





Conducted by a joint Department of Sustainability and Environment, Country Fire Authority and New Zealand National Rural Fire Authority Investigation Team.

Date: 22 May 2007

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This is a report to the Chief Officers of CFA and DSE by the Investigation Team. The report has been prepared in accordance with the Terms of Reference, and the authorisation issued by the Chief Officers. The object of the investigation was to identify in a timely manner, matters that needed to be considered by the Chief Officers.

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1 EXECUTIVE SUMMARY

On Saturday 16th December 2006 a burnover incident occurred at the Mansfield Fire Complex that injured eleven New Zealand firefighters. The burnover occurred in dry, open Eucalypt forest on a day when forecast moderate weather conditions indicated benign fire behaviour.

The New Zealand Task Force of 45 personnel, in nine five-person fire crews, was tasked to work on Timbertop Sector of the Mansfield Fire Complex under the direction of a DSE Sector Commander. Their task was to ground truth a reported slop-over on Steiners Road where it had spread above the road at unconfirmed locations. The strategy, subject to field assessment, was to contain any spot-overs above the road to give sufficient time for a bulldozer to prepare an additional defensible fire control line along the ridge above Steiners Road.

The weather forecast was accurate, fire behaviour was benign and the crews had successfully contained one spot-over. The majority of the crew was deployed to work on a second slop-over above Steiners Road by constructing a rakehoe line around each flank. At approximately 1410 hours they had almost completed this task when the fire behaviour on a section of the main fire edge in unburnt fuel in a gully below the road suddenly increased.

The crew immediately evacuated downhill onto the road. Seven of the firefighters who tried to run to a safe area up the road were cut off by fire as it crossed the road, and another four suffered minor burns as they ran along the road to the safe area. The firefighters cut off by the fire sheltered by lying down on the edge of the road against the bank before making another run to safety, when they saw a gap in the flames. As they ran to safety the fire again crossed the road catching the firefighters and burning them.

As the firefighters reached the safe area their fellow firefighters administered first aid and arranged evacuation from the site. Six firefighters were hospitalised with varying degrees of burns or injury and the remaining five were examined, and released following treatment.

The following is a summary of the findings:

- 1. There were breaches of the Standard Fire Orders and Watchouts.
- 2. Fire control strategy did not directly contribute to the incident.
- 3. The unavailability of aerial infrared linescan imagery and aerial reconnaissance compromised the accuracy of fire mapping and the development of tasking.
- 4. Insufficient attention was given to intelligence from a Sector Commander on the day prior to the incident.
- 5. The omission of the NZ Task Force from the Incident Action Plan did not contribute to the incident.
- 6. The underestimation of the main fire's potential and limitations in the escape route were the most significant contributors to the incident.
- 7. The fact that a dedicated lookout was not deployed had minimal, if any, contribution to the incident.
- 8. Personal protective equipment (PPE) was effective in preventing injury except when it was not donned or not worn correctly.
- 9. Some issued face masks were inadequate for bushfire operations.
- 10. The informal command structure and merging of crews led to confusion when accounting for personnel, but did not contribute to the incident.
- 11. The by-passing of the Division Commander did not directly contribute to the incident.
- 12. The order to evacuate and the subsequent response reduced the number and extent of injuries.
- 13. The action of sheltering against the embankment was an appropriate decision and probably reduced the nature and extent of injuries.
- 14. The first-aid administered was resourceful and reduced the seriousness of injuries.
- 15. The evacuation by road and air was executed in an efficient and expeditious manner.

2 SCOPE

2.1 Investigation Team

The Investigation Team comprised the following personnel:

Rod Newnham	-	Parks Victoria representing DSE
Rick McKay	-	representing CFA
John Rasmussen	-	representing New Zealand National Rural Fire Authority
Rachaele May	-	DSE, co-opted to provide technical support

Fire Behaviour Scientist Jim Gould supported by Greg McCarthy Bushfire CRC was engaged to undertake an inspection of the site and to provide a report on their observations and analysis.

2.2 Duration of the Investigation

The Investigation Team commenced their work on 18 December and continued till its completion on 22 May 2007.

2.3 Authority & Terms of Reference

The Investigation Team responded to an initial request from Alan Goodwin – DSE Assistant Chief Officer, Operations Support, Fire & Emergency Management Division and Greg Esnouf – CFA, Deputy Chief Officer, Manager Operations Performance Improvement.

New Zealand National Rural Fire Authority Chief Officer, Murray Dudfield was invited to nominate a Team Member.

Appendix 1 is a copy of the Joint Memorandum engaging the Team and defining its Terms of Reference.

2.4 Sources of Information

During the course of the investigation the Investigation Team undertook a series of formal interviews with personnel including:

- Selected New Zealand Firefighters at the Incident
- DSE Sector Commanders at the Incident
- Selected Incident Management Team members on duty at the Mansfield Incident Control Centre on 15 and 16 December 2006

Documents including personal and functional logs, Incident Action Plans, Options Analysis, maps, IMT Briefing Minutes, Medical Unit Documents, News Releases and photographs were also sourced.

3 OVERVIEW OF THE MANSFIELD BURNOVER INCIDENT

3.1 Background

On the 1st December 2006 multiple lightning strikes started numerous fires in the North East, Alpine and Gippsland areas of Victoria. Many of these fires started on public land and could not be contained because of extreme drought conditions that have existed throughout Victoria and other States in Australia for a decade. This season had the lowest rainfall on record for this area.

On the 4th December 2006 the Department of Sustainability and Environment (DSE) in Victoria made a formal request to New Zealand for assistance to manage a number of these fires (refer Appendix 2). A multi-agency team of 45 firefighters, including crew leaders chosen for their remote high country and forestry firefighting experience, left Christchurch for Melbourne on the 7th December 2006. The deployment was coordinated by New Zealand's National Rural Fire Authority. Two New Zealand liaison officers coordinated the deployment in Victoria.

The New Zealand crews were briefed and equipped in Melbourne on Thursday 7th December 2006 before traveling to Mansfield for tasking. Briefings were undertaken by DSE and NZ liaison personnel on the conditions they would face at the fires and where they would be deployed. They were also briefed at the Benalla Integrated Fire Agency Coordination Centre(IFACC) and at the Mansfield Incident Control Centre (ICC) prior to their first deployment. Briefing covered a range of topics including fuel type, weather, expected fire behaviour, fire safety, dehydration, equipment, communications (radio) and organisational structure before being deployed onto the fireline for the first time on the 8th December 2006. Emphasis was placed on the extreme weather, fuel and topographic conditions and resultant extreme fire behaviour being experienced.

The New Zealand Task Force was made up of nine, five-member crews, including a Crew Leader. A Liaison Officer based at Mansfield coordinated all non-operations matters between the crews, the Incident Management Team (IMT) at Mansfield and the New Zealand Liaison Officer based out of the DSE office in Melbourne. A Crew Leader had also been appointed as Team Leader for the New Zealand deployment. The New Zealand Task Force commenced fireline duties on the 8th December 2006 and completed their first seven-day deployment on the 14th December 2006.

3.2 Mansfield Fire Complex Friday 15th December 2006

Jamieson Sector, Mt Terrible Division and Timbertop Sector, (NE Alps Division).

Experiencing difficulty in holding fire within control lines and unsuccessful strategy was common during the suppression effort preceding Friday 15th December 2006. Fire conditions experienced had been difficult and at times fire behaviour was extreme. Lack of aerial infrared imagery or aerial reconnaissance created difficulty for the Incident Management Team, in particular for the Planning Unit to produce accurate maps and specific taskings. Regular ground-truthing was required to identify fire boundaries.

On the 15th December 2006 the Sector Commander for the Jamieson Sector was tasked to check Steiners Road to determine the fire boundary. Two bulldozers, a grader and two CFA Strike Teams of tankers and crews were tasked to the Sector.



Map 1 - Incident Location



Map 2 - Incident site

The fire personnel logs for that day show the Jamieson Sector Commander requested an investigation after locating a fire slop-over, which was considered suspicious at a location described in the operations log "1.3 km up Running Creek from camping area" (police later investigated this report and found no fire). The Sector Commander reported that Steiners Road was blocked and would be falling back to Ashwin Road. The Sector Commander radioed the Operations Officer informing them that Steiners Road had been "lost". The CFA Strike Teams on the Sector had also left the area because they considered the terrain and lack of turn around options meant their tankers were not suitable for the task and they had safety concerns.

The incident logs and briefings notes show that the night IMT did not consider Steiners Road to be suitable for CFA tankers until a full reconnaissance (recce) was undertaken. The Incident Action Plan for the day shift of the 16th December 2006 also shows some uncertainty about the size and location of the fire on Steiners Road.

The New Zealand crews were on their one-day rest on the 15th December 2006 before returning to commence their second seven-day deployment the next day.

