Fire Behavior and Impact Analysis of the Garnet Fire, July 22-24, 1994

Report Submitted To:

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By:

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Author's Credentials

Dr. Martin E. (Marty) Alexander, a senior fire behavior research officer with the Canadian Forest Service (CFS) stationed at the Northern Forestry Centre in Edmonton, Alberta, has in his 23-year career with the CFS specialized in studying the physical aspects and impacts of forest fires, including the practical application of such knowledge to fire management issues. He has over 150 scientific and technical publications to his credit. Marty most recently served as a fire behavior specialist on the overhead team assigned to the 175,000 ha Virginia Hills Fire that occurred near Whitecourt, Alberta, in May 1998. He is the CFS's principal authority on the Canadian Forest Fire Danger Rating System and was one of the architects of the Canadian Forest Fire Behavior Prediction System module. He has also been heavily involved in wildland fire behavior training on a national basis. He served as the chair of the Advanced Wildland Fire Behavior Course from 1995-1997 and has served as the co-chair of the Wildland Fire Behavior Specialist Course since 1996, and is frequently called upon to serve as a fire behavior expert in the development of other fire behavior-related training. Marty started with the CFS in 1976, initially at the Great Lakes Forestry Centre in Sault Ste. Marie, Ontario, before transferring to Edmonton in 1981. From 1989 to 1993 he was on professional development/educational leave in Australia where he held a Visiting Fire Researcher position in the Bushfire Research Unit of the CSIRO Division of Forestry's Canberra Laboratory while working as a Ph.D. Scholar in the Department of Forestry at the Australian National University (ANU) and then completed a one-year secondment at the New Zealand Forest Research Institute in Rotorua as a Visiting Fire Research Scientist. Prior to his joining the CFS, Marty was a graduate research assistant in the forest fire science & technology program at Colorado State University (CSU) (1975-76). From 1972-74 he worked seasonally and part-time while attending university for the Colorado State Forest Service Fire Protection Forester and the USDA Forest Service in fire management on the Bighorn National Forest in Wyoming (Greybull hotshot crew) and the Nez Perce National Forest in Idaho (wilderness fuel inventory, slash burning) and in fire research at the Rocky Mountain Forest and Range Experiment Station (National Fire Danger Rating Project) in Fort Collins. Marty received his B.Sc. degree in Forest Management Science (1974) and M.Sc. degree in Forest Fire Science (1979) from CSU. In June 1998 he was awarded his Ph.D. degree in Forestry from ANU; his thesis was titled "Crown Fire Thresholds in Exotic Pine Plantations of Australasia". Marty has previously undertaken expert opinion/witness assignments for the Alberta Land and Forest Service and the New Zealand Forest Research Institute. Since 1996, he has served as a part-time Fire Guardian for the County of Leduc Fire Services in the New Sarepta Rural Fire Response Area where he currently resides.

Introduction

This report has been prepared at the request of the Province of British Columbia, Ministry of Attorney General, concerning the case of *Baenziger et al v. Her Majesty the Queen et al, Supreme Court Action C954014 Vancouver Registry*. The case involves the Garnet Fire which occurred near Penticton, British Columbia, during the 1994 fire season. Baenziger's property is outlined in Figure 1. Specifically, I have been asked to provide expert opinion evidence regarding the following questions in this case:

1) Had Ministry of Forests firefighting crews not entered upon the property of the plaintiff Hans Baenziger (as outlined in red on the map found at Crown document 130), would the encroachment of the Garnet Fire onto his property have caused the same or similar damage as that caused by the firefighting activities?

2) Were the firefighting activities undertaken by Ministry of Forests firefighting crews successful in stopping the advance of the Garnet Fire in a southerly direction which otherwise would have caused more extensive damage to the plaintiff's property?

On the basis of the fire behavior and impact analyses that I have undertaken as documented in this report, my response to both of these questions would have to be an unequivocally YES. In fact, there is every reason to believe from the information presented in this report to indicate that the damages on the plaintiff's property could have been even more severe and extensive than they were had the Ministry of Forests firefighting crews not engaged the fire in the manner they did.

I am responsible for the content of this report, although I have consulted with other forest fire researchers and referred to published scientific literature dealing with the prediction of fire behavior and fire impacts, as listed in the References section, in the preparation of this report.

Background Information

For the purposes of preparing this report, the following items were provided to me by the Crown:

1) Writ of Summons and Statement of Claim of plaintiff;
2) Statement of Defence of defendant Her Majesty the Queen;
3) Answers to requests of plantiff's counsel asked of Denis Gaudry at his examination for discovery on July 10, 1997 and appendices;
4) List of Documents and 1st Supplementary List of Documents of defendant Her Majesty the Queen;
5) Copies of Crown documents tabbed in accordance with their corresponding numbers on the list of documents, being document numbers: 43, 45, 46, 49, 53, 95, 103, 105, 106, 107, 108, 130, 136, 142, 148, 184, 208, 228, 229, 231, 233, 235, 250, 251 and 272.
6) Weather Records for Ministry of Forests (MOF), Protection Branch-Fire Weather System Weather Station 2102 "PENTICTON RS (NEC)" for the 1994 fire season by Judi Beck, MOF Protection Branch, Victoria, BC (an extract of this data is included in Appendix A of this report).
7) Fire Weather Forecasts for Kamloops Fire Region, early days of the fire; and
8) Unified Command Records containing weather information for various dates during the fire.

I was also supplied with a topographic, forest cover and fuel type maps of the Garnet Fire area by the MOF district office in Penticton. I also obtained the entire historical (1970 –1999) daily fire weather and fire danger database as well as the historical (1989-1998) hourly fire weather database associated with the MOF fire weather station 2102 from the MOF Protection Branch, Victoria, BC. I also acquired weather records (hourly observations) for the Penticton Airport for the period July 22-24, 1994 directly from Environment Canada (Appendix B).

I also had in my possession prior to taking the assignment to prepare this report a copy of Lorraine Pattison's (1995) book on the Garnet Fire and the Price Waterhouse Review Team "Garnet Fire Review" report published by MOF in March 1995.

Furthermore, I visited the Garnet Fire site on April 12, 1999, in the company of two MOF employees, Denis Gaudry and Jim Jones. This involved an over flight of the entire burned area by helicopter and ground inspections at selected locations. Following the flight, MOF employee Jim Mottishaw showed me several slides taken of the Garnet Fire between July 20-25, some of which are published in Pattison's (1995) book. All three of these gentlemen were involved in the fire suppression operations associated with the Garnet Fire.

Fire Chronology in Brief

The Garnet Fire which was started by an arsonist at approximately 1815 hours Pacific Daylight Time (PDT) on July 20, 1994. In the ensuing days, the Garnet Fire spread in a southerly direction under the influence of prevailing northerly winds (Figure 1). By 1800 hours PDT on July 22 the fire had increased to 355.5 hectares and was advancing on a broad front (Figure 1). The following narrative adapted from the March 1995 Garnet Fire Review report is pertinent:

> ***July 23***
>
> ***The long range strategy continued to place first priority on defending the communities to the north and west sides of the fire. The tactic was to safely and methodically work around the head of the fire to cut it off with hand or machine guards...***
>
> ***Crews continued to build hand guards along the west flank. The two new crews ordered were placed in the Gillies Creek area to build a guard to link up with this west flank guard. The area was made up of cliffs, table-tops, gorges and talus slopes and was very difficult to work by hand or to gain access by equipment. On the east flank, machines continued to build guard from the north.***
>
> ***During the day, there were some small escapes across Ellis Creek canyon which were quickly contained. At 1800 hours PDT the fire had increased to 493.5 hectares with increases on the south-east and south-west areas. Firecat airtankers, four light and three medium helicopters continued to support ground crews through bucketing and retardant drops. Six bulldozers, two skidders and three tank trucks were used on the fire along with 136 Forest Service staff.***
>
> ***July 24***
>
> ***On this day, the strategies, objectives and tactics followed by the Forest Service continued as they had for the previous few days except that the weather forecast for the next day was for a wind to change to a strong southerly wind. This increased the urgency to complete and reinforce the guards and contain the fire...***
>
> ***During the evening, the hand guard on the west flank was completed to Helipad 5 near the south end at Gillies Creek. A hand and machine guard was built from Gillies Creek to link up with this hand***

guard but the terrain was very difficult to work in and the guard was not secure. The broken rock of the talus slope was full of needles from the trees above and was covered with lichen which burned easily and deeply. Since the Forest Service felt that construction of the guard in the south-west corner was as complete as possible, the burn off proceeded as planned, starting at 1800 hours PDT. Because of the strong winds forecast for the next day they did not wait for the higher humidity the next morning. A helicopter drip torch or "helitorch" was used to light the area and the edges closest to the guard were lit by hand. A helitorch was used for safety and effectiveness reasons because of the burn off needed to be completed as soon as possible due to the forecast wind strength and direction.

All went well for about an hour, until a nearby thunderstorm caused a down draft from the east and the fire began spotting across the guard at the point where talus slope caused a weakness. Air tankers and helicopters were used to slow the fire but the guard was broken from the Helipad 5 to Gillies Creek. Overnight , the fire continued south-west and created an area that was not enclosed by guard.

By 1800 hours PDT on July 24, the fire had increased to 608 hectares and overnight it grew to 765 hectares with all of the overnight growth in the south-west corner. There were 145 people involved on the fire and all other resources remained the same as the prior day.

At around noon on July 25, the Garnet Fire made a major, high intensity (>20,000 kW/m) crown fire run starting from the southwest sector of the fire in a northerly direction under the influence of strong (~ 25 km/h) southerly winds.

Approach to the Problem

If the MOF had not continued its suppression or firefighting operations after 1800 hours PDT on July 22, what would the Garnet Fire have done in terms of probable area burned and fire severity? In order to answer or address this question it becomes necessary to estimate the fire's likely free-burning or non-suppression fire behavior and the resultant impacts or "damages" using existing predictive models and available information on the fuels, weather and topography in order to gauge the relative effectiveness of the firefighting operations (Countryman 1969; Martell 1978).

The Canadian Forest Fire Danger Rating System (CFFDRS) as developed by the federal forestry service is an accepted method or tool for predicting fire behavior in Canadian forests (Stocks et al. 1989; Alexander et al. 1996). The CFFDRS is comprised of two major major modules or subsystems, the Canadian Forest Fire Weather Index (FWI) System (Canadian Forestry Service 1984; Van Wagner 1987) and the Canadian Forest Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group 1992; Taylor et al. 1997). Based on inputs from the FWI System, the FBP System provides outputs of fire spread and intensity, including a model for predicting the likelihood of crown fire initiation (Van Wagner 1977) as dictated by the surface fire intensity, moisture content of conifer tree foliage and the live crown base height (LCBH). Fire intensity, expressed in terms of kilowatts per meter (kW/m) is a major determinant of certain fire impacts and the difficulty of controlling a wildfire (Alexander 1982). Fire intensity is directly related to the length of the flames (Byram 1959).

A model for predicting the height of lethal scorching or heat desiccation of conifer tree crowns due to hot convective gases above the flames of a forest fire based on fire intensity does exist (Van Wagner 1973). Fire-induced tree mortality is principally a function of two factors, namely the percentage of live tree crown that is scorched and bark thickness which in turn varies with tree species and size (diameter) of the tree (Reinhardt and Ryan 1988; Ryan and Reinhardt 1988). Trees that are fully scorched by a fire's heat for the entire length of their crown are very unlikely to survive. For further information refer to Appendix C.

The vast majority of fuel types in the area burned by the Garnet Fire in the area south of Ellis Creek can be broadly categorized as FBP System Fuel Type C-7 (Ponderosa Pine - Douglas-fir); see De Groot (1993). This assertion is based on the MOF's FBP System fuel typing for the area and the author's personal observation of the fire and adjacent areas made on April 12, 1999.

The mountainous topography is exceedingly complex but for practical purposes it's assumed that the climbing and descending of the slopes by the fire will average out when it comes to the FBP System predictions of cumulative forward spread distance. A zero percent slope was therefore assumed (*cf.* Rothermel 1991). All of the general assumptions pertaining to the use of the FBP System for making fire behavior predictions would naturally apply as well (see Taylor et al. 1997, page 1).

Relevant fire weather data and FWI System components were available from two sources, namely the Penticton Airport (elevation: 344 m MSL) and the MOF fire weather station 2102 which is located near the northwest section of the Garnet Fire (elevation: 427 m MSL). The hourly wind speed data from the Penticton Airport was selected to undertake the simulations of free-burning fire behavior and fire impacts because the recorded wind directions during the period July 22-24 more closely match the actual general spread direction exhibited by the Garnet Fire during this time that the MOF station. On the other hand, the Fine Fuel Moisture Code (FFMC) and Buildup Index (BUI) components of the FWI System from the MOF fire weather station 2102 (Table 1 and Appendix A) were considered more indicative of the burning conditions in the fire area although admittedly there was not much difference in the values between the two stations (the Penticton Airport had a slightly higher BUI). Even though there is roughly a 300-600 m difference in elevation between the MOF fire weather station and the fire area, this was judged not to be of any significance due the synoptic weather situation prevailing over the area at the time (Nimchuk 1998). The FFMC as calculated from the 1300 hours PDT fire weather observations was diurnally adjusted for the time of day as per Lawson et al. (1996); this represents a very conservative approach to estimate the FFMC considering the actual diurnal weather conditions that prevailed at the time.

It was decided to begin the simulation of free-burning fire behavior and fire impact beginning from the southern most point of the fire's perimeter at 1800 hours PDT on July 22 and continuing up to 1800 hours PDT on July 24 when the southwest sector of the Garnet Fire was influenced by downdraft winds from a nearby thunderstorm. The average wind direction during this 49-hour period was within a few degrees of north. In my professional opinion, the approach taken in this simulation constitutes a very conservative estimate of the fire's probable behavior and impact (i.e., the tendency would be to underpredict rather than to overpredict). So as not to appear to bias the results, in addition to applying the wind speeds observed at the Penticton Airport in the simulation (referred to as Case A), a zero wind simulation of the cumulative forward spread distance was also undertaken (referred to as Case B). All FBP System predictions were carried out with the FBP93 software (Remsoft Inc. 1993).

Fire Behavior and Impact Simulation Results

The relevant fire behavior and fire impact characteristics associated with the Garnet Fire covering the period from 1800 hours PDT on July 22 to 1800 hours PDT on July 24 are summarized in Tables 2-4. Keep in mind that all of the predictions given in Tables 2-4 are for zero percent slope. If a slope were considered, all fire behavior and impact predictions would increase. For example, a 30% slope would cause the head fire rate of spread (ROS) and intensity to at least double in value and correspondingly increase both the crown scorch height and crowning potential.

