans, Kootenay Region”, concurred with the nhc/TCL report and identified the Sitkum Creek fan as a debris flood prone fan with a high hazard rating (defined in the 1998 report).

The RDCK incorporated the information from Figure 1 and created the NSFAE areas shown on Figure 2 and Drawing 2.

According to the RDCK Floodplain Management Bylaw No. 1650, the areas designated on Figure 2 with “F” are:

> “Flooding by moderate velocities flows possible: typical of the alluvial and debris fans of moderate size streams, small streams with steeper slopes, on the transition zone of larger alluvial and debris flow fans”.

Areas designated on Figure 2 with “E” are:

> “Flooding and erosion from: high velocity flows, avulsions, debris flows or bank stability problems possible. Typical of areas on alluvial/debris flow fans of larger streams, moderate sized streams with steeper slopes or erodible banks in the floodway of larger rivers.”

Areas designated on Figure 2 with “1” are:

> “Shallow flooding by low velocity flow possible; typical of the alluvial/debris flow fans of small streams with moderate slopes or the run-out areas of larger alluvial/debris flow fans.”

The nhc/TCL 1990 report noted that either flooding or avulsion events occurred on Sitkum Creek fan on May 27, 1968, June 3, 1972, and June 1974. Mr. Dwain Boyer, P.Eng., Ministry of Environment, stated that water has overflowed the banks of Sitkum Creek at the Highway 3A bridge, and crossed the highway on the east side of the bridge, on 2 or 3 occasions including and since 1968 (January 8, 2008 personal communication). Thus, prior to the 2007 wildfire, Sitkum Creek fan had been identified as having flood and debris flood hazards.

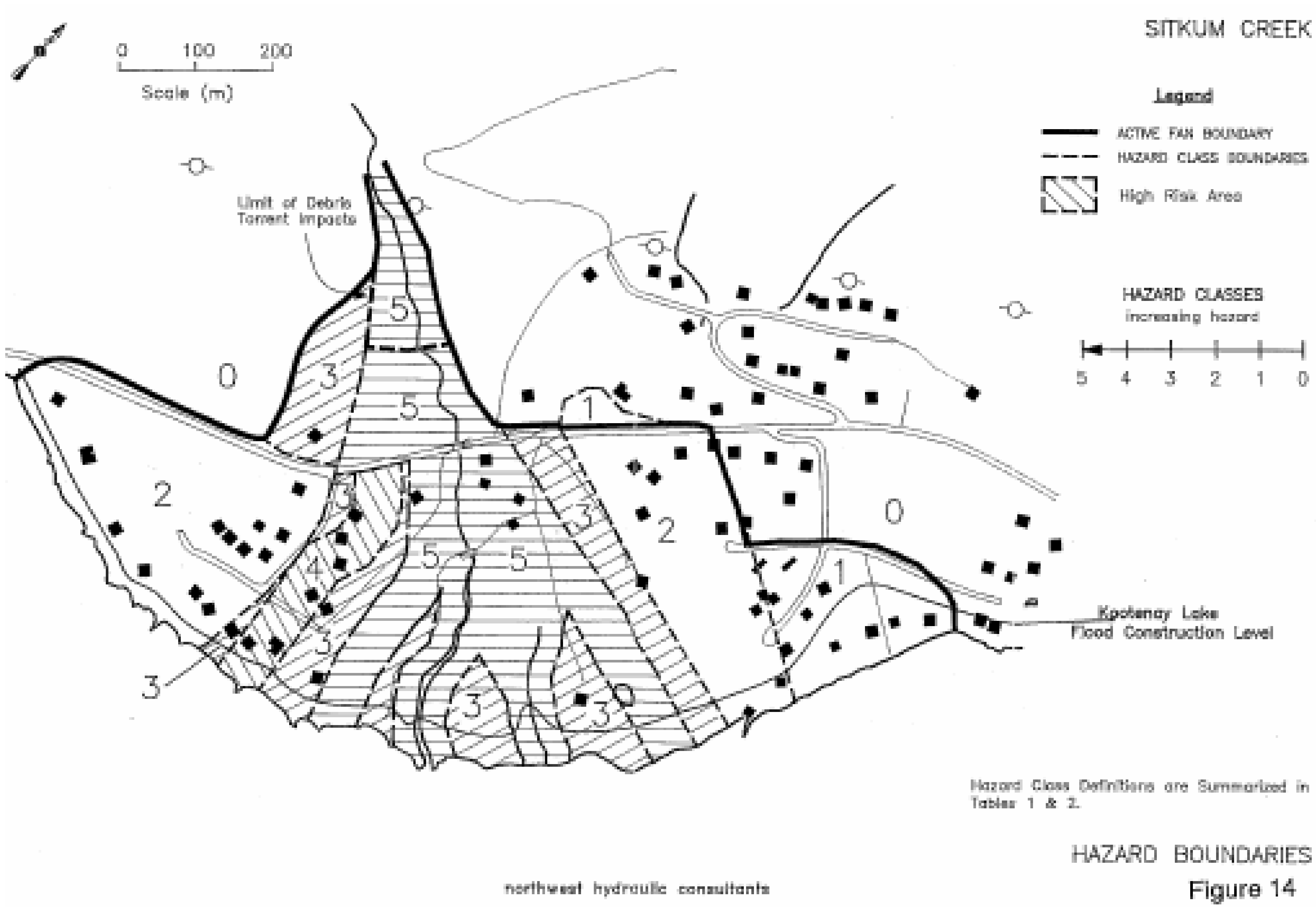


Figure 1 Sitkum Fan Hazard Area Delineation (nhc/TCL 1990 report)

