District of Squamish
Community Wildfire Protection Plan

Submitted to:

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Executive Summary

Over the last century, human activity has altered the natural disturbance patterns and ecological processes that have historically maintained the integrity of our ecosystems. Hazardous fuel accumulations in our forests, and the related threat from wildfires, have become a growing concern across the province. The District of Squamish (District) recognizes this growing threat and has taken the initiative to responsibly assess and manage wildfire risk in and adjacent to its limits. This Community Wildfire Protection Plan (CWPP) is an indication of the District's desire to abate the wildfire risk to the community.

A wildfire risk analysis was completed for the district. Interface fuel hazard assessments were conducted for high-risk polygons and were ranked according to the site-specific hazard. The official policies, bylaws and growth strategies of the District were reviewed for issues that contradicted FireSmart guidelines. The District was divided into seven Fuel Management Areas (FMAs) each with area-specific recommendations to address the wildfire risk. Appendices are included that provide background information on fire behavior, fuel management treatments, pre-development fuel hazard reports, fuel treatment development prescriptions, and the methodology associated with all aspects of the CWPP.

Much of Squamish lies within valley-bottom flood plain and subsequently is dominated by deciduous species. These features offer some protection to the community and a resultant low risk to the majority of the valley bottom development. The valley bottom contains only minor areas of coniferous stands, which poses a risk to the community. These areas should be treated as recommended and prioritized in the report through modifying the fuels profile. Prescriptions for altering stand structure for the purpose of mitigating wildfire risk should be done by qualified professionals.

The developments within the District in moderate to high wildfire risk areas are located on the valley slopes, particularly on the east side of Highway 99. Most of these areas also have limited or single access points. Areas at risk should be treated as per recommendations and prioritization in this report. Additionally, developments for which there are single or limited access points should be addressed through future development planning (i.e. improving access through road development).

Consideration should be given to insisting all future development within the District boundary be carried out following the FireSmart guidelines while maintaining the ecological function of the natural lands. Development permits should require the developer to conduct a 'Fuels Hazard and Fire Risk Assessment' of the site, explaining how the developer will address the wildfire hazard and risk on the development site. An example table of contents for such an assessment has been included in Appendix G.

In addition to addressing the wildfire risk through means internal to the District, the District should work with adjacent landowners or managers to address the fuel hazard risk, and subsequent wildfire risk, that exists on adjacent lands. These landowners includes BC Timber Sales (BCTS), BC Transmission Corporation (BCTC), CN Rail (CNR), Ministry of Environment (MoE), Ministry of Forest and Range (MoFR), Squamish-Lillooet Regional District (SLRD), and Squamish First Nation. All of these agencies have values at risk adjacent to the community and cooperation between the District and these agencies would result in mutually beneficial protection of these values at risk.

The District should conduct emergency pre-planning in the event of a wildfire. This would include determining those areas where access will be an issue in the event of a wildfire, assessing local water bodies as water sources for fire suppression purposes, and establishing an evacuation plan or protocol. Additionally, working with the Protection Branch and other emergency services on joint exercises would allow the District to respond quickly in the event of a wildfire incident. This may include developing a wildfire management plan in conjunction with the Protection Branch.

A review of the District's official documents resulted in numerous opportunities to adopt FireSmart recommendations into the official plans. The District should assess these recommendations and give some consideration to implementing the recommendations where practical to do so.

As a result of this report, there are many areas within the District for which fuels management would be practical. It is recommended that the District access funding through the Union of BC Municipalities (UBCM) for a Fuels Management Pilot Project (FMPP). After successfully completing such a project, the District could move into an operational fuel management project for which UBCM funding is also available.

A qualified professional with relevant past experience should complete the prescriptions necessary to conduct fuels management. Additionally, prior to engaging in such a project, the District should begin disseminating public information about this report, the existing wildfire risk, and the need to alter stand structure and surface fuel loading in order to abate this risk through mitigating the fuel hazard.

Summary of Recommendations

The following is a summary of the recommendations being submitted as a result of the work conducted during the development of this CWPP. Some of the recommendations contained within each of the Fuel Management Area (FMA) section are identical and, for ease of reading, have been removed from this summary. Therefore, the numbering of the recommendations below differs slightly from the numbering of the recommendations in the report.

Recommendations: Landscape Level Risk Abatement Strategies

1. Utilizing this report, embark upon fuel management projects (FMPPs) as part of a District Fuel Management Strategy.
2. Pursue funding for FMPPs and operational fuel management projects (OFMPs).
3. Dialogue with the MoFR to address wildfire risk and fuel management in higher level planning for those areas adjacent to the District.

Recommendations for all FMAs:

4. Promote the FireSmart program for existing homes and for future developments.
5. Work with the SLRD to ensure any future developments adjacent to the District boundary follow FireSmart guidelines.
6. Ensure BCTC mitigates the slash hazard on the transmission corridors.
7. Work with private landowners, First Nations, CN Rail, BCTC, and other agencies to address the fuel hazard on their associated lands.
8. For areas requiring treatment, ensure qualified professionals are utilized to develop ecologically appropriate fuel treatment recommendations.
9. Develop procedures for dealing with traffic flow should Hwy #99 become impassable due to a wildfire.
10. Work with BC Transportation to mitigate ignition fuels adjacent to the highway.

Recommendations: FMA #1

11. Promote public education to homeowners along interface of the eastern edge of the valley.
12. Place signage warning recreation users of existing fire hazard.

Recommendations: FMA #2

13. Work with CN Rail on mitigating fuel hazards on their right-of-way (ROW).
14. Develop an evacuation plan for Paradise valley.
15. Promote public education to homeowners in Paradise valley. Emphasize the importance of maintaining defensible space around homes.

Recommendations: FMA #3

16. Promote FireSmart and public education to homeowners; in particular on the northern edge of Brackendale.

Recommendations: FMA #4

17. Work with BCTS and other licensees to ensure harvesting activities are conducted in a manner that decreases accidental ignitions.
18. In cooperation with BCTS and BCTC, develop a landscape level fuel break east of FMA #4 along the BCTC corridor.

19. Pile and burning of harvest sites should be conducted under safe conditions during a good venting period. The Squamish Fire Rescue Department (SFRD) should acquire information on these activities.
20. Work with the university to develop an evacuation plan.
21. Work with the MoFR to create a landscape level fuel break along the eastern edge of this area.

Recommendations: FMA #5

22. Work with BCTS and other licensees to ensure harvesting activities are conducted in a manner that decreases accidental ignitions.
23. Pile and burning of harvest sites should be conducted under safe conditions during a good venting period. The SFRD should acquire information on these activities.
24. Consider developing a secondary access route to the Valleycliffe area for evacuation purposes during a wildfire.
25. Promote fire awareness among the climbing community.
26. Enhance trails around the smoke bluffs to improve access and provide strategic ground fuel breaks.

Recommendations: FMA #6

27. Work with CN Rail to mitigate fuel hazards on their ROW.
28. Work with the MoE on fuels management within Stawamus Chief Provincial Park.
29. Promote fire awareness among the climbing community.
30. Work with Squamish First Nation to promote fire awareness on the reserve.

Recommendations: FMA #7

31. Work with the owners of the old pulp mill site to mitigate any fuel hazard.
32. Any consideration of future development within this FMA should address fuel and spotting hazards.

Recommendations: Interface Fuels Treatment Strategy

33. Develop site-specific interface treatments that are ecologically accurate, operationally and economically feasible, and socially acceptable.
34. Prioritize treatments based on wildfire risk (as per this report and local knowledge).

Recommendations: FireSmart Community Planning and Design

35. New developments in the interface should follow FireSmart guidelines and recommendations in this report.
36. A Fuel Hazard and Fire Risk Assessment report should be completed for each new development.
37. Ensure contractors have a Fire Management Plan completed prior to conducting operations.

Recommendations: District Management of Natural Lands

38. Manage natural lands within the District using the fuel hazard assessment system (Appendix B) and the fuel treatment prescription methodology (Appendix E) provided in this report.
39. Trained professionals should determine which areas require treatment and develop ecologically appropriate and socially acceptable treatment prescriptions.

Recommendations: Access

40. Establish trail standards that will ensure that trails act as surface fuel breaks and provide access for suppression crews.
41. Develop standards for the abatement of residual activity fuels associated with trail building.
42. Consider constructing trails into remote wooded areas with poor access (for suppression purposes).

Recommendations: Water Availability

43. Develop a GPS database of waterways within and adjacent to the District that have adequate supply for suppression purposes.
44. For new developments, consider establishing or enhancing water bodies within the develop area that could serve as emergency water sources.

Recommendations: Reducing Ignition Sources

45. Compile a database of human caused fires within the District to determine high risk areas and problem sources.
46. Work with schools to promote wildfire awareness and prevention.
47. Engage in public education programs to reduce human caused ignition.
48. Work with CN rail to ensure their right-of ways do not contain light cured fuels prior to the fire season.
49. Develop a District policy for ensuring power distribution lines within the District are assessed regularly for tree risk and are properly maintained.
50. Work with BCTC and BC Hydro to ensure that distribution lines and transmission corridors are assessed regularly for tree risk and that the District is kept informed of this activity.

Recommendations: Future Desired Stand Conditions

51. Use the Future Desired Condition descriptions, in conjunction with the Current Stand Conditions, as guidelines when developing site specific fuel treatment prescriptions.

Recommendations: Priority Treatment Areas

52. Treat all identified interface polygons in prioritized sequence as funds become available.
53. Dialogue with adjacent landowners and governments when treating interface areas to ensure the maximum benefit is realized from the treatment through treating larger areas.

Recommendations: Official Policies and Guidelines

54. Consider adapting the recommendations resulting from the review of the official policy and guidelines.
55. Future development of official policy and guidelines should consider the need to abate wildfire risk.

Recommendations: Wildfire Act

56. Prior to granting a development permit, ensure construction contractors operating within the District are aware of their responsibilities as described within the Wildfire Act.
57. Consider developing bylaws which restrict certain construction activities during high and extreme fire danger rating periods.

Recommendations: Initial Attack Preparedness

58. Develop an annual training session to ensure District staff are familiar with the fire management plan.
59. Ensure SFRD staff has S-100 training.
60. Strategically place suppression equipment in high risk interface areas.

Recommendations: Interagency Cooperation

61. Consider conducting annual, multi-agency training sessions involving mock interface drills.
62. Ensure the SFRD has the necessary equipment to deal with an interface fire prior to the arrival of wildland fire crews.

Recommendations: Public Information

63. Make FireSmart brochures available at: fire halls, insurance agencies, real estate offices, city hall, recreation centers, and other public locations. Consider disseminating FireSmart information in an annual mail out (i.e. with the tax assessment mailing).
64. Include a wildfire management link on the District website.
65. Conduct a public presentation prior to engaging in any fuel management work and disseminate project information accordingly.
66. Hold annual FireSmart information sessions.
67. Promote FireSmart principles through the public education system utilizing the local fire department and Protection Branch.

Recommendations: Post Fire Evaluation

68. In the event of a wildfire within or adjacent to the District, conduct a Post-Fire Ecosystem Impact Assessment to determine the short and long term fire-effects on the District.
69. Keep a log of all human caused fires within and adjacent to the District to assist with future abatement strategies.

Recommendations: Post-Fire Rehabilitation

70. Rehabilitate any burned areas in a manner that is ecologically appropriate. Native species should be utilized wherever possible.
71. Conduct post-fire tree risk assessments to ensure public safety.
72. Address post-fire erosion concerns before they arise.

Recommendations: Wildfire Suppression Planning

73. Develop a District Fire Management Plan or other plan that encompasses communication and evacuation plans in the event of an approaching wildfire.

Recommendations: Wildfire Detection and Reporting

74. During the fire season, post the wildfire reporting number at key locations within the District.

Recommendations: Other

75. Utilize a Fuel Treatment Template to ensure consistency between fuel treatments.
76. Consider all options for treatment regardless of controversy. Determine the level of social acceptability of each treatment method prior to engaging in treatments.
77. Develop feedback loops within the District as a means of collecting the public's sentiment regarding fuel management.
78. Employ adaptive management in regards to wildfire and fuels management.

By implementing any number of the above recommendations, the District will improve the survivability of the community, decrease the potential for a catastrophic wildfire and work towards maintaining the world-renowned recreational opportunities for which the community is famous.

Introduction

The Need for a Community Wildfire Protection Plan

Over the last century, human activity has altered the natural disturbance patterns and ecological processes that have historically maintained the integrity of our ecosystems. Urban development, resource harvesting, agriculture, range use, wildfire suppression, and the introduction of non-native species are among some of the influences that have changed natural ecosystem succession. As a result, biological and physical stresses are being expressed across the province, including fuel accumulations, forest disease and insect outbreaks as well as unstable wildlife populations.

Hazardous fuel accumulations in our forests, and the related threat from wildfires, have become a growing concern across the province. This threat has never been made more apparent than during the fire season of 2003 when over 2,500 fires burned more than 265,000 hectares across BC at a cost of $375 million. The most dramatic was the Okanagan Mountain Park fire, which reached a size of 25,600 hectares, caused the evacuation of 33,050 people and damaged or destroyed 238 homes. Catastrophic fires of this nature, threaten structures and human lives, impact wildlife populations, damage soils, increase erosion, degrade water quality and increase air pollution. These events are a stark reminder of how vulnerable our communities are from wildfires.

As we continue to suppress natural fires in fire-dominated ecosystems and leave the accumulating fuels untreated, there is a high probability that a large-scale wildfire is imminent. Compounding this threat is the continuing development of homes into the urban/wildland interface. The District of Squamish (District) recognizes this growing threat and has taken the initiative to responsibly assess and manage wildfire risk in and adjacent to its limits.

Wildfire Management Objectives and Initiatives

Wildfire is a natural process within the forested landscapes of coastal BC. While the risk of wildfire cannot be eliminated, we can effectively prepare for wildland fires by reducing fire behavior potential in fire-prone areas. In recent years, public awareness of the threat of interface fires has been heightened by wildfire events in our province. This Community Wildfire Protection Plan (CWPP) has been developed to address the threat of wildfires in the wildland-urban interface zone (WUI) in the District.

The overall objective of this management strategy is to provide recommendations and tools that will reduce the long-term wildfire risk within the WUI. Specifically the objectives are to:

- Assess wildfire risk on a landscape level and recommend long term land use planning strategies to reduce this risk;
- Assess the fuel hazard accumulations within the WUI, prioritize high risk areas to allow for the effective allocation of funds for treatments, and recommend general fuel treatment strategies that will reduce the risk to structures and human lives;
- Review official governing documents, including bylaws and policies, and provide recommendations on improving these documents in order to reduce wildfire risk.

Background

Project Study Area

The District is located approximately 70 km north of Vancouver on Hwy 99 in the Sea to Sky corridor. The town, with a population of approximately 16,000 people, is located at the north end of Howe Sound, at the mouth of the Squamish River and at the base of the Stawamus Chief. Highway #99 is the main transportation route through the District and the Sea to Sky corridor. The total area of the District is 12,307 hectares.

The study area for this project extends to the legal boundaries of the District. The wildfire hazard analysis and subsequent management recommendations include all forested stands that are greater than 1 hectare (ha) in size. All areas within the District boundaries were assessed including:

- District recreation parkland
- District owned non-recreation green space
- Natural parkland
- Greenbelts and restrictive covenant lands
- Provincial lands
- Privately owned lands

Climatic Data and Biogeoclimatic Classifications

Most of the District occurs within the Coastal Western Hemlock Dry Maritime biogeoclimatic (BGC) subzone (CWHdm). Adjacent BGC subzones include the CWHvm1, CWHvm2, MHmm1 at higher elevations and CWHds1 to the north (and not included in Table 1).

Table 1. Mean and standard deviations (in parentheses) of climatic conditions for Biogeoclimatic subzone CWHdm in the District (Meidinger and Pojar 1991).

Climatic Characteristics	CWHdm	CWHvm	CWHds
Mean annual precipitation (mm)	1827 (326)	2787 (367)	1627 (367)
Mean precipitation April-Sept (mm)	498 (89)	752 (200)	419 (109)
Mean precipitation of driest summer month (mm)	53 (10)	75 (21)	45 (11)
Mean annual temperature (°C)	9.8 (0.4)	8.2 (1.1)	7.8 (1.2)
Mean temperature of warmest month (°C)	17.6 (0.5)	16.0 (1.1)	17.4 (1.4)
Number of months with mean temperature >10 (°C)	5.7 (0.4)	4.9 (0.6)	5.0 (0.6)

The CWHdm occurs along the main valley bottom and the lower elevations of the tributary valleys. This subzone has cool, relatively dry summers and moist, mild winters with little snowfall at lower elevations.

The CWHvm1 is located adjacent and upslope (at higher elevation) to the CWHdm predominantly at the southern end of the study area where there is a greater maritime influence. It has a wet, humid climate with cool summers and mild winters with relatively little snowfall.

The CWHvm2 is generally located adjacent and upslope (at higher elevation) to the CWHdm. It experiences a wet, humid climate with cool, short summers and cool winters with substantial snowfall.

The MHmm1 is further upslope in the sub-alpine and experiences long, wet and cold winters and short, cool, moist summers. Snowfall is high and can persist well into the summer months.

The CWHds1 occurs north of the District boundary, near Cheakamus Canyon and is a coast/interior climatic transition zone with warm, dry summers and moist, cool winters with moderate snowfall.

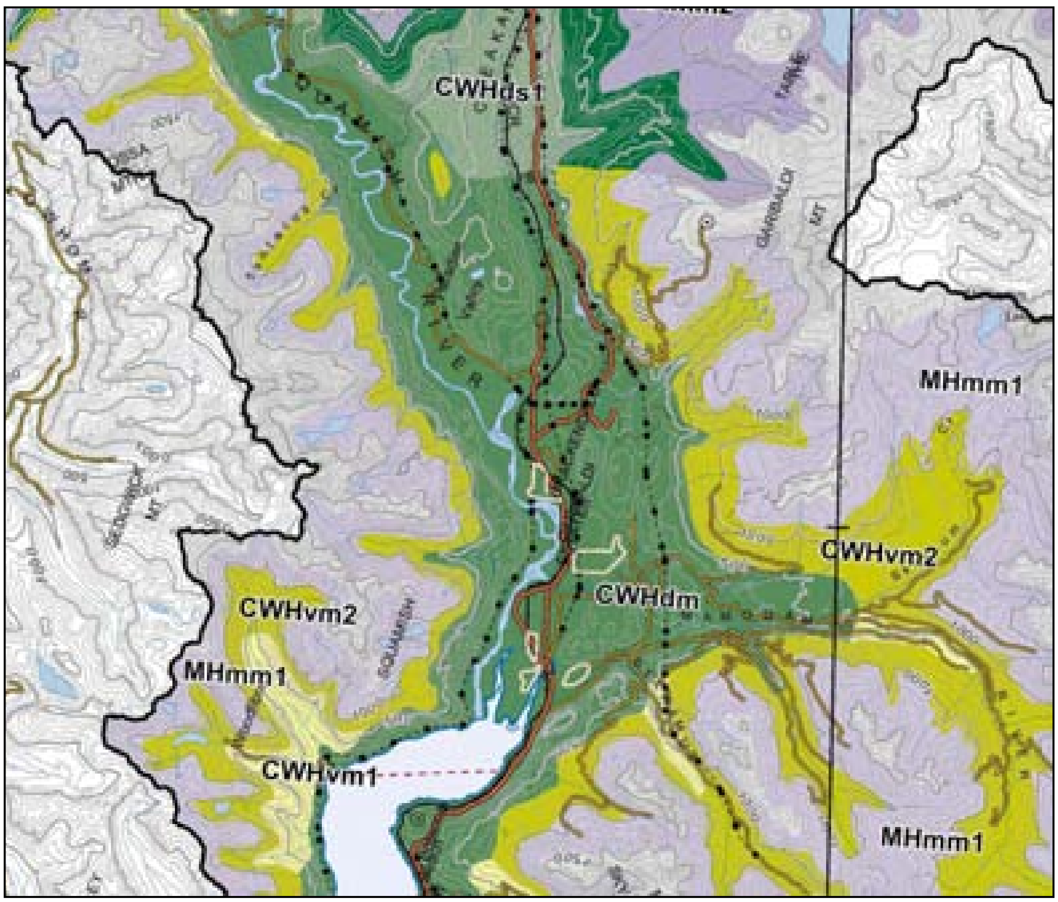

Figure 1. Biogeoclimatic subzones in and around the District of Squamish (Source: http://www.for.gov.bc.ca/hre/becweb/resources/maps/index.html).

