The Jamieson Track bushfire and its escape into Wye River and Separation Creek townships

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Foreword

This report is unique because it tracks a disaster from embryo to consequence to rebuilding. Having drawn out the known facts, the strong hand of the government is evident throughout each stage, either by action and inaction - suppression of the bushfire, escape of the bushfire, bushfire behaviour on route to and within the towns, preparation of the towns for a bushfire attack, house loss rate and finally the rebuilding program.

My strong position as a forest bushfire professional is that house loss is preventable even in a Black Saturday bushfire scenario. The benefits of saving the house are that you save the house and the life, and that peoples' lives can continue with minimum disruption. How do we save the house?

- Apply bushfire protection practices guided by valid science, logic and proven principles.
- Apply best practice fire suppression
- Apply best practice township protection before the bushfire attack occurs
- Apply best practice house protection before the bushfire attack
- Empower residents to self defend within an environment made safe by the above, before the bushfire attack occurs.

Assuming no householder wants their house to burn down in a bushfire attack, a 116 house loss toll under a moderate level bushfire attack indicates a serious level of ineptitude and bushfire policy failure by the fire authorities and their supervisors in Treasury and Parliament. But collectively, government did not share this view or even acknowledge a problem. Instead, they deflected criticism and suggestion. They praised the fire fighters for their efforts and the people for their resilience as they quietly paid for the huge suppression, rehabilitation and reconstruction costs from the public purse.

What became evident to me while preparing this report was the dichotomy between what people wanted (ie, no house loss) and what government wanted - a high priority to defend its actions in the media, to secure peoples' obedience for evacuation and reconstruction policies, and to promote its concept of resilience after disasters. It became clear to me that the practice of bushfire protection by valid science, logic and proven principles has been overridden by the government's very successful practice of bushfire protection by words and media spin. For example, it was very important to government that its conduct was declared to be satisfactory by the independent government inspector, yet government downplayed the destructive outcome for two towns and their people by saying they dodged a bullet and it could have been much worse. If they really believe Mother Nature fired the bullet and the result was out of their control, people can expect more disasters.

I live in hope the government policy will change to protection of houses, but they must realise it is incompatible with bushfire protection by words and media spin. Until then, I hope this report will encourage the community to eschew government spin and learn the practice of bushfire protection by valid science, logic and proven principles and apply them to protect their own town and own property.

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Abbreviations and definitions

AS3959	Australian Standard 3959
BAL	Bushfire Attack Level determined by AS3959 method
DTBAL	Bushfire Attack Level determined by DELWP and Terramatrix method
BMO	Bushfire Management Overlay
CFA	Country Fire Authority
CSIRO	Commonwealth Scientific and Industrial Organisation
DELWP	Department of Environment, Land, Water and Planning
FLIR	Forward Looking Infrared
Helitack	Helicopter water bomber
IC	Incident controller
IGEM	Inspector General Emergency Management
Line scan	Infrared scan of fire extent
Sit Rep	Situation Report
TFB	Total Fire Ban
Urban fuel	Flammable household / yard related items beside, under or near the house whose flame can reach the house. It is distinct from the surface and shrub fuel load of defendable space and the fine fuel build ups in gutters and roof.
WMO	Wildfire Management Overlay (predecessor of BMO)
VBRC	Victorian Bushfire Royal Commission

Chapter 1 Introduction

By any reasonable standard, this bushfire event was a failure of government practice and policy, with the possible exception of one aspect. This observation is supported by the simple facts that the fire persistently escaped when the consistent daily goal was to prevent escape and the destruction of over 100 houses when the residents' goal was for zero house loss (in contrast to the presumed fire authority goal of minimise house loss). The one fire authority policy success was zero loss of life, which was achieved by planned evacuation, but this success must be weighed against its unintended consequences of massive house loss and concomitant massive personal socio economic disruption, as is evident in Figure 1.

Figure 1 Upset anxious residents at a public meeting. Photo in The Age

My enduring goal as a forest fire professional is to demonstrate that elimination of the bushfire menace is achievable when correct understanding and application of valid bushfire behaviour science is combined with appropriate threat mitigation strategies aimed at house protection (with a target of zero house loss). It is not only achievable, but it has the triple benefit of preventing life loss, preventing house loss and thereby preventing upheaval of peoples' socio economic life, and generating a community that becomes self reliant and resilient as it becomes empowered to eliminate the bushfire menace in partnership with government.

Whilst I regard the growth and escape of this fire as an avoidable tragedy in several ways, it has now happened and we would be foolish not to learn from it, so that future millions of public money will not diverted to avoidable emergencies and another hundred houses will not be not destroyed. Collectively, we are now fortunate to make use of excellent media coverage and access to government documents and reports to turn this bushfire tragedy into a valuable learning experience.

This document covers each day of the week long bushfire from the 19th December, 2015 from its ignition to its escape and attack on two townships on Christmas Day. It identifies actions taken and through the mechanism of questions to a willing student, it asks the reader to compare actions with best practice forest fire protection. The journey analyses actions and outcomes in the areas of bushfire suppression, bushfire behaviour, township protection, house loss and post bushfire rebuilding. In some ways this paper is an exercise in how not to suppress a fire and how not to protect a town that might fall on deaf ears because despite strident criticism to date, the fire authorities defended its people and its processes, and the government then defended its authorities. Nevertheless, I hope this paper will be useful as a training tool for fire control teams in applying forest fire behaviour science to suppression tactics. I also hope the paper will lead to an improvement in community protection policy by applying forest fire behaviour science in a way that provides effective bushfire protection to all towns.

My keen interests are in studying forest fire behaviour and assessing the choice of fire control tactics against principles of world best practice fire suppression and township protection. The analysis also addresses how the homeless residents have now been thrust into enforced acceptance of government policies of new house regulations, despite a recent CSIRO report (and other data) which showed the regulations conferred the same protection as non compliant houses. The examination indicates that ineffectiveness of regulations is due to several distortions of science and logic including (1) mitigating a negligible ignition threat (radiation) and doing so with the use of invalid science and (2) enforcing the new house builder to pay extra to protect against a deemed bushfire hazard that is itself never removed. I have attempted to present appropriate data and observations in a dispassionate manner. I also try to keep the paper readable and understandable to the non professional.

The student can assess the approach taken by authorities in the following events and compare it to best practice.
The student should be alert to the rationale behind the following core events and assess his or her approach to these and other issues:

- Each day, a fire control plan was set and reset, but each day, why were the objectives never achieved, particularly on Day 1?
- Was the change of strategy from direct attack on a smaller fire area with Jamieson Track as a fall back control line to indirect attack on a larger fire which made Jamieson Track the last line of defence with no fall back line a serious error of judgement? Was it exacerbated by adding fresh fire to the last line of defence two days before severe weather?
- Was the possibility of the bushfire escaping seriously evaluated? Was the effect of bushfire attack on the townships of Wye River and Separation Creek seriously considered?
- The fire authorities enacted their full suite of available policy options for township protection but why was the outcome a loss of over 100 houses?
  - Their policy of evacuation was enacted.
  - They provided aerial water bombing services to the townships but few ground forces because it was declared as too dangerous for fire fighters to enter, even though the average flame height was less than half a metre
- Were the fire authorities at fault by omission, by making decisions whereby:
  - The townships of Wye River and Separation Creek were not protected externally to prevent fire entry, or internally to prevent flame spread
  - The boundary of National Park had no infrastructure to prevent fire escape.
- Why do the fire authorities now require that burnt houses be rebuilt at the highest level of bushfire resistance, despite the fact that a third of houses built to the highest level of fire resistance were destroyed when the forest flame was less than half a metre tall?

During this journey of discovery, the student can consider the impact of policy influences on bushfire suppression and town protection:
➔ Policy focus on a vague concept of risk management may prevent high level focus on identifying real threats and mitigating the threats that cause most damage. Eg,

- In fire suppression, the real threat is failure of control line security
- In town protection, the real threats are entry of the moving flame and non management of ember ignitions due to depletion of defender numbers

- In individual house protection, the real threats are non management of flame and embers from any source, not artificial radiation from nearest vegetation.

➔ Policies that focus on protection of the individual house, namely the new house, may prevent holistic community protection policy

➔ Policies with sole focus on protecting life may prevent the more efficacious policy of protecting houses, because saving the house saves the house and the life, and house loss disrupts peoples' quality of life.

➔ Policies that focus on evacuation of people from an unprotected town may prevent mitigation of hazards and threats and therefore prevent the town being protected

➔ Policies that focus on forcing the house owner to pay for self protection (new house and retro fit) against a deemed threat may prevent mitigation of that threat

➔ Policies that avoid mitigation of each threat may prevent achievement of policy of bushfire safe community

Source material

Most real time source data for this study was published in the daily Australian press and on the fire authority web sites as the fire progressed. This has been supplemented by subsequent government reports and studies. I have also included summaries of interviews with local residents and fire fighters. Although I view the data through the perspective of an experienced forest fire professional, I resist the temptation to moralise or criticise. This is consistent with the educational purpose of this paper.

Government reports are useful provided we understand that they have a specific purpose or meet specific terms of reference. Example 1 is the IGEM report. Its focus was on how well the fire control team followed government policy and procedures before the fire escaped, and had no interest or comment about how strategies and actions complied with world best practice forest fire suppression. Example 2 is the CSIRO report. It was commissioned by a fire authority to examine how the fire entered the townships and why some houses burnt and some did not. It presents a large amount of data but does not analyse all data because this task was not within the terms of reference. Nevertheless, the data can be analysed independently.

The following Chapters present analyses of the six interrelated events in this bushfire and when viewed as a whole, the range of topics covers most aspects of bushfire protection planning and suppression relevant to a town. The events are suppression of the bushfire, escape of the bushfire, bushfire behaviour on route to and within the towns, preparation of the towns for a bushfire attack, house loss rate and finally the rebuilding program. The issues for examination by the student are highlighted in green, and the reader is also invited to consider them.

Chapter 2 Theories, Principles and Best Practice

Valid bushfire behaviour science

My starting position is that best practice fire suppression and township protection cannot occur without application of valid bushfire behaviour science and that bushfire behaviour science is only valid when it can be traced back to first principles of scientific theory. For example (1) the fire authority belief that fuel load reduction lowers the speed of the fire and that the reduction in speed protects the house derives from invalid science. In contrast, valid science explains that fuel reduction on a given site reduces flame height on that site, that lower flame height produces lower heat flux (via radiation, convection and advection), that increasing separation distance reduces heat flux further, and that reducing the heat flux is what protects the house. (2) The fire authority belief that rate of spread of the fire can be used to predict flame height derives from invalid science. In contrast, valid science shows that in wind driven fires there may be a loose coincidental connection (eg, Project Vesta, 2007), but there is no logical or causal correlation between rate of spread, which is a dependent variable that derives from independent variables including fuel particle size, fuel bed aeration and wind speed and flame height which is a dependent variable deriving from independent variables including fuel particle size and fuel bed height Moreover, a useful rule of science is that dependent variables should always derive from independent variables.

Best practice forest fire suppression

Based on a lifetime of training, experience, observation and study, I can pragmatically summarise best practice forest fire suppression as reducing the chance of a bushfire escaping from a designated control line by the application of strategies, tactics and resources guided by proven principles and experience. Proof of best practice suppression is when the bushfire attack stops at the designated control line with minimum outlay of resources and expenditure.

Implicit in the definition is a strong goal that is quantifiable and achievable on the fire ground by adequate committed resources within a nominated period. The definition recognises that forest fire fighting is a perimeter exercise whose progress is measured by length of mineral earth control line against length of fire perimeter, and logically the fire is controlled when control line length equals fire perimeter and is secured to prevent flame and ember escape.

Best practice therefore requires adequate resourcing for each stage of the fire suppression process - control line construction, securing the line by blacking out, and patrolling. Control line strategy includes a fall back control line strategy. Line construction by water bombing must be secured with a mineral earth break and patrolling because its effect on a forest flame is ephemeral.

Best practice aims to keep the fire area small by direct attack, particularly when fire is close to settlements or when fire occurs early in fire season or when severe weather in imminent. Because forest fire suppression by direct attack in the heat of the day is impossible unless the flame height is low and access is safe, it is done when weather moderates, usually overnight.

Best practice forest fire suppression requires a back-burn or burn-out strategy to have a minimum depth of blacked out forest upwind of a good track to stop the flame and to absorb some of the short distance spotting. It also requires appropriate resourcing and infrastructure to prevent escape of spot fires that ignite downwind.

Best practice township protection
Based on a lifetime of experience, observation and study, I can summarise best practice township protection as reducing the chance of house loss by a bushfire attack in a nominated area by the application strategies, tactics and resources guided by proven principles and experience. Proof of best practice township protection is when the bushfire attack on a nominated area results in zero house loss.

Implicit in the definition is the goal of house protection rather than life protection because houses are static whereas people can move out of danger. It is self evident that when the house is properly protected, the surrounds are safe for the resident and the fire fighter alike to remain during the bushfire attack.

Thus best practice township protection prevents entry of the most dangerous part of the bushfire, ie, the advancing flame, by strategic combination of low flame and no flame zones, prevents internal spread by fuel bed discontinuity, and creates a safe environment to manage ember attack by facilitating suppression of spot fires while small within the township.

Causes and prevention of house loss in severe bushfire attack
I can summarise a large body of research as follows. In a bushfire attack, the known causal agents that can ignite a building are flame contact, radiant heat, and ember attack. For ignition of building material to occur by the first two causes, the flame must to be close to the building but ember attack typically occurs when the flame is at a distance. To prevent ignition, there are two techniques – passive or static protection and active protection.
(1) To provide passive protection against ignition by the first two agents, the flame's proximity, size and separation distance can be managed or the fire resistance of the exposed building material can be increased. To prevent ignition of the building by embers requires specific treatment of the building against the expected size and intensity of the ember.
(2) Active protection against ignition of the building is typically done with water or foam spray onto the surface, the aim of which is to keep temperature and oxygen supply below ignition point. Active protection can also be direct - against the flame of the attacking bushfire and the flame of a spot fire, or indirect - wetting the adjacent fuel bed to make it non flammable and thereby prevent lateral flame spread. Active protection by people requires the defence area to be rendered bushfire safe which is done by strategically managing fuel bed discontinuity.

Passive protection policy is effective when it causes substantial decline in house loss rate when its measures are deployed. Prior to 2009, the fire authorities operated two policies for protection of new houses. The WMO system was based on the width of defendable space from the nearest forest that was deemed to have a large radiating flame, and the AS3959 system was based on a higher fire resistance level of building materials if the house was located closer to the nearest forest that was deemed to have a large radiating flame. The VBRC asked for evidence that the WMO and AS3959 reduced house loss, and was told there was none (VBRC, 2010). However, evidence

was presented by the Building Commission and Shires that confirmed that neither policy had a significant impact on reducing house loss rate.
Example (1) Of the 5,375 houses within the fires' perimeters, 2118 were destroyed (Leonard et al, 2009). Using data from reports submitted to the VBRC (Buxton et al, 2009 and Leonard et al, 2009), the estimated proportion of AS3959 compliant houses at the time of the bushfire was between 8 and 12%, average 10% or 537 houses. The Victorian Building Commission advised the VBRC that of 2006 destroyed houses, 177 were AS3959 compliant, ie, were built higher fire resistance. Thus the house loss rate for compliant houses averaged 33% (= 177 / 537), which is rather close to the 38% house loss rate for non compliant houses (= [(2006-177) / (5375-537)].
Example (2) Marysville town data (provided by the Shire) showed that of over 400 houses, the total house loss rate was 90%. It also showed that 26 dwellings were built with WMO permits, and 22 of them were destroyed. Thus, the house loss rate for WMO compliant houses was 85%, which is imperceptibly better than the overall loss rate (Referenced in Bushfire Solution Paper 6A).

Warning note: There was one unexpected and worrying loss rate within the VBRC data. Life loss rate (measured as percentage of houses with bodies) was three times higher in compliant houses (7.3%) that non compliant (2.5%). Indeed evidence taken by the VBRC supported the view that people saw compliant houses as safer and sought shelter in them (Referenced in Bushfire Solution Paper 6B).

Despite the above evidence and other strident criticisms, the VBRC recommended a review, but the fire authorities adopted an amended AS3959 in 2009 and in the following year, amalgamated the two into one BMO system.

Active protection policy is effective when it results in a substantial decline in house loss rate when houses are actively defended. Before the VBRC in 2009, defensive suppression of a house by residents or fire fighters (ie, active defence during or shortly after bushfire attack) had long been known as the most influential factor in reducing house loss during a bushfire attack. A study of the Ash Wednesday fire at Macedon (Wilson and Ferguson, 1984) found the house loss rate of "vacant, undefended houses" was 65%, the house loss rate for occupied houses was 18% and the house loss rate for houses actively defended by able-bodied people was 10%. A later study based on post-bushfire surveys found if houses are not attended, house losses are 3 to 6 times greater than attended houses (Blanchi & Leonard 2008b). This outcome was independent of their fire resistance level.

Data collected during the VBRC also confirmed that active defence yielded a substantially lower house loss rate than vacated houses, but it is unlikely the VBRC saw this data before its final report date. For example, Whitaker et al reported these findings in 2013 from their survey:

- Of the 766 houses that were occupied and defended, the house loss rate was 19% [house loss rate was two in ten houses.]
- Of the 498 undefended houses, the house loss rate was 54% [house loss rate was five in ten houses.]

Where extra help was available to the defenders (eg, from family, friends, neighbours, fire agencies), the house loss rate was even lower.

- Where helped by other people, house loss rate was 1 in 10
- Where helped by fire services, house loss rate was 0.3 in 10, or 3 in 100.

Despite such consistent evidence, the VBRC was unmoved. Faced with the bushfires' huge death toll and the VBRC's strong mantra that human life must be protected as first priority, the VBRC report indicated it lost faith in the ability of residents to self defend and recommended in favour of a pro-evacuation policy, which the government immediately adopted. This recommendation was made despite awareness of the above research and despite evidence about the downstream consequences of evacuation, in particular, the negative effects of house loss on the quality of life of the resident and on other socio economic consequences.

Wind the clock forward to now, the two passive protection policies used by the fire authorities that had no influence on reducing house loss rate of policy-credentialed new houses, have now been amalgamated, and active protection is discouraged by the fire authorities despite the consistent data that it results in substantial house loss rate. Their policy is to strongly encourage evacuation and discourage self defence.

Chapter 3 The bushfire grows and escapes

Day 1 Saturday, 19 December, 2015
This day was a Total Fire Ban (TFB) day for the whole state, with northerly winds. Historically, TFB days are declared for specific areas when forecast Fire Danger Index is around 50 or above. It generally means if a fire ignites, it will grow rapidly and be difficult to control. The CFA web site confirmed that the previous day was a TFB in this region, the following day was a TFB for the whole state and Christmas Day was a TFB in this region.

In the afternoon, lightning storms ignited two fires in the Otway Ranges. One was 1.2 km from Jamieson Track. (The other was several kilometres inland and was controlled within a few days.) The first report of the Jamieson Track fire was in the Sit Rep (Situation Reports, 2016) at 16.10, when it was reported as 0.5 ha with moderate spread potential. Initially, a six person ground crew and a reconnaissance aircraft were despatched.

The final Sit Rep for the day at 20.39 reported that a dozer track had almost been built to the fire edge, that a helitack had dumped water onto it and that the fire size was 1ha. A fire of this area has an estimated perimeter of approx 0.4 km. The fire control plan was to construct a mineral earth line around perimeter, patrol and then mop up overnight. Control was expected by midday tomorrow. The Sit Rep mentioned (1) a night crew of 9 people will monitor the fire edge, and (2) the forecast for tomorrow is difficult weather, but the controllers would have been aware that a TFB had been declared.

The IGEM investigation report was a little confusing. It said the dozer continued working till 1am, but said that night crews did no containment work on the fire edge after dusk and overnight. Because the access track into the fire was almost completed by 8.39pm, this suggests the dozer may have started work on the fire edge without ground crew help. It was unclear about actual overnight crew numbers at the Jamieson Track fire were uncertain. It confirmed that large numbers of CFA fire fighters were stood down before nightfall. (Direct quotes from IGEM report are in blue)

- The crew continued to work on the containment line until light failed. For safety reasons the crew was withdrawn to the dozer track at this time, but maintained a watch on the fire overnight.
- The dozer was able to work until approximately 1am on 20 December, when it encountered steeper terrain.
- The night crew of 10 personnel was shared across the two fires.
- CFA responded on 19 December with 27 personnel and 9 tankers. These crews were stood down at 6.40pm on this date as the terrain was inaccessible for the tankers. CFA returned on the afternoon of 22 December to support the back-burn operations.

Thus the clear conclusion from the evidence to date is that the fire edge was not contained by the overnight crews because they were not deployed to do so.

Best practice fire suppression requires that a small fire is rapidly contained and made safe overnight before difficult weather the following day. This calls for an aggressive suppression effort by adequate committed crews overnight. To me as a forest fire professional, a hand constructed perimeter around a fire edge of approx 400m should have been achieved with on site resources, and would have been secured if a relief crew and large dozers arrived in early morning.

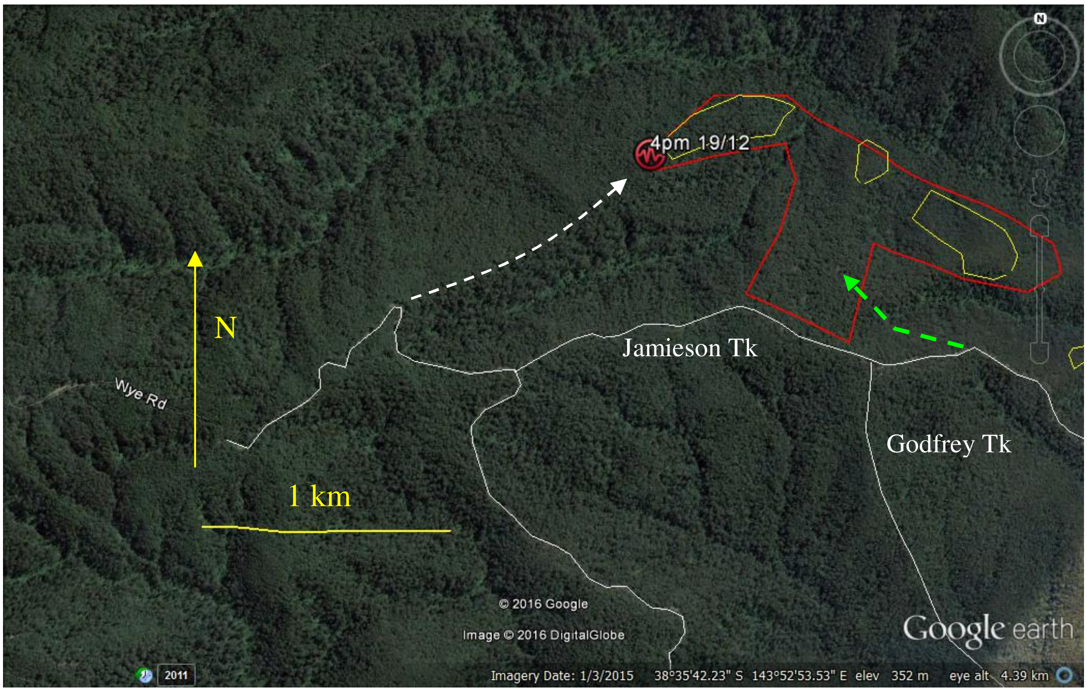


Figure 2 Shows approximate location of fire origin at 4 pm on 19 December 2015. White dashed arrow is approx path of initial dozer track along ridgeline. Yellow outlines approx scorched areas caused during fire escapes in the westerlies on Day 2. Green arrow is approx location of subsequent dozer track, presumably installed to access yellow areas after Day 2. Red outlines approx fire boundary on Day 4 after escape up the steep slope to Jamieson Track.