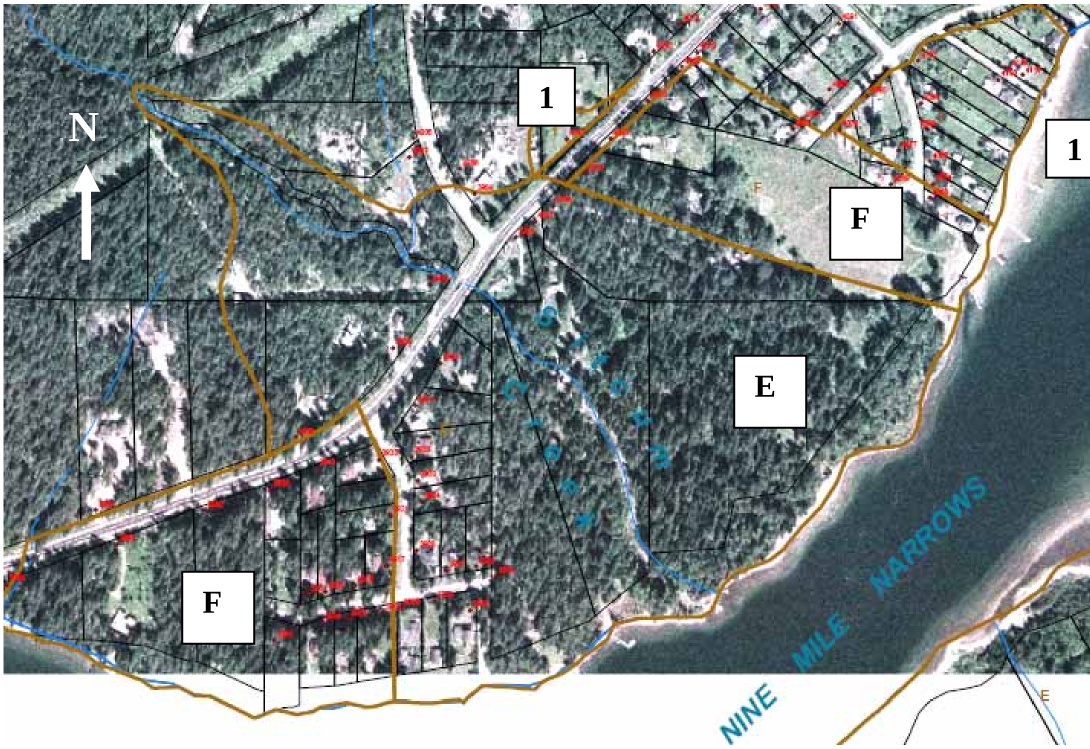


Figure 2 Sitkum Fan RDCK Non-Standard Flood and Erosion Areas Classification

3.2 Wildfire Impact

The 2007 Sitkum Creek Fire N70347 burned approximately 31% of the watershed and 26% of the watershed was classified as either high or moderate burn severity (Table 1 and Figure 3, provided by the MoF). Figure 3 was produced from Landsat Satellite images using techniques used by the US Forest Service called Burned Area Reflectance Classification (BARC) mapping. BARC maps determine burn severity from the reflectance values.

Figure 3 shows that the 2007 fire was confined to the west side of the Sitkum Creek basin. The southern end of the burn area is approximately 4.5 km from of the apex of the Sitkum Creek fan.

Table 1 Sitkum Creek Fire N70347 Statistics

	km^2	Percent
Watershed Area	27.0	100
Area Burned	8.4	31
High Severity Burn	2.1	8
Moderate Severity Burn	4.7	18
Low Severity Burn	1.6	6
Area Unburned	18.6	69

Data provided by MoF, February 15, 2008.

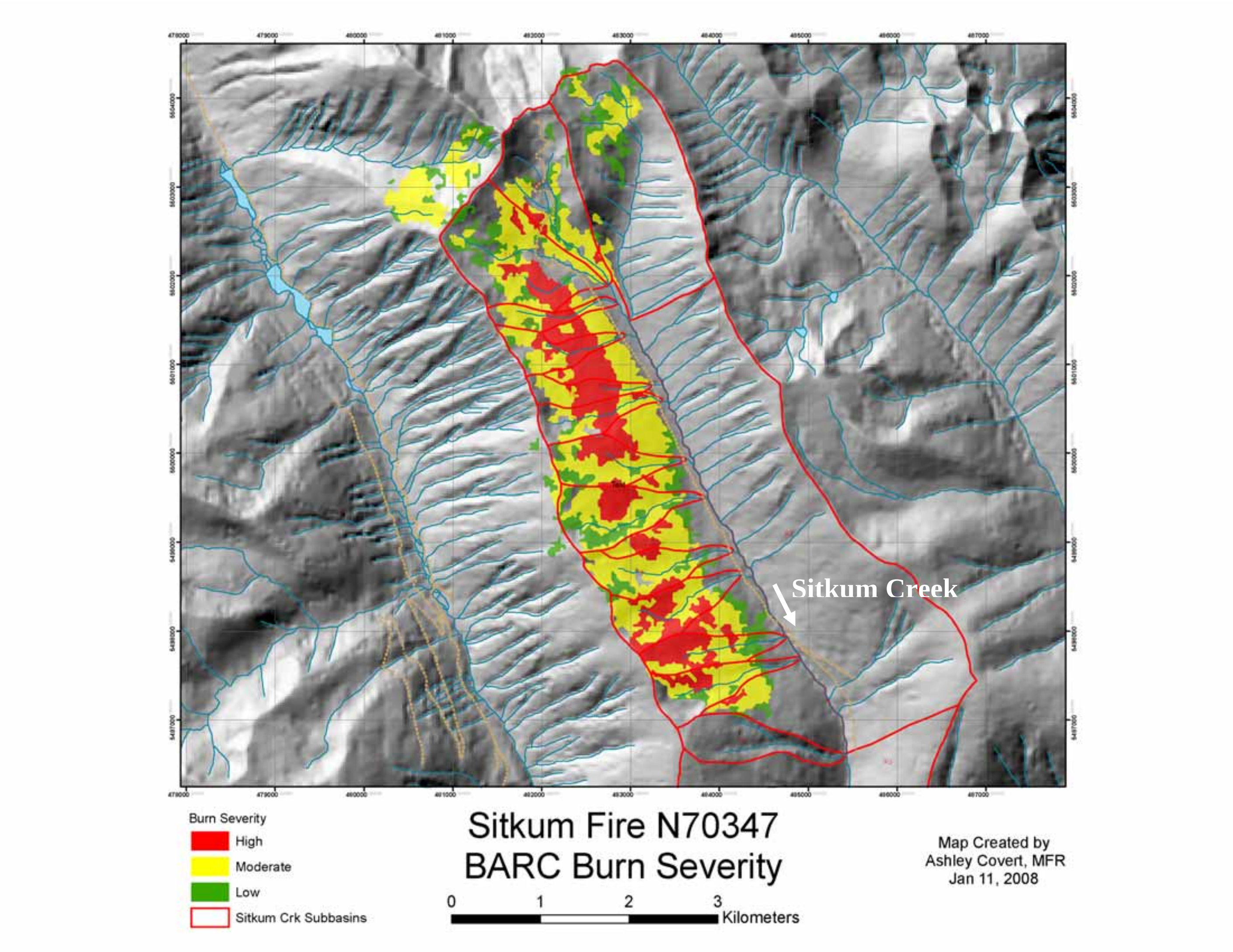


Figure 3 Sitkum Creek Fire N70347 BARC Burn Severity Map

3.3 Flood Frequency Analyses

Historically there was an Environment Canada streamflow gauge on Sitkum Creek (station number 08NJ115), but it was a manual gauge and only operated for the summer periods of 1937, 1939, 1946, and 1948. There are no annual peak flows reported for this station.

There is an active Environment Canada streamflow gauge on Redfish Creek (station number 08NJ061), the adjacent creek to the east of Sitkum Creek. Redfish Creek has a similar aspect and shape to Sitkum Creek and has approximately the same catchment area, 27 km^2. Although the Redfish Creek station started in 1923, annual maximum daily flow data have only been summarized by Environment Canada since 1968.

Due to the similarities between Redfish Creek and Sitkum Creek, the flow data from Redfish Creek are considered to be representative of Sitkum Creek flows without adjustments.