The Historic Role of Wildfire

Ecosystem Succession

An ecosystem is a broad term used to describe the interactions of living organisms with the physical environment (Meidinger and Pojar 1991). The nature of an ecosystem is influenced by the climate, the local physiography and the physical and chemical properties of the soil parent material. Over time, the ecosystem reaches a condition of dynamic equilibrium known as the climax stage. In a climax ecosystem, a balance is reached between the living components and the physical environment. The plant species are self-perpetuating and are present at all stages of their life cycle. The plant community does not change in composition, only in structure.

Ecosystems reach this climax state through a process known as ecological succession. This is a process of change where a site is occupied by a series of distinct plant communities through time, known as seral stages. Each of these seral stages is composed of species best adapted for the existing site conditions. Each seral stage alters its surrounding environment until a better-adapted seral stage takes over. Eventually the climax seral stage is reached.

Each seral stage provides certain habitat features required by various animal and plant species. Maintaining a natural and healthy distribution of these seral stages across the landscape ensures a high level of biodiversity and habitat for a variety of wildlife and plant species.

Succession and Natural Disturbance Regimes

All ecosystems are influenced by periodic disturbances that vary in size, severity and occurrence. Examples of common disturbances include: wildfire, windthrow, ice and freeze damage, water, landslides, insect and disease outbreaks as well as human caused events such as logging. These disturbances change the progress of an ecosystem along its successional pathway. Usually the ecosystem is altered to an earlier stage but occasionally a disturbance can forward its progress towards its climax state.

Historically, agents of disturbance were viewed as unhealthy and a threat to the integrity of the forest as a timber resource. Hence, it was standard policy to suppress all wildfires. The resultant effect is that fire dependant ecosystems are expressing biological and physical instabilities such as hazardous fuel accumulations and pest outbreaks. Only recently have we gained an understanding of the integral role that disturbance agents play in maintaining spatial and temporal diversity in our ecosystems.

Wildfire is often the most dramatic disturbance type and has the ability to significantly alter the physical and biological characteristics of an ecosystem. It can change the structure and species composition of a forest, remove some or the entire forest floor organic layer and alter the chemical properties of the soil. In ecosystems where natural wildfires are frequent, they help to prepare seed beds, recycle nutrients, alter plant succession, maintain a diversity of seral stages across the landscape, control insect and disease outbreaks as well as reduce fuel accumulations. Many of the native plant species in fire-dominated ecosystems depend on it for their existence.

All biogeoclimatic subzones have been separated into five natural disturbance types (NDT) according to the Forest Practices Code Biodiversity Guidebook. These NDTs are classified based on the size and frequency of natural disturbances that occur in those ecosystems as per the following:

- NDT 1 - Ecosystems with rare stand-initiating events
- NDT 2 - Ecosystems with infrequent stand-initiating events
- NDT 3 - Ecosystems with frequent stand-initiating events
- NDT 4 - Ecosystems with frequent stand-maintaining fires
- NDT 5 - Alpine Tundra and Sub-alpine Parkland ecosystems

The higher elevation and cooler ecosystems including CWHvm1 and CWHvm2 are classified as NDT 1 - Ecosystems with rare stand-initiating events. The drier and lower elevation ecosystems including CWHdm and CWHds1 are classified as NDT 2 -Ecosystems with infrequent stand-initiating events.

There are some drier stand types that exist within the District that are similar to stands found in the NDT 3 of the interior of the province; i.e. pure lodgepole pine (*Pinus contorta*) stands. Although these stand types exist in a cooler climate than in the interior of the province, they still have the potential to exhibit fire behavior typical of intensities found in drier interior ecosystems.

The Effects of Wildfire

<u>The Effects of Wildfire on Vegetation</u>

Fire dependent forest ecosystems have intricately evolved with the influence of fire. The roles that fire has played in these ecosystems include: seed bed preparation; recycling of nutrients; altering plant succession; creating a diversity of seral stages across the landscape; controlling insect and disease outbreaks as well as the reduction of fire hazard. In these ecosystems the native plant species have evolved with frequent fires and in many cases depend on it for their existence.

The influence that fire has on vegetation varies depending on the species. Vegetation can either impede or accelerate a fire depending on its flammability characteristics. Consequently, each species reacts and adapts to fire in different ways depending on the intensity and nature of the fire.

The survival of plants and trees during a wildfire depends on their ability to tolerate heat, which is largely dependent on the moisture levels of their tissue. Fire resistance refers to the ability of the plant to survive the passage of a fire (DeBano *et al.* 1989). This depends on the food reserves and fire-adapted traits of the plant, as well as the frequency and characteristics of fires to which the plant is exposed.

Where wildfires are a regular occurrence, some plant species have developed traits that help them to survive and/or regenerate following wildfire. Some pine trees produce serotinous cones that only open and release seeds after exposure to heat associated with a fire. Other species produce hard-coated seeds that require fire to scarify them. Still others have thick, fire resistant bark that helps the tree survive the passage of wildfires. Certain species have food and bud reserves located between the root and the shoot and therefore protected from fire. These buds will sprout and use the food reserve to stay alive following a wildfire.

Herbaceous species are generally less affected by wildfire largely due to their protected position near or below the ground. The seeds of these plants are also more easily transported and can establish more quickly from adjacent sites than those of shrubs and trees.

Wildfires can have a dramatic effect on the soil properties and forest floor, which in turn determines which species can establish and survive. Depending on fire intensity, the organic layers of the forest floor can be burned off and there are changes to the soil's physical, chemical and biological properties.

In the study area, there are two main tree species that have fire-adapted traits. Douglas-fir (*Pseudotsuga menziesii)* has very thick bark, deep roots and high crowns that help it survive surface fires. This species also regenerates readily under post-fire conditions. Lodgepole pine does not have fire resistant traits but instead produces serotinous cones that ensure that it will quickly re-occupy a site following a fire. The survival and/or re-establishment of these species following wildfire depend on the previous stand composition, site characteristics and fire behavior.

<u>The Effects of Wildfire on Wildlife</u>

Fire effects on wildlife are highly dependent on the wildlife species. In general, fire has a greater impact on critical habitat characteristics than on individual animals. Death directly caused by wildfire is rare for large animals and more common in smaller animals that are not as mobile. The greatest impact to wildlife populations is on the availability of food, cover habitat and the structural diversity of the ecosystem. These changes can be either beneficial or detrimental depending on the species.

Fire can drastically change the quality and abundance of available food by reducing overstory cover and increasing ground forage. A reduction in tree cover affects both protective cover requirements (hiding from and escaping predators) and thermal cover opportunities (preventing body heat loss). Where the overstory cover is removed, there is often an increase in ground cover, which can either be detrimental or beneficial depending on the habitat requirements of the species.

Wildfires rarely burn uniformly across a landscape and, consequently, produce patches of unburned forest. This creates important stand edge effects between seral stages (i.e. habitat types). These boundaries between habitat types and stand structure types are critical for wildlife diversity and survivability. They are especially important for many large herbivores since they provide protective cover as well as access to forage. Wildfires tend to leave numerous dead trees standing, which provide critical habitat for a variety of birds, small mammals, reptiles, amphibians, and invertebrates.

Mammals with larger home ranges such as moose, black-tailed deer, grizzly bear, elk and black bear tend to benefit from wildfires that leave a variety of seral stages, a critical habitat requirement for these species. Regular wildfires help to maintain a mosaic of forest types across the landscape and generally increase the short-term abundance of forage on a site. This can be attributed to increased isolation and the subsequent increased temperature, release of nutrients and decreased competition for site resources between shrubs and trees. Wildfires usually kill older and poorly digestible plant parts, which are replaced with younger more succulent parts that contain more digestible proteins, minerals and fiber.

The survivability of small mammals during a wildfire depends on the location and mobility of the animal and the size and intensity of the fire. The amount of coarse woody debris is probably the most important small mammal and amphibian habitat component affected by wildfire. Fires will generally lower small mammal populations for 1 to 3 years before they return to pre fire levels (DeBano *et al.* 1989). Amphibians and reptiles are more often found in moist ecosystems and are able to find shelter by burrowing into the soil. The effects to birds tend to vary with the intensity of the fire and the existing populations. In general, birds that feed on herbaceous forage tend to increase following wildfire whereas those which use the forest canopy or the boles of trees tend to decline.

The Mountain Pine Beetle and Wildfire

The continuous tracts of even aged forests naturally found in lodgepole pine ecosystems create uniform conditions that are often prone to insect and disease outbreaks. These outbreaks are often naturally controlled by agents such as wildfire. Fire suppression and a warmer climate have negated this balance and created unstable conditions that have resulted in the largest outbreak of Mountain pine beetle (MPB) ever experienced in North America. It is estimated that by 2013, 80% of the province's pine could be killed.

An intricate and cyclical relationship between wildfire and the MPB exists. While the beetle depends on lodgepole pine dominated forests for habitat, beetle outbreaks create fuel buildups making the forest prone to wildfire. These resulting stand-replacing fires control the MPB outbreak, but ensure the regeneration of lodgepole pine (an early seral stage species in these ecosystems). Although the beetle creates conditions detrimental to its short-term population, it ensures the long-term survival of the species by maintaining lodgepole pine forests. Similarly, lodgepole pine provides a habitat for the MPB, contributing to its own mortality, but in turn creates conditions favoring the regeneration of its own species.

It is speculated that both historic fire suppression over the past century and climate change have created conditions that have lead to this historic outbreak. Fire exclusion has increased a large amount of lodgepole pine in the susceptible older age classes and the unusually warm, recent winters have allowed the outbreak to continue to grow.

There are small, isolated pockets of lodgepole pine located within the District boundary, particularly on dry, rocky outcrops. The current MPB outbreak has extended south of the Whistler area and is continuing to move towards Squamish. In these pockets of pine, it is likely that there will be high mortality within the next 3 to 5 years. In the case of such an attack, the resulting fuel accumulations will pose a significant wildfire threat to adjacent developments.

Rare and Endangered Species and Plant Communities

It is widely agreed that the protection of rare and endangered species is critical for conserving both genetic and species diversity in BC. The Government of Canada has developed a national strategy for species at risk to prevent other species from becoming at risk. The strategy includes the Species at Risk Act (SARA), which came into force in June 2003. SARA is intended to protect the wildlife found on federal lands, as well as their critical habitat. The purposes of the Act are to prevent Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species, and encourage the management of other species to prevent them from becoming at risk. The species assessment process is conducted by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Based on the status report, they use a committee of experts to conduct a species assessment and assign the status of a wildlife species believed to be at some degree of risk nationally.

On a provincial level, the British Columbia Conservation Data Centre (CDC) works along side of the SARA process. It is a part of the Wildlife Inventory Section of the Resources Inventory Branch of BC. This organization is responsible for collecting and storing information on rare and endangered plants, animals and plant communities in BC Entities that have been ranked as red-listed are considered extirpated, endangered, or threatened in British Columbia.

The impacts of fuel treatments to these plants, animals and ecosystems should be taken into considerations for future urban development and when prescribing fuel treatments across the study area. Details regarding the management requirements of these entities can be found on the Conservation Data Center website (http://srmwww.gov.bc.ca/cdc) and on the federal Species at Risk website (http://www.speciesatrisk.gc.ca/default_e.cfm).

The Current Fire Environment

Historic Fire Weather Analysis

Table 2. MoFR weather stations.

Station Name/Number	Latitude/ Longitude	Elevation (m)	Year Installed
Squamish Camp (63)	50 07 00 / 123 23 48	200	1970
Squamish R/S (76)	49 42 00 / 123 06 00	0	1970

Table 3. Weather statistics for the months of May to Sept.

Weather Attribute	May	Jun	Jul	Aug	Sep	Avg
Daily Average Temp (°C)	16	19	22	23	19	19.8
Daily Maximum Temp (°C)	37	35	38	37	32	35.8
Daily Average Precipitation (mm)	2	2	2	2	3	2.2
Average Wind Speed (km/h)	10	11	11	11	7	10

Table 4. Fire weather indices between the months of May to September.

Station	Fine Fuel Moisture Code	Duff Moisture Code	Drought Code	Initial Spread Index	Build Up Index	Fire Weather Index	Temperature
90^{th} Percentile	92	76	473	9	101	26	28
Average	73	35	247	4	48	10	20
Maximum	100	265	771	31	264	68	38

*Indices definitions can be found on the Canadian Wildland Fire information System at http://cwfis.cfs.nrcan.gc.ca/en/background/bi_FWI_summary_e.php

Local Fuel Types

Sixteen national benchmark fuel types are used by the Canadian Fire Behavior Prediction System. This system divides fuels into five major groups and 16 more specific fuel types. These groups are used to describe fuels according to stand structure, species composition, surface and ladder fuels and the organic (duff) layer. It should be noted that each fuel type represents a fire behavior pattern and may not necessarily match the fuel types described in the classification system. In addition, many of the fuel profiles are not exact matches, however they are the closest profiles available using FBP97 as a fire behavior model.

The fuel types were derived by running the vegetation resources inventory database for this area through an algorithm. If possible, these areas were updated using existing inventories, field reconnaissance, or air photo interpretation.

Table 5. The fuel types and representative areas found within the District.

Fuel Type Classification	Area (ha)	% of area
C2	926	6.9
C3	290	2.2
C4	180	1.3
C7	127	0.9
D1	3639	27.2
M2	3902	29.2
I (Interface)	2484	18.6
N (Non-fuels)	426	3.2
W (Water)	1397	10.4

<ins>Current Stand Conditions:</ins>

The fuel type classification is a descriptor for potential fire behavior characteristics of the stand, but it does not provide an accurate description of the stand condition. Within the District, the forest has been divided into a number of characteristic stand types or 'current stand conditions' (CSC).

These structural conditions are described in general terms below.

CSC #1: Coniferous dominated stands - Mature

These are generally moderately dense stands (200-500 stems/ha) which are dominated by a mix of predominantly mature or veteran Douglas-fir, western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) (>80 years old). These stands typically have a stand structure that is gappy and multi-storied , with moderate to heavy shrub complexes and surface fuel loading that can range from low to moderate. The height to the main canopy is generally greater than 4 m, but the presence of shade tolerant conifers (hemlock and cedar) and tall shrub complexes contribute to ladder fuels. Canopy fuel loading is generally high and continuous.

These stands pose a high fire behavior potential.

CSC #2: Coniferous dominated stands – Young

These are generally young, dense (800-2000+ stems/ha) pole sapling stands of Douglas-fir with mixed components of western hemlock, western red cedar and lodgepole pine. These stands were likely harvested within the past 20 years. They are short (<6 m in height) and have branches extending down to or near ground level. The shrub layer is sparse to moderately developed due to high crown closure and there is often a moderately aged slash loading from harvesting. Crown loading and ladder fuels are high and continuous.

These stands pose a high to very high fire behavior potential.

CSC #3: Lodgepole pine stands

Within the District, pure lodgepole pine stands generally occur as isolated pockets on dry, rocky outcrops and other typically drought prone sites. These stands tend to occur around the rocky, climbing areas within the southern and eastern portion of the District and at the northern boundary of the District. The stands can be very dense (>800 stems/ha) with poor to moderately developed shrub/herb layers. These stands tend to have a moderate amount of dead standing stems resulting from stem exclusion. The ground fuel loading is generally moderate to high as decomposition rates are slow in these poor, dry ecosystems.

These stands pose a high to very high fire behavior potential.

CSC #4: Mixed higher elevation stands

These stands are found at higher elevation and consist of old growth and mature mixed, shade tolerant conifer species. These stands typically have a stand structure that is gappy and multi-storied, with heavy shrub complexes and surface fuel loading that can range from low to moderate. The height to the main canopy is low and the tall shrub complexes contribute to ladder fuel loading. Canopy fuel loading is generally high and continuous.

Due to their elevation and typically higher snow levels, these stands generally experience less days in the higher fire danger classes. However, they can be highly volatile due to the waxy nature of the needles associated with high elevation species. Under high danger class conditions these stands can pose a high fire behavior potential. While the stands are generally substantial distances from the interface, their high canopy fuel loading and exposure to upper levels winds can pose a spotting hazard during extreme fire hazard situations.

CSC #5: Deciduous dominated stands

Typical of flood plains, large tracts of deciduous stands occupy a substantial portion of the District. These stands occur across most the valley bottom and along the secondary rivers and creeks. These stands predominantly consist of red alder (*Alnus rubra*) with mixed components of black cottonwood (*Populus trichocarpa*) and bigleaf maple (*Acer macrophyllum*). There may also be minor inclusions of mixed coniferous trees including spruce variants, western redcedar and western hemlock. Deciduous species are not as flammable as conifer species and, therefore, do not contribute to a high potential fire behavior, particularly in maritime ecosystems. The understory vegetation tends to be lush and rich but has a high moisture regime throughout the year. These stand types have proven to be effective canopy fuel breaks due to their lower volatility and their association with wetter understory environments.

Wildfire Risk Analysis Methodology

Overview

The recommendations outlined in this document were based on two levels of wildfire risk mapping. The first is a landscape level "Wildfire Risk Analysis." This GIS based model spatially quantifies and analyzes the relationships that exist between fire behavior potential, values at risk and constraints to suppression capabilities. This analysis produces a ranking of fuel polygons across the landscape based on landscape-level and site-specific attributes.

Polygons with the highest ranking and which are adjacent to structures at risk, undergo a more detailed Interface Fuel Hazard Assessment. This ranking system was used to determine where fuel treatments will effectively reduce wildfire threat and to prioritize these areas for treatment.

Together, these two assessments provide a foundation for developing treatment strategies on both a broad landscape level, as well as specific treatments adjacent to structures at risk. Detailed methodologies for these risk assessments can be found in Appendix A and Appendix B.