3.3 Mansfield Fire Complex Saturday 16th December 2006 Jamieson Sector, Mt Terrible Division and Timbertop Sector NE Alps Division

At the morning briefing on the 16th December IMT personnel realised that the New Zealand crews had not been included in the day's Incident Action Plan (IAP). Misunderstanding of the New Zealanders rest days or an impending Minister's visit are reasons raised for the omission. The Operations Officer was concerned about losing the fire across Steiners Road and he was happy to have an additional resource to assign to the Timbertop Sector Commander. They were to work closely with the Sector Commander, Jamieson Sector, Mt Terrible Division. The task was to ground truth, assess the situation and if appropriate build hand constructed control lines to contain areas where the fire had crossed Steiners Road so that bulldozers could develop a fire control line on the main ridge above the road. Although Steiners Road was not seen as an ideal location to backburn from because of corners and steepness, it was seen as a critical line to stop the fire's spread as the next logical fall back control line was some distance away. With the benign fire behaviour expected it was considered likely the fire could be held on Steiners Road.

The New Zealand Team Leader and some Crew Leaders were briefed by the Timbertop Sector Commander. The New Zealand crews then travelled to the job in convoy in four wheel drive dual cabs and wagons as the three slip on units requested to support them were unavailable due to servicing requirements. By 1030 hrs the New Zealand crews arrived at the intersection of Howqua Hills Track and Steiners Road. Two bulldozers were also working in the sector on the day.

The Timbertop Sector Commander and the New Zealand Team Leader drove down Steiners Road to undertake a reconnaissance (recce) while the remainder of the crew waited at the intersection for further instruction. One slop-over and one tree across the road were encountered. The supervisors returned to the intersection of Howqua Hills Track and Steiners Roads to walk along the ridge to determine the extent of the burn area. The maps provided did not accurately reflect the location of actual area burnt. The supervisors determined the slop-over was small and burning with only low intensity and could be contained with handconstructed control lines The supervisors then went back to the crew to organise the clearance of the tree from the road,

task the crews, and also enable access down Steiners Road to see what else they could find.

At a later point, but before the incident, a crew of five firefighters was redeployed by the Timbertop Sector Commander to assist with another task on a different section of the fire in the Brocks Road area. The remaining crews were briefed and tasked to construct a rakehoe line around the first slop-over while the drivers took the vehicles down Steiners Road to a turnaround from where, after direction from the Timbertop Sector Commander, they returned to a safe location up Steiners Road past the first rakehoe area where the fire had burnt above and below the road. Weather conditions at the time were mild with fire behaviour described as only a low creeping ground fire. By 1300 hrs the crews had almost completed putting a control line around the first slop-over, with some of the crews arriving back at the vehicles.

The Timbertop Sector Commander and New Zealand Team Leader then went down Steiners Road to determine whether they could round up a second slop-over above the road that had been identified earlier by the Timbertop Sector Commander. Between the first and second slop-over there was an area of unburnt fuel below and above the road. No fire was observed below the road at that time apart from fire in the top of an old tree estimated to be 3-400 metres down the hill. The firefighters who were not still working on the first slop-over were tasked and briefed, and then split into two groups to establish rakehoe lines up the west and east flanks of the slop-over. The Timbertop Sector Commander then left to travel further down Steiners Road to the west to continue ground observation.

Weather conditions at that time (approximately 1330 hrs) were still benign with temperatures recorded as $20.5^{\circ}C - 21^{\circ}C$, Relative humidity was 26-28% with less than 3 kph wind. Onsite weather readings were being recorded by the New Zealand crews using hand-held weather instruments. The onsite weather readings were consistent with the weather forecast in the day's IAP. The area was covered with quite thick drifting smoke and this condition had persisted all day.

The New Zealand Team Leader took charge of the crew on the west flank of the second slop-over and was walking Steiners Road between the west and the east flanks to monitor any fire activity below the road, communicate with the appointed supervisor on the east flank and act as lookout for both flanks. The slope below the road has since been found to be between 30 and 35 degrees. The Team Leader was aware that he couldn't see everything but felt those up the hill could have a good view into the gully.

As the crews completed their tasks on the first slop-over they walked down the road and were tasked to assist in the construction of the rakehoe line on the east flank of the second slop-over. There were eventually 23 crew members working on this east flank prior to the incident. One of the last crew walking between the two slop-overs said he reported flame 80-100 metres below the road to the Team Leader. The nature and content of this conversation is unclear.

The east flank rakehoe line of the second slop-over was tied in to the road. Despite this, a small spot fire occurred close to and above the road which was difficult to control as it was in slightly heavier fuels. Additional crew members were directed back down the line to provide support and another rakehoe line was started above the road some 20 metres to the east of the first rakehoe line in unburnt but very light fuels. This second rakehoe line was joined into the first rakehoe line approximately 50 metres north of and above the road.

All firefighters on the east flank were then directed to come down the line and spread out over the 50 metres of rakehoe line to monitor the line while the fuel burnt out between the two lines on the east flank. From interviews fire behaviour was observed by a couple of firefighters at this time to have increased slightly in intensity with flame heights flaring up to 1.5 metres in height, and an increase in wind speed to between 5 and 10 kph. The crews had been working quite hard and were instructed to take a break by their supervisor. At that time, the majority of the crew who were working on the eastern flank stated that they felt comfortable with their position except for three firefighters two of whom had arrived later to the second slop-over. One reported feeling there was something not right but couldn't identify exactly what.

The other, as described previously, said he saw some flame below the road when walking down the road, and along with the third firefighter, didn't feel comfortable with the unburnt fuel below them.

3.4 The Blow-Up, Escape and Evacuation.

From interviews, it appears that most of the crews on the east flank of the second slop-over, as well as the New Zealand Team Leader, became aware around the same time that there was an increase in fire behaviour in the gully below them and they were in danger. At first the fire was not seen but heard, with the sound described as a roaring noise like a jet aircraft or a freight train. The change in situation was described as occurring within seconds.

The crews on the eastern flank were then ordered by the Crew Leaders to immediately run and get down onto the road as fast as they could. At the same time the fire above the road being burnt out between the two rakehoe lines on the east flank had increased in intensity negating, in the views of those there, of any practical option of the crews closer to the road of getting into the burnt ground. The fire from below the road was approaching slightly from the firefighters' right as they ran down towards the road cutting off any access in that direction leaving the only option for escape to get onto and run up the road towards the safe area where the vehicles were parked. Firefighters further up the slope ran on a slight angle to the road instead of down the rakehoe line.

The remaining New Zealand firefighters working on the first slop-over and the west flank of the second slop-over retreated safely to Steiners Road on hearing the noise of the fire blow up.

The fire below the road is thought to have started to build in intensity some 180 metres below the road. With the multiplying effect of slope, the fire is estimated to have reached the road in less than five minutes, as modeled by a fire behavioural specialist. By that time all the firefighters were off the rakehoe line and had scrambled or jumped off a two-metre bank onto the road. They were then urged to run up the road as fast as they could. Slower firefighters were supported by Crew Leaders and fellow firefighters. Sixteen of the firefighters escaped up the road to the Safe Area, with four receiving only minor burns before the second fire cut off the retreat of the remaining seven firefighters.





Second slop-over - looking from top of East flank down hill



Second slop-over - Looking up East flank from Steiners Road



Looking East along Steiners Road from Eastern flank of second slop-over

The Crew Leader directed these firefighters to take shelter on the road against the embankment. The seven firefighters were heaped together and ordered to "hold" in this position. The group stayed in this position on the ground, probably for less than a minute, until they saw a gap in fire activity up the road, at which time they were again ordered to run. The Crew Leaders in the group ensured that all firefighters were ahead of them and assisted their escape to the safe area. It was during this final run that the majority of the burns were sustained by the seven firefighters as the fire again crossed the road. The decision to shelter probably reduced the nature and extent of injuries.

The injured firefighters were given immediate first aid by other members of the team who had escaped or who were working in the first slop-over area. Water and ice carried in chilly bins/eskys was applied to burns. Not long after this time the Sector Commander from Jamieson Sector and then Timbertop Sector Commander arrived at the western end of the burn over where the New Zealand Team Leader and his crew were cut off from the vehicles, injured firefighters and the remaining firefighters.

Arrangements for evacuation were immediately put in action at around 1415 hrs. The injured firefighters were driven to Tobacco Flat where two helicopters were arranged to meet and take the injured firefighters to Mansfield, where some were treated locally and the more seriously injured were either flown or driven to Melbourne and Wangaratta hospitals. The remaining crews on site worked through the process of accounting for all members of the team before leaving the fire site. The timeliness, method of evacuation of and treatment of these injured has been recognised by those involved as excellent.



Firefighter demonstrating how crew members took refuge at actual site



Firefighters emerging from the burnover having taken shelter and made a second run to safety

A total of eleven NZ firefighters were treated for varying degrees of burns or injury with the four most seriously injured being hospitalised in Melbourne, one hospitalised in Wangaratta and one hospitalised in Mansfield. The remaining five were released following treatment.