Column 2 of Table 2 presents the recorded annual maximum daily flow data (pre-wildfire) for Redfish Creek. Column 3 presents the estimated (post-wildfire) flows for Sitkum Creek. Note that the years that flooding on Sitkum Creek reported by nhc/TCL (1990), 1968, 1972 and 1974, were also high flow years on Redfish Creek. The year 1986 was also a relatively high flow year on Redfish Creek, although no flooding was reported on Sitkum Creek. Due to the effects of the wildfire, the flows on Sitkum Creek are expected to increase. MoF has estimated that annual maximum daily flows could increase by up to 20%, while maximum daily flows in the fall could increase by 150% (for high floods) and up to 300% (for average floods), depending on the return period (October 22, 2007 MoF/MoT meeting notes). The estimated post-wildfire annual maximum daily flows are presented in Column 3 of Table 2.

Table 2 Redfish Creek Annual Maximum Daily Flows (Environment Canada Station 08NJ061)

Year	Annual Max Daily Flows (m^3/s)	
	Recorded	Estimated for Sitkum Creek post-wildfire
1968	11.2	13.4
1969	8.0	9.6
1970	7.8	9.3
1971	7.3	8.7
1972	10.1	12.1
1973	5.6	6.7
1974	10.2	12.2
1975	5.8	7.0
1976	6.4	7.7
1977	5.6	6.7
1978	7.4	8.8
1979	4.5	5.4
1980	7.9	9.5
1981	6.4	7.6
1982	7.3	8.8
1983	7.8	9.4
1984	8.1	9.7
1985	7.5	9.0
1986	10.2	12.2
1987	7.3	8.8
1993	5.3	6.3
1994	4.8	5.7
1995	5.5	6.5
1996	6.5	7.8
1997	8.9	10.7
1998	6.6	7.9
1999	6.9	8.3
2000	5.4	6.5
2001	6.9	8.2
2002	8.6	10.3
2003	7.9	9.5
2004	6.1	7.4
2005	5.7	6.9
2006	8.9	10.6

A flood frequency analysis was carried out using the 34 years of streamflow data. The Generalized Extreme Value distribution was used for both the fall and annual maximum daily flows. The fall period is assumed to be from September to February. The results of the analyses are presented in Table 3 and Figure 4. They indicate that, for example, the annual maximum daily Q_{200} (pre-wildfire) flow of 13.0 m^3/s will increase to a Q_{200} (post-wildfire) flow of 15.6 m^3/s. Because the frequency curves are so flat, a small increase in flow results in a significant increase the return period for that flow. For example, as illustrated in Table 3and Figure 4, the post-fire annual maximum daily flow of 11.5 m^3/s has a return period of 10 years, but the estimated post-fire annual maximum daily flow of 13.8 m^3/s has a return period of 50 years.

Table 3 Redfish Creek Flood Frequency Analysis Results

Return Period (year)	Fall Max Daily Flow (m^3/s)		Annual Max Daily Flow (m^3/s)	
	Pre-fire	Post fire	Pre-fire	Post-fire
2	1.2	3.5	7.0	8.4
5	2.2	4.8	8.6	10.3
10	3.1	5.8	9.6	11.5
20	4.1	7.1	10.5	12.6
25	4.5	7.5	10.7	12.9
50	5.9	9.1	11.5	13.8
100	7.5	11.2	12.3	14.7
200	9.5	14.3	13.0	15.6
500	12.9	19.3	13.9	16.7

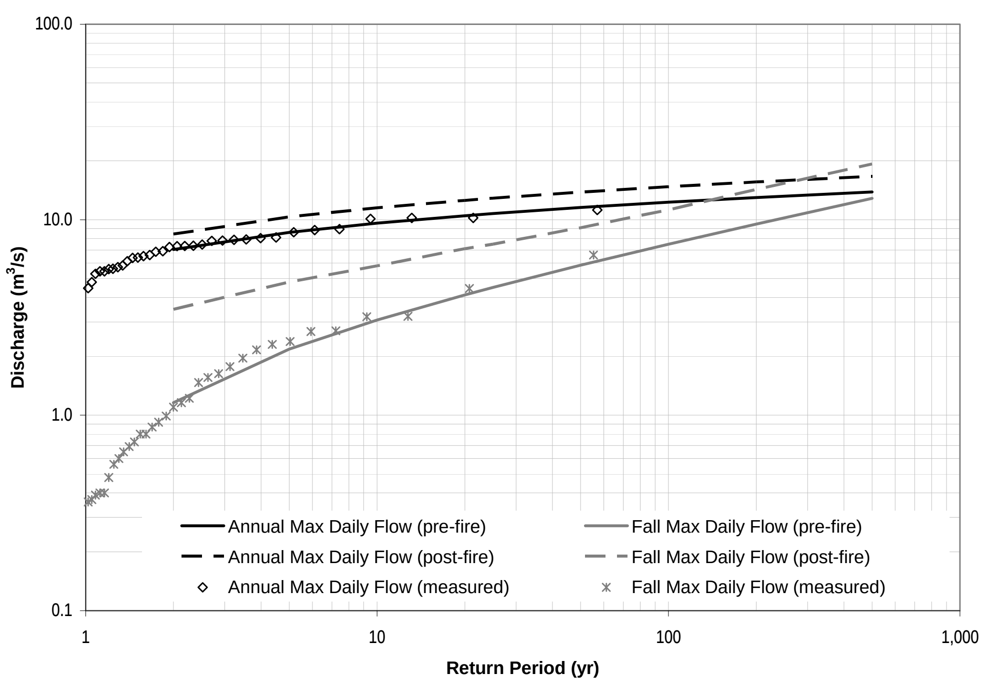


Figure 4 Redfish Creek Flood Frequency Analyses Results

Maximum daily flow values have been used in the flood frequency analyses described above. Maximum instantaneous flows have been recorded for Redfish Creek (Table 4). It is expected, that on average, the ratio of the maximum instantaneous flows to the maximum daily flows would be similar for both Redfish Creek and Sitkum Creek. On average the maximum instantaneous flows are 1.26 the maximum daily flows, with maximum and minimum ratios of 1.59 and 1.07 respectively.