Wildfire Risk Assessment

The "Wildfire Risk Analysis" is a GIS based model that spatially quantifies and analyzes the relationships that exist between the critical factors affecting wildfire risk. The objective of this model is to provide planners with a decision making tool that spatially identifies the severity of wildfire threat on a landscape level. This information allows planners to analyze and explore the implications of different management activities in relation to wildfire risk.

The overall hazard ranking spatially determines wildfire threat by incorporating four key components as follows:

1. Fire behavior characteristics (40% of the weighting)
2. Risk of ignition (10% of the weighting)
3. Threat to structures, natural features and cultural features of significance (25% of the weighting)
4. Suppression constraints (25% of the weighting)

These four components are in turn calculated from contributing factors, each of which is represented by a layer in the geographic information system. The wildfire hazard of each of the components is calculated by overlaying the relevant contributing factors. The layers representing these four components are subsequently overlaid to produce the final wildfire risk rating.

The objective of the WRA is to provide a landscape level overview of the risk posed by a potential wildfire. The WRA provides valuable direction for land use planning on a broad scale. However, due to the coarse scale of the input data, its application to site specific treatments is often limited. The results from the WRA should be used to determine how to reduce the potential for a large scale wildfire using strategies such as land use and building guidelines, fuel modification, forest harvesting, silviculture, and the construction of roads and recreation trails.

Interface Fuels Hazard Assessment

The Wildfire Risk Analysis provides an excellent coarse filter, at a landscape level, for identifying high-risk areas. However, its utility for developing detailed fuel abatement strategies in the urban interface zone is limited. To compliment the WRA and provide more accurate analysis of the fuel hazard within the interface, an Interface Fuels Hazard Assessment (IFHA) has also been completed.

Interface Fuel Hazard Assessment Overview

The wildland-urban interface (WUI) is defined as the area where urban development meets natural ecosystems. These are the areas where the risks of a wildfire pose the greatest threat to urban developments and human lives. Additionally, this is where the greatest risk exists for a human caused fire to spread into natural forest. While the District contains an extensive WUI zone, much of the valley bottom contains deciduous tree species, which contribute to lower fire behavior and crown fire potential than coniferous tree species.

The objective of the IFHA is to prioritize interface areas for fuels treatment though a standardized fuel hazard ranking system that accounts for the fire behavior potential as well as the potential consequences of a fire to interface structures. It provides guidance for determining where fuel treatments will effectively reduce wildfire risk and, subsequently, prioritizes these areas for treatment.

The final risk rating for this strategy considers both the probability of a fire occurrence as well as the consequence. The probability is determined by the fire behavior potential while the consequence incorporates the density of structures at risk as well as the size of the existing defensible space around these structures. The final risk is calculated by adding together the fire behavior ranking (a maximum of 100) and the structures at risk ranking (a maximum of 50) to produce a final ranking out of 150.

Calculating the fire behavior ranking was done by analyzing the factors that influence rate of spread, crown fire potential and fire intensity. In addition, factors that influence how fire will behave, including slope and aspect, were incorporated. The ranking for structures at risk included a measure of the density of structures present. This was then modified to reflect the size of the fuel break between the structure and the adjacent forested stands. A detailed methodology report for this ranking system has been included in Appendix B.

Due to the scope of this study, and the limitations associated with the funding source (UBCM), fuels treatment prescriptions could not be developed for each area that was identified as a treatments priority. Future Stand Conditions are provided for the typical fuel profiles found across the study area as well as a standardized approach for developing and monitoring fuel treatment prescriptions. The IFHA also contains general, site-specific treatment recommendations. In addition, recommendations are made for the proper planning of future developments as well as standards for wildfire preparedness and public education.

Official Document Reviewopments as well as standards for wildfire preparedness and public education.

Official Document Review

All official documents of the District were reviewed and recommendations made as to how to better address the wildfire risk to the District by modifying or introducing policy and bylaws.

Results and Discussion

Landscape Level Risk Abatement Strategies

Certain factors that contribute to the overall wildfire risk, such as terrain, weather conditions, or location of existing structures, are difficult to change. In order to effectively abate wildfire risk, land use planning strategies should focus on addressing those contributing factors that can be easily modified and will have significant immediate and long term risk reduction impacts. These include: ensuring new developments are FireSmart, improving access, increasing water availability, reducing ignition sources, and modifying the fuels profile.

The results of the wildfire risk analysis, the interface fuel hazard assessments and the official document review were utilized to develop land use planning recommendations for the District.

More site-specific fuel treatments within the high-risk areas of the urban interface are addressed later in this report through an Interface Fuels Treatment Strategy.

The District has been divided up into several strategic Fuel Management Areas (FMAs). The delineation of areas was based on wildfire risk, urban density, and geographic features. Areas within an FMA have similar wildfire risk rankings, urban densities, fuel types, and potential management issues. Nomenclature reflects local geography for easy reference. Boundary descriptions should be considered general and amendable.

Landscape level fuels mitigation outside of the District boundaries should be addressed in co-operation with the MoFR.

Specific landscape level treatments have been recommended for each designated Fuel Management Area and are addressed in that section.

Recommendations: Landscape Level Risk Abatement Strategies

1. Utilizing this report, embark on fuel management projects as part of a District Fuel Management Strategy.
2. Pursue funding for fuel management pilot projects and fuel management operational projects.
3. Dialogue with the MoFR to address wildfire risk and fuel management in higher level planning for those areas adjacent to the District.

<u>Modifying the Fuels Profile</u>

The fuels profile can be altered to reduce the fire behavior potential by changing the stand structure (fuel loading, size, and continuity) and/or species composition (deciduous vs. coniferous species). This can be accomplished through silviculture treatments such as partial cutting, thinning and pruning. These types of operational strategies are best implemented by collaborating with private landowners and tenure holders.

Qualified professionals should be consulted to develop plans and prescriptions that are ecologically appropriate for the site.

Fuel Management Areas

The District has been divided up into several Fuel Management Areas (FMAs) as per the following map.

There are a number of recommendations that are consistent for all FMAs. These include:

Recommendations for all FMAs:

4. Promote FireSmart for existing homes and for future development.
5. Work with the SLRD to ensure any future developments adjacent to the District boundary FireSmart.
6. Ensure BC Transmission Corporation (BCTC) mitigates the slash hazard on the transmission corridors.
7. Work with private land owners, First Nations, CN Rail, BC Transmission Corp, and other agencies to address the fuel hazard on their associated lands.
8. For areas requiring treatment, ensure qualified professionals are utilized to develop ecologically appropriate fuel treatment recommendations.
9. Develop procedures for dealing with traffic flow should Hwy #99 become impassable due to a wildfire.
10. Work with BC Transportation to mitigate ignition fuels adjacent to the highway.

FMA #1: Elaho FMA

Boundaries: The Squamish River valley northwest of the junction of the Cheekye River and the Squamish Valley Road.

Description: Most of this FMA is a flood plain that is dominated by deciduous species. There is very little urban interface of concern. The majority of the fuels have a low fire behavior potential with the exception of the coniferous dominated stands on the eastern slopes above the floodplain. There is a low density of residential and agricultural parcels throughout this valley. The area contains a BCTC transmission corridor as well as some light industrial activities.

Key Issues of Concern: This area is relatively far from fire protection services; there is only one access route in and out of the valley; there is a high ignition potential associated with recreation and industry; and slash along the power line transmission corridor presents a fire hazard.

This area is heavily used for camping and recreation.

Values at risk: Homes, power lines, and cultural/natural features (First Nations values and/or species/ecosystems at risk).

Recommendations: FMA #1

11. Promote public education to homeowners along interface of the eastern edge of the valley.
12. Place signage warning recreation users of existing fire hazard.

FMA #2: Paradise FMA

Boundaries: The area north of Squamish Valley Road between, and adjacent to the Paradise Valley Road and the Sea to Sky Highway, extending south to the road leading into Alice Lake Provincial Park and north to the District boundary.

Description: There are scattered residential developments throughout Paradise Valley The eastern portion of this area contains the Sea to Sky Highway, a railway right-of-way (ROW) and transmission corridors.

Key Issues of Concern: This area is relatively far from fire protection services; there is only one access route in and out of Paradise Valley; there is a high ignition potential associated with the highway and railway; there is slash associated with the power line transmission corridor; and restricted traffic flow along Hwy #99 in the event of a wildfire. On the upper slopes, Paradise valley supports dry, dense coniferous stands, many of which possess a high fire behavior potential and pose a risk to existing structures. There is generally very little defensible space adjacent to these structures.

Values at Risk: Homes, power lines, fish hatchery, recreational property, parkland, Hwy #99 and cultural/natural features (First Nations values and/or species/ecosystems at risk).

Recommendations: FMA #2

13. Work with CN Rail on mitigating fuel hazards on their ROW.
14. Develop an evacuation plan for Paradise valley.
15. Promote public education to homeowners in Paradise valley. Emphasize the importance of maintaining a defensible space.

FMA #3: Squamish FMA

Boundaries: West of the Sea to Sky Highway, east of the Squamish River; south of the Squamish Valley Road, and north of Howe Sound.

Description: The area contains the majority of the urban development in the District. Generally, the fuel types found in this area are deciduous dominated and have a low fire behavior potential. There are small pockets with dense coniferous cover. The area also contains the Sea to Sky Highway, a railway ROW, transmission corridors, hydro substations, and industrial activities.

Key Issues of Concern: There is a high density of urban development and a high population base in this area; there is high fire behavior potential in the northern portion of this zone within Brackendale; there is a high load slash associated with the power line transmission corridor; and restricted traffic flow along Hwy #99 in the event of a wildfire.

Values at Risk: Homes, power lines, Hwy #99, hydro substations and riparian ecosystems.

Recommendations: FMA #3

16. Promote public education to homeowners in particular on the northern edge of Brackendale.

FMA #4: Highlands FMA

Boundaries: East of the Sea to Sky Highway, south of the road to Alice Lake Provincial Park, and north of Mamquam River.

Description: This area contains extensive interface areas, including well-used recreation trails. The area also contains the Sea to Sky Highway, transmission corridors, and Alice Lake Provincial Park. Forest harvesting activities occur adjacent and to the east of this FMA.

Key Issues of Concern: Limited access routes to some areas of the Garibaldi Highlands; slash associated with the power line transmission corridor; restricted traffic flow along Hwy #99 in the event of a wildfire; and potential ignition sources associated with adjacent harvesting activities.

The structures built in this area have some of the highest value in the District. They are built within close proximity of the adjacent forests, and have very little defensible space. Currently, there is a university and numerous new subdivisions being constructed in the area.

There are extensive fuels with a high fire behavior potential to the east and north of the existing developments, which could pose a spotting hazard to the developments. It would be worthwhile to work with BCTS and BCTC to develop a landscape level fuel break east of FMA #4, adjacent to the BCTC transmission line and existing harvest blocks in the area.

Values at Risk: Homes, power lines, Hwy #99 and riparian ecosystems.

Recommendations: FMA #4

17. Work with BCTS or other licensees to ensure harvesting activities are conducted in a manner that decreases accidental ignitions.
18. In cooperation with BCTS and BCTC, develop a landscape level fuel break east of FMA #4 along the BCTC corridor.
19. Pile and burning of harvest sites should be conducted under safe conditions during a good venting period. The Squamish FRD should acquire information on these activities.
20. Work with the university to develop an evacuation plan.
21. Work with the MoFR to create a landscape level fuel break along the eastern edge of this area.

FMA #5: Valleycliffe FMA

Boundaries: East of the Sea to Sky Highway, south of Mamquam River, and north of Stawamus River.

Description: Contains major interface areas and recreational trails. The area also contains the Sea to Sky Highway and transmission corridors. Forest harvesting activities occur adjacent to this FMA. This area includes the smoke bluffs climbing area.

Key Issues of Concern: Limited access routes into the Valleycliffe area; slash associated with the power line transmission corridor; restricted traffic flow along Hwy #99 in the event of a wildfire; and potential ignition sources associated with adjacent harvesting activities. The smoke bluffs are used extensively for climbing and contain pockets of dense conifers that pose a high fire behavior potential.

Values at Risk: Homes, power lines, Hwy #99 and riparian ecosystems.

Recommendations: FMA #5

22. Work with BCTS and other licensees to ensure harvesting activities are conducted in a manner that decreases accidental ignitions.
23. Pile and burning of harvest sites should be conducted under safe conditions during a good venting period. The Squamish FRD should acquire information on these activities.
24. Consider developing a secondary access route to the Valleycliffe area for evacuation purposes during a wildfire.
25. Promote fire awareness among the climbing community.
26. Enhance trails around the smoke bluffs to improve access and provide strategic ground fuel breaks.

FMA #6: Stawamus FMA

Boundaries: South of Stawamus River and north of Petgill Lake, east of Howe Sound, and west of the Stawamus Chief Provincial Park.

Description: Contains some structures across from Shannon falls and just northeast of Murrin Provincial Park; includes a number of protected areas with extensive recreation trails. The area also contains the Sea to Sky Highway, a railway ROW and transmission corridors.

Key Issues of Concern: A high ignition potential associated with the railway and recreational activities; slash associated with the power line transmission corridor; and restricted traffic flow along Hwy #99 in the event of a wildfire. There are numerous climbing areas in this FMA and a first nation reserve.

Values at Risk: Homes, power lines, parkland, Hwy #99 and cultural/natural features (First Nations values and/or species/ecosystems at risk).

Recommendations: FMA #6

27. Work with CN Rail to mitigate fuel hazards on their ROW.
28. Work with the MoE on fuels management within Stawamus Chief Provincial Park.
29. Promote fire awareness among the climbing community.
30. Work with Squamish First Nation to promote fire awareness on the reserve.

FMA #7: Squamish River FMA

Boundaries: West of the Squamish River from the pulp mill site to the confluence of the Cheekye and Squamish Rivers.

Description: Contains minor interface by the old pulp mill. The area is inaccessible by road from Squamish, is steep with dense fuels and contains a transmission corridor. The Squamish River and associated deciduous forest provides a substantial fuel break to adjacent developments.

Key Issues of Concern: Heavy slash associated with the power line transmission corridor; restricted traffic flow along Hwy #99 in the event of a wildfire; and high fire behavior potential and spotting hazard to the main town site.

Values at Risk: Power lines, parkland, cultural/natural features (First Nations values and/or species/ecosystems at risk).

Recommendations: FMA #7

31. Work with the owners of the old pulp mill site to mitigate any fuel hazard.
32. Any consideration of future development within this FMA should address fuel and spotting hazards.

Interface Fuels Treatment Strategy

The WUI is defined as the area where urban development meets natural ecosystems. These are the areas where the risks of a wildfire pose the greatest threat to urban developments and human lives. Additionally, this is where the greatest risk exists for a human caused fire to spread into natural forest.

Mitigating the interface fuel hazard requires that site-specific treatment prescriptions be developed that produce future stand conditions that both reduce potential fire behavior, and result in a healthy and resilient residual stand. Treatments must be ecologically accurate, operationally and economically feasible, and socially acceptable. Additionally, the areas requiring treatment should be prioritized with the highest hazard areas being treated first.

Recommendations: Interface Fuels Treatment Strategy

33. Develop site-specific interface treatments that are ecologically accurate, operationally and economically feasible, and socially acceptable.
34. Prioritize treatments based on wildfire risk (as per this report and local knowledge).

FireSmart Community Planning and Design

The FireSmart manual was developed to provide guidelines to individuals, communities and planners on how to reduce the risk of loss from interface fires. The guidelines describe interface issues, evaluate interface hazards, provide mitigation strategies and techniques, and include regional planning solutions. An overview of the general guidelines and recommendations within the FireSmart manual as they pertain to WUI development are summarized in Appendix F.

The increasing sprawl of communities and the proliferation of homes into wildland areas complicate wildfire risk management. Government agencies need to ensure proper design of development, homes and landscaping.

New developments have historically been designed and built with little consideration for the potential consequences of a wildfire. A responsible development plan should consider prevention of two types of wildfire interface scenarios. The first is that of a wildfire starting in the forest and spreading into the interface community, the second is that of a fire starting from human activity in the urban environment and spreading into the adjacent forest.

Responsible development planning must consider the prevention of both scenarios in the short and long term. Short-term measures during the construction phases include prevention potential ignition sources and ensuring suppression resources are available in the case of a wildfire. This can be accomplished by ensuring the developer/contractor has a Construction Fire Management Plan in place prior to commencing operations. Long-term planning includes the strategic placement of structures and roads within the development, as well as treating interface fuels to reduce the fire behavior potential and creating defensible spaces around structures within the interface.

All new areas that are proposed for development should comply with FireSmart guidelines and the fuel management recommendations outlined in this report. It is important for architects and developers to consider wildfire threat during the planning and design phases of a development since factors such as the location of alternate water sources, road access and hydrant location, may have major influence on the overall design. The FireSmart Guidebook is an excellent resource and should be referred to at all levels of design and planning (home, yard, subdivision, and community).

A pre-development 'Fuels Hazard and Fire Risk Assessment' report should be completed, by a qualified individual, as a requirement of the development permit application process. This report would include a Fuels Hazard Ranking for the site, FireSmart recommendations and a fuel treatment prescription to reduce potential fire behavior. The developer would be required to meet the recommendations of this report to the satisfaction of the District. Placing this responsibility on the developer will reduce the burden on District taxpayers. A suggested table of contents for such a report is included in Appendix G.

Recommendations: FireSmart Community Planning and Design

35. New developments in the interface should follow FireSmart guidelines and recommendations in this report.
36. A Fuel Hazard and Fire Risk Assessment report should be completed for each new development.
37. Ensure contractors have a Fire Management Plan completed prior to conducting operations.

District Management of Existing and Newly Acquired Natural Lands

The procedures for assessing hazard and developing fuel treatment prescriptions described in this document should be used to manage fuels on existing natural lands and natural lands newly acquired by the District. In addition, these procedures should be used to address public complaints and to justify subsequent treatments. All areas slated for treatment should be assessed on the ground by a trained professional. A walkthrough of the area should be undertaken to gain an understanding of fuel characteristics and to stratify into similar stand/fuel types if necessary.

Each stand/fuel type that is a candidate for treatment should be evaluated using the Fuel Hazard Assessment methodology (or a similar methodology) described in Appendix B. The results of this assessment should be used to determine whether treatments can significantly alter fire behavior and to prioritize them accordingly. If it is determined that an area requires treatment, a detailed, ecologically based prescription should be developed using the guidelines provided in this report. Using the Fuels Hazard Assessment as a guideline will help to ensure that fuels are assessed and treated consistently across the District.

Recommendations: District Management of Natural Lands

38. Manage natural lands within the District using the fuel hazard assessment system and the fuel treatment prescription template provided in this report.
39. Trained professionals should determine which areas require treatment and develop treatment prescriptions.

Improving Access

Planning to improve access through the development of roads and recreation trail systems can also reduce wildfire risk. Access roads can act as effective fuel breaks for surface fires (and potentially crown fires) and can also provide access for equipment and control lines for suppression efforts. This should be considered when planning new road systems for harvesting, recreation or new developments.