The flame front intensity, crown scorch height and crowning potential at both the "head" and "flanks" (west and east sides of the fire) of the fire are given. Note that the critical surface fire intensity threshold or “trigger point” for crowning in this particular case is 6740 kW/m according to Van Wagner's (1977) criteria based on a foliar moisture content of 120% (estimated by the FBP System from the elevation, latitude/longitude and calendar date) and the nominal LCBH of 10 m assigned to FBP System Fuel Type C-7.

The cumulative forward spread distance is based on the summed computation of the head fire ROS x 60 minutes for each one hour time interval.

For benchmark purposes, the following general fire suppression interpretations should be borne in mind with respect to the fire intensities given in Tables 2-4 (after Alexander 1992):

- Less than 500 kW/m (< 1.4 m flame lengths), ground crews with hand tools can be effective;

- 500-2000 kW/m (1.4-2.6 m flame lengths), water under pressure and/or heavy machinery (e.g., bulldozers) are required;

- 2000-4000 kW/m (2.6-3.5 m flame lengths), helicopters with buckets dropping water and airtankers delivery water or chemical fire retardants can be effective; and

- Greater than 4000 kW/m (> 3.5 m flame lengths), very difficult if not impossible to control with conventional fire suppression techniques and resources normally used for initial attack fire operations, and quite often the only course of action is indirect attack using aerial ignition devices (Quintilio et al. 1985).

The crown scorch height and crown fire potential predictions presented in Tables 2-4 would need to be judged in relation to specific information on tree heights and the height to live crown base for a given area. This kind of comparison is beyond the scope of this report. Only generalities can be offered at this time.

Using the MOF's progress map for the Garnet Fire , I'd judge the distance between the southern limit of the fire at 1800 hours PDT on July 22 and the northern boundary of Baenziger's property to be approximately 300 m. Based on the simulation results presented here in Tables 2-4, I would conclude that the Garnet Fire would have reached the northern boundary of Baenziger's property by about 1915 hours PDT on July 22 (Figure 2) had there been no suppression activity at the head of the fire (i.e., aerial fire suppression action). This is in contrast to the actual arrival of the fire front at about 1800 hours PDT on July 23 (Figure 2) with some further intrusion by the wildfire during the next 24 hours. The exceedingly high crown scorch heights (> 30 m) predicted for the afternoons of July 23 and 24 are noteworthy (Tables 3 and 4).

Note that even if no winds had been applied to the simulation (i.e., Case B under cumulative forward spread distance in Tables 2-4), the fire would have easily cleared or reached a point that coincided with the southern boundary of the west half of Baenziger's property by 1800 hours PDT on July 24 (Figure 3) when thunderstorm activity in the area resulted in strong easterly winds which would have drove the fire in a westerly direction as a high intensity flame front. Assuming winds of 30-50 km/h, fire intensities would have reached 20,000-45,000 kW/m and the fire would have spread ~ 500-2500 m depending on the duration of the downdraft winds[1].

[1] Thunderstorm downdraft winds occur during the mature and dissipating stages of a thunderstorm (Schroeder and Buck 1970). The onset of these winds is very abrupt, and the winds may be strong. Speeds of 30 to 50 km/h are common and speeds of 100-120 km/h have been measured (Rothermel 1983). Usually the winds will be of short duration, perhaps 15 to 30 minutes but in some cases lasting as long as an hour. Because of their localized occurrence, such spurious winds may not be detectable from observations taken at a single, nearby weather station.

Discussion

According to the records of MOF fire weather station 2102, as of July 22 the last measured rain occurred on July 5, 17 days earlier. Fine, medium and heavy fuels were very dry as indicated by all the three fuel moisture codes and BUI component of the FWI System (Figures 4-7); the Duff Moisture Code and BUI levels were well above the seasonal average for mid to late July. These critically dry fuel conditions greatly affected the fire suppression strategies and tactics employed by the MOF in combating the Garnet Fire.

The fire persistence or smoldering potential would thus have been exceedingly high and mopping-up the fire accordingly difficult and time consuming. In other words, the fire edge and interior areas of the fire would not be readily self extinguishing (Lawson and Dalrymple 1996c; Lawson et al. 1997) until relief in the form of a substantial wetting rain occurred which did not come until August 8-9 when 21.7 mm of rain fell.

The very high ambient air temperatures and moderately low relative humidities (RH) overnight (Figure 8) which were well above and below the average, respectively, were not conducive to increasing the moisture content of the fine, fire carrying surface fuels. Normally, one can generally expect good overnight RH recovery (e.g., 70-100%) which in turn leads to increases in fine fuel moisture content (Schroeder and Buck 1970) thereby gaining a reprieve and temporarily decreasing the escalating fire potential in the transition that occurs from nighttime to daytime burning conditions; this situation has been observed on other difficult and complex wildland fire incidents such as the 1988 Yellowstone fires (Hartford and Rothermel 1991).

The dry fuel conditions coupled with the very warm air temperatures and low RH values during the day (Table 1) would have also resulted in conditions favourable for rekindling and for "burn-thru" situations following application of water, foam or chemical fire retardants from airtankers and helicopters with buckets on or near the active fire edge.

Fortunately winds were relatively light during the period from 1800 hours PDT on July 22 to 1800 hours PDT on July 24, seldom exceeding 15 km/h (Tables 2-4). As a result, head fire spread rates were not especially great (i.e., less than 7 m/min), although the growth or enlargement of the fire was steady and unrelenting due to the dry fuel conditions. The amount of fuel available for combustion exceeded 90% according to the FFMC and BUI components of the FWI System recorded at MOF fire weather station 2102 based on the fuel consumption models in the FBP System. This would have contributed to the significant surface fire intensities during the afternoon and evening and in turn lead to potentially high crown scorch heights, depending on the tree characteristics (i.e., total height and live crown length) for a given area. Some isolated torching or limited crowning activity would also have been expected. Firefighting operations could not be undertaken at night, when fire intensity levels were considerably less, due to safety concerns related to the difficult terrain (e.g., poor footing, rolling debris).

Maximum surface fire intensities (around 6500 kW/m or about 4.4 m flame lengths) would suggest that the mineralized or "fuel free" fireguards required to halt the fire's advancing flame front would have had to have been at least 6-7 m wide (i.e., about two bulldozer blade widths) according to Byram's (1959) rule of thumb that the minimum fireguard width should be at least one and a half times the flame length in the absence of spotting. However, in order for firefighters to work safely on the ground from an existing barrier or a prepared fireguard so as to attend to short-range spot fires and other potential breaches in their line of defense, the actual separation distance would have had to have been at least 20 m as dictated by the potential fire intensities according to existing models and associated guidelines dealing with safety zones for firefighters (Fogarty 1996; Butler and Cohen 1998). This would realistically only have been achievable through the intentional use of fire by burning the ground and surface fuels out (i.e., consuming them)[2] from along the existing roads and constructed fireguards (either prepared by ground crews or bulldozers) given the production rate of ground crews and machinery, the amount of fire perimeter and its rate of increase, and the urgency of the fire situation at the time. Furthermore, this "light hand on the land" approach to fire suppression would have been far more environmental friendly than preparing wider fireguards requiring more extensive clearing of ground and surface fuels to bare mineral soil with bulldozers and the felling of trees in order to create a defensible space. This would have the MOF's intent in areas A, B and C marked on Crown document 130.

During the "peak" or maximum burning conditions at around 1700 hours PDT on July 23 and 24, ignition probabilities from spot fires or wind-blown firebrands (embers) would have been 98-100% (Lawson and Dalrymple 1996b). Maximum potential spot fire distances would have been 200-400 m during this time according to the predicted fire intensities and prevailing winds (Morris 1987; Andrews and Chase 1989).

I would conclude from the fire behavior and impact analyses presented in this report that the free-burning growth potential of the Garnet Fire was definitely influenced by MOF suppression activities. In other words, the fire's spread in a southerly direction which occurred between 1800 hours PDT on July 22 and July 24 was delayed by the

[2] The use of fire in the suppression operations can take many forms (e.g., to reduce intensity of, slow, or steer a wildfire; to remove potentially dangerous fuel concentrations; to widen and strengthen control lines; to expedite mop-up), each having its own unique terminology (Merrill and Alexander 1987). Regardless of the specific use, in the application of "fighting fire with fire" the main objective is to speed up and/or strengthen control actions on free-burning wildfires (Cooper 1969). As Deeming and Wade (1974) note, "... it is the most economical, fastest, and least damaging means of widening control lines ...".

firefighting activities from spreading completely through the eastern portion of Baenziger's property.

I would like to point out that in addition to the severe burning conditions associated with the Garnet Fire, the resistance to fireguard construction would also be extremely high because of the difficult terrain in which the fire was burning over (i.e., steep slopes, sharp irregularities in the topographic surface, loose soils, rock bluffs, etc.). As a result, the MOF had no choice but to limit their ground suppression activities with hand crews and bulldozers along the fire's edge or perimeter to the west and east flanks of the fire. It's worth noting that these actions along the western flank of the fire was limiting spread downslope towards surrounding homes and subdivisions. It was thus not physically possible to attempt any on-the-ground suppression work at the head of the fire (which had been steadily progressing in a southerly direction since July 20) until such time as the fire front reached the area which coincidentally just happen to correspond to Baenziger's northern property boundary.

It's also worth pointing out that the fire suppression strategy and tactics employed by the MOF had the safety of firefighters firmly in mind. In other words, it was far too dangerous and futile to engage in any activities at the head of the fire due to the fire's intensity as dictated by the fuel and weather conditions, access problems, poor foot travel over difficult terrain, and the lack of suitable escape routes and safety zones. Recall that the U.S. had lost 14 firefighters on the South Canyon Fire in Colorado (Butler et al. 1998) just over two weeks earlier (July 6) in mountainous terrain under very dry fuel conditions as well. Thus, the fire environment associated with the Garnet Fire would have many similarities with the South Canyon Fire and several other fatality wildfires that have occurred in western North American forests (Rothermel 1993; Goens and Andrews 1998). I believe that the MOF were as aggressive as they could possibly be under the circumstances. In fact, a few helispots were burnt out (see Pattison 1995, page 11) suggesting that they were "pushing the envelop" as much as they dared. The fact that there were no major firefighter injuries or deaths associated with the Garnet Fire is a tribute to the organization. Considering the southern British Columbia fire environment, MOF has a remarkable safety record when it comes to fatalities from wildfire burnover incidents, although there has obviously been several "close calls" or "near misses" (Anon. 1994).

What would have happened to the western half of Baenziger's property in the ensuing days had there been no attempt by the MOF to contain the Garnet Fire? Based on the simulation results, it would be quite reasonable to conclude that the flanking action of the fire would have certainly consumed the remaining property (compare the actual forward spread distances and fire perimeters of July 21 and July 22 given in Figure 1 with the projected free-burning forward spread distances given in Figures 2 and 3 in order to visualize the flank fire growth to the west). Even if the fire hadn't done so, the easterly winds associated with the thunderstorm activity on the evening of July 24 which produced the westerly "surge" in fire growth (roughly a 1000 excursion) noted on the MOF fire progress map (Figure 1) would have ensured that the entire western flank of the fire that ran through Baenziger's property would have reverted to a high-intensity head fire run in a westerly direction similar to what transpired on the afternoon and early evening of July 25 and effectively burned over much if not all the remaining property.

The free-burning fire spread and growth simulations presented here certainly indicate that had the MOF not engaged the fire in the manner they did, that all of Baenziger's property would have been burnt over by the fire and in that sense the "damage" potential would have certainly been higher that had the MOF done nothing in checking the southerly advance of the Garnet Fire and simply concentrated on protection of life and personal property (i.e., homes) in other areas immediately threaten by the fire.

From my visit to the Garnet Fire site on April 12, 1999, it certainly seems that most of the presumed damaged to the forests on the Baenziger property is largely related to the crowning that occurred (i.e., complete flame defoliation) and/or complete crown scorching that occurred in the Douglas-fir thickets on his property. These fuel situations are unnatural and result from excluding natural fires and/or not undertaking proper forest/fuel management practices (Parminter 1991; Holmes 1995; Lawson and Dalrymple 1996a; Taylor et al. 1998) which lessen the damage or impact to the overstory tree cover when wildfires due occur under extreme burning conditions (Weatherspoon and Skinner 1995). Furthermore, except for the area affected by the July 25 afternoon and early evening run of the Garnet Fire in the northerly direction which occurred under far more serious burning conditions (i.e., stronger winds) that what was burned over earlier on and thus experienced higher fire intensities which would result in complete tree death, there is a notable lack of tree mortality in the area burned by the fire on crown lands during the period from the morning of July 21 to noon on July 25. The tree mortality in the Douglas-fir thickets in the eastern half of Baenziger's property south of areas A and B marked on Crown document 130 is quite pronounced.

