AFFORESTATION OF HAINING FARM DON VALLEY

Bushfire Risk Assessment

Prepared for

Yarra Waterways Group

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EXECUTIVE SUMMARY

This executive summary is largely a critique of papers put forward by the government in support of a proposal to afforest Haining Farm adjacent to the Don Valley residential estate, ostensibly founded on an assertion that the bushfire threat will not be increased, and consideration of related matters sourced by me.

The assertion that the bushfire threat will not increase seems to be based on the results of the application of a bushfire behaviour model that predicts probability of house loss: PHOENIX RapidFire. Unfortunately, vegetation or bushfire fuel loads that is species and concentrations were not available from Parks Victoria/DELWP, the principal proponents of the afforestation of Haining Farm, when this report was finalised. And, I understand from Yarra Waterways Group, the project owner, it was not for want of requesting this information.

A questionable feature of the bushfire risk assessment is the uniform percentage housing loss across a relatively large study area, questionable because it seems not to take account of what could only be an increase in bushfire fuel load given a Greening Australia statement that "over 315,000 trees and shrubs will be planted next year [2018], along with 100 different types of understory plants …"

Given the lack of information available on vegetation species and planting concentrations proposed for the afforestation — and data used in the PHOENIX RapidFire modeling (?) — I consider a statement from one of the independent experts supporting the proposal incredible: "I do not consider the revegetation on Haining Farm to significantly change the bushfire risk in the Yarra Valley around Don Valley".

Also questionable is the factoring in of emergency response firefighting resources, including firebombing aircraft, as integral to reducing any bushfire threat associated with the afforestation. Anyone with a real knowledge of bushfire occurrence, suppression difficulty and concentration of such resources according to the risk exposures will know that this is a promise that may not be able to be delivered when most required. Passive protection rather than reliance on emergency response should be the focus of Parks Victoria/DELWP, particularly with the exposed Don Valley residential estate adjoining to the east.

Minimising the bushfire threat posed to the adjoining residential estate is critical to minimising the potential for loss of homes, and in this case a school, due to the government's urging the "go early" approach on the community that leaves homes without people available to deal with ember attack to supplement any fire brigade attendance.

When researching current bushfire protection arrangements for the Don Valley residential estate I was disturbed to find that there was no current Yarra Ranges Municipal Fire Prevention Plan according to section 55A Country Fire Authority Act 1958. I've heard of excuses that section 55A has been overridden by the Emergency Management Act or that is to occur. However, section 55A remains in the Country Fire Authority Act and I cannot imagine the Office of the Chief Parliamentary Counsel Victoria allowing any conflict between Acts to remain, and to my knowledge other forms of instruction or advice do not override an Act of parliament.

From within the papers perused I have extracted the primary objectives for bushfire management on public land, including the statement "human life will be afforded **priority** over all other considerations".

Having experienced the aftermath of several major bushfires, particularly the Trentham East–Macedon fire of Ash Wednesday 1983, Kilmore East and Murrindindi fires of 2009 and the Wye River–Separation Creek fire of 2015, it is reasonable to comment that very many people were hurt emotionally and/or financially through loss of homes, important and valuable possessions, including tools of trade, devastating to those affected — human life must be viewed more widely than just life loss or injury due to being caught in a fire.

Finally, the protection of the Helmeted Honeyeater and Leadbeater's Possum should be able to be achieved without increasing the bushfire threat to the Don Valley residential estate and beyond.

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COVER PHOTOGRAPH

Accumulation of bark around the base of a gum eucalypt on the western side of the Don River photographed from the southern side of Dalry Road, approximately 80 metres west of the Don Valley residential estate.

In the event of fire burning under the influence of a northwest–southwest wind in this part of Haining Farm the bark will be the source of firebrand attack on the residential estate and further afield.

In the right foreground of the photograph is a suspended ribbon of gum bark set up to become a firebrand. This is one of many numerous bark ribbons suspended from gums in this part of Haining Farm.

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1 INTRODUCTION

This report and recommendations responds to a request from the Yarra Waterways Group to consider and advise on the bushfire risks posed by the afforestation of Haining Farm and is largely based on consideration of various papers, associated matters and personal inspection, of which some will be referred to as evidence.

2 EVIDENCE

Prominent amongst the matters considered:

2.1 The proposal

I have perused the "Haining Farm Don Valley, Victoria, Community Information" paper dated June 2017, by the Haining Farm Redevelopment Working Group (*Working Group*) in conjunction with Parks Victoria/Department of Environment, Land, Water and Planning and understand the objectives, including protection of riparian areas and restoration of habitat for the Helmeted Honeyeater and lowland Leadbeater's possum.

2.2 Greening Australia

I have also examined the "Greening Australia Year in Review 2017" report, which includes an outline of its final concept plan: "Haining Farm: A Place where People and Threatened Species Can Go Wild Together".

The outline includes the following statement:

> Over 315,000 trees and shrubs will be planted next year [2018], along with 100 different types of understory plants that will serve as important food sources for the threatened wildlife.

2.3 Haining Farm Bushfire Risk Analysis – undated

The "Haining Farm Bushfire Risk Analysis", paper prepared for the *Working Group* sent to the Yarra Waterways Group late on 30 January 2018 was perused and as considered necessary is addressed below.

2.4 Yellingbo Investigation Area Landscape Risk Analysis

I have seen elements of this paper in another form, all of which must be bewildering to lay members of the community trying to understand the bushfire threat resulting from the project.

I must add that this being one of the more recent of the supporting documentation I've seen, and observed how all of the explanatory documents vary when dealing with the probability of house loss percentages — see subclause 3.1 Haining Farm Community Update, January 2018, below — I have the feeling that it is back-filling to support the preferred option of the *Working Group*, which is not necessarily the best option if the well-being of the Helmeted Honey Eater and Leadbeater's Possum is a real concern.

2.5 Haining Farm Bushfire Risk Analysis – Version Two – undated

A late entry from Parks Victoria/DELWP handed to me on 15 February, with the only noticeable change from the earlier version being this addition under the heading 1.3 Other factors that reduce bushfire risk:

> Victoria is a high bushfire risk State and management of private property to reduce bushfire risk is also important. There are actions that residents can take around their homes to reduce ember and radiant heat impacts, as well as on larger properties. See Landscaping for Bushfire, produced by the CFA to guide residents on how to plan and maintain a garden in high bushfire risk areas.

A shame this information was not included in the Haining Farm Community Update, January 2018 and it supports my view that there has been some back-filling going on.

The above extract has some similarity with part of a response email sent to one of the Don Valley residents — prior to Version Two — who expressed concern over the proposal to one of the independent experts:

> What makes the biggest difference to being able to protect a house from a bushfire is how well the house is maintained and now well the fuels within 30m of the house are managed. Next most important is how well fuels are managed within 100m of you [sic] home. These are the biggest issues for individual home owners. Most homes in Don Valley that I have seen could do much more to improve their own bushfire safety without having to be concerned about the broader landscape.

A major concern here is what seems to be an attempt to pass responsibly for dealing with any increase in the fire risk at Haining Farm to its neighbours. The reality of this approach is that most people have short memories or never really understand how fire can be ignited in their own backyards by embers/firebrands, a recent example being the Carrum fire on 6 January 2018.

Plate 1 Vegetation amongst dwellings at least 120 metres from the fire in the reserve behind dwellings on the western side of Darnley Drive, Carrum, apparently ignited by embers or firebrands from a fire in the reserve

If the government insists on increasing the fire fuel load on Haining Farm then it should accept responsibility for implementing government funded hands-on measures to commensurately increase the level of fire resistance in the adjoining residential estate, including the primary school, and more than just scare messages on television, the web and in the print media.

3 BUSHFIRE RISK

3.1 Haining Farm Community Update, January 2018

I note the following statement under the heading Project Criteria, "Haining Farm Don Valley, Victoria, Community Information" paper concerning bushfire risk:

> The Victorian Government made a commitment to the community that the development of Haining Farm would not increase the bushfire risk to the community. All concepts presented to the community have been modelled using Phoenix bushfire modelling which indicates that they do not increase the bushfire risk to the community.

Fire risk

From the "Haining Farm Don Valley, Victoria, June 2017 Community Information" paper:

Concept 1 – Boutique Farm With Conservation

Decrease in fire risk – 0.1% — from the Working Group (see below) 17.7% average probability of house loss

I have also seen what I understand to be an earlier draft of Concept 1 that states an *increase in fire risk of 0.6%*.

Concept 2 – Commercial Agri-Tourism Farming Operation

Decrease in fire risk – 0.1% — from the Working Group (see below) 17.7% average probability of house loss

Concept 3 – Habitat Restoration For Threatened Species With Community Access

Increase in fire risk – 0.0% — from the Working Group (see below) 17.7% average probability of house loss

And, from the "Haining Farm Bushfire Risk Analysis", *Working Group*, sent to the Yarra Waterways Group late on 30 January 2018 i.e. the recommended option:

Increase in fire risk – 17.8% average probability of house loss; and

Current vegetation – 17.8% average probability of house loss

In considering the Haining Farm Bushfire Risk Analysis and having regard the Greening Australia announcement of the "planting of over 315,000 trees and shrubs will be planted next year [2018], along with 100 different types of understory plants" I have been unable to establish what the actual vegetation changes will be. Here, it would be helpful to learn of what fuel types and quantities the fire analyst used in the PHOENIX RapidFire modelling.

3.2 Assessment of the bushfire risk

There is a paper headed "FFDI 100 Haining Farm Revegetation 2 House Loss Probability change – House Loss Probability change for target area: Average change is 17. 84% to 18.55%" and another "FFDI 100 Haining Farm Revegetation 2 House Loss Probability change – House Loss Probability change for target area: Average change is 17. 84% to 18.21%" — Appendix A House loss probability changes.

Plate 2 View of the ragged base of gum eucalypt photographed in a similar location on Haining Farm to that shown on the front cover.

A number of questions arise from the assessment of the bushfire risk by Parks Victoria/DELWP in what I understand to be its most recent advice to the affected communities — Haining Farm Community Update, January 2018 — stating the following:

> Phoenix Bushfire Modelling indicates that the Haining Farm project will not materially increase the existing bushfire risk to the community. This has been reviewed by independent fire experts.

And further:

> As recommended by the technical fire experts, an open woodland area to prevent an increase in bushfire risk will be created on the northern and eastern boundaries of the site.

To me, the earlier and varying house loss probability percentages are an indicator of the uncertainty or lack of specificity involved with the risk assessment process and weakens the Parks Victoria/DELWP advice being distributed to the affected communities that the Haining Farm Project "will not **materially** increase the existing bushfire risk to the community". [my emphasis]

Here, it is important to consider the meaning of "materially" in the context it is used in the Parks Victoria/DELWP advice to the community. The *Macquarie Dictionary Fifth Edition* defines "materially" as:

1. to an important degree; considerably.

Seems to me that Parks Victoria/DELWP is willing to accept the loss of an indeterminate number of houses, as I am unaware of what the loss percentage increase actually means for example 18.55 per cent increase over a previous house loss percentage or 18.55 per cent from a zero base that equals 18.55 houses out of every 100 houses or as for the *Working Group* preferred option 17.8%, and does that percentage loss increase remain constant over distance involved with a spreading fire?

A significant weakness in the bushfire risk assessment is confirmed by the following extracts from the "Yellingbo Investigation Area Landscape Risk Analysis":

> <u>Current Vegetation</u>
>
> Current vegetation was determined by using vegetation reports commissioned by Melbourne Water and conducted by independent contractors as well is examining aerial imagery and 2005 EVC mapping. **For**

> **best accuracy, extensive fieldwork and mapping needs to be done to determine exactly what is on the ground**. [my emphasis]
>
> Re-vegetation options
>
> Re-vegetation was determined by 'current vegetation 'mapping, Phoenix fuel layer mapping and mapped 2005 EVC's. **For better results, supplying detailed-revegetation plans would be more accurate than estimating what might be planted**. [my emphasis]

It should be apparent that the absence of "detailed re-vegetation plans" and relying on current vegetation data can only result in an underestimation of the eventual bushfire threat, given the Greening Australia statement that "over 315,000 trees and shrubs will be planted next year [2018], along with 100 different types of understory plants".

> Woodland buffer
>
> The woodland buffer was same as used in Haining Farm analysis (gum woodland with moderate bark hazard, herbaceous understory). In areas revegetated in large bends of the river.

This statement conflicts with the statement in the "Haining Farm Bushfire Risk Analysis" under the subheading 3.1 Open woodland buffer:

> An open woodland buffer incorporating a managed and manicured landscape that includes features to reduce the impact of embers, direct flame contact and wind driven fire behaviour can be used as a bushfire mitigation method. **This would consist of a band of smooth barked trees with no mid-story and some maintained grasses the intention of the buffer is that these trees do not produce embers** and reduce the influence of wind. **An open woodland with a maintained grassy surface fuel layer and no significant mid-story fuel would not sustain a crown fire**. [my emphasis]

A related and very significant matter is a fire line intensity of 10,000 kW/m² put forward by the fire analyst — see Appendix B Yellingbo Investigation Area Landscape Risk Analysis extract.

3.3 Afforestation

Not having seen any plans to the contrary, it's reasonable to conclude that the EVCs for the Haining Farm area will be the basis of the revegetation.

Concerning **smooth barked trees**, EVC 18: Riparian Forest and further west and east of the Don River EVC 16: Lowland Forest and in the vicinity EVC 83: Swampy Riparian Woodland, the tree canopy cover mentioned is Messmate Stringybark, Manna Gum, Narrow-leaf Peppermint, Yertchuk and Swamp Gum, **none of which are smooth barked trees** — see the cover photograph and caption on page 1 and Plate 1.

3.4 Landscape fire

Landscape is frequently mentioned in the bushfire risk assessment papers forwarded to the Yarra Waterways Group. I am curious as to what the fire analyst means by "landscape", particularly given the reference to so many computer generated ignitions across the 'landscape'.

The following extract from the report of the 2009 Victorian Bushfires Royal Commission Volume II: Fire Preparation, Response and Recovery, 1 Victoria's Bushfire Safety Policy, page 36–37 deals with landscape fire:

> Analysis conducted by the Commission showed that a considerable proportion of those who died in or around dwellings or who died fleeing from their properties were in areas that were closely adjoining or in some cases completely surrounded by heavy forest. Others were on the crests of hills or on upper slopes surrounded by large concentrations of forest and in similar positions the Commission considers would have been undefendable on 7 February, even if the properties themselves were relatively clear and well maintained. Defendability is affected by the surrounding environment, such as proximity to a heavily forested area. These broader factors affect the ferocity of the approaching fire and whether the house could be subject to very heavy ember attack.
>
> Properties close to heavily forested areas are more prone to ember attack than those in open farmland. The momentum and ferocity of a fire travelling through heavy forest will be different from and greater than a fire burning in grazed paddocks. **Assessments of defendability should therefore consider the nature of the nearby undergrowth and fuel load** [my emphasis]. On the basis of the evidence before the Commission, broader landscape influences are not adequately identified, considered or explained by the CFA when it is assessing the defendability of properties.

A Bushfire CRC study of bushfire penetration into urban areas in a selection of fires in south-eastern Australia since 1967 (including Marysville and Kinglake) concluded that, by avoiding building structures within 100 metres of bushland boundaries, 'the majority of building damage would be avoided'. This has implications not just for limiting property damage (see Chapter 6) but also for the safety of people who choose to stay and defend.

Professor Roz Hansen, an urban planner, provided advice to the Commission about how far away houses and the urban edge should be from adjacent bushland. The 2007 CFA kit. *Building in a Wildfire Management Overlay*, focuses on vegetation and fuel within 100 metres of the proposed house; the New South Wales Rural Fire Service advises this should he 140 metres. Professor Hansen went on to say:

> Land in more isolated locations, or on allotments on the edge or fringe of township boundaries, or adjacent to but outside these boundaries, **may require a wider assessment of existing vegetation cover beyond distances of 100–140 metres**. This is especially relevant to land which is close to large tracts of forest and bushland where fuel loads can be high and the severity and extent of an approaching bushfire can be potentially catastrophic. [my emphasis]

The Commission's hearings into the fire-related deaths revealed that a large number of people died in homes the Commission considered were undefendable on 7 February. This question needs more serious analysis, and objective measures and tools to help determine minimum set-back distances from heavy fuel concentrations when assessing a house's defendability need to be developed.

3.5 Bushfire Management Overlay

Having regard to the Commission's concern over fire in the broader landscape — VBRC Recommendation 1, includes "improve advice on the nature of fire and house defendability, taking account of broader landscape risks" — Clause 44.06 Bushfire Management Overlay Yarra Ranges Planning Scheme (VC 132) requires the following as part of a bushfire hazard assessment that covers part of the Don Valley residential estate that is in a Green Wedge Zone (GWZ).

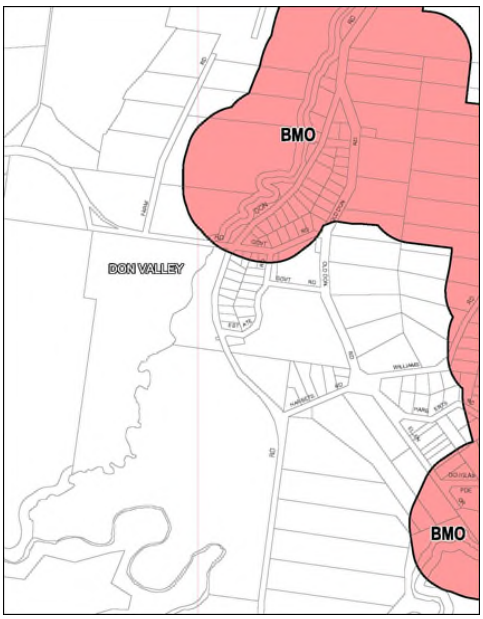

Figure 1 Extract from the Yarra Ranges Planning Scheme showing the BMO coverage in the area of Haining Farm.