Recreation trails are generally not as effective as fuel breaks as compared to roads and do not provide vehicle access. They do, however, facilitate access for ground crews and act as fuel breaks to help stop the spread of ground fires. In protected areas where tree removal and road building are not options, the establishment of new recreation trails should be considered. Trail-building standards should be wide enough to provide ATV access where possible and applicable.

It should be noted that improving access through the establishment of new roads and trails also increases the risk of human caused ignitions.

Recommendations: Access

40. Establish trail standards that will ensure that trails act as surface fuel breaks and provide access for suppression crews.
41. Develop standards for the abatement of residual activity fuels associated with trail building.
42. Consider constructing trails into remote wooded areas with poor access (for suppression purposes).

Water Availability

During suppression activities, the availability of water is the single most important resource. Where fire hydrant coverage is limited, particularly in remote settings, determining which natural water bodies will suffice as water sources during the dry fire season can improve suppression success. Potential sites that are suitable for helicopter bucketing or as pump sites for suppression crews should be identified and mapped.

This task of setting up water delivery systems is best performed by personnel with suppression experience. These water sources should be assessed during the driest summer months to determine their state during the fire season. Good sites should be identified and located on a map using GPS.

In addition, when new areas are proposed for developments, adequate fire hydrants should be established in strategic locations in the interface zone. In high-risk areas that have no other water sources, artificial water sources should be strategically located.

Recommendations: Water Availability

43. Develop a GPS database of waterways within and adjacent to the District that have adequate supply for suppression purposes.
44. For new developments, consider establishing or enhancing water bodies within the develop area that could serve as emergency water sources.

Reducing Sources of Ignition

Causes of ignition can be separated into human caused and lightning caused. Lightning caused ignition is difficult to predict across the landscape. Traditionally, about one half of all wildfires are caused by human activities. Within an urban area there is an abundance of human caused ignition sources including:

- Camp fires
- Heavy industry activity
- Discarded cigarettes and matches
- Vehicle traffic
- Railways
- House related fires

- Power lines
- Vandalism

The most cost effective component of any fire prevention program includes predicting and preventing human caused ignitions. This is best achieved through ongoing public education campaigns. A history of fires within and adjacent to the District, including the cause and location should be compiled and updated to identify high-risk areas. Public education campaigns should focus on these areas and their related user groups.

Historically, railroad tracks are another concern with regard to human caused ignitions. Railcars can cause sparks that ignite fires adjacent to tracks. This is of particular concern where there is a continuous forest between the railroad and homes. These areas should be identified and fuels accumulations between the tracks and structures should be treated.

Tree failure adjacent to power lines is also a potential ignition source. All transmission and distribution lines should be assessed annually for hazard trees.

Recommendations: Reducing Ignition Sources

45. Compile a database of human caused fires within the District to determine high risk areas and problem sources.
46. Work with schools to promote wildfire awareness and prevention.
47. Engage in public education programs to reduce human caused ignition.
48. Work with CN rail to ensure their ROW do not contain light cured fuels prior to the fire season.
49. Develop a District policy for ensuring power distribution lines within the District are assessed regularly for tree risk and are properly maintained.
50. Work with BCTC and BC Hydro to ensure that distribution lines and transmission corridors are assessed regularly for tree risk and that the District is kept informed of this activity.

Fire Behavior and Fuels Treatment Overview

An understanding of the factors which affect and drive fire behavior is the foundation to determining how to implement fuels treatments in order to reduce potential fire behavior.

Appendix D, "Fire Behavior and Fuels Treatment Overview" provides background information on these topics. This section should be consulted when developing public information and prior to undertaking fuel management projects. A qualified professional with related experience should make recommendations for fuel management projects.

Fuels treatment prescriptions provide recommendations for altering stand structure or ground fuel loading as a means of reducing potential fire behavior. Each fuel treatment method is specific in how it affects fire behavior. There is no one specific treatment type or strategy that works in all situations or locations. Treatments should be site specific, ecologically-based, scientifically sound, economically and operationally feasible and socially acceptable.

These prescriptions should be developed by professionals with experience in fire behavior, fire suppression and forest ecology.

The current UBCM CWPP funding program do not fund the development of treatment prescriptions. In lieu, there is an in-depth explanation for developing fuel treatment prescriptions included in Appendix E.

Future Desired Conditions

The Future Desired Condition (FDC) to be achieved by the fuels treatment prescriptions will vary with each site depending on the current stand condition, the fuels profile, the ecology of the site, the topography, and the presence of structures and natural features at risk. Due to the scope of this project it was not possible to specify FDCs for each treatment polygon. Instead, broad treatment recommendations were made based on the fuel types covered in the Current Stand Condition section of this report.

Differences between CSCs and FDCs are generally accounted for in changes to the stand density and species composition, height to live crown, ladder fuels, and the loading and continuity of surface fuels. Almost all FDCs will have lower stand densities, more fire resistant conifer species, more deciduous species, fewer ladder fuels, higher canopy base heights, and lower and non-continuous surface fuel loadings.

The abatement of existing surface fuels or resulting activity fuels are not addressed in this section. Options for surface fuels treatments are covered in Appendix D.

FDC descriptions are provided for those stands within or immediately adjacent to the District boundary and considered to be of concern to the District.

Recommendations: Future Desired Stand Conditions

51. Use the Future Desired Condition descriptions, in conjunction with the Current Stand Conditions, as guidelines when developing site specific fuel treatment prescriptions.

FDC #1: Conifer dominated stands - Mature

Mature Douglas-fir is the most fire-resistant tree species found within the District and, if ecologically appropriate, it should be favored as a residual tree when planning fuel treatment prescriptions. Thinning of the overstory will likely be necessary in order to reduce crown fuel loading. Average target densities should be low enough or canopy gaps should be strategically created to significantly reduce the potential for a crown fire.

Pruning these residual trees will likely be necessary to eliminate ladder fuels and raise the canopy base height. Additionally, thinning and/or removing understory canopy trees and shrubbery may be necessary to reduce the fuel loading in the lower canopy and to reduce ladder fuels which allow a fire to move from the surface to the canopy. Ground fuels should be treated through chipping, removal, or piling and burning to a level that will not support a fast moving ground fire.

Distribution of residual trees should be site-specific and take into account the location and density of suitable residual trees, their wind firmness, individual tree health, proximity to structures and survivability of the species due to forest health issues. Monocultures should be avoided, as should increasing the overall age of the stand too much. As a solution, recruitment trees within the understory should be left. In order to meet canopy fuel loading targets, some of the co-dominant trees within the understory can be removed in favour of leaving younger recruitment trees.

FDC #2: Conifer dominated stands – Young

These stands will require extensive thinning and pruning due to their high canopy fuel loading and ladder fuels. Understory vegetation and shade tolerant tree species, if present, should be removed. The same factors as FSC #1 should be considered for the distribution of residual trees. Additionally, overstory diversity should be taken into account when selecting residual trees. Deciduous trees should be favored over less fire resistant species and shade tolerant species.

Average target densities should be low enough or canopy gaps should be strategically created to significantly reduce the potential for a crown fire. All residual trees will likely require pruning to 3 to 5 m to eliminate ladder fuels and raise the canopy base height. All woody material and ground fuels should be treated through chipping, removal or piling and burning to a level that will not support a ground fire.

FDC #3: Lodgepole pine stands

Lodgepole pine is a fire-dependent species and relies on the occurrence of fire as part of its regeneration strategy. This species promotes fire on the landscape: it grows at high densities on drought prone sites; undergoes heavy stem inclusion which contributes to high surface fuel loads; has very flammable bark; and the trees maintain their lower branches which act as ladder fuels. This susceptibility to fire makes the presence of pure lodgepole pine stands within and adjacent to the District a concern.

Pure lodgepole stands can be difficult to treat. They are often growing on rocky sites with limited access. Once thinned, these stands are more prone to wind throw. The high densities of low value trees can make treatment economically challenging. Additionally, these sites are difficult to regenerate due to the shallow, dry nature of the site.

For these stand types, the best treatment may be to completely remove the stand and plant another species (if feasible and ecologically appropriate). Other treatments are to thin the stand in strips that run perpendicular to the typical wind direction. This will maintain some of the wind firmness of the stand, reduce the canopy fuel continuity and produce surface fuel breaks which can be coupled with future trail locations. If wind firmness can be maintained, it may be possible to thin residual strips.

It is important to reduce ground fuels in these stands as decomposition rates are very slow.

FDC #4: Upper elevation stands

Although these stands tend to occur some distance from the District boundary and interface, they can still be a threat to the District. With their high canopy fuel loading and exposure to upper levels winds, these fuel types can pose a spotting hazard during extreme fire hazard situations. Due to their remote nature, treating these stands may not necessarily be the best use of funds.

These stands are best addressed through approaching the licensees that are responsible for harvesting them. Appropriate post-harvest treatments should be implemented to reduce the resulting harvest slash and the associated fuel hazard. If post-harvest slash is treated properly, harvested blocks can be used as crown and surface fuel breaks.

FDC #5: Deciduous stands

Deciduous stands will likely not require any fuel treatments due to their low volatility. However, as these stands move through succession (change to coniferous stands) their fuel hazard levels should be re-assessed.

Non Forest Fuels

Non-forested fuels include cured grassland and shrub/herb/grass complexes. These fuel types were not assessed during the fieldwork. Typically, these complexes are prime locations for accidental ignitions during the dry fire season as they contain light, easily ignitable fuels. They have high spread rates but also have quick burn out times.

Examples of such fuel are farmer's fields, undeveloped land, and roadside ditches. These fuel types are often isolated from the interface but can be located adjacent to forest fuels. Therefore, these fuel types can be the source of an accidental ignition (cigarette butt, vehicle fire, etc.) along a roadside that could contribute to a wildfire.

Priority Treatment Areas

The interface fuels treatments strategy identifies high-risk fuels that have been prioritized for treatment. Ideally, these areas should be considered in sequence and treated accordingly. However, these areas have been identified based on the fire behavior potential and structures at risk with no consideration for land ownership. In many of these areas, there are multiple landowners and development of treatment prescriptions and operational activities must be in co-operation with all parties.

In each treatment area, all affected and adjacent landowners should be identified and notified of the intended treatments. If all owners are in agreement with the treatment approach and cost, the prescriptions should be developed, reviewed and approved by all parties. If only certain owners are in agreement, the relative effectiveness of only treating portions of the polygon should be taken into consideration.

In many areas, treatment polygons are located on crown land behind homes and may extend onto private lots. The successful treatment of these areas requires that all fuels be treated up to the edge of structures at risk. This will require extensive public education and consultation with private landowners. It is recommended that in these areas, a representative of the District meet with each private landowner and discuss in detail the recommended treatments on their property.

Once all high and very high treatment areas have been considered for treatment, the areas that have been identified as a moderate priority should be ground assessed according to the Fuel Hazard Assessment methodology described in Appendix B.

A prioritized list of the interface polygons is included in Appendix C.

Recommendations: Priority Treatment Areas

52. Treat all identified interface polygons in prioritized sequence as funds become available.
53. Dialogue with adjacent landowners and governments when treating interface areas to ensure the maximum benefit is realized from the treatment through treating larger areas.

Review of Official Policy and Guidelines

The following is a summary of some of the existing District policies and guidelines that relate to wildfire management and fuel treatments. Recommendations have been provided where applicable.

Recommendations: Official Policies and Guidelines

54. Consider adapting the recommendations resulting from the review of the official policy and guidelines.
55. Future development of official policy and guidelines should consider the need to abate wildfire risk.

Official Community Plan

The District Official Community Plan (OCP) (Schedule 'A' to Bylaw 1536) was reviewed for content that was contradictory to FireSmart and for sections where FireSmart guidelines should be implemented. The following sections were found to be of concern and recommendations have been provided for consideration.

4.2 Parks, Recreation and Open Space:

This section fails to mention the importance of designing and utilizing these spaces. Specifically trails can act as emergency access routes to wilderness areas, as well as to function as surface fuel fire breaks for wildfire protection purposes.

Recommendation: Ensure that any improvements of existing natural spaces as well as any new development of this variety follow FireSmart guidelines. Trail systems can function well as fire breaks, while any other areas left in a 'natural state' with current fuel levels could pose a significant wildfire hazard, especially due to the increased human traffic within these areas.

4.2.17 Tree Preservation:

If a tree protection bylaw is developed, ensure that the District doesn't 'handcuff' itself in regards of fuel modification projects to reduce the fuel loading in high-risk wildfire areas. Tree removal (alive or dead) for the purposes of fuel reduction, when deemed necessary by a qualified professional, the local fire department or District staff, should be allowed for in District policy.

4.3 Environmental Protection

***Recommendation*:** This 'protection of the environment' policy should ensure that wildfire and fuels management studies and strategies play a significant role in any new development in the applicable areas within the District. It is also important to recognize the value of returning these natural areas to their historical 'fire resistant' state through an active fuels management program.

4.4 Risk Management Policies

4.4.13 Mitigate Wildfire Potential:

The majority of the Risk Management section is devoted to floods and debris flows.

***Recommendation*:** A wildfire risk and fuel hazard exists in certain parts of the District. This justifies striving to develop a 'FireSmart Community' through active participation of all citizens and agencies. This can only occur if the 'FireSmart' mentality exists at the management/planning level and especially within documents such as the OCP. If the District makes it a priority, and ensures all new development is striving toward the same goals, the rest of the existing community would be more apt to get on board and actively participate on their respective private lands.

4.6 Municipal Services

4.6) Squamish Fire Rescue:

The District must ensure that, with the growth and development mentioned in this section, the auxiliary staff improves their wildfire suppression capabilities as well as their structural fire protection capacity. This would involve annual training of the BC Forest Service S-100: Basic Fire Suppression course as well as supplementing the department with specific wildland fire equipment, should the SFRD feel it necessary.

5.0 Sub Areas

5.1 through 5.13 Environmentally Sensitive and Hazardous Areas:

For each of the Sub Areas, this section has no mention of wildfire hazard. For areas with a significant hazard, the following statement could be added: 'All efforts will be made to mitigate wildfire potential in this Sub Area through strict adherence to FireSmart guidelines derived from consultation with wildfire professionals and the development of appropriate bylaws'.

6.0 Development Permit Areas

DPA 1 through 8 Building Materials –

FireSmart guidelines should be adhered to in all DPAs, most importantly those that are declared to have a high wildfire risk. Fire resistant siding and roofing materials are of primary concern in this regard.

Landscaping –

FireSmart guidelines should also be adhered to in all areas of high wildfire risk with consideration given to fire resistant species selection, location of vegetation in relation to structures, proper spacing of vegetation to reduce fuel continuity, and the discontinued use of flammable bedding material (bark mulch, sawdust, etc).

<u>Bylaws and Policies</u>

District Bylaw No. 1822 was reviewed and the following recommendations are submitted for consideration.

9.0 Application for Complex Buildings:

This section should be altered for all new developments where the owner would be required to obtain a *Pre-Development Fire Risk Assessment and Fuel Management Strategy* performed by a wildfire management specialist. Outlined in this assessment would be all of the FireSmart criteria that the owner/developer would be expected to satisfy within their development, focusing on, but not restricted to, the following areas:

- Fuel modification of existing vegetation
- Setbacks from forested areas
- Exterior building materials (roofing, siding, windows, decks)
- Landscape vegetation selection and location in relation to the structures
- Outbuilding locations and building materials used

Proposed bylaw: Any application for a building permit with respect to a complex building shall include a copy of a *Pre-Development Fire Risk Assessment and Fuel Management Strategy* performed by an experienced wildfire management specialist. The onus will then be on the developer to adhere to the FireSmart recommendations made in this assessment.

10.0 Application for Standard Buildings:

This section should be altered in the same fashion as 9.0 above, understanding that the *Pre-Development Fire Risk Assessment and Fuel Management Strategy* could be considerably less detailed for an individual home than for a full complex or subdivision.

Recommended bylaw: Any application for a building permit with respect to a standard building shall include a copy of a *Pre-Development Fire Risk Assessment and Fuel Management Strategy* performed by an experienced wildfire management specialist. The onus will then be on the owner/developer to adhere to the FireSmart recommendations outlined in this assessment.

16.1.1 Essential Services: Road:

This bylaw should be somewhat more specific in regards to its suitability for access by fire and emergency vehicles and the egress of the public during an emergency evacuation.

Recommended bylaw: The FireSmart guidelines provide dimensional details regarding road or driveway strengths, grades and widths to provide access to buildings by fire and emergency vehicles. Specific dimensions include a minimum road width of 7.3 m and gravel shoulder widths of 1.2 m.

If shoulder parking will occur shoulder widths should be increased to 2.75m.

The District of Squamish Schedule J-1 to Bylaw 1536 (1998) Sea to Sky University Sub Area Plan was reviewed and the following recommendations are submitted for consideration.

2.3 Physical Site Conditions:

This section has no mention of any wildfire risk studies being performed for this development.

Recommendation: Ensure that a *Pre-Development Fire Risk Assessment and Fuels Management Strategy* has been performed by an experienced wildfire management specialist (if not too late at this phase*).*

3.2.1 Green Space / Environment:

There is no mention of any wildfire prevention principles in this section. These areas could pose a fire risk to the community should it go unchanged, thus making fuels management and proper wildfire prevention planning a crucial element of the overall development.

Recommendation: "Strive to create a 'FireSmart' community through consultation with wildfire management professionals" and the local Fire Rescue Department.

4.2.2 Environment:

There is no mention of wildfire risk in this section. These areas could pose a fire hazard to the new community should it go unchanged, thus making fuels management and proper wildfire prevention planning a crucial element of the overall development.

Recommendation: "g) Require that a *Pre-Development Fire Risk Assessment and Fuels Management Strategy* be conducted to mitigate the potential wildfire hazard faced by the new development."

The District of Squamish Schedule 'A' to OCP Bylaw 1536 Amendment Bylaw (Sea to Sky University) 1812 was reviewed and the following recommendations are submitted for consideration.

Development Permit Area #9A A2 Landscaping

A2.1.2 Plant Selection to Enhance Native Environment and Strengthen Campus:

No mention of species selection with regards to fire resistance. The FireSmart guidelines or any related scientific literature can assist in species selection conducive to reducing wildfire hazard.

Recommendation: Select fire resistant vegetation species as per FireSmart guidelines

A2 Landscaping:

No mention is made of vegetation placement. Plants should not be located against structures and adequate spacing should occur between plants and trees to prevent transfer of fire into tree crowns.

A5 Wildland Wildfire Interface

A5.1 Goals:

This section may be intentionally general in nature but should be strengthened to display a commitment by the District to ensure the development strives to be FireSmart.

Recommendation: Wildfire hazard zones within this Sub Area will require a *Pre-Development Fire Risk Assessment* and be expected to comply with the FireSmart guidelines.

C1.2 Objectives: No mention of wildfire preventative measures for the residential portion of the development in this section.

Recommendation: "Residential housing should comply with FireSmart guidelines especially with regard to building materials and landscape design in an effort to create a FireSmart community."