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Appendix A: Ministry of Forests Fire Weather Station 2102 Computerized Listing of Daily (May 25-Aug. 30, 1994) and Hourly (July 22-25, 1994) Fire Weather Observations and Fire Danger Indexes

Station: 2102 PENTICTON RS(NEC

Date	Weather Indices								1300 Hour Observations					Drought Analysis			Fire Behaviour		
YY/MM/DD	FFMC	DMC	DC	ISI	BUI	FWI	DSR	DGR	TEMP	RH	WD	WS	PREC	NORM	%	DATE	ROS	SROS	INT
94/05/28	88.9	64	304	8.2	84	25.3	8.3	3	14.2	36	S	16	0.0	191	159	0626	9.1	9.1	0.0
94/05/29	76.9	63	309	1.4	84	6.3	0.7	2	12.9	58	N	10	1.6	195	158	0628	4.3	4.3	0.0
94/05/30	88.2	67	315	5.7	87	20.0	5.4	3	18.5	28	W	11	0.0	199	158	0629	7.8	7.8	0.0
94/05/31	89.4	70	320	5.9	91	20.7	5.8	3	19.8	37	W	8	0.0	203	158	0630	8.4	8.4	0.0
94/06/01	89.0	74	327	6.8	94	23.6	7.3	3	17.9	29	NW	12	0.8	203	161	0703	9.6	9.6	0.0
94/06/02	90.4	78	334	6.8	98	23.9	7.5	3	19.9	32	W	8	0.0	207	161	0704	9.2	9.2	0.0
94/06/03	92.2	83	342	8.3	103	28.2	10.0	4	24.5	27	W	7	0.0	211	162	0706	10.8	10.8	0.0
94/06/04	27.8	48	328	0.0	70	0.0	0.0	2	14.0	99	SW	6	6.9	216	152	0703	0.1	0.1	0.0
94/06/05	57.0	50	334	0.4	73	1.0	0.0	2	15.5	57	W	6	0.6	221	151	0704	2.1	2.1	0.0
94/06/06	14.5	28	315	0.0	45	0.0	0.0	1	12.4	99	SW	4	8.2	226	139	0629	0.0	0.0	0.0
94/06/07	50.3	19	305	0.3	33	0.4	0.0	1	16.1	43	NW	11	6.1	231	132	0626	1.6	1.6	0.0
94/06/08	75.3	21	312	1.4	36	3.1	0.2	1	17.1	48	W	11	0.0	236	132	0628	4.1	4.1	0.0
94/06/09	87.7	25	319	4.6	42	11.4	2.0	2	21.2	31	W	8	0.0	241	132	0630	6.0	6.0	0.0
94/06/10	88.1	28	326	4.9	47	12.5	2.4	2	19.4	45	W	8	0.0	245	133	0702	7.1	7.1	0.0
94/06/11	88.1	31	333	4.7	51	12.7	2.4	2	21.3	47	W	7	0.0	249	134	0704	6.8	6.8	0.0
94/06/12	89.6	35	341	6.7	56	17.5	4.3	3	21.9	38	SW	10	0.0	253	135	0706	9.0	9.0	0.0
94/06/13	88.4	39	347	7.6	60	20.2	5.6	3	18.0	31	W	16	0.9	257	135	0708	9.1	9.1	0.0
94/06/14	81.3	41	353	2.1	64	7.3	0.9	2	15.7	42	S	9	1.5	260	136	0709	3.4	3.4	0.0
94/06/15	82.9	44	360	2.4	67	8.7	1.2	2	16.7	42	NW	8	1.0	263	137	0711	3.4	3.4	0.0
94/06/16	80.4	45	366	2.0	69	7.4	0.9	2	17.5	42	W	10	1.6	265	138	0713	3.5	3.5	0.0
94/06/17	88.5	49	374	7.7	74	22.6	6.8	3	21.2	36	SW	16	0.0	269	139	0714	9.1	9.1	0.0
94/06/18	44.5	38	373	0.1	61	0.2	0.0	2	12.4	99	SW	6	3.1	273	137	0714	0.8	0.8	0.0
94/06/19	75.5	41	380	1.2	65	4.5	0.4	2	18.4	38	W	9	0.3	278	137	0715	3.9	3.9	0.0
94/06/20	85.7	45	387	3.5	69	12.0	2.2	2	21.8	44	W	8	0.0	283	137	0716	4.5	4.5	0.0
94/06/21	90.3	49	395	5.8	75	18.6	4.8	3	25.1	33	W	5	0.0	287	138	0718	8.4	8.4	0.0
94/06/22	92.4	55	403	6.1	82	20.1	5.5	3	27.0	26	CA	0	0.0	292	138	0719	8.6	8.6	0.0
94/06/23	92.2	59	411	8.3	87	26.0	8.7	3	26.0	38	S	7	0.0	296	139	0720	10.8	10.8	0.0
94/06/24	75.5	47	409	1.4	73	5.5	0.5	2	19.8	41	NW	11	3.6	298	137	0720	4.2	4.2	0.0
94/06/25	84.7	50	416	2.5	77	9.6	1.5	2	20.9	45	NW	4	0.0	301	138	0720	3.4	3.4	0.0
94/06/26	62.2	36	409	0.7	59	1.8	0.1	2	17.6	59	NW	7	4.6	303	135	0720	2.6	2.6	0.0
94/06/27	85.0	40	416	3.9	65	12.6	2.4	2	23.0	36	SW	12	0.0	305	136	0720	5.1	5.1	0.0
94/06/28	92.2	46	424	8.8	72	24.4	7.8	3	26.6	25	NW	8	0.0	308	138	0722	11.1	11.1	0.0
94/06/29	92.6	51	432	10.8	78	29.4	10.8	3	25.2	27	NW	11	0.0	312	139	0723	12.3	12.3	0.0
94/06/30	92.6	55	440	8.4	84	25.6	8.5	3	22.4	32	W	6	0.0	316	139	0724	10.4	10.4	0.0
94/07/01	74.0	55	446	1.0	84	4.6	0.4	2	16.9	94	NW	7	1.3	322	139	0725	3.5	3.5	0.0
94/07/02	57.8	28	395	0.5	48	0.9	0.0	1	17.8	40	NE	8	14.1	326	121	0718	2.3	2.3	0 0
94/07/03	78.4	31	402	1.2	52	3.6	0.3	2	18.5	40	NA	4	0.0	330	122	0719	2.7	2.7	0.0
94/07/04	85.8	33	409	4.1	56	12.0	2.2	2	19.1	45	NW	11	0.0	334	123	0720	4.9	4.9	0.0
94/07/05	65.5	20	387	0.9	35	1.8	0.1	1	21.3	50	NW	11	8.4	337	115	0716	3.3	3.3	0.0
94/07/06	87.1	24	395	4.0	42	10.0	1.6	2	26.4	33	W	7	0.0	342	116	0718	5.8	5.8	0.0
94/07/07	91.8	29	404	13.7	49	27.4	9.5	2	28.7	32	SW	18	0.0	345	117	0719	14.1	14.1	0.0
94/07/08	92.2	34	413	8.8	56	21.5	6.2	3	27.9	31	W	8	0.0	350	118	0720	11.1	11.1	0.0
94/07/09	92.3	37	421	6.9	61	18.9	4.9	3	24.2	35	W	3	0.0	353	119	0721	9.5	9.5	0.0
94/07/10	94.4	43	430	10.3	69	26.6	9.0	3	28.2	20	SW	5	0.0	357	120	0722	12.1	12.1	0.0
94/07/11	93.8	47	438	9.9	74	27.1	9.3	3	25.4	30	W	6	0.0	361	121	0723	11.4	11.4	0.0
94/07/12	93.8	52	447	12.2	81	32.4	12.8	3	27.3	30	NW	10	0.0	365	122	0725	13.0	13.0	0.0
94/07/13	93.8	57	455	10.4	86	30.2	11.3	3	26.9	30	NW	7	0.0	370	123	0726	11.8	11.8	0.0
94/07/14	93.8	62	464	10.5	93	31.4	12.1	4	29.5	30	NW	7	0.0	375	124	0727	11.8	11.8	0.0
94/07/15	93.4	66	473	9.4	98	29.9	11.2	4	27.3	33	W	6	0.0	381	124	0729	11.4	11.4	0.0

Station Summary For 9..101 to 940830

Station: 2102 PENTICTON RS(NEC

Date	Weather Indices								1300 Hour Observations					Drought Analysis			Fire Behaviour		
YY/MM/DD	FFMC	DMC	DC	ISI	BUI	FWI	DSR	DGR	TEMP	RH	WD	WS	PREC	NORM	%	DATE	ROS	SROS	INT
94/07/16	92.1	70	481	7.8	103	27.0	9.3	3	27.1	41	NA	6	0.0	388	124	0730	10.4	10.4	0.0
94/07/17	92.2	74	490	7.9	108	27.7	9.7	3	27.8	38	NW	6	0.0	394	124	0801	10.4	10.4	0.0
94/07/18	90.9	77	498	6.9	111	25.8	8.6	3	22.9	44	NW	7	0.0	401	124	0802	9.0	9.0	0.0
94/07/19	92.7	82	507	11.0	117	35.9	15.4	4	28.1	28	NA	11	0.0	408	124	0803	12.3	12.3	0.0
94/07/20	92.7	87	515	9.0	122	31.9	12.5	4	27.4	36	W	7	0.0	416	124	0804	10.8	10.8	0.0
94/07/21	92.8	92	525	8.6	128	31.5	12.2	4	31.9	35	W	6	0.0	423	124	0806	10.4	10.4	0.0
94/07/22	94.0	97	534	11.4	134	38.6	17.5	4	32.8	26	W	8	0.0	431	124	0807	13.4	13.4	0.0
94/07/23	94.1	103	544	10.3	140	36.8	16.1	4	32.0	29	W	6	0.0	438	124	0809	12.5	12.5	0.0
94/07/24	94.1	108	553	10.4	145	37.4	16.5	4	32.2	32	W	6	0.0	445	124	0810	12.5	12.5	0.0
94/07/25	95.0	115	563	18.5	152	54.5	32.2	5	33.1	22	SW	15	0.0	452	125	0812	18.6	18.6	0.0
94/07/26	95.0	120	572	11.8	157	41.4	19.8	4	29.6	26	NW	6	0.0	458	125	0815	13.8	13.8	0.0
94/07/27	95.1	125	581	11.3	163	40.6	19.1	4	27.7	21	W	5	0.0	464	125	0821	13.3	13.3	0.0
94/07/28	92.6	129	589	8.3	167	33.5	13.6	4	26.4	40	W	6	0.0	471	125	0826	10.4	10.4	0.0
94/07/29	92.6	133	598	8.0	171	32.7	13.0	4	27.5	36	W	5	0.0	477	125	0829	10.1	10.1	0.0
94/07/30	93.6	139	606	9.6	176	37.2	16.4	4	27.6	24	W	6	0.0	483	126	0908	11.4	11.4	0.0
94/07/31	93.0	143	615	9.3	181	36.5	15.8	4	25.3	34	W	7	0.0	489	126	0911	10.8	10.8	0.0
94/08/01	92.7	146	622	8.5	184	34.6	14.4	4	26.9	36	W	6	0.0	496	126	0913	10.4	10.4	0.0
94/08/02	92.8	151	631	9.0	189	36.1	15.5	4	29.4	31	W	7	0.0	502	126	0915	10.8	10.8	0.0
94/08/03	92.6	154	639	6.8	192	30.0	11.2	4	27.0	37	SW	2	0.0	509	125	0917	9.2	9.2	0.0
94/08/04	92.4	158	647	10.0	196	38.8	17.6	4	28.7	39	W	10	0.5	516	125	0930	11.9	11.9	0.0
94/08/05	92.2	161	654	10.2	200	39.3	18.1	4	23.9	36	NA	11	0.0	523	125	0930	12.3	12.3	0.0
94/08/06	92.2	165	662	8.8	203	35.9	15.4	4	24.4	30	NW	8	0.0	530	125	0930	11.1	11.1	0.0
94/08/07	92.3	169	669	8.9	207	36.1	15.5	4	26.0	30	NW	8	0.0	537	125	0930	11.1	11.1	0.0
94/08/08	27.1	65	530	0.0	99	0.0	0.0	2	16.7	88	S	3	21.7	543	98	0806	0.1	0.1	0.0
94/08/09	62.0	59	536	0.7	92	2.9	0.2	2	20.9	45	NW	7	2.2	550	98	0807	2.6	2.6	0.0
94/08/10	80.4	61	543	1.8	95	8.3	1.1	3	21.9	52	W	8	0.0	555	98	0808	3.2	3.2	0.0
94/08/11	87.2	64	551	4.1	99	16.6	3.9	3	24.9	46	NW	7	0.0	559	99	0810	5.8	5.8	0.0
94/08/12	90.4	68	559	6.2	104	23.0	7.0	3	27.6	37	W	6	0.0	564	99	0811	8.7	8.7	0.0
94/08/13	90.5	71	567	6.2	108	23.6	7.3	3	26.4	40	W	6	0.0	567	100	0813	8.7	8.7	0.0
94/08/14	91.0	75	575	6.7	113	25.3	8.3	3	28.0	37	W	6	0.0	570	101	0817	9.5	9.5	0.0
94/08/15	92.4	79	583	8.1	118	29.4	10.8	4	27.3	29	W	6	0.0	572	102	0822	10.4	10.4	0.0
94/08/16	91.4	82	590	7.8	122	29.0	10.5	4	25.4	43	W	8	0.0	574	103	0826	10.1	10.1	0.0
94/08/17	91.4	85	597	8.7	126	31.6	12.3	4	23.9	36	W	10	0.0	575	104	0828	10.8	10.8	0.0
94/08/18	90.3	88	605	7.4	129	28.6	10.3	4	23.2	47	W	10	0.0	575	105	0908	9.9	9.9	0.0
94/08/19	90.3	91	612	5.8	133	24.4	7.8	3	24.3	44	W	5	0.0	577	106	0910	8.4	8.4	0.0
94/08/20	91.8	95	620	8.3	137	31.7	12.3	4	26.7	31	W	8	0.0	579	107	0912	10.1	10.1	0.0
94/08/21	91.9	99	627	8.4	141	32.2	12.7	4	24.4	30	NW	8	0.0	581	108	0915	10.1	10.1	0.0
94/08/22	83.5	100	634	2.3	144	12.8	2.5	3	18.7	54	SW	6	1.1	583	109	0916	3.4	3.4	0.0
94/08/23	90.2	104	641	6.6	148	27.8	9.8	4	23.2	30	SW	8	0.0	584	110	0929	9.2	9.2	0.0
94/08/24	90.3	107	648	6.3	151	27.1	9.4	4	21.9	37	W	7	0.0	586	111	0930	9.0	9.0	0.0
94/08/25	90.3	110	654	6.1	154	26.5	9.0	4	21.2	42	NW	6	0.0	588	111	0930	8.7	8.7	0.0
94/08/26	70.4	73	640	1.0	114	5.4	0.5	3	20.0	51	SW	9	4.1	591	108	0917	3.4	3.4	0.0
94/08/27	80.2	75	646	1.7	116	9.1	1.4	3	18.6	61	NW	8	0.0	594	109	0930	3.2	3.2	0.0
94/08/28	87.7	78	653	4.6	120	19.9	5.4	3	22.0	39	NW	8	0.0	597	109	0930	6.0	6.0	0.0
94/08/29	88.0	80	660	3.9	123	17.9	4.5	3	22.0	48	W	4	0.0	598	110	0930	5.2	5.2	0.0
94/08/30	88.3	83	667	5.0	126	21.6	6.3	3	22.5	47	W	8	0.0	598	112	0930	7.1	7.1	0.0