The student can assess whether the overnight non-deployment was consistent with best practice fire suppression, whether the fire control plan was achievable overnight with allocated resources, and whether the lack of action overnight minimised the chance of fire escape on the following day. The student can assess why the stated fire control plan of rounding the fire up overnight was not achieved with the combination of strategy and actions. In particular, was the construction and securing of a hand made control line of some 400m achievable overnight in safety with the available resources, or could it have been achieved with additional or appropriately equipped resources? For the latter question, what resources were required, were they available, why were they not deployed to achieve the overnight target?

Day 2 Sunday 20 December, 2015

This day was declared a TFB for the whole state, with westerly winds on the fire ground.

The Sit Rep of 7.22 am reported that 80% of the fire edge was untracked. The fire area was still only 1 ha. This confirms the IGEM statement about no action on the fire edge overnight. The expected time of control was midday today.

The Sit Rep of 10.25 reported the fire was 20 ha, and two dozers were working on the edge. They now needed to construct 2 km of perimeter track. The expected time of control was changed to 10 pm today.

The Sit Rep of 12.37 reported a fire area of 28 ha, and the 15.36 one reported 65ha, with respective perimeters of 4 km and 6km. The 15.36 Sit Rep reported that 2 km of control line had been constructed. It also reported that light rain began to fall. The final Sit Rep at 19.40 reported a fire area of 65ha, 2km of constructed control line and a total live perimeter of 6km, and the strategy was direct attack, ie, construct a control line along the fire perimeter. The expected time of control was changed to 10 pm on the next day.

Whilst it is clear that two successive fire control plans failed to achieve their targets today, the reasons are not clear. The IGEM report adds to confusion by stating that (1) personnel numbers were increased to 14 and dozers to three, (2) that terrain slowed line construction rate and (3) that terrain prevented deployment of more resources.

The forest fire professional regards 14 personnel as under resourced if the hand crew construction rates are slow. If three large dozers were deployed on line construction in this steep terrain, four km of control line should have been cut within a few hours and these lines would need to be patrolled by more slip ons and tanker crews than had been allocated. The concept of terrain preventing additional resources can be rejected as nonsense, particularly because the resource allocations in the following days were well above today's. The fire professional finds it incongruous that such a large fleet of water bombers could not prevent expansion of the perimeter before the rain fell. Relevant IGEM quotes were:

- Firefighting resources were increased to 14 and 8 personnel (day and swing shift respectively), one tanker, four slip on units, and three dozers. The terrain precluded more resources being deployed.
- One crew was only able to cut 140 m of containment line by hand in a day.
- Construction of bare earth containment lines continued during 20 December. On-ground resources were also increased, with three dozers, and 30 firefighters (8 night crew were shared across the 2 fires). Of the six kilometres fire perimeter, crews had established two kilometres of containment by late on 20 December.
- At 6.58am on 20 December the IMT requested aircraft at the fire ground as soon as possible. The medium helitack and support aircraft were airborne at 7.24am. At 8.23am further aircraft were requested as the fire had broken the containment lines and was growing rapidly. The aerial response was strengthened between 9am and 1.30pm with a total of 7 firefighting (as opposed to observing) aircraft including 4 water bombers (2 large air tanker and 2 smaller tankers) and 3 helitacks (2 medium, one large).

Best practice forest fire suppression suggests that lulls in expansion rate of fire perimeter should be taken advantage of by maintaining or increasing line construction rate.

The student can assess whether the failure to achieve two fire control plans was due to under allocation of resources, misallocation of resources or other reasons. The student can assess why the total line construction rate by three dozers for the whole day was 2km, a zero increase since the 15.36 Sit Rep. Eg, was it because they were not allocated to line construction or because the terrain was too difficult?

Day 3 Monday 21 December, 2015
Mild weather

The Sit Rep of 11.03 am reported the fire area was 86 ha, the total perimeter was 7km, and 2km of control line had been built. Control was expected by 10pm tonight. The focus of the plan was to complete the remaining 5 km of control line. The number of personnel on the fire ground was deduced as 40 (70 total less 30 in control HQ at Colac), and either 3 or 4 dozers. The final Sit Rep at 22.31 quoted a fire area of 92 ha, a live perimeter of 8km and 2 km of completed control line. Sit Reps report spot fire activity during the day. One grew to 3 ha.

The IGEM report wording implied productive work occurred on the fire edge today when no additional control line was built: Milder conditions allowed firefighters to continue building containment lines. Crews had established 2 km of containment line on the fire's 7 km perimeter.

Best practice forest fire suppression suggests the remaining 5 km of control line would have been constructed as the highest priority today so that it was made secure before Friday the 25th.

The student can assess why no additional fire line was constructed today, despite at least 3 dozers on site. Eg, was it because they were not allocated to line construction or because the terrain was too difficult or other reasons?

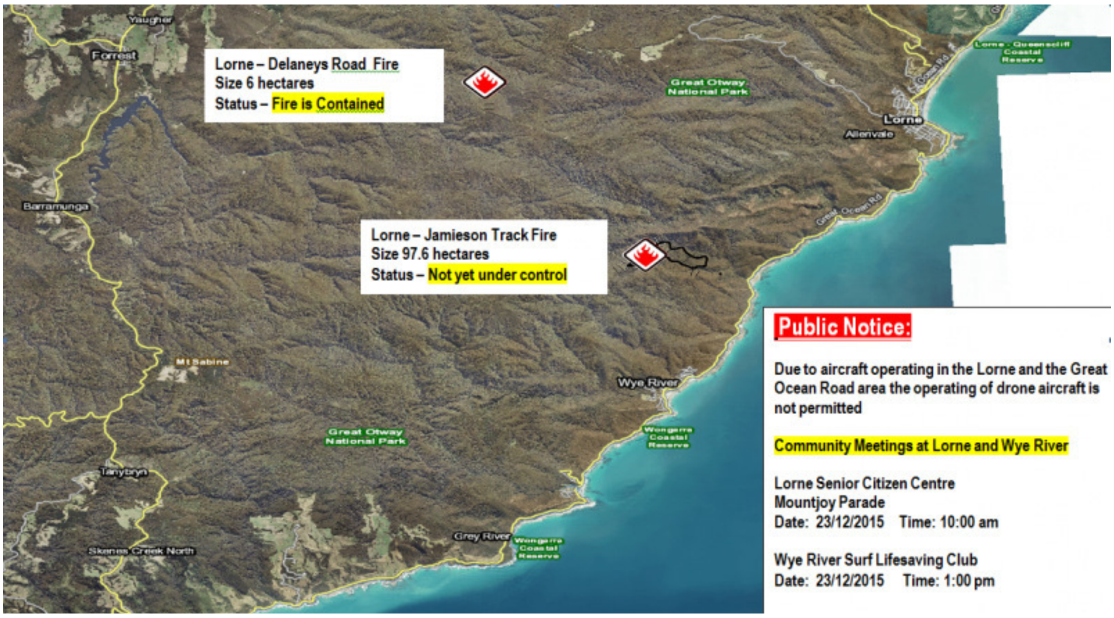


Figure 3 Fire update, from CFA web site, dated 23 Dec, 2015

Day 4 Tuesday 22 December, 2015
Mild weather

The Sit Rep of 14.26 stated the fire area was 141 ha, fire perimeter was 8 km and constructed control line static at 2 km. Part of the fire escaped and ran up to the Jamieson Track. There were now 113 personnel on the fire ground and six dozers.

IGEM stated that during the night the fire burnt to within 10 m of Jamieson Track. The night shift crews continued to patrol and work on the containment line where it was safe to do so. The fire grew to 141 ha by 2.26pm on the afternoon of the 22 December.

The same Sit Rep reported that a back burn strategy from Wye Rd along Jamieson Track to the coast had been approved and will commence this afternoon (Figure 4).

IGEM stated: The IC, together with team leaders of the IMT, identified Option 4 (the back-burn option) as the approach that had the greatest chance of succeeding in containing the fire.

The Sit Rep stated: "Consequence of failure in relation to current strategy is a much larger fire and potential threat to assets longer term". IGEM restated this as follows: Incident planners had identified a much larger fire and risk to assets as the consequence of the back-burn strategy failing. The IGEM added: Reflecting these significant consequence and their significant implications for communities, the IC initiated planning for community engagement and safety strategies for communities to the north, and south of the fire, and for the Great Ocean Road.

Figure 4 Map of planned back-burn. The burnt area along Jamieson Track increased ten fold

This was a substantial change of control plan. The new control plan can be restated as follows: Prepare a back burn along Jamieson Track. The unstated assumption was that the back-burn will stop the fire spreading south if it is in place by Friday 25th. However, the Sit Reps do not define the bushfire spread mechanism the back burn is intending to stop, (ie, flame or embers or both) nor do they define their standards for a successful back-burn, eg, width of burn or depth of blackout.

Thus the fire's width along Jamieson Track (in the E-W direction) had now increased ten-fold from a few hundred metres to over 4 km. Because the control team was aware of a northerly wind on Friday, it must also have been aware that an escape fire would approach the southern towns as a front up to 4 km wide. The consequences (ie, life and house loss) of this possibility were not countenanced. Later Sit Reps mention preparation for evacuation.

IGEM stated: The IC anticipated the favourable conditions would last until the night of 23 December, providing two days for the back-burn operation. The IC was aware that temperatures were expected to increase and winds to strengthen later in the week.

Thus the IGEM appears to uncritically accept the control team's assumption that a summer burnout in a forest is like a burning a patch of grass – once the burn has been done, everything is black and non flammable. Yet in reality, forest fires retain hundreds of hot spots in the ground, in stumps, in logs, in trunks and in upper branches that smoulder for days that come to life when winds increase.

The change of strategy from moderate cost / moderate level resources to high cost / high level resources seems to have changed the focus of the control team. Instead of a focus on preventing the spread of the original fire, it now became a focus on how well the new burn was progressing. The goal of stopping the fire's spread by the tactic of back-burning was superseded by the goal of achieving a good back-burn. Thus the tactic became the goal, and the quality of the burn became the measure of success. The IGEM appears to have adopted a similar mindset. This is indicated by an absence of criticism when reporting the fire escape. The scrutiny of whether and how the back-burn will actually stop fire spread to the south was not obvious.

This IGEM report indicated acceptance of the new strategy: The window of opportunity for back-burning was favourable, The required containment lines were in place and back-burning offered the greatest potential to reduce the risk to communities and assets.

The 17.55 Sit Rep reported the fire area at 180 ha, fire perimeter 11.5 km and even though only 2km of control line had been constructed, there was 6 km of control line to be built. The extra area was due to the back burn operations. There were now 178 personnel on the fire ground and an additional 20 CFA fire fighters. The number of resources on line contradicts the IGEM's earlier statement above that The terrain precluded more resources being deployed.

The Sit Rep summarised burn depths and the IGEM paraphrased it as follows: By late 22 December, reports indicate that the back-burn was progressing well, with flame heights of 1–1.5 m. Crews were achieving between 10 and 30 m depth in the western sector, and 50 to 100 m in the eastern sector

The student can assess whether the IGEM's uncritical acceptance of the Sit Rep statements of success was appropriate. In particular, can an independent audit technically adopt the label of success when the results cannot be compared against the targets? Eg, If the standard of success is a blacked out depth of 75 m, any depth less than this is a failure, no matter how hot the fire or how tall the flame.

Best practice forest fire suppression suggests the original control plan target of 6 km of control line would have been constructed as the highest priority so that it was made secure before Friday the 25th. The decision to change the strategy from direct attack to indirect by back-burning two days before a severe weather day and a few days after two consecutive severe weather days in dry remote forest is not consistent with best practice. Adding fresh fire in forest along the last line of defence two days before a severe weather day is best practice only when the downwind area has highly discontinuous surface fuel bed, a high level of vehicle access and a high level of well trained defenders. These conditions did not occur south of Jamieson Track.

The student can assess why no additional fire line was constructed today, despite the presence of at least 3 dozers. The student can calculate what depth of blacked out area will be required to prevent flame spread across Jamieson Track, and what depth is required to prevent spread by embers. They can also consider that whereas Jamieson Track was a useful fall back control line when the fire control plan was direct attack, the choice of Jamieson track as the burn-out line made it the last line of defence because there was no prepared fall back line in the south. The student can consider whether a narrow freshly burnt strip of forest can harbour smouldering embers for two days and thereby become a source of spreading embers, or whether it will be wide enough to capture all embers generated upwind. If the possibility exists that the burnt area cannot prevent spread by embers from the last line of defence, what strategies can be enacted to prevent fire spread to the south on Friday 25th? Were they implemented?

[The IGEM commented: Crews undertook work to assess contingency containment lines to the south of the fire on 22 December. Reports indicate works to cut the lines were scheduled, but do not confirm their completion.]

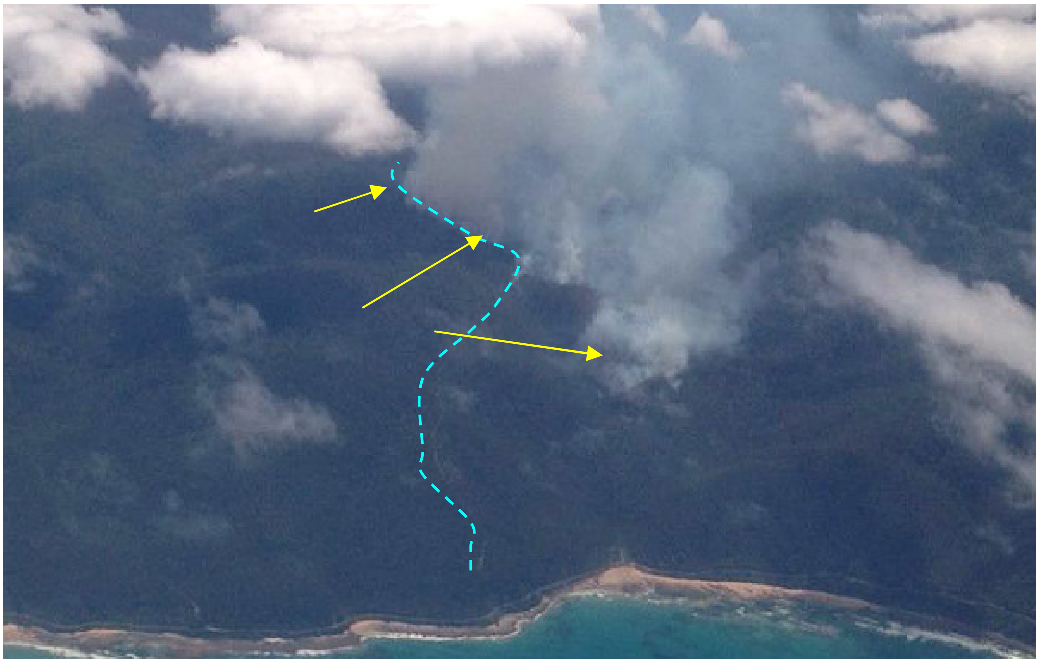


Figure 5 View to the west along Jamieson Track on 22 December showing start of burning out operations. Photo published by CFA Facebook.
Blue dash line is Jamieson Track. Top arrow is Godfrey Tk intersection. Middle arrow is line ignition with smoke incorporating into low cloud. Bottom arrow is probably smoke from slowly expanding original fire. The white smoke is consistent with a low intensity fuel reduction burn, ie, a low flame height in fuels with high moisture content.
Commentary on CFA website News and Media on 24 December:" Approximately 100 Firefighters are working around the clock in difficult terrain to bring the fire under control. Smoke and flames will continue to be visible. Crews have under-taken a successful burning-out operation in difficult terrain with the aim of removing fuel from the path of the fire and strengthen containment lines prior to hot, windy weather that is expected on Thursday 24 and Friday 25" .

Day 5 Wednesday 23 December, 2015

Mild weather

The Sit Rep of 10.25 stated the fire area was 163 ha, the fire perimeter was 16 km and constructed control line was now 16 km, with no more control line to be built. It reported good depth of burn along Jamieson Tk. It also mentions resources for fall back lines have been requested, but not yet provided. Control was expected by 18.00 on 26 December. There were 70 personnel on the fire ground. The Sit Reps of 13.07, 16.04 and 22.55 report fire areas of 254, 246 and 246 ha respectively, and total control line was reduced to 14 km.

Figure 6 Published fire area 11.27 on 23/12/2016, CFA web site

The 22.55 Sit Rep again stated today's burning was successful, "burning out most of the remaining unburnt areas".

IGEM appeared to uncritically support the back burn strategy and the consistent reports of success of the burns in the Sit Reps despite the unstated back-burn targets: Progress continued on 23 December, with situation reports indicating the back-burn was mostly successful.

Best practice forest fire suppression requires a back-burn strategy to have a minimum depth of blacked out forest upwind of a good track to stop the flame and to absorb some of the short distance spotting. Successful management of other short distance spotting requires active defence in a prepared area downwind – eg, a highly discontinuous surface fuel bed, a high level of vehicle access and a high level of well trained defenders. Medium distance spotting also requires active management, particularly vehicle access and adequate defence forces to deal with spot fires while small, supplemented by accurate aerial attack on small spot fires with helitacks and ground crew back up.

The student can assume that the burnt area will prevent flame spread across Jamieson Track, and can consider how to advise this fire control team to deal with fire escape by short and medium distance spotting across Jamieson Track in Friday's severe northerly weather according to best practice forest fire suppression. What are the theoretical requirements of fuel bed discontinuity, vehicular access and fire fighting equipment and personnel compared to the actual situation? The student can also consider the speed and method of spread of the escaping spot fires.

Day 6 Thursday 24 December, 2015
Mild weather

The Sit Rep of 11.19 stated the fire area was 246 ha, the fire perimeter was 14 km and constructed control line was 14 km, with no more control line to be built. It reported successful burning yesterday along Jamieson Tk. There were 81 personnel at the fire ground.

The Sit Rep of 22.49 stated the fire area was 271 ha, the fire perimeter was 14 km and 13 km was completed with 1 km to be completed. It again reported successful burning yesterday along Jamieson Tk. There were 81 personnel at the fire ground. The Sit Rep at 0.27 on 25 December said there were 37 personnel on the fire ground.

The IGEM report uncritically corroborated the Sit Rep statements and endorsed the back-burn strategy as a success:

- Reports from 24 December indicate the fire was quiet throughout the day, and remained within the existing containment lines. By 24 December, crews were finalising the back burn.
- The IC was satisfied that the burns conducted over the previous days had been successful. Crews continued to patrol the fire edge, and black out fire along Jamieson Track.
- Reports indicate the back-burn progressed as planned, implementing the strategy of protecting against fire spreading with northerly winds forecast for 25 December
- This strategy was successful in reducing fuels and potential fire intensity (infrared mapping had previously identified 1000 hot spots in the original fire).
- With the back-burn providing protection against spread of the fire to the south, crews prepared containment lines on the northern side in preparation for a wind change expected for late on 25 December.

The test for the IGEM's endorsement will come tomorrow. Will it achieve its purpose, and help prevent fire escape in a strong N wind?

The student can compare these remarkably positive comments with those of local firefighters who worked on blacking out Jamieson Track this evening. They advised me of their great concern of an escape because of the amount of roostering they saw across the track. By roostering, they meant sprays of live embers from hot spots in the ground and in trees.

Day 7 Thursday 25 December, 2015
Severe weather, strong wind from north.

The Sit Rep of 5.33 am stated the fire area was 271 ha, the fire perimeter was 14 km and constructed control line was 13.2 km, with 0.8km of control line to be built. It again reported successful burning yesterday along Jamieson Tk. There were 37 personnel and 8 slip on units and 1 tanker at the fire ground. The control plan was "direct attack to contain within current boundaries and continue to patrol and blackout".

The student can assess how realistic this control plan was and how well resourced it was. Does the plan recognise spotting across the line and thereby deploy adequate resources on ground and in air to deal with spot fires? Can the student explain why aircraft were not mentioned in the resources list?

The IGEM also reported 37 personnel on line, but the experienced bushfire professional regards the list as an editing failure, perhaps due to pressure in the control centre because the resources table remained unchanged throughout the day until after 10 pm. However, if the resources figure is accurate, it is sadly inconsistent with best practice forest suppression.

The student can readily calculate that 37 people over 4 km of patrol line is approx 10 per km, and can compare it to the desirable resources ratio required on a last line of defence with fresh forest fire alongside.

The 11.29 Sit Rep reported spot fires and expressed doubt that they can be contained. It stated a new control plan – "air attack to slow the rate of spread and preparation for asset protection at Wye River. Strike team set up at Wye River. Call to evacuate Wye River will be made by 11.50".

