Suite #3, 385 Baker Street
Nelson, BC, V1L 4H6
250 509 1009

BC Ministry of Forests, Lands, and Natural Resource Operations and Rural Development

POST-WILDFIRE NATURAL HAZARDS RISK ANALYSIS SYRINGA COMPLEX FIRES (N52497, N52489, N52548 – 2018)

December 13, 2018

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1. Introduction and methods

The Syringa Complex is a group of three wildfires above Lower Arrow Lake which started on August 11 to 12, 2018, and were mostly contained by September 12, with the arrival of cool, rainy weather. The Syringa Creek fire, N52548, burned 3193 ha; the Deer Creek fire, N52489, burned 3849 ha; and the Bulldog Mountain fire, N52497, burned 2227 ha.

SNT Geotechnical Ltd. was retained by the Southeast Fire Centre to do a reconnaissance risk analysis of the three fires. This work consists of two parts. First, a preliminary report using a standard form gives a brief summary of the burned areas, hazards, and risks, along with burn severity maps. This was submitted on November 26, and is included with this report as Appendix B. Second, a follow-up report (this document) gives background information, and further details on the hazards and risks. It includes a detailed risk analysis for areas where significant risks were identified, based on field inspections of elements at risk. The detailed risk analysis includes, where relevant, recommendations for mitigation measures (Appendix C).

Burn severity maps are used to assess the potential hydrologic effects of the fire in each watershed, due to forest cover and soil changes. These are BARC (Burned Area Reflectance Classification) maps based on satellite imagery taken before and after the fire, which show vegetation burn severity. The definitions of high, moderate, and low vegetation burn severity (VBS) are given in Hope et al. (2015) and Parsons et al. (2010), as well as the procedure for preparing a burn severity map. Briefly, the vegetation burn severity categories are:

High – trees dead, needles, twigs, and understory consumed;
Moderate – trees dead, scorched needles remain on trees, and understory burned; and
Low – canopy mostly unburned and understory lightly burned.

Soil burn severity (SBS) is similarly classified as high, moderate, or low, and is based on the extent of consumption of the forest floor and fuels on the ground, and on the extent of exposed bare soil. Although it tends to be correlated with vegetation burn severity, it can only be accurately assessed by field observations:

High – forest floor and near-surface roots consumed, mineral soil structure altered;
Moderate – litter consumed, duff partly consumed or charred, mineral soil unaltered; and
Low – litter scorched or partly consumed, often with patchy forest floor burn.

Burn severity maps are prepared in-house by MFLNRO specialists in remote sensing and GIS. A burn severity map for the Bulldog Mountain fire was available on October 1, but maps for the Deer Creek and Syringa Creek fires were not available until October 29, as suitable satellite images were not obtained due to cloud cover. The map for the Syringa Creek fire has some missing areas due to valley cloud. On some steep north and west facing slopes in the Syringa and Deer Creek fires, the burn severity polygons may be inaccurate due to strong shadows in the post-fire image.

The authors did an initial inspection by helicopter on October 3, during which photographs were taken of the burned areas and downslope features which might be at risk. Field work on the ground was done on October 4, in road-accessible areas of the Deer Creek and Syringa Creek fires, and a follow-up trip was made on October 26 to inspect properties on Broadwater Road below the Syringa Creek fire which are potentially at risk. No ground-based field work was done on the Bulldog Mountain fire, as it is more difficult to reach by road, and no significant risks were identified during the aerial inspection. A LiDAR hillshade image covering lower Pup Creek and part of Bulldog Mountain was made available by BCTS.

Watershed boundaries were mapped on 1:20,000 base maps with 20 m contours. In part, these were based on computer-generated drainage divides identified in the "BC Watershed Atlas" (available on iMap BC and online databases). Larger watersheds were subdivided into tributary watersheds where necessary, to identify areas draining to specific elements at risk (e.g. domestic water intakes below the Bulldog Mountain fire). Intervening slopes between creek watersheds were identified as face unit drainage areas; these typically have few identifiable stream channels, but may have small gullies or drainage features too small to map separately. Arbitrary names were assigned to watersheds where no known names were available on published maps. A table of all the watershed data is given in Appendix D.

Maps of the three fires are appended to this report (Appendix A). They show burn severity, watershed boundaries, and other information based on the BC Government data warehouse and other sources (see metadata in the References section below). This includes "structures" (most of which are homes); however, the available data are incomplete. Many homes in areas of interest are missing from the database; these were added manually, based on orthophotos and on photos taken during the aerial inspection. Some other structures shown in areas of interest do not exist, or are minor outbuildings.

Mapping of potential post-wildfire hazards and the analysis of risks followed the general methodology outlined in Hope et al. (2015). In the 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 highway) with consideration to the spatial and temporal probability but not the value or vulnerability of the elements at risk. Detailed risk analysis involves inspections of individual sites. Subjective terms (low, moderate, high) are used to describe hazard and risk, based on generally accepted definitions used in other risk analysis studies and mapping projects in British Columbia (Hope et al., 2015). The qualitative risk matrix used for the determination of partial risk in this study is shown below (Figure 1).

P(HA), annual probability (likelihood) of occurrence of a specific hazardous landslide and it reaching or otherwise affecting the site occupied by a specific element		**$P(S{:}H) \times P(T{:}S)$ Probability (likelihood) that the landslide will reach or otherwise affect the site occupied by a specific element, given that the landslide occurs**		
$P(HA) = P(H) \times P(S{:}H) \times P(T{:}S)$		**High**	**Moderate**	**Low**
P(H), annual probability (likelihood) of occurrence of a specific hazardous landslide	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*

Figure 1. Qualitative risk matrix for partial risk (Wise et al, 2004. Land Management Handbook 56)

2. Terrain and watershed conditions

The three fires cover mostly hilly terrain, ranging in elevation from about 700 m on the lower slopes above the lake, to about 1400-1700 m on the ridgetops. The major creeks, such as Syringa, Tulip, Deer, and Dog (the headwaters of which are unburned) include subalpine and alpine terrain above 2000 m. The geology consists mostly of competent granitic rocks, with some metasedimentary rocks in the Deer Creek area. All three fires include areas of steep, mostly unvegetated, bedrock – these are especially prominent in the eastern part of the Syringa Creek fire, where steep granite cliffs occupy the lower slope areas. Otherwise, most of the area is covered by coarse to medium-textured soils of morainal and colluvial origin.

Most of the burn areas are (or were) forested; biogeoclimatic zones include ICHxwa, ICHdw1, and ICHmw5, and common tree species are Douglas fir, ponderosa pine, lodgepole pine, and western larch. The area has a history of extensive logging. Many of the burn areas include immature plantations and recent clearcuts, with the exception of Syringa Provincial Park.

Residential development is mostly on glaciofluvial terraces bordering Lower Arrow Lake, or on gently sloping deltas or fans at the mouths of the large creeks. These include the communities of Deer Park at the mouth of Deer Creek, Renata at the mouths of Dog and Renata Creeks, and Brooklyn at the mouth of Pup Creek. Below the eastern part of the Syringa Creek fire, there is residential development on the steep, debris flow dominated, alluvial fans of Allandale and Irwin Creeks. A campground and other facilities of Syringa Provincial Park occupy part of the fans of Syringa Creek and several smaller creeks, and intervening terraces. There is a condominium development and marina just east of the Syringa Creek fan.

Streamflow is dominated by spring runoff. On larger streams which include subalpine areas, such as Deer Creek, summer and fall rains seldom or never cause flows as high as typical spring peaks. However, on small, lower-elevation streams, summer or fall rainstorms can cause localized floods. Deer Creek is the only gauged stream in the area; its hydrograph is shown below (Figure 2).

3. Potential hazards as a result of the fire

Debris flows and floods following wildfires can occur as a result of high-intensity rainfall on severely burned and/or water-repellent soils, typically in mid to late summer. Examples of past events in BC include the Kuskonook Creek debris flow near Creston, and debris floods in Kelowna and near Falkland, which followed the 2003 wildfires. 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 greater snowfall accumulation and rapid snowmelt in burned areas. Examples include several debris flows which followed the 2007 Springer fire near Slocan. They can also occur, although less commonly, during fall or early winter rain-on-snow events; for example, several debris flows which followed the 2003 Ingersoll fire near Burton.