4 ANALYSIS

4.1 Topography

The Incident area is located in Mansfield State Forest, south west of Howqua Hills Historic Area. Steiners Road runs generally east-west from Running Creek Camping Area in the west to an intersection with Howqua Hills Track in the east. Running Creek can be found approximately 1.5 km south of Steiners Road.

Terrain in this area of the Mansfield State Forest is dry mountain foothills with rugged steep slopes, small streams and gullies, and elevations of between 800–1000m. The incident occurred on the south-southwest aspect of a slope, at an approximate elevation of 760m.

The topography of the burn over area is characterised by mountainous terrain of steep slopes which drop sharply into creek gullies of the Running Creek watershed. The burn over occurred on Steiners Road along a road side cutting which consisted of slope between 32° and 36° below the road and 25° slope above the road. (Figure 1) Other features in the area were two small creek draws below the road (Figure 2).



Figure 1: The road side cut near the vicinity of the burn over site illustrating the slope above and below the road surface. At the incident site the road surface was approximately 7 m wide.

4.2 Fuels

This typical dry open forest is predominantly made up of Narrow Leaf Peppermint, (Eucalyptus radiata), some Candlebark (E. rubida) and little understorey on the higher slopes. Wetter gullies contain an assortment of Pomaderris species, Blanket Leaf (Bedfordia spp), Musk Daisy Bush (Oleria spp) and blackberries in more protected aspects. This forest type is characteristic of the lower rainfall hill country found in the eastern and north eastern parts of Victoria.

In this forest type, the understorey may vary from a floor of tussock grasses along the ridge lines to a few wattles, common Cassinia, Daviesia, Prickly Leaf Currant Bush and Dogwood on the upper slopes. Typical vegetation further down-slope in the gullies consists of Narrow Leaf Peppermint with a wetter understorey.

The predominant Ecological Vegetation Classes are grassy dry forest or herb rich foothill forest.

Narrow leaf peppermint grows to about 25m in height with persistent short fibrous bark on the trunk and large branches. Candlebark is smooth-barked over most of the trunk and branches, usually lacking ribbons, and can grow up to 35m in height. The fuel characteristics of the tree species mean that this forest type is prone to intense fire behaviour. The peppermint bark, with its vertical fibrous arrangement, is conducive to short-distance spotting.

Fuel type described above is a typical open dry eucalypt forests predominantly made up of fibrous and smooth bark overstorey trees and mixture of understorey plants. Fuels were inspected in January 2007 with Greg McCarthy in the vicinity of the burn over site and adjacent areas of similar aspects and slope. Assessments of the fuel hazard ratings for selected areas are given in Figure 1 using the Overall Fuel Hazard Guide (McCarthy *et al.* 1999). Estimates of available fuel loads surrounding the burn over incident sites for the different fuel hazard layers are:

Surface fuel 10 t/ha Near-surface fuel (adjust the surface by one class) 6 t/ha Elevated fuel 2-6 t/ha Bark 2-5 t/ha



Figure 2. Estimated pre-burn overall fuel hazard levels SF (Surface fuel), NSF (Near-surface fuel), EF (Elevated fuel) and bark fuel.

4.3 Fire Weather

Automatic Weather Stations

The nearest Automatic Weather Station (AWS) was located at the Eildon Fire Tower. Eildon Tower (638m), although at a similar height to the incident site, is more exposed and would be markedly hotter and drier. In addition, Running Creek catchment may have been affected by an inversion layer which was keeping smoke in, sunshine out and restricting visibility.

In the two days prior to the 16^{th} December 2006, records from the Eildon AWS showed that temperatures ranged from less than 10° C (early AM on 15 & 16 Dec) to 30° C (14 Dec PM). Wind direction tended North West-North East. At the time of the incident (approx 1408-1412hrs) the following information was recorded at Eildon Fire Tower (AWS):

Obs Date and Time	Wind Direction	Wind Speed (kph)	Air Temp.	Max Wind Gust	Relative Humidity	Drought Index	Forest Fire Danger Index
16/12/2006 13:30	260	20.4	19.9	17	31	100.9	13
16/12/2006 14:00	290	14.8	19.8	14	30	100.9	12
16/12/2006 14:30	230	18.5	21.6	16	23	100.9	18

Portable Automatic Weather Stations

The nearest Portable AWS's in the area prior to or on the day of the incident were located as such:

- PAWS VicH was deployed at Mt Terrible south of Jamieson (elevation 1316m)
- PAWS VicF was deployed to Matlock (elevation 1224m)

DSE records indicate that while it was deployed to Mt Terrible from Wednesday 13th December 2006, PAWS VicH did not record *any* data between 1300 on 14th December 2006 and 1620 on the 16th December 2006. Similarly, PAWS VicF (based at Matlock) did not record *any* data between 1300 on 14th December 2006 and 0850 on the 16th December 2006.

It appears that both the Vic H (Mt Terrible) and the VicF (based at Matlock) PAWS stopped transmitting data during these times due to low power levels. High levels of smoke during that period prevented the solar panels from recharging the batteries. While both PAWS should have still had sufficient power to record data over this period, which has since been downloaded, location-specific information was not available to the IMT Planning Unit.

Spot Weather Forecasts

A spot weather forecast was requested at 2230 on 15th December 2006, and the Bureau of Meteorology subsequently issued a Spot Weather Forecast at 0133 on 16th December 2006. The following information was provided in Forecast no 31 for Mt Terrible:

Time (local)	Wind Speed (kph) and Direction at 10m	Air Temperature (°C)	Relative Humidity (%)
0300	SE 5g10	6	80
0600	SE 5g10	5	85
0900	SSE 5g10	8	70
1200-2400	S 10g20 tend SE 20g30 after 1600	13 increasing to 18 (max), decreasing to 9 by 2400	50 decreasing to 35 at max temperature, increasing to 60 by 2400

Field Observations

Field observations for the site at 1250 on 16th December 2006 were recorded by the Timbertop Sector Commander. They indicated that temperature was 23°C, relative humidity was 25% and the wind was less than 10 km/h from the south. Additional field observation recorded by the fire crews near the incident site were noted at approximately 1240 hours temperature of 20°C, relative humidity of 26% and low wind speed and at 1330 hours temperature of 21°C, relative humidity of 26% and light variable winds.

In the days prior to Saturday 16th December, the weather in the Mt Terrible-Jamieson area had been very hot and windy, with extreme fire weather experienced on Thursday 14th December. That day was declared a day of Total Fire Ban for the entire State. High temperatures and low relative humidity, with WNW winds were experienced before a south westerly wind change came across at approximately 1715 on Thursday 14th December (according to the Bureau of Meteorology (BoM) Wind Change Chart). Friday 15th December was a mild day with temperatures in the mid 20's, moderate relative humidity (12-20%) and light south-south easterly winds.

Weather forecasts indicated that Saturday 16th December 2006 would be a relatively mild day, warmer in the north, smoky, with temperatures between 22-29 degrees and light to moderate south easterly winds in the north east of Victoria. The Spot Weather Forecast issued in the early hours of Saturday 16th December confirms these forecasts, as do the field observations recorded.

4.4 Fire Behaviour

On 16th December fire crews were tasked to construct hand trails to contain two small spot fires north of Steiners Road. Fire weather observations recorded at fire ground recorded by the fire crew of temperature 21°C, relative humidity 26% under light variable winds at 1330 hours. The crew also commented on the benign fire behaviour with flame heights less than 1 m high and spreading slowly up slope on the northern side of the road. Before 1400 hours a crew member took a small video footage of the western spot fire showing flame heights < 1 m high. The interpretation of flame height from the field observation of char height ranged from $\frac{1}{2}$ to 1 $\frac{1}{2}$ m high in the spot fire burnt area west of the hand trail indicates flame heights less than 1 $\frac{1}{2}$ m high. Also from the video footage the area below Steiners Road was very smokey with visibility less than 25 m below the road. Figure 3 illustrates the understorey fuel structure and char height near one of the spot fires on the northern side of Steiner Road.



Figure 3. Construction of a hand trail showing the understorey fuel structure on the northern site of Steiners Road at slop-over 1 (estimates elevated fuel hazards of HIGH) (left) and low char height in the spot fire burn area (right). These photographs were taken between 1300 and 1320 hours..

There was some uncertainty on the location of the fire perimeter below Steiners Road. Information from the fire ground observation location of the fire perimeter was approximately 200 m down slope from Steiners Road (See Figure 4). Also, a crew member observed flames approximately 300 m below Steiners Road. No time was noted for either of these observations.

There is a common tendency to overestimate the distance to a fire when observing through the forest¹. On Project Vesta (Gould *et al.* 2001) fires it was nearly impossible to see the flames in a forest containing a 2 m shrub layer and an intermediate tree layer when the fires were 100 m distant, even when there was intermittent crowning in the overstorey. When flames were clearly visible, even experienced observers consistently overestimated the distance between the flames and some reference point such as the plot boundary, at times by more than 100%. This illusion may lull firefighters into thinking there is more time for egress to a safe location than is actually the case (Cheney *et al.* 2001).