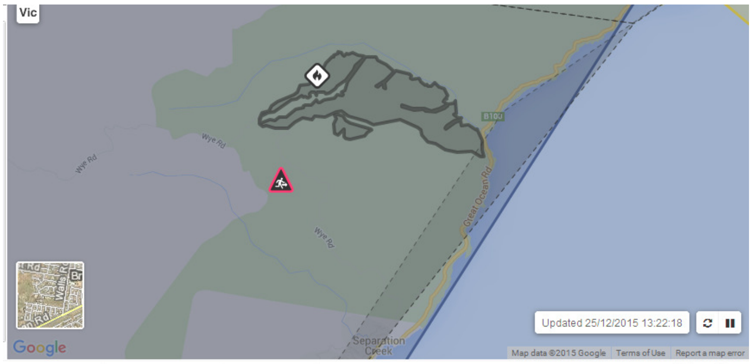
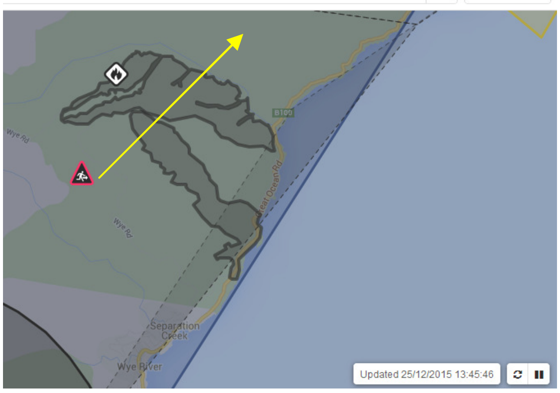


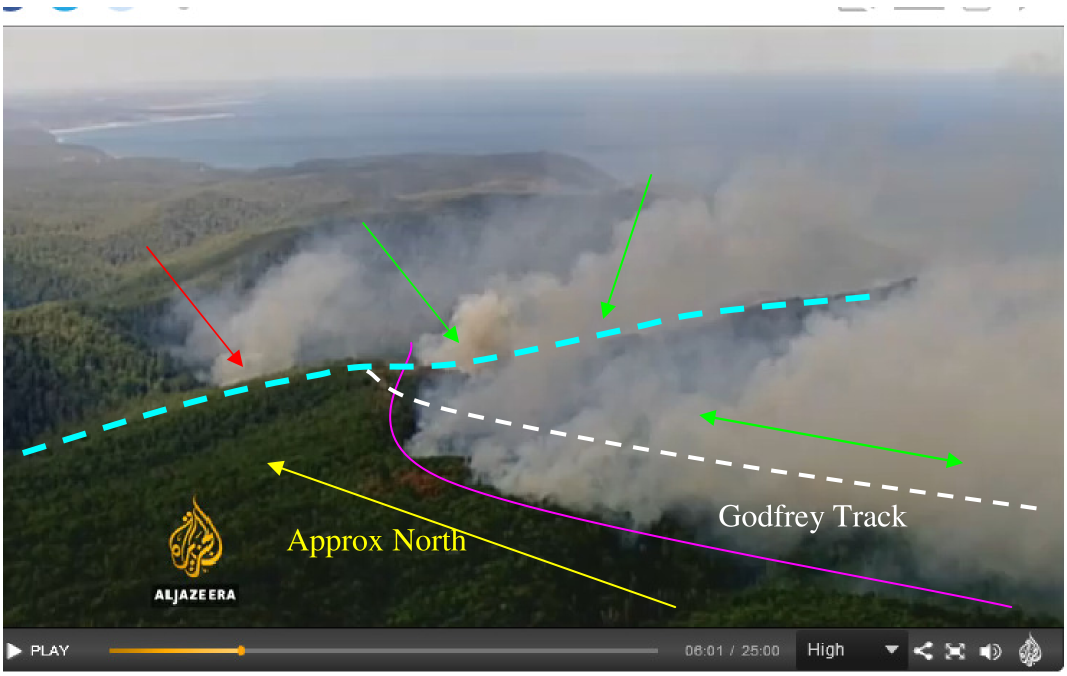
Figure 7 Published fire area, updated 13.22, but it indicates the 30 ha breakaway of the 12.45 report. CFA web site.

The 12.45 Sit Rep stated fire area was 301 ha. It reported a spot fire of 30 ha near Jamieson Track and another on the Great Ocean Rd. The control plan was changed again to "asset protection – aircraft focused on asset protection in Wye River and Separation Creek". This control plan continued in the 14.07, 15.10, 16.17, and 17.24 Sit Reps.

The 14.07 Sit Rep stated the fire area doubled to 600 ha, and the spot fire front was 700m from Separation Creek. It also reported crews were withdrawn from the fire ground, but did not specify if they were redeployed to Wye River or elsewhere. A personal account by a fire fighter suggests her team began on the fire ground at 8 am, witnessed the first spot over at 11 am and was helping with evacuations at 2pm presumably in Separation Creek. "To see the fire come over the hill and into Separation Creek and see those houses disappear and all the animals coming out; it was intense" http://parkweb.vic.gov.au/about-us/news/an-inside-look-at-the-wye-river-fire2
It is likely that the elongated SE run of Figure 8A represents the Sit Rep. Figure 8B is a still from news footage across Jamieson Track taken around this time. I have matched its location using Google Earth. The photo looks NE across the junction of Jamieson Tk and Godfrey Tk along the coastline. Table 1 reveals a sustained NNW wind flow at Aireys Inlet between 12.30 and 2 pm. There may have been a terrain-caused deflection of air flow to NW.



A Published fire area, updated 13.45, CFA web site. Yellow arrow is direction of photo in B.



B Media photo looking NE across initial breakaway, Source Al Jazeera. Probable time 1.30 – 2 pm. Blue dashed line is Jamieson Track. White dashed line is Godfrey Track.
The red arrow is smoke north of Jamieson Tk. The green arrows show the major sources of fresh smoke, ie, they indicate fresh outbreaks of flame. The pink line is the upwind edge of smoke activity. Smoke direction appears to be SE, meaning wind is from NW.

Figure 8 Fire's status between 1.30 and 2 pm.

The Figure 9 media photo appears to correspond closely with this timing.

Figure 9 Media photo looking from south across Separation Creek township. Photo presented by krock.com.au Probable time of photo 1.30 - 2 pm.
Red arrow points to fresh vigorous smoke from spot fires running up the northerly slopes near the coast, which is clearly different from the thinner sub canopy smoke of the initial down slope escaped spot fires near the initial breakaway of Figure 8B (yellow arrow). Wind has a strong NW influence.

The 15.10 Sit Rep reported "houses in Mitchell Grove now being impacted by fire in Separation Creek". The 16.17 Sit Rep reported the fire front was at Wye River. It also stated an evacuation order was issued for Lorne, and power was cut to Sep Ck and Wye River because power lines on ground were a threat to fire fighters.

The wording of the control plan in these Sit Reps specified aircraft activity only. The non-mention of ground fire fighting units is consistent with feedback given to me by local fire fighters. One advised me that there were several aircraft water drops before and after 3pm, and that shortly after 3pm, a few CFA units were quelling spot fires in parts of Separation Creek, some in open defiance of local chiefs, who declared some areas unsafe. Another fire fighter reported that just after 4pm, there were two CFA units in Separation Creek. One was quelling spot fires and the other was stationed at the creek with a pump. One strike team was in Wye River from 8am and saved several houses from spot fires in the Boulevard area. Thus, on the ground fire fighter activity during the fire attack was sparse compared to house numbers under threat.

The IGEM praised the fire control team for their procedural response: Incident records show readiness for the events of 25 December, and a rapid turn to protecting the safety of crews and communities, and assets in the townships to the south. But sadly, this praise seems detached from the actual outcome of the decisions of the fire control team, namely, that the fire escaped control lines and caused the destruction of over 100 houses.

The student can assess the outcome of the range of fire control plans and strategies over the previous week, as summarised in Figure 10 against the continuing plaudits of the IGEM: IGEM recognises the appropriately scaled approach to control and resource allocation throughout this fire. The effectiveness of strategy planning and implementation were highly likely to have contributed to the successful outcome of preserving life and minimising further losses.

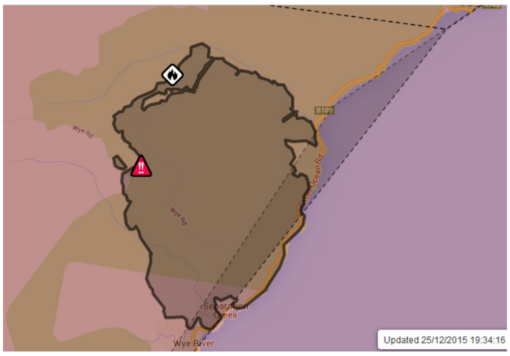


Figure 10 Official fire map at 7.34 pm, Christmas Day, CFA web site

The student can assess whether praise for the process despite escape and catastrophic house loss was another example of the Miller et al (1984) distinction between capability of enacting a disaster plan and capability of suppressing the fire.

Summary

On Day 1, the 1 ha fire escaped control of the night time crew. Was it because overnight suppression on the fire edge was not conducted after dark?

In the first few days, the planned control line was along the fire edge and the fall back control line in the south was Jamieson Track.

In those first few days, each daily fire control plan failed to achieve its objective. We can ask – were the plans wrong, were the tactics wrong, were the resources inadequate for the weather and the terrain, was the leadership or commitment level strong enough?

When the control plan changed tactics to a 4 km back-burn along Jamieson Track, the southern control line became Jamieson Track, but there was no fall back line. Fresh fire along the southerly control line just ahead of a severe northerly wind forecast made escape inevitable, but the control plan failed to prevent breakaways.

Chapter 4 The bushfire escape across Jamieson Track

When and where

The successive line scans in Figure 11A and B show that the Jamieson Track control line breached at different times in different places. The central section breached in at least four places (red arrows) just before the 1.20 pm scan, probably under the NNW wind. The western section breached in at least three places (green arrows) two hours or so later, possibly 30 minutes just before the 3.50 pm scan. The eastern section breached along a long line (green arrow) just before the 3.50 pm scan. Table 1 indicates that the Aireys Inlet wind was NNW until 2 pm, N from 2 to 2.30 pm, NNW from 2.30 to 4pm, and N after 4pm.

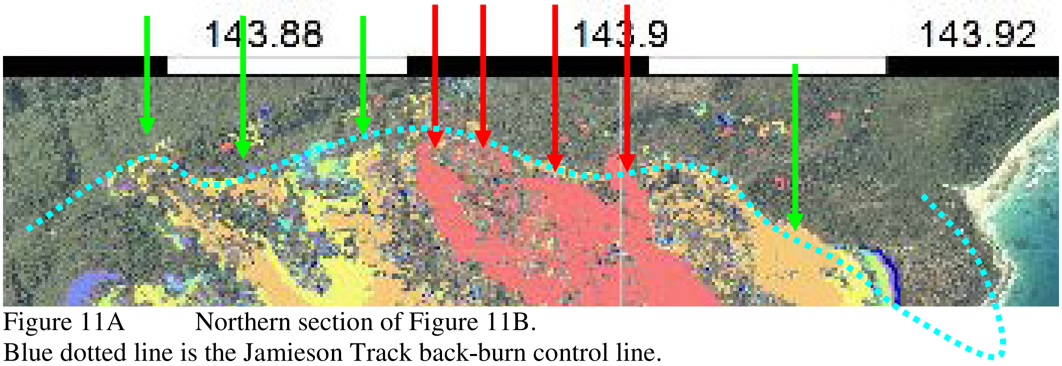


Figure 11A Northern section of Figure 11B.
Blue dotted line is the Jamieson Track back-burn control line.
Red arrows are heat signatures of recent flame in the 1.20 pm line scan that had disappeared by the 3.50 pm line scan. Green arrows are heat signatures in the 3.50 pm line scan that were not present in the 1.20 pm line scan.

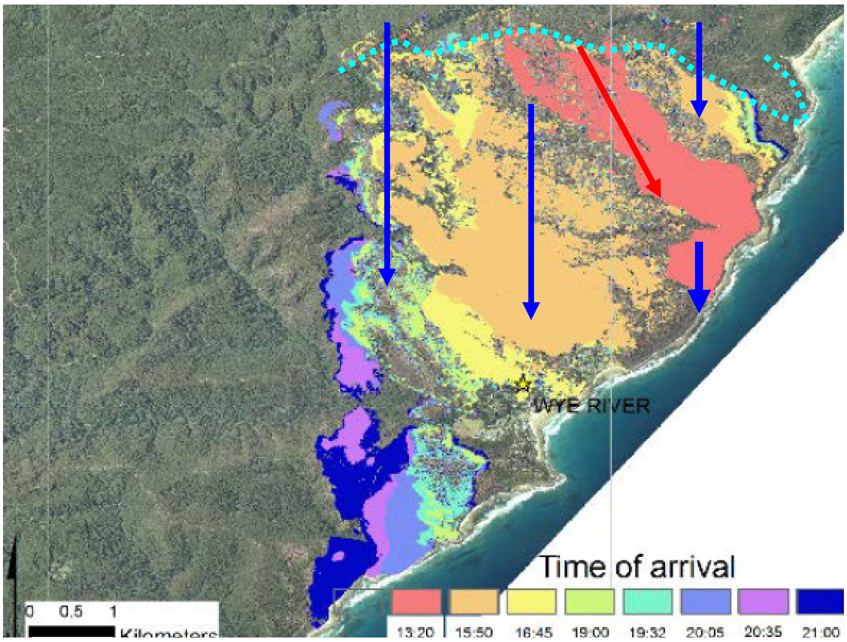


Figure 11B

Blue dotted line is the Jamieson Track back-burn control line.
Red arrow indicates NNW wind, which differs from net direction of escaping spot fires.
Blue arrows indicate N wind.

Base map is copy of Fig 15 in CSIRO report. Cumulative line scans are colour coded to indicate maximum heat emission.

The student can compare the credibility of the IGEM report about the source of the 11.30 spot fire with the Sit Reps and the line scans. By 11.30am spot fires were burning outside containment lines. The fire spot over is reported to have been started by a tree falling from an area that had been previously well burnt. As the tree fell it provided additional unburnt fuel which caught fire, and started throwing embers as a result of the hot and extremely windy conditions. These embers resulted in spotovers and breach of the containment line.

The student can compare the bushfire escape locations and mechanisms with the following comments by Fire Commissioner Lapsley:

> Backburn may have caused Wye River fire to escape
> Nick McKenzie, Richard Baker and Tammy Mills
> The Age on line January 13, 2016 - 8:36PM
>
> Mr Lapsley confirmed a controlled burn-out took place from December 22.
> He said the fire was in deep, inaccessible country and it could not be extinguished. He said a decision was made by the incident controller, with support from the regional controller and himself and his team to conduct a burn-out when conditions were milder. He said this decision was made public to residents at community meetings on December 23. The aim was to bring the fire out into country where it could be controlled. However, firefighters could not access the fire still burning in a deep gorge before the weather changed. It's from this gorge that strong northerly winds picked the fire up and flicked it over a ridge, causing three spot fires, and onto a path straight to Wye River on Christmas Day, Mr Lapsley said.
> "We knew the risks and you're damned if you do and damned if you don't," he said.
> "You've got to try and bring it and finish it and if you do nothing it creeps around by itself and it ends up in the same spot anyway. We have to trust the people in the seat at the time and they're experienced bush people."
> Mr Lapsley said he believed the fire would have done exactly the same thing even if controlled burns were not conducted. He said "every option" to control the fire was taken before the decision was made to burn out.
> "They exhausted every option before they put fire into it," he said.
> He said an investigation into the fire by the Inspector-General for Emergency Management would be a sufficient response.
> "That will be published to a community so it's transparent," he said.

Table 1 Wind records for Christmas Day at closest Automatic Weather Stations
Table summarises wind direction and average wind speed for each time block.

Aireys Inlet 22 km distant to north

	10 am	11 am	12 pm	1 pm	2 pm	3pm	4 pm	5 pm
N	**30**	**33**	**33**		**28**		**28**	**26**
NNW		**32**	**30**	**30**	**32**	**22**		

Cape Otway 40 km distant to south

	10 am	11 am	12 pm	1 pm	2 pm	3pm	4 pm	5 pm
N	**43**	**33- 43**	**33**	**32**	**30**	**20**	**26**	**24**
NNW			**37**	**37**				

Notes:
(1) Precise times of wind direction changes at Jamieson Track are not known, but because it is only 20 km south of Airey's Inlet, along a similar coastal terrain and the weather moves from west to east, times can be deduced as approx 10 minutes before Aireys.
(2) Similarly, precise wind direction at the fire ground is not known. Post fire maps show directions of fire spread on Christmas Day ranged between SE and S which is consistent with a net air flow between NW and N. It is possible the steep easterly fall of terrain near the coast together with channelling in steep westerly gullies contributed to a more westerly deflection of local wind direction. For example, Fig 73 in CSIRO report showed that direction of hot convection air at 3.50 pm at Wye

River township was SE. It stated that "hot convection air scan travels in direction of prevailing wind", which means net air flow was from NW.

The successive line scans in Figure 11B show that the control line breached in unusual patterns. These variable fire directions can be explained by wind direction and terrain effects.
The 1.20 pm line scan: The red 13.20 scan ran approx SE when the prevailing wind was NNW (red arrow - see Table 1). When overlaid on Google Earth, this scan area follows a deep valley. This suggests wind channelling along the valley may have occurred. This was unexpected because the terrain was leeward and down slope from the very prominent Jamieson Track ridgeline. Figure 9 demonstrates two different fire behaviours along this breakaway, wispy smoke corresponds to down slope leeward fire spread and vigorous billows of smoke correspond to rapid uphill spot fire runs on northerly slopes.

The student can confirm calculations. The distance of the breakaway in the 1.20 pm line scan was approx 3 km. Based on Sit Reps which mentioned the first escapes across the control line were at 11.30, the maximum duration was approx 2 hours, meaning rate of spread of leading spot fires was at least 1.5 kph.

The 3.50 pm line scan: (1) The 15.50 line scan in Figure 12 shows that the 13.20 heat signature had disappeared to multiple small hot spots.
(2) Figure 12 clearly indicates that there was minimal hot spot activity north of the control line at the time. The lack of fire activity north of Jamieson Track is confirmed by contemporaneous photos in Figures 13 and 14.
(3) The western arrow indicates a spotting distance of 1km and another jump to its south of up to 0.5km, indicating a Northerly wind influence. A net NW wind influence is also apparent in some parts of the scan, probably due to wind channelling in gullies.
(4) The scan clearly shows breakaways across Jamieson Track control line in the western and eastern ends.

The student will realise that these breakaways occurred after the control line was abandoned at 14.07, and can consider whether the escapes occurred due to zero patrolling or were inevitable due to inadequate resourcing or spotting distances beyond where they could access.

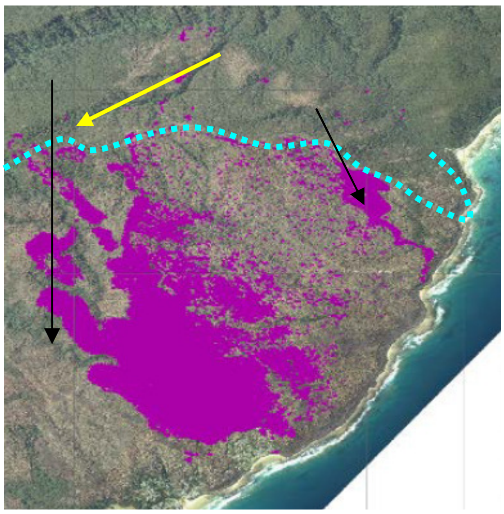


Figure 12

This 15.50 line scan shows saturated pixels which indicate maximum heat emission. Same scale as Figure 11B above. Base map is copy of Fig 73 in CSIRO report.

Yellow arrow is direction of valley view photo in Figure 13.
Black arrows are western and eastern escapes prior to 3.50 pm. The western escape shows long spotting jumps occurred under a Northerly wind, which Table 1 suggests occurred between 2 and 2.30 pm. The eastern escapes show influence of a NW air flow, which occurred between 2.30 and 4 pm. Both breakaways originated from the back-burn area.

Figure 13 View from north of Jamieson Track looking SW along ridge at approx 3 pm. Channel 9 footage
Yellow arrow is same valley as yellow arrow in Figure 12. Yellow circled area is near junction of Jamieson Tk and Wye Rd Black arrow is Godfrey Tk. Scorched areas in foreground are from original fire (refer Figure 2). Red circle is approx vicinity of fire origin. Picture shows several spot fires in valley bottom and sides. Note the little amount of smoke and flame activity north of Jamieson track.

The student can confirm calculations rate of spread of the southern end of the 15.50 scan. The western escape had not occurred at 1.20 pm, but we can assume a solid northerly blast began around 2 pm lasting 30 minutes before a NNW resumed. If so, the southern edge travelled 3.5 km in just under two hours, which is a minimum rate of spread of 1.7 kph.

The 4.45 pm and 7 pm line scans: Fire spread between 3.50 and 4.45 pm occurred under the prevailing Northerly wind in the vicinity of Wye River, travelling around 1 km in approx 25 minutes, meaning rate of spread was approx 2 kph.
Spot fires reached the coastline 1.5 km south of Wye River before the 7 pm scan.

The student can compare the direction and speed of spread caused by prevailing wind against that caused by slope and gully channelling, and the mechanism of fire spread – continuous line of flame, spotting ahead or both.

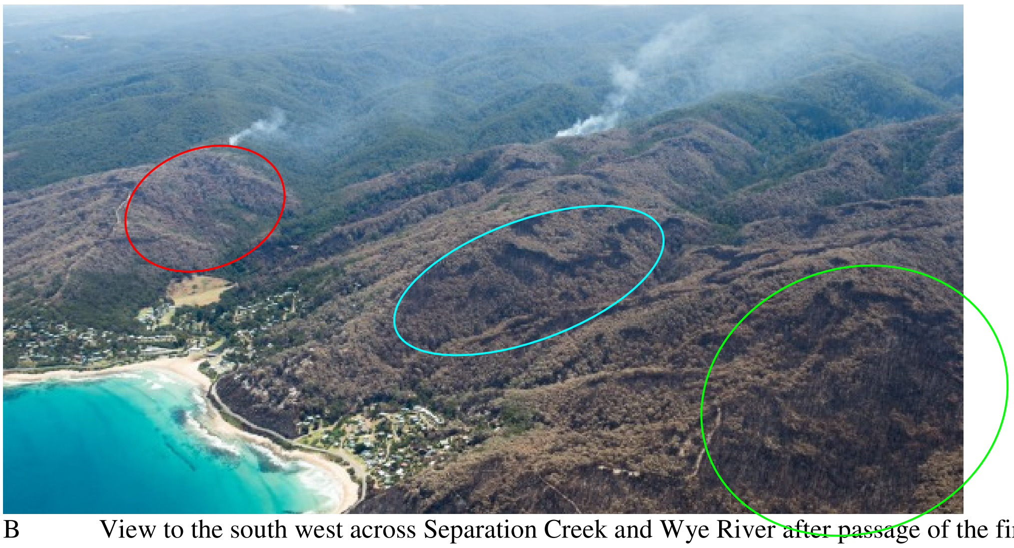
Wind flow patterns in high relief terrain:
- The student will observe that most of Jamieson Track runs along a steep prominent ridge running E – W, and therefore perpendicular to the N wind. This terrain scenario is known to generate very high speeds up slope and turbulence rolls on the lee side. - The student can assess the effect of these wind patterns on ember throw and the direction and speed of the spot fires that ignite on the lee slope.
- If the wind hits a steep slope or prominent knob at an angle, the student can assess the upslope and leeward air flow patterns and their influence on ember throw and flame behaviour.
- Where the ridge line is more rounded, the combined Coandă effect / Bernoulli effect creates low pressure areas on the ridge line and down hill flows on the lee side. The student can assess the air flow pattern on upslope and down slope and their influence on ember direction and flame behaviour.