Permit application requirements subclause 44.06-3

Unless a schedule to this overlay specifies different requirements, an application must be accompanied by:

- A bushfire hazard site assessment including a plan that describes the bushfire hazard within 150 metres of the proposed development …
- A bushfire hazard landscape assessment including a plan that describes the bushfire hazard of the general locality more than 150 metres from the site …
- A bushfire management statement describing how the proposed development responds to the requirements in this clause and Clause 44.06 …

The BMO coverage is generated by the Don River north of Dalry Road as shown in Figure 1. — see Appendix C 150 Metres Radius Google Earth Photo

Included as a purpose of the BMO: **"to ensure that the development of land prioritises the protection of human life and strengthens community resilience to bushfire."** [my emphasis]

3.6 Primacy of human life according to the 2009 Bushfires Royal Commission

Very early in the summary of the Final Report of the 2009 Victorian Bushfires Royal Commission:

> The Commission views protection of human life and the safety of communities as the highest priority for bushfire policy and directed its efforts accordingly. This priority guided the Commission in its analysis, the collection of evidence, its reports and the formulation of its recommendations. The recommendations further reflect the Commission's recognition that includes individuals, fire agencies and Commonwealth, State and local governments share responsibility for preparing for fire and improving people's safety. While placing the preservation of human life at the heart of its deliberations, the Commission also sought to ensure that due consideration was given to Victoria's environmental sustainability.

Helmeted Honeyeater and Leadbeater's Possum

I will address "environmental sustainability" that is the Helmeted Honeyeater and Leadbeater's Possum later in this report.

3.7 Protection of human life Clause 13.05 Bushfire Yarra Ranges Planning Scheme

From Clause 13.05 Bushfire:

> Protection of human life
>
> Give priority to the protection of human life by:
>
> - Prioritising the protection of human life over all other policy considerations.
> - Directing population growth and development to lows risk locations and ensuring the availability of, and safe access to, areas where human life can be better protected from the effects of bushfire.
> - Reducing the vulnerability of communities to bushfire through the consideration a bushfire risk in decision-making at all stages of the planning process.

3.8 CFA Community Information Guide

In the absence of a CFA Community Information Guide – Bushfire/Grassfire for Haining Farm or nearby Launching Place, given a similar environment for the Don Valley the Community Information Guide for Yellingbo is relevant. This guide is introduced as follows:

> Yellingbo sits in a valley surrounded by hills. Forest reserves blended with grassland creates the extreme bushfire risk. Living in this area means you must have a well developed bushfire survival plan for ALL days when hot, dry and windy weather increases the risk of bushfire. Leaving once a bushfire has started will not be a safe option.

Currently there is NO designated Neighbourhood Safer Place – Place of Last Resort in this area.

And further:

> The major bushfire risk to the township is from fire in Yellingbo Conservation Reserve particularly with the south-west wind change [the same can be said to apply to the threat from Haining Farm to the adjoining residential estate].

Likewise, there is no designated Neighbourhood Safer Place in Launching Place relatively nearby to the south of Haining Farm.

4. PHOENIX BUSHFIRE MODELLING

I am familiar with the use of PHOENIX RapidFire by Emergency Management Victoria to predict the spread or path of a 'going fire', including ember or firebrand spread. However, I have misgivings over the manner PHOENIX seems to have been used to determine the bushfire threat involved with the proposed afforestation of Haining Farm.

Attached an annotated version of "Assessing Potential House Losses Using PHOENIX RapidFire" by Tolhurst and Chong as Appendix D.

The highlighting provides some information on intent of the use of PHOENIX RapidFire and the factors contributing to house loss, which identifies that embers — I include firebrands, burning gum bark that

is mentioned in the report of the 2007 Victorian Bushfires Royal Commission — as the main method of fire spread.

On page 76 the "convection column" begins to be mentioned as important to ember/firebrand transportation.

On page 78 I've highlighted that fire line intensity is measured as kilowatts/metre, **not kilowatts/square metre** as twice mentioned under the heading Intensity in APPENDIX B Yellingbo Investigation Area Landscape Risk Analysis from the fire analyst. I initially thought the analyst might be confusing "ember density" but that's been given a weight or distribution of its own.

Concerning the generation of embers/firebrands, which varies according to vegetation types, to add eucalypts into the currently predominantly grassland areas of Haining Farm will increase the potential for heavier embers than normal for grassland. For further explanation see Appendix E NBRU Firebreak Research.

[redacted] the fire risk will be reduced needs explanation as to how the risk would decrease. While a forest is known to decrease wind speed it would be helpful to have [redacted] estimate of the wind speed reduction as a percentage of that for open grassland at near ground level where the majority of the fine fuel that carries the fire front is found, given the relatively narrow woodland strip.

Now, the Conclusions on page 84. As I understand Tolhurst and Chong, the use of PHOENIX RapidFire in this manner is about "probability" and in my opinion somewhat vague. The final paragraph states that it "provides a useful basis for assessing the relative threat of fire in a range of circumstances". Apart from some value in predicting some ember/firebrand attack potential, I'm not convinced that it does any more than provide a very broad picture of what might occur but not specifically where.

Conversely and I quote the final sentence of the final paragraph, "It is therefore expected that this modelling approach could be used to evaluate the relative benefits of different fire mitigation options …". Maybe this is an argument to abandon or at least modify the revegetation in the Haining Farm–Yelllngbo Conservation Area. By modification I mean based on site-specific bushfire risk assessment, not some table top/computer modelling that does not specifically identify the houses at risk so that their individual vulnerability can be remedied.

Finally, referring back to the measuring of fire line intensity mentioned on page 78, the fire analyst twice concludes "Areas of high potential fire line intensity >=10000 kW/m2".

Butler and Cohen in their research paper "Firefighter Safety Zones: A Theoretical Model Based on Radiative Heating", International Journal of Wildland Fire, 1998, reported the following on the effect of radiant heat:

> As one would suspect, it is difficult to find analytical studies reporting the effect of heat on human skin. Most of the work that has been done was performed on prisoners of war during World War II or on military volunteers in later studies. Green and Schimke (1971) state that 12 kW-m² will cause injury, no exposure time is given. Others suggest that the upper limit of incident radiant heat flux on bare skin that can be sustained without injury for a short time (less than 2 minutes) is approximately 2.3 kW-m² (Stoll and Greene 1959; Budd and Cheney 1984; Fogarty 1996).
>
> Other studies have explored the performance of fabrics used in firefighter clothing (Braun and others 1980: Behnke 1982; Bond and Cheney 1986). These studies have led to several proposed testing methods that do not require human subjects. The data reported by Braun and others (1980) suggest that when firefighters wear Nomex cloth (210 g-m²) second degree burns will occur after 90 seconds at incident radiant heat fluxes of approximately 7 kW-m².

What then the fate of the Don Valley residential estate generally immediately east and northeast of Haining Farm? With the standard of buildings involved it would probably cease to exist, as would humans, and any Helmeted Honeyeaters and lowland Leadbeater's possums exposed to 10000 kW/m² radiant heat flux.

Australian Standard *AS 3959—2009 Construction of buildings in bushfire-prone areas* specifies Bushfire Attack Level Flame Zone (BAL-FZ) for <12 metres from Woodland and 12–<16 metres from Woodland for BAL-40 — 40 kW/m² maximum exposure to radiant heat flux — for the "receiver", a house.

The source of 10,000 kW/m² over an unspecified distance to a receiver, other than a low yield nuclear explosion, should be food for thought for Parks Victoria/DELWP.

Obviously the fire analyst is in error with the 10,000 kW/m² radiant heat flux. However, I am perplexed that those findings appear to be supported by "independent and technical fire experts"!

[redacted] I disagree with the value placed on PHOENIX RapidFire to determine house loss probability, as more than once in the documents that I have perused it is stated that that the use of the modelling in this manner cannot be specific.

The complexity of PHOENIX RapidFire is shown schematically in Appendix F PHOENIX RapidFire – a bushfire simulator and risk assessment decision support tool.

4.1 Standing of PHOENIX RapidFire in the scientific community

While not wishing to denigrate [redacted] work in developing PHOENIX Rapidfire there are other models available to predict fire behaviour — see *A guide to fire spread models for Australian vegetation,* 2015, CSIRO/AFAC. One of those more recent models is "Spark" being developed by CSIRO. Different to PHOENIX RapidFire, Spark as at 27 May 2017 did not predict ember/firebrand transmission and on questioning the developers I was informed that they considered it too uncertain.

To be as reliable as possible any desktop fire behaviour modelling should **supplement** real knowledge of fire behaviour!

4.2 PHOENIX RapidFire limitations

From Clause 7. Assumptions in the "Haining Farm Bushfire Risk Analysis":

> PHOENIX RapidFire (PHOENIX) – page 18
>
> The key model underpinning this report is PHOENIX RapidFire (PHOENIX).
>
> PHOENIX is a research tool developed by the University of Melbourne (Kevin Tolhurst and Derek Chong). It has been used by DELWP and other fire agencies for both incident prediction (State Control Centre PHOENIX RapidFire system) and as the key tool for bushfire risk assessment in a new strategic approach to fire management planning. All modelling has limitations (as set out below); however, PHOENIX is a useful tool in analysing landscape scale bushfire risk.
>
> Use of PHOENIX is coordinated through an agreement between DELWP, the University of Melbourne, and the Bushfire and Natural Hazards Cooperative Research Centre. DELWP acknowledges that a model designed for research is being applied operationally. PHOENIX is generally acknowledged by many stakeholders in the field, including DELWP, as a state-of-the-art, world-leading planning tool, critical for helping us understand how to reduce risk to life and property from major bushfires.
>
> PHOENIX simulation outputs may not reflect actual fire spread. There are several input layers and submodels within PHOENIX, each of which needs to be validated. The model is sensitive to minor differences in inputs. Small shifts in the weather, fuel accumulation functions, or time of ignition, can cause large differences in results. PHOENIX RapidFire version 5.0 was used for the creation of this report.

Suppression – page 19

> PHOENIX is limited in how it can measure risk when it comes to response and suppression. It can measure the benefits of first attack, such as calculating the effectiveness of the immediate response of a certain number of vehicles and aircraft. However, it cannot measure variables that may hinder first attack, such as the condition of roads or the location of water points relative to the location of the fire. It also cannot account for decisions made during suppression efforts. 'First attack suppression modelling was included to minimise emphasis of small fires.

Vegetation mapping – page 19

> Current vegetation mapping for PHOENIX was checked with aerial imagery and DELWP's Ecological Vegetation Class (EVC) mapping.
>
> Re-vegetation was determined by using the checked 'current vegetation' mapping and modifying the PHOENIX fuel layer to suit concept designs as per existing EVCs and suitable Fuel Types.

The three preceding extracts are examples of the limitations of PHOENIX RapidFire as used in the Haining Farm bushfire risk assessment.

4.3 Efficacy of PHOENIX RapidFire

During the afternoon of 19 December 2015 a lightning strike started a fire near the Jamieson Creek in the Otway Ranges forest between Lorne and Separation Creek–Wye River. During the following week the size of the fire increased until Christmas Day when it destroyed numerous houses in both communities. Throughout that preceding week no concern was raised by DELWP/Parks Victoria/CFA/EMV for both communities until Christmas Day when the urgent evacuation of both communities was recommended.

Was that disaster due to deficiencies in PHOENIX RapidFire or failure of the analyst/s involved or something else?

5. YARRA RANGES MUNICIPAL FIRE PREVENTION PLAN

I examined the Yarra Ranges Municipal fire Prevention Plan (MFPP) to see if a Township Protection Plan existed for the Don Valley residential estate that includes a primary school adjoining Haining farm, but did not find anything.

6. BUSHFIRE MITIGATION ARRANGEMENTS FOR HAINING FARM

6.1 Emergency response vs passive protection

Rapid early suppression is mentioned under the “House loss probability” on page 6 of the Haining Farm Bushfire Risk Analysis:

> Rapid early fire suppression has not been included in this modelling, but is a critical method to minimise bushfire impacts. There are several CFA stations within and surrounding the Investigation Area, 3 DELWP/Parks Victoria work centres with fire fighting vehicles and machinery and helicopters. The Yellingbo Bushfire Risk Management Plan currently being created in consultation with CFA brigades is investigating how to increase the likelihood of successful early fire control.

Dealing with reality, there is no guarantee that the CFA stations within and surrounding the Investigation Area or the three DELWP/Parks Victoria work centres will be able to be first responders to Haining Farm as they may already be committed elsewhere, for example:

- a large forest fire burning south-east of Cann River prior to Christmas 2017 required considerably more DELWP/Parks Victoria resources committed to this fire than were available in the local area; and
- a bushfire threatening houses at Carrum on 6 January 2018 dragged in CFA brigades from surrounding districts; and
- water bombing aircraft should not be counted as a resource at DELWP/Parks Victoria work centres; they are a state resource with commitment controlled by EMV. Indeed, the availability of water bombing aircraft may be curtailed by a need to control several lighting strikes deep in the Gippsland–North East mountains following lightning activity, as was the situation at the end of January this year — fortunately the weather was relatively mild at the time.

And, very strong wind can affect aircraft availability as follows:

- fixed wing aircraft at some airstrips may not be able to take off at some points during the day due to wind strengths being greater than cross-wind thresholds
- some helicopters may not be able to turn blades due to wind strengths being above start up thresholds and the potential for tail strike
- fixed wing aircraft may be tied down and helicopters will have blades tied down and therefore response times are likely to be longer than normal
- fixed wing aircraft and helicopter flight into head winds will significantly affect equivalent speed over ground
- wind strength and turbulence may affect the safety of operations
- effectiveness of dropping loads may be significantly compromised due to excessive wind drift and therefore be ineffective and inefficient

Including early fire suppression intervention is in effect promising a bushfire risk mitigation method that cannot be guaranteed.

6.2 DELWP Code of practice for bushfire management on public land.

Primary objectives for bushfire management on public land:

1. To minimise the impact of major bushfires on human life, communities, essential and community infrastructure, industries, and the environment.

   Human life will be afforded **priority** over all other considerations.

2. To maintain or improve the resilience of natural ecosystems and their ability to deliver services such as biodiversity, water, carbon storage and forest products.

From DELWP's *Strategic bushfire management plan East Central* Introduction, page 3, published in November 2015:

> Established under the Conservation Forests and Lands Act 1987, the Code of Practice for Bushfire Management on Public Land 2012 spells out how we will manage bushfire risk on public land. The code's two primary objectives are to:
>
> - **minimise the impact of major bushfires on human life …**
> - **maintain or improve the resilience of natural ecosystems …**

in that order of precedence.

What does "impact of major bushfires on human life" mean, just only people losing their lives or being injured or should there be a wider interpretation?

Though no lives were lost at Separation Creek–Wye River it is reasonable to comment that many people were hurt emotionally and/or financially through loss of homes, important and valuable possessions, including tools of trade, devastating to those affected.

In assessing the effect on human life, consideration needs to be given to the values of the people of Don Valley and further afield!

Another extract from DELWP's *Strategic bushfire management plan East Central* Introduction, page 3:

> We developed this plan in the context of Victoria's new emergency management arrangements. The Victorian Government's ***Emergency Management Reform White Paper*** and subsequent legislation aim to build community resilience through increased participation and shared responsibility. This plan helps achieve that aim by:
>
> - pairing local knowledge with world-leading technology to simulate how bushfires behave
> - **working with communities, industries and other stakeholders to understand what they value and want to protect from bushfires** [my emphasis]
> - identifying the most effective options to reduce bushfire risk
> - monitoring, evaluating and reporting how bushfire risk has been reduced.

7 PARKS VICTORIA/DELWP AND THE CODE OF PRACTICE FOR BUSHFIRE MANAGEMENT ON PUBLIC LAND

Parks Victoria/DELWP has a history of poor performance when it comes to protecting its neighbours' structural assets, with Kennett River currently being a prime example.

Plate 3

Plate 3 shows two **timber houses** on five small lots fronting on to the Great Ocean Road, approximately 320 metres northeast of Kennett Road, Kennett River.

Plate 4 shows a high voltage powerline maintenance track behind the two dwellings that is just visible upslope and at top left in the photograph.

Plate 5 shows the result of fuel reduction burning undertaken up to the right or inland side of the track at the end of summer 2017.

Begs the question, why were those two vulnerable dwellings left unprotected?

Plate 4

Plate 5

Plate 6

Plate 6 shows Kennett Road with the result fuel reduction burn mention earlier visible at right of the vehicle. Obviously Kennett Road was the southern-most control line for this burn.

Plate 7 shows the vegetation — fire fuel — on the general northern side of Cassidy Drive, Kennett River.

Plate 8 shows relatively unprotected dwellings on the opposite side of Cassidy Drive from the vegetation shown in Plate 6

Begs the question, why were those vulnerable dwellings in Cassidy Drive and further in left unprotected?

Plate 7

Plate 8

Also, it is well understood that DELWP/Parks Victoria's failure to manage the fuel load in the forest to the north led to the scale of loss in Separation Creek–Wye River, and damage to the forest itself and its fauna.

If required I can provide what I consider to be other examples of DELWP/Parks Victoria failing to meet the bushfire protection priorities of the DELWP *Code of practice for bushfire management on public land*.

Yarra Waterways Group, indeed the broader community, should be wary of any assurance from Parks Victoria/DELWP that the proposed afforestation of Haining Farm will be managed to protect the Don Valley residential estate and further afield.

8 ISSUES NEEDING ATTENTION

3.3 Afforestation – page 7

Given what appears to be an absence of EVCs for the pasture land and vineyards around Haining farm, how did the fire analyst determine the fuel load for the ignitions generated in those areas by PHOENIX RapidFire?

3.4 Landscape fire – page 7

Was any thought given to other forms of ignition, how and where they may occur and under what weather influence for example an escape from a motor vehicle accident on the surrounding roads?