Around 1400 hours the crew on the western hand trail were taking a rest and were hearing loud cracking and roaring noises below them and decided to evacuate the fire ground and their escape route marked in Figure 4. The distance between the western hand trial and the crew vehicles was approximately 500 metres.



Figure 4. Progression of the flanking fire and sequence of 3 fire blow outs toward Steiners Road with run one (1) over running the fire fighters on their escape route

¹ When an object is viewed through space filled with other objects there is an illusion that viewed the object is further away (Jim McLennan, Senior Research Fellow, Swinburne Computer-Human Interaction laboratory, *pers.comm.*).

It appears the fire spread slowly as a flanking fire below Steiners Road most of the morning with the Forest Fire Danger Index (FFDI) of Moderate increasing to High by early afternoon. Also, the fire in the low gullies would have been sheltered by the winds, thus the benign fire behaviour before 1400 hours. Post fire assessment located at start of severe canopy scorching approximately 180 m below the road where the flanking fire flared up and increased its fire intensity and fire spread up slope towards Steiners Road.

The distance from this increasing fire intensity to Steiners Road is 180 m on a 35° slope. At the rate of spread predicted on level ground of 270 m hr⁻¹ the fire would have taken over 40 minutes to travel to Steiners Road but, when the rate of spread is corrected for 35° slope this time is reduced to less than 5 minutes.

Field observation from the fire crew indicated there were three separate up slope runs to Steiners Road. The photograph sequences shown in Figure 5 were taken approximately at 1406 hours showing flames over the road. Because of the three separate runs up slope in a series of narrow tongues, the head fire probably did not reach its full potential rate of spread. Observation on the western edge of the fire run noted the third run was approximately 10 minutes later and took longer to spread up to the road.



Figure 5. Sequence of photographs showing the flame crossing Steiners Road and the smoke (d) when the last of the crew walk out towards their safety zone.

Given this potential rate of spread once the fire flared up there was only time for the crew to abandon their fire line activities and leave. Assuming an estimated hiking speed during the escape to an established safety zone is approximately 80 m min⁻¹ on a 5% gradient. The fire took less than 5 minutes to travel up slope to Steiners Road, leaving insufficient time for the crew to reach a safety zone (little over 6 minutes to hike 500 m on 5% gradient).

Luke and McArthur (1978), Brown and Davis (1973), Chandler et al. (1983) give a very good gualitative description of fire behaviour in general. These authors mention the important role of wind and topography and describe the behaviour of fire on steep slopes. The behaviour of fires on steep slope is seldom gradual process and this is usually the results of factors like an increase in wind speed, start of crowning, rapid growth of spotting or a combination of all these factors. There are many examples in the literature of fire related incidents (fatalities, injuries and near-misses) that occurred in steep country, canyons or mountainous terrain. A few well known examples are the Mann Gulch Fire (Rothermel 1993); the Storm King Fire (Butler et al. 1998), the Thirtymile Fire (Furnish et al. 2001) and the Buckland Crossing Fire (Pearce et al. 2004). In the description of these incidents the term frequently mentioned that a "blow-up" of the fire or a sudden explosion occurred (Viegas and Pita 2004). They all mentioned that the fire changed suddenly and in an unexpected way which surprised all involved. These case studies reported that the fire consumed in very few minutes an area larger than that burned during the previous hours (Viegas and Pita 2004).

Cheney *et al.* (2001) highlighted three examples of the risks to firefighters undertaking suppression on bushfires in heathland and eucalypt forests where entrapments occurred. The common theme in their examples is that firefighters were caught by a sudden escalation in fire behaviour that resulted from changes in wind direction and/or strength influencing an established line of fire. The rapid response by the fires to changing conditions and the distance between the fire edge and the fireline left the firefighters with only a very short time to assess the situation, communicate the decision amongst the crew, and take evasive action. Similarity to the incident on Steiners Road, regardless of the specific tactics, and subsequent actions taken after the wind change, and/or slope, it appears that the fires spread much faster than the firefighters anticipated and they did not allow sufficient time for safe egress.

Radiant heat flux

The prediction of thermal radiation from bushfires is important in a number of fields, especially fire fighter safety (Fogarty 1996; Butler and Cohen 1998; Sullivan *et al.* 2003). Reviewing the literature reporting the effects of heat on humans suggest that upper limit of radiant heat on bare skin that can be sustained without injury for a short time (less than 2 minutes) is approximately 2.3 kW m⁻² (Fogarty 1996; Budd and Cheney 1984; Stoll and Green 1959). Other studies have explored the performance of fire fighter personnel equipment and their fabric use in fire fighting clothing (Braun *et al.* 1980; Behnke 1982; Bond and Cheney 1986). The data from Braun *et al.* (1980) suggest fighter wearing protective clothing i.e. Nomex, second degree burns will occur at incident radiant heat flux of approximately 7 kW m⁻².

Fogarty (1996), Butler and Cohen (1998) and others have developed models that predict incident radiant heat energy on fire fighters either related to fire intensity, flame size and size of break. Knight and Sullivan (2004) developed a radiant heat flux model based on basic radiation transfer equations, flame characteristics (flame geometry and temperature) and review of the flame at the receiving element i.e. fire fighter safety zone. Knight and Sullivan (2004) model was applied to simulate different fire scenarios to predict the radiant heat flux. Two simulation runs were done to compare the affect of the road width where the crew crouch on the road site. The measurement of the road width at the crouch site was 7 m wide which is slightly wider than the normal forestry road surface of 4 - 5 m wide. The predicted radiant heat flux, based on a flaming zone of 10 m wide and 8 m flame height, for the 7 m wide road surface is 6.5 kW m² compared to 21.4 kW m² on a 4 m wide road surface. Thus, if the road surface was narrower than 7 m wide there would be a very high probability of major burn injuries and/or even fatalities occurring under these fire behaviour conditions.

4.5 Engagement of New Zealand Personnel

In early December 2006, DSE initiated discussions with the New Zealand National Rural Fire Authority regarding a possible request for NZ fire personnel to assist with the Victorian Wildfires.

DSE Assistant Chief Officer, Liam Fogarty specified to NZ National Rural Fire Authority Chief Fire Officer Murray Dudfield on 3rd December 2006 that Victoria would probably require 100 fire crew personnel and 20 Incident Management Team personnel for two rotations. It was outlined that the rotations would probably be for a 30-day tour as either:

- 4 nights then one day break followed by 4 nights then 2 day break; or
- 7 days then one day break followed by 7 days then 2 day break.

Murray Dudfield (NZ) responded that this tentative request could be met, and suggested that the guidelines adopted in 2003 for a similar request could be used as the basis for the 2006-2007 arrangements.

The email dated 3rd December 2006 stated that the first deployment of NZ fire personnel would land on 7th December 2006, followed by a one- day induction and then deployed to the field for a 14-day assignment.

Subsequently, DSE Chief Fire Officer Ewan Waller formalised the request by letter on 4th December 2006 (See Appendix 2). The letter requested liaison officers, up to 100 crew / crew leaders for firefighting and 30 incident management personnel.

A response from NZ on 5th December 2006 confirmed that 40 NZ fire crews and IMT personnel would be landing in Melbourne on 7th December 2006. It was members of this deployment who became involved in the burnover incident on 16th December 2006.

In his letter dated 4th December 2006, DSE Chief Officer Waller clearly stated that the NZ fire personnel must be:

- Trained and competent in remote area firefighting (to relevant Australasian Fire Authorities Council National Standards);
- Have Alpine country and/or forest firefighting experience;
- Familiar with dry firefighting techniques; and
- Physically fit (i.e. will be expected to walk up to 2 hours to access fires).

Chief Officer Waller requested that NZ provide DSE with a description of the skills and accreditations of all fire personnel to be deployed to Victoria.

The relevant Australasian Fire Authorities Council National Standards stated in Chief Officer Waller's letter refer to the training competencies outlined in the Public Sector Training Package as used by DSE and CFA.

The International Liaison Unit (ILU) within the DSE Emergency Coordination Centre coordinated and oversaw the New Zealand resource management once in Australia. This included the collation and management of NZ personnel information.

4.6 Fire Control Strategies

• In the two days preceding the burn-over event, strategy was developed to establish a control line in the Jamieson and Timbertop Sectors. This control line would essentially follow a path from east of Jamieson, northerly along Masters and Symes Tracks, then easterly along Steiners Road, northerly along Howqua Hills Track to Sheepyard Flat, easterly along Brocks Road to 8

Mile Flat, then further easterly along the Howqua Walking Track to 16 Mile Track.