Table 4 Redfish Creek Maximum Instantaneous and Daily Flow Data

Year	Maximum Instantaneous Flow (m^3/s)	Maximum Daily Flow (m^3/s)	Ratio of Instantaneous to Daily Flow
1968	12.9	11.2	1.15
1969	11.0	8.0	1.37
1970	10.3	7.8	1.32
1971	9.7	7.3	1.34
1972	12.1	10.1	1.20
1973	7.8	5.6	1.39
1974	11.6	10.2	1.14
1975	6.6	5.8	1.13
1976	7.3	6.4	1.13
1977	7.7	5.6	1.37
1978	9.5	7.4	1.29
1979	5.5	4.5	1.23
1980	12.3	7.9	1.55
1981	8.7	6.4	1.37
1982	9.5	7.3	1.30
1983	8.8	7.8	1.13
1984	11.9	8.1	1.47
1985	11.9	7.5	1.59
1986	14.9	10.2	1.46
1987	8.7	7.3	1.19
1993	6.4	5.3	1.21
1994	5.1	4.8	1.07
1995	6.4	5.5	1.18
1996	7.4	6.5	1.14
1997	10.3	8.9	1.15
1998	7.6	6.6	1.15
1999	8.4	6.9	1.22
2000	6.1	5.4	1.12
2001	8.0	6.9	1.17
2002	10.2	8.6	1.18
2003	9.0	7.9	1.14
2004	8.5	6.1	1.39
2005	7.0	5.7	1.22
		Maximum	1.59
		Average	1.26
		Minimum	1.07

3.4 Debris Flood Discharge Estimate for Sitkum Creek

A debris flood is a very rapid, surging flow of water, heavily charged with inorganic debris in a steep channel (Jakob and Hungr, 2005). A debris flow is similar except there is a larger concentration of inorganic debris and a lower water content. Both events carry similar quantities of organic debris. Debris flows can be 20 times larger than debris floods. The likelihood of debris floods has been increased on Sitkum Creek due to the burn extent and burn severity.

A debris flood could be initiated along the Sitkum Creek itself, or as a result of a debris flow from one of the tributaries either continuing down Sitkum Creek or creating a blockage of Sitkum Creek during a high water flow event. This blockage would likely be overtopped and create a debris flood, which could reach the Sitkum Creek fan.

Typically, debris floods can range from 2 to 3 times the magnitude of major water floods (Jakob and Hungr, 2005). For the present analyses a maximum debris flood flow at the Sitkum Creek fan has been assumed as 3 times the Q_{200} (post-wildfire) flow of 15.6 m^3/s, resulting in an estimated debris flood flow of 46.8 m^3/s.

3.5 Modelling of Sitkum Creek Fan Channel Capacity

The Sitkum Creek channel has been modelled to determine the effects of the increased flood flows and debris floods. Potential locations for channel avulsions and the capacity of the Highway 3A bridge have been investigated.

3.5.1 Topographic Data

As part of KCBL’s assignment, nine cross sections along Sitkum Creek were surveyed, along with some detailed bank topography, upstream of the Highway 3A bridge. This information was combined with LIDAR contour survey data, provided by BC Hydro, to create Drawing 2. The surveyed cross sections are labelled as A through I on this drawing. The survey cross sections, prepared by Sproulers’ Enterprises Limited under KCBL’s direction, are presented in Figure 5.

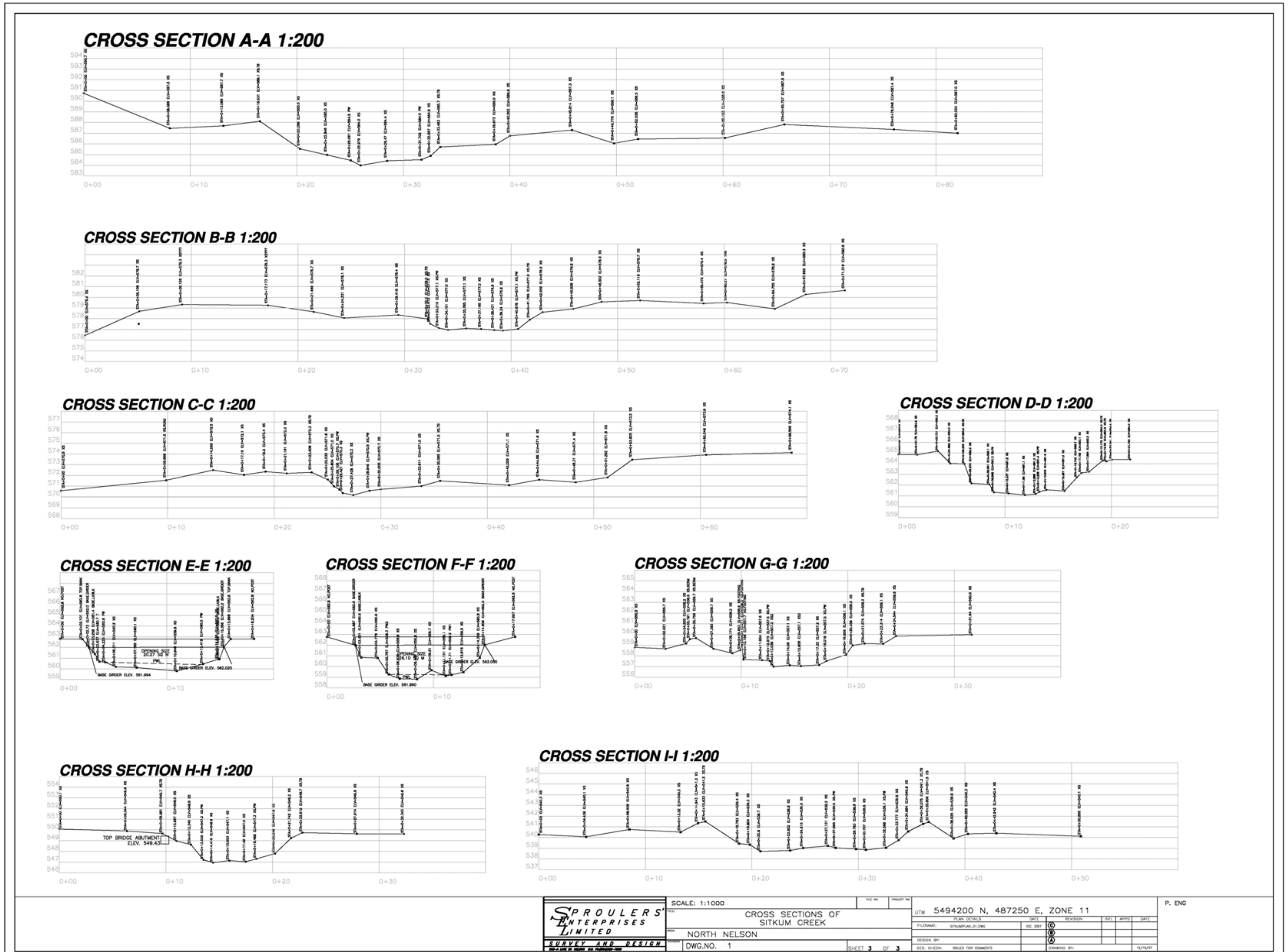


Figure 5 Sitkum Creek Survey Cross Sections (Sproulers' Enterprises Limited)

3.5.2 Model Description and Calibration

Sitkum Creek flows were modelled using the US Army Corps of Engineers HECRAS model. This model uses Manning's equation and standard step backwater calculations to determine water level and velocities in creeks and rivers. Turbulent flood flow conditions are difficult to simulate in any model, but the HECRAS model provides an analytical indication of relative flow levels. The model has been calibrated by knowing that during several of the peak flow events water spilled out of the channel immediately upstream of the bridge crossing (Section 3.1).