Figures 14A and B show post fire aerial photos after the bushfire's travel on Christmas Day. The curious feature is that the site of the original fire north of Jamieson Track control line is predominantly green canopy and the fire run on Christmas Day is predominantly brown, meaning the canopy was scorched by a sub canopy flame – a hot but low flame height. Blackened areas where canopy was burnt by a moderate to tall flame height are much less frequent, generally located on northerly uphill runs. They are dense on the slope north of Separation Creek, scattered on the slope between Separation Creek and Wye River, and sparse on the slope south of Wye River.

The student can consider the reason for the lessening frequency of canopy denudation is of interest because there was no significant change in wind speed, temperature or humidity as the fire progressed. For example was it slope? Was it a change in percentage of flammable trunks, or a change in understorey height and density?

The student can determine if the heavily denuded slope (green circle) was a major source of embers into Separation Creek and Wye River between 3 and 4pm. Assume the wind was NNW. Cross check with Figure 15.

A View across Jamieson Track towards the south west after the fire. Photo published by ABC. Blue dash line is Jamieson Track. It is the dividing line between predominantly green canopy foliage and scorched canopy. Blue oval appears to be a broad area of burnt canopy along a northern uphill run, corresponding with the larger blue oval in Figure 15, being an upslope run just north of Wye Rd.



B View to the south west across Separation Creek and Wye River after passage of the fire. Photo published by Canberra Times
Green circle indicates high density canopy loss on the slope north of Separation Creek.
Blue circle indicates scattered canopy loss on the slope between Separation Creek and Wye River,
Red circle indicates sparse canopy loss on the slope south of Wye River.

C Uphill sub canopy flame, seen in green circle area of Figure 14B and blue and red ovals of Figure 15. Photo in Herald Sun / Channel 9 footage

Figure 14 Successive southerly post-fire views showing distribution of unburnt canopy, scorched canopy and burnt canopy

The student can use Figure 15 to check the likely source of embers into Separation Creek and Wye River townships. According to line scans, the fire mass engulfed the yellow uphill run areas by 3.50 pm, presumably arriving between 3 and 3.30 pm. The wind at this stage was from NNW (but allow for local deflection to NW). After 4 pm, the wind direction was from N. Pink arrow uphill runs began after 4 pm.

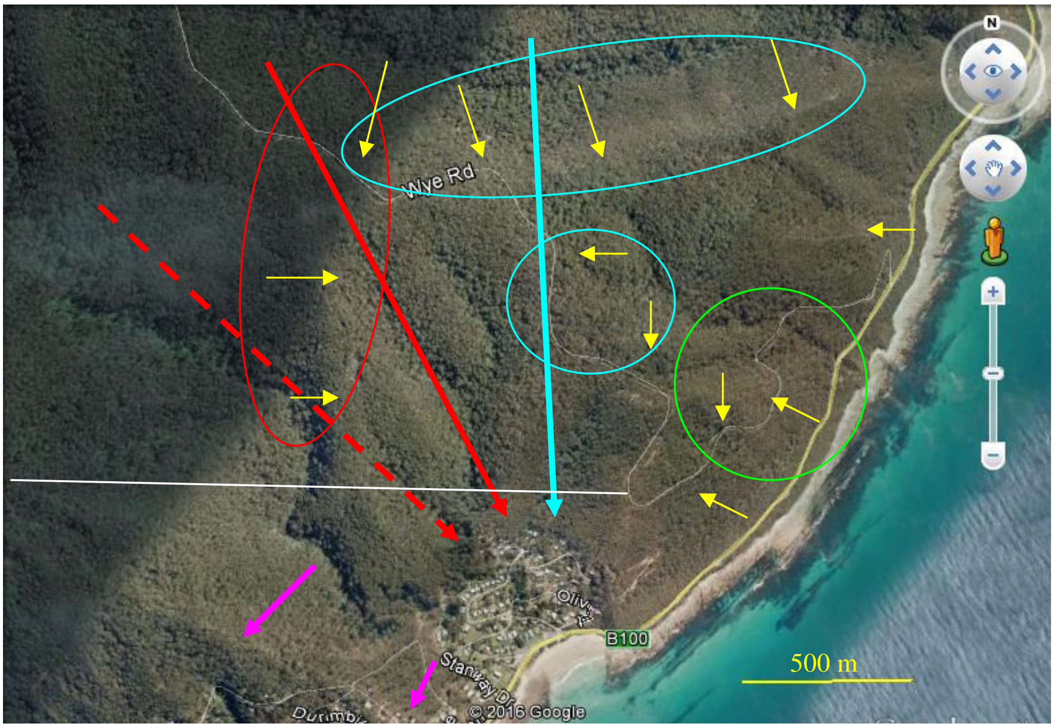


Figure 15 White line is approx National Park boundary Yellow arrows are uphill runs before 3.50 pm. Pink arrows are uphill runs after 4 pm. Blue arrow is north wind, red arrow is NNW, red dash is NW. Blue ovals are potential ember source areas in N wind, Red oval is potential ember source area in NNW to NW wind. Green circle corresponds with green circle on Figure 14B

Spread mechanisms of flame and embers

Six formal spread mechanisms can be identified within this bushfire attack:

(1) Wind driven spread mechanism
(2) Short distance spotting spread mechanism
(3) Wandilo effect spread mechanism
(4) Upslope spread mechanism
(5) Down slope spread mechanism
(6) Medium distance spotting spread mechanism

(Referenced in Manual of bushfire behaviour mechanisms in Australian vegetation)

In forests where there is no spotting and no terrain changes, the wind driven spread mechanism (1) is expected when there is a prevailing wind. A wind of 30 kph suggests sub canopy wind speed of 7 kph or so on flat ground. A reasonable rule of thumb for a wind driven litter bed spread rate is 10% of sub canopy wind speed. Flame spreads faster up hill and slower down hill, and McArthur (1967) observed that time over distance, the rate of spread averages out. If this were the case, the average flame speed would be around 0.7 kph, which is half to a third of the observed spread rate. It can be presumed that this mechanism occurred in some locations, but was boosted in most areas by spotting and terrain influences.

Photographic evidence shows two types of short distance spot fire spread mechanisms - (2) short distance spotting spread mechanism (scattered spot fire ignition a short distance ahead of smoke mass) and (3) a moderated version of Wandilo effect spread mechanism (multiple simultaneous spot fire ignition a short distance ahead of the smoke mass). The former mechanism (eg, Figure 18) does not have the ability to increase the spread rate because the mother fire front tends to overrun them, but the latter mechanism does. Figures 16 and 17 show high density simultaneous spot fire ignitions ahead of the smoke mass. Figure 22 shows vertical smoke from multiple spot fire ignitions being drawn into the convection column despite a prevailing wind of 30 kph.

Earlier in the afternoon, because they originated from isolated ember sources rather than a broad flame mass, the first escape spot fires were probably due to short distance spotting up to 100 or 200m. They ignited where the terrain generally ran southerly down hill but there were also up hill runs towards the ridgelines. Down hill spread was achieved by spot fires igniting 50 to 200m ahead of the main southerly spreading smoke mass and running back uphill in the windless leeward sub canopy environment according to the upslope spread mechanism. The down slope spread mechanism (5) also occurred, but very slowly. Where spot fires ignited on northerly, easterly or westerly slopes, they spread by the upslope spread mechanism (4) through unburnt vegetation and grew vigorously in speed and width, and threw multiple short distance spotting as well as medium distance spotting, up to 1 km or so. Figure 9 indicates wispy smoke as the fire spread slowly down hill and vigorous billows as it spread rapidly on uphill runs. The slope driven mechanism occurred on steep uphill runs, eg, Figure 14C shows it in forest and Figure 21 shows it in coastal scrub.

The probable spread mechanism of the broad front of the 3.50 pm scan, which spread rapidly, was recurring bursts of the Wandilo effect spread mechanism (3), particularly downwind of perpendicular ridge lines.

The 3.50 pm line scan (Figure 12) shows evidence of the medium distance spotting spread mechanism (6) of a kilometre or so that clearly occurred during on the Northerly wind on the western edge of the fire area. This mechanism was also apparent in at and south of Wye River township, eg, Figure 18.

The student can assess the flame height, spread rate and spread mechanisms in different terrains by considering the following variables:
Some forest areas were predominantly tall blue gum with non flammable trunks, meaning low propensity for spotting, but other areas had a higher percentage of messmate / stringybark, which generate a higher spotting density.
What determines sub canopy flame height?
What was the effect of the breadth of the escaping fire mass on the spread rate?
As the fire travelled south, the coastline caused the fire's width to shorten.
What flame depth and flame duration is expected?
If the line scan was a continuous long flame, would that explain an average spread rate of 2 kph in this forest in this terrain, in this wind?
Uphill runs were generally short, eg, a few hundred metres.
Were they all ember launch ramps?
Pall of vertical smoke in a 30 kph prevailing wind suggests convection column was strong enough to block it. Some spot fires had vertical smoke. Were spot fires drawn back into convection column or was it normal uphill run in windless conditions?

The following photos show the smoke mass approaching each town in turn with indications of short distance spotting spread mechanism, Wandilo effect spread mechanism, and medium distance spotting spread mechanism

A

B

Figure 16 Successive views to the east across Separation Creek. Photos published by ABC. White oval shows fresh smoke of multiple spot fires igniting ahead of the smoke pall, estimated time 2.30 pm .

Orange arrow is strip of fire retardant recently applied ahead of the approaching smoke pall.

Figure 17 View to the east into the towns is blocked by smoke. Channel 9 footage, estimated time after 4pm. White ovals indicate likely areas of mass spotting.
Note large area of unburnt forest with spot fire smokes, yet contemporary line scan shows full heat signature.

Figure 18 View to the east across Wye River. Photo from ATW News
Black arrows show short distance scattered spotting.
Green oval shows smoke from simultaneous spot fires far hillside, 1 km down wind.

Summary

Fire escaped at different times in different locations. First escapes were via short distance spotting from the tallest peak along Jamieson Track around 11 - 11.30 am
A second escape occurred after 12.30. The 1.20 pm linescan had heat signature trails suggesting at least four recent breakaway points along the back-burn area in Jamieson Track / Godfrey Track area that ran firstly towards the coast and then along the coast toward Separation Creek township when the wind became Northerly.
A third escape occurred prior to 2.30 pm. The 3.50 pm line scan had old heat signature trails suggesting there were four recent breakaways along the western end of Jamison Track that leap frogged under a North wind towards Separation Creek and Wye River townships. A fourth breakaway occurred after 3 pm along the eastern end of Jamieson Track, as suggested by the recent heat trail on the 3.50 pm line scan. It ran toward the 1.20 pm breakaway burn area.

Fire spread initially under NNW wind towards the coast but later fluctuated between N and NNW, probably with terrain induced deflections to a NW air flow. After 4 pm, wind direction stabilised at Northerly.
Fire spread rate averaged around 2 kph.
Most of the fire spread featured a sub canopy flame that scorched the canopy, but occasionally flared up and destroyed canopy patches, particularly on steep up slopes.

Spread mechanisms were dominated by short and medium distance spotting ahead of the smoke pall. There were two categories – scattered spotting and dense spotting. Scattered spotting was both short (few hundred metres) and medium distance (1 km or so). Dense spotting was akin to the Wandilo effect spread mechanism, however, it is probable that it was common because it was the mechanism with most potential to boost the spread rate above wind driven rate.

It is probable that the initial source of embers into Separation Creek was in the National Park, approx 1 km to the NW

Chapter 5 Bushfire behaviour within the townships

Figure 19 suggests the fire at the 3.50 pm scan was a huge mass of flame approx 3 km width and similar depth. This apparent flame mass is indicated by the purple heat signature, akin to an encroaching pestilence that engulfed everything in its path as it moved south into Separation Creek. But the next line scan at 4.45 pm (not shown here) showed that this purple mass did not spread any further down this slope but gapped across to Wye River township where it also moved part way down the southerly slope and stopped.

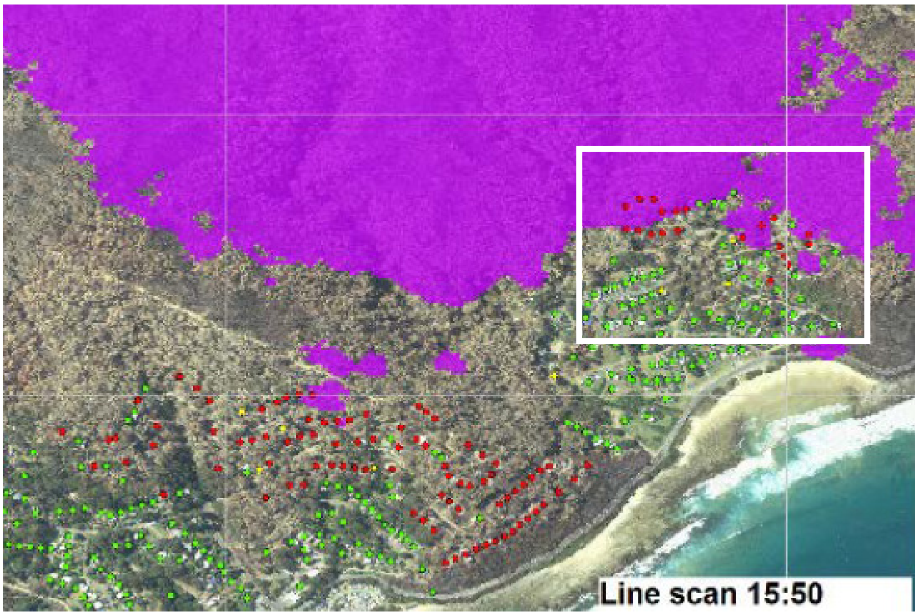


Figure 19 Copy of Fig 19 of CSIRO report Purple mass is heat signature, representing probable location of active flame at 15.50 on 25 Dec, 2015.
Red dots are destroyed houses; green dots are houses with no damage. The white rectangle refers to Figure 20

The CSIRO report describes “spotting ahead of the approaching fire fronts ignited and burnt back upslope towards the approaching fire, reaching the perimeters of the townships before the approaching fire front.” Other data in the CSIRO report corroborates media photos (eg, Figures 20 – 25) and reports from eye witnesses that the bushfire attack on Separation Creek and Wye River townships was an ember attack up to 200m ahead of southerly moving spot fires.

But the purple mass cannot be assumed to be a solid mass of flame, nor can the southern edge be assumed to be a continuous line of spreading flame. Technically, the expected maximum depth of a fire front in this forest in this wind is a few metres and the duration of the flash flame at any one point is around 30 seconds. The smoulder flame will burn longer as the thicker branches, logs and stumps burn out. This was endorsed in the FLIR images in Figure 20 where active flame was indicated as bright white. The images show that active flame occurred in localised areas, the leading edge was patchy and had a narrow depth. Thus the following sequence of FLIR and line scan images shows they were not neatly compatible, suggesting the method, speed and extent of fire spread down this slope was not as simple as the purple heat signature suggested.

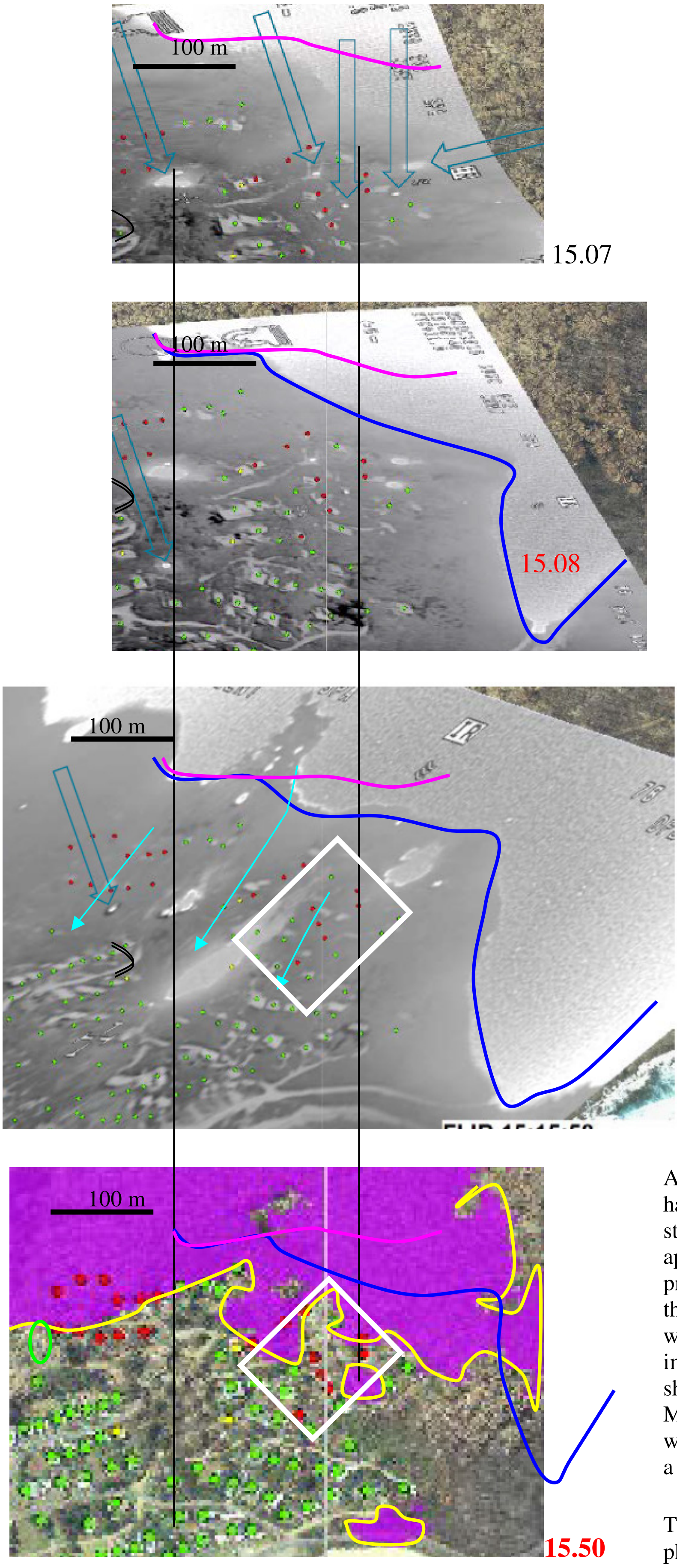


Figure 20 Fire front and spot fires spread down slope into Separation Creek at 15.50 pm on 25/12/2015. (blue hollow arrows are new spot fires)
Allowing for slightly different photo angles, these FLIR images show the apparent fire front moved down slope from pink at 15.07 to blue at 15.08 to unshaded at 15.15, to yellow at 15.50, a maximum distance of 150m in 43 minutes (= 0.2 kph), and then stopped spreading. Assuming the brightest white areas are active fires, the less bright white areas may have other explanations than the flame itself. The 15.07 and 15.08 images suggest the main fire was north of the pink line and a few spot fires developed 100 – 200m ahead of the apparent front.

By 15.15, some of these spot fires were spreading actively either along the contour or up slope, some died out and a few new spot fires had developed.

Blue arrows are indicative gully locations.
Overlay black lines show approx N-S alignment

At 15.15, two spot fires have a dull white area stretching towards the apparent fire front, but it is probably smoke. The thickest apparent fire fronts were in the NW of the image and in the SE, with a short fire edge in between. Most of the apparent edge was dull white, suggesting a heated air mass.

The white rectangle is area photographed in Figure 23

The attack on Separation Creek township was from two directions. Figure 21 shows the flame running vigorously upslope through coastal scrub. It is probable that embers from these flames were thrown by the NNW wind into the sea, not onto houses. Figure 22 shows spot fires igniting ahead of the smoke pall moving down slope. The ember source area was in the NW (see Figure 15). Early house ignition in Figure 23 was probably due to fine flammable fuel on roof or adjacent to house.

Figure 21 Photo by Tom Jacobs, published by ABC Looking north to Separation Creek, approx 3 pm. Flames leap above coastal scrub as they run uphill.

Figure 22 The fire entering Separation Creek from the north. Photo in Herald Sun. Between 3.15 and 3.50 pm
Red circles are spot fires. Blue circle encloses the two house fires in Figure 23. White circle is large airborne ember.
White arrow indicates a wide pall of vertically rising smoke at a time when prevailing wind is a 30 kph Northerly. If it is flame front, it is descending downhill. If it is a mass of simultaneous ember ignitions, it is a Wandilo spread effect mechanism

The student observes the heat signature did not go much further down hill after this photo. WHY?
The student can consider whether the stoppage was due to a downward spreading flame expiring when the wind penetration into sub canopy on the lee slope ceased or the mass comprised spot fires that ignited mid slope and ran uphill.

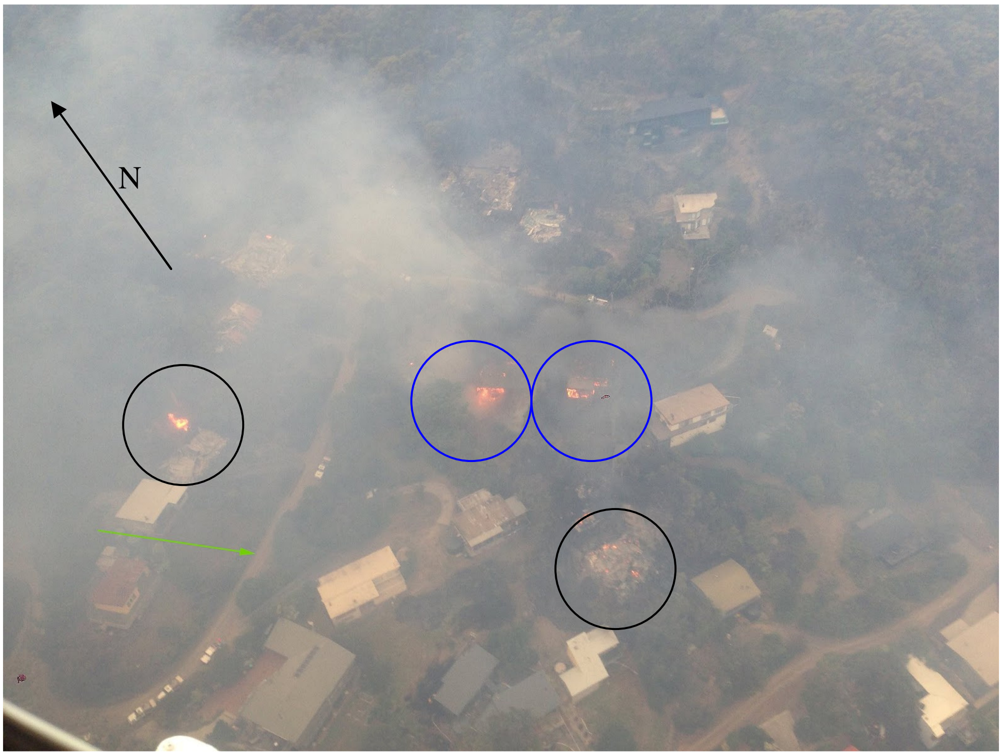
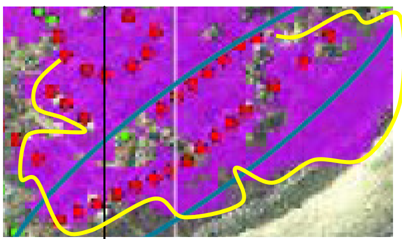
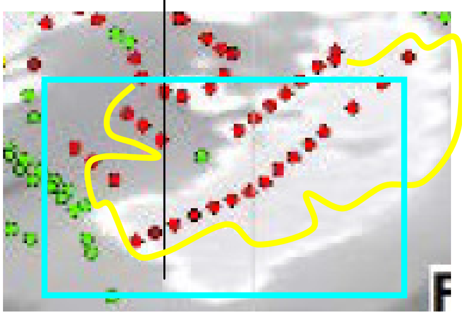


Figure 23 Image from http://bushfireaustralia.blogspot.com.au/. Footage Channel 7, ABC. Photograph shows houses in flame due to ember attack near Mitchell Grove (green arrow). Estimated time 3.15 – 3.50 pm

Similarly, the line scan and FLIR images for Iluka Avenue were not neatly compatible. Figure 24 suggested that this area was engulfed by flame at 4.45 pm (purple line scan) but the 6 pm FLIR image showed active flame in the same area on all perimeters spreading uphill, downhill and across contour. Persistence of flame for over an hour is not because the flash flame residence time for coastal shrub local vegetation is around 30 seconds and the smoulder time could be up to 10 minutes or so in thicker dead branches.