In the Syringa complex fires, potential debris flow and flood hazards are most likely to result from spring snowmelt. On the larger watersheds of Syringa, Tulip, and Deer Creeks, significantly increased flood flows in spring are unlikely, as spring runoff is dominated by higher elevation areas which were unburned. On smaller and/or lower elevation watersheds, increased spring peak flows can be expected where there are substantial areas of moderate or high burn severity. These include most watersheds in the Syringa fire, Broadwater Creek in the Deer Creek fire, and Brooklyn Creek in the Bulldog Mountain fire. Except for "Campground 1 and 2" creeks in Syringa Provincial Park, most of these smaller watersheds have had extensive logging in their headwaters, and increased spring peak flows due to clearcut areas are probably more significant than the incremental increase due to the fires.

The small, steep watersheds in the east part of the Syringa Creek fire could also be subject to floods or debris flows from short-duration, high-intensity, rainfall events. The incremental effect of the fire is limited, however, as burn severity is mostly moderate and low. The area has "gentle-over-steep" topography, and the upper plateau has extensive past and recent logging. Possible drainage diversions due to roads are an important factor in this area, as there is an extensive network of old roads, which are now mostly deactivated and/or overgrown. Two previous landslide incidents occurred in this area – a large debris flow in 1999 was caused by a road drainage diversion, and a debris slide in 2012 was not related to development.

Soil burn severity data were collected at seven field plots, five in the Deer Creek fire and two in the Syringa Creek fire. Generally, soil burn severity was relatively high, compared to that typically observed in previous years for fires in this region. At all high and moderate burn severity plots, water repellency was observed. Although not a necessary condition, water repellency makes it more likely that overland flow will be generated during high-intensity rainfall. High soil burn severity also causes reduced infiltration capacity and therefore susceptibility to overland flow, even without water repellency. In areas of moderate and low vegetation burn severity, needle fall from the dead trees creates an effective mulch, which tends to slow down surface runoff and promote infiltration.

Soil erosion can be a significant process in high soil burn severity areas, due to exposed bare soil and lack of a protective litter and duff layer. Increased sediment load during flood events can contribute to drainage diversions, by blocking culverts and ditches. It can also contribute to the likelihood of debris flows in steep watersheds. Soil erosion on its own can cause water quality impacts if sediment reaches a creek. In the west fork of Deer Creek, a large area of high burn severity could cause erosion which could contribute sediment to the creek. In Brooklyn Creek, burn severity in recent cutblocks appears to be unusually high (as viewed from the air; see photos following); local soil erosion could block ditches and culverts on the road, and cause possible water quality impacts.

4. Potential risks as a result of the fire

The values which are potentially at risk from the fire include the following items. These are discussed more specifically for each of the three fires below, and are summarized in the reconnaissance risk analysis tables (Appendix B). High risks are found only in the east part of the Syringa Creek fire. A field review was made of sites at risk in this area; see Appendix C.

- Broadwater Road, which accesses the Syringa Creek area and Deer Park and the Deer Creek Forest Service Road;
- Private homes and properties along Broadwater Road east of Syringa Creek, in the communities of Renata and Brooklyn, and in isolated locations near or within the Deer Creek fire;
- Syringa Provincial Park facilities, including the campground and boat launch area;
- Domestic water quality in creeks downstream from burned areas; and
- Recreation trails near Bulldog Mountain.

4.1 Syringa Creek Fire (N52548)

4.1.1 Tulip Creek: The Tulip Creek watershed has 12% moderate and high severity burn, mostly concentrated in two small tributaries. The higher elevation headwaters are unburned; much of the higher elevation area has been logged. The incremental effect of the burn on peak flows is probably very low, although there could be a flood or debris flow hazard in the burned tributaries. There is no development on the Tulip Creek fan, other than the Deer Creek FSR crossing and a short trail leading to Tulip Creek falls.

4.1.2 Campground watersheds and adjacent faces: The headwaters of "Campground Creek 2" has been partly burned (59% total) at low and moderate severity (Photo 2). It has a forested alluvial fan which was probably formed by debris flows, but has no evidence of recent activity. The creek is incised about 3.5 m in a stable channel, and crosses both the campground access road (old highway) and the Deer Creek FSR in 900 mm culverts. Campground facilities are located east and west of the fan. Debris flow and flood hazards due to the fire are considered to be low and partial risk to the campground is low.

"Campground Creek 1" is smaller and does not have an obvious fan. Its watershed and the adjacent faces to the east and west have only small patches of low and moderate burn severity. Hazards due to the fire are very low. The lower part of the face is shown as "missing" on the burn severity map, as this area was concealed by cloud when the satellite imagery was obtained. As seen from the air, it is mostly unburned with a few small patches of low severity burn (Photo 1)

4.1.3 Syringa Creek fan: The watershed of Syringa Creek is 19% burned at moderate and high burn severity, mostly at mid elevation (1200 to 1700 m). The higher elevations (to 2100 m), which dominate spring snowmelt runoff, were not burned. The hazard of increased peak discharge due to the fire is considered low. The creek channel is stable on its fan (incised 3 to 4 m near the mouth). The partial risk to facilities on the fan, and to Broadwater Road, is low.

4.1.4 Broadwater Road between Allandale Creek and Syringa Creek: The road, and the marina and condominium complex 300 m east of Syringa Creek, are at low to very low risk from effects of the fire. They are separated from the steep, mostly unburned, slopes above by a broad terrace 100 m (vertical) above the road. There is a small burned patch on the terrace which is outside the mapped fire perimeter.

4.1.5 Allandale Creek: There are about 10 properties along Allendale Crescent, on the fan of Allandale Creek. The upper part of the watershed has been burned at low and moderate severity, and most of it has been logged over about the last 30 years. There is an active mainline road, and many spur roads, most of which are overgrown and/or have been deactivated. The burned area has slightly increased the hazard, already present due to the logging history, of increased peak flows during spring snowmelt, and there is a possibility of drainage diversions into or out of the watershed by roads. There is a hazard, considered low to moderate, of a debris flow in the steep lower channel resulting in a low to moderate partial risk to the houses (public safety).

Near the apex of the fan, the creek banks are low, and there is a moderate hazard of an avulsion of the creek caused by high flows or additional gravel deposited in the channel. This hazard existed before the fire, and the fire has increased the hazard slightly. (See Appendix C for more information.). The resulting partial risk to houses as a result of flooding/stream avulsion is considered high. The consequences are not likely life threatening (nuisance flooding).

4.1.6 Broadwater Road between Irwin Creek and Allandale Creek: Two landslides are known to have impacted the road in the past, in 1999 and 2012 (Figure 3). One of these was caused by a road drainage diversion. Two steep drainages, "Landslide Creek" (site of the 1999 event) and "Unnamed East Creek" intersect Broadwater Road. Most of the upper plateau which has not been recently logged has been burned, at moderate severity with some patches of high severity. Debris flow hazard is moderate (pre-existing, somewhat increased by the fire), and partial risk to the road is high. The intervening steep faces were not affected by the fire.

4.1.7 Irwin Creek: There are three properties on the steep fan of Irwin Creek. (The name is not shown on maps, but water licenses use that name.) The creek is deeply incised on the right (west) side of the fan, and the houses are at low risk. Only a small part of the watershed is burned, mostly at low severity. The partial risk to a water intake system located above the fan apex is considered moderate. (See Appendix C for more information.)

4.2 Deer Creek Fire (N52489)

4.2.1 Deer Creek flooding and water quality: The west fork of Deer Creek has been extensively burned (34% moderate and high severity). Some increase in peak flow is likely. Sediment and ash could enter the creek from an area of high severity burn above its right (west) bank (Photos 5 and 13). The west fork is only about 16% of the total watershed area of Deer Creek, so its contribution to peak flows is minor. The larger east fork has some small areas of high severity burn on steep slopes (Photo 6) which also could contribute some sediment locally. The riparian zone of both the east and west forks is unburned.

There is a small possibility of water quality impacts on Deer Creek, from sediment and ash introduced from high burn severity areas. This would most likely occur in the first year after the fire, in early spring, or during summer rainfall events.

4.2.2 Broadwater Creek: There are several houses near the mouth of Broadwater Creek (Photo 7). The upper part of Broadwater Creek has been burned at low and moderate severity. Most of the burned area is in immature plantations. The incremental effect of the fire on peak flows is likely to be small.

