ATTACHMENT (SIX PAGES) TO SUBMISSIONS ON BEHALF OF MR MCRAE DATED 30 JUNE 2006

In his paper *"On the sub-synoptic scale meteorology of two extreme fire weather days during the Eastern Australian fires of January 2003"*[1], Dr Graham Mills, from the Bureau of Meteorology Research Centre and the Bushfire Cooperative Research Centre, noted that in the case of each of the 18th January 2003 fires in the ACT and the 30th January 2003 fires at Mt Hotham, there were features apparently associated with cold fronts that *"do not necessarily fit established paradigms of cool-change morphology over southeastern Australia"* which *"had significant impact on the fire weather of each of those days."*

For over a decade after the Ash Wednesday fires of 1983, a key national research topic was cold front reconnaissance[2].The goal was to be better able to forecast the arrival of wind changes during fires. It had become clear there was much to learn about cool-change morphology. The experience during the alpine fires showed that this is still the case.

Being outside existing paradigms, of course, means that the effects were not predicted by BoM in the fire weather forecasts upon which the ESB acted.

Under the heading January 18 – an observational perspective, Dr Mills wrote:

> *"The time-series of observations at Canberra Airport shows <u>fascinating evolution</u> during 18 January 2003... Winds were light and variable*

[1] Mills, G. (2005a). On the sub-synoptic scale meteorology pf two extreme fire weather days during the eastern Australian fires of January 2003. Australian Meteorological Magazine, Volume 54, No. 4 (December 2005).

[2] See, for example, the proceedings of "Fire Weather Workshop", Mt Macedon, 16-20 June 1991. Bureau of Meteorology.

overnight, but with the onset of daytime heating after 0830[3] *the wind direction settled to the north and then slowly back to the northwest. The gust factor increased from around 0900. After this change, the wind speed increased again to nearly 35 km/hr*[4]*, with gusts approaching 55 km/hr. The relation between the temperature, the wind speed and the dewpoint series is interesting. The initial increase in wind speed coincides with the commencement of daytime heating and is consistent with the breaking of a nocturnal surface inversion. However at around 1100 the speed and gustiness further increased steadily for some hours and coinciding with this there was a decrease in dewpoint, which might be interpreted as a mixing of low- to mid- tropospheric air as the daytime mixed layer depth increased. The wind speed and gustiness decreased markedly after 1530, but with little change in wind direction during this period. There were however, <u>two further marked decreases in humidity</u> – one at 1400, when the dewpoints decreased from 4C to -3C, and a second very abrupt marked drying from 1630 to 1800, when dewpoints decreased to -13C. The abrupt arrival of the easterly wind change at 1900 is marked by an increase of wind speed and gustiness immediately after the change, and a rapid increase in dewpoint and a decrease in temperature, showing the effects of the inland penetration of the cooler air propagating northward along the NSW coastline…* [emphasis added].

Some commentaries on the event (eg McLeod 2003, p42) have hypothesised that the gustiness in the mid-afternoon and the abrupt drying in the late afternoon were associated with the convection column

[3] Global endeavours such as the military, aviation and meteorology use a standard reference time – known as UTC. Mills uses only UTC in his paper. During the fires, local time was eleven hours ahead of UTC. The conversions have been made for clarity, as some events on the 18th in local time occurred on the 17th in UTC.

[4] Industries such as aviation measure velocity in knots (nautical miles per hour). Fire weather analysis seeks to estimate the passage of fires over distances measured in kilometres and times measured in hours. Thus the knots that Mills uses in his paper have been converted to kilometres per hour (and rounded to 5 km/hr units) for clarity.

above the fire west of Canberra, and so was fire-driven. Meteograms of observations at elevated stations in the region surrounding Canberra, where observations are available at Thredbo (1957m), Cooma (930m), Cabramurra (1482m) and Goulburn (640m) ... may be compared with the Canberra meteograms .... All these stations show a similar pattern, with a maximum in wind speed and gustiness in the mid afternoon, a sudden dramatic drying southeast in the evening with decreasing temperatures and increasing humidity. Clearly the gustiness and the abrupt and dramatic decreases in humidity at Canberra were the response to significantly larger scale atmospheric flow features than would be the case had the drying been induced by subsidence associated with the pyrocumulus cloud west of Canberra. There is some suggestion that the drying occurred earlier in the south and east and later in the north and west, indicating that the circulation features that led to the drying were coherent and northward/westward moving."