4.45 pm line scan Copy of Fig 20, CSIRO Report



6 pm FLIR image Copy of Fig 22, CSIRO Report

Figure 24

Successive heat signatures of Iluka Avenue area at 16.45 and 18.00

The CSIRO report explains the Iluka area may have been subjected to multiple fire approaches. But these successive scans do not match. The FLIR image's bright white flame perimeter may be expanding south from the yellow 16.45 outline, which appears logical, but its northern perimeter expanding within the yellow outline suggests some of the purple area was not burning at 16.45.

Blue rectangle area is the area photographed in Figure 25

The attack on Iluka Avenue was led by spot fires around 4 pm. Figure 25 shows there was no nearby mass of flame. Smoke from spot fires was heading uphill. This suggests the fires were not influenced by prevailing wind, meaning they were in lee shelter of the ridge or the fire front was blocking the wind. At least three houses were burning in Iluka Avenue, probably due to fine flammable fuel adjacent to house. Blue circle was most likely the dense smoke of merging spot fires (because of smoke direction) rather than an advancing fire front (if so, smoke would lean down wind).

Figure 25 Image from http://bushfireaustralia.blogspot.com.au/. Footage Channel 7, ABC. Estimated time is after 15.50, before 16.45.
Blue dashed line is Iluka Avenue. Blue arrow is prevailing Northerly wind
Yellow and red arrows are spot fire ignitions. Blue circle is most likely the dense smoke of merging spot fires.

The CSIRO report found that fire-impacted areas of Wye River and Separation Creek were typically the steepest areas, with gradients approaching 30 degrees. The report found leaf freeze was in the uphill direction, and Figure 20, 22 and 25 supported this, showing upslope smoke flow. They do not support the existence of a broad fire front creeping down hill. Figures 22 and 23 show spot fire attack on Separation Creek was scattered. Figure 25 shows many spot fires igniting simultaneously near Iluka Avenue before running uphill into vacant undefended houses. This confirms known bushfire behaviour that spot fires tend to run uphill in steep areas on lee slopes. FLIR images in less steep areas (Figure 20) show that spot fires in surface fuel beds ran across slope, upslope and downslope.

The CSIRO report also found that average flame height within the township was less than 0.4 metres. In some isolated areas flame rose into elevated fuels, eg, below Iluka

Avenue, and along creek lines. The report mentions average flame height at Iluka Avenue was 0.8m. The report also found that surface fuel throughout townships was virtually continuous, meaning there was little impediment to spread of flame wherever a flame front or spot fire occurred.

The CSIRO report found evidence of aerial water bombing and fire fighter activity near burnt and unburnt houses, but was unable to quantify activity levels. Media coverage suggested the main fire fighting effort was aerial water bombing mainly by helicopter buckets onto spot fires and some by fixed wing. Presumably, this continued until smoked out, around 4 pm. Figure 26 is a media photo of fixed wing bombing during the afternoon, corresponding with the strip of retardant shown on Figure 16.

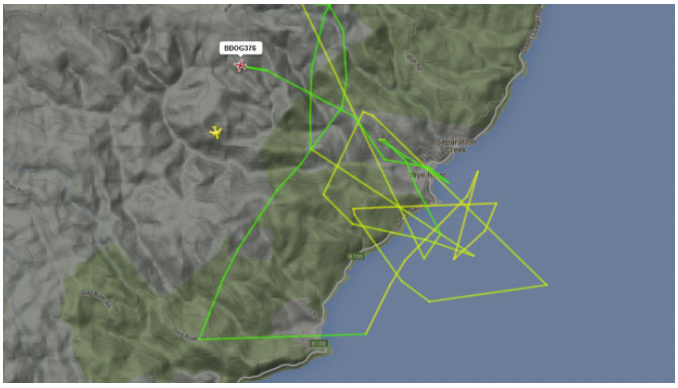


Figure 26 “Water bombers are doing bombing runs over Separation Creek and Wye River in a bid to contain the fire threatening those communities” (The Age, 3:07pm)

The student can explain whether the areas shown in Figures 23 and 25 presented fire fighters with a dangerous environment when the spot fires were small.
Explain how these neighbourhoods could have been made safely bushfire protected for fire fighters and residents to extinguish embers in safety.

Summary

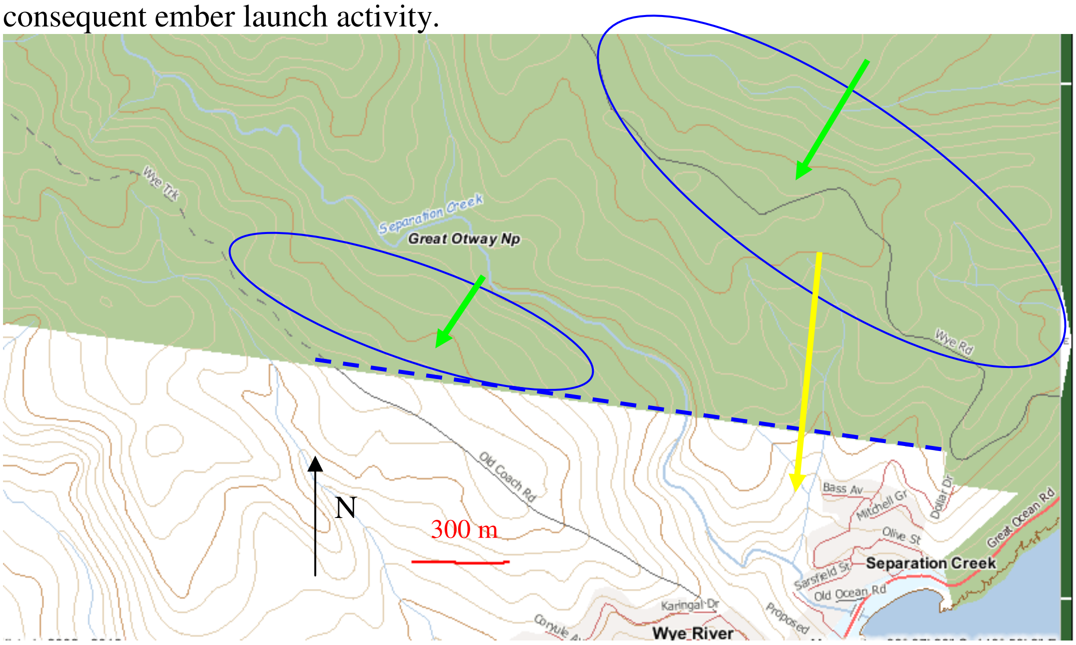
The initial bushfire attack into both towns was by embers commencing in Separation Creek around 3 pm and Wye River before 4 pm. The line scans suggested they was a huge fire mass, but FLIR images showed the leading edge comprised patchy fire fronts with narrow flame depths. Spot fires were up to a few hundred metres ahead of the mother smoke mass. Spot fire smoke direction varied between vertical, with the prevailing wind and opposite to the prevailing wind.

Most spot fires ignited the surface fuel bed on litter and grass, generating a low flame. Some ignited flammable fuel on house roof and sides and developed rapidly into a fully involved house fire. Some spot fires spread into higher fuel loads near houses that then ignited the house. Several houses burnt within half an hour or so after the ember attack began.
The continuous fuel between houses allowed uphill and lateral spread of the spot fires throughout the town.
Average flame height in surface fuel was under 0.4 m. but rose to 0.8 m when flame rose uphill in scrubby areas, eg Iluka.
The main fire fighting effort was aerial water bombing mainly by helicopter buckets onto spot fires and some by fixed wing.

Chapter 6 Preparation of the towns for a bushfire attack

This discussion considers a bushfire attacking from the North.

Figure 27 shows the southern boundary of National Park is a line on a map. There is no boundary track or fence line between public and private property. From the fire's point of view, if there is no fuel reduced infrastructure, it will run seamlessly across the boundary. The first upwind track from Separation Creek is the Wye Road which crosses the National Park diagonally along a ridge line. It theoretically could have been fuel reduced along its northerly slopes to prevent some flame run ups and consequent ember launch activity.



A Copy of DELWP map, http://nremap-sc.nre.vic.gov.au/MapShare.v2/imf.jsp?site=forestexplorer
Blue ovals indicate northerly upslope runs of relevance for a bushfire attack from the north.

B 3D aerial view of townships overlain by the area burnt by the bushfire (shaded brown) and the unburnt area (shown as unshaded).

Figure 27 White line is approx southern boundary of National Park. Yellow arrows indicate down slope runs. Green arrow indicates up slope run. Blue arrow indicates approx air flow of a Northerly wind.

The student can consider whether a link track along the boundary is possible and whether fuel reduction on the marked slopes would have stopped the spread of the fire into the townships or reduced the impact of the ember attack in the townships. The student can ask whether this infrastructure should have been an appropriate fall back control line strategy when the control team decided to back-burn along Jamieson Track.

The student can also consider this legal question – what infrastructure would be adequate or acceptable for the northern land owner to install along the forested boundary to meet his duty of care obligations to prevent fire escape from his property. The student can consider that a track along the boundary with a deep enough fuel reduced area would stop flame spread if it was a recent burn and if the track was adequately patrolled to prevent escapes.

The burn area would also absorb some of the short distance embers, but how can the land owner prevent escape of longer distance spotting? The student can consider two approaches – preventing ember production by fuel reduction at likely ember source areas and suppressing spot fires down wind of the boundary while small. Because suppression of spot fires that originate from the National Park is a foreseeable consequence of ember escape, the landowner may be expected by a court to either provide suppression capability or provide suppression assistance to residents down wind. The student can assess what a court ruling of "reasonable attempt to prevent fire escape" might be. The student can also consider what a court may rule if the landowner had installed no escape prevention infrastructure.

National Parks protection burning program

The only protection burning was in planning stage but it had been approved as Figure 28 shows. The dark pink area was scheduled for burning south of Old Coach Road in two years and the light pink area was scheduled in 3 years time. The planned burn area extended north to Godfrey Tk and the entire area north of Jamieson Track up to Cumberland Track (DELWP Forest Explorer web site, October 2015, reconfirmed July, 2016). Figure 28 shows the proposed burn area included a large area of private property (blue circle) abutting Separation Creek. Clearly, a boundary track along the National Park was not envisaged. One month before the fire, local residents advised me that National Parks staff sought permission to construct a track abutting Separation Creek township, no doubt planning for this burn.

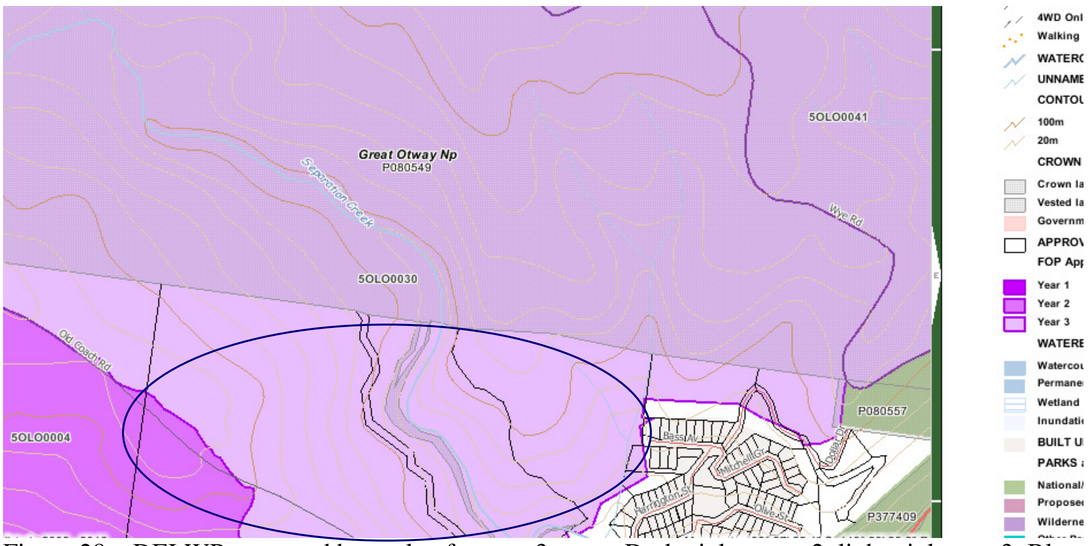


Figure 28 DELWP approved burn plan for next 3 years. Dark pink – year 2, light pink year 3. Blue oval encircles private property within planned burn area.

Formal public land bushfire planning

In 2015, the predecessor of DELWP published the Barwon Otway Strategic Bushfire Plan. Its Map 8 showed that the public land around Wye River area was classified as a Bushfire Moderation Zone.

Bushfire moderation zone: where there is fuel management to reduce the speed and intensity of bushfires, either close to towns or as they spread through the landscape

Its Map 9 showed they expected the public land around Wye River area to be burnt 5 to 6 times over the next 40 years.

The document explained their new risk based planning approach. The stated DELWP guiding premise was that an area with maximum fuel hazard was at maximum risk. They explained that this also meant maximum risk of damaging to houses and other assets, but they did not clarify that the Phoenix risk model was referring to fuel loads in 1 ha or 4 ha blocks of public land and that houses were on private property that was usually distant from public land but at worst was adjacent to public land.

The student can assess whether its guiding principle of maximum fuel load equalling maximum risk is appropriate since the theory behind the McArthur model for calculating rate of spread was disproven for wind driven fires a decade or more ago. [The Phoenix risk model uses the McArthur theory, which is that rate of flame spread is proportional to fine fuel load].

The student can assess whether the DELWP understanding that maximum fuel load is the sum of the fine fuel components on a given site (as its publication "Overall Fuel Hazard Guide describes) or the fuel load consumed by the flash flame phase, which is typically a small to medium percentage of the former. The student can compare DELWP's maximum fuel load approach with not so recent research by Vesta and Burrows which confirmed that the tall flash flame consumes only the top layer of the litter bed to generate flame height and flame spread rate.

The Plan said "Bushfires, and our fuel management strategy, reduce fuel hazard and so reduce bushfire risk. The remaining risk is called the residual risk".

The student can explain if considering bushfire as a means of reducing bushfire risk could be perceived as a conflict of interest or not.

The DELWP Plan said methodology for developing this plan was based on the International Standard for Risk Management, ISO 31,000. The risk assessment process aimed to determine the likelihood and consequence of a major bushfire impacting on people and properties.

The student can compare the value or relevance of using a risk based methodology like ISO 31,000, whose aim is to create value (it asks - what is the cost of defence and is it greater than the loss if no defence expenditure occurred), with a threat based methodology like ISO 27,000 which aims to identify specific threats and develop actions to mitigate or manage those threats.

The DELWP Plan used the Phoenix risk model to map likelihood of bushfire origins and consequences, in particular, potential house loss scenarios, and then prioritised to "protect those things at highest risk through the mitigation actions in this plan". for example, "DELWP has assumed that properties will be affected when fire intensity or ember density reach particular thresholds (intensity > 10,000 kW/m or ember density > 2.5 embers/m^2" (DELWP, 2015, Measuring Bushfire Risk in Victoria)

The student can assess the merit of using the Phoenix model to determine government policy that may influence house loss rate. For example, is it reasonable to base house loss on an assumption that house loss occurs when calculated ember density is 2.5 per sq m or calculated fire intensity is 10,000 kW / m? Does house loss assume the houses are defended or vacated? The student can also seek out and verify the sources of such data, bearing in mind that ember density is rarely measured and is not a proven cause of house loss, and that calculated fire intensity is a theoretical and unmeasurable concept.

The Plan showed on Fig 2 that residual risk was now 60% and that when the fuel burning program is fully implemented, it should reduce to 50%. Figure 3 (reproduced in Figure 29) shows how the expected house loss compares to residual risk. It shows that when DELWP's program is fully implemented, Wye River will lose 100 houses in a Black Saturday bushfire scenario. If this figure was credible, it is unnervingly close to the 116 house loss on Christmas Day 2015 which was not as severe.

DELWP has no intention of eliminating bushfire risk on public land: "Fuel management in many areas of public land cannot be undertaken because they are inaccessible, it is not safe to do so, or for other operational reasons".

The student can assume that DELWP apparent view that "the 100 house loss scenario is an acceptable loss rate" derives from the use of the ISO 30,000 approach, suggesting any further expenditure on protection has no additional benefit. Bearing in mind that inland Wye River has National Park on its danger sides, the student can assess whether the Wye River community would be satisfied with a government view that it another 100 house loss is acceptable. Presuming that no Wye River resident wishes to lose their house in a future bushfire, the student can consider how to advise Wye River township to achieve a zero house loss in a severe bushfire.

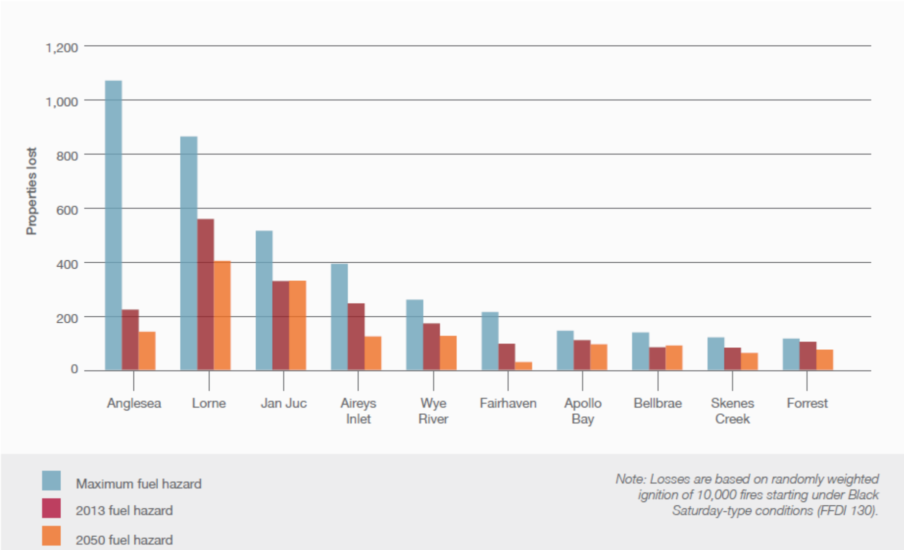


Figure 29 Expected house loss in severe bushfire, before and after fuel management. Copy of Fig 3 in Barwon Otway Strategic Bushfire Plan

The student can assume each local community will be dismayed by the government's attitude that – this is our fuel management program and these are the house losses, and that is all we are going to do. The student can reverse the approach – determine a house toll acceptable to each town and propose strategies deliver it to each.

Formal private property bushfire planning

In 2012, the Colac-Otway Fire Management Plan was approved under the CFA Act for the Shire, and it included Wye River township. It declared the Wye River / Separation Creek complex was at extreme risk and that a severe fire was "likely" and the consequence will be "catastrophic". It assigned a priority of 1B. It proposed a selection of action categories (100, 106, 111, 202, 217, 219, 223, 307, 418, 420, 700). The categories that relate to works on the ground and community empowerment are listed below:

100 Community Education/ Engagement: Bushfire education, engagement and training programs targeted at numerous community groups including school children, elderly, employees, and businesses
202 Burn program: Removal of selected vegetation in large patches to protect townships
217 DELWP Fire Management Zones: To provide areas of sufficient width to reduce the spread of Bushfire.
223 Vic Roads: Roadside Vegetation Management Removal of vegetation along roadsides.
420 CFA: Township Protection Plans Planned response (for both emergency services and the community) to a bushfire within close proximity to a township, which has the potential to impact on the local community.

The list shows the only protection from an incoming bushfire was reliance on the DELWP burn program. Apart from clearance along major roads by VicRoads, there was no internal fuel reduction program. The above was selected from a longer list of action categories. For townships classified as "extreme", there were some surprising omissions that related to works on the ground and community empowerment:

- Community Fire Guard A CFA key engagement strategy, community development program to help reduce the loss of lives and homes in bushfires.
- Fuel Hazard Management Reduction and removal of fuel to decrease the risk of bushfire in preparation for the Fire Danger Period.
- Crown Land Fuel Reduction Reducing fuel loads on crown land.
- Fire Access Roads and Tracks Establishment of constructed and maintained roads, bridges
- and tracks to allow safe passage for fire fighting vehicles.
- Asset Protection Zones Buffer zone between bushfire hazard and the asset.

- The student can observe that the only works on ground referred to in this Plan were burning programs by DELWP and road clearing by VicRoads, and that fuel hazard management on house sites was omitted as well as attention to fire access roads.
- The student can consider whether this plan was of acceptable standard to achieve its stated objectives of "protect and preserve human life" and "manage and reduce the risk of fire".
- The student can examine if this Plan had potential or intention to reduce the extreme risk status of the townships of Wye River and Separation Creek.
- The student can also examine whether the following supervisory clauses in the CFA Act were met and if they were of any assistance in protecting these towns in the recent bushfire: "Identifying areas, buildings and land use in the Colac Otway Shire that are at particular risk in case of fire; Specifying how each identified risk is to be treated and who is responsible for treating those risks"

Summary

The townships were rated at extreme bushfire risk but there was no protection. There were plans, but the towns had no fuel reduction infrastructure in place for protection from external bushfire. There was no program for internal fuel reduction. There was no infrastructure in place to prevent spread of flame or embers from National Park.