4.3 Bulldog Mountain Fire (N52497)

4.3.1 Churchill Creek and lower Pup Creek face: Churchill Creek is a small tributary of Pup Creek, entering just above the community of Brooklyn (Photo 8). It has 23% moderate and high severity burn, in the upper part of the watershed. There is a cutblock planned in this area, which would include most of the moderate and high severity burn. There is some potential for debris flows in the steep creek channel, although from the LiDAR imagery, it appears that past events have stopped on a bench in the valley below, and not reached Pup Creek. The hazard of a debris flow which could reach Pup Creek is considered low. Houses at Brooklyn are separated from the steep slopes to the southwest by a dissected terrace and by a broad area of flat land at the mouth of Pup Creek and so the partial risk is very low.

4.3.2 Water quality in Pup Creek: There is an extensive area of mostly moderate burn severity in Brooklyn Creek, on the southeast side of Bulldog Mountain. Much of the burned area is in recent cutblocks (Photos 10 and 11). There is some potential for sediment to be introduced to Brooklyn Creek by erosion from the burned area or the logging road below. The incremental hazard due to the fire is considered low; previous erosion and a landslide from the road, and a failure several years ago on the old rail grade, are probably responsible for most sediment in Brooklyn Creek.

4.3.3 Water quality in Dog Creek, and hazards at Renata: There are several houses on the east side of lower Dog Creek, below the northwest part of the fire (Photo 9). The burn on the slope consist only of small patches, and hazards due to the fire are very low. As Dog Creek is a large watershed and only a very small part of it has been burned, effects on peak flow and water quality are likely to be negligible. The partial risk to houses is low.

4.3.4 Recreation sites and trails: The Bulldog Tunnel is a significant historical feature on the Columbia & Western rail trail. Small areas of mostly moderate burn severity are above the tunnel entrances on both sides, but the incremental hazard of landslides that could affect the rail grade are considered low. A landslide several years ago from the logging road on the slope above came close to the tunnel entrance (Photo 11).

The natural arch recreation site and trail is just west of Brooklyn. The arch is in the canyon of a small steep creek ("Arch Creek"). Hazards due to the fire are low, as the burned area on the plateau above is small.

5. Closure – Report Use and Limitations

This report was prepared for the exclusive use of the MFLNRO. The material in it reflects SNT Geotechnical Ltd.'s best judgment and professional opinion 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 decision to be made based on it are the responsibility of such third parties. SNT Geotechnical Engineering Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decision made or action based, or lack thereof, on this report. No other warranty is made, either expressed or implied. The report and assessment have been carried out in accordance with generally accepted professional practices in B.C. The discussion and recommendations presented are based on available information and limited field investigation and inferences from surficial features. No subsurface investigation was carried out as part of this assessment or development of conclusions or recommendations. Inherent variability in local precipitation, run-off conditions, soil and vegetation burn severity, surface and subsurface conditions may create unforeseen situations. Property fire numbers and boundaries (private, municipal, reserve, crown) referred to on maps and in the text were obtained via publicly available cadastral layers overlain onto orthoimagery (e.g.: Regional District web site) and is approximate and may not be accurate for the purposes of locating risk mitigation strategies. Boundaries should be confirmed prior to design and implementation of risk mitigation strategies.

Prepared by: Reviewed by:

ORIGINAL SIGNED AND SEALED

Peter Jordan, P.Geo., PhD. Michael Burnett, EIT

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Doug Nicol, P.Eng.

6. References

Hope, G., P. Jordan, R. Winkler, T. Giles, M. Curran, K. Soneff, and B. Chapman. 2015. Post-wildfire natural hazards risk analysis in British Columbia. Province of B.C., Victoria, B.C. Land Management Handbook 69. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/LMH69.htm

Parsons, A, Robichaud, PR, Lewis, SA, Napper, C, and Clark, JT. 2010. Field guide for mapping post-fire soil burn severity. USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR- 243.

Wise, M.P., G.D. Moore, and D.F. VanDine (editors). 2004. Landslide risk case studies in forest development planning and operations. B.C. Min. Forests, Research Branch, Victoria, B.C. Land Management Handbook 56. http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh56.htm

Data Sources (Maps):

Contours 20m	BCGW - WHSE_BASEMAPPING.TRIM_CONTOUR_LINES
Fire Perimeter	BCGW - WHSE_LAND_AND_NATURAL_RESOURCE.PROT_CURRENT_FIRE_POLYS_SP
Watersheds	BCGW - WHSE_BASEMAPPING.FWA_WATERSHEDS_POLY
Trails	BCGW - WHSE_BASEMAPPING.NTS_BC_TRANSPORT_LINES_125M
Structures	RDCK
Roads	Combination of MOT, FTEN Road Sections, DRA Roads
Base data, water	BCGW - Fresh Water Atlas
Cadastre	BCGW - WHSE_CADASTRE.PMBC_PARCEL_FABRIC_POLY_SVW
BARC data	Will Burt - Deer, Syringa, Bulldog - ftp://ftp.geobc.gov.bc.ca/publish/Provincial/burn severity/2018/

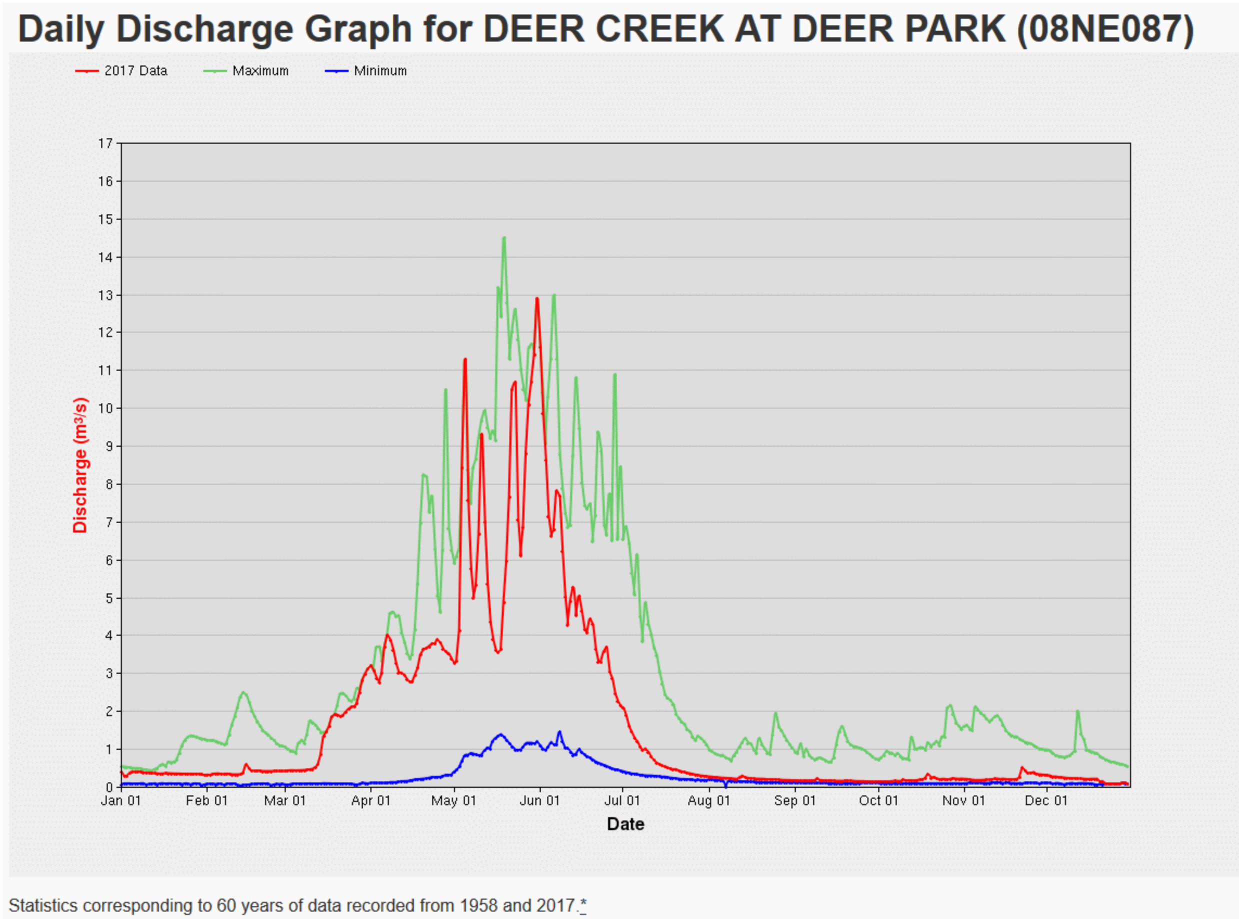

Figure 2. Summary annual hydrograph for Deer Creek, with 2017 data shown as an example. Drainage area is 81.6 km^2.

