Attachment 1 – Evidence of Fire Behaviour

Fire Spread of Fire Behaviour

1. In relation to the issue of fire spread and behaviour the State refers to the following:

Point of origin to Saunders Road

1.1 The area of origin of the Kilmore East fire was immediately adjacent to power pole number 38 at grid reference 55H 0324267 - 5871651 on the private property of Mr John Sullivan. The size of the area of origin was approximately three metres by five metres.[1]

1.2 The Kilmore East fire started at approximately 11:45 on 7 February 2009 and was first spotted by Mr Peter Coleman from the Pretty Sally fire tower who reported the fire to Mr Philip Searle at the Mount Hickey fire tower. Mr Searle saw smoke billowing from a paddock to the south-west of his tower, between Saunders Road and the Kilmore Sunday Creek Road. He described the smoke as blue to white in colour and that he did not see any flames. He saw the smoke traveling in a southerly direction being pushed along by the northerly wind. He immediately contacted 000 via the fire tower landline and noted the time of the call as 11:47[2].

1.3 The Kilmore Gap automatic weather station (AWS) records indicate that the wind direction between 11:30 and 12:30 on 7 February 2009 was from 360 degrees and 350 degrees (northerly) and that the wind strength was between 48 and 56 kilometers per hour (kph) with gusts up to 72 kph.

Saunders Road to Hume Freeway

1.4 The Kilmore Gap AWS records indicate that the wind direction between 13:30 and 14:00 on 7 February 2009 was from 330 degrees (north-west) and that the wind strength was between 46 and 57 kph with gusts up to 85 kph.

1.5 Senior wildfire instructor and fire investigator, Mr Fabian Crowe, gave expert evidence to the Royal Commission in relation to the Kilmore East fire. He noted that between Saunders Road and the Hume Freeway burn and char patterns clearly indicated that the running section of the fire traveled in a south-easterly direction over undulating land through eaten out pasture and through approximately 200

[1] Crowe Ex 514, WIT.3004.022.0001, [16].
[2] Crowe Ex 514, WIT.3004.022.0001, [34] – [35].

hectares of plantation logging slash. One portion of the run of the fire was up a slope immediately north of the Hume Freeway.[3]

1.6 The logging slash was set up in windrows about 10 to 15 metres apart ready to be burned prior to the re-establishment of the plantation. Mr Crowe noted that there was little available fuel between the rows. The majority of the windrows were running east-west across the run of the fire. The existence and set up of the windrows and the lack of available fuel between them slowed the progress of the fire considerably, because each gap between the windrows acted as a barrier that the fire had to cross. If this area had continuous available fuel it is likely that the running section of the fire would have traveled significantly faster than it did.

1.7 The combination of the high intensity fire within the plantation logging slash and the presence of pockets of native vegetation adjacent to the freeway and in the median strip provided the necessary quantity and arrangement of fine fuel to carry the fire across the Hume Freeway.[4] Mr Crowe produced a photograph provided by Mr Gary McCluskey a DSE forest ranger showing the head of the fire crossing the Hume Freeway near Stotts Road, to the east of the main Wandong township at approximately 13:36.

1.8 Mr Crowe's supplementary statement confirms that the distance between the area of origin and the junction of Stotts Road and the Broadford/Wandong Road is approximately 6kms. Taking into account the time the fire was first reported, at about 11:45, Mr Crowe calculated the average rate of spread over the portion of the landscape to the Hume Freeway was just in excess of 2.5 kph.[5] In under an hour this was already a fast fire within known fire behaviour parameters as at 7 February, but bears little comparison to the behaviour of the fire as it climbed Mt Disappointment and thereafter.

1.9 Mr Crowe refers to a line scan image of the Kilmore East fire which was taken at approximately 12:55 on 7 February 2009, which illustrates the head of the fire approaching the Hume Freeway.[6] This line scan was produced at figure 9.4 in the Commission's Interim Report. When viewed along with the line scan produced at figure 9.3 taken at 12:46, it can be seen that the movement of the fire at this time is almost in a direct north-south direction, in a line to the west of the township of Whittlesea.

[3] Crowe Ex 514, WIT.3004.022.0001, [43].
[4] Crowe Ex 514, WIT.3004.022.0001, [47].
[5] Crowe Ex 514, WIT.3004.022.0001, [52].
[6] Crowe Ex 514, WIT.3004.022.0001, [53].

Hume Freeway to Yabamac-Hollowback Reservoir

1.10 As mentioned above, the Kilmore Gap AWS records indicate that the wind direction between 13:30 and 14:00 was from 330 degrees (north-west) and that the wind strength was between 46 and 57 kph with gusts up to 85 kph.