One example, will a fire burning to the west or southwest of Haining Farm under the influence of a strong westerly-southwesterly wind reach the farm? Another extract from the email mentioned earlier:

> In most years, the grasslands in the Yarra Valley would be too green to carry a running fire. This may not be the case in a very severe drought. **However, a bushfire could still cross the valley by jumping from patches of forest in the valley and especially from burning embers coming from surrounding hills starting spotfires in the valley. This would make a bushfire in a severe drought and extreme fire weather very dangerous in the Yarra Valley**.
>
> If the proposed revegetation of Haining Farm goes ahead, it would have little direct impact on the fire safety of Don Valley beyond what already exists. Certainly, if revegetated as proposed, an intense fire could occur on Haining Farm, but most of the effects would be restricted to Haining Farm and not impact on the neighbouring areas. In fact, the revegetation would slow the bushfire spread across the valley, **but it would also contribute more embers downwind** [my emphasis]. This would be more of an issue for the areas west of Yarra Junction rather than Don Valley. In any case, the impact would be small compared with what could already happen in the Yarra Valley without any change to Haining Farm. With some of the other proposed fire protection works promised to be carried out in connection with the Haining Farm work, the overall level of bushfire risk would not change.

> **I do not consider the revegetation on Haining Farm to significantly change the bushfire risk in the Yarra Valley around Don Valley.** Don Valley is already a bushfire prone area that could experience disastrous wildfires in droughts. The best fire protection strategy for those living in the Yarra Valley is to prepare and protect their own property and to encourage or help others in their neighbourhood to do the same. **The majority of houses lost in Canberra in 2003, Marysville in 2009 and Wye River in 2015 were lost due to small spotfires starting around their house or by being ignited by a burning house, building or fence within 12m of it, not from a fire front coming from the bush**. [the three emphases are mine]

Thinking more about a fire approaching Haining Farm from the west or southwest and the statement in the above extract **a bushfire could still cross the valley by jumping from patches of forest in the valley and especially from burning embers coming from surrounding hills starting spotfires in the valley. This would make a bushfire in a severe drought and extreme fire weather very dangerous in the Yarra Valley.** Here, the following extract from *Bushfires in Australia*, Luke and McArthur, 1978 is instructive:

> Atmospheric instability and high solar radiation is common on a day following a dry cool change. Such days are frequently cool but the atmosphere is very clear and intense solar radiation produces very high surface temperatures and extremely high lapse rates in the first 3 or 4 m above ground level.
>
> Under these conditions fires start more readily and burn at much higher intensities than most fire suppression organisations plan for such a relatively cool day. The slow absorption of moisture by eucalypt fuels following a severe drying cycle may also be one of the reasons for erratic fire behaviour on such days.

Generally, the further a fire travelled the more threatening it would be when it reached Haining Farm. Without knowledge of the vegetation species and planting distribution it is reasonable to conclude that the fuel load, particularly plant species close to the ground, will further increase fire intensity above that predicted by the fire analyst and the weight of ember/firebrand attack on the Don Valley residential estate and beyond. Consequently, I find the statement **I do not consider the revegetation on Haining Farm to significantly change the bushfire risk in the Yarra Valley around Don Valley** in the above extract incredible.

Global warming

Considering future fire behaviour, did the fire analyst give any weight to the concern over the popular theory on global warming and how fuel dryness affecting flammability might change in the future?

An extract of a letter from Ms Kelly Crosthwaite, Regional Director Port Phillip DELWP, to Ms Jenny Barber dated 13 February 2018:

> A specific bushfire risk review for Haining Farm was led by Dr Kevin Tolhurst and Justin Leonard, two of Victoria's leading bushfire risk experts. The independent bushfire experts advised that revegetation of the site could be achieved without increasing the bushfire risk to the community. The experts' advice was that the addition of an open woodland on the boundary of the site acts as a bushfire mitigation measure by reducing the impact of embers and the effect of wind on the surrounding area. This open woodland allows revegetation of the site without increasing the bushfire risk to the local and broader communities and is considered essential to ensuring any development of the site meets this requirement.

3.5 Bushfire Management Overlay – page 8

An important question concerning community safety is why does the Don River south of Dalry Road not generate BMO coverage? And, equally important, will the increase in vegetation on Haining Farm proposed by Greening Australian further justify extending the BMO further south from Dalry Road, particularly as Clause 13.05 Bushfire Yarra Ranges Planning Scheme applies?

3.6 Helmeted Honeyeater and Leadbeater's Possum – page 9

Acknowledging a need to foster/protect the honeyeater and the possum, is Greening Australia's afforestation proposal logical or does it endanger them due being caught in very hot fire behaviour in the event Haining Farm becomes involved?

Has a detailed plan been prepared that addresses the actual habit needs of both animals rather than seemingly give Greening Australia carte blanche?

4 PHOENIX BUSHFIRE MODELLING – page 9

In analysing this further it would be helpful to have access to the fuel inputs used by the fire analyst, as the Yellingbo Investigation Area is large and involves different vegetation or fuel types, and I cannot find an EVC for the large areas of pasture grass around Haining Farm.

I am informed that Yarra Waterways Group has more than once asked for the inputs, but without success. I am wondering, does this tardiness indicates a blind and the fire analysis is a sham?

4.2 PHOENIX RapidFire limitations – page 11

Having considered the information under the heading PHOENIX RapidFire limitations on page 11 I have concluded that extending PHOENIX RapidFire to predict probability does no more than that and should be disregarded. To convince me otherwise I would want to see it used to assist with identification of specific vulnerabilities that is specific dwellings and critical infrastructure at risk that were then used as inputs to the preparation of Municipal Fire Prevention Plans.

I don't recall it being used to identify vulnerabilities pre-fire at Separation Creek–Wye River and question why it seems not to have been considered in planning and implementing the fuel reduction burn between Wye River–Separation Creek mentioned earlier in this report.

4.3 Efficacy of PHOENIX RapidFire – page 12

Why was notification to evacuate Separation Creek–Wye River left until the fire was virtually 'coming over the back fence', did PHOENIX RapidFire fail as a predictor of fire behaviour or was it due to a failure of the Incident Controller to understand and utilise it effectively that led to the loss of 116 houses Christmas Day and the subsequent difficulties imposed on people seeking to reestablish by the imposition of an draconian amendment to the Colac Otway Planning Scheme?

What difficulties would be encountered by Don Valley residents in seeking to reestablish themselves in the event homes were lost, would the Yarra Ranges Planning Scheme be amended similar to Amendment C93 in the Colac Otway Planning Scheme, having regard to the second dot point in Clause 13.05 Bushfire:

- Directing population growth and development to low risk locations and ensuring the availability of, and safe access to, areas where human life can be better protected from the effects of bushfire.

5 YARRA RANGES MUNICIPAL FIRE PREVENTION PLAN – page 12

Given the Greening Australia statement that "over 315,000 trees and shrubs will be planted next year, along with 100 different types of understory plants", has the impact of those plantings on the vulnerability of the Don Valley residential estate to bushfire been considered?

From the Country Fire Authority Act 1958:

55A Municipal fire prevention plans

(1) A municipal council must prepare and maintain a municipal fire prevention plan (MFPP) for its municipal district in accordance with the advice and recommendations of the municipal fire prevention committee.

(2) A municipal fire prevention plan must contain provisions in accordance with the regulations—

(a) identifying areas, buildings and land use in the municipal district which are at particular risk in case of fire; and

(b) specifying how each identified risk is to be treated; and

(c) specifying who is to be responsible for treating those risks; and

(ca) identifying all designated neighbourhood safer places in the municipal district or if no places have been designated, recording that fact; and

(cb) identifying any places in the municipal district that are community fire refuges within the meaning of section 50A; and

(d) relating to any other matter prescribed for inclusion in the plan.

Disturbingly, I did find that the MFPP currently only covers the period 2011–2014, which should be of concern to the people of Yarra Ranges.

Extracts from postings on the Yarra Ranges Council "Conservation and community access ahead for Haining Farm internet discussion forum":

> As a ratepayer I would have hoped that the Council would have satisfied its duty of care to protect us all from the threat of bushfire before endorsing Greening Australia, DELWP & Parks Victoria's planned revegetation of Haining Farm in Don Valley. Not even a mention of the fire risk assessment, or its importance, Maybe possums and birds are more important than human lives and that's why Council have not had their Municipal Fire Plans audited since 2014 as required by the CFA Act 1958, which requires an audit at least once every 3 years. (Clause 55 B1). I would like to think when I am paying my rates this week that these issues will be dealt with as a matter of urgency.
>
> Yarra Waterways Group | 13 February 2018; and
>
> Hi, Thanks for your comment. The Municipal Fire Plan (a joint-agency Fire Management Plan involving CFA, MFB, Parks Victoria, DELWP, VicRoads and Yarra Ranges Council) was audited by CFA in 2015. The Plan is currently being updated by the Municipal Fire Management Committee and will be audited by the CFA later this year. This is in compliance with the CFA Act (1958).
>
> Kind regards, Jesse 14 February 2018

Those responsible for the MFPP should be reviewing it annually and had the plan finalised for the next period to achieve a seamless transition. Causes me to wonder where the CFA is on this.

The MFPP should include direction to the Municipal Fire Prevention Officer in the use of "fire prevention notices" according to Section 41 Country fire Authority Act 1958, particularly where settlements such as Don Valley are concerned.

6.2 DELWP Code of practice for bushfire management on public land – page 13

In the event the afforestation of Haining Farm proceeds what will be the standard of vegetation management guaranteed to protect the adjoining public roads and the residential estate?

Is there a project manager responsible for the whole project and if yes who is that? Is there a comprehensive project plan that includes species and plantings spacing, finance and timelines, and is there a commitment to recurrent funding into the future, including assured people and machinery, to ensure Haining Farm is managed into the future consistent with the following undertaking from Ms Kelly Crosthwaite, Regional Director Port Phillip DELWP, in her letter to Ms Jenny Barber dated 13 February 2018:

> I want to assure you that DELWP and Parks Victoria, as the agencies responsible for bushfire management on Crown land in Victoria, take bushfire management very seriously and will implement a range of measures to reduce the risk of bushfire in this area. DELWP is currently in the process of preparing a bushfire management plan for the Yellingbo Conservation Area in partnership with the CFA and Parks Victoria. The purpose of the plan is to identify areas of existing bushfire risk and mitigation measures that can be implemented to ensure there is no increased risk of bushfire resulting from the implementation of the Yellingbo Conservation Area.

Concerning the extract from Ms Crosthwaite's letter, my earlier reference to an email from one of the independent experts to a concerned Don Valley resident on 8 February causes me to wonder given Parks Victoria/DELWP performance in other parts of Victoria.

9 CONCLUSION

This report is largely a critique of papers put forward by the government in support of a proposal to afforest Haining Farm adjacent to the Don Valley residential estate, ostensibly founded on an assertion that the bushfire threat will not be increased, and consideration of related matters sourced by me.

The assertion that the bushfire threat will not increase seems to be based on the results of the application of a bushfire behaviour model that predicts probability of house loss: PHOENIX RapidFire. Unfortunately, vegetation or bushfire fuel loads that is species and concentrations were not available from Parks Victoria/DELWP, the principal proponents of the afforestation of Haining Farm, when this report was finalised. And, I understand from Yarra Waterways Group, the project owner, it was not for want of requesting this information.

A questionable feature of the bushfire risk assessment is the uniform percentage housing loss across a relatively large study area, questionable because it seems not to take account of what could only be an increase in bushfire fuel load given a Greening Australia statement that “over 315,000 trees and shrubs will be planted next year [2018], along with 100 different types of understory plants …”

Given the lack of information available on vegetation species and planting concentrations proposed for the afforestation — and data used in the PHOENIX RapidFire modeling (?) — I consider a statement from one of the independent experts supporting the proposal incredible: “I do not consider the revegetation on Haining Farm to significantly change the bushfire risk in the Yarra Valley around Don Valley”.

Also questionable is the factoring in of emergency response firefighting resources, including firebombing aircraft, as integral to reducing any bushfire threat associated with the afforestation. Anyone with a real knowledge of bushfire occurrence, suppression difficulty and concentration of such resources according to the risk exposures will know that this is a promise that may not be able to be delivered when most required. Passive protection rather than reliance on emergency response should be the focus of Parks Victoria/DELWP, particularly with the exposed Don Valley residential estate adjoining to the east.

Minimising the bushfire threat posed to the adjoining residential estate is critical to minimising the potential for loss of homes, and in this case a school, due to the government’s urging the “go early” approach on the community that leaves homes without people available to deal with ember attack to supplement any fire brigade attendance.

When researching current bushfire protection arrangements for the Don Valley residential estate I was disturbed to find that there was no current Yarra Ranges Municipal Fire Prevention Plan according to section 55A Country Fire Authority Act 1958. I’ve heard of excuses that section 55A has been overridden by the Emergency Management Act or that is to occur. However, section 55A remains in the Country Fire Authority Act and I cannot imagine the Office of the Chief Parliamentary Counsel Victoria allowing any conflict between Acts to remain, and to my knowledge other forms of instruction or advice do not override an Act of parliament.

From within the papers perused I have extracted the primary objectives for bushfire management on public land, including the statement “human life will be afforded **priority** over all other considerations”.

Having experienced the aftermath of several major bushfires, particularly the Trentham East–Macedon fire of Ash Wednesday 1983, Kilmore East and Murrindindi fires of 2009 and the Wye River–Separation Creek fire of 2015, it is reasonable to comment that very many people were hurt emotionally and/or financially through loss of homes, important and valuable possessions, including tools of trade, devastating to those affected — human life must be viewed more widely than just life loss or injury due to being caught in a fire.

The protection of the Helmeted Honeyeater and Leadbeater’s Possum should be able to be achieved without increasing the bushfire threat to the Don Valley residential estate and beyond.

From the range of papers and other documents considered, these issues stand out:

9.1 Generally the 'drip feeding' of information to Yarra Waterways Group (YWG) over time to support the proposal to afforest Haining Farm that to me appears to be 'backfilling' responding to questions or requests from YWG;

9.2 Significantly, the continuing failure to provide actual fuel input data used by the fire analyst in PHOENIX RapidFire;

9.3 The uncertainty or lack of specificity involved with the bushfire risk assessment process

Consequently, my principal advice to Yarra Waterways Group is that it should press the government to be directly and actively represented on the body preparing the project plan to afforest Haining Farm then monitor its implementation.

The Honourable Lily D'ambrosio MP, Minister For Environment

In a letter to Mr Rick Houlihan, Chairman, Yarra Waterways Group, dated 23 July 2017, Minister D'Ambrosio stated the following:

> The main purpose of the working group is to develop a plan for the site that considers the views of the community and does not materially increase the bushfire risk to the local and broader community. I understand that the working group began by looking at the existing bushfire risk and used the original concept plan prepared for the site to determine whether revegetation of the site could be considered as a viable option without increasing the bushfire risk.

To me, the proof will be in the 'pudding'!

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John Nicholson, AFSM
Graduate Institution of Fire Engineers
Director
Community Safety Services Pty Ltd

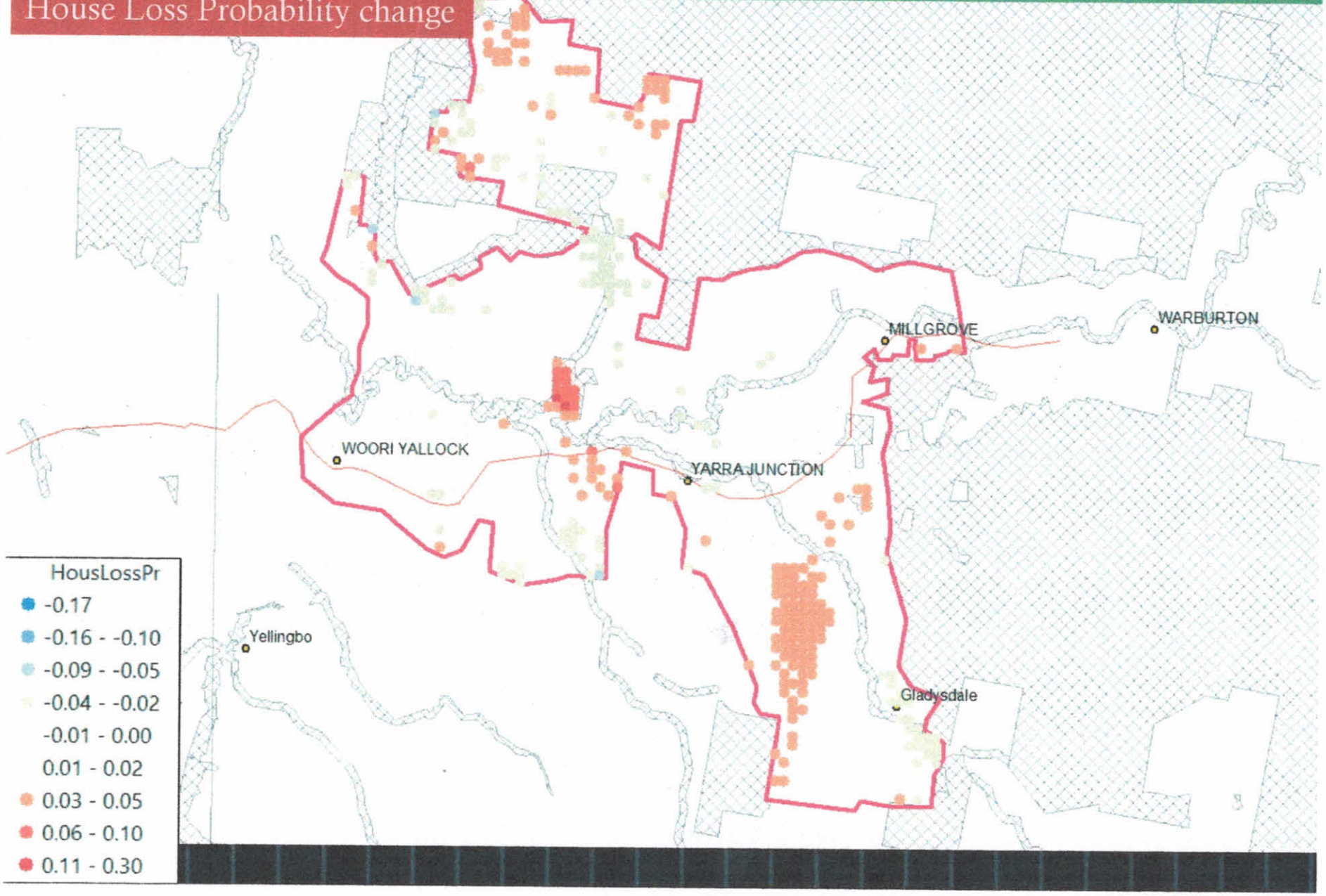
Member Expert Advisory Board, Bushfire Building Council of Australia