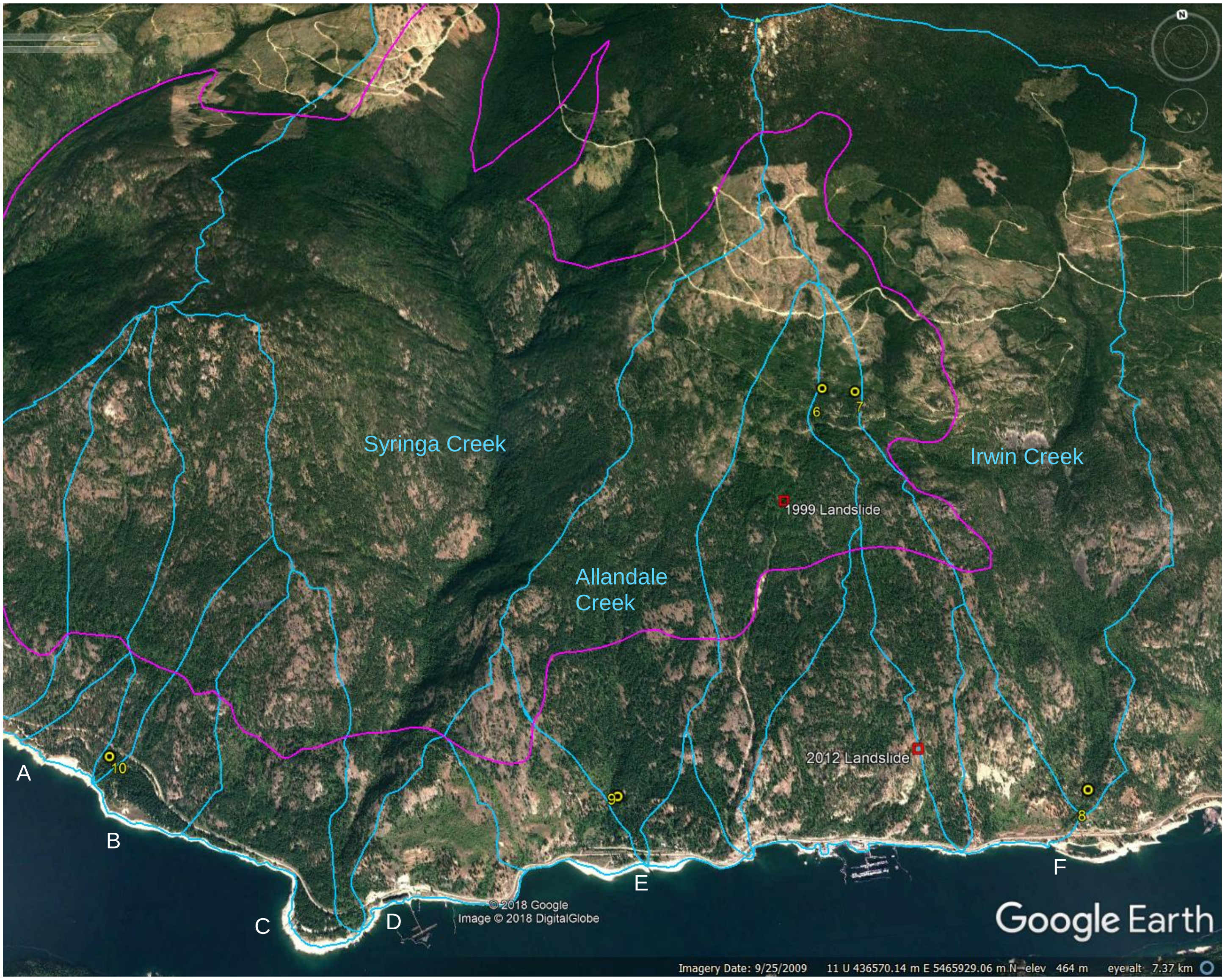

Figure 3. Google Earth oblique view of the Syringa Creek fire, showing watersheds (blue lines) and fire perimeter (purple). Elements potentially at risk include: Provincial Park campground (A and B), park group campsite, day use facilities and boat launch (C), marina and condominium development (D), houses on Allandale Creek fan (E), and houses on Irwin Creek fan (F).

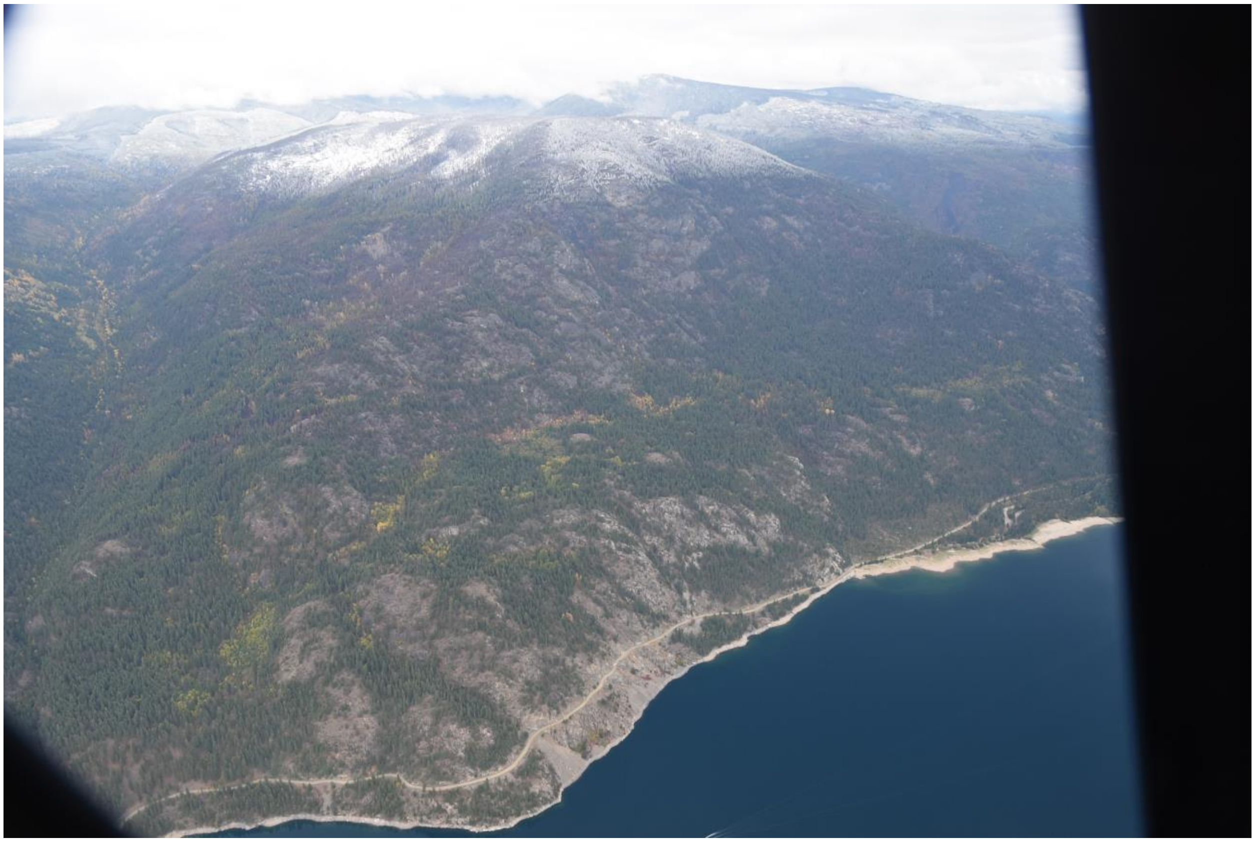

Photo 1. Syringa Creek fire. Tulip Creek on left, campground on right.

Photo 2. Syringa Creek fire. Campground area at left and centre; “Campground 2” creek enters at A. Syringa Creek fan at far right.


Photo 3. Syringa Creek fire, looking northeast over Allandale Creek. The terrace above the marina-condominium complex is at lower left.