Based on the Redfish Creek streamflow gauge data, the 1968, 1972 and 1974 flood events on Sitkum Creek had maximum daily flows of 11.2 m^3/s 10.1 m^3/s and 10.2 m^3/s, respectively. The corresponding instantaneous flows were 12.9 m^3/s, 12.1 m^3/s and 11.6 m^3/s. It is assumed that the Sitkum Creek channel was near bankfull conditions at other locations along the creek during these same floods.

A peak flood event flow of 11.2 m^3/s was used for model calibration. This value was chosen since it was the highest recorded daily flow at Redfish Creek and is representative of the maximum floods on Sitkum Creek. Due to the numerous boulders in Sitkum Creek, and the relatively rough sinuous channel, Manning's "n" values of 0.2 and 0.25 were selected for the main channel and overbank areas, respectively.

To obtain flood levels consistent with observed spillage at the bridge (January 8, 2008 personal communication from Mr. Boyer) it was necessary to add 1.5 m to the calculated flood levels, immediately upstream of the Highway 3A bridge, and 0.7 m to the calculated flood levels for other reaches of the creek. This calibration adjustment was needed due to the highly turbulent flow conditions and likely transport of sediment and debris. This calibration adjustment was used for subsequent modelling of Sitkum Creek to provide an indication of expected water levels.

3.5.3 Creek Modelling Results

The Q_{200} (post-wildfire) flow of 15.6 m^3/s was modelled to determine if the Sitkum Creek channel could contain this flow. From the results of the model, this flow overtopped the creek banks by 0.2 m to 1.0 m at several locations, both upstream and downstream of the highway, see Drawing 2. The modelling assumed that there were no organic or inorganic debris dams impeding the flow. The calibration adjustment accounts for the normal transport of debris and sediment. These bank overtopping estimates should be considered as minimum values, and during a 200-year flood event the amount of overtopping could quite likely be higher.

Modelling of a debris flood was also carried out using the HECRAS model. As discussed in Section 3.4, the assumed maximum flow for a debris flood is approximately 3 times the Q_{200}, resulting in a debris flood flow of approximately 46.8 m^3/s. Modelling this flow resulted in a significant extent of creek bank overtopping both upstream and downstream of the highway, with overtopping depths varying from 0.3 m to 2.0 m, see Drawing 2. Therefore, based on this modelling, in the event of a debris flood it is expected that Sitkum Creek will overflow its banks at numerous locations.

3.5.4 Bridge Modelling Results

As part of KCBL's assignment, MoT requested that an estimate of the flow capacity and corresponding flood return period be determined for the existing Highway 3A bridge (see Photo 2). Based on the flood frequency analyses presented above, and the surveyed opening beneath the Highway 3A bridge, prior to the Sitkum Creek wildfire, it is estimated that the bridge could carry a 20 to 50-year return period flood. This estimate has no freeboard allowance and has a small amount of water flowing over the highway and splashing on the bridge deck. Due to the increase in maximum daily flows resulting from the Sitkum Creek wildfire, it is estimated the bridge can pass a 5 to 10-year return period flood under the same conditions of no freeboard allowance. MoT are investigating various mitigation and risk management options for this bridge.

Photo 2 Upstream side of Highway 3A bridge (September 12, 2007)

3.6 Other Affected Infrastructure

Power, cable and telephone poles are located across the fan on both sides of Highway 3A. Due to the dispersed nature of overland flow and the unpredictability of where overland flows will occur, and how they will concentrate, it is not possible to predict which poles might be affected by future floods and debris floods. Nelson Hydro, Shaw Cable, and Telus should be made aware that the wooden poles on the Sitkum Creek fan could be affected by a flood or debris flood event..

Two community water supply intakes are located on the Sitkum Creek fan, one near the apex of the fan (400 m upstream of the Highway 3A bridge, see Photo 3), and another 100 m upstream of the bridge, see Photo 4. Both these intakes could be affected by sediment laden water or could be washed out by a significant flood or debris event.

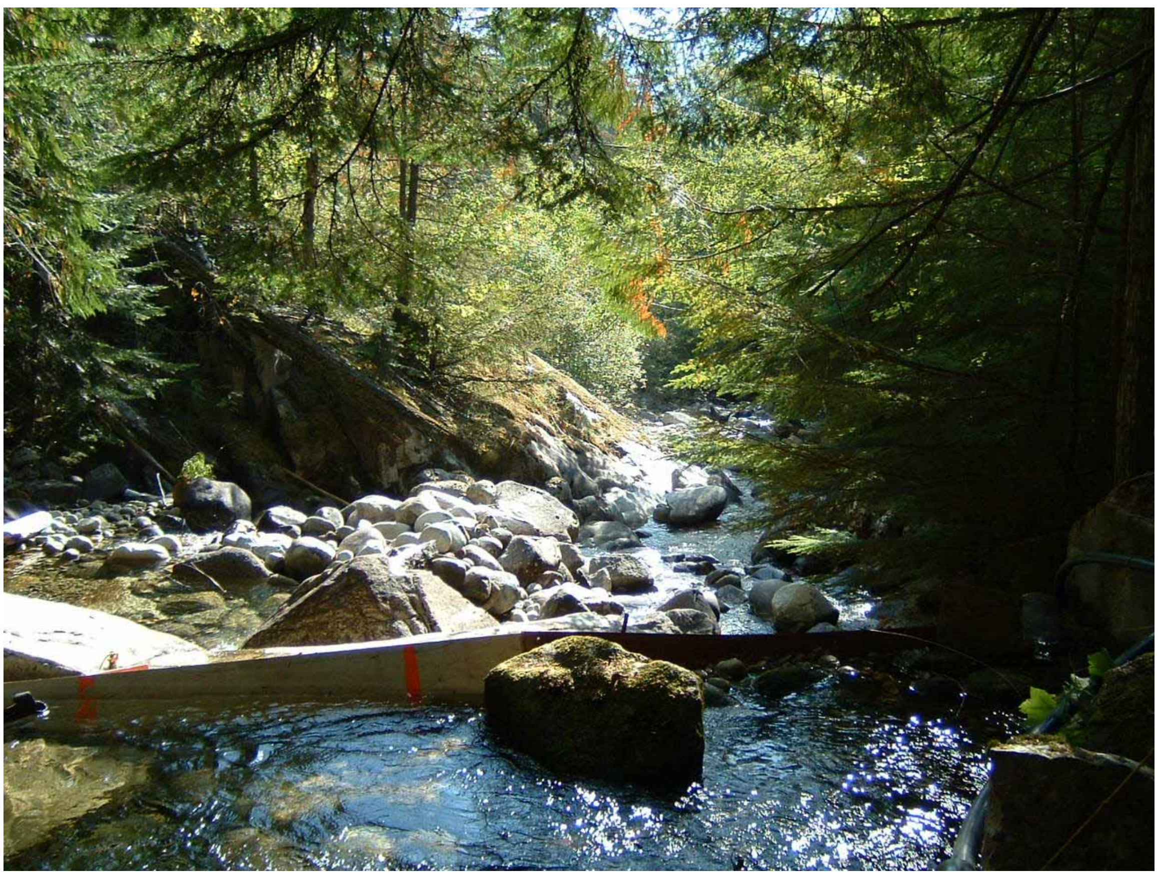


Photo 3 Community water intake near apex of fan 400 m upstream of Highway 3A (September 12, 2007)