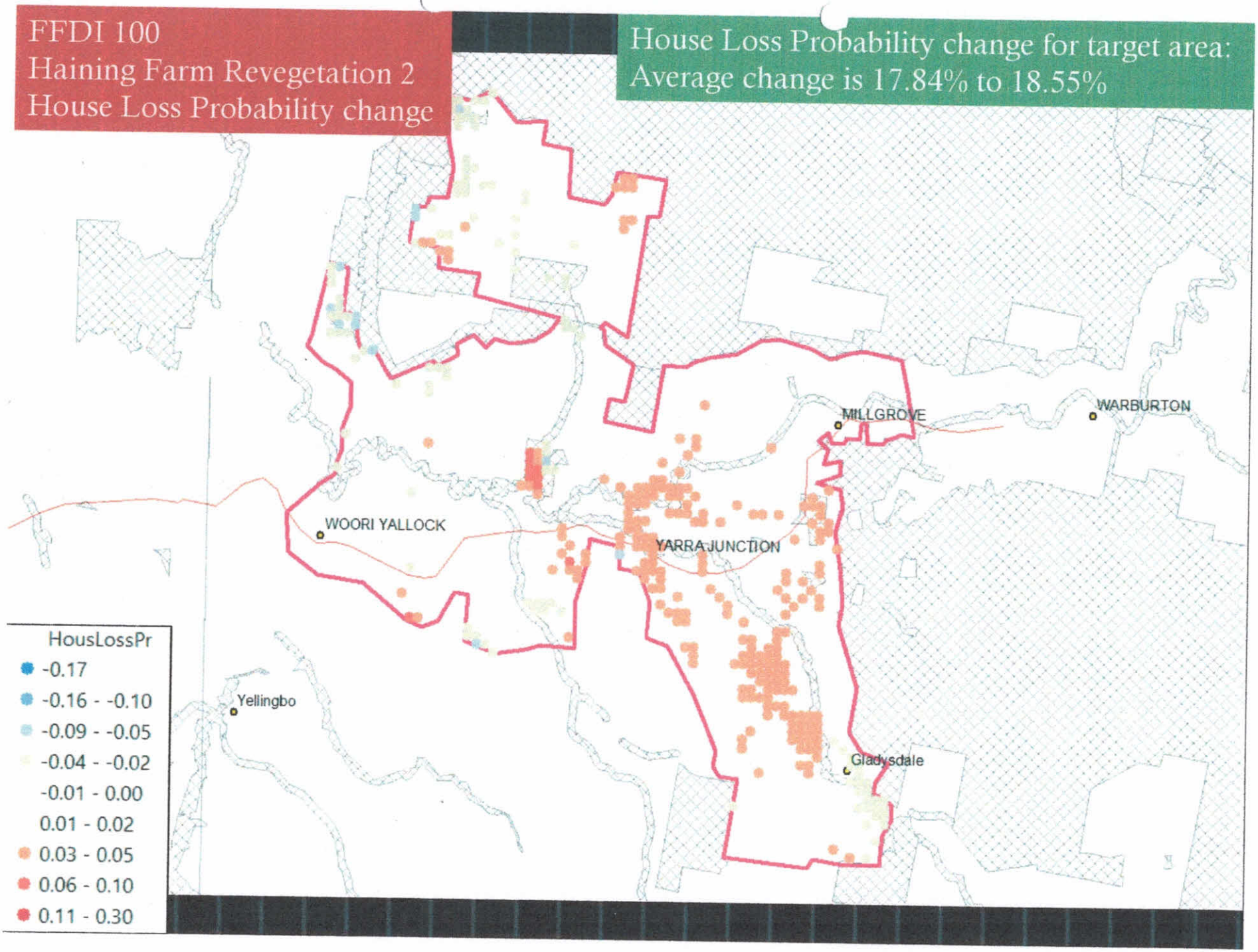
APPENDIX A

House loss probability changes

FFDI 100
Haining Farm Revegetation
House Loss Probability change

House Loss Probability change for target area:
Average change is 17.84% to 18.21%




FFDI 100
Haining Farm Revegetation 2
House Loss Probability change
House Loss Probability change for target area:
Average change is 17.84% to 18.55%
MILLGROVE
WARBURTON
WOORI YALLOCK
YARRA JUNCTION
Yellingbo
Gladysdale
HousLossPr
-0.17
-0.16 - -0.10
-0.09 - -0.05
-0.04 - -0.02
-0.01 - 0.00
0.01 - 0.02
0.03 - 0.05
0.06 - 0.10
0.11 - 0.30

APPENDIX B

Yellingbo Investigation Area Landscape Risk Analysis extract

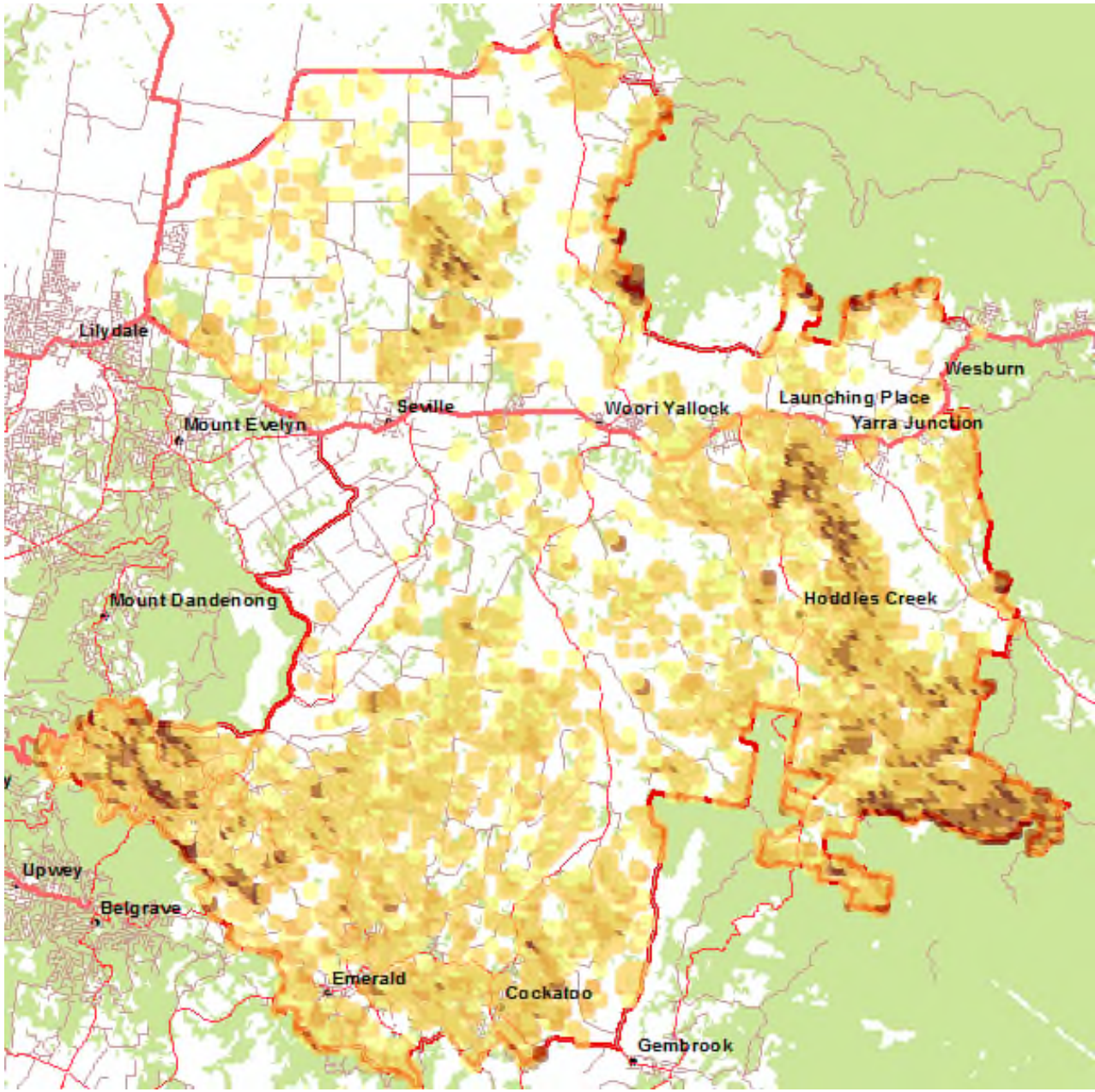
Yellingbo Investigation Area

Landscape Risk Analysis

Intensity

Areas of high potential fire line intensity >=10000 kW/m2

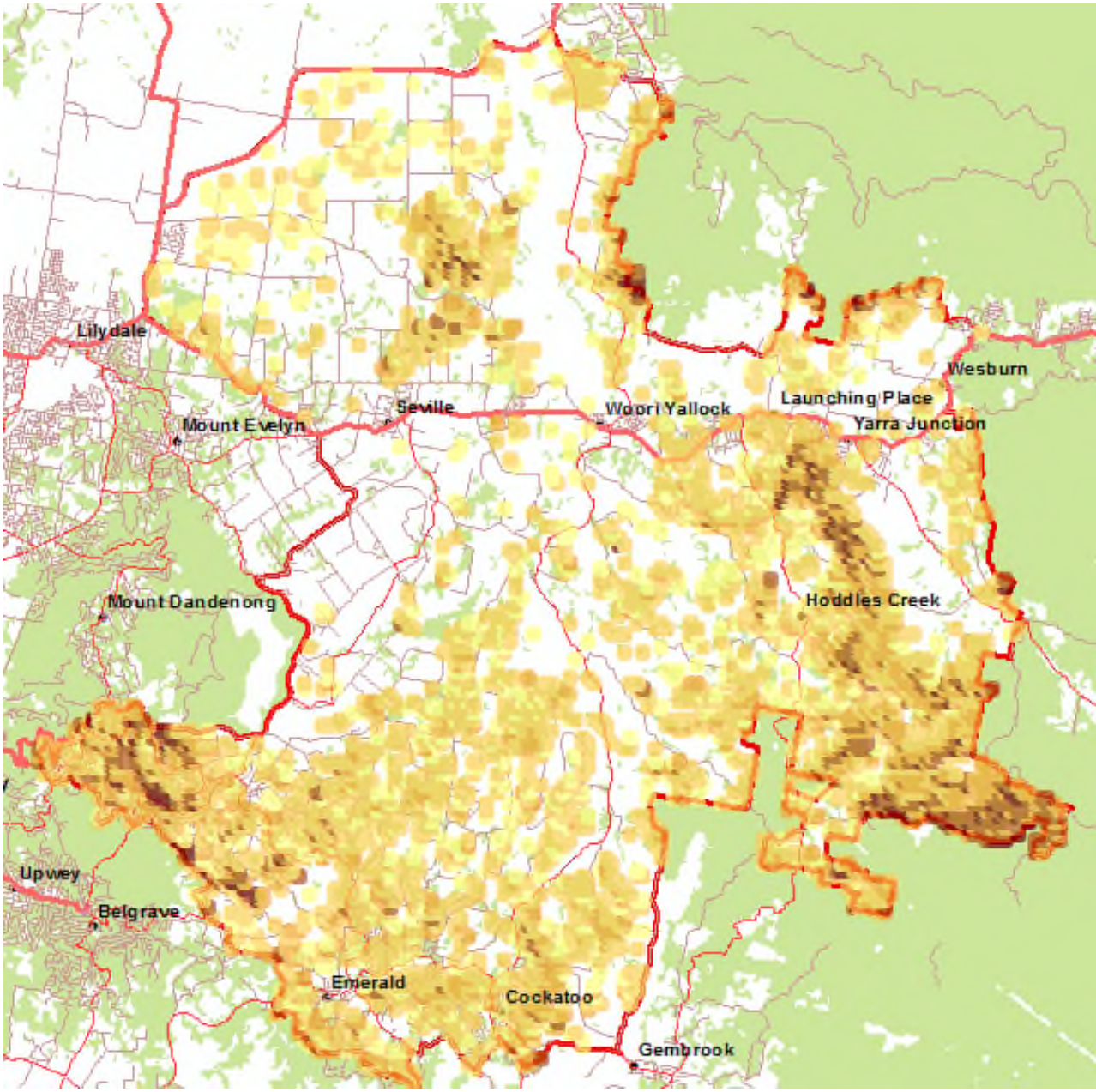
Current vegetation



Intensity

Areas of high potential fire line intensity >=10000 kW/m2

Crown suppression
- No large changes



APPENDIX C

150 Metres Radius Google Earth Photo


Don Valley Residential Estate
Google Earth
Dairy Rd
Old Dairy Rd
150 metres BMO assessment
radius required by CFA
Estate Rd
Don Valley Pimary
School
Don Valley
C506
Don Rd
Old Don Rd
Williams Rd
Harberts Rd
200 m
N
Google earth
© 2018 Google
Image © 2018 DigitalGlobe

APPENDIX D

Assessing Potential House Losses Using PHOENIX RapidFire

Assessing Potential House Losses Using PHOENIX RapidFire

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Abstract

There has been a considerable body of work identifying the characteristics of houses and their surroundings that contribute to house loss in bushfires (Wilson & Ferguson 1986, Ramsey et al. 1987, Cohen 1995, Blanchi et al. 2006, Blanchi et al. 2010, Mell et al. 2010) . However, the characteristics of a bushfire, such as flame length, intensity, size, and spotting characteristics are also important. PHOENIX RapidFire characterizes fire in a spatially and temporally explicit way. One logical use of a simulation model such as PHOENIX RapidFire is to estimate the number of houses that might be lost when they are impacted by a bushfire. The recent Black Saturday fires in Victoria, have provided an opportunity to evaluate the utility of PHOENIX RapidFire to assess potential for house losses under Black Saturday conditions) nt conditions associated with about 2000 house losses. This dataset has provided an opportunity to develop a potentially better predictive model of house loss for use by emergency response agencies during a bushfire event as well as provide criteria to evaluate the potential benefits of a range of planning and land management activities on reducing the impact of bushfires on houses.

This paper presents the results from this analysis and the algorithms developed for predicting house loss based on modelled fire behaviour characteristics from PHOENIX RapidFire.

Introduction

Barrow (1945) was the first person in Australia to record the fact that house loss in bushfires is not a random event. He identified that embers were a major house ignition source, and that building details rather than building materials were important to house survival, in the 1944 fire in Beaumaris, then on the outskirts of Melbourne. Since then, research by Wilson and Ferguson (1985), Ramsey *et al.* (1987), Leonard and Blanchi (2005), Blanchi *et al.* (2006) and others have increased our understanding of the mechanisms by which houses are ignited in bushfires and other factors leading to their destruction. These studies have identified that factors related to fire characteristics such as fireline intensity, flame height, and ember production are important to the probability of house loss. They have also shown the importance of building design, construction materials, degree of maintenance and siting were also important. And an additional factor of high importance is whether or not someone was actively defending the home by extinguishing ignitions while they were in their early stages of development.

This study investigates the feasibility of using PHOENIX RapidFire (Tolhurst *et al.* 2008), a fire characterization simulator, to adequately spatially and temporally describe some key fire characteristics, to find a statistically significant connection between these modelled fire characteristics and the known pattern of house loss from the 2009 Black Saturday bushfires in Victoria.

Methods

An extensive survey of houses, both damaged and undamaged, in the areas affected by the Black Saturday fires in Victoria was coordinated by the Bushfire CRC. This provided an unusually large dataset for model evaluation. Records from 5024 houses surveyed were used in this analysis. The dataset used was supplied by Geoscience Australia. The dataset comprised houses that were affected by the Churchill, Murrindindi and Kilmore East Fires. Of the sample 2640 houses were either damaged or destroyed by the fires and 2381 survived. The Black Saturday fires were large (about 300,000 ha burnt in the first day) and intense and occurred in largely dissected mountainous terrain with pronounced spotting being a major feature of the fire behaviour. A further 58 houses were included in the sample from the Deep Lead fire, near Stawell, from 2005, 13 of which were destroyed. The Deep Lead fire burnt in mixed agricultural and remnant bushland in gently undulating terrain and was primarily a wind-driven grass fire with minimal spotting contributing to the overall fire behaviour, providing a contrasting set of conditions to the Black Saturday fires. All houses surveyed that had been damaged or destroyed were classified as "Lost" in this analysis and all others were classified as "Survived".

PHOENIX RapidFire is a spatio-temporal fire characterization model (Tolhurst *et al.* 2008) that estimates fire behaviour characteristics as it burns through a landscape. Fire spread is calculated as a series of continuous variables across the landscape, but the fire characteristics are only recorded within a fixed square grid, the cell-size of which can be selected by the user, but in this analysis, a 180 x 180 m cell size was used. This grid size

R.P.Thornton (Ed) 2011, 'Proceedings of Bushfire CRC & AFAC 2010 Conference Science Day' 1 September 2011, Sydney Australia, Bushfire CRC

(3.24 ha) provided sufficient detail to see the fire pattern across the landscape without unnecessarily consuming computer time on details that make little difference to the fire pattern. In each cell, 10 input variables related to fuel, terrain, and access are recorded and 14 output variables related to fire characteristics and modified winds are recorded. The fire characteristics are: the time a cell is burnt since ignition, its average rate of spread and associated fireline intensity (Byram 1959), the time when the first embers arrived since ignition, the maximum distance embers have travelled to reach this cell, cumulative ember density landing in a cell until it ignited, the time from ignition when fire was suppressed, the time from ignition when fire self-extinguished, the average flame height when fire first entered cell, the flame depth when fire first entered cell (assuming a 10 second residence time in grassland and 80 seconds in shrubland and forests), maximum relative convective updraught strength[4] in cell, fine fuel moisture content, local wind speed as affected by terrain, and local wind direction as affected by terrain. In the analysis here, two additional fire variables were derived from the basic 14, these being flame cross-sectional area (FlameXS) which assumed the flame was a triangle with a base length (L) equal to the flame depth and the triangle height (H) being equal to the flame height (Fig. 1). The second derived variable was "convection density" where the local convective strength was averaged across an area with a 2000 m radius and recorded with 100 m resolution using a kernel density routine in ESRI ArcGIS. The house locations were intersected with the fire characteristics in ArcGIS to produce a dataset that connected the house location with the simulated fire characteristics. It was this dataset that was used in the analysis report here.