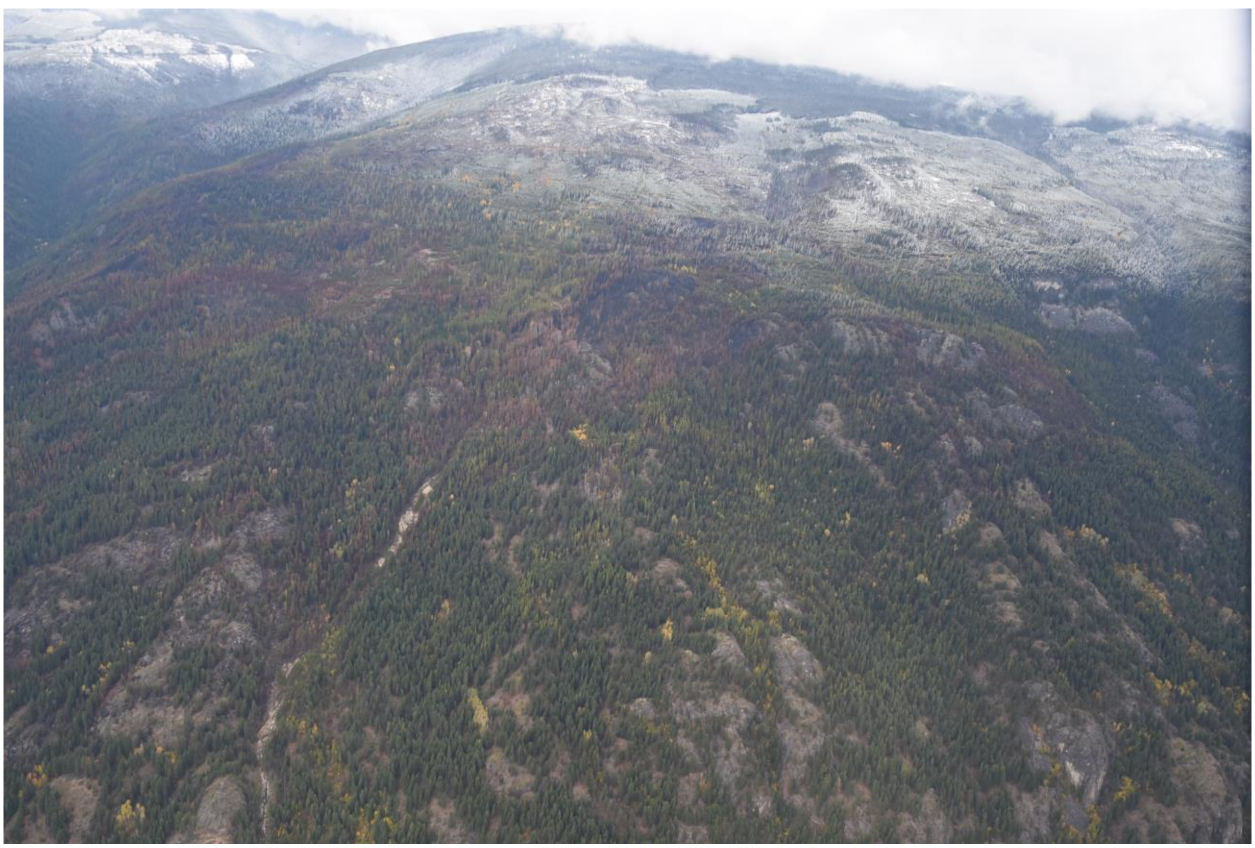
Photo 4. Syringa Creek fire, looking north over eastern part of the fire. 1999 landslide is at centre left; upper Syringa Creek is on top left.


Photo 5. Deer Creek fire, looking north up west fork. Note unburned riparian zone, and high severity burn on slope above (centre).


Photo 6. Deer Creek fire, looking northeast up east fork. Note unburned riparian zone, and high severity burn on steep northwest facing slope above.

Photo 7. Deer Creek fire. Broadwater settlement at lower centre; patchy low and moderate severity burn and logged areas in upper part of Broadwater Creek watershed, centre distance.

Photo 8. Bulldog Mountain fire. Settlement of Brooklyn and mouth of Pup Creek.

Photo 9. Bulldog Mountain fire. Houses on right bank of Dog Creek at lower left; slopes above have isolated small patches of burn.

Photo 10. Bulldog Mountain fire. View north over Bulldog Mountain with recent logging along ridge. Burned cutblocks and forest to right are in Brooklyn Creek watershed.

Photo 11. Bulldog Mountain fire. Looking west up Brooklyn Creek. Rail grade and entrance to Bulldog Tunnel are visible at left. Note landslide from road just above tunnel entrance. Cutblocks were logged in 2015 to 2016, and have unusually severe burn (mapped as “moderate” on BARC map).

Photo 12. Bulldog Mountain fire. Looking north down lower Pup Creek to Brooklyn; Bulldog Mountain on left.


Photo 13. High severity burn in west fork of Deer Creek. Strong water repellency was observed at this site.


Photo 14. Moderate vegetation burn severity site, with high soil burn severity; east fork of Deer Creek. Note fallen needles which provide a mulch.

Appendix A – Maps (separate files)

Map 1 – N52548 Syringa Creek

Map 2 – N52489 Deer Creek

Map 3 – N52497 Bulldog Mountain

Appendix B – Reconnaissance Risk Analysis Tables (separate file)

SyringaComplex_2018_PWNHRA_recce_forms.pdf

Appendix C – Detailed Risk Analyses Summary and Tables

Irwin Creek Fan – MacLean Road

Allendale Creek Fan – Allendale Crescent

Syringa Creek

Campground Creek 2

Table C1 Summary of sites, hazard, and partial risk

Site	P(H) Soil Burn Severity	Site Description	Process	Spatial and Temporal Probability P(S:H) x P(T:S)	Partial Risk	Remedial Measures
Irwin Creek	**L**[1]	Fan with 3 houses adjacent to McLean Road	Flood, debris flood/flow	**L** (houses) **H** (water Intake system)	**VL** (Houses) **M** (water intake system)	None
Allandale Creek	**L-M** (debris flow) **M** (flood/ avulsion)	Several properties and houses situated on the Allandale Creek fan	Debris flow, flooding and channel aggradation/ avulsion	**M** (debris flow affecting houses) **H** (flooding/ avulsion affecting houses)	**L-M** (debris flow-houses) **H** (flooding avulsion-houses)	Construct berms
Syringa Creek	**L**	Syringa Creek fan facilities (road and boat ramp)	Flood	**M** (Broadwater Road, fan infrastructure)	**L**	None
Campground Creek 2	**L**	Deer Creek FSR and Syringa Campground road (at fan location)	Flood and debris flood/ flow	**M** (campers and infrastructure)	**L**	Map campground sites on the fan and restrict access

[1] L = Low, M = Moderate, H = High

Irwin Creek

The Irwin Creek fan is located 2.85km west of Hugh Keenleyside Dam with the fan apex 210m from Broadwater Road. Left bank elevation has been raised about 1m (via machine – Photo 6) from the fan apex for a distance of approximately 50m. Channel slopes above the fan apex are 30% and below fan apex are 20%. There are many very large boulders on fan (some sub-angular).

The drainage area is approximately 1156 Hectares with only 5% burned at Low and Moderate burn severity (none at High).

A large (2500mm) culvert is located across Broadwater Road (Photo 7). The Q_{100} is estimated (via the formula below) at 6m^3/sec while the 2500mm culvert capacity is in the order of 12m^3/sec so the small increase in creek flows will have a small incremental hazard at the crossing location.

$Q_{100} = (Q_{100}/Q_{2)} * 2.5\ kA^{0.75}$ with k = 0.375, A = drainage area, $Q_{100}/Q_2 = 2.5$

There is a water intake system (pipes, settling ponds – Photos 1 through 3) above the fan apex and there are three properties on the fan (Figures 1 and 2) with buildings (source BC Assessment) as follows:

5065 McLean Road (west side of fan, house on east side of Irwin Creek))

5055 McLean Road (mid fan, house on east side of Irwin Creek)

5041 McLean Road (east side of fan)

Conclusions: Given low fire burn severity, incremental hazard is low and partial risk is very low (houses). There is a higher partial risk (moderate) to the water intake system. Culvert at Broadwater Road appears to have excess capacity for creek flow volumes. Even though the water intake system is spatially exposed the hazard is low and no additional works (as a result of the fire) are warranted.