Dr Mills went on to hypothesise that the abnormal behaviour is linked to the dry band of air plotted in his Figure 10, with the sudden decline of humidity being caused by the *"mixing of this dryer air to the surface"* and cites recorded evidence from Wagga of sudden dewpoint drops from -6C to -22C consistent with the movement of the dry band.

It is noteworthy that the passage of the dry slot over the local area, seen in his Figure 10, coincides with the peak development of the plume. The emergence of a massive pool of upper atmospheric moisture is clearly seen in the sequence of images.

In a second paper Mills shows a similar pattern during the Eyre Peninsula fire of 11 January, 2005.[5]

Dr Mills hypothesis is that the *"dry slot"* of extremely dry air that can be observed in the extant imagery offers direct evidence for the proposition that it was this feature that affected fire behaviour so dramatically on the 18th. The feature was hitherto neither predicted nor well understood. Dr Mills proposes that it may indeed be predictable, though it wasn't predicted for the 18th, stating that:

> *"It must be acknowledged, though, that the forecast model has under-forecast the degree of drying to a considerable extent."*

He offers suggestions as to how forecasters may be able to forecast these events in future *"with some hours warning".*

Given Dr Mills' stance that the regional fire weather was unusual, it offers logical, evidence-based support for the proposition that the fire behaviour was not only unusual, but unpredictable. We say *"unpredictable"* in the sense that a prediction upon which others will commit resources and commit to strategies ought to be evidence based. Initially, there were only observations of eye-witnesses to confirm or deny claims to unusual fire behaviour. However, there is now a considerable body of science to indicate unusual fire behaviour.

Professor John Dold, of Manchester University, has been working with Rodney Weber of UNSW at the Australian Defence Force Academy, and others, on some

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[5] Mills, G. (2005b). Lower atmospheric drying, stability, and increased wildfire activity. Sixth Symposium on Fire and Forest Meteorology, October 2005; American Met. Society. Published (2006) 45 Australian Meteorology Magazine.

unusual aspects of combustion observed during the fires[6]. Reports from witnesses such as Mr Neil Cooper, Mr Phil Koperberg, Mr Simon Katz and Mr Matt Duttkiewicz have indicated the presence of premixed combustion. This led to spectacular flame behaviour, including 10m flames in areas with no fuel [Koperberg], 200m tall flames [Duttkiewicz], and rolling walls of blue flames [Cooper].

In a far more technical paper, Mitchell *et al* discuss the aerosol emissions from the fires. They found that the smoke generated on the 18th January was unusual in particle size, and suggest that it indicates both the fuel types and the extreme intensity of the fire. They cite a personal communication from M. Raupach estimating a lineal fireline intensity of up to 10^5 kW per metre.

A paper by an international team, headed by Mike Fromm, US Naval Research Laboratory, examined the convection generated on that day.[7] Monitoring of satellite data of upper atmospheric particulates indicated an extreme event. Investigation of its source showed that it originated near Canberra on the 18th of January. Detailed analysis of BoM radar data indicated the extreme scale of development of cloud within the smoke plume. This cloud, referred to as a violent pyro-cumulonimbus (fire thunderstorm), contained anomalously small droplets, more typical of volcanic plumes. It increased the particulate load of the southern hemispheric stratosphere by 25% for three months – indicating that this event had a global impact. In fact it is claimed that it is the second largest convection event ever recorded by the satellites (25 years of data), and is the first test of nuclear winter theories. This work also examines the tornado development from the thunderstorm.

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[6] John Dold, Rodney Weber, Malcolm Gill, Peter Ellis, Rick McRae and Neil Cooper (2005). Unusual phenomena in an extreme bushfire. Proceedings 5th Asia- Pacific Conference on Combustion, Adelaide 2005.

[7] Michael Fromm, Andrew Tupper, Daniel Rosenfeld, Rene Severanckx and Rick McRae (2006). Violent pyro-cumulonimbus storm devastates Australia’s capital and pollutes the stratosphere. Geophysical Research Letters, Vol 33, L05815.

This is a considerable body of peer-reviewed material that demonstrates that this fire event was unusual on a global scale.

By comparison, the reviews of fire weather carried out by the BoW, and presented to this inquiry, were formulated much closer to the event, and in light of emerging evidence and analysis, are, to that extent, *"dated"*. It is likely that evidence given today by the BoW would depart in significant respects from that which is before the inquiry.