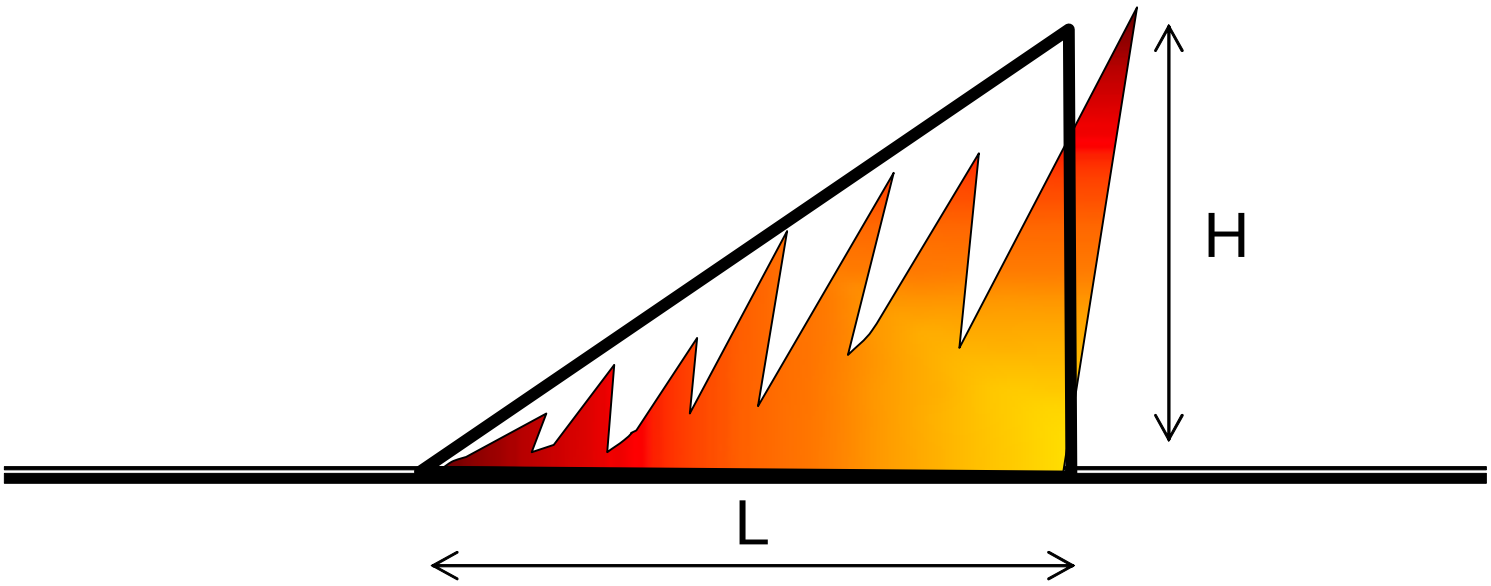

Figure 1. Diagramatic representation of how the flame cross-sectional area is calculated. H is the flame height and L is the flame base length.

Both univariate and multivariate statistical analyses were used. Univariate analyses were primarily non-linear regression analyses. Before the regression analysis, output variables were grouped into classes and the probability of loss for each class was based on the

[4] Relative Convective Strength was calculated as the total energy output (MW) of a segment of the fire perimeter which was assessed to be drawn into a common convection centre, at each timestep of the modelling process.

number of houses "Lost" as a proportion of the total number of houses in each class. These data were graphed for each of variables and regression analysis was made to find the best regression model to describe the relationship between the probability of house loss and the variable of interest. Multivariate analysis consisted of a Principal Component Analysis and Logistic regression using Minitab version 16 (Minitab Inc., 2010).

Results

The multivariate analysis (Principle Component Analysis) showed that there was a strong correlation between the local convection strength ("Convect") and the generalized convection density ("ConvectDens") (Fig. 2). Similarly, there was a strong correlation between flame height ("FlameHt"), flame depth ("FlameDpth") and fireline intensity ("Intensity"). Flame cross-sectional area was correlated to the other flame dimensions, but showed some independence. Modelled ember density ("Embers") was independent of all other fire variables, but explained a smaller proportion of the variation in the data than the other variables. This analysis shows that there are three relatively independent factors describing the simulated fire characteristics associated with house loss on Black Saturday - "Ember Density", Flame Height/Flame Depth/Flame Cross-sectional area/Fireline Intensity, and Convective Strength/Convective Strength Density.

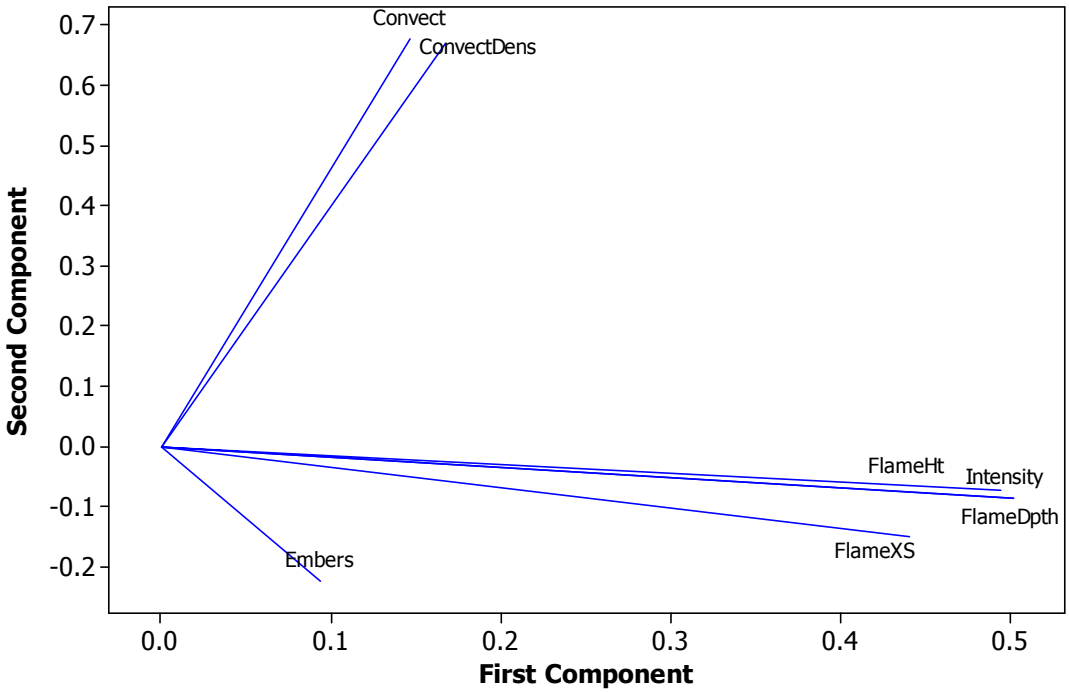

Figure 2. Principle Component Analysis of predicted fire variables for houses destroyed in the Kilmore East, Murrindindi and Churchill fires on Black Saturday 2009.

Analysis of individual fire characteristics showed significant trends between the magnitude of each factor and the probability of house loss (Figures 3 to 8). The line of best fit for each factor is given in Table 1.

Table 1. Line of best fit regressions for a number of modelled fire parameters and the probability of house loss.

Fire Parameter	**Model**	**R value**
Flame height (m)	Pr(Loss) = 0.8348/(1+1.10667*EXP(-0.05726*FlameHt))	0.896
Flame cross-sectional area (m^2)	Pr(Loss) = 0.40935*FlameXS^0.0793	0.935
Ember density (No./m^2)	Pr(Loss) = 0.5715*(1.1747-EXP(-0.9513*Ember))	0.907
Fireline Intensity (kW/m)	Pr(Loss) = 1/(4.5278-1.7366*Intensity^0.05456)	0.952
Convection	Pr(Loss) = 0.2543*(Convect+5.6966)^0.104	0.981
Convection Density	Pr(Loss) = 0.9303-0.7554*EXP(-0.0000926*ConvectDens^0.7085)	0.989

If instead of predicting a probability of house loss, each house was assessed on the basis of a binary classification of "Lost" or "Survived", then the threshold values of each fire parameter that would be define the 50/50 chance of loss or survival are listed in Table 2. This analysis does not consider the interaction of variables, e.g. the enhancing of house ignition by embers when there is also a significant radiation heat load, which would be confounded in these thresholds. For example, it is likely that a house might be subjected to both radiation and ember attack, but these factors cannot be separated in this analysis.

Table 2. 50% survival/loss threshold value for each fire parameter based on the line-of-best-fit regression lines in Table 1.

Fire Parameter	**50/50 Survival Threshold Value**
Flame height (m)	9 m
Flame cross-sectional area (m^2)	13 m^2
Ember density (#/m^2)	1.3 embers/m^2
Fireline Intensity (kW/m)	1,000 kW/m
Convection	700

Convection Density	220,000

Two binary logistic regressions were fitted to the house survival/loss data using Logit. A range of factor combinations were explored, but only two combinations were considered to be generally applicable. Three factors were used in each of the two models. Both included Flame Cross-sectional Area and Ember Density. The difference between the two regressions was the use of either Convective Strength or Convective Density. Both these regressions are statistically significant at the p=0.001 level and the ranked-based non-parametric statistic, Somers' D (Newson 2002), indicates that 51% of the variation in the probability of house loss is explained by equation 1 and 42% of the variation is explained by equation 2.

Logistic equation 1.

Pr(Loss)=1-EXP(0.63076-0.0000021*ConvectDens-0.0002662*FlameXS-0.01832*Embers)/(1+EXP(0.63076-0.0000021*ConvectDens-0.0002662*FlameXS-0.01832*Embers))

Somers' D = 0.51

Logistic equation 2.

Pr(Loss) =1-EXP(0.2894-0.000487*FlameXS-0.02003*Embers-0.0000157*Convect)/(1+EXP(0.2894-0.000487*FlameXS-0.02003*Embers-0.0000157*Convect))

Somers' D = 0.42

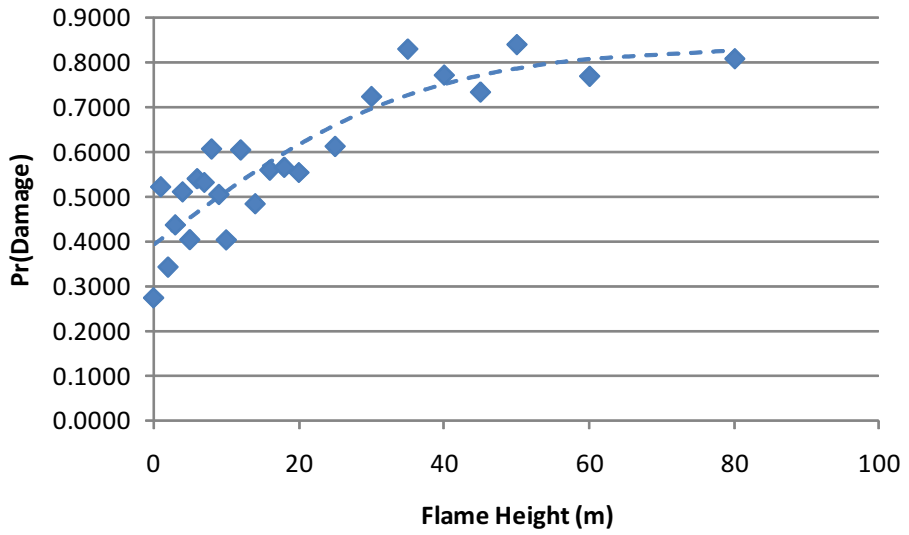

Figure 3. Probability of house loss when associated with predicted flame height.

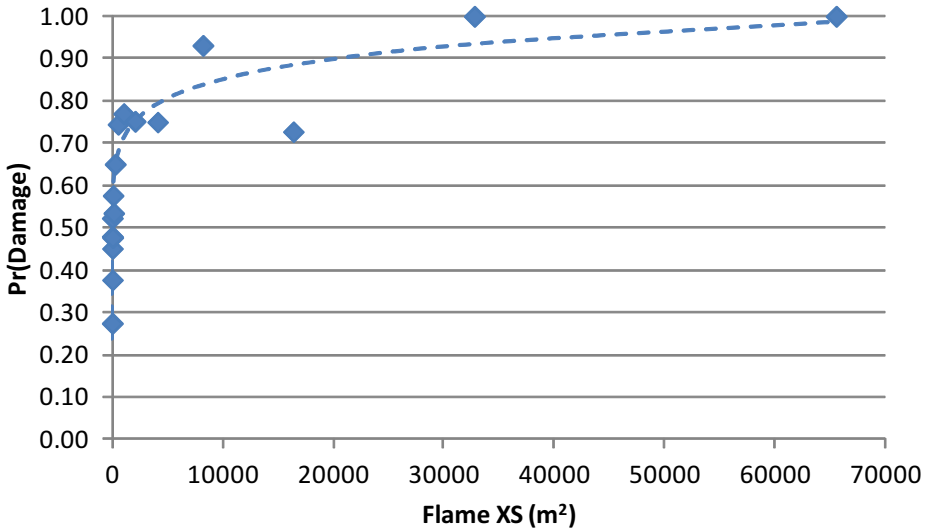

Figure 4. Probability of house loss associated with predicted flame cross-sectional area.

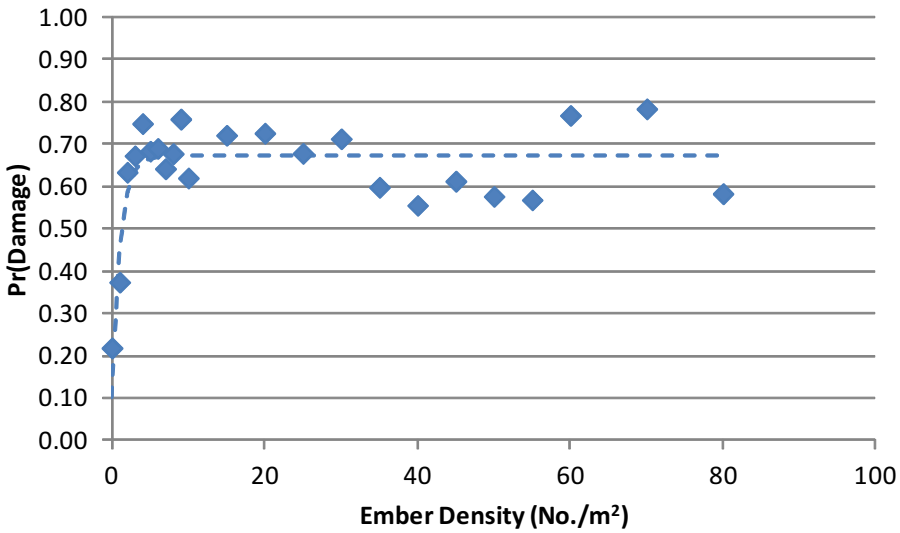

Figure 5. Probability of house loss associated with predicted ember density.

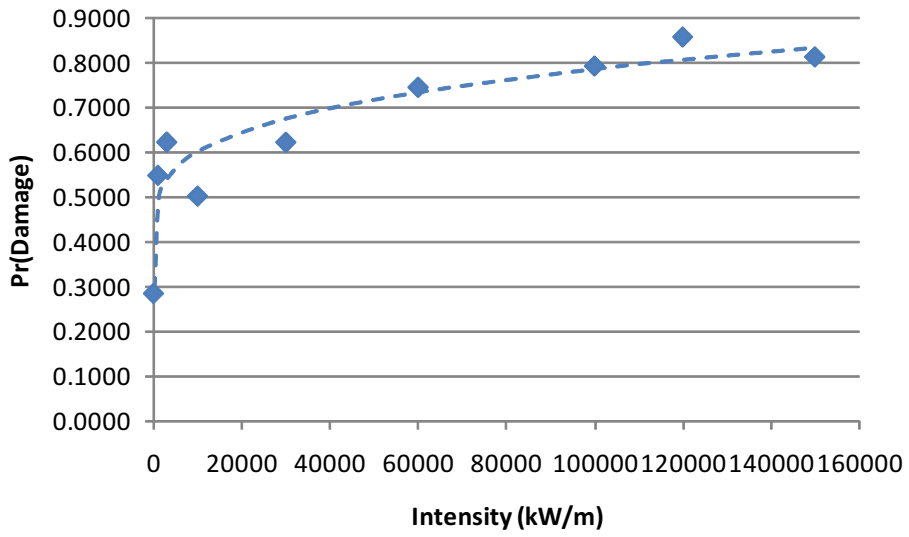

Figure 6. Probability of house loss associated with predicted fireline intensity.