Chapter 7 House loss rate

House loss rate

The IGEM (2016) reported that 116 houses were destroyed, 18 in Separation Creek and 98 in Wye River. In this bushfire attack, almost all residents were evacuated by fire and emergency agencies. As discussed in Chapter 2, house loss rate in a bushfire attack is influenced by both passive and active protection measures. In this case, the influence of active protection is assumed to be minor. The IGEM noted that

- Planning for evacuation and traffic management commenced on 21 December.
- All houses in the evacuation areas were door-knocked, and most residents chose to safely evacuate.
- IGEM considers the evacuation strategy to be prudent, well planned and executed. It is an example of leading practice for shared learning.

The fire authorities commissioned the CSIRO “to perform a review and commentary of surviving and destroyed houses in Wye River and Separation Creek with the aim of identifying factors that led to the loss, damage and survival of houses and to illustrate these factors by citing examples from the fire footprint. Of particular interest are the more recently constructed houses built under the Bushfire Management Overlay (BMO) provisions”.

Even though the main focus was the influence of passive protection measures, the CSIRO report mentions some evidence of water bombing and on-ground fire crew activity, but was unable to assess the scale of suppression. Eye witness reports given to me by local fire fighters and residents suggests that on-ground fire fighting was patchy and in some cases was actively restricted by brigade captains and strike team leaders due to the general perception of danger. There was evidence that no attempt was made to stop the slow spread of the surface flame. Fire fighters on duty reported watching it continue to progress through Wye River township during the early morning (2 – 4 am) of the following day, igniting cars and houses almost 12 hours after the first ember attack.

As this analysis proceeds, the student can assess the impact of evacuation in this bushfire attack. By removing the opportunity for the occupant to defend their house, their house survival now depended on the action of fire fighters. Were sufficient resources allocated to cover their absence, or was the survival of their house put at risk by the evacuation policy?

The CSIRO report found there were 80 AS3959 planning referrals within Wye River and Separation Creek since 2003, but only 21 had usable data, ie, they were fully compliant - completed to occupancy and were exposed to bushfire attack. The CSIRO report made these observations:

(1) They found 21 houses that were AS3959 compliant and of these, 7 were destroyed, ie, house loss rate of fire resistant houses was 33%.

Further calculations reveal that 5% of the total house population (21/413) or 6.5% of the Sep Ck / Wye north house population (21 / 321) were AS3959 compliant and 6% of destroyed houses (6 / 116) were AS3959 compliant. This means there was no significant difference in house loss rate between compliant and non compliant houses. Black Saturday data estimates were that 10% (8 – 12%) of the housing population was AS3959 compliant that 9% of destroyed houses (177 / 2006) were AS3959 compliant. Again, suggesting that AS3959 compliance conferred no net extra protection (Bushfire Solution Paper 6B)

(2) "Of the buildings within the fire area**, roughly 80% were lost to fire".
[** "Within the fire area" is not defined, but it appears to mean within the burnt area (estimated on Figure 30), as distinct from within the area of ember rain.]
(3) They subdivided house loss rate by compliance dates - pre and post 2009, when some changes were made to AS3959. The post AS3959-2009 category had a 57% loss rate and the pre 2009 category had a 21% loss rate". The CSIRO report concluded the AS3959 standards provided "marginal improvement" in protection levels. The unstated inference in the report was that the post 2009 standards were less effective than the pre 2009 standards.
(4) They closely studied the fate of several compliant houses and all were BAL 29 and above. The inference can be drawn that compliant houses in these towns were of the highest fire resistance levels.

It can be noted at this stage that (1) a house loss rate of 80% is double the average house loss rate of the 2009 Black Saturday fires and (2) The 33% house loss rate in fire resistant houses (probably AS3959 compliant at highest levels) is a similar rate for all houses in the Black Saturday fires (39% within the fire perimeters (Leonard et al, 2009) and 33% for surveyed (Whitaker et al, 2013).

The student can assess whether outcome of this comparison is expected or unexpected. Why should the highest fire resistant houses have the same loss rate as non compliant houses? Why should the highest fire resistant houses in Wye Sep have the same loss rate as all houses on Black Saturday fires? Why should the Wye River fire have a higher house loss rate than Black Saturday fires if it occurred in milder weather?

The CSIRO presented other data but, in keeping with their terms of reference, they did not analyse it. However, this paper now does so by counting the red and green dots and reconciling the red dots with the known house toll of 116. The results of the count are in Table 2.

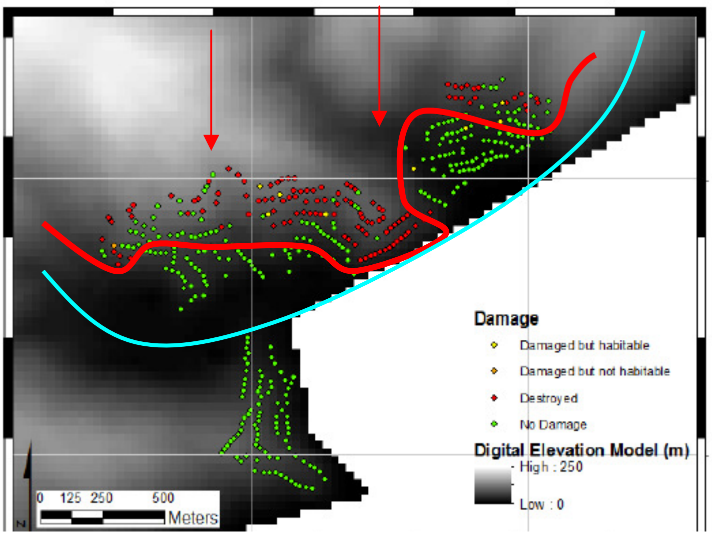


Figure 30

Copy of Fig 29, CSIRO Report

Shows clumped distribution of destroyed houses (red dots) on steeper slopes. Red line is estimated extent of burnt area. Blue line is estimated extent of similar intensity ember rain area. Red arrow is direction of fire spread

There are two ways of calculating average house loss rate – using the estimated ember rain area or using the physically burnt area. Because the burnt area is not reliably

estimated from the line scans, because the method of bushfire attack was embers, and because the location of the compliant houses is not known, the ember rain area is chosen to enable comparison of like with like. Wye River south can be excluded from the statistical analysis because of its greater distance from the ember source and zero reported house loss. Assuming similar ember rain across Separation Creek and Wye River north settlement, Table 2 shows that 321 houses (=120 + 201) were exposed to bushfire attack. Therefore, average house loss rate was 36% (= 116/321).
Of the 21 houses that were AS3959 compliant with the highest fire resistance levels, loss rate was 33% [7 destroyed / 21]. However, we can assume one quarter of the 21 houses were in Wye south area, the house loss rate of compliant houses within the ember rain area (Figure 30) was 43% (= 7 / 16).

Thus, there was either a negligible difference in house loss rate between the populations of AS3959 compliant and non compliant houses or more statistically likely, the AS3959 compliant houses had a significantly higher loss rate. This former possibility is similar to the Black Saturday data averages, but there was one significant difference, Wye River weather and fire behaviour was moderate whereas Black Saturday was very severe.

The student can ponder the worth and efficacy of the AS3959 standards if houses constructed to the highest fire resistance levels can have the same loss rate as non compliant houses in a moderate ember attack where the maximum flame height was 0.4m.

Table 2 House numbers and house loss numbers derived from Figure 30

Number of dots (approximates no. of houses)	Separation Creek	Wye River (north of river)	Wye River (south of river)	Total
Green dots	102	103	92	297
Red dots	18	98	0	116
Total dots	120	201	92	413
Estimated green dots inside fire area**	4*	20*	0*	24*
Red dots inside fire area**	18	79		97
Red dots outside fire area**	0	19		19

* Destruction numbers are estimated from red dot ratio per location 18:98:0. Based on CSIRO estimate of “80% house loss within fire area” [If 97 houses were destroyed within fire area, 24.5 were not destroyed (= 97 (1 / 0.8 – 1) = 24.5].
** Fire area is defined as falling within CSIRO’s purple area in Figs 19 and 20. Note: even though the burnt area is known to extend beyond the purple area, it can be considered as reasonable estimate.

Causes of house loss

The CSIRO report suggests there were four causes of house ignition – direct ignition by embers, ignition by flame in surface fuel which was ignited by embers, and ignition by flame in urban fuel that was either ignited by embers or ignited by flame in surface fuel that was ignited by embers. The embers originated either in short distance spotting from the nearby smoke mass or in medium distance spotting from up to 1 km upwind.
The CSIRO report observed that steep slopes led residents to use sub floor spaces for storage of flammable urban fuels, including domestic gas cylinders. These spaces

were significant in the house loss toll because the spot fires running uphill ignited them, thereby breaching the defence of the building's outer shell with a potent flame directly beneath the flammable interior of the house.

The report identified that few houses were ignited by surface fire but most were ignited by urban fuels that were in turn ignited by contiguous surface fire, most likely spot fires running up hill. Thus, surface litter provided a continuous fuel bed into these heavier elements. The main causes of house loss were listed as:

- House to house spread, when house separation was up to 12 m
- Retaining walls especially very flammable treated pine
- Under floor storage areas

House to house spread is of interest because it suggests ignition of the walls by radiation from the vertical flame of the adjacent burning house. Theoretically, the AS3959 model is designed to deal with high radiation from a close flame. It would therefore disturbing if any AS3959 certified houses ignited in this way.

It is instructive to summarise estimated house loss findings using the Blanchi et al (2006) categories of primary and secondary causal agents, subdivided by ignition mechanisms. Primary agents derive from the advancing fire fronts. Secondary agents derive from fuel ignited by one or more primary agents (usually by embers). The middle column summarises their research findings for several bushfires, and the third column is an indicative estimate based on data and comments in the CSIRO report. It indicates that the major cause of house ignition in these townships was flame contact by urban fuel that was most probably ignited by spread of low flame in the continuous fuel bed of grass and litter that was ignited by short distance embers.

Table 3 House loss by primary and secondary causal agents

Threat	**Contribution to house loss**	
Primary causal agents (from fire front in forest)	**Quantitative benchmark ****	**Qualitative estimate Wye River / Sep Ck**
Ember attack	Up to 90%	Low to moderate (1), (5)
Radiation	negligible	Nil (2)
Flame contact	negligible	Minor (3)
Secondary causal agents (flame and embers from urban fuel) *		
Ember	minor	Negligible (1), (6)
Radiation	minor	minor
Flame contact	10% plus	High (1), (4), (5)

* Blanchi et al (2006) identified urban fuel as flammable fuel close to the house, including fences, garden beds, other flammable yard fuel, sheds and houses. Typically, embers from the fire front ignite them when the fire front is distant. When they ignite, they generate their own ignition mechanisms – radiation, flame contact and ember attack, very close to the house.
** The Blanchi et al (2006) benchmark model explains the causal agents and their relative contribution to house loss. It assumes the house is vacant and not defended. It can be assumed that the secondary causal agents originate from the primary ember attack. They found that direct ember attack from the flame front onto the house in combination with urban flames were causes of almost all house loss in urban areas.

The following complementary notes refer to numbers in the third column:
(1) According to eye witness reports given to me, the residential area of Separation Creek was first attacked by embers. The scale of house ignition by direct ember attack cannot be deduced from the CSIRO report, but it is assumed to be significant. However, the CSIRO

report suggests the more common cause of house ignition was indirect ember attack, meaning that embers ignited the continuous surface fuels between houses, generating a low flame (0.4m) which spread unhindered into heavier urban fuel. Thus most houses were ignited by either spreading flame in surface fuel or stationary flame in urban fuel.

(2) Because the surface flame was very low, incident radiation was low and therefore radiation can be eliminated as a causal ignition mechanism.

(3) The CSIRO report suggested surface flame may have caused simultaneous house ignitions prior to 15.50 as the advancing fire mass spread down slope into Separation Creek. This would mean the ignition mechanism was direct flame contact. The report also suggested the taller flame near Iluka Avenue had the potential to impact the house directly, but did not confirm that the flame ignited them. Apart from these potential examples, there was no evidence of house ignition by the flame contact mechanism from the flame in the surface fuel bed.

(4) The CSIRO report found that the high house loss rate was due to flame in urban fuels that were adjacent to or underneath buildings. “These include adjacent houses (house-to-house ignition), combustible retaining walls, combustible decking, combustible stairways, vehicles, stored equipment, plastic water tanks and firewood”. See INSET below.

(5) Urban fuel could have been ignited by embers or by spot fire in surface fuel that embers ignited. The proportions of each cannot be determined from the CSIRO report, but it is proposed that because sub floor areas were well shielded from ember fall, most urban fuel was lit by surface flame, ie indirect ember ignition.

(6) It is possible that some urban flame could have thrown embers onto the house, but the report makes no reference to it.

INSET: The ignition mechanism was flame contact from below or adjacent, meaning the predominant heat transfer mechanism was the convection component of the combustion zone and the advection component due to the heat and speed of the flame body. Their combined flux can be up to a few thousand kW / sq m, which is one to two orders of magnitude above the flame’s radiation emissions of 100 kW / sq m, let alone the AS3959 specifications of 29 or 40 kW / sq m.

A simple example clearly shows that the AS3959 specifications grossly underestimate the heating power of convection and advection flux. Consider a wide flame face of 2m height and a 1 kg timber object at 1m from the wall of flame on a windless day. Assume the object receives incident radiation of 50 kW / sq m. Based on the Thomas (1970) figure of 1,000 kJ per kg, it takes 20 seconds to raise the object to ignition temperature (300^0C above ambient).

Consider the peak heat release rate (HRR) of the fuel bed which empowers the flame. Based on a litter bed with a peak mass loss rate of 0.05 kg / sq m / sec, peak HRR is around 900 kW / sq m. It can be assumed that around 20% of this is lost in radiation within and from the flame body (McGrattan et al (2000) found the percentage ranged from 10% for large diameter fires to 30% for small diameter), meaning vertical convection flux due to fuel bed combustion is around 700 kW / sq m.

Now consider the tip of the flame. Its air speed due to buoyancy is correlated with temperature and flame height. It generates an advective flux which derives from the movement of hot air, and is not connected with the peak HRR, and therefore adds to the total heat flux of the flame.
Upward velocity: Assuming the top of the solid flame is 800^0C above ambient with air density of 0.33 kg / cu m, and the top of the fluctuating flame is 500^0C with air density of 0.45 kg / cu m, the upward velocity of a 2 m solid flame is around 5.5 m/sec and of a 2m fluctuating flame is around 4.5 m/sec (equation in Thomas, 1962).
Advective flux: At the top of the solid flame, flux is around 1400 kW / sq m, and at the top of the fluctuating flame, it is around 1000 kW / sq m (equation in Thomas, 1970). This superheated air blast now takes one second to raise the same 1 kg object to ignition temperature. If the flame is taller, the flux increases, if a shorter flame, the flux decreases.
Now consider the same flames with a strong wind of 10m / sec. The early researchers would have said that the tilted flame increased net incident radiation onto the object, meaning it might take 10 - 15 sec to raise the object to ignition temperature. What they overlooked was the convective and advective flux in the parcels of the solid flame body being pushed laterally at 10 m/sec, delivering a massive flux of around 2,500 kW / sq m. The 1 kg object now reaches ignition temperature in 1/3 second.

But there is more. In addition to convective fluxes, when an object is impinged by a flame of temperature T Kelvin, it also receives radiation in proportion to T^4, which may be up to 200 kW / sq m

The student understands that the BAL level matches the heat flux of radiation from the flame face in nearest vegetation. The highest level of resistance is around BAL 40, meaning it theoretically prevents piloted ignition under radiation loads of 40 kW / sq m. The student can now calculate the upward velocity and advective flux from the tip of a solid flame of 1m, 4m and 10m tall.

The CSIRO report stated "It is clear that buildings built to the bushfire regulatory standards … were subject to these heavy (domestic) fuels, and many were not capable of withstanding the radiant heat or flame contact from these fuels. This appears to be a key reason why such a large house loss rate was experienced".

- The student can assess whether the AS3959 model caters for the flame of urban fuel, and if not, why not, and how can it be amended to do so.
- The student will realise that protection by the AS3959 model depends entirely on preventing flame penetration through the outer shell of the building. The CSIRO report mentions flammable storage in the sub floor. Explain why the AS3959 model failed to prevent sub floor flame penetration.
- The student can consider two aspects of the fire agencies' BMO defendable space concept – the specifications allow (1) fuel bed continuity and (2) low fuel load. This means if every house in these townships was compliant with defendable space specifications, there would be a continuous bed of low fuel load between the houses that if ignited, would generate a low flame that would spread unchecked. The CSIRO report described that this exact scenario occurred. How then can the student reconcile that this scenario, which was well within fire authorities' tolerance for BMO specifications, was declared as dangerous for fire fighters and residents alike, and was also the cause of mass house loss?

Oblivious to the above findings that a low flame in a continuous fuel bed was the source of catastrophic house loss of highly fire resistant houses compliant with the regulations, the fire authorities and other government agencies have persisted with current planning law. The next chapter examines the problematic logic and the science behind these laws and tries to assess their effectiveness. It clarifies how the laws are supposed to work. But then we discover a twist. Have the authorities thrown out the rule book and are now inflicting the house loss victims with another burden they do not need?

Summary

House loss rate The average house loss rate within the fire area was 80%. The average house loss rate within the ember rain area was 33%. The average house loss rate of AS3959 compliant houses was at least 33%, and probably around 43%. Thus there was either a negligible difference in house loss rate between the populations of AS3959 compliant and non compliant houses or more likely, the AS3959 compliant houses had a significantly higher loss rate.

Causes of house loss: Some houses were directly ignited by embers (via accumulations of fine dry flammable fuel in gutters, roofs and adjacent to walls), but most were ignited by flame in urban fuels that were ignited by low flame in contiguous surface fuel bed, most likely spot fires running up hill, which were in turn ignited by live embers originating from a few hundred metres to 1 km upwind. Continuous surface fuel bed of litter / grass provided an uninterrupted pathway to the flammable urban fuels. Few houses were ignited directly by flame in surface fuel bed.

Chapter 8 Rebuilding the burnt houses

Current planning legislation for new house construction under the Bushfire Management Overlay can be summarised in PPN 65 as follows. For an allotment within residential and township zones, as these destroyed houses were, Clause 52.47.1 applies. A site assessment and a bushfire management statement are required whereas a landscape assessment is not. Clause 52.47.2 applies to new house construction in other planning zones and it also applies to subdivisions, requiring documentation in all three categories - site assessment, landscape assessment and a bushfire management statement. For both Clauses, BAL level derives from distance between house site and the deemed hazard. Separation distance becomes defendable space. PPN 65 gives an example of the inverse correlation between the two - “the greater separation distance between the bushfire hazard and the proposed building, the lower the bushfire risk and construction cost.” In the case of subdivisions, Clause 52.47.2 is applied to groups of allotments by requiring that the building envelope on each allotment meets individual defendable space and BAL requirements, and to ensure implementation, a Section 173 agreement is inserted on each title.

The point to make here is that the government has established a set of rules and the last thing we would expect is what they have changed them for the house loss victims in these towns. But it has. In principle, a change that streamlines the bureaucratic processes should be welcomed. Unfortunately it will increase the financial burden of bushfire victims by inflating BAL levels well above the existing set of rules.

To understand how the rule changes inflate BAL levels beyond current laws and why the changes are ill founded and add no additional protection, the current laws are now outlined together with their flaws of logic, science and threat management.

Current planning laws for building new houses

It is public policy that a new house within a BMO area is deemed to be protected from ignition by severe bushfire when its AS3959 derived construction design rating (Bushfire Attack Level - BAL) matches the calculated radiation from a wall of flame in the fire front in accordance with the procedure and equations in AS3959. Severe bushfire is defined as tall flame in the nearest vegetation to the new house, and its separation distance becomes defendable space which determines the BAL. Thus, planning law implies that BAL ranks the bushfire threat level to the new house site and it is mitigated when (1) construction complies with that BAL and (2) defendable space maintained according to AS3959 specifications. The specifications include low fuel load on the ground within defendable space, which means authorities regard a low flame height as acceptable. They have no specifications about discontinuity of fuel load.

Outline of the AS3959 model

The AS3959 model identifies a bushfire threat to the house, quantifies it and provides a means of mitigation in proportion to the level of the threat.

Overview

The narrative of the model can be deduced as follows:
Identify the threat:

The threat is rapid piloted ignition of the outer shell of the house. The source of the threat is the fire front which is deemed to occur in the nearest vegetation to the house site within 100m radius. This fire front generates flame, radiation and embers, and the closer the vegetation is to the house, the higher the level of radiation** and "risk of ember attack" and flame contact at the house site. The threat level is quantified as the maximum radiation level received on the house wall from the tallest possible flame in the nearest vegetation. (The vegetation is assumed to be at maximum fuel load and to generate a flame which is 100m wide and of two minutes duration with a height calculated by AS3959 equations. See below). The threat level is classified as Bushfire Attack Level or BAL. It ranges from 12.5 to 40+, reflecting incident radiation levels of 12.5 to 40+ kW / sq m.

** Technically, higher radiation means construction materials ignite faster. The model assumes radiation from the flame face lasts for 2 minutes, which means if high heat flux causes ignition time is less than two minutes, the highest BAL 40 design will ignite.

Mitigate the threat:

Each element of the building's outer shell is identified and the component materials are assessed for resistance to ignition at each threat level. This allows fire resistance of building materials to be graded to match that threat level. For each BAL, the AS3959 model presents a package of construction specifications whose component materials have been tested in the lab to resist ignition at that BAL. Thus the AS3959 model deems that if a house site occurs where the threat level is assessed at BAL 29, building the house with the materials specified in the BAL 29 package will mitigate the bushfire threat.

NOTE: no other ignition source is contemplated, eg, fine fuel build-up on or near the house, cracks or surface roughness in materials, flame from close urban fuel.

Detail

Calculating the threat level:

The AS3959 procedure is firstly to identify the nearest vegetation within 100m of the proposed house site, then to measure the horizontal distance between house and vegetation and then to assume that this vegetation is the fire front. The fire front has a defined width of 100m and the AS3959 equations calculate the tallest possible flame height in it. This wall of flame radiates onto the house site with a level between 12 and around 50 kW / sq m. This flame also generates the embers that fall onto the house. The closer the vegetation is to the house, the higher is the radiation level and risk of ember attack.

Equations for calculating flame height:

After identifying the vegetation type with AS3959's ecological vegetation classes within 100m of the house site, AS3959 defines each vegetation type with a maximum fuel load (W). It defines weather as 40^{0}C, 12% RH and wind speed 40 kph.