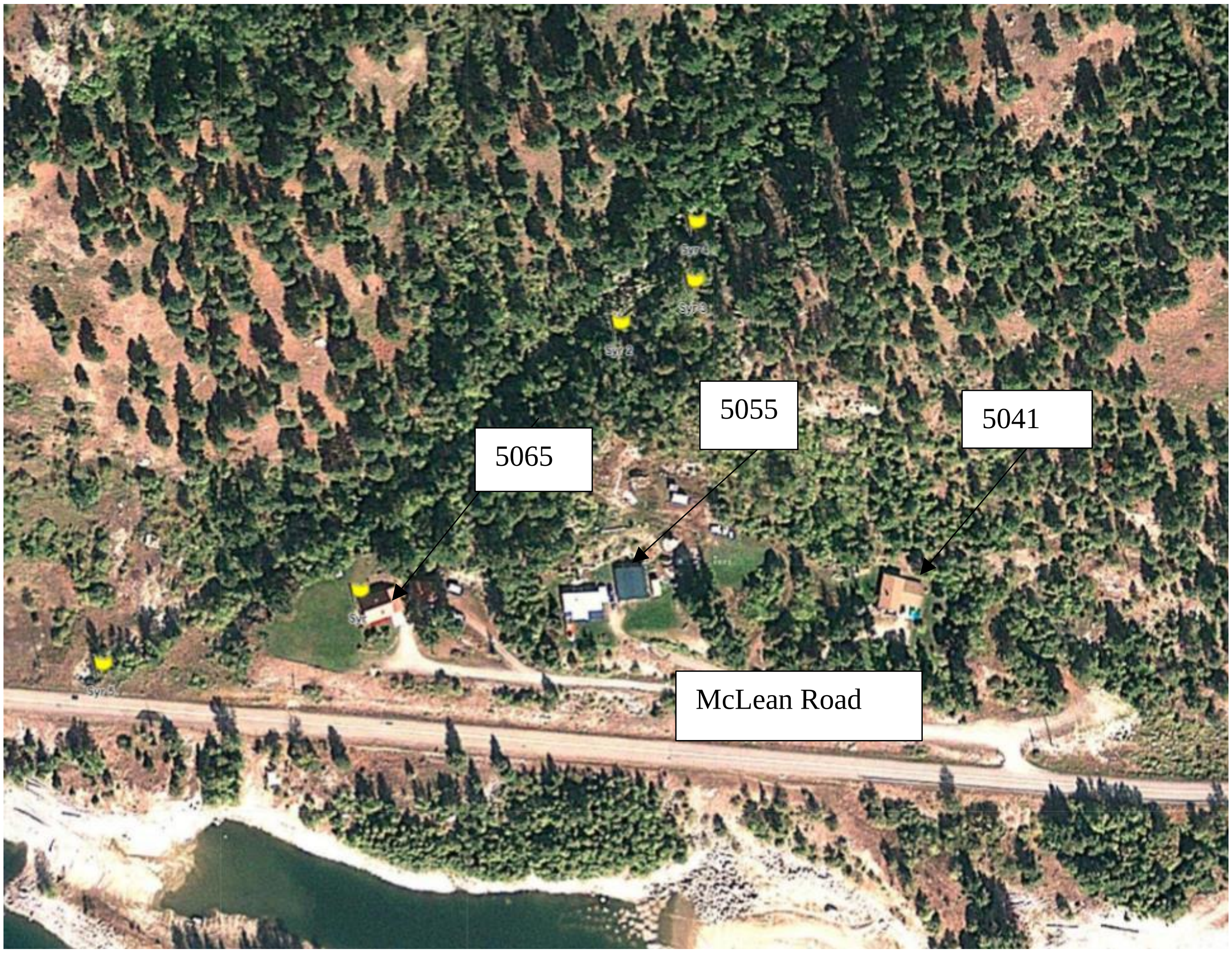

Figure 1. Irwin Creek fan

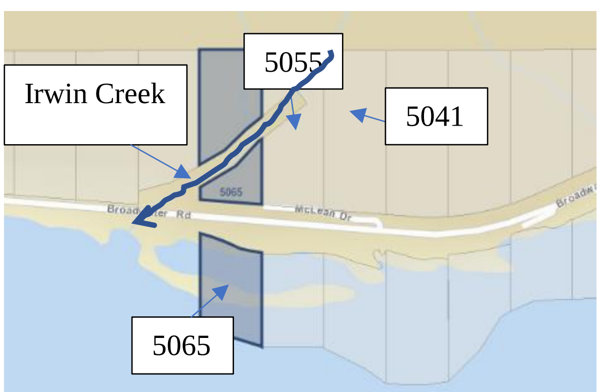

Figure 2. Irwin Creek fan and property fire numbers adjacent to McLean Road

Photo 1. Water system access bridge

Photo 2. Water system upstream of fan

Photo 3. Fan apex below water system

Photo 4. 5055 McLean Road from fan apex

Photo 5. Irwin Creek channel on fan


Photo 6. Machine constructed berm along left bank for a distance of 50m


Photo 7. 2500mm diameter culvert at Broadwater Road

Allandale Creek

The Allandale Creek drainage area is 350 hectares with approximately 20% having a moderate burn severity with most of this at high elevation.

There are about 10 properties and houses on the Allandale fan (Figures 1 and 2).

Allandale Creek crosses under Allendale[2] Crescent and Broadwater Road through 1100mm corrugated metal pipe (CMP) culverts.

The Q_{100} is estimated (via the formula below) at 2.4m^3/sec while the 1100mm diameter culvert capacity is in the order of 1.5m^3/sec (assuming no excess head above culvert inlet).

$Q_{100} = (Q_{100}/Q_{2}) * 2.5\ kA^{0.75}$ with k = 0.375, A = drainage area, $Q_{100}/Q_2 = 2.5$

Near the apex of the fan, the creek banks are low, and there is a hazard of an avulsion of the creek, if high flow occurs or if additional gravel is deposited in the channel (Photos 1 through 4). This hazard existed before the fire, and the fire has increased the hazard slightly. The post wildfire hazard P(H) is considered L-M for debris flow and M for flood/channel avulsion. The spatial and temporal probabilities P(S:H) and P(T:S) for the houses are considered moderate (M) for debris flows and high (H) for flooding/channel avulsion. The post wildfire partial risk is considered low to moderate (L-M) for debris flows affecting houses and high (H) for flooding/channel avulsion affecting houses. It is noted the hazard was present pre-fire and is now elevated.

Recommendations

Regardless of the effects of the fire, risk reduction can be achieved by providing increased channel conveyance area which will reduce the likelihood of flood flows and channel aggradation which could cause the creek to be directed towards houses below. Increased channel conveyance will also reduce the likelihood that a debris flow will cause an avulsion (although it will not eliminate the potential for an avulsion).

One way to increase the channel conveyance area is through the construction of berms. At locations where the creek banks are less than 500mm in height, berms could be constructed (minimum 1m height) adjacent to the creek (minimum 20m segment on right bank and minimum 8m segment on left bank).

Consideration should be given to replacing the apparently undersized culverts across Allendale Crescent and Broadwater Road; however, there are no houses directly downslope of roads, so consequence low as long as culvert overflow can't flow longitudinally down the Broadwater Road.

[2] Note: On topographic maps, the creek is named "Allandale Creek", but on the RDCK map the road is named "Allendale Crescent".