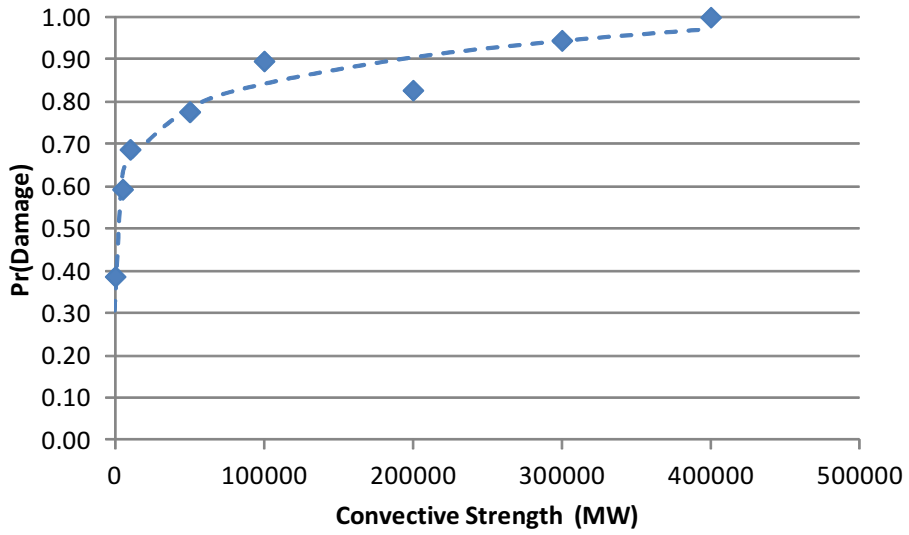

Figure 7. Probability of house loss associated with predicted convective strength.

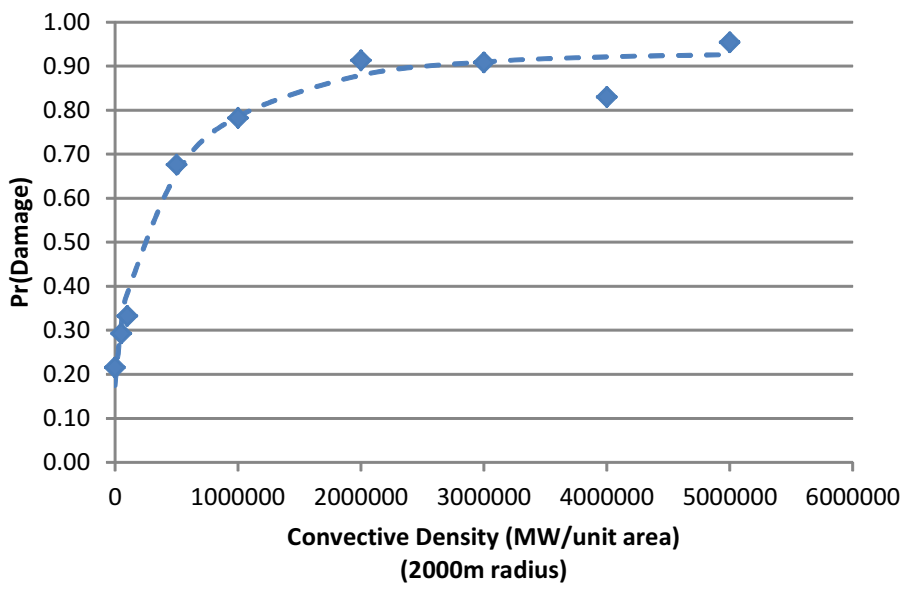

Figure 8. Probability of house loss associated with predicted convective strength smoothed over a 2000 m radius.

Table 2. Average probability of house loss predicted by each of the proposed models (Table 1 and Logistic equations) compared with the actual house status "Lost"/"Surv", subdivided by fire event. (Flame XS = flame cross-sectional area, EmberDens = ember density, Intensity = fireline intensity, Convection = convective strength, ConvectDens = convective strength density.)

	Logit1		Logit2		FlameXS		FlameHt		EmberDens		Intensity		Convection		ConvectDens	
FIRE	Lost	Surv	Lost	Surv	Lost	Surv	Lost	Surv	Lost	Surv	Lost	Surv	Lost	Surv	Lost	Surv
Churchill	0.59	0.46	0.58	0.50	0.52	0.35	0.53	0.48	0.61	0.34	0.58	0.47	0.50	0.39	0.52	0.35
Kilmore	0.61	0.45	0.58	0.49	0.53	0.41	0.58	0.49	0.53	0.37	0.57	0.48	0.49	0.38	0.52	0.35
Murrindindi	0.54	0.41	0.50	0.45	0.48	0.33	0.50	0.46	0.52	0.24	0.54	0.43	0.40	0.34	0.52	0.33
Stawell	0.36	0.37	0.43	0.44	0.51	0.47	0.44	0.44	0.13	0.15	0.60	0.57	0.33	0.38	0.25	0.27
Total	**0.59**	**0.44**	**0.56**	**0.48**	**0.52**	**0.40**	**0.55**	**0.48**	**0.53**	**0.34**	**0.56**	**0.47**	**0.47**	**0.38**	**0.52**	**0.34**

The average probabilities of house loss predicted by various models compared to the actual status of each house on an individual basis is not strongly differentiated, certainly not as strongly differentiated as might be expected from the consistency of the relationships shown in Figures 2 to 7. This is interpreted to suggest that the relationships between the fire characteristics predicted by PHOENIX RapidFire and the probability of house loss are not a very good basis for predicting the probability of loss of individual houses even though the predictions about the general house loss for groups of houses is quite strong. In all cases in Table 2, the averaged predicted probability of house loss is higher for the damaged and destroyed houses ("Lost") than for the houses that survived ("Surv"), so each of the models work on average

Table 2 shows an interesting distinction between the three fires analyzed from Black Saturday and the Stawell fire. With most of the models, the predicted probability of loss is

less than 0.5 and distinctly less than the probabilities for the Black Saturday fires. The Stawell fire was a fast moving, wind-driven grassfire largely in grassland with only scattered areas of forest and woodland, quite different to the situation in the Kilmore East, Murrindindi and Churchill fires which were largely in mountainous forested country and developed very large convective plumes. Even though the "EmberDens", "ConvectDens" and "Logit1" models gave the best overall prediction of house loss, it was the model based on the Flame Cross-sectional Area ("FlameXS") which gave the most consistent prediction regardless of whether the fire was in grassland or forest.

In all cases, except one, the average probability of house loss predicted for surviving houses was less than 0.5. The sole exception was for the houses surviving the Stawell fire when using the predictive model based on Fireline Intensity. The intensity of the Stawell fire was dominated by the rapid rate of spread rather than the effect of fuels and topography, as would be expected in a grassland-dominated fire.

Discussion

House loss in bushfires results from the combination of many interacting factors including characteristics of the house construction, the presence or not of fire suppression efforts during the fire event, the level of garden (fuel) and house maintenance, the proximity of flammable objects to the house, the nature of the bushfire itself, the position of the house in the terrain and an element of chance (Wilson & Ferguson 1986, Blanchi *et al.* 2006). Previous attempts to predict bushfire threat in terms of potential house loss using a static view of geospatial data such as vegetation, slope, aspect and potential fire intensity, had limited success in identifying houses most at risk (Lowell *et al.* 2009). It is not surprising that it is difficult to accurately predict which specific houses will survive and which will be lost when it is not possible to accurately quantify all the interacting factors during a fire event. However, there are some factors which can be adequately quantified and have a significant bearing on the probability of a house surviving or being destroyed during a bushfire. These probability ratings can give a reasonable prediction of the likely number of houses that will be lost in a neighborhood, without being certain about specific houses and this has been demonstrated in this study. A dynamic view of fire behaviour as provided by a simulator such as PHOENIX RapidFire is likely to result in better predictive ability than a bushfire threat model based on a static view of fire.

Detailed analysis of the circumstances associated with house loss in bushfires has identified the critical factors. Some of these factors are related to the nature of fire and it is these that have been used here. Flame characteristics such as flame height and flame cross-sectional area affect the radiative heat load on a house and the likelihood of flame contact, so it was not surprising to find a strong association between the flame characteristics predicted by PHOENIX RapidFire and the known level of house loss. Fireline intensity was also identified by Wilson and Ferguson (1986) as being strongly associated with house loss and again, there was a strong relationship between the modelled fire intensity and the probability of house loss. Embers have been associated with about 90% of all house losses as either the primary ignition source or an ignition source in combination with other factors (Leonard and Blanchi 2005). In the analysis here, the probability of house loss increases rapidly with ember density and then seems to "saturate" at relatively low levels. The addition of further embers does not change the probability of house loss, and the probability of house loss with

embers alone does not exceed about 70%. A unique aspect of using PHOENIX RapidFire to assess the nature of the fire is the ability to calculate the local convective strength. Strong convective influences only occur in large intense fires where the weather, fuel and topography combine to create suitable convective development. Convective strength has not been a factor specifically included in house loss studies because of the difficulty in determining it. Computer modelling makes this possible, even if the method used to calculate convection in PHOENIX RapidFire is not a 3-dimensional fluid-dynamic model it provide sufficient convective characteristics to correlate local fire behaviour with potential house loss. In this study, the convective strength (and convective density) was strongly correlated with the house loss in the fires of Black Saturday in Victoria, but was not as important in the Stawell fire in 2005 where grass fuels dominated and the topography was flat to undulating.

The most robust model for predicting the probability of house loss is the logistical model that combines the effects of flame cross-sectional area, ember density and convective strength density. These three variables represent the three main components of the data shown in Fig.1. This model incorporates the main factors, related to the fire itself, that are known to be associated with house loss. However, the model using just flame cross-sectional area would give a more consistent prediction of house loss across contrasting fire types - flat grassland fires compared with fires in forested hills and mountains. Flame characteristics explain the greatest amount of variation in the house loss data (Fig.1). Given the history of greater house loss in forested hills and mountains, it would seem prudent to use the logistical model as the first choice in complex landscapes.

Conclusions

PHOENIX RapidFire provides an adequate spatial and temporal characterization of bushfires to be able to estimate the probability of house loss at a neighborhood scale. Although the fire characterization by PHOENIX RapidFire has not been, nor is ever likely to be validated at a scale similar to that used here (3.24 ha) it does provide a realistic range of fire behaviour characteristics and spread that can be used for analyses such as this. A logistic model incorporating flame cross-sectional area, ember density, and convective strength density produced the most robust model overall. A non-linear regression model using just flame cross-sectional area gave more reliable results in grassland dominated landscapes.

House design and level of preparation and maintenance were not considered in this modelling process, nor was the level of active defense during the passage of the fire. These are known to also be important contributing factors to the probability of house survival, but could not be included in this analysis due to lack of adequate data.

The predicted level of house loss using simulated fire characteristics, provides a useful basis for assessing the relative threat of fire in a range of circumstances. It is therefore expected that this modelling approach could be used to evaluate the relative benefits of different fire mitigation options such as broadscale planned burning and fuel modification in and around townships and small communities.

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APPENDIX E

NBRU Firebreak Research

Predicting the effectiveness of firebreaks

Family tradition and the width of a farmer's plough are probably the main determinants of the placement and proportions of many firebreaks in rural Australia. The National Bushfire Research Unit has now developed a statistical model that provides some pointers on construction of such breaks and makes predictions about their likely success rate when confronted by grassland fire.

Most farmers and graziers construct firebreaks to protect the homestead and other assets, to exclude fires at property boundaries, or to isolate crops, timbered land, and other fire-prone areas. They are formed deliberately by cultivation, mowing, grazing, or burning, but roads, fallow land, and green crops can also halt fires.

So any strip of land that is denuded of flammable material can serve as a break — allowing access to fires, providing a line from which to back-burn, and, if all goes well, actually slowing or stopping an approaching front. They range in size from narrow cattle or sheep pads (that can hold up extremely mild fires) to vast strips, 50 m or more wide, sometimes constructed in plantations.

Firebreaks are commonly used and often required by law. In the agricultural region of Western Australia alone, the length constructed each year amounts to a total of the order of 200 000 km. Their construction requires much effort, equipment, and money, and reduces the area available for grazing and crops. Some are unsightly or prone to erosion, and their construction can degrade or destroy important remnants of native vegetation, especially along roadsides. On the other hand, of course, in the event of bushfire they may reduce both suppression costs and damage.

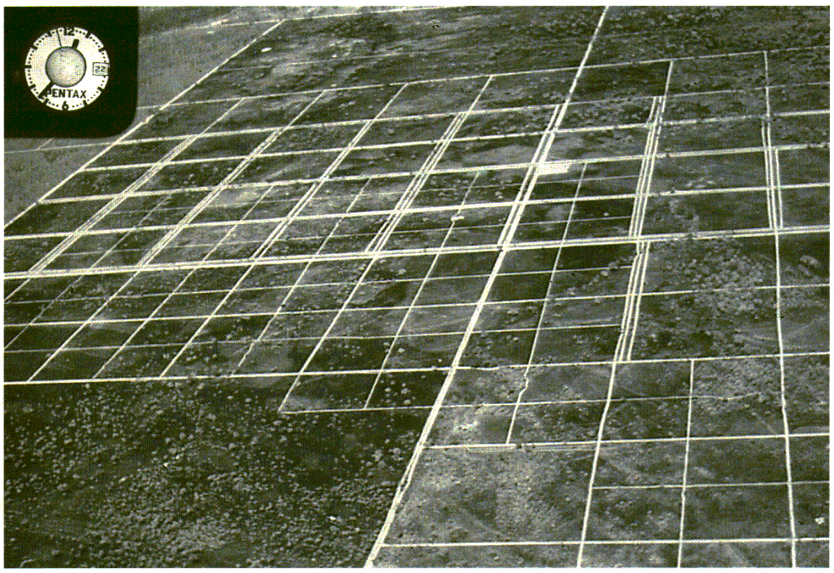
But how effective are firebreaks? And how wide should they be? Those on farms are usually 2–3 m wide, perhaps 5 m in wheat country, and often follow fence-lines or roads.

Grading a furrow from which to burn a firebreak.

Yet some authorities on the subject believe that a fast-spreading grass fire fanned by strong winds will even cross firebreaks greater than 30 m wide. At the other extreme, firebreaks only 30 cm across will sometimes stop very mild fires.

Without firm quantitative information on the effectiveness of breaks of various widths in halting the progress of bushfires, landowners relying on traditional strips 2 or 3 m wide may well be taking a gamble. In the event of a fire these breaks will probably not perform up to the landholders' expectations.

An aerial view of the experimental area — grassland divided by firebreaks in a distinct grid pattern. The smallest blocks measure 100 × 100 m.

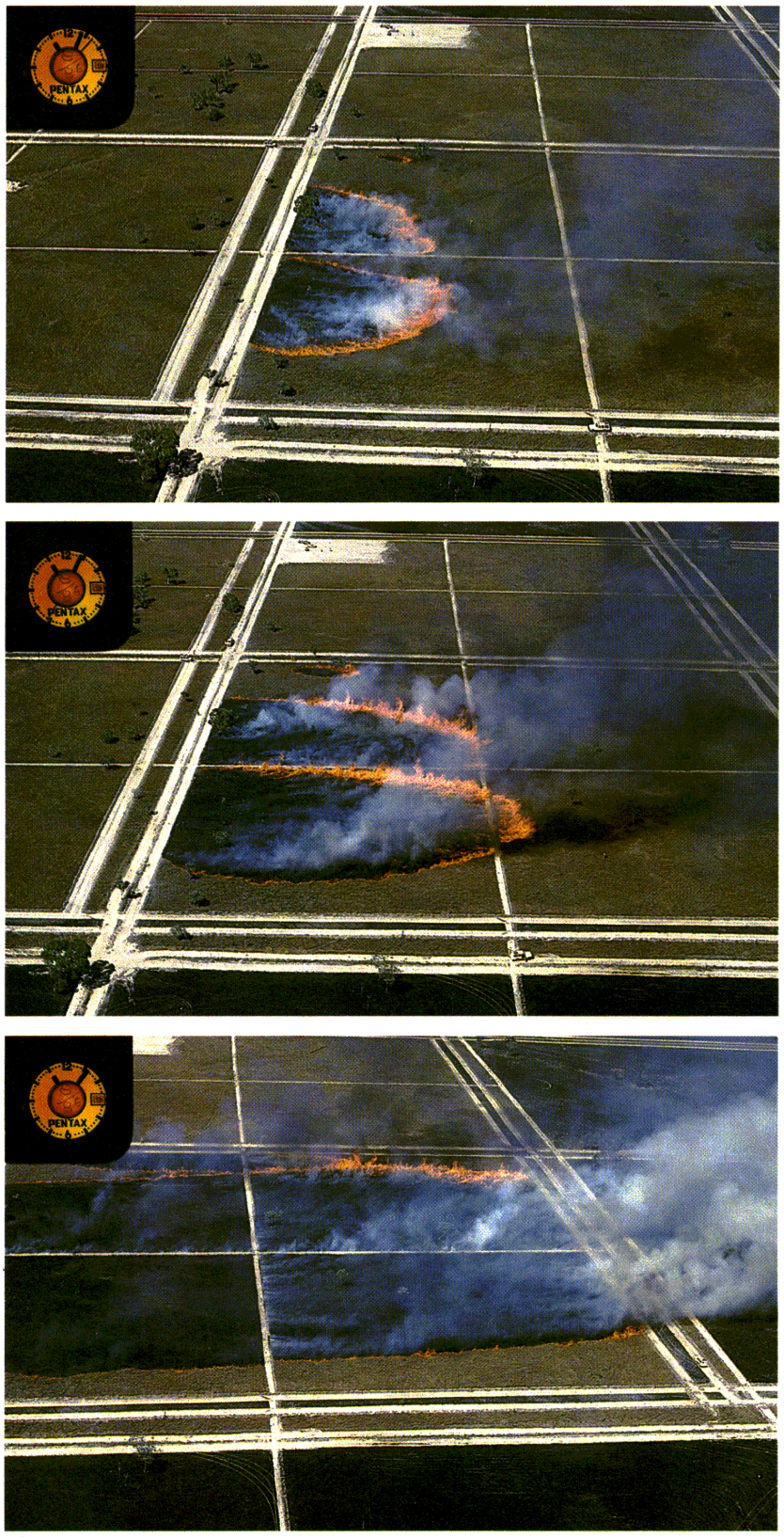


Firebreaks put to the test

Recently, scientists of the CSIRO National Bushfire Research Unit conducted an investigation into fire behaviour that included a study of the effectiveness of firebreaks in grassland at Annaburroo Station, some 120 km south-east of Darwin. On this station, where conditions during the Dry invariably favour burning, large uninhabited areas were available and the researchers were allowed to light experimental fires even during periods of very high fire danger.