1.11 Mr Crowe's examination around the Scanlons Road, Stotts Road, Clonbinane Road and Epping/Kilmore Road areas revealed pockets of partially burned vegetation which indicate that the fire had multiple tongues when it crossed the Hume Freeway.[7]

1.12 The total of the width of these tongues of fire was approximately 5 kilometres from between Clonbinane Road and the north-eastern railway line. The burn and char patterns in this area also indicate that the running tongues of fire merged at various stages between Wandong and Clonbinane as they moved in a south-easterly direction towards the settlement of Yabamac and the Wandong Regional Park.

1.13 Mr Crowe explains that burn and char patterns in various areas indicate that there was significant change in the direction of the running fires.[8] These include an area on the western side of Clonbinane Road near Hibberds Lane where the burn and char patterns indicate that the fire had run in a south-easterly direction. To the east of this point the burn and char patterns indicated that the fire had run in a north-easterly direction. West of Drag Hill Road, the burn and char patterns indicated that the fire ran in a south-easterly direction and to the east of this point the burn and char pattern indicated that the fire had run in a north-easterly direction. Mr Crowe opines that given that the change in wind direction from north-westerly to south-westerly was not recorded at the Kilmore Gap AWS until approximately 18:10, the north-east movement of fire at Hibberds Lane and Drag Hill Road did not occur until about that time.[9]

1.14 In the vicinity of Shiels Road, Clonbinane the burn and char patterns clearly indicated that as the fire entered the forested area, it increased in intensity and continued its run in a south-easterly direction up the north-west facing slopes of the Great Dividing Range towards Mount Disappointment. The increased intensity of the fire behavior was due to the nature of the vegetation on the foothills of Mount Disappointment. This included a mixture of eucalypt species dominated by Mesmate (stringy bark) and Peppermint (platy bark). Mr Crowe explains that stringy bark species are prone to mass short distance fire spotting because of the nature of the stringy bark.[10] This short distance spotting contributed to the rate of spread width and

[7] Crowe Ex 514, WIT.3004.022.0001, [57].
[8] Crowe Ex 514, WIT.3004.022.0001, [61].
[9] Crowe Ex 514, WIT.3004.022.0001, [61.3].
[10] Crowe Ex 514, WIT.3004.022.0001, [62].

intensity of the head of the fire. Short distance spotting is often drawn back towards the main fire front thereby increasing the speed with which the landscape in consumed by fire.

1.15 Whilst Mr Crowe observes that it was not possible to determine the origin of new fires or spot fires in this area, annexed to his supplementary statement is a photograph taken by the witness, Richard Alder at about 15:00 illustrating the nature of the spotting activity during this part of the run of the fire.[11]

Yabamac-Hollowback Reservoir to Mount Disappointment

1.16 The Kilmore Gap AWS records indicate that the wind direction between 14:00 and 15:30 was from 330 and 340 degrees (north-westerly) and that the wind strength was between 46 and 63 kph with gusts up to 91 kph.

1.17 Mr Crowe examined areas on the north-western and western slopes of Mount Disappointment adjacent to Lords Road and Hilliers Road which run generally east-west through the fire effected area. He also examined the areas adjacent to Disappointment Road, Harpers Creek Road and Engine Camp Road, which run generally north-west to south-east through the fire effected area.

1.18 Around these areas, particularly to the west of Disappointment Road, the fine fuels in the crowns of the trees were completely removed and in other parts these fine stems were intact but charred and distorted. All of the surface and elevated fine fuels had been completely consumed by the fire. There was a bed of white ash on the forest floor up to 200 millimetres deep in some locations. These identified characteristics indicate that the fire burnt with very high to extreme intensity in these areas.[12]

1.19 Mr Crowe further observed that the fine stems in the crowns of the trees were distorted and pointing in a south-easterly direction. He noted the depth of char on the trunks of the stringy bark trees was greater on the north-eastern surfaces and that rocks were stained and significantly more stained on the north-eastern surfaces. He also noted that standing stems of elevated vegetation was swept in a south-easterly direction and that all of these burn and char patterns clearly indicated that the run of the fire was in a south-easterly direction.