99/03/31
e: 96

MINISTRY OF FORESTS: PROTECTION BRANCH

Fire Weather System
Hourly Summary From Date: 94010000 To Date: 94083000

tion: 2102 PENTICTON RS(NEC

Date	Weather Indices			Hourly Observations					Fire Behaviour		
YY/MM/DD/HH	FFMC	ISI	FWI	TEMP	RH	WD	WS	PREC	ROS	SROS	INT
94/07/22/02	0.0	0.0	0.0	22.8	30.0	90.0	4.9	0.0	0.0	0.0	0.0
03	0.0	0.0	0.0	21.1	34.0	90.0	5.3	0.0	0.0	0.0	0.0
04	0.0	0.0	0.0	20.9	36.0	90.0	5.4	0.0	0.0	0.0	0.0
05	0.0	0.0	0.0	21.5	38.0	45.0	5.8	0.0	0.0	0.0	0.0
06	0.0	0.0	0.0	21.7	40.0	45.0	6.1	0.0	0.0	0.0	0.0
07	0.0	0.0	0.0	24.2	37.0	315.0	4.5	0.0	0.0	0.0	0.0
08	0.0	0.0	0.0	26.0	38.0	270.0	4.8	0.0	0.0	0.0	0.0
09	0.0	0.0	0.0	28.8	32.0	225.0	6.2	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	30.3	26.0	315.0	7.8	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	31.5	26.0	315.0	8.1	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	32.8	26.0	270.0	7.7	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	34.8	21.0	315.0	10.1	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	35.6	19.0	315.0	11.0	0.0	0.0	0.0	0.0
15	94.7	13.4	49.5	36.4	19.0	315.0	10.3	0.0	18.4	18.4	0.0
16	95.1	12.3	45.0	36.6	19.0	315.0	7.4	0.0	17.3	17.3	0.0
17	95.3	12.7	43.0	36.1	21.0	315.0	7.5	0.0	17.6	17.6	0.0
18	95.5	10.8	37.1	35.4	21.0	0.0	3.9	0.0	15.6	15.6	0.0
19	95.5	13.0	42.4	34.0	20.0	45.0	7.4	0.0	18.0	18.0	0.0
20	95.5	13.0	36.0	30.4	26.0	135.0	7.3	0.0	18.0	18.0	0.0
21	95.5	12.6	33.6	29.3	27.0	90.0	6.9	0.0	17.3	17.3	0.0
22	95.3	11.0	30.0	27.3	30.0	90.0	4.6	0.0	16.0	16.0	0.0
23	95.2	11.8	32.1	27.0	31.0	90.0	6.4	0.0	16.8	16.8	0.0
24	0.0	0.0	0.0	26.2	32.0	90.0	6.8	0.0	0.0	0.0	0.0
94/07/23/01	0.0	0.0	0.0	25.4	33.0	90.0	6.6	0.0	0.0	0.0	0.0
02	0.0	0.0	0.0	24.0	36.0	90.0	5.3	0.0	0.0	0.0	0.0
03	0.0	0.0	0.0	21.9	41.0	90.0	5.2	0.0	0.0	0.0	0.0
04	0.0	0.0	0.0	21.0	43.0	45.0	5.1	0.0	0.0	0.0	0.0
05	0.0	0.0	0.0	21.2	42.0	135.0	6.9	0.0	0.0	0.0	0.0
06	0.0	0.0	0.0	20.9	46.0	135.0	2.6	0.0	0.0	0.0	0.0
07	0.0	0.0	0.0	24.7	38.0	0.0	5.5	0.0	0.0	0.0	0.0
08	0.0	0.0	0.0	25.4	43.0	270.0	4.7	0.0	0.0	0.0	0.0
09	0.0	0.0	0.0	26.8	44.0	270.0	5.4	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	28.1	36.0	270.0	6.3	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	30.1	30.0	270.0	5.5	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	32.0	29.0	270.0	5.5	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	33.2	24.0	225.0	5.9	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	35.4	23.0	270.0	7.0	0.0	0.0	0.0	0.0
15	94.5	10.2	40.3	36.0	22.0	225.0	5.4	0.0	15.2	15.2	0.0
16	94.8	11.0	41.4	36.7	23.0	270.0	6.1	0.0	16.2	16.2	0.0
17	95.1	9.5	37.7	35.8	20.0	225.0	2.4	0.0	14.5	14.5	0.0
18	95.3	15.3	50.1	35.1	20.0	135.0	11.3	0.0	20.2	20.2	0.0
19	95.4	13.2	45.0	34.3	20.0	135.0	8.0	0.0	18.4	18.4	0.0
20	95.4	12.9	38.0	31.1	27.0	90.0	7.5	0.0	17.8	17.8	0.0
21	95.4	12.2	36.8	30.0	28.0	90.0	6.5	0.0	17.1	17.1	0.0
22	95.4	14.8	41.9	31.1	25.0	90.0	10.2	0.0	19.8	19.8	0.0
23	95.4	12.2	36.8	29.4	29.0	90.0	6.7	0.0	17.1	17.1	0.0
24	95.2	11.9	36.8	0.0	0.0	0.0	0.0	0.0	13.8	13.8	0.0

MINISTRY OF FORESTS: PROTECTION BRANCH

Fire Weather System
Hourly Summary From Date: 94010000 To Date: 94083000

tion: 2102 PENTICTON RS(NEC

Date	Weather Indices			Hourly Observations					Fire Behaviour		
YY/MM/DD/HH	FFMC	ISI	FWI	TEMP	RH	WD	WS	PREC	ROS	SROS	INT
94/07/24/01	95.1	11.3	35.1	27.6	31.0	90.0	5.7	0.0	16.1	16.1	0.0
02	95.0	11.1	35.5	27.6	30.0	90.0	5.7	0.0	16.0	16.0	0.0
03	94.9	10.0	32.7	27.1	31.0	135.0	3.9	0.0	14.8	14.8	0.0
04	94.7	9.2	29.0	24.8	36.0	90.0	2.9	0.0	14.0	14.0	0.0
05	94.3	9.3	28.8	23.3	40.0	90.0	4.0	0.0	14.5	14.5	0.0
06	94.0	8.2	26.5	23.3	42.0	135.0	2.5	0.0	13.2	13.2	0.0
07	93.9	8.2	30.0	26.7	35.0	90.0	2.7	0.0	13.1	13.1	0.0
08	93.9	8.1	32.7	29.4	29.0	270.0	2.4	0.0	13.1	13.1	0.0
09	94.0	8.7	32.9	30.1	33.0	225.0	3.6	0.0	13.6	13.6	0.0
10	94.0	9.2	34.1	30.2	33.0	270.0	4.8	0.0	14.1	14.1	0.0
11	94.0	9.6	36.2	31.9	31.0	270.0	5.5	0.0	14.6	14.6	0.0
12	94.1	9.8	36.2	32.2	32.0	270.0	5.8	0.0	14.7	14.7	0.0
13	94.1	9.5	35.0	33.8	30.0	270.0	4.9	0.0	14.3	14.3	0.0
14	94.2	10.0	36.3	35.4	28.0	270.0	5.8	0.0	14.8	14.8	0.0
15	94.5	9.3	37.1	36.5	24.0	270.0	3.6	0.0	14.2	14.2	0.0
16	95.2	10.3	44.1	39.7	17.0	315.0	3.6	0.0	15.2	15.2	0.0
17	95.8	12.2	47.8	39.4	16.0	315.0	5.2	0.0	17.3	17.3	0.0
18	96.2	12.1	44.6	38.2	17.0	225.0	4.2	0.0	17.2	17.2	0.0
19	96.4	14.7	48.1	36.6	17.0	90.0	7.6	0.0	19.4	19.4	0.0
20	96.4	16.6	47.6	33.8	19.0	90.0	9.8	0.0	20.9	20.9	0.0
21	96.3	13.7	37.4	30.6	25.0	90.0	6.2	0.0	18.7	18.7	0.0
22	96.3	15.0	40.0	30.3	25.0	90.0	8.3	0.0	19.9	19.9	0.0
23	96.3	14.9	41.3	31.3	23.0	45.0	8.1	0.0	19.9	19.9	0.0
24	96.2	14.2	38.9	0.0	0.0	0.0	0.0	0.0	15.1	15.1	0.0
94/07/25/01	96.1	12.7	36.7	29.6	26.0	45.0	5.3	0.0	17.7	17.7	0.0
02	95.9	11.7	33.6	26.7	32.0	45.0	4.4	0.0	16.7	16.7	0.0
03	95.5	14.2	38.5	25.7	33.0	90.0	9.2	0.0	19.2	19.2	0.0
04	95.3	10.8	32.7	25.3	33.0	45.0	4.4	0.0	15.9	15.9	0.0
05	95.0	9.3	29.8	24.9	35.0	90.0	2.1	0.0	14.5	14.5	0.0
06	94.7	9.9	31.1	25.6	37.0	90.0	4.2	0.0	15.1	15.1	0.0
07	94.6	9.8	32.4	27.2	35.0	0.0	4.4	0.0	14.9	14.9	0.0
08	94.4	8.9	30.6	27.3	37.0	90.0	3.0	0.0	14.1	14.1	0.0
09	94.3	9.5	33.6	29.3	34.0	270.0	4.5	0.0	14.5	14.5	0.0
10	94.1	9.5	32.4	29.7	37.0	270.0	4.9	0.0	14.3	14.3	0.0
11	94.2	10.3	38.0	31.3	30.0	270.0	6.4	0.0	15.3	15.3	0.0
12	94.4	16.4	54.5	33.1	22.0	225.0	15.0	0.0	21.4	21.4	0.0
13	94.8	18.1	58.7	34.9	21.0	225.0	16.0	0.0	23.0	23.0	0.0
14	95.1	21.0	62.6	35.0	21.0	225.0	18.2	0.0	25.3	25.3	0.0
15	95.4	22.8	66.3	35.7	20.0	225.0	19.0	0.0	27.0	27.0	0.0
16	95.5	19.1	57.0	35.0	21.0	225.0	15.2	0.0	23.6	23.6	0.0
17	95.7	18.7	57.7	35.6	19.0	225.0	14.2	0.0	23.3	23.3	0.0
18	95.7	17.2	52.3	34.3	20.0	225.0	12.4	0.0	21.8	21.8	0.0
19	95.6	15.9	44.7	31.7	29.0	0.0	11.1	0.0	20.8	20.8	0.0
20	95.5	13.3	40.5	30.2	30.0	45.0	8.0	0.0	18.5	18.5	0.0
21	95.3	12.3	37.2	28.4	33.0	45.0	7.0	0.0	17.5	17.5	0.0
22	95.1	13.1	38.9	27.0	31.0	0.0	8.8	0.0	17.8	17.8	0.0
23	94.8	10.8	32.6	24.5	35.0	45.0	5.6	0.0	15.7	15.7	0.0

Appendix B: Hourly Weather Observations for Penticton Airport, July 22-24, 1994.

Environment Canada
Environnement Canada

FAX COVER SHEET

Fax to: CANADIAN FOREST SERVICE
5320 - 122nd Street
Edmonton,
Alberta
Attn: Marty Alexander

Phone: (780) 435-7346

Fax: (780) 435-7359

Fax from: Environment Canada
Climate Data Services
Ste 120 - 1200 West 73rd Ave.
Vancouver, B.C. V6P 6H9

Phone:	*Order data*	604-664-9067
	Verbal information	1-900-565-1111
Fax:		604-664-9133
E-mail:		gary.myers@ec.gc.ca

4 pages to follow.

Date: 4/23/99

If you fall to receive the number of copies listed above, please call the above phone number.

Originals will follow in the mail along with your VISA or Mastercard receipt if applicable.

Further notes: Customer file number 0

Surface Aviation Hourly Reports for Penticton for July 22 - 24, 1994

Invoice to follow.

Charges: $32.10
This is not an invoice!

Please direct any questions to:

Climate Data Services

Gary Myers, Dave Robinson
Giselle Duhamel
Pacific and Yukon Region

Applications and Services

EXAMPLE: YWG SA 15ØØ 3 SCT M7 OVC 11/2R-FK 115/5/4/Ø41Ø/983/SF3ST7 VSBY SW1/2F 3ØØ4

Coded	Decoded	Additional Information
YWG	WINNIPEG, MANITOBA	*Three Letter identifiers* are used by Canadian weather reporting stations. e.g. YVR indicates Vancouver, YYZ Toronto (Malton), YOW Ottawa etc.
SA 15ØØ	REGULAR OBSERVATION 1500 GMT SUBTRACT 8 HOURS FOR P.S.T. 7 HOURS FOR D.S.T.	*TYPE OF REPORT DESIGNATORS* SA – Regular observation RS – Regular special observation SP – Special observation RS COR – Corrected regular special observation (may be used with other designators also) Each designator is followed by a four number time group giving the hour and the minute that the observation was taken.
3 SCT	300 FEET, SCATTERED	*Cloud Layers* are reported in ascending order of height. *Sky Condition Abbreviations* are: CLR (clear) ....no cloud –X (partially obscured) less than ......10/10 of sky concealed by a layer of fog, snow, dust, etc., based on ground. X (obscured) ....10/10 SCT (scattered) ....1/10 to 5/10 BKN (broken) ....6/10 to 9/10 of sky covered by a layer based aloft. OVC (overcast) ....10/10 A minus sign (–) preceding SCT, BKN or OVC means the sky cover is thin. The sky conditions –BKN or –OVC do not constitute a ceiling.
M7 OVC	MEASURED CEILING 700 FEET OVERCAST	A letter always precedes the numerical value of the ceiling. This letter indicates the nature and the method of determination of the ceiling. M = Measured B = Balloon P = Precipitation A = Aircraft W = Indefinite E = Estimated Base heights of layers aloft, or vertical visibilities in surface-based layers, are expressed in hundreds of feet. The letter "V" following the numerical value of the ceiling indicates that the ceiling is variable and requires an entry in the Remarks section giving the range of variability (e.g. CIG 3–5 means varying from 300 to 500 feet).
11/2	VISIBILITY 1½ MILES	*Prevailing Visibility* is reported in statute miles and fractions. Visibility more than 15 miles may be indicated as 15+. The letter "V" following the visibility value indicates that the visibility is variable and requires an entry in the Remarks section giving the range of variation (e.g. VSBY 1–3).
R-FK	LIGHT RAIN FOG SMOKE	*Tornado* or *Waterspout* is always written out in full. *Weather Symbols* are: T+ ...Heavy Thunderstorm ZR ...Freezing Rain SW...Snow Shower T ...Thunderstorm ZL ...Freezing Drizzle SP ...Snow Pellets R ...Rain IP ...Ice Pellets SG ...Snow Grains RW...Rain Shower IPW...Ice Pellet Shower IC ...Ice Crystals L ...Drizzle S ...Snow A ...Hail A plus (+) following a precipitation symbol indicates "Heavy" intensity. A minus (–) indicates "Light" intensity; double minus (– –) "Very Light". The absence of a "+" or "–" indicates "Moderate" intensity. *Obstruction to Vision Symbols* are: F ...Fog D ...Dust Haze IF ...Ice Fog H ...Haze K ...Smoke BN...Blowing Sand BD...Blowing Dust BS ...Blowing Snow
115	SEA LEVEL PRESSURE 101.15 KILOPASCALS	The three coded digits represent, units, tenths, hundredths of kilopascals.
5 4	TEMPERATURE 5° CELSIUS DEW POINT 4° CELSIUS	A minus sign (–) prefixed to the figures indicates a below zero temperature.
Ø41Ø	WIND 040° 10 KNOTS (with reference to true north)	*Wind Direction* is reported to the nearest tens of degrees true, e.g. a wind direction of 134 degrees is reported as 13, 065 degrees as 07, 004 as 36, and calm as 00. *Wind Speed* is reported in kt, e.g. 5 kt as 05, 16 kt as 16, and calm as 00. *Gusts* are indicated by the letter "G" after speed. *Squalls* are indicated by "Q" after speed. A figure following a letter "G" represents the highest gust observed during the previous 10 min. A figure following "Q" represents the highest 1 min. mean squall speed during the previous 10 min.
983	ALTIMETER SETTING 29.83 INCHES	The three coded digits represent units, tenths and hundredths of inches of mercury.
SF3 ST7	CLOUDS STRATUS FRACTUS 3 STRATUS 7	*Clouds* or obscuring phenomena corresponding to each symbol reported in the sky condition are given by an abbreviation for type followed by a number giving the tenths of sky concealed (opacity) by each layer.
VSBY SW 1/2F	REMARKS VISIBILITY TO SW ½ MILE FOG	Brief remarks, generally in abbreviations and symbols are used to report any weather phenomena or variations thereof, not previously indicated.
3ØØ4	PRESSURE TENDENCY	This information is intended for use by forecasters. When given, it appears at the end of the report.