Mr Andrew Wilson, now with the Fire Protection Branch of the Victorian Department of Conservation, Forests and Lands, ran a series of firebreak experiments. His aim was

Aerial photos of a grass fire spreading at 8 km per hour from the ignition line (top), crossing a 2-m-wide firebreak (middle) and finally coming to a halt at a 10-m firebreak (bottom).



to develop a relation between the probability of firebreak failure and variables such as firebreak width and fireline intensity (that is, the quantity of heat released per metre of fire front).

Grasses at the site — mostly kerosene grass, kangaroo grass, and sorghum — are similar to many found in the open grasslands of southern Australia, where the research results are likely to be of greatest interest. The grasses were almost fully cured, and low eucalypts and paperbarks (*Melaleuca* species) occurred sparsely on the site (average 10 trees per hectare).

Assisted by the Northern Territory Bush Fires Council, the scientists divided the site into 170 blocks (200 × 200 m or 100 × 100 m in size) by grading tracks 1 to 3·5 m wide. They also constructed additional firebreaks (5, 10, or 15 m wide), at a distance of 10 m from some of the block edges, by grading or burning strips of grass so that no flammable material remained.

From the air the site somewhat resembled a vast chessboard, and indeed a helicopter was used to photograph each fire so that the scientists could later determine its rate of spread and so calculate fireline intensity. (The latter depends on fire speed and fuel load. Fire speed, in turn, varies with air temperature, relative humidity, and wind speed.)

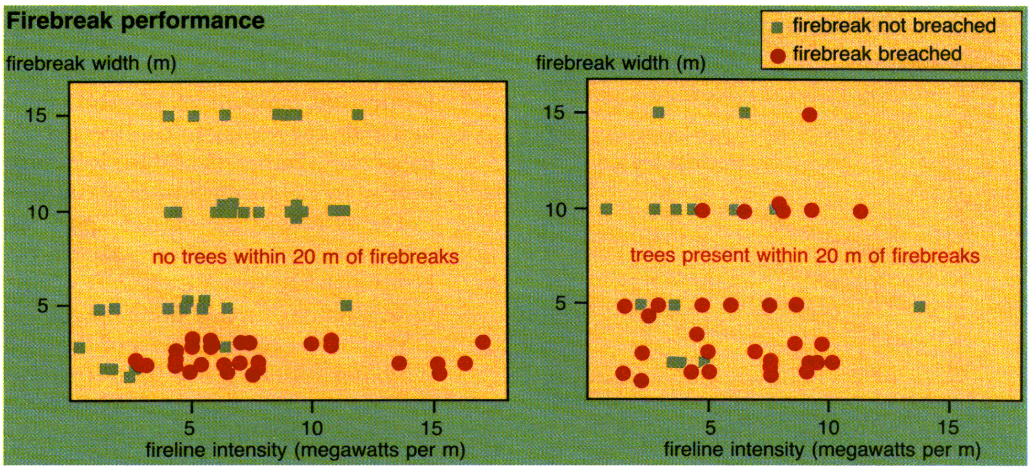
The scientists systematically measured the fuel characteristics and found that most fuel loads fell between 2 and 5 tonnes per hectare and that the grass height was usually between 0·15 and 0·55 m. During the experiments, wind speed varied from 3 to 30 km per hour, relative humidity from 13 to 55%, and air temperatures from 19 to 36°C.

Controlled arson

The researchers lit the 113 fires either at a single point or in a line 60 to 200 m in length. The headfires burned 20 to 200 m before reaching a firebreak. Their speed ranged from 0·4 to 8·0 km per hour. No trees stood within 20 m of the firebreak for 58% of the fires studied; for the remainder the number of trees present was generally less than four, and almost always less than eight.

Proximity of trees proved a vital factor in determining whether a firebreak failed, so we present the data in two groups, depending on

With no nearby trees (left), firebreaks 4·5 m or more wide stopped all the grassland fires, while narrower ones proved less effective. When trees were present (right), more than half the wider breaks failed to stop fires, and the narrower ones performed about as poorly as before.



the presence or absence of trees within 20 m of the firebreak (see the diagrams).

When trees were absent, none of the wider firebreaks (4·5 to 15 m wide) were breached while 83% of those 1 to 3·5 m wide were.

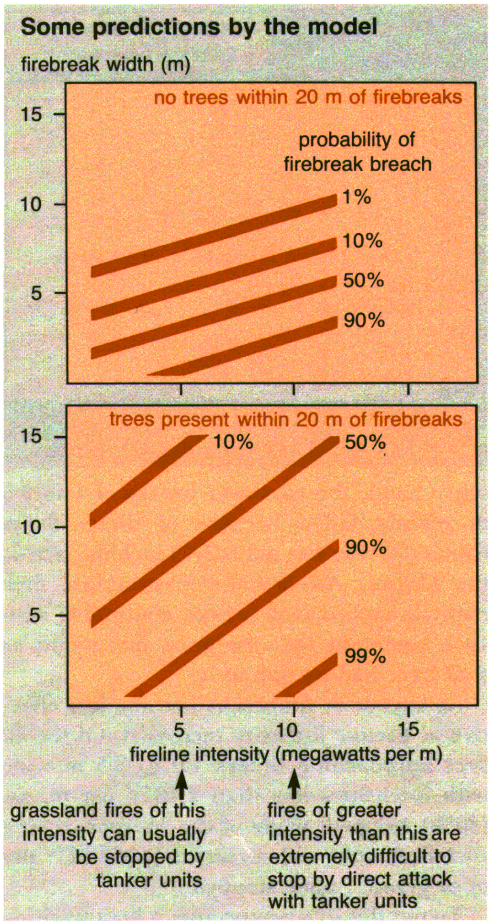
A quite different pattern emerged for firebreaks with trees present within 20 m: in particular, only 45% of the wider breaks with nearby trees managed to stop fires (compared with the 100% success rate in the absence of trees). The effectiveness of the narrower ones (1 to 3·5 m wide) proved about the same as that in the absence of nearby trees. So the main difference when trees are present is the poor performance of wider firebreaks.

The fires invariably jumped these wider breaks directly opposite trees, and firebrands (such as burning bark or leaves that can start spot fires) were the principal cause. On the other hand, the narrower breaks of 1 to 3·5 m mainly failed because of direct flame contact — the fire actually 'reaching' across the barrier. All bar the least-intense fires easily breached such breaks, continuing with such contempt that the grass fuel might as well have had no gap in it.

As expected, firebreaks became less effective as fireline intensity increased. Of the 20 fires approaching breaks 1·0 to 3·5 m wide with intensities less than 7 MW per m, six (30%) stopped; while of the 15 approaching such firebreaks with an intensity of 7 MW per m or greater, none stopped.

To put this into perspective, a fire travelling at 6 km per hour in a medium pasture with a fuel load of 4 tonnes per hectare will burn with an intensity of 12 MW per metre. A fire spreading at half that speed would have an

Grassland fire can gain the upper hand when firebreaks are too narrow or too close to trees. At left, a fire travelling at 8 km per hour breaches a 2-m firebreak by direct flame contact and (on the right) a fire crosses a graded track because of spot fires from trees.



Lines generated by the computer model predict the probability of breach for firebreaks of varying width with and without nearby trees. For example, in the absence of trees (top), a 2-m firebreak has about a 50% chance of breach in a very mild 1-MW fire, but 90% if faced with a fiercer 8-MW front — unless tanker units come to the rescue.

intensity of 6 MW per metre, while one spreading at 3 km per hour and with 2 tonnes of fuel per hectare would have an intensity of 3 MW per metre. Any fire with an intensity greater than 10 MW per m is extremely difficult to stop by 'direct attack' — that is, by fire-fighters using water tankers and without the benefit of a firebreak.

A predictive model

In order to put the results of the firebreak experiments to practical use, Mr Wilson developed a statistical model that calculates the probability of firebreak breach under given conditions. After testing various alternatives, he found that an equation taking into account fireline intensity, the presence or

Chances for the home during bushfire

A neat little circular slide-rule, developed by the CSIRO National Bushfire Research Unit, allows farmers and other bushland home-owners to assess, realistically, the chances of their house turning into a pile of ashes when the next wildfire sweeps through. It is designed for houses exposed to a forest fire, but is also useful (if less accurate) for those in grassland or other settings.

The ingenious piece of cardboard, with its rotating dials, is a wonderful incentive for owners to do the right thing and attend to the major contributory factors to this hazard of life in the bush. These factors are: amount of surrounding fuel; slope of the land; which materials the walls are constructed of; what the roof is made of, and its pitch; whether the house is occupied during a fire; and whether nearby trees, woodheaps, or sheds are present.

The beauty of the new gadget is that it conveys, numerically, the relative importance of each factor. Now a home-owner can evaluate how much the survival chances of his or her house will be improved by eliminating certain fire hazards.

Within the rotating dials of the 'house-survival meter' are distilled the bitter lessons learnt from a study of why 450 houses did, or did not, survive the tragic 'Ash Wednesday' fires of 1983. The study was undertaken by Mr Andrew Wilson while at Melbourne University, before he joined the National Bushfire Research Unit.

After a roaring wall of fire had swept through the secluded Mt Macedon township, Mr Wilson undertook the lengthy task of accumulating data on the design and siting of the 229 houses that were destroyed and the 221 that survived. Interviews with residents took 6 months. Colour aerial photographs taken 9 days after the fire contained the information on the intensity of fire that confronted each home.

He used a computer, and its statistical package, to analyse the data, seeking to gauge the main contributors to house survival. The computer's linear logistic model identified seven significant contributory factors, and these are the ones that have been built into the circular slide-rule.

Fire intensity was found to be the dominant factor influencing the outcome. Translating this conclusion to any given bushland home is a matter of using a standard formula for fire intensity, which involves fuel load, ground slope, and current weather conditions.

The slide-rule assumes that the fire occurs on a day of extreme fire danger — the sort of weather in which the majority of houses in Victoria and Tasmania have, historically, been lost to fire.

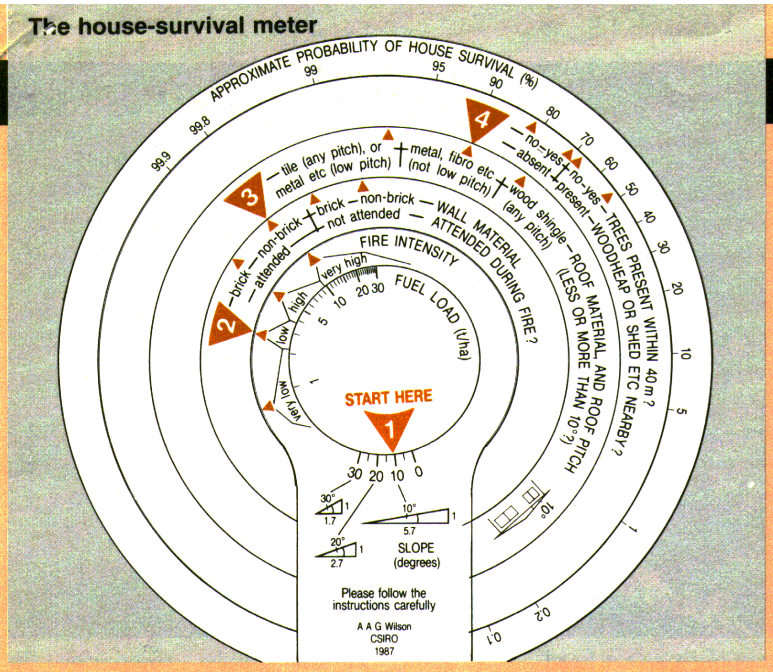
Mr Wilson suggests that householders calculate the appropriate fuel-load figure themselves. Here, they need only consider the amount of fine fuel lying on the ground — dead leaves, bark, grass, and twigs thinner than a pencil. These instantly contribute to a conflagration, and determine its intensity, whereas larger pieces do not ignite quickly enough to contribute to the moving fire front (although they may burn for some time after it has passed).

Simply measure out a 1-m square on the ground close to the house and collect all the dead fuel lying in it. After making sure this is thoroughly dry, weigh it on kitchen scales. It's a good idea to measure out several plots within about 40 m of the house and average the results.

Once you have set the fuel-load figure and land slope on the slide-rule, you can read off the fire intensity. The readings demonstrate an important point: that fire intensity increases with the square of the fuel load. Thus, if you can halve the fuel load, intensity will fall by a factor of four. Mr Wilson emphasises that minimising the amount of fine fuel lying on the ground is generally the best way to improve the odds for survival.

For most houses, reducing the fuel load is the cheapest and most effective way of protecting it, and of making it a safer refuge during a

The house-survival meter



Home-owners set the rotating dials at appropriate positions to obtain the home's probability of surviving fire.

fire. Fuel can be removed by burning in mild weather, or by raking, grazing, or mowing.

Trees near a house (within about 40 m for most situations in southern Australia) do increase the fire hazard by a small amount, and another wheel on the slide-rule makes due allowance for them, as well as for the presence of woodheaps and sheds, which catch alight easily and, even if fire-fighters are on hand, are difficult to extinguish. Property-owners should perhaps consider planting any new windbreaks at least 40 m from the homestead.

Another vital point the meter highlights is that residents have a strong chance of saving their homes if they have the will-power to stay in them while the fire front passes. At Mt Macedon, 90% of the houses defended by able-bodied occupants survived, whereas only 30% of unoccupied houses (which were also unattended by neighbours or fire-fighters) survived.

A house is usually your safest refuge during a fire, for even a house that subsequently burns will protect you from the lethal peak of the blazing bushfire. Evacuations on smoky, fire-lashed roads are risky. Of course, children and disabled people should never be left alone during a fire.

According to the meter, an unattended brick-veneer house on level ground, with a flat metal roof and no trees within 40 m, but having a nearby garden shed and a surrounding fuel load of 2 kg per sq. m, would have about a 10% chance of survival. But if the same house was attended, the chance would rise to more than 50% — a substantial increase.

Not all factors are included on the meter. The effects of window protection, under-floor enclosure, elevation, and the presence of timber decking have been singled out by Dr Caird Ramsay and colleagues at the CSIRO Division of Building Research. Like Mr Wilson's, their work began after Ash Wednesday, but covered 1153 houses in the Otway Ranges.

However, Mr Wilson reiterates that the real key to bushfire safety for any house lies in clearing up surrounding tinder.

Meters can be obtained from: CSIRO National Bushfire Research Unit, P.O. Box 4008, Queen Victoria Terrace, A.C.T. 2600.

Andrew Bell

Predicting the probability of house survival during bushfires. A.A.G. Wilson and I.S. Ferguson. *Journal of Environmental Management*, 1986, 259–70.

absence of trees within 20 m, and firebreak width was most accurate.

It is summarised in the graphs opposite, each plotted line representing a selected probability of firebreak breach — for example, 10% or 50%. For a fire of known intensity and a break of given width, we can use the graphs to determine the approximate odds that the firebreak will work. Separate graphs apply to breaks with or without nearby trees.

So, what does the model predict? Apart from confirming that firebreaks generally become less effective with increasing fire intensity, closer proximity of trees, and/or decreasing firebreak width, the model can be more specific. For example, it predicts that a 3-m-wide firebreak has only a 50% probability of stopping a grass fire (no trees nearby) that approaches head-on with an intensity of 5 MW per m. (A fire of this intensity can usually be contained by tanker units, albeit perhaps after causing some substantial damage on a local scale, such as the destruction of a cereal crop.) On the other hand, a 5-m break has a 90% probability of stopping the same fire.

Nevertheless, we know that firebreaks only 2–3 m wide can sometimes limit the spread of quite intense fires if they approach at a steep angle, since the effective width of the firebreak is then greater. Land-owners can also use narrow breaks for other firefighting purposes — such as providing access and a line from which to backburn.

Land-owners may wish to use the graphs to gauge the likely effectiveness of existing firebreaks against fires of given intensity, or to aid decisions on placement and dimensions of new firebreaks. However, they should take into account the specific nature of their paddocks. The grassland where the research was conducted contained few firebrand sources, and many of the trees had smooth bark, so the firebrand problem was relatively moderate.

It is a different story on many southern farms, where the rough bark and litter of trees, as well as sheep droppings, cattle dung, thistles, and phalaris seed-heads, once alight, can act as firebrands — rolling or 'flying' across firebreaks and initiating spot fires at distances even much greater than 20 m. To take an example, the model predicts that a firebreak 10 m wide has, in the absence of

Burning a 5-m firebreak at night — between a furrow and a graded track.

trees, a 99% chance of stopping a severe head fire (of about 11 MW per m). But if the firebreak were to be located in a grassland containing, say, a phalaris pasture, it may have a much lesser chance than predicted of stopping a fire fanned by wind strong enough to transport smouldering seed-heads across the barrier.

Mr Wilson warns that more research is needed to test the accuracy of his results in southern pastures. However, he believes that the effectiveness of narrow firebreaks is likely to be the same Australia-wide.

Firebreaks require some thought

A farmer about to put in firebreaks has a lot to consider — including location, width, cost, convenience, and fence protection — in deciding his priorities. The model described here can help to make these decisions.

Firstly, it would seem wise to err on the side of generosity as far as width is concerned.

Sampling grass to determine fuel load.

A glance at the graphs, comparing the probabilities of, say, a 10-m firebreak and a 2-m one failing to stop a fire of given intensity, should be enough to convince anybody of this. If land is at a premium, it may be better to have one wide firebreak than a network of narrow ones. Why not consider combining with neighbours to construct adjacent firebreaks?

Secondly, the graphs highlight the danger of firebrand material. Given the benefits of trees and other native vegetation on farms, the solution is certainly not to clear a swath around firebreaks, but careful placement should increase the firebreaks' worth. On properties where trees tend to be concentrated along fence-lines or roads, it would seem sensible to install firebreaks some distance away from fences and property boundaries, so minimising the firebrand hazard.

Even with the aid of the graphs it is impossible to predict with accuracy the performance of a given firebreak, as the prevalence of firebrand material and other factors introduce some error. Certainly, though, the model takes much of the guesswork out of such predictions and provides some helpful guidance for land-owners tackling the complex task of planning and constructing their firebreak defences.