- Extensive work was required to enhance the condition of this line with heavy machinery, in anticipation of backburning operations, where appropriate, to contain the main fire which was advancing from the south.
- Fire behaviour predictions were provided to the IMT during the evening of 14 December. The predictions stated that *"Fire behaviour will be very benign for the next four days. Any spread will be limited to late afternoons and dominated by slopes. Each night, fires will die down and move very little."*
- Issues relating to the availability of the aerial infra-red linescan and subsequently its accuracy adversely impacted on fire mapping capability. This necessitated extensive reconnaissance and ground truthing to determine the location of the fire edge. Aerial reconnaissance was also difficult at times due to smoke lingering in the generally calm conditions.
- On 15 December, the fire had crossed Mitchells Track which then made Steiners Road the critical control line. It was recognised by the Day-IMT that Steiners Road was not an ideal control line as it is a side cut road, across slope with many corners. However, the Operations Officer considered that it had a reasonable chance of holding due to the quiet fire behaviour.
- The Jamieson Sector Commander travelled Steiners Road in the late afternoon of the 15 December and found that fire had breached the road near the Howqua Hills Track.
- Two CFA Strike Teams were in the area and advised the Sector Commander that they were not prepared to fight the fire for safety reasons and the lack of turnaround points. They also considered that tankers were inappropriate in that environment. The Strike Teams returned to the Staging Area and were stood down. The Strike Team Leader and Deputy visited the ICC and reported their concerns in relation to Steiners Road to the Deputy Incident Controller.
- The Jamieson Sector Commander continued to recce Steiners Road and reported to the ICC that the fire had crossed Steiners Road and provided details of the location.
- The day Operations Officer for the 15 December decided that no crews on the night shift would be deployed to Steiners Road because of uncertainty of fire behaviour and location.
- The night shift on 15-16 December undertook a recce of the area and were also unable to confirm the exact location of where the fire had crossed the road.
- On the morning of 16 December, to maintain the strategy to hold the fire on Steiners Road, the Operations Officer briefed the Timbertop Sector Commander to assess the situation on Steiners Road from the East. The NZ Task Force was assigned to the task as it had not been otherwise deployed in the Incident Action Plan. The Jamieson Sector Commander was briefed to assess Steiners Road from the West and to work in with the Timbertop Sector Commander to develop tactics to deal with the fire across Steiners Road.

4.7 Tactics

- Following the arrival of the NZ Task Force at the intersection of Steiners Road and Howqua Hills Track to the west, the Sector Commander and NZ Task Force Leader undertook a recce and located a slop-over of the fire on Steiners Road.
- Having assessed the situation, it was agreed that it should be possible to establish a control line by the NZ crews using hand tools (rakehoes), around its perimeter.
- The NZ crews were briefed by the Team Leader and deployed to the task. The crews drove to the site in nine four wheel drive vehicles, turned them around and parked them on the road in the black. It should be noted that no Slip-on Units were included in the fleet allocated to the NZ Task Force as none were available due to scheduled servicing.
- While the crews were constructing the line, there was a request for one crew of 5 firefighters to be redeployed to assist with a task on Brocks Road. They subsequently left the site of the slop-over.
- As the work continued under the supervision of the Team Leader, the Sector Commander travelled further west along Steiners Road and found another slop-over.
- The Sector Commander returned to the first slop-over and requested the NZ crews to attend to the second slop-over as they came off the line of the first.
- A number of personnel were retained at the first to finish off the task and to maintain a watch.
- Meanwhile a D4 dozer and operator came on scene from the west and was directed by the Timbertop Sector Commander to work on the ridge line on the old jeep track above the slop-overs.
- On arrival at the second slop-over crews were divided, with eight members on the western flank, and the remainder on the eastern flank. The number of personnel on the eastern flank increased to 23 as they progressively came from the first slop-over. The retasking from the first to the second slop-over resulted in the merging of some personnel outside their formal crew structures. This did cause some confusion later when accounting for personnel.
- The task was to rakehoe a line around the fire. The Team Leader, who was supervising the western flank, stayed on the road and maintained a watch of the unburnt area between the two slop-overs on the down slope of the road.
- As he moved between the west and east flanks, he observed a breakaway across the rakehoe line on the eastern flank. He radioed the leader supervising the eastern flank, who tasked a number of personnel to attend to it. A further rakehoe line was cut to contain this breakaway.
- About this time the supervisor of the eastern flank advised the Team Leader by radio: Temperature 21°C degrees, RH 26% and no wind.
- The Sector Commander had left the scene, and travelled further west along Steiners Road while the crews were working the second slop-over. He met the Jamieson Sector Commander, who was travelling east along Steiners Road, at a point where there was another fire across the road.

- The two Sector Commanders discussed the situation, and questioned the value of working on the slop-overs given the size of this third slop-over which had significantly breached Steiners Road.
- The Jamieson Sector Commander radioed Mansfield IMT (Operations) to advise that the fire was "gone" and could not be contained and requested aerial observation.
- The Jamieson Sector Commander continued travelling east, while the Timbertop Commander went west to a turnaround point.
- On arrival at the second slop-over at 1415 hours the Jamieson Sector Commander found that an incident has just occurred involving the NZ personnel.
- The time of the incident is estimated to be between 1408 and 1412 hours.
- The Jamieson Sector Commander raised the alert by radio, requested Mt Buller Tower to clear channel 77 and requested air ambulance.

4.8 **Protective Equipment**

- All crew were fitted with personal protective equipment (PPE) in accordance with agency standards and provided adequate protection when worn properly. There was some variation in make and style of coveralls, helmets and boot types.
- PPE included Helmet, Coveralls, Boots, Goggles, Leather Gloves, and Face Masks. All PPE was available through the Supply Unit of Logistics.
- Interviews indicate that all firefighters had their full PPE at the time of the blow up - however some had removed gloves in their rest break and others did not have them on as they do not always use them when undertaking manual work.
- One firefighter, although wearing gloves, had his coverall sleeves rolled up to assist in cooling when resting prior to the blow up, did not pull his sleeves down, and as a consequence suffered burns to his arms.
- One firefighter was not wearing his helmet when burnt as it fell off at the time of jumping off the bank onto Steiners Road and he could not recover it.
- All PPE performed to an acceptable standard except for facemasks which degraded when exposed to flame and high temperature.

4.9 Equipment

- Equipment used on this sector of the fire was considered appropriate given the location, task and type of fire encountered on the day.
- The CFA Strike Team Leader considered that Tankers were inappropriate for Steiners Road given the road standard and grade and lack of turnarounds on the road.
- It would have been desirable to have provided some water capacity to this sector in the form of the three Slip on Units as was requested.

• Equipment used on the day performed to an acceptable standard. The exception was some face masks, which were only rated at 50°C, and some were damaged by radiant heat.

4.10 Training

New Zealand Firefighters

- New Zealand applied a strict selection criteria and process to match DSE's request for all identified roles.
- The selection process included a review of personnel history, competency and currency, and includes both medical check and fitness test appropriate to the position, by the NZ parent agency.
- All NZ personnel deployed signed the Forest Fire Management Group Standard Code of Conduct prior to deployment.
- All NZ Firefighters were attested by their principal officer as having met the required competency, currency and fitness standards for the specified role prior to deployment.
- A number of personnel deployed as firefighters exceeded the competency and skills required of this role.
- Two orientation briefings were undertaken by DSE and NZ liaisons prior to arrival at fire location where specific incident briefings commenced.

4.11 Communication Planning

The New Zealand Crew were deployed to work in the North East Alps Division on the Timbertop Sector, with a local officer as Sector Commander. On Saturday 16th December the Incident Action Plan contained a completed Communications Plan.

The Timbertop Sector Commander could be reached on the same channels as the other Sector Commanders in that Division: command channel 240, fire ground channel 8 and fallback channel 164. These same channels were in place for Dec 16 and 17 and no significant issues with the function of these channels, or the Communications Plan, has been recorded.

4.12 Incident Management

- Both day and night shift Incident Management Teams developed and implemented incident action plans (IAPs).
- Both IMTs reported the difficulty in developing IAPs, particularly in relation to fire mapping during the period when aerial infrared linescan imagery was either unavailable or unreliable. To obtain sufficient information, alternatives involving aerial or ground reconnaissance were required to ground truth the location of the fire. At times, aerial reconnaissance was also restricted due to smoke. These factors adversely impacted on planning in terms of strategy development, tasking and resource requirements.
- In the period prior to 16 December 2006, there were differing views between the day and night IMTs in regard to strategy and tasking. This did cause some tension between the teams and was subsequently addressed by developing 24 hour IAPs.

• Confusion as to the availability of the NZ Task Force, which had a rest day on 15 December 2006, resulted in it not being included in the IAP for the day shift on 16 December 2006.