*TIMES ARE IN GREENWICH MEAN TIME *
* NEED TO SUBTRACT 7 HOURS TO GET PACIFIC DAYLIGHT SAVINGS TIME *

Archive of Climate Data by the Pacific Weather Center

The Station_Id is YYF.
The Start_Date is 22 07 1994.
The End_Date is 24 07 1994.

Local Day: Friday, July 22 1994 PST (DATES/TIMES IN GMT)
71889 PENTICTON, BC CANADA Elev: 344 m.

2208 YYF SA 0800 280 SCT 15+ 112/23/4/0202/989/CI1 FOREST FIRE 3MI E 1311
2209 YYF SA 0900 -X 15 117/22/5/3505/990/K1 FOREST FIRE 3MI E 2016 8611
2210 YYF SA 1000 -X 280 -SCT 15 121/24/5/3508/992/K1CI1 FOREST FIRE 3MI E 8723
2211 YYF SA 1100 -X 280 SCT 15 125/22/4/3407/993/K1CI1 FOREST FIRE 3 MI E 1422
2212 YYF SA 1200 -X 280 SCT 15 129/19/5/3406/993/K1CI1 FORESTFIRE 3MI E 2010 6522
2213 YYF SA 1300 -X 300 SCT 15+ 133/21/8/3607/995/K1CI1 4711
2214 YYF SA 1400 20 SCT 300 SCT 15+ 131/23/10/3305/994/K1CI1 HVY K ALG MTNS E-S 3111
2215 YYF SA 1500 20 SCT 160 SCT 300 SCT 15+ 143/25/11/3308/995/K1AC1CI1 3007 5300
2216 YYF SA 1600 20 SCT 160 SCT 300 SCT 15+ 141/26/10/3407/995/K1AC1CI1 1200
2217 YYF SA 1700 22 SCT 300 SCT 15+ 137/27/11/3308/993/K1CI1 SMOKE PLUME FROM LRG FOREST FIRE E 4011
2218 YYF SA 1800 22 SCT 300 SCT 15+ 123/29/12/0110/992/K1CI1 FOREST FIRE PLUME E RDG 8011 1511
2219 YYF SA 1900 22 -SCT 300 SCT 15+ 117/31/12/3511/990/K1CI1 HVY K ALG MTNS E-S 6514
2220 YYF SA 2000 25 -SCT 70 SCT 250 SCT 15+ 112/31/12/3412/989/K1ACU1CI1 HVY K ALG MTNS E-S 4825
2221 YYF SA 2100 25 -BKN 70 BKN 250 BKN 15+ 100/33/12/3612/985/K1TCU1CI1 HVY K ALG MTNS E-S 7023 9727
2222 YYF SA 2200 25 -BKN 70 -BKN 250 -BKN 15 095/36/12/3306/984/K1TCU1CI1 FOREST FIRE 3 MI E 5128
2223 YYF SA 2300 27 -BKN 300 -BKN 15 086/35/12/3308/981/K2CI1 FOREST FIRE 3 MI E 3338
2300 YYF SA 0000 27 SCT 50 SCT 300 -BKN 15 083/36/12/3307/980/K2TCU1CI1 FOREST FIRE 3E 8017 9948
2301 YYF SA 0100 27 SCT 50 SCT 300 -BKN 15 081/35/12/3306/979/K2SC1CI1 TCU W 0549
2302 YYF SA 0200 27 SCT 50 SCT 300 -BKN 15 075/33/11/3303/978/K2SC1CI 4548
2303 YYF SA 0300 27 SCT 50 SCT 300 -BKN 15 077/31/13/3603/978/K3SC1CI1 7006 8958
2304 YYF SA 0400 27 SCT 50 SCT 300 -BKN 15 081/30/11/3605/979/K2SC1CI2 4948
2305 YYF SA 0500 25 SCT 300 -BKN 15 085/30/10/3305/981/K3CI 3438
2306 YYF SA 0600 25 SCT 300 -BKN 15 089/29/10/3307/982/K3CI1 2014 1848
2307 YYF SA 0700 25 SCT 300 -BKN 15 092/28/9/3307/983/K3CI 1336

The Station_Id is YYF.
The Start_Date is 22 07 1994.
The End_Date   is 24 07 1994.

Local Day: Saturday, July 23 1994 PST (DATES/TIMES IN GMT)
71889 PENTICTON, BC CANADA Elev: 344 m.

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2308 YYF SA 0800 25 SCT 300 -BKN 15 093/37/9/3406/984/K2CI1 7736
2309 YYF SA 0900 25 SCT 15 098/26/8/3407/985/K2 2009 6822
2310 YYF SA 1000 25 SCT 15 100/23/8/3306/986/K2 8622
2311 YYF SA 1100 25 SCT 270 -SCT 15 105/23/8/3507/987/K1CI1 0623
2312 YYF SA 1200 25 SCT 270 -SCT 15 107/23/7/3507/988/K1CI1 2009 2424
2313 YYF SA 1300 25 SCT 270 -SCT 15 113/20/7/0000/990/K1CI1 8124
2314 YYF SA 1400 22 SCT 300 SCT 15+ 116/24/10/3504/990/K1CI1 7100
2315 YYF SA 1500 22 SCT 300 SCT 15+ 119/25/10/3405/991/K1CI1 1010 9900
2316 YYF SA 1600 22 SCT 300 SCT 15+ 118/26/10/3405/990/K1CI1 7100
2317 YYF SA 1700 22 SCT 300 SCT 15+ 116/27/10/3607/990/K1CI1 7400
2318 YYF SA 1800 22 SCT 300 SCT 15+ 109/28/11/3407/988/K1CI1 8012 2800
2319 YYF SA 1900 22 SCT 300 SCT 15+ 103/30/10/3605/986/K1CI1 3411
2320 YYF SA 2000 22 SCT 300 -SCT 15+ 096/33/10/3510/984/K1CI 6714
2321 YYF SA 2100 25 -SCT 70 SCT 300 -SCT 15+ 088/33/10/3610/982/K1CU1CI
         7019 3915
2322 YYF SA 2200 25 -SCT 70 -SCT 300 -SCT 15+ 084/35/11/3606/981/K1TCU1CI
         5625
2400 YYF SA 0000 25 SCT 70 SCT 300 -BKN 15+ 067/35/13/3606/976/K1TCU2CI1
         7019 2647
2401 YYF SA 0100 25 SCT 70 SCT 300 -BKN 15+ 066/35/13/0303/976/K1TCU2CI1
         6049
2402 YYF SA 0200 20 SCT 70 SCT E300 BKN 15 071/33/14/1204/978/K3TCU2CI1
         4769
2403 YYF SA 0300 20 SCT 70 SCT E300 BKN 15 085/35/10/0000/981/K3TCU2CI1
         VIRGA N 3016 0469
2404 YYF SA 0400 20 SCT 70 SCT E300 BKN 15 085/33/10/3408/981/K3TCU2CI1
         6169
2405 YYF SA 0500 -X 70 SCT E300 BKN 15 085/30/11/0602/981/K3TCU2CI1 1969
2406 YYF SA 0600 -X 70 SCT E300 BKN 15 092/28/11/0000/982/K3AC2CI1 3005
         4969
2407 YYF SA 0700 -X 70 -BKN 300 -BKN 15 093/27/11/0000/983/K2AC2CI1 6358
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The Station_Id is YYF.
The Start_Date is 22 07 1994.
The End_Date   is 24 07 1994.

Local Day: Sunday, July 24 1994 PST (DATES/TIMES IN GMT)
71889 PENTICTON, BC CANADA Elev: 344 m.