The following equations are used for forest and woodland vegetation.

(F1) Calculate rate of spread (R) with **R = 0.0012 x FDI x W,**

(F2) Adjust rate of spread for slope with **Rslope = R x exp (0.069 x slope)**

(F3) Calculate flame length (Z) with Z = **(13 x Rslope + 0.24 x W) / 2**

(F4) Calculate radiation from flame length using View Factor equations, assuming the flame face is 100m wide flame front and emitting radiation at 100 kW / sq m.

The following equations are used for shrub or scrub vegetation

(S1) Calculate rate of spread **R = 0.023 x wind^1.21 x veg height^0.54**

(S2) Adjust rate of spread for slope with **Rslope = R x exp (0.069 x slope)**

(S3) Calculate Byram's Fireline Intensity - **BFI = H x fuel load x Rslope**

(S4) Calculate flame length with **Lf = 0.0775 x BFI^0.46**

(S5) Calculate radiation from flame length using View Factor equations, assuming the flame face is 100m wide flame front and emitting radiation at 100 kW / sq m.

Summary:
The perceived AS3959 threat is piloted ignition of the house by a fire front in the nearest vegetation deemed to be at highest fuel load.
The ingredients of piloted ignition are heat and pilot flame, and this fire front delivers them with flame, radiation and embers.
The closer the vegetation is to the house, the higher the radiation level, which means the faster the construction materials ignite.
Ignition of construction materials is prevented at any radiation level by using AS3959 materials whose fire resistance has been tested against that level.

Evaluation of AS3959 as a proxy for assessing and mitigating threat of house loss

Assessing threat of house loss
1 The AS3959 model assumes radiation is the major cause of house loss in a severe bushfire.
In reality, radiation is a negligible cause of house loss. The overwhelming causes are ember attack onto the house and urban flame from urban fuel that embers have ignited. Thus, the AS3959 package is designed to treat a threat that is insignificant.

2 AS3959 assumes piloted ignition from the fire front is the major cause of house loss. Piloted ignition (also called hot ignition) is preheating the surface to vapourise the volatile gases and providing a spark to ignite them. In a bushfire, piloted ignition occurs when the fire front is very close to the house.
In reality, the fire front rarely reaches the destroyed house. Most houses are ignited by embers when the source fire is not close. When these embers ignite the house, the mechanism is “cold ignition”.

The student asks - why can’t the AS3959 model protect these houses from “cold ignition”? If the nearest classified vegetation is at a distance, the BAL is low (or 12.5 in Victoria), meaning it provides some ember protection to the building shell by gap size restriction, but because it assumes there is no fuel threat other than the tested building materials, it ignores flammable fuel sites in and adjacent to the house, eg, dead leaves in gutters and roof valleys, dead grass or mulched garden beds against walls, or fences. A low BAL also means that the external shell has materials of lower fire resistance. Therefore, if embers ignite and the spot fires grow, their flames can ignite flammable bits of external building materials by flame contact or crack windows and allow flame entry. Thus AS3959 is designed to protect specified building materials on the building shell from piloted ignition, but assumes the many other flammable things in, on, under and near the house do not exist. Because the flames from the peripheral materials have heat fluxes that are one to two orders of magnitude higher than even the highest BAL’s, AS3959 compliance levels provide no resistance to rapid ignition.

3 AS3959 assumes there is no threat to the house from beyond 100 m radius. It assumes the only threat comes from the nearest vegetation patch because the fire front occurs there and it generates all the radiation, flame and embers that fall onto the house.
In reality, embers can source from any distance upwind or down-hill from the house site. In a severe bushfire, they occur in very high density within 500m of an established fire front in a forest, and at reducing density as distance increases. If these embers ignite the house, the mechanism is “cold ignition”.

The student asks - why can’t the AS3959 model protect these houses from “cold ignition”? See above answer

4 AS3959 assumes there is a main fire front and that it passes over the house site.
In reality, a severe bushfire in a forested landscape is a multitude of spot fires of varying size, running in parallel and leap frogging independently across the landscape generating short,

medium and long distance spotting simultaneously. This is why the first bushfire element to attack a house is the ember, when the source flame is not within sight.

The student asks - why can't the AS3959 model protect these houses from "cold ignition"? See above answer

5 AS3959 assumes the nearest vegetation ignites to become the fire front.
In reality, the nearest vegetation can only become the fire front if it is downwind of the advancing flame and upwind or down hill from the house site. If we assume the danger side is between N and SW, only 1/3 of the nearest "classified vegetation" can become a threat to the house site. Neither AS3959 not the fire authorities recognise direction in the planning laws and require such house sites to have a BAL based purely on distance to nearest vegetation.

6 AS3959 assumes the fire front does not come closer than the nearest vegetation
In the AS3959 model, BAL is calculated from distance to nearest vegetation. AS3959 assumes the flame stops at the nearest vegetation and uses it to calculate radiation levels onto the house. Meanwhile, the fire authorities deem this distance as defendable space and assign it with fuel load specifications that reduce the flame height near the house and presumably make it safe for fire fighters that may come to extinguish the house. Thus, fire authorities allow a low flame into defendable space, whereas AS3959 magically keeps it fuel free.

7 Equations used to calculate deemed flame height in deemed fuel hazard are not only invalid but are used in ways that breach bushfire behaviour science theory and principles.
The process of calculating flame height from rate of spread is scientifically untenable because there is no evidence or logic supporting a causal correlation between the two. For example, equation (F1) is based on an equation that was disproven several years ago, and equation (F3) is an unverified variation of an equation that was also disproven several years ago.

Mitigating threat of house loss

8 AS3959 considers only one way to mitigate the assumed threat, ie, protect the new building from ignition. Australian Standards is not responsible for how fire authorities use its AS3959 system as a unilateral solution for new houses.
The fire authorities evidently agreed strongly with the AS3959 approach for the new house because it is the only method that they use and they require it to be done by law. Even though new houses are usually interspersed among existing houses, and they may encourage existing house owner to retro-fit according to BAL construction standards, they have no legally enforceable program to protect individual existing houses against the same assumed threat.

In reality, there are at least two options to mitigate a real or a deemed threat – make the house builder protect the house from the threat or make the owner of the hazard mitigate the threat to protect the neighbourhood. The latter approach is the common law / duty of care approach for dealing with a threat in a neighbourhood, whereas the fire agency approach of making the house fire resistant is a reversal of duty of care protocols.

Fire authorities have an incongruous approach to community protection even though they are legally responsible for providing prevention and suppression services. They identify the nearest vegetation to a new house site as a deemed threat, but there is no process to reduce the threat, nor to advise the owner of the threat's danger and his duty to mitigate it, nor to warn surrounding residents of the threat's existence. Instead, the authorities almost secretly require owner of the new house to pay tens of thousands dollars more for self protection and the deemed threat remains in place. Because the owner of the hazard is not required to mitigate the hazard, the whole neighbourhood remains threatened by the deemed threat in perpetuity. That is the case if the nearest vegetation is a real hazard of legitimate concern. If it is a real threat, and the fire authorities leave it unmitigated when they have the powers to mitigate, they can be accused of abrogation of their legal obligations. If it is not a real threat, they can be accused of unfairly penalising the new house builder to pay unnecessarily for a non existent threat. Either way, their incongruous approach is inadequate.

The student can consider if their one eyed determination to force individual new houses to build according to AS3959 construction standards at inflated prices has blinded them to community wide bushfire protection by using much more effective and efficient methods?

9 The AS3959 process of maximising flame height may have suited its purposes of a built-in safety factor, but its rigid application by fire authorities precludes any prospect of encouraging mitigation of a fuel hazard.
Fire authorities' requirement that new houses have maximum fire resistance and their lack of desire to mitigate the deemed hazard ensures it remains intact. If it is a true hazard, as some are, all incentive for the house builder and neighbours to encourage the owner of the hazard to mitigate it is removed.

10 If the AS3959 model was effective, house loss statistics would show that AS3959 or BMO compliant houses have a lower house loss rate than non compliant houses in the same bushfire attack.
Pre 2009 research found the major influence on house loss rate was whether the house was defended or undefended. The house loss rate of defended houses was one sixth of undefended houses. The 2009 bushfires destroyed 2000 houses. The VBRC was told by the fire authorities and building authorities there was no evidence that the AS3959 compliance systems reduced house loss rate. I analysed the data presented to VBRC and found that there was no difference in house loss rate between the compliant and the not compliant. One bushfire averaged 9% for both. One town averaged 85+% for both. I analysed CSIRO data from the Wye River bushfire's 116 house toll and found the house loss rate the compliant and the not compliant were the same at around 33%.
Thus, there is no evidence that AS3959 model reduces house loss rate in severe or non severe bushfires.
Warning note: There was one unexpected and worrying loss rate within the VBRC data. Life loss rate was three times higher in compliant houses that non compliant. Indeed evidence taken by the VBRC supported the view that people saw compliant houses as safer and desperately sought their final shelter in them.

Summary:
The AS3959 package cannot be regarded as a **proxy for assessing risk of house loss** because its assumptions do not align with reality:
The AS3959 package focuses on radiation, but in reality it is a negligible cause of house loss.
AS3959 regards the threat to the house is ignition under heat from the fire front, but in reality the fire front is rarely near the house at time of ignition.
AS3959 assumes there is negligible threat to the house from beyond 100m, but in reality it is the source of most threat.
AS3959 assumes the fire front passes over the house, but in reality, a main fire front does not exist
AS3959 assumes the threat is the nearest vegetation, but in reality up to 2/3 of closest vegetation is not excluded because it is not on the danger side.
AS3959 assumes the fire stops at the edge of nearest vegetation, but in reality, fire authorities allow low flame to run up to the house site.
Equations used to calculate deemed flame height are invalid and used unscientifically

The AS3959 package cannot be a **proxy for mitigating risk of house loss** because:
AS3959 was not intended to indicate risk of house loss because it proposes only one solution for a specifically designed threat to the new house, yet the fire authorities apply it without supplementing it with other threats or solutions and with no regard for protecting existing houses from the deemed AS3959 threat.

The AS3959 concept of maximum flame height is copied by fire authorities and the result is that incentive to mitigate a true hazard is precluded
Available post fire data shows AS3959 compliant houses have the same house loss rate as non compliant houses

Changing the rules

Sequence

On 10 March, unbeknown to the local burnt out community, a document ("Wye River and Separation Creek bushfire affected properties (March, 2016)") was submitted to the Minister to amend the local planning scheme, but it was not subjected to public exhibition. It was approved under "Minister Intervention" powers on 31 March and the planning scheme was duly amended - Amendment C089 - by adding this "incorporated document" to Schedule of Clause 81.01. One main purpose was to "specify bushfire attack levels for the purpose of regulation 811(1) of the Building Regulations 2006". These levels were referenced to a government map "The *Wye River and Separation Creek bushfire attack level GIS data 2016* (Department of Environment, Land, Water and Planning)". The section below reveals that these bushfire attack levels are different from the levels referred to in the Building Regulations. To differentiate each in this report, the AS3959 levels will be referred to as **BAL's** and the government revised levels will be referred to as the **DTBAL**'s.

On 31 March, the government authorities' Fact Sheet (2016) notified the residents http://wyesepconnect.info/Fact%20Sheets/Fact%20Sheet%20Bushfire%20Attack%20Level%20final_310316.pdf
of Wye River and Separation Creek who suffered house loss that their property had been pre-classified at a specific **DTBAL**, and that if they comply with the streamlined process, their rebuilding application can be done much more smoothly than if they proceed through the process as required by current planning law. It made no mention of changes made to planning laws via Amendment C089.

On 5 April 2016, the community was advised of an amendment to planning scheme – http://wyesepconnect.info/minister-planning-approves-planning-amendment/.
The notification stated: "the settlement wide (**DT**)BAL reflects the shared responsibility of individual landowners in reducing bushfire risk to enhance community safety".

On 8 April, 2016 the local peak community group expressed major concerns:
Message from Community Representatives on the Wye River and Separation Creek Community Resilience Committee: We are dismayed and disappointed by the Minister for Planning's unilateral determination on such an important community issue. The Minister's determination to restrict appeals against (**DT**)BAL ratings has not considered all the evidence and removes the basic right to independent review of a decision that could detrimentally affect the viability of hundreds of properties in Wye River and Separation Creek. There has been no adequate consultation to date about the BAL rating process with the community of Wye River and Separation Creek.
http://wyesepconnect.info/minister-planning-approves-planning-amendment/

To summarise so far, Amendment C089 was approved in March and the public was advised in April. Two key supporting documents (Terramatrix and CSIRO) were released later and both were dated after March, suggesting their contents may not have been fully considered during the March approval process. For example, when the Terramatrix report, dated April 2016, was released, it revealed that the DELWP bushfire attack level map was derived from the Terramatrix report, and that the methodology to derive their **DTBAL's** was very different to the AS3959 method of calculating **BAL's**. In May 2016, the CSIRO report (dated April 2016) to CFA about house loss was released to the public, revealing the high loss rate of houses with very high **BAL**'s despite an average flame height of only 0.4m. http://wyesepconnect.info/csiro-report-released/

Analysis of changes and their implications

The Government authorities' Fact Sheet (2016) seemed to be a part explanatory but largely marketing document with fulsome reference to a comprehensive and detailed study, protection of life and easier and cheaper process. A statements like "It is strongly recommended that residents consider the new BAL assessment rating established as part of the settlement wide study" gave no indication that the planning scheme had just been changed. This section now addresses some technical issues raised in the Fact Sheet where it implied that (1) residents will save money, (2) the new streamlined process was "designed to prioritise community safety", (3) the pre-determined **DTBAL's** were a proxy for risk and were based on a detailed study of bushfire risk, (4) the **DTBAL's** were the same as the AS3959 **BAL's**, and (5) changes were legally valid.

(1) Will residents save money?

The government authorities claimed the streamlined process will save residents the cost of preparing a Bushfire Management Statement, but they did not explain that their imposed **DTBAL**'s are much higher than if they were calculated according to current planning law and that the higher **DTBAL**'s add tens of thousands of dollars to their construction costs.

The student can explore the impact of and the reasons behind such a "sales-type" argument. The student can explore the implications if the streamlined process is found to be legally invalid, eg, will residents be entitled to be compensated for this cost differential?

(2) Was the new streamlined process "designed to prioritise community safety"?

The government's adoption of the Terramatrix report implies acceptance of the unsubstantiated and incorrect Terramatrix opinion that "Overall a net improvement (in public safety) should be achievable by building to BAL FZ, BAL 40 or BAL 29". In contrast, an alternative view was stated by the Building Construction Advisory Panel on 10 May 2016: "a higher BAL rating is not necessarily an improvement on personal safety or guarantee of building survival, especially when Fire Danger Ratings reach severe and above".

The student can consider the following Terramatrix arguments and examine if the government's apparent acceptance of their conclusion that higher BAL improves bushfire safety was reasonable or ill-advised:

> It should be noted that under the BMO, the BAL for a dwelling requires that the requisite distance of defendable space be provided between the building and the hazardous vegetation. Thus the applicability of the BAL mapping in providing an acceptable risk, according to the BMO, is dependent on the geographic extent and fuel reduction standard of the vegetation management around and within the settlements. The BAL mapping assumes that the requisite defendable space will be provided. As discussed by the Project Reference Group, an alternative approach would be to achieve a net improvement in bushfire safety compared to pre-December 2015 conditions. A net improvement should be achievable by building to BAL-FZ, BAL-40 or BAL-29 as appropriate, even if compliance with the provisions of the BMO cannot be achieved on individual lots. This would be a pragmatic approach that recognises the significant constraints of the existing settlements, but is a policy decision for DELWP or government.

The Terramatrix argument in this excerpt is now paraphrased and annotated:

Terramatrix assertion	Comments
BAL requires defendable space distance to be provided	Incorrect . BAL is calculated from defendable space
BMO requires acceptable risk, so the applicability of BAL mapping relies on adequate fuel reduction in surrounding vegetation and within towns.	BMO makes no reference to or requirement for BAL mapping
BAL mapping assumes defendable space meets specifications	Ditto
Because Terramatrix and government authorities do not believe locals can achieve this on their allotments, BAL will be increased to compensate.	Ill-informed and subjective judgement
Increasing BAL will achieve net improvement in bushfire safety (encircled in red)	No evidence is available that links BAL to bushfire safety. Available evidence suggests BAL system causes no change in house loss rate.

The student can consider if the authorities misunderstood Table 1 of Clause 52.47.3. For example, if BAL is 29 or above, properties need only be maintained to specification within property boundaries, which may only be a few metres. Conversely, if BAL is lower, properties have to be maintained to specification for full defendable space. Would not a wider area of low fuel load have been a better township level fire protection approach, than a narrow area?

The student can compare the Terramatrix suggestion that higher BAL levels within a town improve bushfire safety with available evidence about house loss rate, particularly as the purpose of the BAL system is to mitigate a cause of house loss that is non existent in severe bushfires - radiation from the flame face of an artificial fire front. Other evidence includes the poor opinion of the VBRC toward the AS3959 system and data in the May 2016 CSIRO report that the house loss rate for the highest BAL levels was no different to the house loss rate of non compliant houses, both being much too high, at 33% or more (analysis data available from author).

(3) Can the pre-determined DTBAL's be used as a proxy for risk and were they based on a detailed study of bushfire risk?

The Fact Sheet identified the study was a "BAL assessment study" done by Terramatrix. The Terramatrix study (dated April, 2016) stated that the assessment of the study area "was done using the site assessment methodology of the BMO", and stated their vegetation maps were simplifications (based on specific definitions), saying they do not necessarily resemble either pre or post recovery vegetation. As such, the study cannot qualify technically as a genuine assessment of either the site or the vegetation for a determining true bushfire risk.

The Fact Sheet strongly implied the imposed **DTBAL's** were the result of a comprehensive risk analysis model and that the map they produced was a map of bushfire risk. The Fact Sheet quotes included:

- The (DT)BAL assessment study, based on a comprehensive settlement wide risk-analysis model, has considered topography, vegetation classifications and the impact of fuel management scenarios.
- The State Government has conducted a detailed assessment of bushfire risk for the Wye River and Settlement Creek region. This study has considered topography,

vegetation classifications and the impact of fuel management scenarios on the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact.

- The government and Council have partnered to map the bushfire risk — known as 'Bushfire Attack Levels' — in the impacted areas of Wye River and Separation Creek.
- The assessments have been completed in accordance with the finding of the 2009 Victorian Bushfires Royal Commission.
- This study is based on a comprehensive settlement wide risk-analysis model that aims to minimise bushfire risk. This assessment is designed to prioritise community safety, liveability and drive community resilience to bushfires.

The student can consider the following responses to these quotes:

- To imply that the AS3959 BAL or the DTBAL is based on a comprehensive risk analysis model is a gross misrepresentation. The AS3959 BAL derives from defendable space, which is the distance between the house site and nearest vegetation.
- The DELWP map of "bushfire risk" was done by a private company Terramatrix, not by government, and it was technically a DTBAL map calculated using Terramatrix innovative methods and opinions. Their package was accepted by government.
- To state that the State Government has conducted a detailed assessment of bushfire risk for the Wye River and Settlement Creek region is a misrepresentation because the Terramatrix study was entitled "BAL assessment study".
- To suggest that bushfire risk is associated with AS3959 BAL is a gross misrepresentation of both BAL and bushfire risk. BAL measures theoretical radiation onto the house from an artificially inflated flame in the nearest vegetation, but because approx 2/3 of nearest vegetation is on the non danger side and because radiation is a negligible cause of house loss in a severe bushfire, BAL has no correlation to either bushfire risk or risk of house loss. The Terramatrix method of calculating DTBAL is very different to AS3959 method, and because it is based on radiation levels and subjective opinion of residents' future maintenance failings, it has even less correlation to either bushfire risk or risk of house loss.
- To state the assessment complies with the Royal Commission findings is bizarre because the VBRC was very critical of the AS3959 model and besides, the assessment method for DTBAL would have been foreign to VBRC.
- To claim that the AS3959 BAL risk model aims to minimise risk is a gross misrepresentation. If they believe BAL is a measure of bushfire risk, to reduce risk means BAL must be reduced. But because BAL is based on distance to nearest vegetation which is unchangeable, risk level cannot be reduced unless the vegetation is removed.

Nevertheless, the government authorities seem to have adopted a view that the concept of **BAL** or **DTBAL** is a universal measure of bushfire risk, when it is not. Terramatrix seem to believe BAL and DTBAL are a universal measure of bushfire risk. Appendix 1 of their report summarised their approach to an earlier assessment of bushfire risk at eight towns in the Otways. They conducted two levels of risk assessment, landscape risk and BAL mapping. For BAL mapping, they innovated by changing the procedure of AS3959. Instead of calculating BAL **after** measuring defendable space and slope, they calculated radiation from the forest boundary using maximum fuel load and then assumed that all allotments within the settlement would also have high radiation levels. Their map of Wye River and Separation Creek showed almost all allotments had very high DTBAL. If they had used the AS3959 procedure, the very high DTBAL allotments would have been restricted to 25 metres or so from each upslope forest boundary.

Using AS3959 BAL as a measure of bushfire risk is to extrapolate AS3959 well beyond its design criteria, which targets only one threat. Its stated objective is to reduce risk of piloted ignition by the fire front which resides in the nearest vegetation. Because BAL is based solely on distance between house and vegetation, the only way that AS3959 risk of ignition changes is when the distance between the house site and vegetation changes. Therefore, technically the AS3959 concept of risk can only be applied to an area where a house exists, where the nearest classified vegetation is within 100m of it, and where the fire front sweeps into and consumes the nearest classified vegetation which showers radiation and embers onto the house and menaces the house with one threat - piloted ignition, and then continues past the house site. Because such a scenario is rare in Victoria, AS3959 cannot be validly extrapolated as a measure of bushfire risk.

Ironically, a few edges of the Wye River and Separation Creek towns almost met the AS3959 concept, except that house ignition was caused by a different threat - flame contact with convective fluxes that exceeded BAL levels by one to two orders of magnitude. The CSIRO report found that most house loss occurred when urban fuel was ignited by free running low flames between the houses. These and other flame sources are not envisaged by AS3959, which assumes the flame stops at the edge of nearest classified vegetation. When authorities adopted the AS3959 system, they defined the separation distance between house site and vegetation as defendable space and allowed continuous low fuel load within it, which meant they tolerated low flame within defendable space. Theoretically, the AS3959 model could work if all houses had defendable space that was fuel free, but it would have been undermined by the fire authorities' acceptance of continuous low fuel load within defendable space.