1.20 As the run of the fire progressed to the higher elevation of the north-west slopes of Mount Disappointment, it entered forest dominated by Mountain Ash and other gum bark species of trees. Gum bark trees are prone to long distance spotting. The nature of the bark on these

[11] *Photograph Taken by Richard Alder at Approximately 15:00*, Crowe (Annexure 20) Ex 514, WIT.3004.022.0424.
[12] Crowe Ex 514, WIT.3004.022.0001, [69].

trees is significantly different to that of the string bark trees. The gum bark species have long strips or ribbons of bark, which is lightweight and has a tendency to curl. This makes it aerodynamic in nature and likely to remain alight for longer periods of time. When alight and lifted by convection forces in suitable circumstances, it can carried by prevailing winds and can start new fires considerable distances from the head of the original or main fire.

1.21 Whilst the head of the fire that originated at Kilmore East was approaching Mount Disappointment the western flank was moving laterally out of the run towards the western extremities of Lords and Mahady's Roads, Upper Plenty. According to the Witness Christodolou the fire reached this area at approximately 16:20, which time was consistent with Mr Crowe's knowledge of where the head of the fire was at that time.

1.22 Mr Crowe notes, that between Disappointment Road and Harpers Creek Road and between Harpers Creek Road and Engine Camp Road, the topography included south-east to north-west gully systems, which influenced the direction of the fire to the south-east.[13] Mr Crowe notes that the burn and char patterns show that there were numerous short runs of high to very high intensity in easterly and north-easterly directions up the slopes towards Harpers Creek Road and Engine Camp Road. These runs of fire diminished in intensity after they crossed the roads and moved towards the bottom of the gullies. The burn and char patterns show that within each of the gully systems there were short runs of high to very high intensity fire, running in a south-easterly direction and that such localised fire movement is consistent with the nature of the vegetation in the gullies which included gum barks. Mr Crowe suggests that much of the area to the east of Mount Disappointment Road was not in the main run of the fire to the south-east and that the area was essentially burnt by the eastern flank of that run. At paragraph 82, Mr Crowe states that given that flanking fire continues its movement after the passage at the head of the fire it is reasonable to conclude that these short runs of fire up the gullies in a south-easterly direction may have contributed to further spotting activity into the Wallaby Creek Catchment and the Kinglake West area.

1.23 In his evidence before the Royal Commission, Mr Crowe relevantly observed that when the fire was between the Hume Freeway and Mount Disappointment the wind shift was more to the north-west and along with the terrain, influenced the movement of the fire front to the east. He stated that 'the slopes of Mount Disappointment were welcoming the fire, if you wish. It was pointing straight at the wind.'[14]

[13] Crowe Ex 514, WIT.3004.022.0001, [77].
[14] Crowe T10980:6 –T10980:13.

Mount Disappointment to Humevale (west flank) and Kinglake West (east flank) - the Humevale fires

1.24 The Kilmore Gap and Tullamarine AWS records indicate that the wind direction between 15:00 and 16:30 on 7 February 2009 was from 330 degrees and 310 degrees (north-westerly) and that the wind strength was between 53 kph and 63 kph with gusts up to 90 kph.

1.25 Mr Crowe's examination revealed that it was evident that there was active fire burning in gum bark vegetation on the north-west face of Mount Disappointment and in the southern part of the Wallaby Creek Catchment during this run of the fire. The burn and char patterns in the Mountain Ash areas of Mount Disappointment and the southern part of the Wallaby Creek Catchment clearly indicate that the fire burnt with very high to extreme intensity. Mountain Ash trees are very tall, many in excess of 50 metres in height. Whilst Mr Crowe observed that the canopy of these trees was not completely removed by fire, the fine stems and foliage in the crowns were charred and distorted and pointing in a south-easterly direction. Mr Crowe opines that this suggests that the flames in these areas were in excess of 50 metres in height.[15] The surface and elevated fine fuels were almost completely consumed. Those stems of the elevated vegetation that were still standing were also charred and bent, pointing in a south-easterly direction. All of this evidence is consistent with a fire burning under a strong north-westerly wind up a north-west facing slop, as the weather records indicate was the case. Given the nature of the bark types on the higher slops of Mount Disappointment, the extreme intensity of that fire in that area, the weather and fuel conditions and the strength of the winds at the time, it is reasonable to expect that burning ribbons of bark would be lifted by the convection forces and carried significant distances.

1.26 Mr Crowe refers in his evidence to accounts given by various witnesses and observations later made by himself to confirm that this long distance spotting did indeed occur.

1.27 Mr Crowe refers to some examples of reliable evidence of witnesses placing spot fires starting in the Humevale area between 15:15 and 16:00.[16] These accounts were consistent with the examination of the relevant areas by Mr Crowe. Some of this evidence is referred to below when evidence regarding initial suppression efforts is examined.