C1.4 Landscape:

This section needs some emphasis on vegetation selection and placement.

Recommendation: Should include: "Emphasis on selection of fire resistant species in accordance with FireSmart guidelines. Vegetation should be planted away from buildings and spaced appropriately to prevent transfer of fire to tree crowns."

C1.5 Materials and Colour

C1.5.1 Materials:

No mention of fire resistant building materials.

Recommendation: "Consideration should be given to utilizing fire resistant building materials, specifically for roofing and siding in accordance with FireSmart guidelines"

C2.3 and C3.3 Siting of Buildings,

C2.3.1 and C3.3.1 Site Setbacks-Side and Rear Setback Guidelines:

Consideration needs to be given to those sites that are adjacent to the interface in regards to the position of buildings. FireSmart guidelines suggest a fuel free zone for a minimum of 10 m from all buildings. Situating a home at the back of a lot adjacent to a forested area would contravene this policy and increase the wildfire risk to that residence or building.

Recommendation: As a general recommendation, the District may want to develop a bylaw to preclude any structures from being constructed within 10 m of a forested area. Alternatively, the District could require that forested stands within 10 m of proposed building locations should have any existing fuel hazard abated through an ecologically appropriate treatment.

The Wildfire Act

The Wildfire Act places the responsibility for preventing wildfires clearly on the public, construction operators, and/or developers and provides an avenue for the government to charge for suppression costs and damages caused by an accidental ignition. In order to reduce the potential for a wildfire, the District should consider ensuring developers and construction contractors are aware of this responsibility when applying for development permits. Additionally, the SFRD may want to consider site inspections of construction sites to ensure contractors are attempting to reduce ignition starts.

Alternatively, development permits could only be issued if a construction fire management plan was in place.

Recommendations: Wildfire Act

56. Prior to granting a development permit, ensure construction contractors operating within the District are aware of their responsibilities as described within the Wildfire Act.
57. Consider developing bylaws which restrict certain construction activities during high and extreme fire danger periods.

Initial Attack Preparedness

Every year, prior to the fire season, a training seminar should be organized to ensure that District staff members are familiar with the fire management plan, from initial detection through to public evacuation. Communication is the most critical component of wildfire management. All staff should know their role once an interface wildfire is detected or a large-scale wildfire approaches the District.

The District fire department and parks staff who work frequently in the field should be trained in the WCB recognized S-100 Basic Fire Suppression Course. This will provide them with basic wildland suppression skills that they can use should suppression crews not be available or should supplementing Protection crews be necessary.

Standard suppression equipment should be kept in strategic locations around the District. This equipment should be inspected and maintained annually. At a minimum, this should include standards outlined in the “Wildfire Act” including basic hand tools, fire extinguishers and communication devices. The preferred location for this equipment would be with the Squamish FRD or near high-risk natural areas, such as parks.

Recommendations: Initial Attack Preparedness

58. Develop an annual training session to ensure District staff are familiar with the fire management plan.
59. Ensure SFRD staff have S-100 training.
60. Strategically place suppression equipment in high risk interface areas.

Interagency cooperation

The MoFR Protection Branch mandate is to fight forest fire throughout the province. Local municipal governments are required through the *Local Government Act* to establish fire departments that are responsible for fire prevention and suppression. Traditionally, municipal fire departments are better equipped to fight structural fires, whereas the MoFR is trained in wildland fire suppression and maintains equipment that is more suited to suppressing wildland fires. Interface fires, however, involve both wildland and structural fires.

As both the local fire department and the Protection Branch agencies are likely to be involved in an interface fire, interagency training between the local Protection Fire Zone and the District fire departments should be considered. Increased cooperation between these two agencies will result in better fire protection. Joint field training sessions involving mock fire scenarios would be a useful undertaking for both these agencies. Similarly, in the event of a pilot project being undertaken, these two agencies could use any proposed prescribed burning as a training session.

A review of equipment belonging to the fire department necessary for interface fires should be conducted to determine if any shortfalls exist. If this equipment must be purchased, budget allocation should be provided to the departments to ensure the District has the best possible fire service. Alternatively, the fire service may be able to access the necessary equipment from the Protection Branch through an off-season loan agreement.

Recommendations: Interagency Cooperation

61. Consider conducting annual, multi-agency training sessions involving mock interface drills.
62. Ensure the Squamish FRD has the necessary equipment to deal with an interface fire prior to the arrival of wildland fire crews.

Public Information

In order to undertake fuels treatment in the interface, it is important to have public support. Public consultation is a worthwhile pursuit, although it can be a lengthy and time consuming process. Following are suggestions for disseminating information to residents.

The Protection Branch prints a FireSmart manual that outlines the basics of the FireSmart program and how homeowners can Fire-safe their home and property. The District, regional district, and fire department should have these manuals readily available at their respective offices. However, distributing these manuals at higher profile locations would reach a wider public audience. Such locations would be the local service stations, grocery stores, insurance agents, restaurants, and outdoor shops.

These manuals could also be distributed with the annual property tax assessments. For this method, a more concise summary of FireSmart, on standard letter size paper, may be more cost effective to distribute. This inclusion would only summarize the major points of FireSmart. This distribution method would also be useful for providing an information package to residents regarding any proposed fuel treatments around the District, and interface treatment work and scheduling.

The official web page of the District should be updated to include a Wildfire Management link. This link would provide a copy of this report, general information to the public about FireSmart, proposed interface treatments, and other pertinent wildfire information.

Upon the completion of this report, a public presentation should be planned. A summary of the findings and recommendations should be provided to the public. This summary should include: the location of required interface treatments and a planned schedule of treatments, if known.

In the event the District is successful in obtaining a provincially funded Fuels Management Pilot Project, an announcement regarding this project should be followed by a public presentation. The presentation should outline the area proposed for treatment, the treatment to be undertaken, the objectives to be achieved, and the potential work schedule.

Annual FireSmart public presentations or workshops should occur prior to each fire season. Information on how to FireSafe homes and properties delivered during these sessions would help maintain the importance of fire abatement at the forefront of the public's mind.

The local schools should be approached regarding potential education ventures. Classroom presentations by local Protection staff would be beneficial, as would field trips to existing fuel treatments in the area. School field trips could occur to the FMPP site during and after completion of the project. Classes could embark on a contest to develop wildfire awareness in the District.

Recommendations: Public Information

63. Make FireSmart brochures available at: fire halls, insurance agencies, real estate offices, city hall, recreation centers and other public locations. Consider disseminating FireSmart information in an annual mail out (with the tax assessment mailing).
64. Include a wildfire management link on the District website.
65. Conduct a public presentation prior to engaging in any fuel management work and disseminate project information accordingly.
66. Hold annual FireSmart information sessions.
67. Promote FireSmart principles through the public education system utilizing the local fire department and Protection Branch.

Post Fire Evaluation

Once a wildfire within or adjacent to the District has been suppressed, a post fire ecosystem impact assessment should be completed. A qualified professional should visit the burned area and make observations regarding the impact of the fire on the ecosystem including:

- The estimated area burned
- The percentage of crown burned and distribution of remnant patches
- The species and size of surviving trees
- The distribution and type of vegetation burned and remaining after the fire
- The estimated depth of forest floor burned
- Notes regarding any wildlife using the site
- Potential soil erosion issues

- The presence of invasive species or potential for introduction
- The estimated number of hazard trees created per hectare

This information will be useful to consult in the following years to determine the long-term impacts of the fire on the District. Additionally, a summary of the entire operation should be documented. This should include the management decisions made and actions taken as well as any incidents of concern. A log of all interface fires should be compiled for future reference.

Recommendations: Post Fire Evaluation

68. In the event of a wildfire within, or adjacent to, the District conduct an Ecosystem Impact Assessment to determine the short and long term fire-effects on the District.
69. Keep a log of all human caused fires within and adjacent to the District to assist with future abatement strategies.

Post Fire Rehabilitation

Wildfire is a natural disturbance agent in these ecosystems. If the fire has occurred in a protected area, and invasive plant species are not considered an issue, the site could be left to rehabilitate naturally. The only types of damage that should be addressed are those caused by suppression activities such as the construction of fire breaks and the use of heavy machinery in the forest. If the fire has occurred on private or crown owned lands, the landowner should be consulted to determine the extent of rehabilitation efforts required and who is responsible for these costs.

If the wildfire causes extensive degradation of the organic horizons on a steep slope or within a riparian area, the site should be assessed for slope stability. Erosion control may be required, especially if any riparian areas are at risk.

Wildland fire may create hazard trees that should be assessed. Any hazard trees that pose a striking danger to adjacent roads and trails should be removed immediately.

Recommendations: Post Fire Rehabilitation

70. Rehabilitate any burned areas in a manner that is ecologically appropriate. Native species should be utilized wherever possible.
71. Conduct post-fire tree risk assessments to ensure public safety.
72. Address post-fire erosion concerns before they arise.

Wildfire Suppression Planning

When a catastrophic wildfire occurs, lack of preparation can quickly lead to panic and disorganization. This greatly increases the risk to human lives, structures and natural resources. Planning to manage a wildfire involves a great deal of uncertainty. It is difficult to predict how the wildfire or the public will behave under varying circumstances. Therefore, it is essential that decision-makers are highly organized and prepared so that evacuation and suppression response can occur as quickly and efficiently as possible.

A detailed wildfire action plan should be developed for the district that includes a communication and evacuation plan. Such a plan should be developed in cooperation with the local Fire Rescue Department, the local Protection Branch, the Provincial Emergency Program, and the Officer of the Fire Commissioner.

Recommendations: Wildfire Suppression Planning

73. Develop a District Fire Management Plan or other plan that encompasses communication and evacuation plans in the event of an approaching wildfire.

Wildfire Detection and Reporting

The MoFR is the agency responsible for fire detection. Fires are located with the assistance of the lightning locator system, aerial patrols and public observation. In an urban center, a wildfire is most likely to be detected by the public. All fires should be reported to the Provincial Forest Fire Reporting Center in Victoria through their toll free number 1-800-663-5555. The agent will then collect as much information regarding the fire including:

- The exact location
- The estimated size
- The type of fuel burning and adjacent fuel source
- The rate of spread and direction of the fire
- The colour of the smoke
- The values at risk

Recommendations: Wildfire Detection and Reporting

74. During the fire season, post the wildfire reporting number at key locations within the District.

Other Recommendations

The requirements for managing fuels in urban interface areas are highly variable and dependent on fuel loading, values at risk, terrain and access. This report outlines assessment procedures and broad recommendations for treatment that will ensure that areas are prioritized and prescriptions are developed consistently across the District. To further standardize this process, it is recommended that a fuel treatment prescription template be developed.

It is also recommended that pilot projects be established to assess the use of several abatement techniques (chipping, grinding, piling and burning, and controlled burning) as potential treatment options within the District. Some of these treatments can be contentious and the use of some may not be possible considering existing regulations related to air quality. However, it is recommended that all options be considered.

Additionally, adaptive management should be undertaken to effectively incorporate scientific knowledge to monitor, evaluate and improve strategies. Prescriptions and monitoring reports should be kept on file to assess the success of treatments over time. As new treatment methods are introduced, and as new scientific knowledge becomes available, treatments should be adapted accordingly.

Recommendations: Other

75. Utilize a Fuel Treatment Template to ensure consistency between fuel treatments.
76. Consider all options for treatment regardless of controversy. Determine the level of social acceptability of each treatment method prior to engaging in treatments.
77. Develop feedback loops within the District as a means of collecting the public's sentiment regarding fuel management.
78. Employ adaptive management in regards to wildfire and fuels management.

Conclusion

The potential for a catastrophic wildfire is very real within the District of Squamish. The community is growing rapidly as is evident by the numerous developments currently under construction or in the planning phase. Given the forested landscape within and surrounding the District, the potential for a catastrophic interface fire is very real. However, it is possible to reduce this potential through careful planning and operations.

The District should consider adopting the recommendations made within this report. By implementing any number of the above recommendations, the District will improve the survivability of the community, decrease the potential for a catastrophic wildfire, and work towards maintaining the world-renowned recreational opportunities for which the community is famous.

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Appendix A - Wildfire Risk Analysis Methodology

The following document is an overview of the methodology followed to produce the landscape level Wildfire Risk Analysis (WRA) for the District and adjacent area. It is meant to provide some base line knowledge of the ranking system structure and how the results are presented.

The WRA is a GIS based model that spatially quantifies and analyzes the relationships that exist between the critical factors affecting wildfire risk. The objective of this model is to provide planners with a decision making tool to spatially identify the severity of wildfire threat on a landscape level. This information allows planners to analyze and explore the implications of different management activities in relation to wildfire risk.

The overall hazard ranking spatially determines wildfire threat by incorporating four key components as follows:

1. Fire behavior characteristics (40% of the weighting)
2. Risk of ignition (10% of the weighting)
3. Threat to structures, natural features and cultural features of significance (25% of the weighting)
4. Suppression constraints (25% of the weighting)

These four components are in turn calculated from contributing factors, each of which is represented by a layer in GIS. The wildfire hazard of each of the components is calculated by overlaying the relevant contributing factors. The layers representing these four components are subsequently overlaid to produce the final wildfire risk rating.

Component #1 - Fire Behavior

The fire behavior component of the WRA measures how wildfire will behave under extreme weather conditions. The Canadian Fire Behavior Prediction System (FPB) provides quantitative outputs of selected fire behavior characteristics for the major Canadian fuel types (Hirsch 1996).

Fuel Types

Sixteen national benchmark fuel types, which are divided into five categories, are used by the Canadian Fire Behavior Prediction System to forecast how wildfire will react. These fuel types were defined using the forest inventory and guidelines developed by the Ministry of Forests. Six fuel types were identified in the study area. It is important to note that these fuel types represent a type of behavior pattern and their generic names do not accurately describe the type of stand that is found. These descriptions are referenced from the MoFR Protection Branch website at:
www.for.gov.bc.ca/protect/organization/Kamloops/Zones/Kamloops/FuelsManagement/FuelTypes.htm

Fuel type C-2 (boreal spruce): This fuel type is characterized by pure, moderately well stocked black spruce stands on lowland (excluding Sphagnum bogs) and upland sites. Tree crowns extend to or near the ground and dead branches are typically draped with bearded lichens (Usnea sp.). The flaky nature of the bark on the lower portion of stem boles is pronounced. Low to moderate volumes of down woody material are present. Labrador tea

(Ledum groentandicum Oeder) is often the major shrub component. The forest floor is dominated by a carpet of feather mosses and/or ground-dwelling lichens (chiefly Cladonia). Sphagnum mosses may occasionally be present, but they are of little hindrance to surface fire spread. A compacted organic layer commonly exceeds a depth of 20 to 30 cm.

Fuel type C-3 (mature jack or lodgepole pine): This fuel type is characterized by pure, fully stocked (1000 to 2000 stems/ha) jack pine (*Pinus banksiana*) or lodgepole pine (*P. contorta* Dougl.) stands that have matured at least to the stage of complete crown closure. The base of live crown is well above the ground. Dead surface fuels are light and scattered. Ground cover is feather moss over a moderately deep (approximately 10 cm), compacted organic layer. A sparse conifer understory may be present.

Fuel type C-4 (immature jack or lodgepole pine): This fuel type is characterized by pure, dense jack or lodgepole pine stands (10,000-30,000 stems/ha) in which natural thinning mortality results in a large quantity of standing dead stems and dead down woody fuel. Vertical and horizontal fuel continuity is characteristic of this fuel type. Surface fuel loadings are greater than in fuel type C-3 and organic layers are shallower and less compact. Ground cover is mainly needle litter and suspended within a low (*Vaccinium sp*.) shrub layer.

Fuel type C-7 (ponderosa pine-Douglas-fir): This fuel type is characterized by uneven-aged stands of ponderosa pine (*Pinus ponderosa* Laws.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in various proportions. Western larch (*Larix occidentalis* Nutt.) and lodgepole pine may be significant stand components on some sites and elevations. Stands are open with occasional clumpy thickets of multi-aged Douglas-fir and/or larch as a discontinuous under-story. Canopy closure is less than 50% overall, although thickets are closed and often dense. Woody surface fuel accumulations are light and scattered. Except within Douglas-fir thickets, the forest floor is dominated by perennial grasses, herbs, and scattered shrubs. Within tree thickets, needle litter is the predominant surface fuel. Duff layers are nonexistent to shallow (<3 cm).

Fuel type D-1 (leafless aspen): This fuel type is characterized by pure, semi-mature trembling aspen (*Populus tremuloides* Michx.) stands before bud break in the spring or following leaf fall and curing of the lesser vegetation in the autumn. A conifer understory is noticeably absent, but a well-developed medium to tall shrub layer is typically present. Dead and down roundwood fuels is a minor component of the fuel complex. The principal fire-carrying surface fuel consists chiefly of deciduous leaf litter and cured herbaceous material that are directly exposed to wind and solar radiation. In the spring the duff mantle (F and H horizons) seldom contributes to the available combustion fuel due to its high moisture content.

Fuel types M-1 (boreal mixedwood-leafless) and M-2 (boreal mixedwood-green): These fuel types are characterized by stand mixtures consisting of the following coniferous and deciduous tree species in varying proportions: black spruce (*Picea mariana*), white spruce (*Picea glauca*), balsam fir (*Abies amabilis*), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), trembling aspen, and white birch (*Betula papyrifera*). On any specific site, individual species can be present or absent from the mixture. In addition to the diversity in species composition, stand mixtures exhibit wide variability in stand structure and development, but are generally confined to moderately well drained upland sites. Two phases associated with the seasonal variation in the flammability of the boreal mixed wood forest are recognized: the leafless stage occurring during the spring and fall (fuel type M-1) and the green stage (fuel type M-2). Rate of spread in both fuel types is weighted according to the proportion (expressed as a percentage) of softwood and hardwood components. In the summer, when the deciduous overstory and under-story are in leaf, fire spread is greatly reduced with maximum spread rates only one-fifth that of spring or fall fires under similar burning conditions.

Weather inputs

Weather conditions used to calculate fire behavior were derived from MoFR historic records dating back to 1970. This data was compiled and statistically analyzed to determine the average 80th percentile fire weather indices for the months of May to September. The fire weather inputs were as follows:

BEC subzone	Fine fuel moisture code (FFMC)	Build-up index (BUI)	Wind (km/h)
CWHdm	88.0	60.3	10
CWHds1	90.8	90.9	10
CWHvm1; CWHvm2	88.2	59.4	10
MHmm1	89.6	63.5	10

The topographical attributes required to predict fire behaviour include slope and aspect. The study area was delineated into polygons based on slope breaks of 10% intervals and aspects of 45 degrees. The cardinal wind direction was calculated from the aspect so that it was blowing upslope and the elapsed time was set at 24 hours.

All of the data pertaining to fuel types, topographical attributes, and fire weather was compiled for the entire study area. This information was then run through FPB97 to create the three output fire behavior layers: fire intensity, rate of spread and crown fraction burned.

Fire Intensity

This layer is a measure of the rate of heat energy released per unit time per unit length of fire front. It is based on the rate of spread and the predicted fuel consumption. The units for this layer are kilowatts per meter.