Photo 4 Community water intake 100 m upstream of Highway bridge (August 28, 2007)

Terasen Gas have a 150 mm diameter gas pipeline buried in the downslope shoulder of Highway 3A. This pipeline is suspended from the downstream superstructure of the bridge (Photo 5). The pipeline is steel, where suspended from the bridge, and plastic in the shoulder of the road. The gas is at its distribution pressure of 60 psi (March 4, 2008 personal communication with Mr. Russ Arnott). Terasen Gas should consider placing a protective plate over the suspended pipeline so that if the bridge were overtopped by water and/or debris, there would be some protection for the suspended pipeline. Rev 080506

Photo 5 Terasen Gas pipeline on the downstream superstructure of Highway 3A bridge (August 28, 2007)

3.7 Snow Avalanche Assessment

The nhc/TCL 1990 report mentions the possibility of snow avalanche hazards in the Sitkum Creek basin. MoF (November 30, 2007 personal communication from P. Jordan) have indicated that the east side of the watershed has experienced snow avalanches but that these have not resulted in flood or debris flood events on the creek. The west side of the watershed, which has been burned, is flatter and less prone to snow avalanches. In addition, according to MoF, should a snow avalanche occur on the west side of the watershed it would likely travel into forested lower slopes, or if it reached the creek, it would do so where the creek is wider and less confined.

Based on the above, the potential for a snow avalanche leading to in a flood or debris flood event on Sitkum Creek is considered low.

3.8 Hazard Area Delineation

The analyses presented above confirm that Sitkum Creek is a flood and debris flood prone fan with a high hazard rating. The Sitkum Creek Fire N70347 has increased the frequency of flood and debris flood events and increased the magnitude of floods.

Based upon the results of the analyses, and a review of the fan topography, it is recommended that the existing hazard boundaries, shown on Figure 2 and Drawing 2, should be maintained, as is. These boundaries are subject to the RDCK Floodplain Management Bylaw No. 1650 requiring a professional engineer or professional geoscientist assessment report in areas “E” and “F”. Hazard assessments on this fan need to take into account findings from previous studies, the elapsed time since the fire occurred, the hydrological recovery of the burn area, and any MoF reports on the status of the burn area.

4. RECOMMENDATIONS

Based on the information presented in this report KCBL provides the following recommendations.

1. Within the hazard area delineated on Drawing 1, the RDCK, MoT and ILMB should request a landslide assessment by a qualified professional engineer or professional geoscientist prior to allowing development.

2. The extent of the hazard area shown on Drawing 1 should be reviewed and modified as hydrological recovery of the burned areas takes place.

3. MoT and Telus should be informed of the hazards to their infrastructure within the hazard area shown on Drawing 1.

4. MoT should investigate various mitigation and risk management options for the Highway 3A bridge over Sitkum Creek.

5. Nelson Hydro, Shaw Cable, and Telus should be informed that the wooden poles on the Sitkum Creek fan could be affected by a flood or debris flood event.

6. Both community water supply organizations on Sitkum Fan should be advised that their intakes on Sitkum Creek could be affected by sediment laden water or the intakes could be damaged out by a significant flood or debris flood.

7. Terasen Gas should consider placing a protective plate over their suspended pipeline on Highway 3A bridge at Sitkum Creek, so that if the

bridge were overtopped by water and/or debris, there would be some protection for the pipeline.

8. Based upon the results of the analyses, and a review of the Sitkum Fan topography, it is recommended that the existing hazard boundaries, shown on Figure 2 and Drawing 2, should be maintained, as shown.

Should you have any questions with any of the above, please don't hesitate to contact the undersigned.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Richard F. Rodman, P.Eng.
Manager, Nelson Office

Attach.	Drawing 1	Springer Creek Fire Burn Severity and Hazard Area
	Drawing 2	Sitkum Creek Fan
	Two CD's:	1 with Report and 1 with Drawing Files

REFERENCES

Curran M (2007), “Springer Fire N50372: Erosion Risk Mitigation Options and Hillslope Soil Mitigation Treatment Plan ”, internal BC Ministry of Forest and Range, Kootenay Lake Forest District Report, dated September 23.

Curran, M. (1990), Chow, B., Toews, D., Boyer, D.,. “Landslide Study – Cape Horn Bluffs Area Detailed Report” for the Ministries of Forests and Environment, July 20.

Jakob M. and Hungr O. (eds). 2005. Debris-flow Hazards and Related Phenomena. Praxis, pp 363-385. [[need the chapter and author]]

Jordan P.(2007), Glunns D., Curran, M., Covert, A., “Sitkum Creek Fire, 2007, N70347 Post-Wildfire Risk Analysis”, internal Ministry of Forests Report, September 17.

Klohn Crippen 1998. “Terrain Stability Inventory, Alluvial and Debris Torrent Fans, Kootenay Region”, for Ministry of Environment, Lands and Parks, PW 757601, February.