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2408 YYF SA 0800 -X 70 -BKN 300 -BKN 15 098/24/11/0000/984/K2AC2CI1 1358
2409 YYF SA 0900 -X E70 BKN 300 BKN 15 101/24/11/0000/986/K3AC3CI1 1009
        8379
2410 YYF SA 1000 -X E70 BKN 300 BKN 15 103/23/11/0000/986/K2AC4CI1 3478
2411 YYF SA 1100 -X E70 BKN 300 BKN 15 105/22/12/0000/987/K2AC4CI1 3677
2412 YYF SA 1200 -X 60 SCT 80 SCT 15+ 107/21/10/0000/987/K1CU2AC1 2006 0744
2413 YYF SA 1300 -X 60 SCT 80 SCT 15+ 111/20/9/0000/989/K1CB2AC1 3244
2414 YYF SA 1400 -X 10 115/21/11/0000/990/K3 2933
2415 YYF SA 1500 -X 12 124/26/11/0202/992/K3 2017 1233
2416 YYF SA 1600 -X 10 126/28/13/0302/993/K2 8923
2417 YYF SA 1700 -X 10 122/29/13/0404/992/K2 2923
2418 YYF SA 1800 -X 10 116/32/12/0104/990/K2 8006 1423
2419 YYF SA 1900 -X 65 SCT 5K 112/32/13/3306/989/K1CU1 2723
2420 YYF SA 2000 -X 65 SCT 10 103/34/12/3608/987/K2CU1 7333
2421 YYF SA 2100 -X 65 SCT 12 096/35/12/3606/984/K1CU2 7020 9233
2422 YYF SA 2200 -X 65 SCT 12 088/36/13/3606/982/K2TCU2 1144
2423 YYF SA 2300 65 SCT 12 084/37/13/3604/981/TCU2 9722
2500 YYF SA 0000 65 SCT 290 -SCT 15 073/37/13/3603/978/TCU2CI K CB E 8023
        3325
2501 YYF SA 0100 20 SCT 65 SCT 290 -SCT 15 067/38/12/3605/975/K1TCU1CI 6025
2502 YYF SA 0200 20 SCT 65 SCT 290 -SCT 15 068/37/13/3302/976/K3TCU1CI 7045
2503 YYF SA 0300 -X 65 SCT 290 -BKN 15 066/35/16/0000/976/K3TCU2CI VSBY N
        10 K 5005 5157
2504 YYF SA 0400 -X E70 BKN 290 BKN 10 071/30/11/2702/978/K4SC2CI VSBY N 4K
        7169
2505 YYF SA 0500 -X 70 SCT E290 BKN 10 080/28/10/0000/980/K3SC2CI1 3869
2506 YYF SA 0600 -X 70 SCT 290 -BKN 10 089/28/10/0000/982/K3AC2CI 2021 5357
2507 YYF SA 0700 -X 70 SCT 290 -BKN 10 101/30/9/0000/986/K3AC2CI 7457
```

Appendix C: Reinhardt and Ryan's (1988) nomogram for estimating tree mortality from crown scorching by fire.

Sample Calculation: Tree Species - Douglas-fir (DF); Tree Diameter at Breast Height - 17 inches (43.2 cm); Tree Height - 100 feet (30.5 m); Crown Ratio - 0.5 (i.e., Live Crown Length is one half of the Tree Height); Crown Scorch Height - 60 feet (18.3 m). ***Probability of Mortality: 20%.***

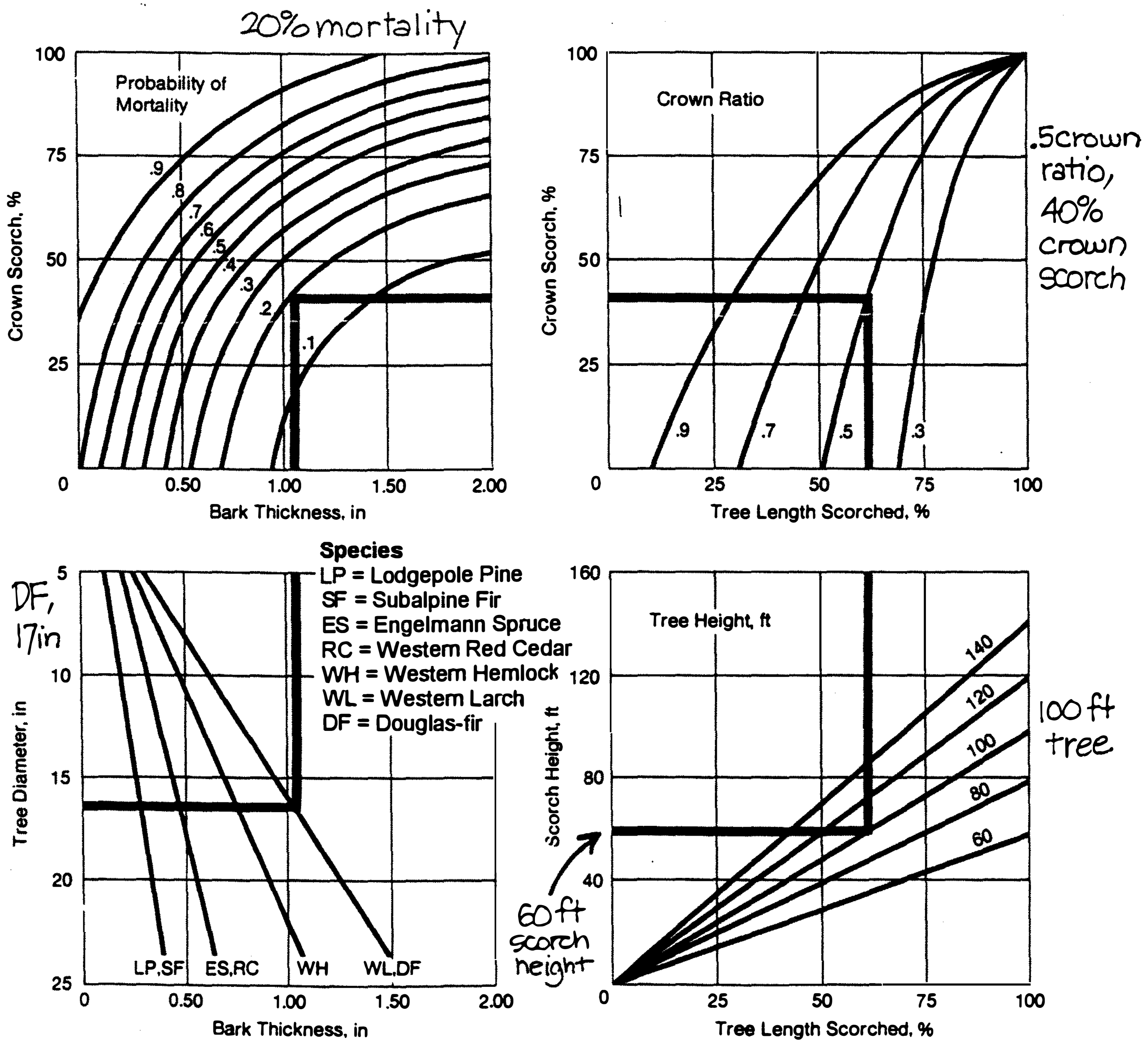

Figure 1: Ministry of Forests fire progress map covering the southern half of the 1994 Garnet Fire. Map scale: 1 cm = 200 m

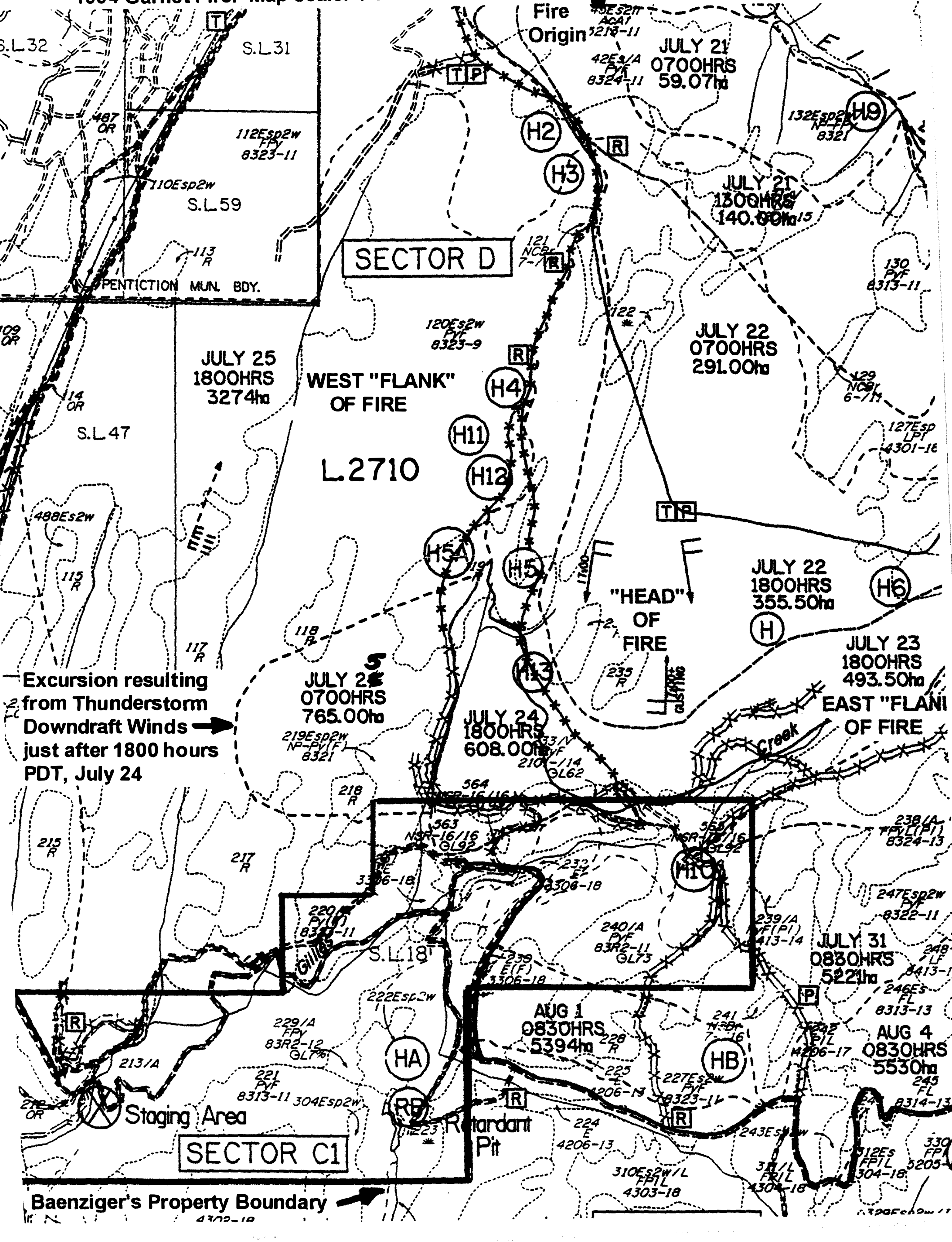

Figure 2: Simulation of free-burning head fire spread for the Garnet Fire, July 22-24, 1994 - Case A (with observed winds speeds applied). Map scale: 1 cm - 200 m.

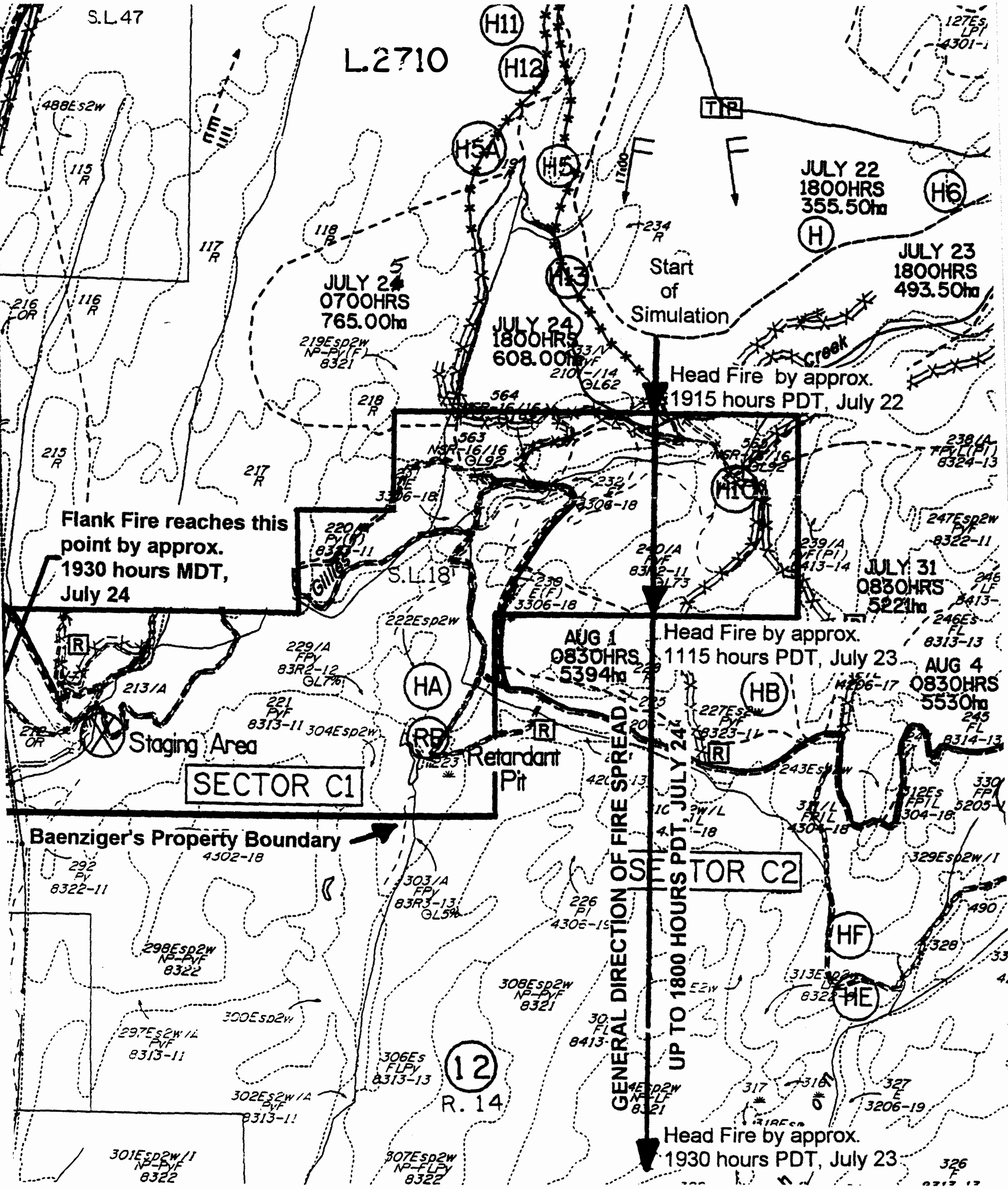

Figure 3: Simulation of free-burning head fire spread for the Garnet Fire, July 22-24, 1994 - Case B (with zero wind speeds applied). Map scale: 1 cm = 200 m.

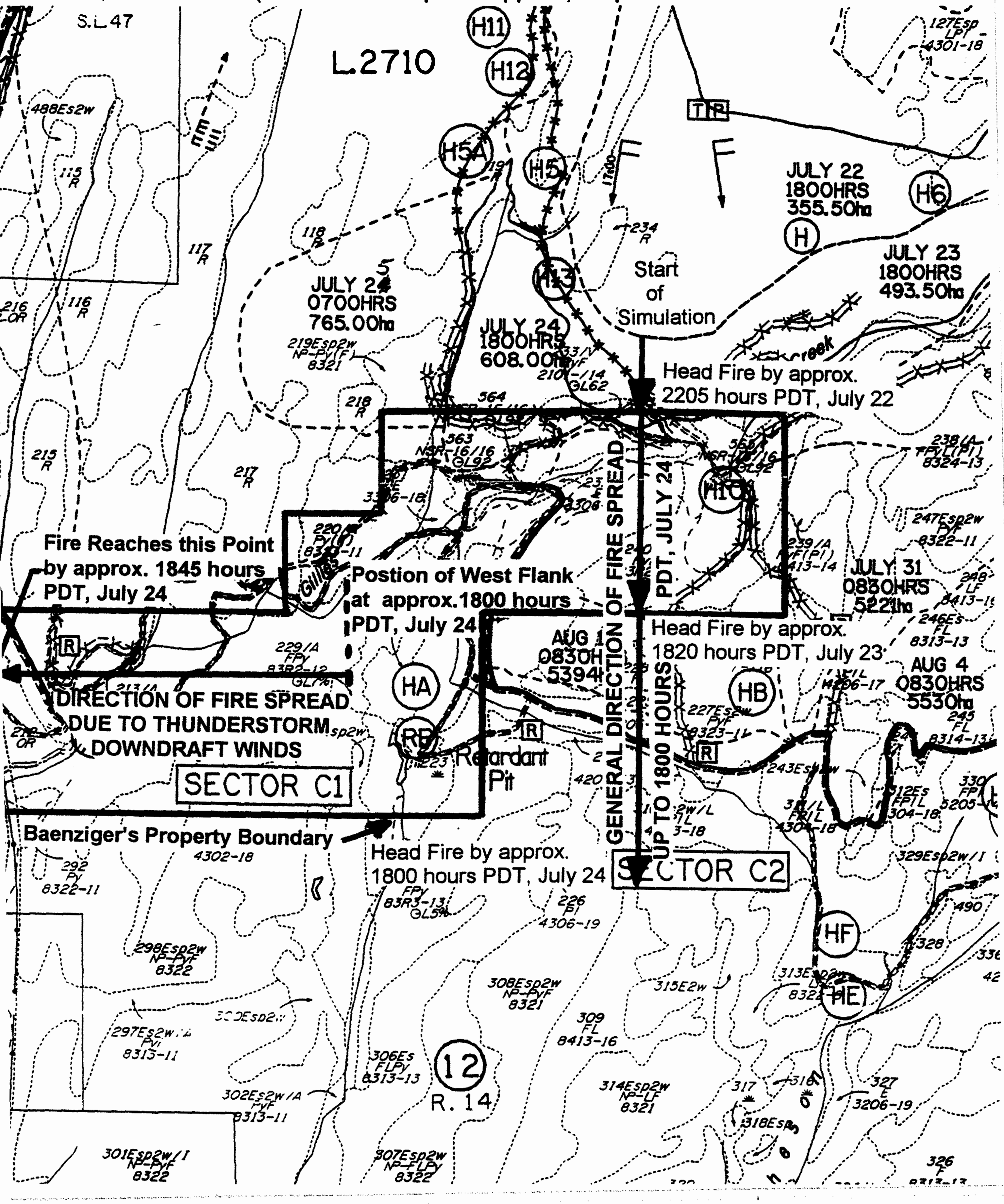

Figure 4:

Seasonal display chart for the Fine Fuel Moisture Code (FFMC) at the Ministry of Forests Fire Weather Station 2102 (Penticton RS (NEC))

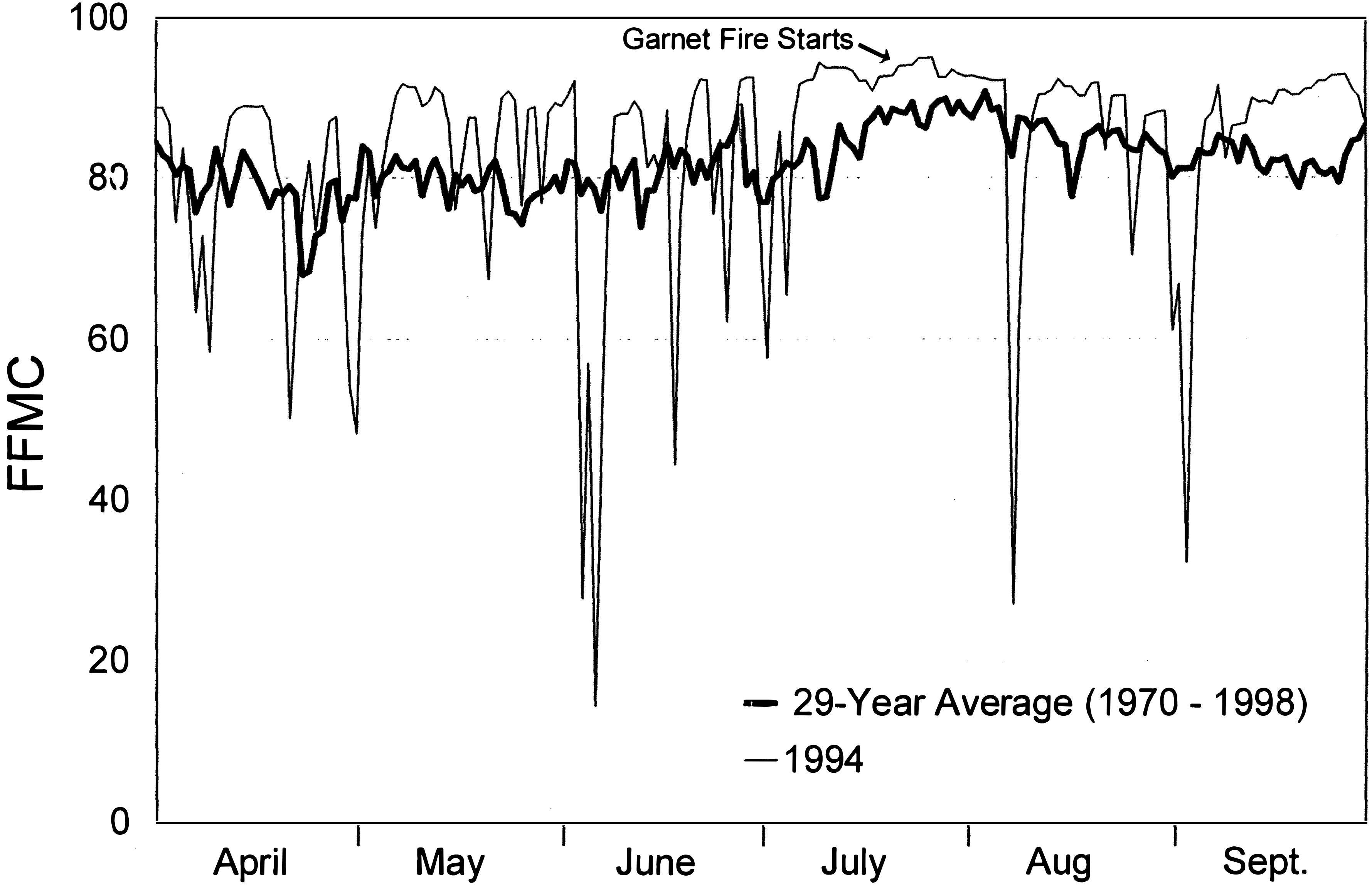

Figure 5:

Seasonal display chart for the Duff Moisture Code (DMC) at the Ministry of Forests Fire Weather Station 2102 (Penticton RS (NEC))

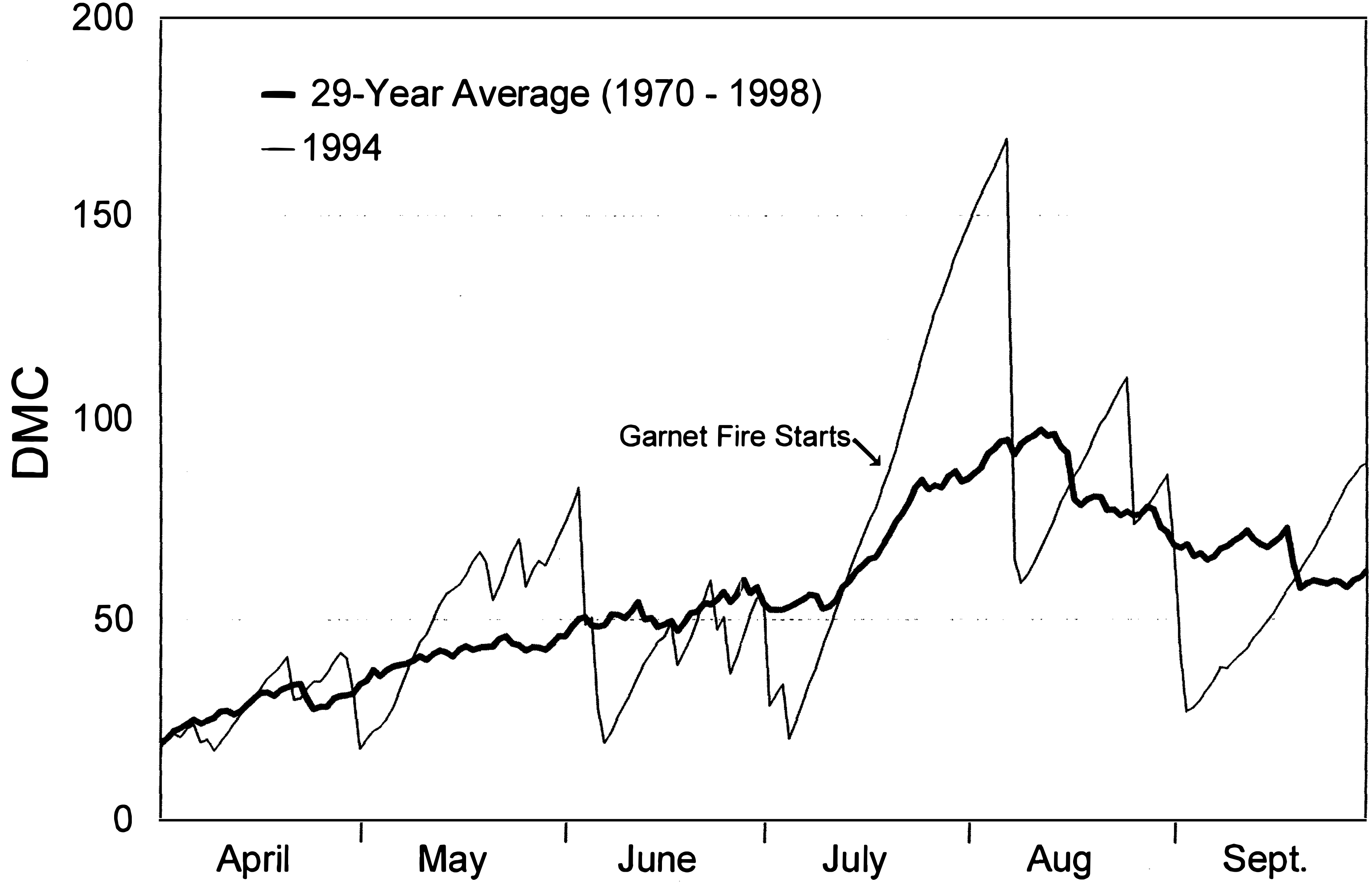

Figure 6:

Seasonal display chart for the Drought Code (DC) at the Ministry of Forests Fire Weather Station 2102 (Penticton RS (NEC))

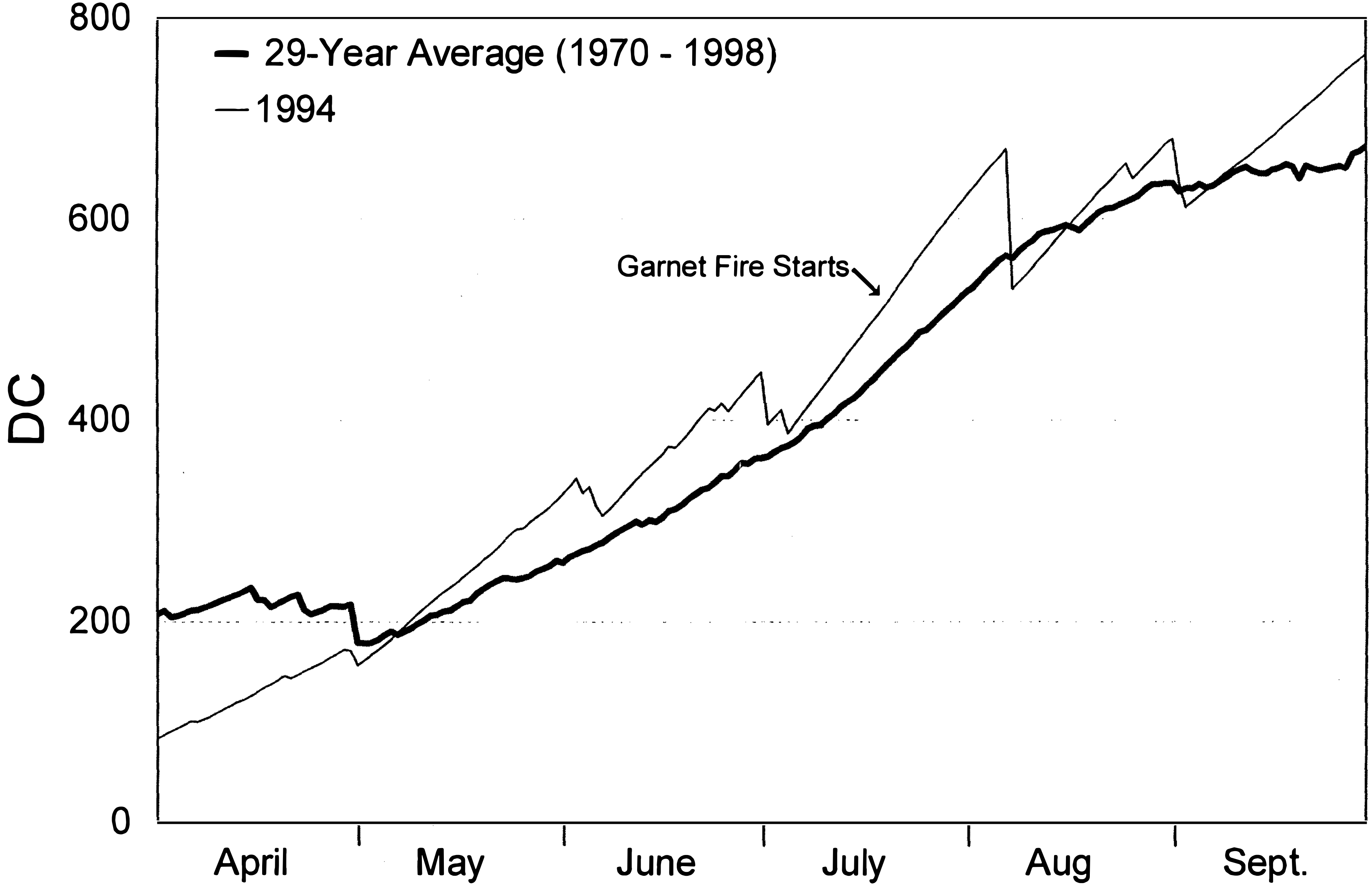

Figure 7:

Seasonal display chart for the Buildup Index (BUI) at the Ministry of Forests Fire Weather Station 2102 (Penticton RS (NEC))

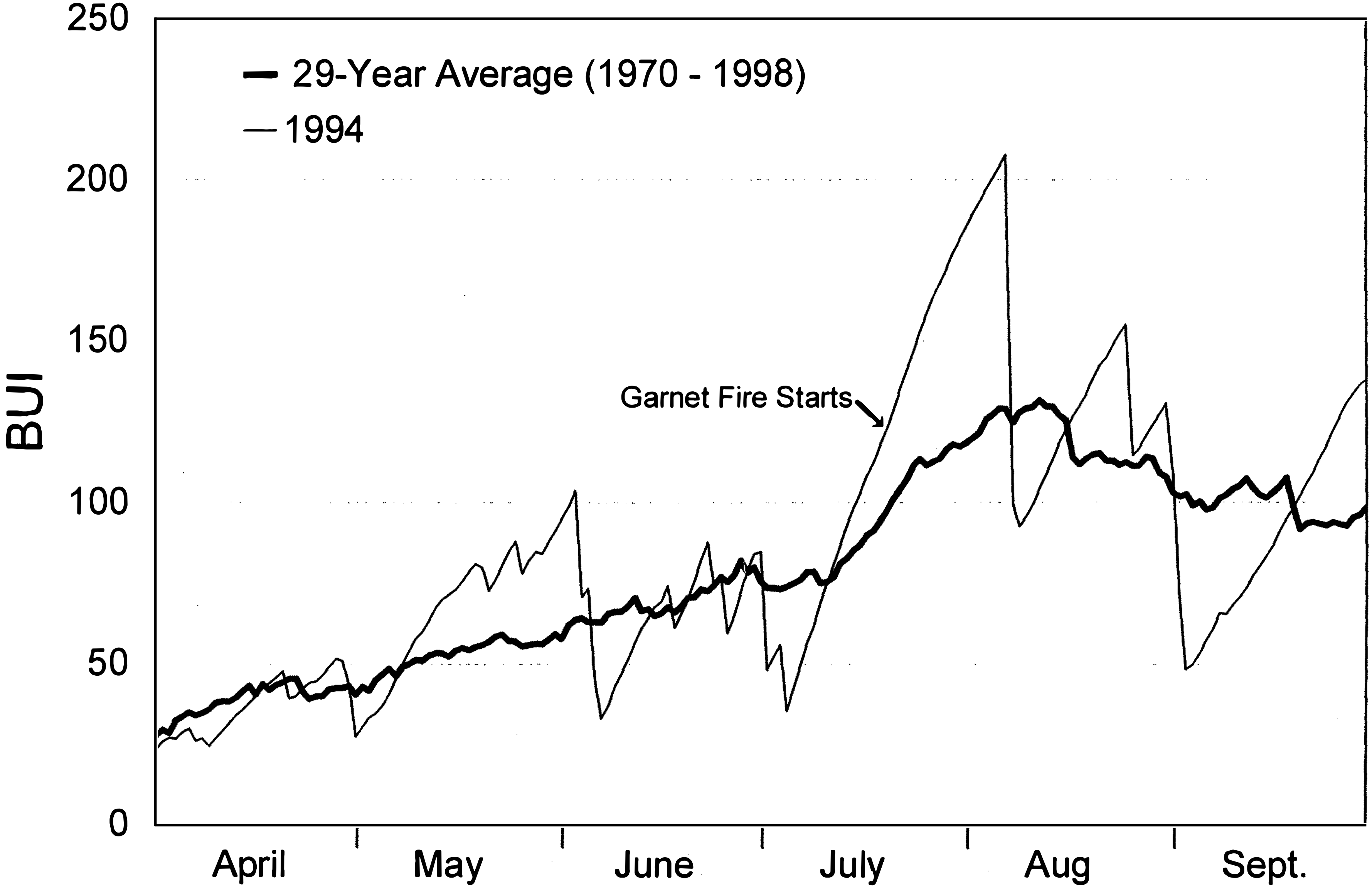

Figure 8:

Diurnal trends in Dry-bulb or Ambient Air Temperature and Relative Humidity (RH) at the Ministry of Forests Fire Weather Station 2102 (Penticton RS (NEC))

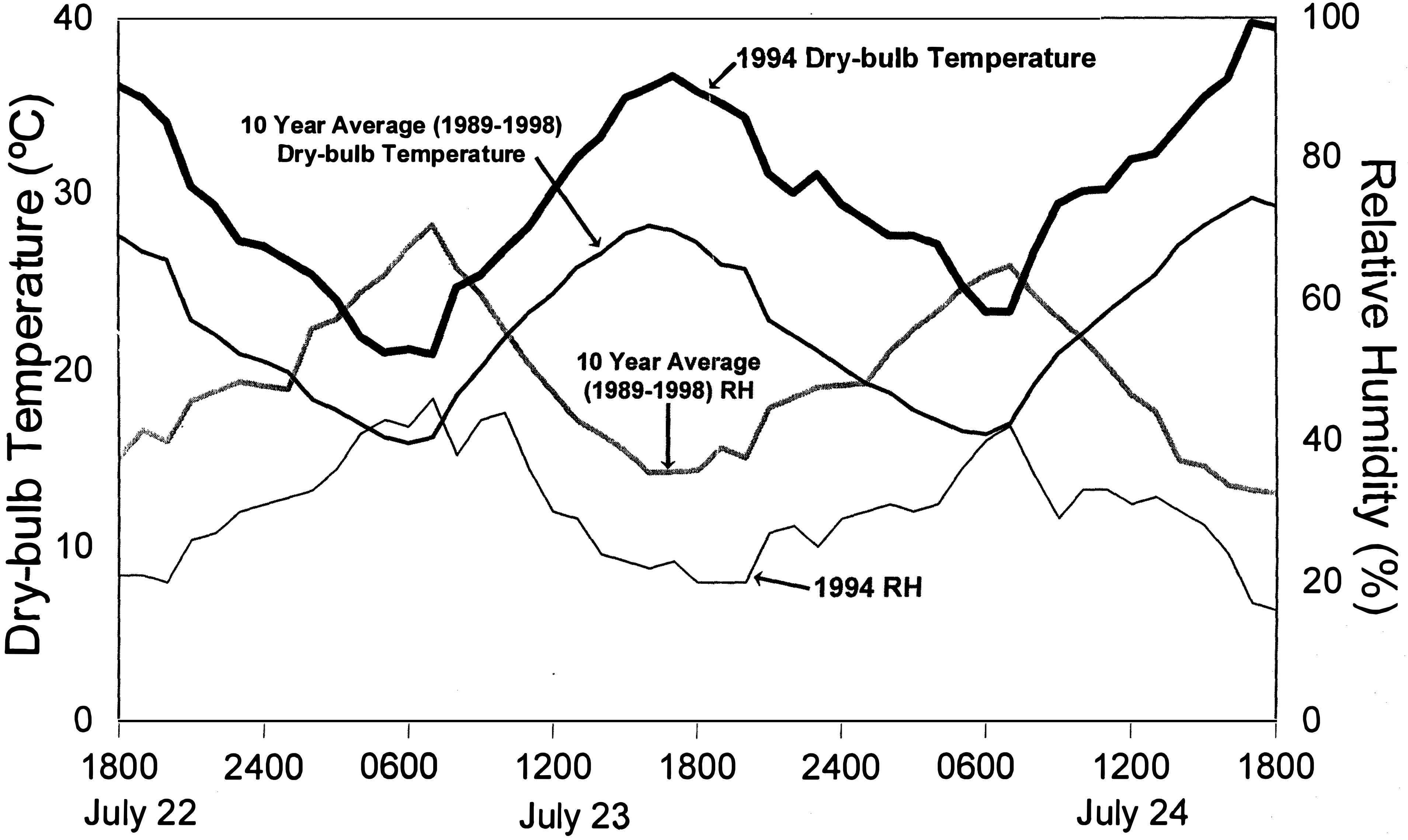