4.13 Safety Procedures

- The tactic of putting a rakehoe line around the second slop-over commencing from an anchor point above the road would have been appropriate if the risk presented by the unburnt fuel below the road was appropriately managed.
- The fire below the road had not been scouted sufficiently to know where and what it was doing.
- Although a lookout function was being undertaken, this was neither full time nor undertaken from a position where the fire could be clearly observed below the road.
- Safety zones and escape routes were considered by Crew Leaders prior to tasking although it is unclear how well they were communicated to the crews present prior to the incident.
- At the time of the blow up instructions on escape routes were clear and decisive and were the best option in the prevailing circumstance.
- The standard escape route "into the black" was not at all times a safe option as there was still burning fuel and the canopy was not burnt within the "black".

4.14 Medical Evacuation

- On arrival at the safe area, where the vehicles were parked on Steiners Road, all personnel were accounted for.
- First aid was administered to the injured by other crew members, the main treatment being the cooling of burns with cold water from 'chilly bins' (Eskys). This was the only suitable water available in adequate quantity. No Slip-on units were on scene.
- Crew members then travelled approx 9 kms by road in their four wheel drive vehicles to Tobacco Flat to await the arrival of aircraft to transport injured personnel.
- Air Operations activated two helicopters for immediate deployment to Tobacco Flat. Two four wheel drive road ambulances were also deployed from Mansfield and Jamieson.
- An Emergency Management Team (EMT) was established at the Mansfield ICC, in accordance with the Mansfield Remote Incident Procedures.
- Two helicopters, Fire Bird 301 and Helitak 331, arrived at Tobacco Flat at 1510 hrs. At 1520 hrs both helicopters departed Tobacco Flat with injured personnel on board and arrived at Mansfield SES Helipad at 1532 hrs.
- Three NZ personnel were transported by air ambulances and one by road ambulance and admitted to the Alfred Hospital Melbourne, one was transported by road ambulance and admitted to Wangaratta Hospital, one was admitted to Mansfield Hospital, and the remaining five were treated at Mansfield Hospital and released to crew accommodation.

• The emergency response to this incident, in terms of control, command, coordination, including communication, leadership and speed, was both efficient and effective. The development and implementation of the Mansfield Remote Procedures contributed significantly to the successful outcome of this incident response.

5 ANALYSIS AGAINST "Standard Fire Orders" AND THE "Watchout Situations"

5.1 The 10 Standard fire Orders

1. Always stay in contact or tell someone where you are going.

- The NZ Task Force was in constant contact with its Sector Commander either in person or by radio on fire-ground channel 8.
- The Sector Commanders had radio contact with both Mt Buller Fire Tower and Mansfield Operations.

2. Know where the fire is and its direction.

• The NZ Task Force and the Sector Commanders were aware that the main fire edge was 2-400 metre down slope to the south of and below Steiners Road. They considered the fire behaviour quiet, in benign weather conditions. Clearly, its potential was underestimated.

3. Know the country or have someone with you who does.

• The Sector Commanders were local Officers, who have worked the area in their substantive positions for a number of years. The NZ Task Force had completed five day shifts in the general area and was familiar with the general environment in terms of topography, fuel types and weather. Some of the New Zealanders had worked in similar conditions during the Victorian Alpine fire in 2003.

4. Plan an escape route.

• An escape route was planned, down the control lines they had constructed, then along the road to where the vehicles were parked to the east (a distance of approx 500m). This was a reasonable escape plan in relation to the immediate task of controlling the slop-over, but inadequate in terms of the unexpected run of the main fire edge through unburnt fuel below the road.

5. Park your vehicle in a safe spot.

• The vehicles were parked in a safe area.

6. Ensure that your instructions are clear.

- Sector Commanders were briefed by IMT Operations following the Change-over at 0700 hrs. The verbal briefing was to investigate and attend to slop-overs on Steiners Road and that the NZ Task Force would be the available resource to operate from the eastern end under the control of the Timbertop Sector Commander.
- The Sector Commander briefed the NZ Task Force leaders at the Mansfield Staging Area prior to travelling to the site.

- Following arrival at the junction of Howqua Hills Track and Steiners Road, the Sector Commander and the NZ Team Leader undertook a recce and agreed on tasking the crews to round up a slop-over on the Northern side of Steiners Road.
- Whilst this was being worked on a further recce by the Sector Commander and NZ Team Leader identified a second slop-over further to the West along Steiners Road. Both agreed that this was capable of being rounded up by hand crews and would be done by the NZ Task Force following containment of the first slop-over.
- The NZ Team Leader briefed the crews on the task required.
- The NZ crews interviewed seemed clear on the task requirements.

7. Build a fire line from a safe anchor point.

- The roadway from which the control lines commenced was considered to be the primary anchor point in respect to the task of controlling the slop-over.
- The location on the road, where the vehicles were parked, at the first slop-over was a secondary anchor point, but proved to be inappropriate, due to distance and unburnt fuel between the escape route and the main fire edge.

8. A full set of safety gear is compulsory.

- All personnel were equipped with personal protective equipment as prescribed by their respective agencies.
- At the time of the burn-over some personnel were not wearing their gloves and/or had their forearms uncovered. A number had their chin straps un-fastened.

9. Don't panic – keep calm and make logical decisions.

- The response to the alert and order to evacuate was immediate and compliant. There was a high level of anxiety amongst crews which could be interpreted as panic however the decisions and actions were appropriate to the situation.
- The decisive orders to the crews to evacuate from the advancing fire by using the road as an escape route to a safe area was clearly the best option in the prevailing circumstances.
- Decisions made prior to the burn-over were critical to the outcome that followed.

10. Accident and ill-health can endanger all the crew.

- Although reluctant to highlight it, some NZ interviewees consider that the progress of fleeing to the safe area was slowed due to the restricted mobility of a crew member.
- All NZ personnel were signed-off by their respective Principal Fire Officers as meeting the requirements for deployment to Australia.
- The NZ personnel had a rest day on 15 December and fatigue is unlikely to be a contributor.

5.2 The 17 "WATCHOUT situations"

Watchout when

1. Building a control line downhill towards the fire.

• The crews working this slop-over had fire activity down slope of them, with unburnt fuel between them and the main fire.

2. On a slope – rolling material can ignite fuel below you.

• This was not considered a significant issue in this instance in regard to rolling material but slope itself was a big contributor to changing fire behaviour.

3. The wind changes speed or direction

• Crews did not experience any substantial increase in wind speed or direction whilst working the slop-over prior to the burn-over event.

4. The weather gets hotter or drier.

- The NZ Team Leader stated that a Crew Leader advised him before the burn-over that the temperature was 21oC, relative humidity 26% and little wind.
- One Crew Leader has stated the wind got stronger gusting to approximately 12-14kph immediately before the burnover. Most of the firefighters did not report any noticeable change in the wind.

5. In heavy cover, with unburnt fuel between you and the fire.

• Crews working the east flank of the second slop-over had unburnt fuels between them and the main fire down slope of Steiners Road. Crews working the west flank of the slop-over had a burnt out area between them and the unburnt area.

6. Terrain or vegetation impedes travel or visibility.

- Perspective of the main fire activity on the down slope may have been compromised by the steepness of the slope from a number of vantage points
- The actual main fire edge in the gully was not clearly visible due to terrain, vegetation, lingering smoke and quiet fire activity.

7. In country you have not seen in daylight.

• Not a factor in this incident

8. Unfamiliar with weather and local fire behaviour.

• The Sector Commanders were local Officers, who have worked the area in their substantive positions for a number of years. The NZ Task Force had completed five day shifts in the general area and was familiar with the general environment in terms of fuel types, topography, and weather. They had also experienced fire behaviour in the general area on previous shifts.

9. Frequent spot fires occur over your control line.

• The fire had burned below the bank and around the rakehoe line requiring a second control line to be constructed immediately before the burnover event. There had not been any spotting activity on the day immediately prior to the incident.

10. You cannot see the main fire or communicate with anyone who can.

• The presence of the main fire edge in the gully below Steiners Road was known to the Sector Commander and the NZ Task Force. Its precise location was undefined due to visibility and very quiet fire behaviour, notwithstanding that one witness stated that he observed minimal flame height about 80-100 metres down slope running parallel to the road.

11. Unclear instructions or tasks are given.

- Refer to item 6, The 10 Standard Fire Orders, above.
- 12. You feel exhausted or want to take a nap near the fire.
 - Not a factor in this incident
- 13. Frontal attack on a fire or constructing a fire control line without a safe anchor point.
 - Refer to item 7, The 10 Standard Fire Orders, above.
- 14. No communications link to crew members or supervisor, or working alone.
 - Face to face or radio communication was used by crews on the fire ground with no difficulties experienced.
 - Regular face to face communication and radio was used to maintain contact with the Sector Commander.