Rate of Spread

This layer is a measure of the speed at which a fire extends its horizontal dimensions. This is based on the hourly Initial Spread Index (ISI) value. It is adjusted for the steepness of slope, the interactions between slope and wind direction and increasing fuel availability as accounted for through the Build Up Index (BUI). The units for this layer are meters per minute.

Crown Fraction Burned

This layer is a measure of the proportion of tree crowns involved in the fire. It is based on the rate of spread, the crown base height and the foliar moisture content. It is expressed as a percentage value.

The weightings of the fire behavior layers were designated as follows with a total maximum value of 40.

Layer	Units	Unit Value	Weight
Fire Intensity	Kilowatts per meter (kW/m)	>0-500 501-1000 1001-2000 2001-4000 4001-10000 10001-30000 >30000	4 – Very Low 8 – Low 10 – Low 12 – Medium 16 – Medium 18 – High 20 – Very High
Rate of Spread	Meters per minute (m/min)	>0-5 6-10 11-20 21-40 >40	2 – Very Low 4 – Low 6 – Medium 8 – High 10 – Very high
Crown Fraction Burned	Percent of canopy crown burned (%)	0 1-9 10-49 50-89 90-100	0 – None 3 – Low 6 – Medium 8 – High 10 – Very high

Component #2 – Risk of Ignition

Fires are ignited by either human or lightning causes. The most common source of human caused ignition includes the use of motorized machinery, discarded cigarettes and matches from smoking, fires started in houses, campfires lit within natural areas, sparks from railways and accidents along hydro distribution and transmission lines. This is accounted for by buffering all areas where these causes are most likely to occur. A 30-meter buffer has been established around all roads, structures, hydro lines and railways. Where these areas run through fuel types that are likely to sustain a fire ignition, the area has been assigned a high-risk ranking.

It is difficult to predict the risk of lighting striking across a landscape. Therefore, all fuel types that are likely to sustain a fire ignition due to a lighting strike have been identified and assigned a moderate risk ranking. All deciduous fuel types have been assigned a low ranking and non-fuels have been assigned a weighting of 0.

Layer	Units	Weight
Risk of Human Caused Ignition	Areas within 30 meters of ▪ Structures ▪ Roads ▪ Trails/Camping areas ▪ Hydro Transmission lines ▪ Railways	10
Risk of Lightning Caused Ignition	All fuel types except deciduous or non-fuels (C2, C3, C4, C7, M2)	5
	All Deciduous fuels (D1/D2)	1
	All non-fuels (W, I, U, N)	0

Component #3 - Values at Risk

The 'values at risk' component of the model identifies human and natural resources which are at risk of being damaged or destroyed by wildfire. This includes the risk to man made structures and the risk that wildfire poses to rare and unique natural features.

<u>Structures at Risk</u>

This layer identifies all human-made structures that have the potential to be destroyed or damaged by wildfire. A structures layer was provided by the District. This was edited using recent orthophotos. 30 m, 100 m and 2 km buffers were then created around these structures. The areas within 30 m of any structures were designated a maximum weighting of 25. Areas further than 30 m but within 100 m were designated a weighting of 20. Areas further than 100 m but within 2 km were designated a weighting of 20.

<u>Natural features at risk</u>

This layer identifies unique natural features that could be detrimentally impacted by wildfire. It includes the locations of key wildlife habitat, rare plants and plant associations. Information pertaining to the rarity, conservation status and locations of animals, plants and plant associations was obtained from the BC MoE, Resources Inventory Branch; Forests Conservation Data Center (CDC). This data includes information pertaining to populations and communities, environmental features associated with the species as well as geographical and ecological data. Element occurrence reports were obtained from the CDC which include verified locations of rare animal species, plant species or plant associations within the study area. The CDC designates buffers to all element occurrences indicating the degree of uncertainly about the exact location. The Sea to Sky Land and Resource Management Plan was also referenced to identify critical habitat features.

Areas within these polygons were assigned a threat weighting which increased with the elements rarity ranking. In addition, the riparian areas of all ephemeral and perennial streams, lakes and wetlands were accounted for by buffering these features by 30 meters.

Cultural features at risk were queried from the Ministry of Tourism, Sports and the Arts Archeology branch. Areas were designated a weighting of 5. It is recognized that there are many more cultural features that should be included in this analysis, however this information is sensitive and was not made available.

The weightings of the structures, natural, and cultural features at risk were designated as follows with a total maximum value of 25.

Layer	Units	Weight
Structures and facilities at risk	Areas within 30 meters of any structures	25
	Areas within 100 meters of any structures	20
	Areas within 2km of any structures	5
Cultural Features at Risk	▪ Areas identified as cultural features at risk	5
Natural features at risk	▪ Red Listed CDC element occurrences (CDC) ▪ CDC Masked Sensitive occurrences (CDC)	10
	▪ Blue Listed CDC element occurrences (CDC)	7
	▪ Riparian Habitat – 30 m from all Fish Bearing/Perennial Streams ▪ Old Growth Forests (>250 years old) (FC1) ▪ Ungulate winter range (CDC) ▪ Record sized trees (CDC)	5
	▪ Riparian Habitat - 30m from all Non-fish Bearing/Ephemeral Streams	3

Component #4 – Suppression Constraints

The ability to suppress a wildfire depends on a number of factors including terrain characteristics, accessibility and the availability of suppression resources. Four factors were used to determine the overall rating for suppression capability including: proximity to roads, proximity to water sources, initial attack time and steepness of terrain.

<u>Proximity to Roads – Access</u>

This layer accounts for the accessibility of suppression resources to fight a wildfire by creating 100 m, 500 m and 1000 m buffers around all roads in and adjacent to the study area. The area within these buffers was assigned threat weightings, which decreased with their proximity to roads.

<u>Proximity to Water Sources</u>

This layer is a measure of the availability of water sources for fire suppression. It was derived by creating 100 m buffers around all fire hydrants and perennial rivers, creeks and lakes. These water sources were designated a buffer of 100 m. Fire hydrants were designated the lowest weighting of 2, perennial water sources (ponds, reservoirs, lakes, rivers) were designated a weighting of 6 and all other areas were designated a weighting of 10.

Steepness of Terrain

Steepness of terrain influences the timely ability of ground crews to access the fire and construct fire lines. Areas were weighted based on their average slope class derived from the municipality DEM database. Designated weights increased relative to the steepness of the slope. The weightings of these four layers were designated as follows with a total maximum value of 25.

Layer	Units	Unit Value	Weight
Proximity to Roads	Distance from roads in meters	0-100 from roads	1
		101-500 from roads	3
		501-1000 from roads	6
		>1000 from roads	10
Proximity to Water sources	Distance from water sources in meters	< 100m from perennial water sources (ponds, reservoirs, lakes, rivers)	5
		>100 meters from perennial water sources (ponds, reservoirs, lakes, rivers)	10
Steepness of terrain	% Slope	0-20	1
		21-40	2
		41-60	3
		60-100	4
		>100	5

*The entire area was weighted based on distance from roads. Then the risk was reduced by three if the area was accessible by a trail.

Final Wildfire Risk Rating

The final wildfire hazard rating has been calculated by adding together the ratings of the four primary components to produce a final weighting out of 100.

Appendix B - Interface Fuel Hazard Assessment Methodology

The WUI is defined as the areas where the urban development meets with natural areas. These are the areas where the risk of a wildfire poses the greatest risk to urban developments and human lives. In addition this is where the greatest risk is of a human caused fire spreading into the natural forest

The objective of this fuels assessment is to provide a standardized fuel hazard ranking system that accounts for the fire behavior potential as well as the potential consequences of a fire to interface structures. It provides guidance for determining where fuel treatments will effectively reduce wildfire threat and to prioritize these areas for treatment.

Due to the extent of the WUI within the District, the forest cover inventory and landscape level wildfire risk analysis (WRA) was first queried to narrow down the critical areas to be assessed on the ground. The database was clipped to within 100 m of all structures and all areas that ranked as moderate or higher were visited and assessed using the IFHA methodology.

The final risk rating for the interface fuel considers both the probability of a fire as well as the consequence of a fire occurring. The probability is determined by the potential fire behavior while the consequence incorporates the density of structures at risk as well as the size of the defensible space around the structures at risk. The final risk is calculated by adding together the fire behavior ranking (a maximum of 100) and the structures at risk ranking (a maximum of 50) to produce a final ranking out of 150.

The Fire Behaviour Ranking

The fire behavior ranking fuel loading was divided into fuel characteristics that influence rate of spread, crown fire potential and fire intensity. In addition, factors that influence how fire will behave were incorporated. The following table summarizes the weighting of the five indicator categories:

Indicator	Contribution %
Spread Rate Index	25
Crowning Potential Index	35
Fire Intensity Index	25
Fire Behavior Modifiers	15

The weightings of each of the four indicator categories are calculated from a number of fuel and site characteristics. For each table, the weights of the individual variables were added together to produce the category weighting. The four category weightings were then added together to determine the final fire behavior ranking.

Spread Rate

The *Spread Rate* is a measure of the relative rate of spread or reaction intensity of a surface fire. It is based on the quantity and horizontal continuity of surface fuels including sound woody fuel, litter, and flammable shrubs and grasses.

Variable	Nil	Low	Medium	High	Very high
fine fuel loading (<1 cm including litter)	0	1	3	4	5
fine fuel loading (1-7.5cm)	0	2	5	8	10
Horizontal continuity of fine fuels <7.5cm)	Very Non-uniform 0	Non-uniform 1	Moderately Uniform 3	Uniform 4	Very Uniform 5
Understory ground cover of flammable shrubs and grasses (%)	0 0	<10 1	10 to <25 3	25 to <50 4	>50 5
Total Spread Rate Index					____

Crowning Potential

The *Crowning Potential* measures the probability of fire reaching, and burning through, the tree canopy. It is based on the quantity and continuity of ladder fuels and flammable crown mass.

Variable	Nil	Low	Medium	High	Very high
Crown mass[2] (St/ha)	<50 st/ha 0	50 <250 5	250-<500 10	500-<750 15	>=750 20
Ladder fuels (any fuels reaching to within 2 m of main crown)	0	2	5	8	10
Horizontal continuity of crown fuels	Very Non-uniform **0**	Non-uniform **1**	Moderately Uniform **3**	Uniform **4**	Very Uniform **5**
Total Crowning Potential Index					____

[1] – (st/ha of coniferous trees reaching from the ground fuel to within 2 meters of the crown canopy)
[2] – st/ha of codom/dom coniferous trees

Fire Intensity

The *Fire Intensity* is a measure of how hot and intense a fire will burn and how much biomass it will consume.

Variable	Nil	Low	Medium	High	Very high
Thickness of duff layer excluding litter (cm)	None 0	<1 1	1-5 3	5-10 4	>=10 5
Medium and large ground fuel (>7.5cm in diameter)	0	3	8	12	15
Horizontal continuity of medium and large ground fuels	Very Non-uniform 0	Non-uniform 1	Moderately Uniform 3	Uniform 4	Very Uniform 5
				Total Fire Intensity Index	____

[1] – All fuels > 7.5cm including rotten wood and stumps. Measured in Kg/m^2.

Fire Behavior Modifiers

The *Fire Behavior Modifiers* account for topographical features, including slope and aspect, as well as the continuity of fuels into adjacent areas.

Variable	Nil	Low	Medium	High	Very high
Slope (%)	0 to 15 1	15 to 30 2	30 to 45 3	45 to 60 4	>60 5
Size of continuous fuel area* (ha)	<0.25 1	0.25-1 2	1 - 5 3	5 to 25 4	>25 5
Aspect	North 1	East 2	Flat 3	West 4	South 5
				Total Fire Behavior Modifiers	_____

Wildfire Behaviour Ranking

A measure of the *Wildfire Behavior Potential* is accounted for by adding together the *Spread Rate*, the *Crowning Potential*, the *Fire Intensity* and *Fire Behavior Modifiers*. This is a measure of the *Risk* associated with a fire occurrence and can be classified in the following categories:

Wildfire Behavior Ranking (Risk)
<30 – Low 30-45 – Moderate 45-60 – High > 60 – Very High

Structures at Risk

Structures at Risk is a measure of the density of structures adjacent to the fuels and includes their relative slope position and the size of defensible space present. This portion of the assessment should be completed if there are structures within a 100 m distance.

Variable	**Nil**	**Low**	**Medium**	**High**	**Very high**
Structures at risk density (#/ha)	None **0**	Single Structure (1/ha) **5**	Moderate Density (2-5/ha) **10**	High Density (>5/ha) **15**	Industrial/ Commercial/Utilities **20**
Slope position of structure	No Structures **0**	Down slope **1**	Adjacent or flat slope **3**		Uphill or Crest **5**
				Structures at Risk Subtotal	_____

The structures at risk subtotal should be multiplied by the following to account for the presence of fuel breaks. This includes areas located between the fuels and the structures that do not contain any combustible materials such as roads, water bodies or rock.

Size of fuel break	**Structures at Risk Multiplier**
<10 meters	1.0
10 – 30 m	0.8
30 – 50 m	0.5
>50 m	0.1
Structures at Risk Total	_____

Fuel Hazard Ranking

The overall *Fuel Hazard Ranking* is calculated by adding together the Wildfire Behavior Ranking and the Structures at Risk Ranking. This is a measure of both the Risk and Consequences of a wildfire occurring. The overall ranking is classified as per the following categories:

Overall Fuel Hazard Ranking (Risk and Consequence)
<45 – Low
45-54 – Moderate
55-59 – High
>59 - Very High

Appendix C – Interface Fuel Treatment Areas - Priority List

Priority Rankings of Interface Polygons

Priority	Fine Fuel Loading <1cm	Fine Fuel Loading <1cm Rank	Fine Fuel Loading 1-7cm	Fine Fuel Loading 1-7cm Rank	Surface Fuels	Surface Fuels Rank	% Cover understory vegetation	% Cover Rank	Crown Mass	Crown Mass Rank	Crown Fuels	Crown Fuels Rank	Ladder Fuels	Ladder Fuels Rank
1	H	4	H	8	moderately uniform	3	<10%	1	high(500-750)	15	uniform	4	L	2
2	H	4	H	8	moderately uniform	3	<10%	1	high(500-750)	15	uniform	4	M	5
3	M	3	L	2	uniform	4	50-75%	5	very high(>750)	20	uniform	4	H	8
4	M	3	L	2	moderately uniform	3	10-25%	3	very high(>750)	20	very uniform	5	Very H	10
5	M	3	M	5	non-uniform	1	>75%	5	very high(>750)	20	very uniform	5	M	5
6	H	4	H	8	uniform	4	10-25%	3	very high(>750)	15	very uniform	5	H	8
7	M	3	H	8	non-uniform	1	<10%	1	medium(250-500)	10	moderately uniform	3	H	8
8	L	1	M	5	non-uniform	1	50-75%	5	very high(>750)	20	very uniform	5	Very H	10
9	M	3	M	5	moderately uniform	3	10-25%	3	medium(250-500)	10	uniform	4	M	5
10	L	1	M	5	non-uniform	1	10-25%	3	high(500-750)	15	uniform	4	M	5
11	L	1	M	5	non-uniform	1	<10%	1	medium(250-500)	10	moderately uniform	3	M	5
12	M	3	M	5	non-uniform	1	10-25%	3	medium(250-500)	10	moderately uniform	3	H	8
13	L	1	L	2	very non-uniform	0	>75%	5	very high(>750)	20	very uniform	5	M	5
14	L	1	L	2	very non-uniform	0	10-25%	3	high(500-750)	15	moderately uniform	3	M	5

Priority	Fine Fuel Loading <1cm	Fine Fuel Loading <1cm Rank	Fine Fuel Loading 1-7cm	Fine Fuel Loading 1-7cm Rank	Surface Fuels	Surface Fuels Rank	% Cover understory vegetation	% Cover Rank	Crown Mass	Crown Mass Rank	Crown Fuels	Crown Fuels Rank	Ladder Fuels	Ladder Fuels Rank
15	M	3	M	5	non-uniform	1	25-50%	4	medium(250-500)	10	very uniform	5	M	5
16	L	1	M	5	non-uniform	1	10-25%	3	high(500-750)	15	uniform	4	L	2
17	L	1	L	2	very non-uniform	0	>75%	5	very high(>750)	15	very uniform	5	Very H	10
18	L	1	M	5	non-uniform	1	<10%	1	medium(250-500)	10	moderately uniform	3	L	2
19	L	1	L	2	non-uniform	1	25-50%	4	very high(>750)	20	very uniform	5	Very H	10
20	L	1	M	5	moderately uniform	3	10-25%	3	medium(250-500)	10	uniform	4	M	5
21	L	1	M	5	moderately uniform	3	10-25%	3	low(50-250)	5	moderately uniform	3	Very L	0
22	L	1	L	2	very non-uniform	0	<10%	1	very high(>750)	20	very uniform	5	L	2
23	L	1	L	2	very non-uniform	0	50-75%	5	medium(250-500)	10	moderately uniform	3	H	8
24	L	1	L	2	non-uniform	1	>75%	5	high(500-750)	15	very uniform	5	L	2
25	L	1	L	2	very non-uniform	0	25-50%	4	high(500-750)	15	moderately uniform	3	M	5
26	L	1	L	2	non-uniform	1	>75%	5	medium(250-500)	10	uniform	4	H	8
27	L	1	L	2	non-uniform	1	10-25%	3	medium(250-500)	10	moderately uniform	3	L	2
28	None	0	L	2	non-uniform	1	50-75%	5	high(500-750)	15	uniform	4	M	5
29	L	1	L	2	non-uniform	1	>75%	5	very high(>750)	20	very uniform	5	M	5

Priority	Fine Fuel Loading <1cm	Fine Fuel Loading <1cm Rank	Fine Fuel Loading 1-7cm	Fine Fuel Loading 1-7cm Rank	Surface Fuels	Surface Fuels Rank	% Cover understory vegetation	% Cover Rank	Crown Mass	Crown Mass Rank	Crown Fuels	Crown Fuels Rank	Ladder Fuels	Ladder Fuels Rank
30	M	3	L	2	non-uniform	1	>75%	5	high(500-750)	15	uniform	4	L	2
31	L	1	L	2	moderately uniform	3	10-25%	3	medium(250-500)	10	uniform	4	L	2
32	L	1	L	2	non-uniform	1	<10%	1	medium(250-500)	10	moderately uniform	3	M	5
33	L	1	L	2	non-uniform	1	10-25%	3	medium(250-500)	10	moderately uniform	3	M	5
34	L	1	L	2	non-uniform	1	25-50%	4	low(50-250)	5	non-uniform	1	M	5

Appendix D – Fire Behavior and Fuels Treatment Overview

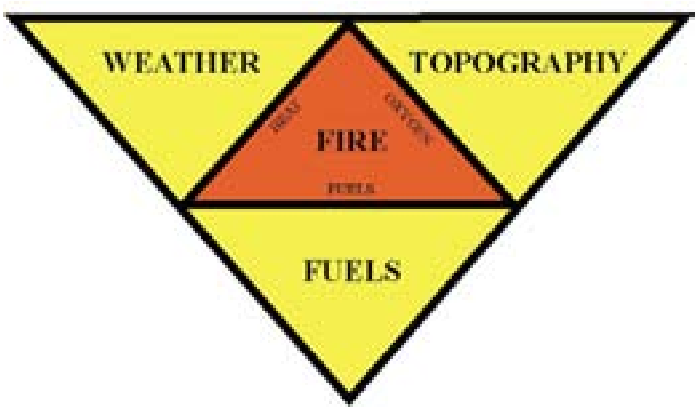
Fire Behaviour Overview

In order for combustion (fire) to occur, three components are required: fuel, oxygen, and heat. These three components form what is often referred to as the 'fire triangle' and is illustrated in figure 1.