Table 1: Fire weather observations, fire danger indexes and climatological extremes recorded at the Ministry of Forests Fire Weather Station 2102 (Penticton RS (NEC)) near the northwest sector of the Garnet Fire.

1300 hours PDT Observations and Fire Danger Indexes										Climatological Observations			
Date (1994)	Dry-bulb Temperature (°C)	Relative Humidity (%)	10-m Open Wind Speed (km/h)	FWI System Components *						Air Temperature Extremes (°C)		Relative Humidity Extremes (%)	
				FFMC	DMC	DC	ISI	BUI	FWI	Maximum	Minimum	Maximum	Minimum
July 22	32.8	26	8	94.0	97	534	11.4	134	39	36.6	20.9	40	19
July 23	32.0	29	6	94.1	103	544	10.3	140	37	36.7	20.9	46	20
July 24	32.2	32	6	94.1	108	553	10.4	145	37	39.7	23.3	42	16

* The three fuel moisture codes and three fire behavior indexes comprising the Canadian Forest Fire Weather Index (FWI) System are defined below (from Canadian Forestry Service 1984):

Fine Fuel Moisture Code (FFMC) - A numerical rating of the moisture content of litter and other cured fine fuels. This code is an indicator of the relative ease of ignition and flammability of fine fuel.
Duff Moisture Code (DMC) - A numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. This code gives an indication of fuel consumption in moderate duff layers and medium-sized woody material.
Drought Code (DC) - A numerical rating of the average moisture content of deep, compact, organic layers. This code is a useful indicator of seasonal drought effects on forest fuels, and amount of smouldering in deep duff layers and large logs.
Initial Spread Index (ISI) - A numerical rating of the expected rate of fire spread. It combines the effects of wind and FFMC on rate of spread without the influence of variable quantities of fuel.
Buildup Index (BUI) - A numerical rating of the total amount of fuel available for combustion that combines DMC and DC.
Fire Weather Index (FWI) - A numerical rating of fire intensity that combines ISI and BUI.

All components have open ended scales except for the FFMC which has a maximum possible value of 99. In all cases higher values represent more severe burning conditions (i.e., lower fuel moistures or increased fire behavior activity).

Table 2: Simulated free-burning fire behavior and impact for the Garnet Fire, July 22, 1994

Local Time (PDT)	FFMC	Wind Speed (km/h)	Wind Direction (degs.)	Head Fire ROS (m/min)	Cumulative Forward Spread* A: (m)	Cumulative Forward Spread* B: (m)	Head Fire Intensity (kW/m)	Flank Fire Intensity (kW/m)	Crown Scorch Height Head Fire (m)	Crown Scorch Height Flank Fire (m)	Threshold LCBH for Crowning Head Fire (m)	Threshold LCBH for Crowning Flank Fire (m)
0100	-	-	-	-	-	-	-	-	-	-	-	-
0200	-	-	-	-	-	-	-	-	-	-	-	-
0300	-	-	-	-	-	-	-	-	-	-	-	-
0400	-	-	-	-	-	-	-	-	-	-	-	-
0500	-	-	-	-	-	-	-	-	-	-	-	-
0600	-	-	-	-	-	-	-	-	-	-	-	-
0700	-	-	-	-	-	-	-	-	-	-	-	-
0800	-	-	-	-	-	-	-	-	-	-	-	-
0900	-	-	-	-	-	-	-	-	-	-	-	-
1000	-	-	-	-	-	-	-	-	-	-	-	-
1100	-	-	-	-	-	-	-	-	-	-	-	-
1200	-	-	-	-	-	-	-	-	-	-	-	-
1300	-	-	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-	-	-
1600	-	-	-	-	-	-	-	-	-	-	-	-
1700	-	-	-	-	-	-	-	-	-	-	-	-
1800	93.5	11.1	330	4.5	270	102	4335	1563	40.5	20.5	6.4	3.2
1900	92.9	5.6	330	2.4	414	190	2337	1375	26.8	18.8	4.2	2.9
2000	91.5	5.6	360	1.7	516	252	1632	955	21.1	14.7	3.3	2.3
2100	90.2	9.3	360	1.7	618	295	1619	672	21.0	11.6	3.3	1.8
2200	88.8	9.3	330	1.2	690	325	1112	460	16.3	9.0	2.6	1.4
2300	87.5	13.0	330	1.2	762	346	1097	337	16.1	7.3	2.5	1.1
2400	86.1	13.0	330	0.8	810	360	748	229	12.5	5.7	2.0	0.9

*** Case A - with observed wind speed applied (this also applies to all other fire behavior and impact predictions presented here)**
Case B - zero wind speed applied (ROS prediction not presented).

Table 3: Simulated free-burning fire behavior and impact for the Garnet Fire, July 23, 1994