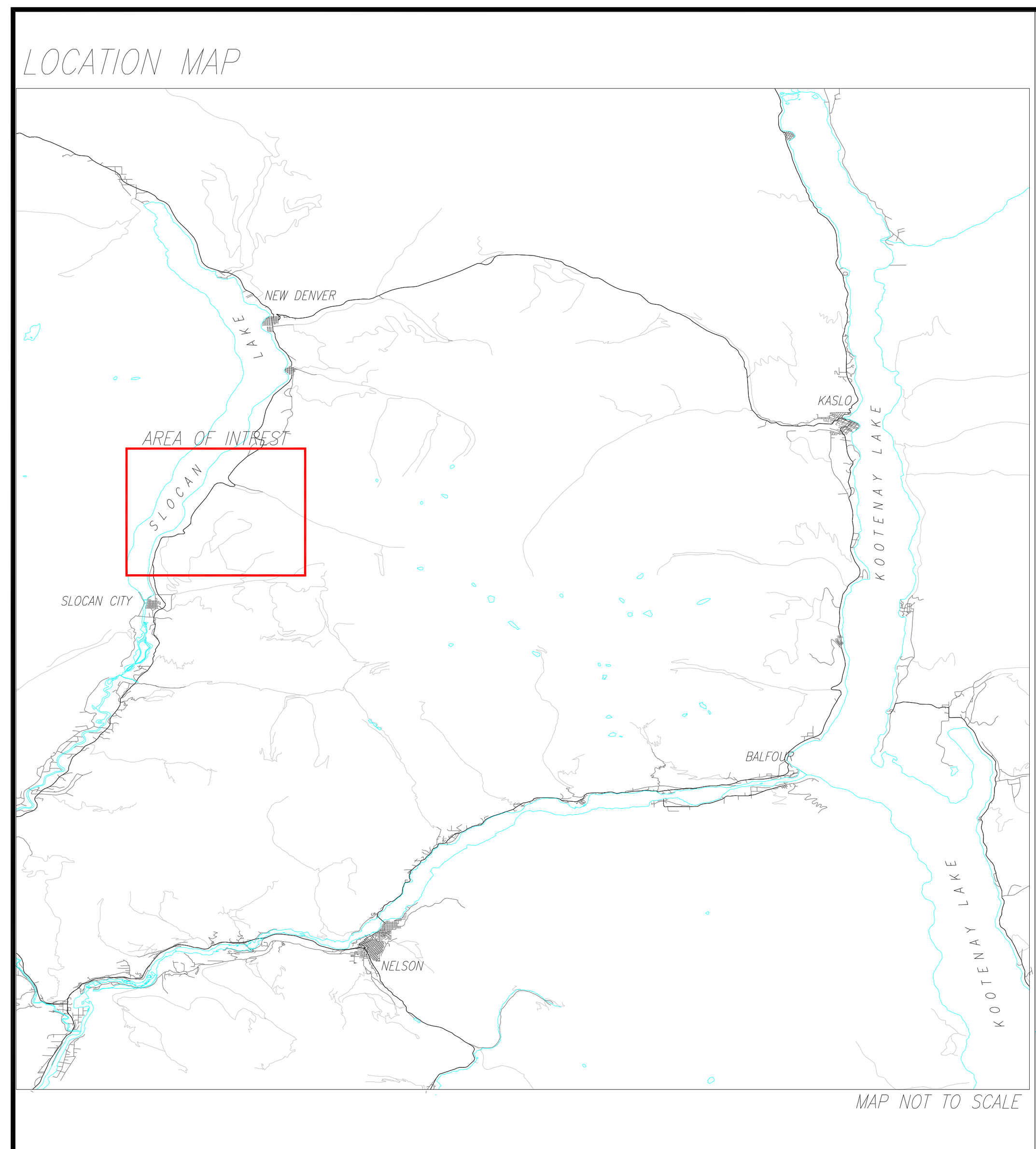
Nicol D.R (2008), “Springer Creek Fire Number 50372 Long Term Risk Analysis Draft”, Prepared for Ministry of Forests and Range South East, D.R.Nicol Geotech Engineering Ltd., February 7.

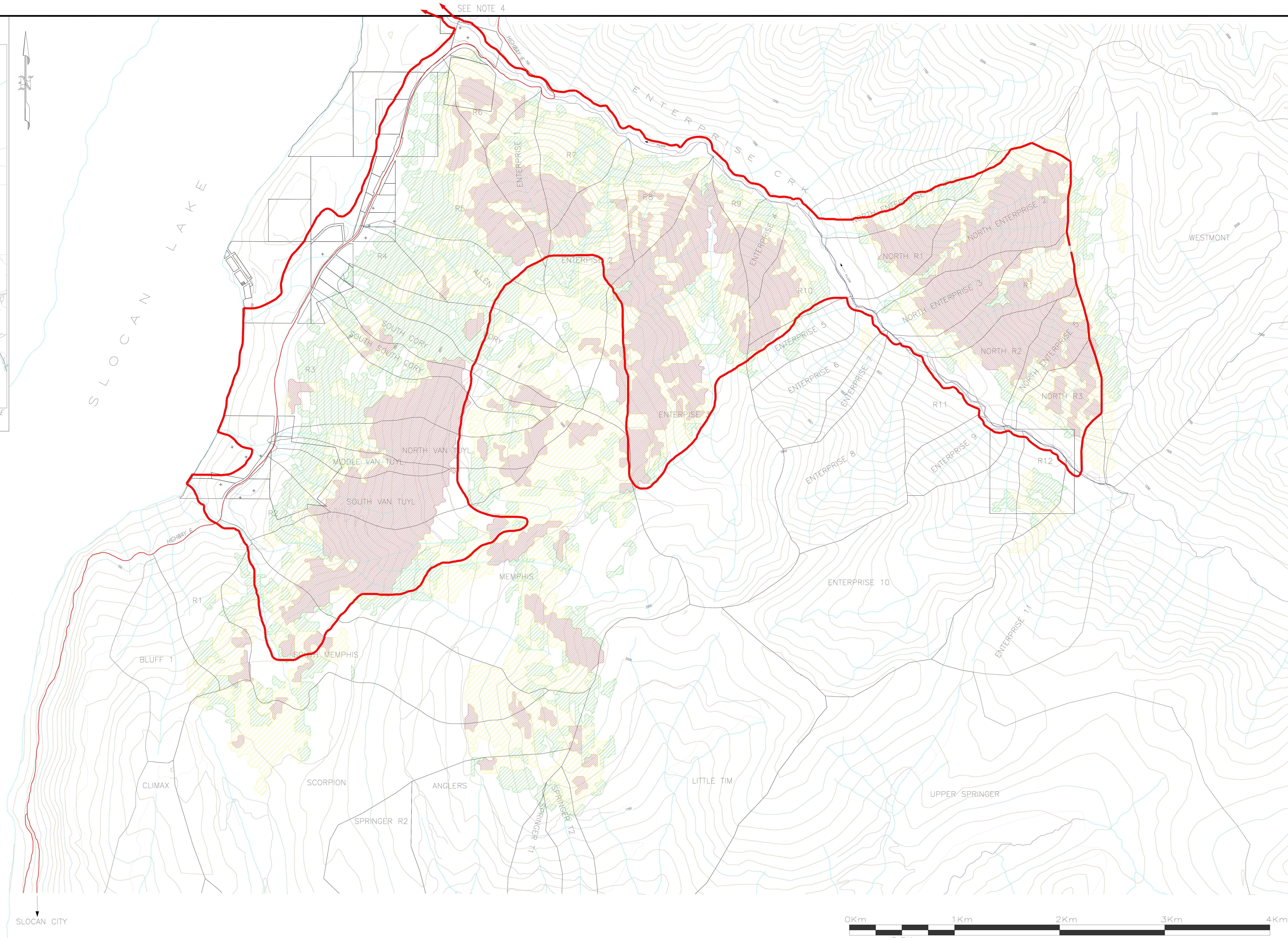
Nicol, D.R. (2007), Jordan, P., Deschenes M., Curran M., Covert A., “Springer Creek Fire Post-Wildfire Risk Analysis”, for Ministry of Forests, September 1, Updated September 14.

Northwest Hydraulic Consultants Ltd. and Thurber Consultants Ltd. (nhc/TCL), "Alluvial Fan Hazard Assessment, Regional District of Central Kootenay Electoral Area "E" & "F", April 1990.