15. Uninformed on strategy, tactics and hazards.

- The Incident Action Plan for the 16 December Day Shift did not specifically identify issues or tactics for Steiners Road or deployment orders for the NZ Task Force.
- Steiners Road had been an element of the operational strategy to hold the advancing fire from the south in both the Jamieson and Timbertop Sectors of the fire in preceding shifts on previous days.
- Sector Commanders for Jamieson and Timbertop Sectors were briefed by IMT Operations following the Change-over at 0700 hrs. The verbal briefing was to investigate and attend to spot-overs on Steiners Road and that the NZ Task Force would be the available resource to operate from the eastern end under the control of the Timbertop Sector Commander.
- The report from the previous day from the Jamieson Sector Commander advising that the fire had breached Steiners Road was not given appropriate consideration when developing the IAP.

- The Timbertop Sector Commander briefed the NZ Task Force leaders at the Mansfield Staging Area prior to travelling to the site.
- Following arrival at the junction of Howqua Hills Track and Steiners Road, the Timbertop Sector Commander and the NZ Team Leader undertook a recce and agreed on tasking the crews to round up a slop-over on the Northern side of Steiners Road.
- Whilst this was being worked on, a further recce by the Sector Commander and NZ Team Leader identified a second slop-over further to the west along Steiners Road. Both agreed that this was capable of being rounded up by hand crews and would be done by the NZ Task Force following containment of the first slop-over.
- The NZ Team Leader briefed the crews on the task required.

16. Safety zones and escape routes not identified.

• Safety zones and escape routes were identified and considered to be appropriate for the circumstance of the allotted task and that the main fire edge was non-threatening. Refer item 4 of the 10 Standard Fire Orders.

17. Fire not scouted or potential assessed.

- The slop-overs were scouted and assessed as being containable with control lines being constructed manually by the NZ crews.
- The main fire edge on the downhill side of Steiners Road was known to exist but appeared to present no immediate threat due to its behaviour and the prevailing weather conditions. The main fire edge was not scouted, although this would have been difficult to do and its potential was clearly under-estimated.

5.3 Common Denominators of fatal & near fatal Forest Fires

A report by Carl C Wilson "Fatal and near fatal Forest Fires The Common Denominators" which reviews the U.S.Forest Service records of deaths and injury from fire between 1926 and 1976, makes the following points.

- 1. Most incidents occurred on relatively small fires or isolated sectors of large fires.
- 2. Most fires were innocent in appearance prior to "flare ups" or "blow ups". In some cases the fatalities occurred in the mop up stage.
- 3. Flare-ups occurred in deceptively light fuels.
- 4. Fires ran uphill in chimneys, gullies, or on steep slopes.
- 5. Suppression tools, such as helicopters or air tankers can adversely modify fire behaviour.

It is often surprising to firefighters to learn that fatal or near fatal incidents occur in fairly light fuels, on small or isolated sectors of large fires, and the fire behaviour is relatively quiet just before the incident

The situation and circumstance of the burn over and injury of the eleven firefighters at Mansfield has the benign appearance prior to "blow-up". Forecast weather conditions for the day and on site weather readings taken during the day indicated that fire behaviour should be benign. This theme was also predicted in the IMT briefing where four days of benign fire behaviour was discussed. These factors may well have contributed to some personnel developing a false sense of security on the day.

Points 1 to 4 are relevant to this fire incident. The change of slope and possible change in wind are likely to be the key factors in creating this blowup situation.

6 FINDINGS

The following findings are presented by the Investigation Team in response to the terms of reference document which requires: "identify the key factors which appear to have contributed to, or are relevant to, the incident".

- The investigation team finds that there were, to various degrees, breaches of a number of the Standard Fire Orders and Watchouts as detailed in the specific points below.
- Within the Incident Management Team, there was a view that Steiners Road had a reasonable chance of holding the advancing fire. Although Steiners Road is side-cut with many corners, it was considered by the day IMT a reasonable option to be included as an element of a major control line commencing from the east of Jamieson to the south of the Mt Buller ski resort, recognising the prevailing weather and quiet fire behaviour prior to, and predicted for the two days following the incident. Fall back strategies had been informally identified, when Steiners Road was reported as having been breached by the fire on the day prior to the incident.

It is found that this strategy was not a direct contributing factor to the incident.

• The unavailability or reliability of linescan information compromised the accuracy of fire mapping and therefore the development of detailed tasking. This placed a level of responsibility on the Sector Commander to confirm tactics, which relied on ground and limited aerial reconnaissance information. Ground recce was difficult because of slope/terrain and the lack of aerial reconnaissance was because of smoke.

It is found that the lack of aerial infrared linescan imagery availability made accurate mapping impossible and was a minor contributing factor to the incident. Even with accurate linescan imagery, it is often several hours old by the time the information is included in maps and crews reach the fireline.

• A Sector Commander's situation report in the late afternoon of the day preceding the incident (15 Dec 2006), advising that the fire had breached Steiners Road, and the subsequent logged note on strategic priority, was not given sufficient attention by both the day and night shift Operations Sections. An analysis of the situation report should have led to a more considered approach.

It is found that the lack of attention to this information was a minor contributing factor to the decision to deploy the firefighters to Steiners Road.

• As the New Zealand Task Force was an available resource on the 16 December 2006, it was reasonable that they be deployed to assist in assessing the Steiners Road situation and undertaking tasks determined by the Timbertop Sector Commander to whom they were allocated. Although they were not formally deployed on the IAP the Operations Officer was able to appropriately task quickly.

While the New Zealanders were not identified in the IAP, this did not contribute to the incident.

- Having successfully controlled the first slop-over utilising dry firefighting techniques, without any problems, it is understandable why an attempt was made to deal with the second slop-over in like fashion.
- The assessment of the situation prior to the commencement of works on the second slop-over, under-estimated the potential of any fire below Steiners Road. Insufficient consideration was given to the slope and unburnt fuel present. The failure to establish an

appropriate anchor point and escape route may have been an outcome of this underestimation.

This under-estimation of the main fire's potential and limitations in the escape route were the most significant contributors to the incident.

• A dedicated lookout was not tasked to watch the main fire. The Team Leader was on the road when the incident occurred and immediately notified those on the line effectively performing the role of a lookout. There is no evidence to conclude that a dedicated observer would have seen any more indications prior to the event than the person performing the role.

The fact that a dedicated lookout was not deployed had minimal, if any, contribution to the incident.

- Whilst all personnel involved in the incident were equipped with personal protective equipment (PPE), as prescribed by their respective agencies, there were instances where some items were either not donned or were inappropriately fitted, resulting in burns to exposed skin. In particular, gloves were not always worn, sleeves were rolled up and helmet chinstraps were unfastened.
- Various standards of face (dust) masks were issued from the Mansfield Staging Area, some of which are inadequate for bushfire operations. There is insufficient evidence to determine if the masks restricted the aerobic capacity and, therefore, the capability of firefighters to flee the fire.
- The New Zealand Task Force consisted of nine (9) crews of five (5) personnel, one of whom was the nominated Team Leader. A Task Force Liaison Officer, worked from the Mansfield Incident Control Centre, but had no line control or command role in respect to fire operations. No formal actions were taken to re-structure the Task Force to ensure that:
 - 1. Task Force Leader(s) were formally appointed and roles confirmed
 - 2. The accepted span of control in AIIMS ICS was considered and applied
 - 3. The Task Force was effectively integrated into the incident control structure

Individuals voluntarily stepped into the leadership vacuum. This lack of formal structure was not apparent to the NZ team, as those individuals performed as if they had been formally appointed.

It is found that the lack of formal structure did not contribute to the incident.

- As a number of personnel were re-tasked without the knowledge of their respective crew leaders, some confusion did arise in accounting for personnel during the incident but it is found this did not directly lead to any person being injured.
- Whilst Divisions had been established at the Incident, a direct relationship and reporting process prevailed between Sector Commanders and the Operations Officer at the Incident Control Centre. Communications difficulties, due to coverage limitations did prevail, between the Sector and Division Command in Jamieson. The Chain of Command was, therefore, technically by-passed.

This situation did not directly contribute to the incident.

• The instant and decisive orders to evacuate from the advancing fire by using the road as an escape route to a safe area was clearly the best option in the prevailing circumstances. This decision and decisive manner in which it was carried out reduced the number and extent of injuries.

- There is little doubt that some firefighters did not escape as quickly as they could have, as they assisted slower team members. It is observed that the fire fitness assessment is based around cardiovascular fitness, strength and muscle endurance not the ability to sprint from a fire.
- The order to shelter against the foot of the embankment on the roadside, when the first wave of fire rolled across the trailing personnel, probably reduced the nature and extent of injuries. It was the appropriate decision.
- The majority of burn injuries occurred in the run to the safe area after taking refuge against the foot of the embankment. This decision was appropriate as a decision not to attempt to reach the safe area could have led to some more serious injuries.
- The first-aid administered to injured personnel by fellow crew members was both appropriate and resourceful in utilising chilled water from their 'chilly bins' (Eskys). This response significantly reduced the seriousness of injuries.
- The evacuation by road to Tobacco Flat and the subsequent airlift to Mansfield was managed and executed in as an efficient and expeditious manner as could be expected.
- No relevant issues have emerged relating to communication infrastructure and systems.