OXYGEN + HEAT + FUEL = **FIRE**

The three components of the fire triangle.

Since all three components are required for a fire to occur, it follows that the removal of one component (side) of the triangle will result in the extinguishment of the fire. This is the basis of fire suppression and fire prevention. Fuels management focuses on the fuel side of the fire triangle. By removing, converting or modifying forest fuels, a manager can greatly reduce the risk of a wildfire, or modify fire behavior in the occurrence of a wildfire. Similar to the fire triangle, fire behavior can be broken down into three components: fuels, weather and topography. These three components form what is often referred to as the 'fire behavior triangle' and is illustrated in figure 2.



The fire behavior triangle and its components superimposed with the fire triangle.

Of these three components, managers can only alter the fuel component of the triangle. Fuels have several attributes that contribute to fire behavior including: porosity, size, quantity and fuel moisture. Fire behavior increases as fuel bed porosity and fuel quantity increases, and fuel size and moisture decreases. Therefore, managers are able to alter fire behavior by decreasing the quantity of fuel loadings, increasing the compactness of the fuel layer, and increasing fuel moisture.

Wildfire Types

There are three general types of fires: subsurface, surface, and crown. Subsurface fires burn beneath the forest floor in the organic layer of a soil. Subsurface fires can require lengthy mop-up operations and can re-emerge months later due to the embers being insulated and undetected below ground.

Surface fires are considered to occur within the area above the first two meters of the forest floor. Surface fires, while being easier to suppress, produce soil heating and can result in the volatizing of soil nutrients. The intense heating of the soil can also create hydrophobic layers that contribute to surface erosion.

Crown fires occupy the canopy layers of the stand. Crown fires are the most difficult and dangerous to suppress. They have the highest intensity levels (energy output), the greatest immediate and long-term ecological effects and pose the greatest threat to structures.

Fuels management, and subsequent treatments, usually involves reducing the potential occurrence for a crown fire and the potential intensity of a surface fire. In order to achieve a decreased fire risk, priorities usually involve reducing surface and ladder fuels and increasing the height to the bottom of the live canopy (Agee *et al.* 2000; van Wagtendonk 1996). Understanding how fire burns and how fire behavior is affected allows managers to choose the right treatment option to achieve fuel hazard mitigation objectives.

Fuel Treatment Options

All resource management activities in fire-dependent ecosystems should aim to strategically restore the natural mosaic of seral stages across the landscape. Ideally these conditions would be achieved over time through the reintroduction of frequent low-intensity surface fires. However, this treatment is difficult to implement within the wildland-urban interface zone. Therefore, the majority of stand objectives are conventionally accomplished through mechanical fuel treatments including thinning, prunning and surface fuel removal.

Fuel treatments to reduce the fire behaivor potential in the urban interface are conventionally accomplished through mechanical fuel treatments including thinning, prunning and surface fuel removal.Prescibred burning is a very efficient and natural means of managing fuel accumuations however it is generally not feasible in the urban interface.

While there is no fuel treatment that can produce a ‘fireproof’ forest stand, it is feasible to move stands toward a more ‘fire-resistant’ condition by altering species composition, stand structure and the characteristics of the fuel loads such that a crown fire is unlikely to occur. The following photos show a stand that has undergone thinning and prescribed fire treatments.

Performing treatments within the interface zone presents several problems. Residents are usually accustomed to, and desire, an unaltered forested landscape adjacent to their homes and, therefore, disapprove of changing the stand structure and habitat values adjacent to their homes. Although the presence of development means that some valuable forest attributes have already been compromised (Brown 2000) altering stand attributes through treatments requires an informative public education program outlining the benefits of fuel treatments. Fuel treatment objectives should incorporate ecologic, economic, and social values while reducing fire hazard and the risk to development.

Prescriptions for fuel treatments should be objective driven. Reasonable objectives would include reducing the potential for a crown fire, not the elimination of a crown fire. Crown fire occurrence and severity is best minimized by: reducing surface fuels; increasing the height to the canopy base; reducing canopy bulk density; and reducing the continuity of the forest canopy (Russel 2004). Managers must understand how different stand management treatments affect certain attributes on the landscape, and how these treatments can be used to alter fire behavior while achieving specific objectives.

<u>Stand Thinning</u>

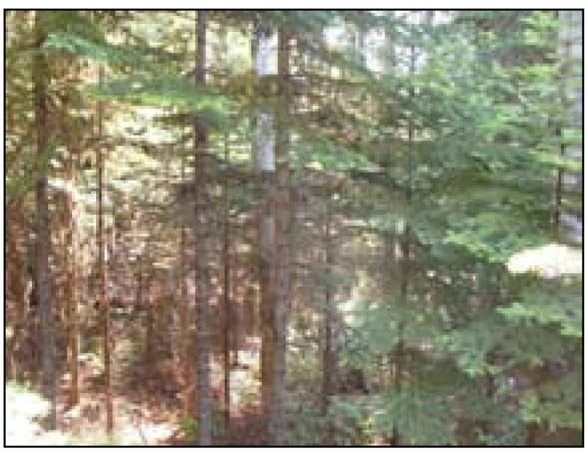
Thinning, often called ‘thinning from below’ or ’low-thinning’ is the removal of small trees from beneath the canopy or from within the canopy. These smaller trees act as ladder fuels as they provide a fuel source that carries a surface fire to the crowns. Thinning is often used to reduce the risk of fire spreading into the canopy through the removal of these smaller trees and to reduce crown fire potential by reducing crown fuel availability. The following photos illustrate a low-thinning one year post-burn from Pemberton and the City of Kelowna.

The specific tree height, diameter and species to be thinned are dictated by the objectives to be achieved, the existing and target stand conditions. In general, thinning should reduce the stand density enough that a crown fire cannot spread from crown to crown. In addition to removing ladder fuels, thinning reduces crown bulk density; improves the health of the stand; increases the growth rate of residual trees; and may increase the growth of understory vegetation, which can retain moisture longer into the summer (Brown 2000).

Thinning operations, without the treatment of residual ground material, can increase the overall fire risk (Waldrop *et al.* 2004, Agee 1996). Thinning can also increase fire risk by increasing the growth of grass or by opening up a stand to the effects of the sun and wind (van Wagtendonk 1996, Weatherspoon 1996). Ideally thinning operations are combined with prescribed fire to best replicate the ecological effects of fire. If not done properly, mechanical thinning can also cause soil degradation through compaction and exposing the soils to the elements. To avoid these detrimental effects, thinning operations should be prescribed carefully according to strict stand-specific and ecologically based objectives.

<u>Pruning</u>

Live or dead branches on a tree bole act as a 'ladder' to carry flames from the ground to the canopy. Pruning involves removing these branches, which eliminates this ladder effect. Pruning of the shrub layers in a forest may also be required where there is a dense or tall shrub component. The following photos show a stand near the airport in the study area that has not been pruned or thinned, as well as an adjacent stand that was thinned and pruned by the private landowner.



The process of pruning also increases the crown base height (CBH): the height from the ground to the base of the canopy. A high CBH reduces the potential for a crown fire, as a greater surface flame length is needed to reach the canopy. Flame length is a function of ambient air temperature, wind speed, fuel moisture, slope and fuel loading. An understanding of how these components interact will allow managers to determine pruning height requirements.

It is important to maintain an adequate crown base height to minimize crown fire initiation (Russel *et al.* 2004). Although topography cannot be altered, pruning higher on steeper slopes will aid in increasing CBH beyond potential flame lengths associated with the fuel loading and slope. Residual pruning material contributes to fuel loading and may produce a large enough flame length, under low moisture conditions and extreme weather conditions, to start a canopy fire. Therefore, residual material should be removed as part of the stand treatment. Prescribed fire and chipping are two of the most common methods to abate surface fuel hazard.

<u>Prescribed burning</u>

Prescribed fire is one of the most practical and natural methods of reducing surface fuels. It produces fire resilient stands and restores sites from the adverse effects of fire exclusion (Ingalsbee 2004). There are numerous natural and social reasons prescribed fire is not utilized more commonly. The re-introduction of fire, after almost a century of fire exclusion on the landscape, is often problematic because fuel loadings are unnaturally high (Agee and Huff 1986).

Prescribed fire affects potential fire behavior by reducing surface fuel loading and continuity, eliminating ladder fuels, and raising live crown base height by scorching the lower branches of the crowns. The effect is to reduce fire intensity and crown fire initiation. Prescribed burning is an art and a science. It requires extensive planning and science-based monitoring, and the operation requires an experienced burn boss and skilled crew. The possibility of an escape must be realized and planned for, and resources and trained personnel must be prepared to suppress the burn at the discretion of the burn boss.

Performing prescribed burns within the wildland interface is not rare, but requires more preparation, public confidence, and is often more expensive. Burning with the District limits is sometime a contentious issue and may not comply with the requirements of any existing Air Quality Management Plans and/or Clean Air Bylaws. Implementing this treatment is unlikely however it should still be considered as an option under special circumstances.

Residual Material Removal (chipping, mastication, mulching, etc.)

Chipping fuels is the most common method used to remove residual treatment material and involves placing woody debris through a mechanical chipper. The chipper reduces the wood into small pieces and spreads them throughout the site. The ecological effects of these treatments differ with size, composition and location of the remaining fuel load. Thick layers of chips can result in reduced levels of oxygen at the forest floor level, which inhibits decomposition. Moreover, when decomposition does occur, the microorganisms responsible for decomposition require large amounts of nitrogen, thereby reducing nitrogen availability for the plant community. For forest ecosystems with very thin forest floors, consisting of predominantly needle litter, the build up of wood chips dramatically alters the composition of the forest floor and should be restricted to areas where other options (such as pile and burning) are limited.

Pile and Burning

Pile and burning is another treatment method that can be employed in the interface zone and can mimic some of the ecological benefits of fire. Woody debris is piled in locations where it is safe to burn and is burnt under safe weather conditions. Burning piles requires planning and an understanding of fire behavior. An experienced burn boss, or fire suppression personnel, should examine potential site locations, and an experienced crew should perform the piling and burning. Some critical factors to consider when piling and burning are adjacent fuel sources, site degradation through soil sterility and the social impacts of smoke management

In areas with poor access and steep slopes, the removal of post-treatment residual material to a roadside chipper is very labor intensive and, therefore, very costly. Piling and burning may prove to be cheaper in these areas and would be worthwhile exploring as a viable option.

Piling and burning within district limits may be a contentious issue and might not comply with the requirements of any Air Quality Management Plans and/or Clean Air Bylaws. However, it is recommended that exemptions be considered for this treatment in areas with poor access.

Surface fire fuel breaks

Once an area has been treated to minimize the potential for a crown fire, there is still the potential for a low intensity surface fire. In the summertime, after grasses cure and shrubs start to dry out, they are easily ignitable and have high spread rates. Although these fuels tend to burn out quickly, they provide resident heat to ignite larger fuels. There is a risk of a surface fire spreading into, or in from, adjacent properties not under control of the local government. In these areas, strategic surface firebreaks can be created to help stop the spread of potential ground fires.

Ground firebreaks are continuous areas of exposed mineral soil that are wide enough to stop the spread of a low intensity surface fire. These breaks can be created in parks to establish new trails for recreation. These trails should be developed wide enough to support an ATV to facilitate access for suppression. If these trails are not used frequently, grasses will naturally re-establish on the trail surface and as such may require ongoing maintenance.

Spatial distribution of treatment areas

FireSmart recommends treatments around structures in three ‘priority zones’. Treatments in these zones involve fuel removal, fuel reduction, and fuel conversion. Detailed goals and treatments can be found in chapter 3 of the FireSmart manual (http://www.partnersinprotection.ab.ca/downloads/). Priority zones are based on distance from the structure, and the slope below the structure, and are defined as:

- Priority Zone 1 (within 10m from structures): Remove fuel and convert vegetation to fire resistance species to produce an environment that does not support combustion.
- Priority Zone 2 (10-30m from structures): Increase fuel-modified area by reducing flammable vegetation through thinning and pruning and produce an environment that will only support low-intensity surface fires.

- Priority Zone 3 (30-100m+ from structures): Eliminate the potential for a high-intensity crown fire through thinning and pruning, thereby slowing a fires approach towards structures.

The area within 30 meters of the structures (priority zones 1 and 2) should be treated heavily enough to create a defensible space between the structures and the adjacent stand. Treatments in priority zone 3 should not be as intensive as those in adjacent to the structures but should still reduce the potential for a crown fire.

The slope of the terrain has a strong influence on fire behavior. The rate of spread (ROS) of a fire doubles for every 30% increase in slope up to 60%. The recommend treatment zone distances around structures should be adjusted accordingly. Steeper slope should be treated to a further distance: thinning should be to a lower density and pruning height should be higher. The distance and extent of treatment should be determined by a fire behavior specialist and clearly described in the fuels treatment prescription.

In addition, treatments should not be implemented uniformly, but should mimic natural stand structure by producing canopy gaps to help break up the canopy fuel mass. The shape, size and distribution of these gaps should be strategically placed to help slow the spread towards the structures or other adjacent hazardous fuels.

Treatment Maintenance Schedules

Forest stands are dynamic systems: as they change through time, so will the potential fire behavior. Changes to potential fire behavior will be dependent on the changes to the fuel loading within the surface, ladder and crown fuel layers. As loading in these layers increases, treatments will need to be undertaken to reduce potential fire behavior. Contributions to loading will involve cladoptosis, infill of regeneration, vigor of the shrub complex and individual tree death or whole stand break-up due to biotic and abiotic forces.

The necessary maintenance schedule will be stand-specific. For areas within the wildland-urban interface, it is better to re-assess the hazard early. This is especially true for new fuel reduction programs. Maintenance treatments may be required every 5-10 years. Re-assessing every 5 or 6 years would allow managers to plan fuel treatment budget requirements for several years ahead.

As urban development continues within the forested ecosystems, fire risk will need to be re-assessed. As new developments move into the forested environment, treatment priorities and fire risks outlined in this report will change. FireSmart community planning and design should be undertaken as a requirement of the development permit process. Subsequent recommended fuel reduction treatments should by financed by the developer (to the satisfaction of the District bylaw office) and should be required by municipal bylaw. Upon completion of the development, the site should be re-assessed to determine where it falls into the maintenance schedule and priority list.

Appendix E - Fuel Treatment Prescription Development

The primary goals of interface fuels treatments are to prevent the occurrence of a crown fire, reduce surface fire intensity and to improve suppression capabilities. In addition, treatments should attempt to mimic natural disturbance regimes and re-create historical stand conditions. To achieve these goals it is important that an objective-driven prescription be carefully developed and followed. A proper prescription includes a detailed description of the present stand, the target stand conditions to be achieved, the operational activities to be implemented and a monitoring program to help determine the success of the project.

The development of a successful fuels treatment program can be divided into the following seven steps:

1. Quantify fuel loading and establish permanent sample plots.
2. Model the fire behavior potential using existing stand/fuel conditions.
3. Develop preliminary target stand conditions.
4. Model the fire behavior potential using target stand conditions.
5. Finalize target stand conditions and develop treatment prescriptions.
6. Carry out operational treatments.
7. Monitor results.

Step 1. Quantify fuel loading and establish permanent sample plots

The first step in developing successful treatment prescriptions is to determine the quantity and distribution of the existing fuels on the site. This can be accomplished by establishing permanent sample plots and measuring such fuel attributes as: surface fuel loading of large and fine woody debris, crown mass loading including vertical and horizontal distribution, canopy base height, ladder fuel loading and duff depth. In addition, each permanent sample plot should include photo stations.

Step 2. Model the fire behaviour potential using existing stand conditions

The fuel loading and topographical information collected in the field should be entered into a fire behavior model using the 90th percentile fire weather conditions for the location to determine the fire behavior potential. An assessment of fire behavior parameters should include rate of spread, fire intensity and the percentage of the stand canopy that would be burned. Several fire model software programs are available but all require a solid understanding of fire behavior, fuel loading, field data collection and considerable experience with the program. Suggested software programs would be *BehavePlus, FBP97, FARSITE, FOFEM, and Fuels Management Analyst*.

Step 3. Develop preliminary target stand conditions

Specific target stand conditions (TSC) should be developed that will reduce fire behavior enough to minimize the potential of a crown fire under hazarodus (90% percentile) fire weather conditions. These TSCs will vary with each site depending on the existing stand, the ecology of the site, the topography and the presence of structures and natural features at risk.

In general the stands that were found in the interface can be roughly grouped into three categories. For each type a range of TSCs have been recommended including stand composition, density and opening size distribution. These can be found in the following scetions and should be used as rough guidelines for the development of treatment presciptions.

Step 4. Model the fire behavior potential using target stand conditions

The fuel loading for the preliminary target stand conditions should be entered into a fire behavior model using the same topographical and weather conditions from step two to determine if the fire behavior potential will be sufficiently reduced following treatment.

Step 5. Finalize target stand conditions and develop treatment prescriptions

The fire behavior outputs from step four should be compared to those in step two to determine if the propopsed treatments will alter fire behavior potential enough to achieve the goals of the prescription. If they do not, the target stand conditions should be altered accordingly and step four should be repeated until the goals are achieved. Based on the findings from the fire behavior modeling, detailed fuel treatment prescriptions should be developed.

A standardized prescription template should be used so that consistency is maintained between treatment programs. The prescriptions should not only include target stand conditions but also requirements for spatial distribution. A map should clearly show treatment areas and target stand conditions for each. In addition, details should be provided regarding the operational methods to be used and approximate costs. The results of the initial fuels assessment should be included along with a monitoring strategy to determine the success of the treatments.

Step 6. Operational treatments

The treatment recommendations specified in the prescription should be carried out under close supervision of a qualified professional. The contract should specify the indicators to be met and payment should be based on meeting the target conditions. Extents of treatment areas and natural features to be protected should be clearly marked in the field.

Step 7. Monitoring of results.

In order to ensure success in achieving hazard reduction and restoration goals, an effective monitoring program is required. While treatment prescriptions establish objectives, a monitoring program will use measurable indicators to determine if the desired conditions have been met and the treatments were successful.