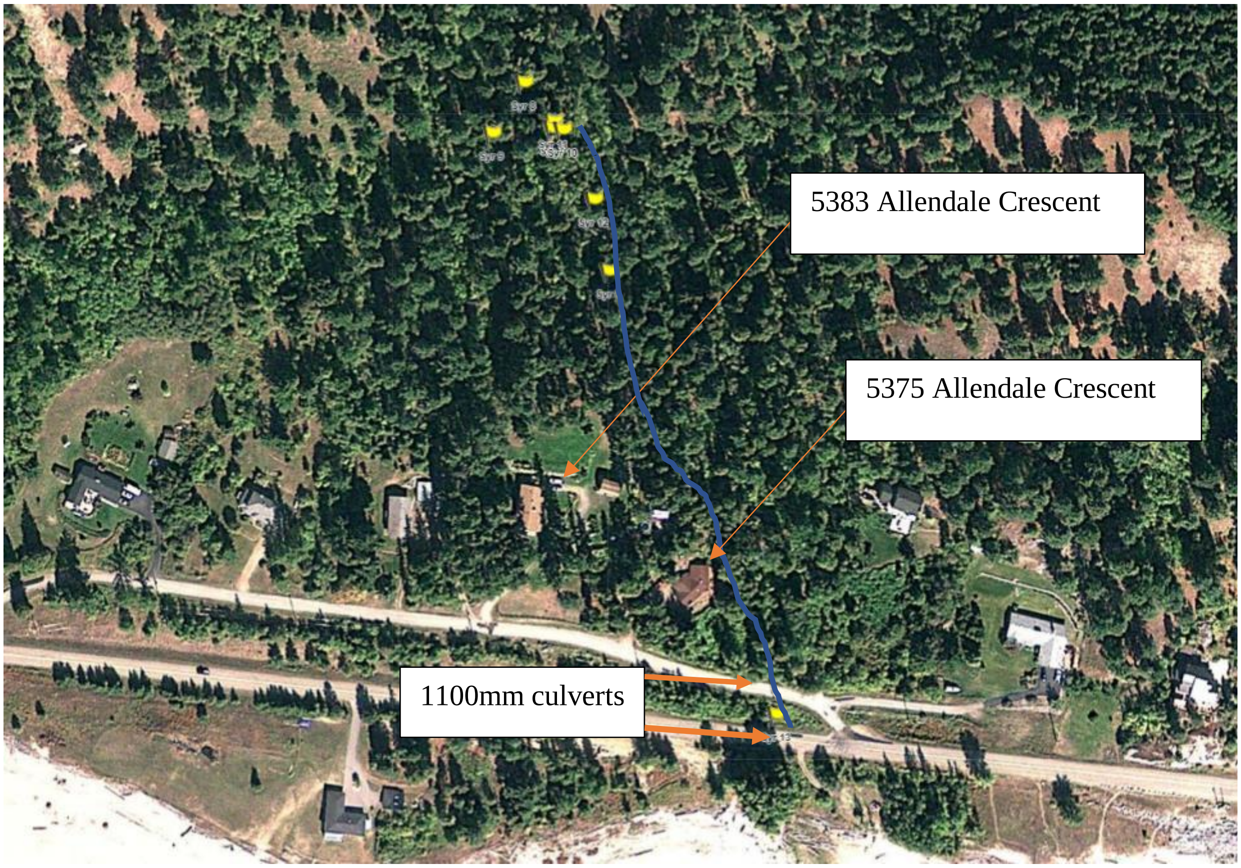

Figure 1. Allandale Creek fan

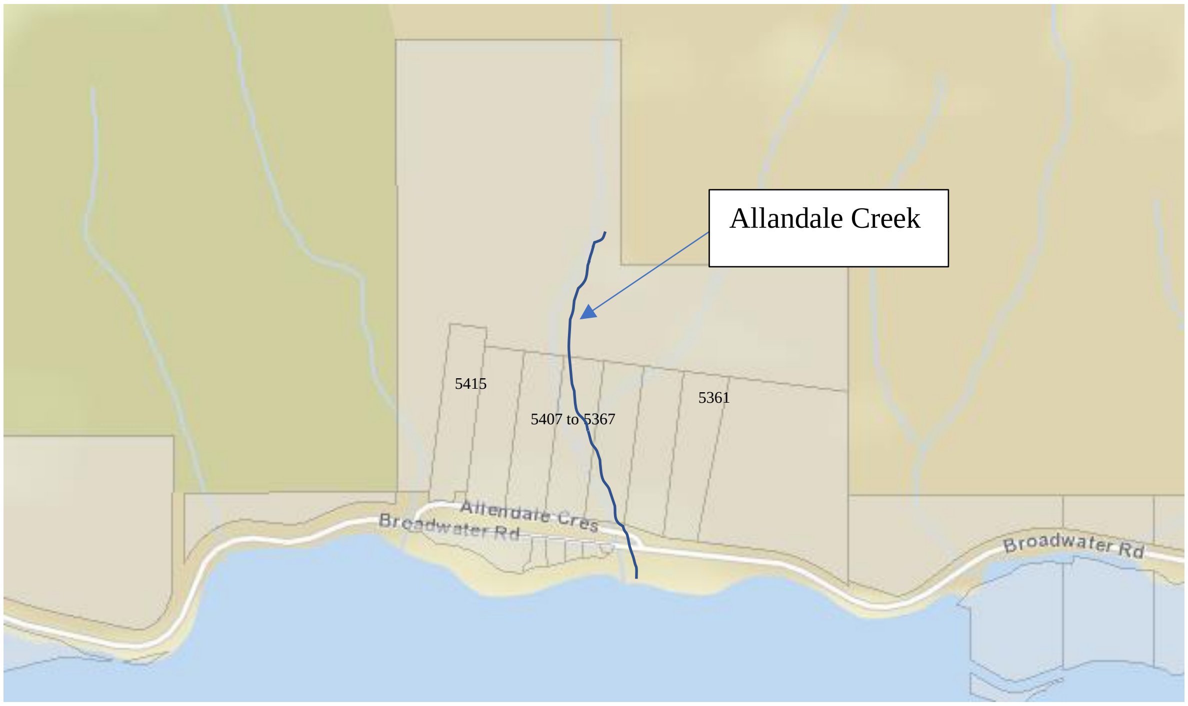

Figure 2. Allandale Creek fan showing property boundaries (RDCK web map)

Photo 1. Allandale Creek reservoir (near fan apex)

Photo 2. Allandale Creek fan

Photo 3. Allandale Creek – note low banks

Photo 4. Allandale Creek fan apex (looking up)

Syringa Creek

The Syringa Creek drainage area is 2169 hectares and has a combined 19% moderate and high burn. The creek crosses under the Broadwater road through an approximate 2000mm by 3000mm culvert. A road and boat ramps are located on the lower parts of the fan (Figure 1 and Photo 1). There are no houses on the fan.

The Q_{100} is estimated (via the formula below) at 9.4m^3/sec while a culvert (approximately 2000mm by 3000mm) across the Broadwater Road has a capacity of approximately 12m^3/sec.

$Q_{100} = (Q_{100}/Q_{2)} * 2.5\ kA^{0.75}$ with k = 0.375, A = drainage area, $Q_{100}/Q_2 = 2.5$

The hazard (flooding) due to the burned area is considered low and the partial risk (Broadwater Road and fan infrastructure) is also low. The culvert appears to have excess capacity to convey some increase in flow volumes.

Figure 1. Syringa Creek fan and Broadwater Road

Photo 1. Syringa Creek near the mouth – well incised

Campground Creek 2

Campground Creek 2 flows through the centre of Syringa Provincial Park campground (Figures 1 and 2). Its' drainage area is 150 hectares and 23.5% was burned to a moderate severity (none at high severity).

There are 900mm culverts located across the Deer Creek FSR and across the campsite road.

The post wildfire hazard of debris flow and flooding is considered low (L). The culverts may be undersized for a Q_{100} flood event; however, they are located 3.5m below local ground grade and so there is potential for increased culvert capacity with the excess head. A debris flow would likely block the culvert at the upper FSR crossing location - potentially redirecting stream flows; however, the nearest campsites are located 200m away at the left distal edge of the fan. The temporal and spatial hazard is considered moderate (M) and partial risk is low (L).

Even though the partial risk is considered low, the cost/effort to reduce the risk further is minimal and involves not having the campsites at the distal edge of the fan occupied until the hazard is reduced (2 to 3 years). If BC Parks requires a reduction in the risk, then the limits of potential debris flow runout should be mapped in the field so that the campsites at risk can be identified and use restricted.