The student can assume that the Terramatrix report correctly transcribes AS3959 Appendix G into its Table 1 (p 19) and the CFA diagram into its Fig 2, and that both accurately show the context of AS3959, ie, that it regards the nearest "classified vegetation" as the fire front and as the sole source of radiation, flame contact and embers. The student will understand that the Terramatrix Table and the diagram describe an increasing radiation level as the AS3959 flame front gets closer to the house, complete with increasing risk of ember attack, ignition of burning debris and flame contact, and that this means the speed of the main AS3959 threat of piloted ignition will also increase. The student can assess whether the BAL's of AS3959 model can be extrapolated as a universal measure of bushfire risk when it is a single focused threat model and if house loss by this threat is negligible.

(4) Were pre-determined DTBAL's the same as the BAL's of AS3959 / BMO?

Although both systems determine the threat to a property and assign a mitigation mechanism, the methods and processes are very different.

- The AS3959 model uses a published process to determine the BAL onto an individual house site (= the BAL of the threat) and then assigns a construction standard of the same level to mitigate the threat (= the BAL construction standard).
- The Terramatrix model determines a perceived threat level for each broad vegetation zone (eg, peak radiation level for forest and scrub and a subjective judgement for Mod Veg and Low Threat) and then assigns a construction standard BAL to mitigate the threat to all allotments within each vegetation zone (= the BAL construction standard).

*Procedure for calculating **BAL's** under current BMO planning laws:*

All the burnt houses allotments are in the Township Zone. The procedure for a new house application in a Township Zone is Clause 52.47.1 methodology, where horizontal distance between nearest vegetation boundary and house site becomes defendable space, which is used to in Table 1 to calculate the BAL of the threat.
If there was an AS3959 BAL map, it would assign the relevant BAL of the threat to each allotment, and it would be known that the BAL construction standard would match each allotment.

*Innovative Terramatrix procedure for calculating **DTBAL's:***
Figure 31 shows the stylised Terramatrix map of vegetation types – forest and scrub on the boundary and inliers, modified vegetation and low threat vegetation. They applied different methods for calculating DTBAL's in each as follows:

Forest and scrub on the boundary and inliers: They used a method that copied information and methodology from PNN 65 and AS3959, but their method was very different. They said they calculated radiation flux using the same invalid equations of AS3959, but in contrast to AS3959, they then declared the adjacent strip will be protected by the DTBAL construction standard of Flame Zone and used the Flame Zone column of Table 1 to derive defendable space distance in each allotment.

To determine BALs in response to the classified vegetation external to the residential area, radiant heat flux was measured from the classified vegetation abutting the settlements using Method 2 of AS 3959-2009. The BAL-FZ band is shown on Map 8 and Map 9 as the red band around the perimeter of the residential area. In the modelling FFDI, flame

This is why the width of the Flame Zone strip (Figure 32) accords with Table 1 in some places, eg, Table 1 requires a defendable space of less than 19m for Flame Zone where the forest is upslope from the house site. Other allotments have received an unwarranted flame zone classification.

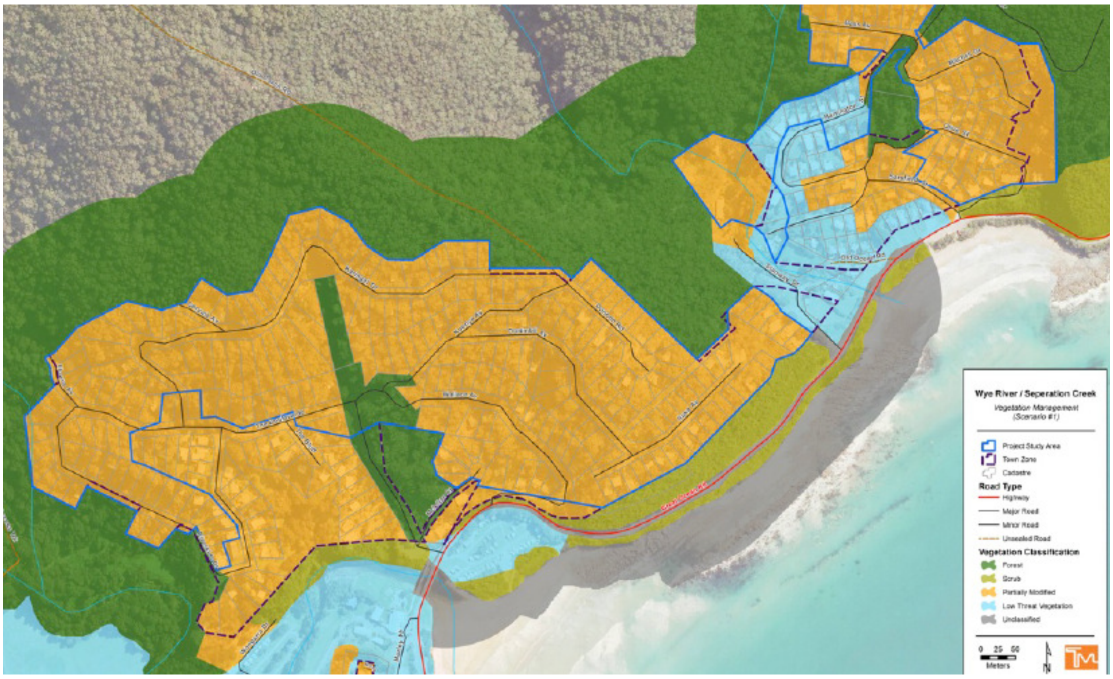
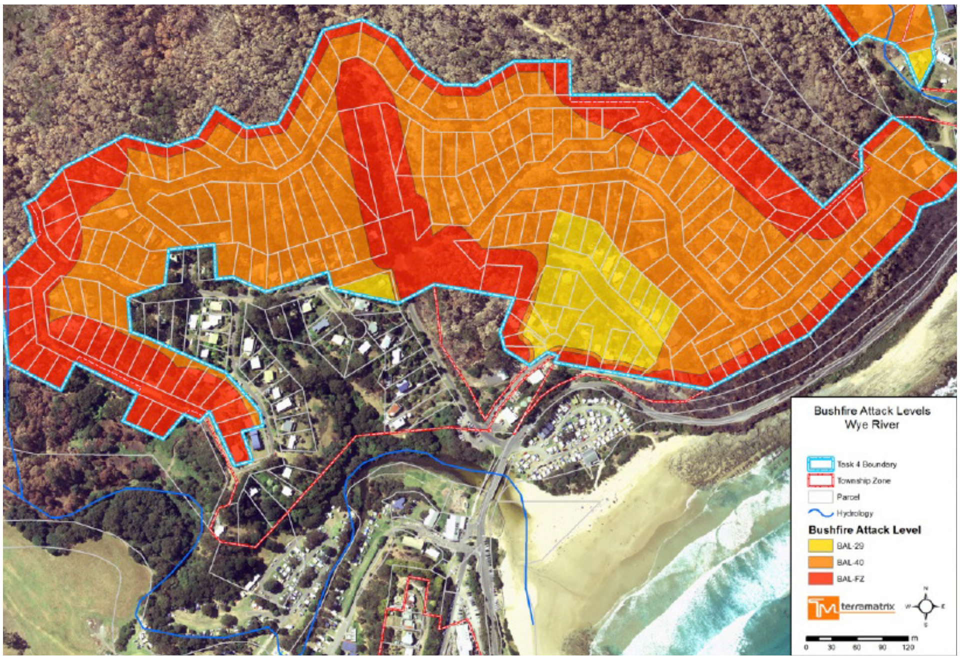


Figure 31 Copy of Map 3 "Managed Vegetation Scenario 1" in Terramatrix report which was selected for assessing BAL and defendable space requirements across the study area (p 5)



A Wye River

B Separation Creek

Figure 32 Copy of Maps 8 and 9 in Terramatrix report.
BAL mapping results are based on Managed Vegetation Scenario 1

Modified vegetation PNN 65 allows the Modified Vegetation category as an alternative fuel type if it is different from the other AS3959 categories but still creates radiation or flame. Eg, the residential area might qualify as Modified if it has gardens or managed understorey beneath a forest or woodland. Compared to PNN 65 definition, the extent of their Modified Vegetation on Figure 31 seemed to be oversized.

Their approach to this vegetation category was very confusing and subjective. Their report arbitrarily determined the perceived threat level will be mitigated with a construction standard DTBAL 40. By deduction, the threat level was very high due to a subjective judgement that allotments within their Modified Vegetation map zone cannot be relied upon to achieve defendable space status (specifically "where defendable space for 50m or the property boundary, whichever is lesser, cannot be reasonably assured" (p 6)). Their stated reasons (p6 and p47) included: "unlikely to be managed as defendable space on a reliable ongoing basis"; "ongoing management of grass and shrubs and clearing of leaf litter will be difficult for some residents"; owner "may be absent for extended periods"; tree canopy removal may be precluded on steep slopes; "elongated flames on steep slopes"; "exposure to convective heat from flames from down slope".

The student might presume that Terramatrix and government officials formed a view that residents will not maintain their properties in the future because they had not done so in the past. Is this a reasonable judgement or have they overlooked other factors such as (1) almost all the burnt houses had been built without permit conditions to maintain their property, and (2) that ongoing property maintenance is a permit condition for new houses, akin to a contractual obligation. If reasonable, explain how a very high construction standard BAL will mitigate the threat, particularly in the light of findings of the CSIRO report.

The student can consider why the government agencies continued to accept this subjective version of threat assessment across the burnt area of the town when it was stripped of almost all tree and understorey vegetation cover by the clean up crews. The student can consider whether the policy was appropriate and fair or heavy handed and unjust.

Low threat vegetation Their report arbitrarily determined the perceived threat level will be mitigated with a construction standard DTBAL 29. By deduction, the threat level was very high due to a subjective judgement that allotments within this zone will be difficult to maintain at a low fuel level.

> The difficulty of maintaining reliably Low Threat vegetation across the settlements was discussed at Project Reference Group Meetings 2 and 3. The consensus of professional opinion was that given the wet forest canopy, steep slopes and, in part, absentee property owners it would be difficult to maintain vegetation on private lots as Low Threat in perpetuity. Rather, it was considered more realistic to anticipate that residential lots would, in the future, contain a mosaic of managed and unmanaged vegetation best classified as Modified under the BMO.

The student can contrast their interpretation of Low Threat zone as a high level threat against the AS3959 definition that it has a low threat status and most sub categories have no requirement for fuel load to be managed.

In summary, the differentiation between BAL's and DTBAL's is justifiable because of their very different calculation methods and procedures. Furthermore, because they apply the bushfire attack level concept as the solution to a perceived or predetermined threat level, their DTBAL map clearly refers to the construction standard BAL and has no reference or correlation to a quantified BAL threat level derived by the AS3959 process.

(5) Were the changes legally valid?
The following questions are now relevant:
What legal framework or legal instrument allows government bodies to require a resident of Wye River or Separation Creek to build a BAL 40 house when current planning regulations calculate it at BAL 12.5? Which government body is liable for compensation if no valid legal instrument exists?

Background - planning law hierarchy for bushfires

The planning system in Victoria proceeds downward from the government objective in a planning hierarchy under the Victorian Planning Provisions (VPP).

Hierarchy Level of VPP	Location
Strategic policy issues that Council must consider	Clauses 10 – 19
Zones that allow or prohibit land uses	Clauses 30 – 39
Overlays that identify issues of concern that may cover one or more Zones	Clauses 40 - 49
Particular provisions for implementing Overlays	Clauses 50 – 59
Decision guidelines	Clause 65
Referrals	Clause 66

Clause 13.05 The Planning hierarchy for bushfires begins with Clause 13.05, which falls within the Hazards category. The objective of Clause 13.05 is "to assist to strengthen community resilience to bushfire". Clause 13.05 is part of the group of Clause 13's environmental hazards. They set a best practice planning approach which aims to avoid or minimise adverse impacts of hazards.

The student can note that bushfire objective is to improve resilience. By contrast, the objective for erosion is much stronger - To protect areas prone to erosion.

Clause 44.06 Next planning level is Clause 44.06, the Bushfire Management Overlay (BMO). It adds body to the Clause 13.05 objectives, and is implemented by Clause 52.47, stating "An application to construct a building … must meet the requirements of Clause 52.47 **unless a schedule to this overlay specifies different approved measures"**
As of 12 Aug 2016, there was no schedule to Clause 44.06 for Colac Otway Shire.

Clause 52.47 This clause details how to implement a permit application under Clause 44.06. Specifically, Clause 52.47-1 applies to an application to construct a single dwelling in a Township Zone. It states – "an application under Clause 52.47-1 must meet all the approved measures" unless "a schedule to Clause 44.06 may specify a different approved measure", and a 52.47.1 application must be accompanied by: bushfire hazard site assessment and bushfire management statement "unless a schedule to Clause 44.06 specifies a different requirement". The decision guidelines include consideration of "whether all of the approved measures have been incorporated into the application". The BAL in this Clause is the AS3959BAL, not DTBAL.

PNN 65 "This practice note provides advice on preparing and assessing an application under Clause 44.06 Bushfire Management Overlay". PNN 65 provides source information about "Modified Vegetation" category and its application in Clause 52.47.3 Tables 1 and 2. The BAL of PNN 65 is AS3959 BAL, not DTBAL.

Amendment C089

The April Terramatrix report stated: "The outcomes of the project will contribute to the development of an integrated planning control (incorporated under Clause 52.03 Specific Sites and Exclusions) for the fire affected area that will streamline the planning permit process for people wishing to rebuild houses lost in the bushfire" (p2).

Since 31 March 2016, there has been a reference in Schedule to Clause 52.03 to an "Incorporated Document" - "Land in Wye River – Separation Creek as identified in

Schedule 1 in the incorporated document - Wye River and Separation Creek bushfire affected properties (March, 2016)", which was Amendment C089.

The explanatory report that accompanied Amendment C089 seems to understate its impact by listing only three affected Clauses that appear to be at the lower end of the planning hierarchy: "This amendment affects clauses and schedules: Clause 52.03 Schedule, Clause 61.01 Schedule, Clause 81.01 Schedule". But the C089 document itself adds several others to the list of affected clauses: 32.05-1, 32.05-5, 32.05-8, 35.06-1, 35.06-5, 42.03, 43.05, 44.01, 44.06, 42.03, 44.01 and 52.17. It does not mention Clause 52.47, which fully interdependent with 44.06.

Part 4.1 of the "Incorporated Document" stated "Any requirement in Clause … 44.06 of the planning scheme to obtain a permit to construct a building or construct or carry out works does not apply to buildings and works associated with one dwelling on a lot". It is the only reference to 44.06. This suggests **Clause 44.06 Overlay** application requirements and the **influence of PNN 65** were extinguished for the burnt properties. Because procedures and requirements of both depend on AS3959, its relevance seems to be also extinguished. These and other aspects may present a few legal problems:

Level of authority
Can a lowly Clause 52.03 order lawfully suspend the superior Clause 44.06 Planning Overlay in these townships in contravention to Clause 44.06 specifications?
The application requirements of the higher order Clause 44.06 and its interdependent subordinate Clause 52.47 are very specific and can only be overruled by a Schedule to Clause 44.06, yet the Amendment does not include a Schedule.

Can a lowly Clause 52.03 order lawfully overrule the very specific measures in the superior Clause 44.06 Planning Overlay that by definition reduce risk to life and property to an acceptable level?
Clause 44.06 has a defined method of reducing such risk from a deemed hazard – it deploys Clause 52.47.1 for Township Zones and upon completion of the 52.47.1 process, the risk is deemed to be acceptable.
By contrast, Clause 52.03 introduces a different process with no clear reference to purpose or deemed hazard. No support paper was referenced in the Amendment C089

Confusion
Clause 44.06 may remain co-active alongside Amendment C089.
If permit application requirements of Clause 44.06 can only be extinguished by a Schedule, it may technically remain active.

Clause 52.47 remains co-active alongside Amendment C089
Amendment C089 extinguished application requirements of Clause 44.06 without reference to its interdependent subordinate Clause 52.47. Amendment C089 did not mention Cause 52.47, which suggests it was not extinguished.

Conflict with purpose of Overlay
Para 4.6 of the "Incorporated Document" which is Amendment C089, requires the responsible authority to consider the decision guidelines of Clause 65, which includes "The purpose of the zone, overlay or other provision". But Amendment C089 extinguished the application requirements of the Overlay that were specifically

designed to achieve the purpose of the Overlay. Therefore, technically C089 extinguishes the method of achieving the purpose of the BMO.

Explanation: Clause 44.06 has two specific purposes which it achieves via 52.47.1 for Township Zones, “unless a schedule to 44.06 specifies otherwise”.
– “To ensure development is only permitted where the risk to life and property from bushfire can be reduced to an acceptable level.”
. To identify areas where the bushfire hazard warrants bushfire protection measures to be implemented.
In regard to the former, C089 includes no mention or consideration of reducing bushfire risk to acceptable level. In regard to the latter, C089 assumes all allotments have a high risk and imposes very high DTBAL levels onto each allotment.

The student can consider whether Amendment C089 requirements for very high DTBAL levels on each allotment and defendable space to the property boundary can be presumed to achieve both purposes of the BMO, or should C089 have included a deeming mechanism, or indeed, have the BMO purposes been extinguished by C089 de facto?

Extinguishment of Clause 44.06 permit requirements means extinguishment of PNN 65 requirements, which together mean extinguishment of AS3959 relevance from burnt area
PNN 65 exists solely to describe the application process for Clause 44.06, the use of Clause 52.47 and reliance on AS3959. By extinguishing application requirements of Clause 44.06 from the map of burnt area, Amendment C089 extinguished each from the burnt area and replaced it with a new model with different processes and requirements. The new model uses the above documents as a reference source.

Extinguishment of Clause 44.06 permit requirements means extinguishment of PNN 65 requirements, which means extinguishment of “Modified Vegetation” Zone requirements from burnt area
PNN 65 is the source document for Modified Vegetation category, and its specific usage in Clause 52.47. The Terramatrix DTBAL map in Amendment C089 used Modified Vegetation as a vegetation category, but applied a very high threat level to it in contrast with the description in PNN 65.

The BAL of Regulation 811 is legally different from the DTBAL of Amendment C089
The second purpose of the Amendment C089 was “To specify bushfire attack levels for the purpose of regulation 811(1) of the Building Regulations 2006”.
Regulation 811 (4) states that “bushfire attack level has the same meaning as in the Australian Standard AS 3959”. Technically, the ***same meaning*** assumes usage of the same calculation method and process to determine the bushfire attack level, ie, the AS3959 method or its slight modification in PNN 65. As shown above, Amendment C089 included a map of **DTBAL’s** that was derived from the Terramatrix report, which used a very different process and calculation method from AS3959 / PNN 65. Thus, Amendment C089 prescribes construction zone DBTAL’s to multiple allotments based on a perceived or predetermined threat level in the vegetation category. This is not related to the BAL of threat that is calculated by AS3959 and mitigated by the corresponding construction standard BAL that the Building Regulations require. In addition, because C089 effectively excludes the AS3959 requirements from the burnt area, it excludes application of the Building Regs. This

seems to mean that building inspectors cannot legally enforce a C089 DBBAL within the burnt area.

What is legal weight of Amendment C089?
In this case, the Amendment is the Incorporated Document.
PPN 13 clarifies that "If a document is incorporated into a planning scheme, its content or strategic basis is less likely to be capable of challenge when using it to make a planning decision. The decision-maker or VCAT is entitled to presume that the strategic basis for the document was considered at the time of its incorporation into the planning scheme and to give it due weight"

It suggests that at least two factors may reduce its weight:

- the amount of public scrutiny the document has been subject to
- the document's currency and whether or not its relevance has been superseded by more recent studies or events.

To change it: "An incorporated document can only be changed by an amendment to the planning scheme. The revised text of the document must be placed on exhibition in addition to any proposed changes to the scheme ordinance".

The student can assess whether the Amendment is still relevant to the Planning Scheme in the light of zero public scrutiny prior to incorporation, dismay in the local community, confusion in legal aspects mentioned above and the almost complete removal of trees and ground vegetation in burnt areas by the clean up crews since March 2016.

Summary
Government has accepted the use of the AS3959 model and its BAL as a proxy for bushfire risk in Wye River / Separation Creek despite flame radiation being a negligible cause of house loss in severe bushfire, the AS3959 model being a single threat model, and the assumptions of AS3959 being unrelated to bushfire reality.

Government has adopted a very substantial variation from the BMO and AS3959 rules for Wye River / Separation Creek via Amendment C089 that has assigned very high **DTBAL's** for house rebuilding If the original BMO rules were in operation, **BAL's** would be substantially lower in almost all areas of the towns. The Amendment was based on a report which calculated **DTBAL's** using subjectively derived perceived or predetermined threat levels. The C089 Amendment is shown to present several legal challenges, particularly its apparent inability to operate in the Building Regulations.

Chapter 9 Summary of the sad saga so far …
How not to stop a bushfire, how not to protect a town

Government-directed-bushfire-suppression fails on Day 1

Government-directed-bushfire-suppression fails on Days 2 – 4

Government concocts carefully considered suppression strategy changes on Day 4 and it backfires on Day 7.

The government-directed-bushfire-suppression escapes the control line. Government withdraws troops at fire ground. Some reallocated to assist evacuations from towns in its path, no reference found yet to suggest a role in town defence.

The Government-directed-bushfire-suppression escapes and runs 4 km through government land, exiting through a non existent barrier into private property and smashes towns that were declared by government years ago as extreme bushfire risk

A government issues sudden warning at Christmas lunch time and evacuates residents from the towns. Government praises the obedient evacuators. Government later evacuates Lorne residents when not endangered. Was this a trial run? Government condemns the disobedient.

Towns have impressive glossy government protection plans to protect them from external fires but government has not yet put protection infrastructure on the ground.

Government laws exist for clearing hazards from private property within the towns, but they have not been enacted.

The out of control ex-government bushfire throws embers into vacated towns that ignite as spot fires

Government provides one strike team which saved houses and aerial bombers which wet several spot fires for the first hour of the bushfire attack on the towns but then seemed to declare it as too dangerous for ground based fire fighters to extinguish spot fires and houses.

Government and fire fighters allow spot fires with half metre tall flames to spread unchecked for over 12 hours, by which time 116 houses are destroyed.

Premier and Fire Commissioner reassure the people, saying a local fire was overdue, so this one was to be expected and that it could have been worse - 200 houses could have been lost.

The government appointed watchdog investigated the above events and declared the government's policies and procedures were applied, including procedures for warning residents. Politicians use this report to reassure the public.

CSIRO report finds that houses built at highest fire resistance were destroyed when the average flame height was less than 0.4m tall.

Government spends millions on rehab, and takes control of house rebuilding program, declaring that houses must be rebuilt at the highest possible fire resistance levels (= most expensive) because it believes residents will not maintain their properties at low fuel load.

Is this really the hand of government policy in action in 2015 / 2016, taking charge, all powerful, free from blame ... Now penalising the burnt out residents, as untrustworthy?

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