Steve Davidson

Further reading

Width of firebreak that is necessary to stop grass fires: some field experiments. A.A.G. Wilson. *Canadian Journal of Forest Research*, 1988, **18** (in press).

'Bushfires in Australia.' R.H. Luke and A.G. McArthur. (Australian Government Publishing Service: Canberra 1978.)

'The Fires of 12 February 1977 in the Western District of Victoria.' A.G. McArthur, N.P. Cheney, and J. Barber. (CSIRO Division of Forest Research: Canberra 1982.)

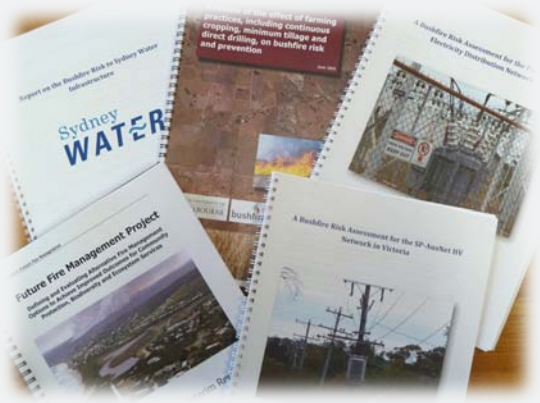
APPENDIX F

PHOENIX RapidFire – a bushfire simulator and risk assessment decision support tool

PHOENIX RapidFire – a bushfire simulator and risk assessment decision support tool

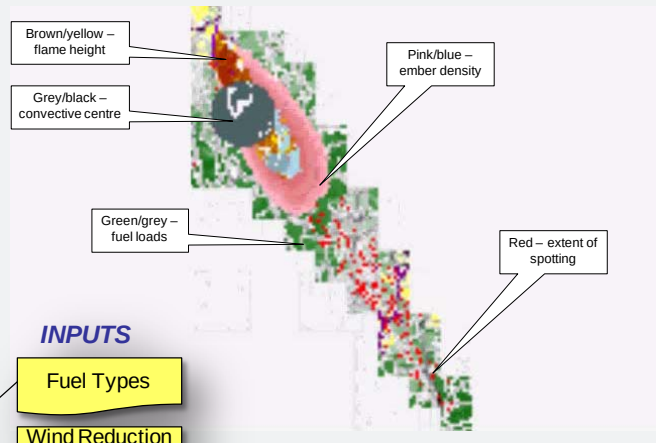
Dr Kevin Tolhurst[1], Derek Chong[2] and Dr Tom Duff[2]

[1] Department of Forest and Ecosystem Science, University of Melbourne, Creswick Victoria
[2] Department of Forest and Ecosystem Science, University of Melbourne, Burnley, Victoria

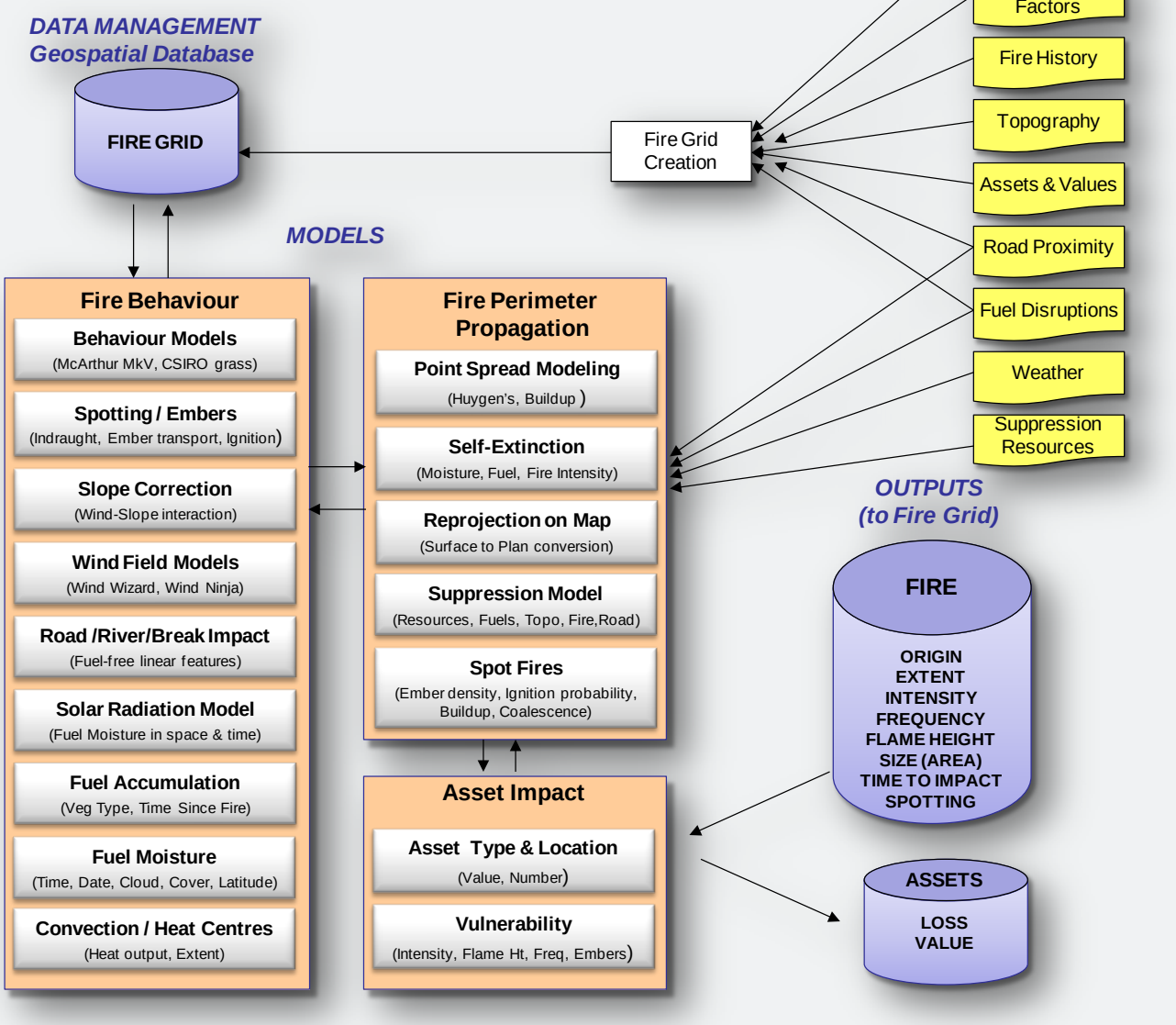


Real world applications – biodiversity, farming, power supply, water supply.

Detailed fire characterization, including flame height, ember density, spotting distance, convection column strength and fire intensity.



A dynamic, deterministic, continuous, empirical fire characterization model.



Visualization of fire dynamics for community warning and education.

Integrating complex interactions between fires and houses and other assets. Providing a basis for evaluating plans and developments.

kgt@unimelb.edu.au

http://www.forestscience.unimelb.edu.au/people/staff/kevin_tolhurst/index.html
http://www.bushfirecrc.com/projects/a41/fire-management-business-model
http://www.bushfirecrc.com/research/program-1

THE UNIVERSITY OF MELBOURNE

APPENDIX G

Professional Resume

PROFESSIONAL RESUME

John Nicholson, AFSM

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Telephone: 03 9740 4893 Facsimile: 03 9018 8050
E-mail: j.nicholson@communitysafety.com.au
Web site: www.communitysafety.com.au

QUALIFICATIONS

Graduate Diploma, Institution of Fire Engineers (GradIFireE)
Diploma of Professional Writing and Editing

PROFESSIONAL DEVELOPMENT

Executive Program, Monash-Mt Eliza Business School
Looking Glass Program, Monash-Mt Eliza Business School
National Senior Command Course, Australian Assembly of Fire Authorities
Managing Risk in the Australian Public Service, Commonwealth of Australia MAB/MIAC Managing Risk Implementation Program
USA Study Tour (3 weeks in 1988) visiting various fire services and fire research agencies, to study fire safety and advances in fire research and new technology related to fire prevention and suppression
Member of the 1997 Australia/New Zealand Rural Fire Management Study Tour of Canada and the USA

PROFESSIONAL AFFILIATIONS

Graduate Member Institution of Fire Engineers
Corporate Member Fire Protection Association Australia
Member, Expert Advisory Board, Bushfire Building Council of Australia

EMPLOYMENT HISTORY

26 March 1999 to date Director, Community Safety Services Pty Ltd, consulting in fire and emergency risk management planning.

July 1994 to 25 March 1999 CFA's first Director Risk Management, responsible for development of corporate risk management policies and strategies to ensure CFA implemented appropriate risk identification, evaluation and treatment programs.

Also responsible for development and implementation of risk communication based community education programs and fire safety programs addressing the structural, dangerous goods and bushfire environments.

EMPLOYMENT HISTORY continued

March 1967 to June 1994 Employed as an operational officer by the CFA, rising to Deputy Chief Officer in 1991, possessing extensive knowledge and actual firefighting experience in the structural and wildfire environments, hazardous materials emergency management, and specialising in wildfire (bushfire) prevention and impact mitigation.

EXPERIENCE

As Director Risk Management, managed the introduction of corporate governance and due diligence policies and procedures in CFA. Also managed an extensive corporate compliance scan to identify the various Commonwealth and Victorian legislation CFA must comply with.

Represented CFA at the Victoria Emergency Management Council (the peak body responsible for emergency management in Victoria) and at the State Emergency Prevention Committee.

Member of an Emergency Management Australia Steering Committee that managed the development of a disaster mitigation strategy for Australia.

Extensive emergency management and operational command experience to Deputy Chief Officer/State Operations Controller level.

MAJOR CONSULTANCIES

In 1995, reviewed the Western Australian Fire and Rescue Service structure and advised on how it could adopt a risk management and prevention approach to business, which it subsequently did.

In 1995, engaged by the Prime Minister's Department, Papua New Guinea, to assist with the development of terms of reference for a review of the PNG Civil Fire Service, which included a strong emphasis on prevention.

Since late 1999 have developed new all-risks Municipal Fire Prevention Plans for Surf Coast, Wellington, Melton, Moorabool and Colac Otway Shire Councils and City of Wyndham, and a municipality-wide risk assessment based wildfire sub-plan for Surf Coast Shire.

During 2001, assisted Freight Australia with the preparation of its fire prevention policy and implementation procedures for railway reserves.

Following the Canberra fires of January 2003, commissioned on behalf of the ACT government to undertake a review of the urban edge of Canberra and non-urban area of the ACT to assess the wildfire threat and determine if any areas should be designated *bushfire-prone* according to the Building Code of Australia.

Engaged by Counsel Assisting the 2009 Victorian Bushfires Royal Commission as an expert witness on fire refuges, "stay and defend or leave early" policy, evacuation, warnings and management of the fires.

CAPABILITIES

Emergency Risk Management Due to extensive experience carrying out fire risk inspections in the natural and built environments and fire investigation, am able to identify hazardous situations and practices in virtually all environments.

To prevent loss of life and property, I can assist with the preparation of comprehensive emergency management plans for all environments. I can also advise on emergency management related corporate compliance and duty-of-care planning, activities critical to the well–being of organisations and their directors and officers.

Interpersonal and Facilitation Skills I have the consultative and conflict management skills needed to collaborate effectively with a wide range of personality types inherent in the volunteer based CFA. I also have the facilitation skills to successfully conduct focus groups within and external to CFA

This capability is complemented by long experience as the statutory appointee representing government's fire interests on the Powerline Clearance Consultative Committee and the Minister's nominee on the Roadsides Conservation Advisory Committee, where a wide range of sometimes conflicting interests are represented.

Legislation Experience in the development of legislation and statutory rules.

Statutory Planning Extensive involvement over many years in land use and development planning matters involving fire prevention, particularly in the urban/bushland interface areas of Victoria. This involvement was at both policy and practitioner levels, and included extensive collaboration with public and private sector planners in the development of CFA's guidelines for subdivisions in bushfire-prone areas and other planning guidelines.

Advocacy Having successfully operated at Director level in the public sector, I have a good knowledge of the *modus operandi* of the bureaucracy. Also have considerable interview experience with television and radio news and current affairs programs and the print media, at regional, state and national level as CFA's fire prevention spokesperson. This, combined with extensive experience in public speaking and training delivery has equipped me to be an effective advocate for the risk management approach to emergency management.

ACHIEVEMENTS

Risk Management in CFA Developed and introduced the risk management approach to fire and emergency planning to the extent where it is now fundamental to all planning in CFA

Strategic Planning Development of CFA's Corporate Plan 1996–2000.

Industry Brigade Legislation Development of amendments to the Country Fire Authority Act 1958 and Country Fire Authority Regulations 1992 to enable the creation of industry fire brigades.

Municipal Fire Prevention Planning Development and introduction of guidelines for an all-risks, community participative approach to fire prevention planning based on risk management principals.

ACHIEVEMENTS continued

Audit of Municipal Fire Prevention Planning Development of CFA's initial procedure for auditing municipal fire prevention plans in accordance with the requirements of the Country Fire Authority Act 1958.

AWARDS

Awarded the Australian Fire Service Medal in the Australia Day Honours 1994, principally for leadership and services to CFA and the wider community in the field of fire prevention.

In 2011 awarded a Fire Protection Association Australia *Meritorious Service Award* for services to fire protection, particularly representing the Association on Standards Australia *AS 3959 Construction of buildings in bushfire-prone areas* committee FP020.

PUBLICATIONS AND ARTICLES

Nicholson, J. 1983, *Guidelines for Municipal Fire Prevention Officers*, CFA

Nicholson, J. 1985, *Planning Guidelines for Subdivisions in Bushfire Prone Areas*, CFA

Nicholson, J. 1994, *MASS EVACUATION: is total evacuation of a community threatened by wildfire a sound strategy?* Institution of Fire Engineers (NSW Branch Inc) 1994 State Conference.

Petris, S., Potter, P., Lavelle, L., & Nicholson, J. 1995, *A Review of all State and Federal Reports on Major Conflagrations in Australia During the Period 1939–1994 and A National Bushfire Preparedness Strategy*, Australian Fire Authorities Council and Emergency Management Australia.

Smith, P., Nicholson, J. & Collett, L. 1996, *Risk Management in the Fire and Emergency Services*, Papers presented to the IDNDRConference on Natural Disaster Reduction, Queensland, September 29 - October 2, 1996.

Nicholson, J. 1997, *Why Risk Management?* Paper presented to Disaster Mitigation Workshop, Emergency Management Australia, Mount Macedon Paper # 5/1997

Nicholson, J. 2001, "Fire Protection and Heritage Buildings in Victoria", *Fire Australia*

Nicholson, J. 2003, "Bushfire Shock and Awe – Will We Ever Learn?", *Fire Australia*

Nicholson, J. 2004, "Residential Smoke Alarms – are they really up to the task?, *Fire Australia*

Chladil, M, and Nicholson, J. 2011, “Update: the evolving bushfire construction standard AS 3959” *Fire Australia*

19 December 2016

PROFESSIONAL RESUME
(Abbreviated Version)

NAME

John Nicholson, AFSM

QUALIFICATIONS

Graduate, Institution of Fire Engineers (GIFireE)

Diploma of Professional Writing and Editing

PROFESSIONAL AFFILIATIONS

Institution of Fire Engineers

Corporate Member, Fire Protection Association Australia

PROFESSIONAL EXPERIENCE

Employed by CFA for thirty-two (32) years as an operational officer, rising to the rank of Deputy Chief Officer and possessing extensive knowledge and actual firefighting experience in the structural fire and wildfire environments, hazardous materials emergency management, and specialising in wildfire (bushfire) prevention and impact mitigation.

For the last five (5) years of my career with CFA (1994 to 1999) I was Director Risk Management and amongst other matters responsible for development and implementation of risk management based wildfire prevention and mitigation programs across Victoria.

Since early 1999, I have consulted extensively in wildfire loss prevention planning, including assessing wildfire risk and developing risk management plans in accordance with the requirements of VPP Clause 44.06 Wildfire/Bushfire Management Overlay and *designated bushfire-prone area* solutions in accordance with Clause GP5.1 and Clause P2.3.4, BCA. Note that in this area of expertise I represented the Australian Association of Rural Fire Authorities and CFA on Standards Australia Committee BD/64 that was responsible for developing much of the contents of *AS 3959—1991*. Later, I represented Fire Protection Association Australia on Standards Australia Committee FP-020 Bushfires (*AS 3959 Construction of buildings in bushfire–prone areas*) that prepared AS 3959—2009.

During my career with CFA and since then as a private consultant I have acquired extensive experience assessing residential development proposals with the objective of preventing loss of life and property due to wildfire.

Amongst my major undertakings, following the Canberra fires in 2003 I was commissioned by the ACT government to review the urban edge of Canberra and non-urban area of the ACT to determine the wildfire threat and whether any areas should be designated *bushfire-prone* according to the Building Code of Australia.

RELEVANT PUBLICATIONS AND ARTICLES

- Nicholson, J. 1983, *Guidelines for Municipal Fire Prevention Officers*, CFA
- Nicholson, J. 1985, *Planning Guidelines for Subdivisions in Bushfire Prone Areas*, CFA
- Nicholson, J. 1994, *MASS EVACUATION: is total evacuation of a community threatened by wildfire a sound strategy?* Institution of Fire Engineers (NSW Branch Inc) 1994 State Conference
- Petris, S., Potter, P., Lavelle, L., and Nicholson, J. 1995, *A Review of all State and Federal Reports on Major Conflagrations in Australia During the Period 1939 –1994 and A National Bushfire Preparedness Strategy,* Australian Fire Authorities Council and Emergency Management Australia
- Nicholson, J. 2003, “Bushfire Shock and Awe, Will We Ever Learn?”, *Fire Australia*
- Chladil, M, and Nicholson, J. 2011, “Update: the evolving bushfire construction standard AS 3959” *Fire Australia*

A detailed resume can be viewed at www.communitysafety.com.au