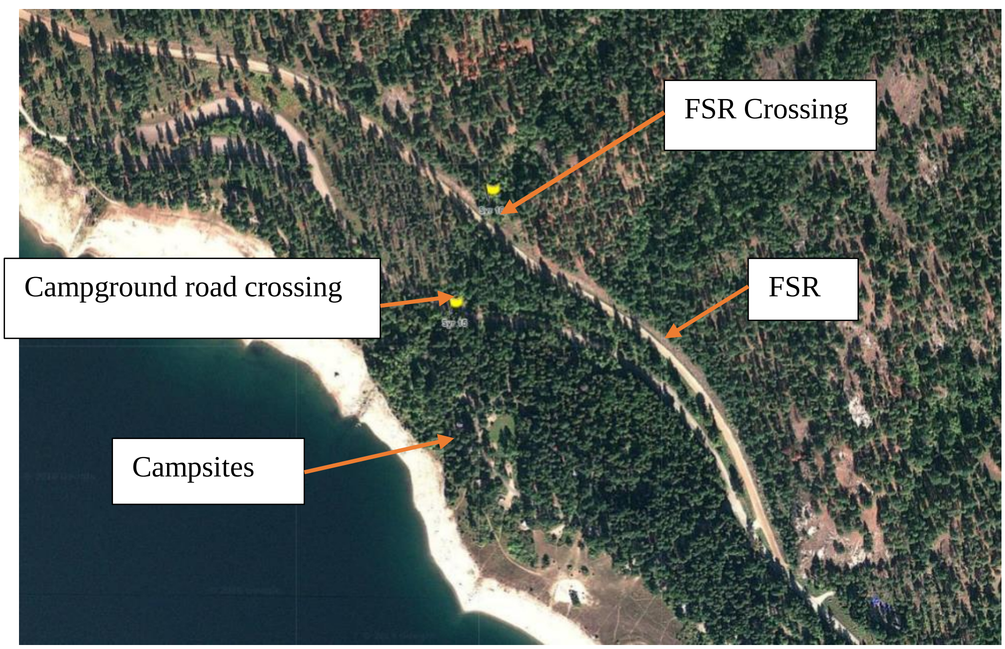

Figure 1. Campground Creek 2

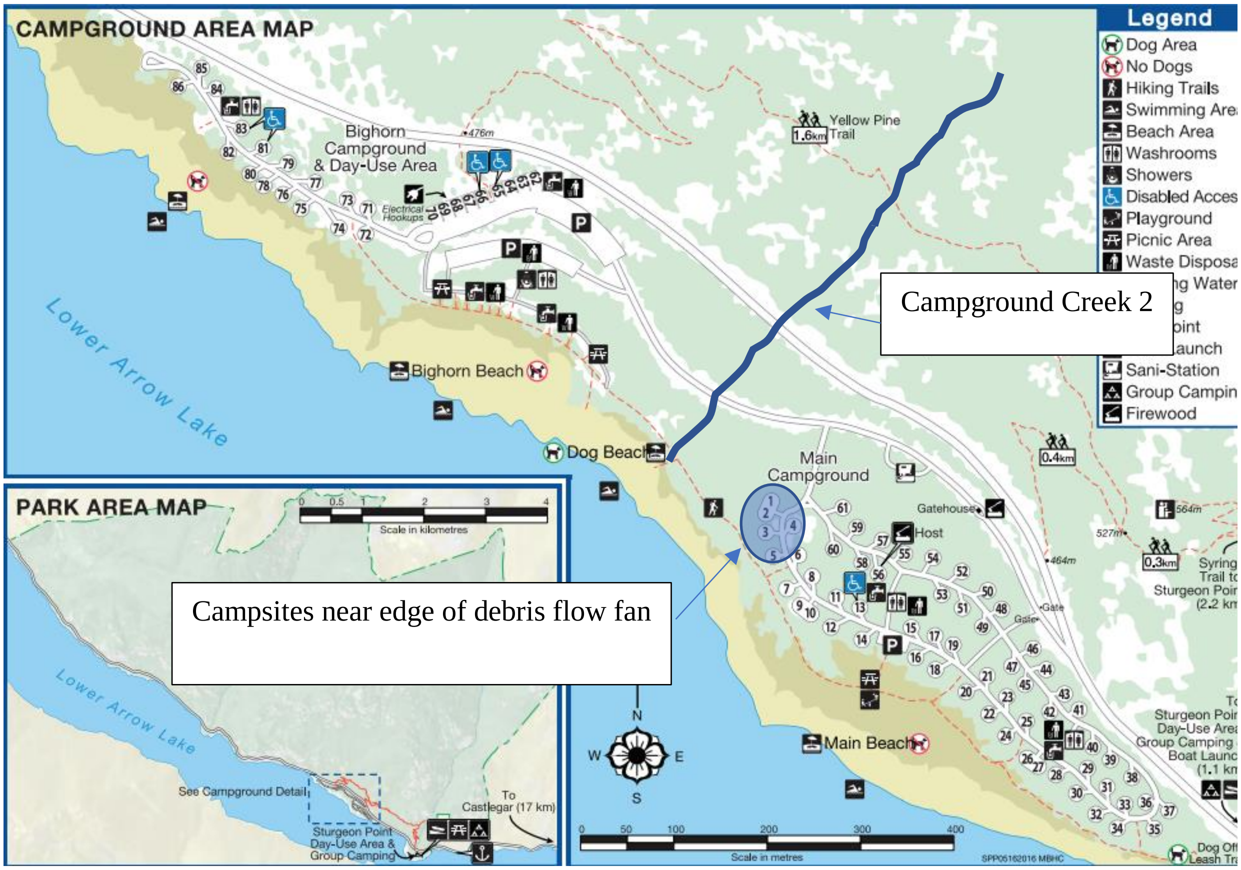

Figure 2. Approximate location of Campground Creek 2 relative to campsite locations

Appendix D – Table of watersheds and burn severity

(Note: Many of the creek names are not official; refer to the maps for watershed locations.)

WATERSHED	TOTAL AREA (ha)	AREA BURNED[1] (ha)	BURN SEVERITY[2] % High	% Moderate	% Low	RELIEF RATIO[3]
Bulldog Mtn Fire						
Arch Creek	214	214	0	6	32	
Arch Face	127	109	0	18	15	
Arrow Lake Face 1	237	215	1	2	7	
Brooklyn N Face	327	223	1	40	21	
Brooklyn S Face	413	0	0	0	0	
Churchill Creek	147	133	2	21	46	0.71
Dog Creek E Face 1	757	658	0	25	23	
Dog Creek E Face 2	220	148	0	3	10	
Dog Creek Tributary	135	132	0	7	31	0.71
Dog-Faith Remainder	18664	436	0	0	0	
Pup Creek Remainder	1303	0	0	0	0	
Pup Creek W Face 1	44	20	0	3	10	
Pup Creek W Face 2	36	8	0	0	9	
Brooklyn Cr sum	740	223	0	18	9	0.33
Pup Cr sum	2269	384	0	7	6	
Dog Cr sum	19776	1375	0	1	1	
Deer Creek Fire						
Broadwater Creek	212	139	0	23	29	0.46
Broadwater Face North	728	241	0	8	16	
Broadwater Face South	449	34	0	2	3	
Deer Creek East	4415	1591	1	9	8	
Deer Creek Lower	2555	479	0	5	5	
Deer Creek West	1285	1125	4	30	29	
Twobit Creek	1565	237	0	4	5	
Deer Creek sum	8256	3195	1	11	10	

WATERSHED	TOTAL AREA (ha)	AREA BURNED[1] (ha)	BURN SEVERITY[2] % High	% Moderate	% Low	RELIEF RATIO[3]
Syringa Creek Fire						
Allandale Creek	350	270	0	20	30	0.73
Allandale Face 1	54	0	0	0	0	
Allandale Face 2	64	18	0	0	17	
Allandale Face 3	20	0	0	0	0	
Campground Creek 1	116	95	0	9	32	1.20
Campground Creek 2	150	137	0	24	36	1.05
Irwin Creek	1156	155	0	3	2	0.49
Landslide Creek	190	121	3	20	23	0.89
Landslide Face	102	1	0	0	1	
Syringa Creek	2169	1273	2	17	14	0.36
Syringa Face 1	23	0	0	0	0	
Syringa Face 2	77	30	0	0	10	
Syringa Face 3	120	53	0	0	9	
Tulip Creek	2126	748	1	11	9	0.35
Tulip Face	367	158	0	4	10	
Unnamed East Creek 1	106	52	1	20	9	1.19
Unnamed Face	49	0	0	0	0	

1. Area within fire perimeter (including areas classified as “unburned” or “unknown”).
2. % of total watershed area.
3. Relief ratio is the range of elevation divided by the square root of watershed area, and is an index of watershed steepness. Only shown where relevant (where there is a defined stream channel in a steep watershed). A relief ratio greater than 0.6 indicates the stream may be subject to debris flows.