VanDine, D.F. 1985. “Debris flows and debris torrents in the Southern Canadian Cordillera”. Canadian Geotechnical Journal, v. 22, pp. 44-62 [[not referred to in text]]

DRAWINGS





TO BE READ WITH KLOHN CRIPPEN BERGER LTD REPORT DATED MARCH 21, 2008

SCALE 1:20000 CONTOUR INTERVAL 50m

- LOW BURN SEVERITY
- MODERATE BURN SEVERITY
- HIGH BURN SEVERITY
- CADASTRAL BOUNDARY
- WATERSHED BOUNDARY
- HIGHWAY 6
- EXISTING HOUSE/ FOUNDATION

HAZARD AREA – BOUNDARY FOR NON-STANDARD FLOOD AND EROSION. REQUIRES PROFESSIONAL LANDSLIDE HAZARD ASSESSMENT.

SOUTH VAN TUYL – WATERSHED NAME

NOTES:

1.) BURN AREAS, WATERSHED BOUNDARIES, EXISTING HOUSE/ FOUNDATIONS AND DEM PROVIDED BY ILMB (INTERGRATED LAND MANAGEMENT BUREAU) & MOF
2.) CADASTRAL BOUNDARIES PROVIDED BY RDCK
3.) CONTOUR INFORMATION WAS CREATED BY SPROULERS ENTERPRISE LTD, FROM DEM MODEL.
4.) HAZARD AREA TO CONTINUE TO SLOCAN LAKE ALONG ENTERPRISE CREEK, 50m ON EITHER SIDE OF CREEK CENTERLINE

CLIENT
PROVINCIAL EMERGENCY PROGRAM

Klohn Crippen Berger

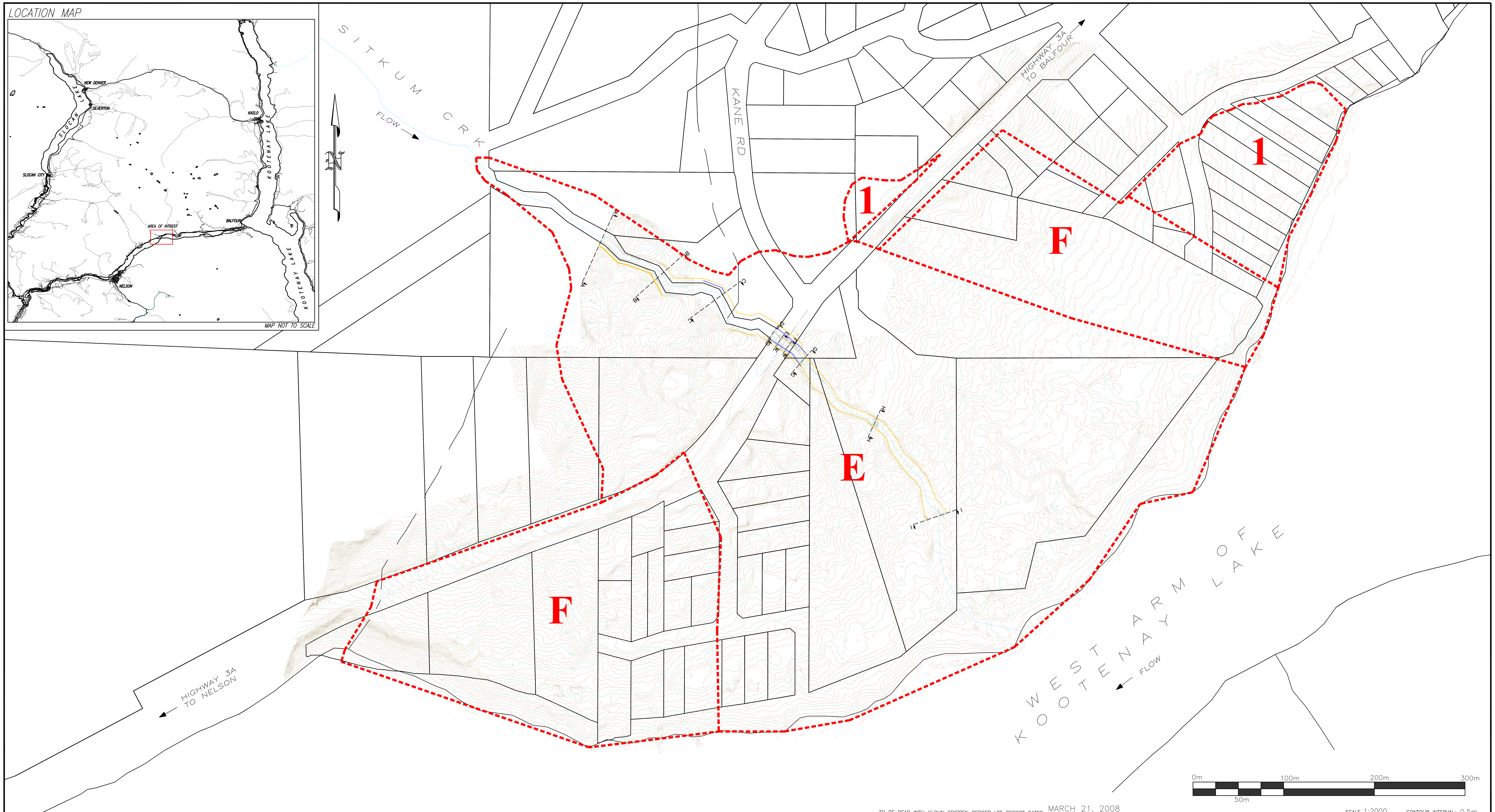
PROJECT
POST WILDFIRE HAZARD ASSESSMENTS

TITLE
SPRINGER CREEK FIRE BURN SEVERITY AND HAZARD AREA

PROJECT No. M09468A01 01 | Drawing 1 | REV. –

KCC-DM

CANCEL PRINTS BEARING PREVIOUS REVISION



TO BE READ WITH KLOHN CRIPPEN BERGER LTD REPORT DATED MARCH 21, 2008

SCALE 1:2000 CONTOUR INTERVAL: 0.5m

A ⊥— — —⊥ A SURVEYED CREEK CROSS SECTION

E RDCK NON–STANDARD FLOOD AND EROSION DESIGNATION

RDCK NON–STANDARD FLOOD AND EROSION BOUNDARY

CADASTRAL BOUNDARY

MODELLED BANK OVERTOPPING FOR POST–FIRE 200 YEAR FLOOD

MODELLED BANK OVERTOPPING FOR POST–FIRE DEBRIS FLOW

NOTE:

1.) CONTOUR INFORMATION PROVIDED BY BCHYDRO AND SUPPLEMENTED BY GROUND SURVEY

2.) CADASTRAL BDY AND FLOOD & EROSION BDY PROVIDED BY RDCK

CLIENT
PROVINCIAL EMERGENCY PROGRAM

Klohn Crippen Berger

PROJECT
POST WILDFIRE HAZARD ASSESSMENTS

TITLE
SITKUM CREEK FAN

PROJECT No. M09468A01 01

Drawing 2

REV. –

CANCEL PRINTS BEARING PREVIOUS

CD's

Report and Drawing Files