7 GLOSSARY / Abbreviations

- AIIMS ICS Australasian Inter-Service Incident Management System, Incident Control Structure - A nationally adopted structure to formalise a coordinated approach to emergency incident management. The major sub-system of AIIMS is the Incident Control System (ICS).
- AWS *Automatic Weather Station* Equipment that provides real-time weather data, located in fixed structures.
- BoM Australian Bureau of Meteorology

Burn-over Section of fire that overruns personnel and/or equipment.

- CFA *Country Fire Authority* The agency responsible for fire prevention and suppression in the Country Area of Victoria.
- Chilly bin New Zealand term for 'Esky' Portable insulated coolers used for storing food and drink at cool temperatures.
- Coveralls New Zealand term for 'Overalls' Made of a range of fire resistant materials, such as Proban treated cotton, Nomex etc, high visibility clothing.
- Crew Leader Fire-accredited person in charge of up to five fire fighters (a crew).
- Division A portion of the fire perimeter, comprising two or more sectors. The number of sectors grouped in a Division should be such as to ensure effective direction and control of operations. Divisions are generally identified by a local geographic name.
- Division Commander Person responsible for implementing the Incident Action Plan appropriate to the division.
- DSE Department of Sustainability and Environment A Victorian Government Department responsible for balancing the development and protection of Victoria's natural and cultural resource base, including resource and industry development, land identification, and the protection, conservation and management' of Victoria's natural and cultural environment. Has responsibility for fire prevention and suppression on public land in Victoria.
- Esky Australian term for 'Chilly bin' Portable insulated coolers used for storing food and drink at cool temperatures.
- FFMG Forest Fire Management Group A committee of Australian and New Zealand land management agencies with responsibility for forest fire management plus representatives from research, education and the forest industry.
- Fire Complex A group of fires usually located within one geographical of administrative boundary, being managed by one Incident Management Team for resource deployment and planning purposes.
- IAP *Incident Action Plan* A statement of objectives, strategies and resources, approved by the Incident Controller, that is to be used to control an incident.
- ICC Incident Control Centre The location where the Incident Controller and various members of the Incident Management Team provide overall direction of response activities.

IMT	Incident Management Team - A group comprising the Incident Controller and the personnel he or she appoints to be responsible for the functions of operations, planning and logistics.		
Liaison Officer	The point of contact for the assisting and co-operating agency representatives associated with an incident. This includes representatives from other fire and forest services, State or Territory Emergency Services, Red Cross, Police, public works and engineering organisations and all others. The person represents their agency providing the coordination of information flow.		
NZ	New Zealand		
Operations Officer	Person responsible for directing and supervising all work within the Operations section of an Incident Management Team.		
Overalls	Australian term for 'Coveralls' - Cotton drill, Proban-treated high visibility clothing.		
PAWS	<i>Portable Automatic Weather Station</i> - Equipment that provides real-time weather data, can be re-located in strategic locations.		
PPE	Personal Protective Equipment - The protective clothing and equipment that must be used by firefighters during firefighting operations and prescribed burning to provide protection against the normal exposure to hazards. It is mandatory to wear firefighting overalls, a safety helmet and firefighting boots, and to carry gloves.		
Rakehoe	A hand tool used for dry firefighting consisting of a handle and a metal head with one pronged edge for raking and one sharpened edge for cutting, chipping and scraping down to mineral earth.		
Sector	A specific area of a fire under the control of a Sector Commander who is supervising a number of crews.		
Sector Commander	rson responsible for implementing the Wildfire Control Plan for a specific rtion of the fire perimeter. Includes the allocation of resources within the ctor, reporting on progress of command operations, status of resources d management of all personnel on that sector.		
Slip on unit	A tank, a live hose reel or tray, a small capacity pump, and an engine combined into a single one-piece assembly that can be slipped onto a truck bed or trailer and used for spraying water and/or foam on wildfires.		
Slop over	The points at which a fire, after it has been contained, escapes into unburnt areas across a fire control line or fire edge. As per 'Breakaway'		
Strike Team	eam A set number of resources of the same type that have an establish minimum number of personnel. Strike Teams always have a leader (usually a separate vehicle), and have a common communications system. They usually made up of five resources of the same type, such as vehicles, cre or earth moving machinery.		
Task Force	A combination of resources assembled for a specific purpose. Task Forces always have a leader (usually in a separate vehicle), and have a common communications system. Task Forces are established to meet tactical needs and may be despatched as single resources.		

8 APPENDICES

Appendix 1	Investigation Review Teams Terms of Reference
Appendix 2	Letter of Engagement: DSE to New Zealand
Appendix 3	References

Appendix 1 – Terms of Reference

MEMORA	NDUM	
то:	Rod Newnham, DSE Rick McKay, CFA	
CC:	Assistant Chiel Officer: Operations Support, DSE Manager: Operations Performance Improvement, CFA	
FROM:	Chief Officer, Fire & Emergency Management, DSE Director of Operations/Chief Officer, CFA	
SUBJECT:	Mansheld Burnover Incident 16 December 2006	
OATE:	18 December 2006	File No:

PURPOSE:

To confirm the verbal request made to you by Greg Esnout and Alan Goodwin to investigate the circumstances surrounding a serious OH&B incident which occurred on 18 December 2006 and resulted in the hospitalisation of 9 New Zealand firefighters, and to formally report on those in accordance with the Terms of Reference below.

BACKGROUND:

A number of firstighters, all believed to be part of a New Zealand Taskforce supporting fire suppression efforts in the Mansfield area, were injured during fireground operations, a number requiring hospitalisation

New Zeeland National Rural Fire Officer, Murray Dudfield was invited to provide a representative to participate in this investigation. John Resmussion of the NZ National Rural Fire Authority has been nominated and accepted as a member of this investigation team. A copy of the final report will also be provided to the National Rural Fire Authority.

REQUEST:

That you:

- undertake the investigations as seen as practicable in accordance with relevant inter-agency agreements and Departmental procedures;
- 2. obtain as appropriate, relevant independent specialist privice;
- 3. determine the factual atroumstances prior to and during the incident;
- 4. Identify the key factors which appear to have contributed to, or are relevant to, the incident:
- 5 identify any learnings that may be gained from the results of your investigation;
- 6 prepare a report in accordance with the template provided
- 7. provide a preliminary report to us by 31 December 2006 or as soon as possible thereafter.

Balla i

Ewan Waller Chiel Officer, Fire & Emergency Management, DBE, Russell Rees Chief Officer, CFA

Appendix 2



Department of Sustainability and Environment

4/8 Nicholson Street East Melbourne VIC 3002 Telephone: 03 9412 4777 Facsimile: 03 9650 8575 ABN 90 719 052 204

4 December 2006

Murray Dudfield Chief Officer National Rural Fire Authority PO Box 2133 WELLINGTON New Zealand

Dear Murray

Request for assistance from New Zealand National Rural Fire Authority for firefighting and coordination personnel assistance

Due to the recent high fire activity in Victoria, in particular in the North East, Alpine and Gippsland areas, fire fighting resources within DSE, Parks Victoria, DPI and the Country Fire Authority are projected to be fully committed within the week. Interstate fire resources have also been affected by extensive fire activity in their own States.

The Department is now requesting assistance from the New Zealand National Rural Fire Authority to help contribute to the fire suppression operations in Victoria.

We are requesting that the New Zealand National Rural Fire Authority provide:

- Up to 100 Crew and Crew leaders for firefighting duties around the State
- Up to 30 Incident Management Team and coordination personnel.
- One Liaison officer is required who will work from the Emergency Coordination Centre at 8 Nicholson Street, East Melbourne, and one Field Liaison Officer.

We are asking for an initial deployment of up to two weeks, with the potential for a second deployment on a thirty-five day rotation.

These personnel must be:

- Trained and competent in remote area firefighting (to relevant AFAC National Standards);
- Have Alpine country and/or forest firefighting experience;
- Familiar with dry firefighting techniques; and
- Physically fit (i.e. will be expected to walk up to 2 hours to access fires).



The need to be self-supporting whilst away from camp on tasked duties and should bring their personal protective clothing and equipment.

Please provide us with a brief description of the skills and accreditations of the Crew Leaders, Sector Commanders and IMT personnel as well as any special requirements any of the personnel may have (dietary, etc).

The Department of Sustainability and Environment will cover transport costs from and to New Zealand, and all associated accommodation and food costs for the contingent. DSE has agreed to pay the New Zealand National Rural Fire Authority \$600AU per person per day. Any other relevant costs will be covered by DSE via invoices.

If you are in the position to meet our request for assistance, I ask that these personnel are able to start by Thursday 7 of December, or Friday 8 December 2006.

If you have any questions, please contact me on 61 3 9412 4777.

Yours sincerely

Elva Waller

Ewan Waller Chief Officer Fire and Emergency Management Division

Appendix 3

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