Local Time (PDT)	FFMC	Wind Speed (km/h)	Wind Direction (degs.)	Head Fire ROS (m/min)	Cumulative Forward Spread* A: (m)	Cumulative Forward Spread* B: (m)	Head Fire Intensity (kW/m)	Flank Fire Intensity (kW/m)	Crown Scorch Height Head Fire (m)	Crown Scorch Height Flank Fire (m)	Threshold LCBH for Crowning Head Fire (m)	Threshold LCBH for Crowning Flank Fire (m)
0100	84.8	11.1	340	0.5	840	370	437	155	8.7	4.4	1.4	0.7
0200	83.5	13.0	340	0.4	864	377	369	113	7.8	3.5	1.2	0.6
0300	82.3	11.1	330	0.3	882	383	224	79	5.6	2.8	0.9	0.4
0400	81.0	13.0	350	0.2	894	387	195	60	5.1	2.3	0.8	0.4
0500	79.8	13.0	350	0.2	906	390	147	45	4.2	1.9	0.7	0.3
0600	78.6	0.0	Calm	0.1	912	392	31	31	1.5	1.5	0.2	0.2
0700	84.1	7.4	350	0.3	930	401	253	123	6.0	3.7	0.9	0.6
0800	85.2	9.3	340	0.5	960	412	411	169	8.4	4.6	1.3	0.7
0900	86.3	9.3	340	0.6	996	427	558	230	10.2	5.7	1.6	0.9
1000	86.8	13.0	360	1.0	1056	444	906	278	14.2	6.4	2.2	1.0
1100	91.7	13.0	340	3.4	1260	509	3295	1019	33.7	15.3	5.3	2.4
1200	92.6	9.3	360	3.1	1446	590	2995	1252	31.6	17.6	5.0	2.8
1300	92.0	18.5	350	5.8	1794	660	5622	1218	48.3	17.3	7.6	2.7
1400	92.6	18.5	360	6.7	2196	742	6448	1398	52.9	19.0	8.3	3.0
1500	93.2	11.1	360	4.2	2448	837	4063	1463	38.8	19.6	6.1	3.1
1600	93.7	11.1	360	4.7	2730	945	4571	1649	42.0	21.2	6.6	3.3
1700	94.2	11.1	360	5.3	3048	1067	5130	1854	45.4	22.9	7.1	3.6
1800	93.6	5.6	30	2.9	3222	1172	2799	1651	30.2	21.2	4.7	3.3
1900	93.0	7.4	120	2.9	3396	1263	2822	1402	30.4	19.0	4.8	3.0
2000	91.6	0.0	Calm	1.1	3462	1326	1010	1010	15.3	15.3	2.4	2.9
2100	90.3	14.8	340	2.9	3636	1371	2724	740	29.7	12.4	4.7	1.9
2200	88.9	3.7	60	0.7	3678	1401	682	477	11.7	9.2	1.8	1.5
2300	87.6	0.0	Calm	0.4	3702	1423	333	333	7.3	7.3	1.1	1.1
2400	86.2	0.0	Calm	0.2	3714	1430	224	224	5.6	5.6	0.9	0.9

*** Case A - with observed wind speed applied (this also applies to all other fire behavior and impact predictions presented here)**
Case B - zero wind speed applied (ROS prediction not presented).

Table 4: Simulated free-burning fire behavior and impact for the Garnet Fire, July 24, 1994

Local Time (PDT)	FFMC	Wind Speed (km/h)	Wind Direction (degs.)	Head Fire ROS (m/min)	Cumulative Forward Spread* A: (m)	Cumulative Forward Spread* B: (m)	Head Fire Intensity (kW/m)	Flank Fire Intensity (kW/m)	Crown Scorch Height Head Fire (m)	Crown Scorch Height Flank Fire (m)	Threshold LCBH for Crowning Head Fire (m)	Threshold LCBH for Crowning Flank Fire (m)
0100	84.9	0.0	Calm	0.2	3726	1448	155	155	4.4	4.4	0.6	0.6
0200	83.6	0.0	Calm	0.1	3732	1456	108	108	3.4	3.4	0.5	0.5
0300	82.4	0.0	Calm	0.1	3738	1461	78	78	2.7	2.7	0.4	0.4
0400	81.1	0.0	Calm	0.1	3744	1465	55	55	2.2	2.2	0.3	0.3
0500	79.9	0.0	Calm	0.1	3750	1468	42	42	1.8	1.8	0.3	0.3
0600	78.7	0.0	Calm	0.1	3756	1471	32	32	1.5	1.5	0.2	0.2
0700	84.3	0.0	Calm	0.1	3762	1480	131	131	3.9	3.9	0.6	0.6
0800	85.3	3.7	20	0.3	3780	1491	248	173	6.0	4.7	0.9	0.7
0900	86.4	3.7	30	0.4	3804	1507	338	236	7.3	5.8	1.2	0.9
1000	89.1	7.4	40	1.1	3870	1539	1019	500	15.4	9.5	2.4	1.5
1100	91.8	7.4	10	2.2	4002	1605	2086	1031	24.8	15.5	3.9	2.4
1200	92.7	11.1	330	3.7	4224	1689	3603	1295	35.8	18.0	5.6	2.8
1300	92.0	14.8	360	4.3	4482	1760	4173	1137	39.5	16.5	6.2	2.6
1400	92.6	11.1	360	3.6	4698	1841	3533	1269	35.4	17.8	5.5	2.8
1500	93.2	11.1	360	4.2	4950	1937	4082	1470	38.9	19.6	6.1	3.1
1600	93.7	7.4	360	3.5	5160	2045	3365	1676	34.2	21.4	5.4	3.4
1700	94.2	5.6	360	3.3	5358	2167	3253	1925	33.4	23.5	5.3	3.7
1800	93.6	9.3	360	4.0	5598	2273	3860	1620	37.5	21.0	5.9	3.3
1900	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-
2100	-	-	-	-	-	-	-	-	-	-	-	-
2200	-	-	-	-	-	-	-	-	-	-	-	-
2300	-	-	-	-	-	-	-	-	-	-	-	-
2400	-	-	-	-	-	-	-	-	-	-	-	-

*** Case A - with observed wind speed applied (this also applies to all other fire behavior and impact predictions presented here)**
Case B - zero wind speed applied (ROS prediction not presented).