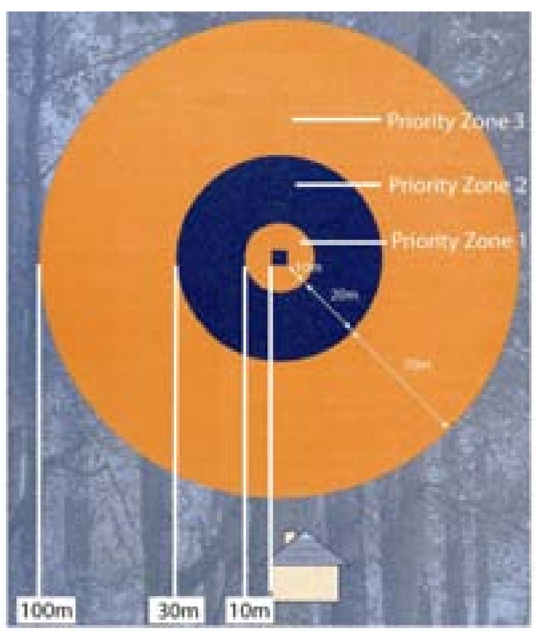
Appendix F - FireSmart Development Recommendations Overview

The FireSmart manual was developed to provide guidelines to individuals, communities and planners on how to reduce the risk of loss from interface fires. The guidelines describe interface issues, evaluate interface hazards, provide mitigation strategies and techniques, and include regional planning solutions.

Vegetation management

FireSmart recommends treatments around structures in three 'priority zones'. Treatments in these zones involve fuel removal, fuel reduction, and fuel conversion. The objective in these zones is to create 'defensible' space around a home from which to suppress a wildfire. Survivability of a home is often dependent on the distance from the structure to the adjacent forest. Detailed goals and treatments can be found in the FireSmart manual in Chapter 3. Priority zones are based on distance from the structure, and the slope below the structure, and are defined as:

- Priority Zone 1 (within 10 m from structures): Remove fuel and convert vegetation to fire resistance species to produce an environment that does not support combustion.
- Priority Zone 2 (10-30 m from structures): Increase fuel modified area by reducing flammable vegetation through thinning and pruning and produce an environment that will only support low-intensity surface fires.
- Priority Zone 3 (30-100 m+ from structures): Eliminate the potential for a high-intensity crown fire through thinning and pruning, thereby slowing the approach of a fire approach towards structures.



A diagram of the three priority zones (from FireSmart Manual)

The area within 30 meters of the structures (priority zones 1 and 2) should be treated heavily enough to create a defensible space between the structures and the adjacent stand. Treatments in priority zone 3 need not be as intensive as those in adjacent to the structures but should still reduce the potential for a crown fire under 90th percentile weather conditions.

The slope of the terrain has a strong influence on fire behavior. The rate of spread (ROS) of a fire doubles for every 30% increase in slope, up to 60%. The recommended treatment zone distances around structures should be adjusted accordingly. Steeper slopes should be treated to a further distance, thinning should be to a lower density and pruning height should be higher. Typically, slopes of 30% below buildings should have the priority zone 2 extended to 60 m below the structure and to 45 m side slope. On a 55% percent slope, priority zone 2 should be extended to 120 m down slope of the structure and 60 m horizontal. The necessary distance and extent of treatment should be determined by a fire behavior specialist and clearly described in the fuels reduction prescription.

Priority Zone 1-Fuel Free Zone (10 m from buildings)

A fuel free zone should be created around all homes and outbuildings. The fuel free zone should extend 10 m from the structure, or further if the terrain is sloped. The following guidelines should be considered:

- There should be enough defensible space to protect buildings from approaching wildfire and to reduce the potential for a building fire spreading to the wildland.
- Annual grasses within 10 m of buildings should be mowed to 10 cm or less and watered regularly during the summer months.
- Ground litter and downed trees should be removed regularly.
- Overmature, dead, and dying trees should be removed.
- Structures at the top of a slope will need a minimum of 30 m of defensible space.
- Vegetation within this zone should be of a fire-resistant species.
- Trees within this zone should be pruned to a height of 2-3 m and not overhang the house or porch.
- Remove all piled debris (firewood, building materials, and other combustible material) to outside of the fuel free zone.
- Defensible space should be provided by the developer and maintained by the property owner.
- Community Strata rules should enforce the maintenance of this zone.

Priority Zone 2-Fuel Reduction Zone (10-30 m from buildings)

Fuel modification in this zone should include thinning and pruning to create an environment that will not support a high intensity crown fire. A surface fire may occur in this zone but it will be of low intensity and easily suppressed. Guidelines for this zone are as follows:

- Actions in this zone should be oriented towards fuel reduction rather than removal.
- Deciduous composition in the overstory should be promoted (i.e. deciduous species should not be thinned out).
- This zone should be extended as slope increases. The 20 m concentric distance from the boundary with zone 1 should be slope distance.
- Thin trees for two tree lengths from buildings.

- Treatments within this zone will include thinning out the canopy, thinning the understory and pruning lower branches
- Leave trees should be the largest on site and canopy heights should be pruned to a height of 2-3 m.
- Remove all dead and dying trees.
- Dispose of all slash created by treatments through pile and burning or site removal.
- This zone should be constructed by the developer and maintained by the property owner.
- Community strata rules should enforce the maintenance of this zone.

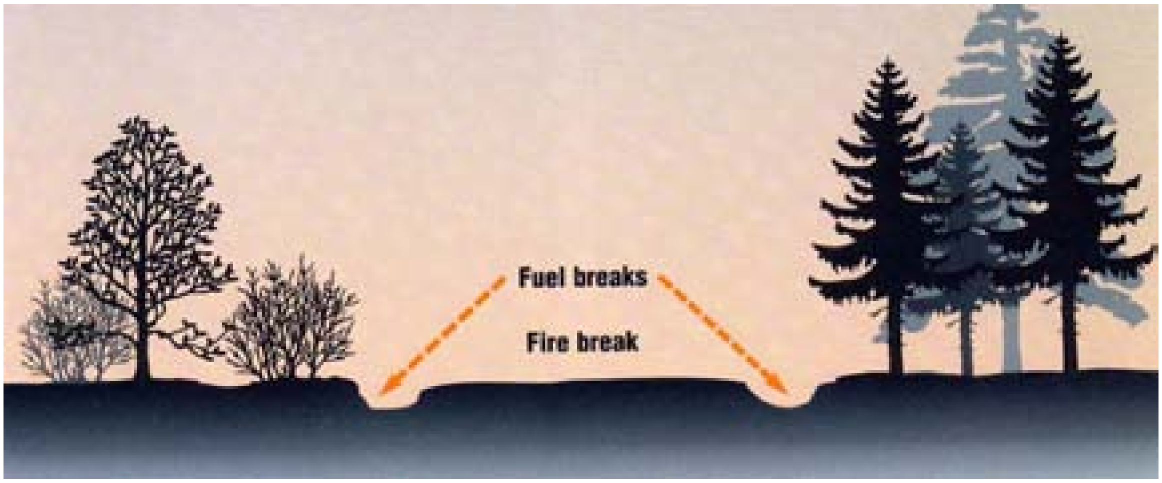
Priority Zone 3-Fuel Reduction and Conversion (30-100 m from buildings)

The strategies for this zone are similar to those of zone 2 with the distance being slope dependent. This environment should be one that does not support a high-intensity crown fire. A surface fire may occur, but it will be of low intensity and easily extinguished. Vegetation management should concentrate on vegetation conversion and reduction rather than removal. The following are guidelines for this zone:

- Fuel management in this zone should only be undertaken if there are high hazard levels from heavy continuous fuels and steep topography.
- Deciduous species should be promoted.
- On sloped terrain, this zone will need to be extended to 100 m slope distance.
- Thinning and pruning
- This zone should be constructed by the developer and maintained by the property owner.
- Community Strata rules should enforce the maintenance of this zone.

Community Fire Guard

The concept of defensible space can be applied to whole subdivisions and communities adjacent to wildlands. An example of this would be to construct a community fireguard defined as a wide, fuel free zone with the fuel management strategies found in the priority zones. Fireguards typically consist of a clearing of reduced fuel as well as a trench dug down to mineral soil that would stop surface fire spread. Figure 4 illustrates a typical fireguard.



A schematic drawing of a fireguard (from FireSmart Manual)

In association with the crown or regional district, the District could design and construct priority zones, with the associated treatments, around remote developments to reduce wildfire risk. Any recreational trails planned for the District could be located to serve as fireguards. Fireguard locations should be determined prior to construction and actual dimensions determined by a fire management specialist.

Buildings and Construction

During an interface fire, homes usually burn down as a result of burning embers landing on and igniting the roof. Alternatively, embers land on or in a nearby bush, tree or woodpile and, if the resulting fire is near the home, the walls of the home will ignite through radiant heat. Small fires in the yard can also spread towards the home and beneath porches or under homes. Therefore, the building material and construction techniques are a paramount concern for homes in the wildlands. Guidelines for buildings and construction are as follows:

Roofs

- Use only fire retardant rate Class A, B or C material on roofs.
- Clear, and maintain, roofs of all combustible material.

Chimneys

- All chimneys should have approved spark arrestors (securely attached and made of 12-guage welded or woven wire mess screen with mesh opening of less than 12 mm)
- Chimney outlets should be 6 m higher than any part of the roof and should have at least 3 m clearance from all adjacent vegetation

Siding

- Siding material should be a fire resistant material and be at least 12 mm thick.
- Siding should extend from the ground level to the roofline.

Windows and Door Glazing; Eaves, Vents and Openings

- Remove vegetation from within 10 m of glazed openings unless there are solid shutters to cover the glazing.
- Small (<1 m^2) thermal pane, tempered windows provide the most protection. Large windows provide less protection and single-pane windows provide minimal protection.
- All eaves, attics, and underfloor openings need solid, non-flammable, exterior protective shutters (such as 12 mm exterior-grade plywood)
- Solid shutters provide increased fire protection and should be made of non-flammable material or 12 mm exterior-grade plywood; in the absence of shutters, metal fire screens with corrosion-resistant mesh no coarser than 3 mm will suffice.
- Screens and shutters should be stored when they can be quickly accessed.

Balcony, Decks and Porches

- Deck material should be of non-combustible or fire-resistant materials.
- Enclose eaves, cantilevers, balconies and undersides or overhangs with 12 mm sheathing (ideally a non-combustible material).
- Stilts can be built from or encase in non-combustible materials. Heavy timbers offer increased fire resistance.
- Slotted deck surface allow needle litter to accumulate beneath the deck. Provide access to this space to allow for removal of this debris.

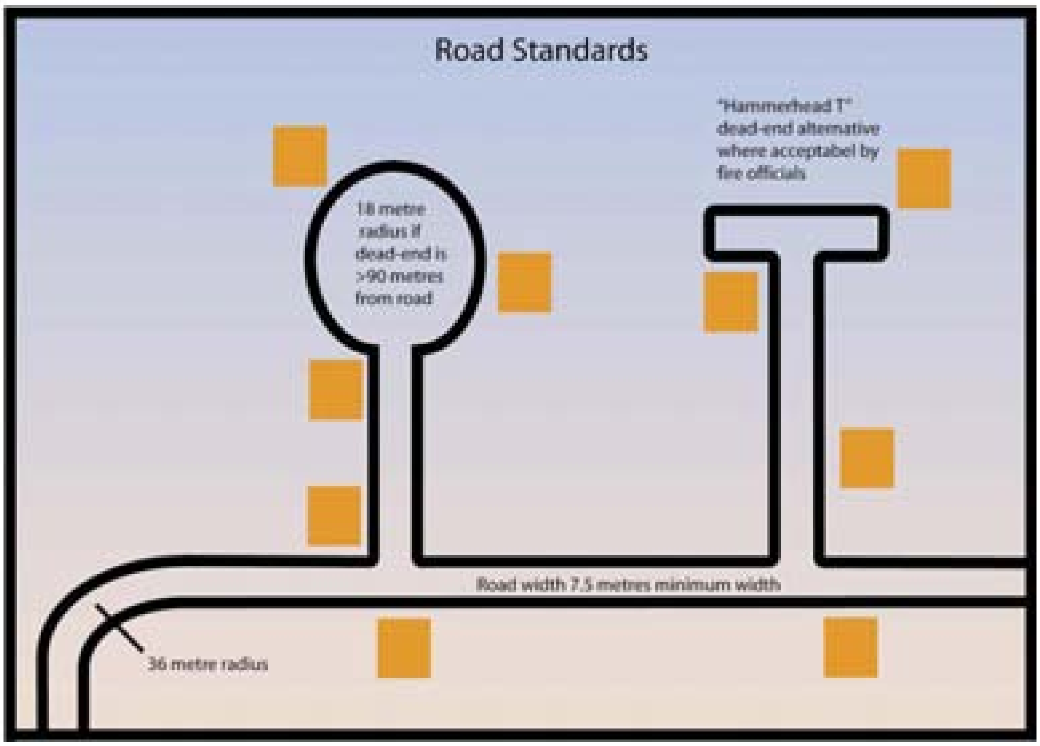
Access Management

The road network into and within a community serves several needs: access for emergency vehicles, escape routes for residents, and firebreaks. Emergency vehicles can weigh up to 20 tonnes and require large spaces for turning around. Communities with cul-de-sacs, narrow driveways and dead-end streets impede fire suppression efforts. Smoky conditions or low light can make house numbers and street signs difficult to see and can delay emergency response times. For the purpose of fire suppression, access route standards are divided into *roadway standards* for an access route that serves three or more dwellings, and *fire services access standard*, for routes to a building that is located more than 45 m from a road. Guidelines for the design of roads for suppression are as follows:

Roadway Standards

- Roadways should allow for simultaneous access for emergency vehicles and public evacuation. They should have a travel way of at least 7.5 m horizontally and 4.5 m vertically.
- Improved road shoulders should be at least 1.5 m wide on each side of the roadway. If parking is permitted on the shoulder, the width should be increased to 2.75 m
- Vegetation on the sides of the road should be maintained below 10 cm.

- Roadway curve radius should be at least 30 from the centerline.
- Road gradients should not exceed 10%.
- Dead-end roadways longer than 90 m should have a turn-around at the terminus with an outside diameter of no less than 36 m. Fire officials may permit a 'hammer-head T' turn around.
- Dead-end roads should be posted as such.
- Any gated roads should have the gates located 9 m from the public ROW; they should open outward, and should provide an opening of at least 0.6 m wider than the traveled roadway. Fire Service personnel should have keys for all gates.
- Roadway material should be all weather and support all emergency suppression.
- Bridges should be designed of all-weather material, support the weight of any fire suppression vehicle and have the load limit clearly posted.



A schematic of road standards (from FireSmart Manual)

Fire Service Access Standards

- Fire service access, including bridges, should be at least 3.7 m wide and have 4.5 m vertical clearance.
- Gradients should not exceed 15%
- Access turns should not restrict access of any emergency vehicle.
- Dead-end roadways longer than 90 m should have a turn-around at the terminus with an outside diameter of no less than 36 m. Fire officials may permit a 'hammer-head T' turn around.
- Dead-end roads should be posted as such.

- Any gated roads should have the gates located 9 m from the public right-of -way, they should open outward, and should provide an opening of at least 0.6 m wider than the traveled roadway. Fire Service personnel should have keys for all gates.
- Roadway material should be all weather and support all emergency suppression.

Water supply

Water is the most effective fire suppression tool. Fire suppression requires large quantities of water to be successful and ensuring an adequate supply for fire suppression may make the difference to saving a community.

Most communities have a hydrant system that provides ample water for suppression purposes. However, many rural areas rely on well systems and stem pipes for their water source. During extreme fire conditions, electricity may be shut off for safety reasons and, therefore, water supplies that rely on electrical pumps will be unavailable. Alternative power sources should be considered for this well system.

Fire suppression crews are often required to rely on natural water sources or the water carried onboard emergency vehicles when dealing with fires in remote wildland developments. When planning new developments in the wildlands, several man-made water storage areas should be designed and constructed. These water sources should be accessible to emergency vehicles in order to refill onboard tanks. Alternatively, underground cisterns could be constructed to store water for suppression purposes. These tanks could supply homes the development with water that was accessible stem pipes throughout the development and would be restricted to suppression use only. The system could also be used to run sprinkler systems during an interface fire.

During the design phase of the remote developments, an experienced fire suppression specialist should be consulted to help determine appropriate locations for man-made water bodies.

Utilities-Electric and Gas

Overhead transmission and distribution lines are a major ignition hazard. Falling trees or branches can knock a powerline to the ground, where it will remain charged and potentially start a fire. Primary distribution lines are the most problematic as they are remote and difficult to inspect and maintain. Secondary lines contain less voltage but are more susceptible to being overgrown by vegetation, which can lead to arcing and ignition. Underground power lines are the most FireSafe.

When planning new developments, underground power lines systems should be considered. Where such a system is not feasible, overhead utility lines should have a clearance of at least 3 m from vegetation.

Propane tanks surrounded by vegetation are potential hazards. Combustion adjacent to these tanks increases the internal pressure causing the tank to vent through a relief valve. The resulting fire is one of high-intensity and will certainly destroy an adjacent building. Hence, when positioning tanks, the relief valves should point away from buildings. Faulty relief valves will not allow pressure to discharge resulting in a boiling liquid explosion capable of killing anyone within 300 m.

Propane tanks should have all vegetation cleared for at least 3 m in all directions. Tanks should be located at least 10 m from any building. Future development around the tank should respect this distance and be monitored by the development strata.

Additional Recommendations

Home Sprinkler Systems

When designing new developments, particularly those in remote locations some distance from emergency services, some consideration should be given to the installation of underground sprinkler systems. These systems can serve as both a method of irrigation as well as an interface suppression tool. Sprinklers can be located on the rooftops of homes and outbuildings. In the event of a wildfire, the sprinklers would be engaged and would increase the relative humidity around the house as well as increase the fuel moisture content of any fuel adjacent to the home resulting in lower flammability and fire behavior potential.

Community Planning, Design Review and Construction Operations

Planners, engineers, and landscape architects should refer to both this report and the FireSmart manual during the designing phase of developments. A fire management specialist should be consulted during the design phase of future developments to ensure development is planned in a FireSafe manner and that any potential problems are addressed early on in the development.

Additionally, all construction operations should be conducted according to the Wildfire Act and associated regulations. Following these regulations helps reduce liability and protects the development as an investment.

Post-Development Fire Hazard Review

Forests are dynamic ecosystems that change over time and space. To ensure developments remain FireSafe, a periodic fire hazard assessment should be completed every 5 to 10 years. All interface areas as well as all established fuel breaks should be assessed and recommendations made for their maintenance.

Appendix G – Pre-Development Fuel Hazard Assessment

Suggested table of contents for a Pre-Development Fuel Hazard Assessment are included below.

Fuel Hazard Assessment
Introduction
Project Area Description
- Wildfire Risk
- Fuel Hazard

Fuel Type Descriptions
Hazard Abatement Methods
- Activity Fuels/Materials Abatement Techniques

FireSmart Implementation
Vegetation Management
Priority Zone Risk Abatement
Building and Construction Materials
- Roofs
- Chimneys
- Siding
- Windows and Door Glazing; eaves, vents, and openings
- Balcony, decks and porches

Access Management
- Roadways
- Driveways
- Property Access for Fire Services

Water Supply
Utilities – Electric and Gas
Fire Management Plan for Construction Phase
Conclusions