1.28 Mr Crowe examined the area around Humevale including land near where various spot fires were identified, namely adjacent to the Whittlesea-Yea Road, Jacks Creek Road, Humevale Road, Parkers and Coombs Road. The terrain in Humevale includes steep slopes

[15] Crowe Ex 514 ,WIT.3004.0022.0001, [88].
[16] Crowe Ex 514, WIT.3004.022.0001, [90].

and gully systems that feed north up towards the Hume Range and the settlement of Kinglake West. Coombs Road is a ridge-top road that links the Whittlesea-Yea Road and Parkers Road, which in turn links with Humevale Road. The vegetation includes small pockets of pasture and significant areas of gum bark and stringy bark forest.

1.29 The complex landscape led to the fire moving in several directions, despite the existence of the strong prevailing wind. It was evident from the examination of the area by Mr Crowe that multiple spot fires started in this area. Significantly, some of the spot fires ran northward against the prevailing wind, up the gully systems towards Kinglake West. Others ran up to the ridge-tops from north-west to south-east and others again ran up to the ridge-tops from south-east to north-west.

1.30 The fact that these spot fires ran in different directions suggests that there were numerous junction zones, a point at which two separate fires merge to become one fire, which would have added to fire intensity and potentially caused further long distance spotting out of the gum bark trees.

1.31 It is apparent that given the evidence of the fire that originated at Kilmore East was approaching the top of Mount Disappointment at or after 15:00 into an area where there was fuel conducive to long distance spotting, the weather conditions prevailing and that new fires were igniting in the Humevale area from about 15:15, the fires at Humevale were caused by embers emanating from the north-west slops of Mount Disappointment, some 10 kilometres to the north west.

1.32 In his evidence to the Royal Commission, Mr Crowe was asked about his observations in the Humevale area. He gave evidence that 'that part of Humevale is steep rising country to the north towards Kinglake, lots of ridges and gullies, and the nature of the fuel once again is gum bark species of trees rather than stringy bark species of trees, some steep rises both towards Kinglake to the north and steep rises and ridges facing the south-east, and therefore we would have had runs of fire in multitudes of directions in that locality.'[17] Mr Crowe was asked: 'you refer in your report to reports of spot fires in and around Jacks Creek Road and other areas of Humevale. Where did those spot fires emanate from in your analysis? He answered: 'At that stage the fire front was still climbing Mount Disappointment.'[18]

1.33 Mr Crowe explained how those Humevale spot fires 'within a very short space of time they had developed into a significant fire in their own right'.[19] He then described that despite the prevailing wind, the Humevale Fires ran in a south-easterly direction and portions of it ran northward, driven by the influence of the gully systems that run north-

[17] Crowe T10988:18 – T10988:25.
[18] Crowe T10988:14 – T10988:30.
[19] Crowe T10988:14 – T10988:30.

south. He gave evidence that: 'some of the runs of fire actually went back towards the north; convection forces would have dragged the fire back up the slopes.'[20]

1.34 Mr Crowe confirmed that the Humevale Fires impacted upon Kinglake West 'a long time before the wind change'.[21] He confirmed that it was the local terrain and fuel that caused that fire, namely the Humevale Fire, to run contrary to the prevailing wind towards Kinglake West.[22]

1.35 With the Kilmore East fire front approaching the top of Mount Disappointment and throwing multiple long distance spot fires, the western flank of the fire continued to spread laterally down the slopes towards Eden Park and Glendale. Evidence referred to by Mr Crowe describes this portion of the fire reaching the forest boundary between 16:30 and 17:00. In the area between the Whittlesea-Yea Road and Kinglake West Mr Crowe observed the burn and char patterns clearly indicating a very high to extremely intense run of the fire crossing the road, moving in a south-easterly direction. The burn and char patterns on the slopes between Humevale and the Whittlesea-Yea Road also showed that the fires in the Humevale settlement ran up the slope in isolated sections in a generally northerly direction against the prevailing wind. These runs occurred within the proximity of Hawks Road and Coombs Road. Mr Crowe stated: 'The northerly movement of the fires can be explained by the convection forces and the shape of the terrain which can cause fires to move in seemingly unexpected directions until they come under the influence of the prevailing winds.'[23]

The Strathewen and St Andrews North Fires

1.36 The Tullamarine AWS and other records indicate that the wind direction between 15:30 and 17:19 on 7 February 2009 was from 330 degrees and 300 degrees (north-westerly) and that the wind strength was between 53 kph and 41 kph, with gusts up to 81 kph.

1.37 The terrain in Strathewen and St Andrews North includes steep slopes and gully systems that feed north up towards the Hume Range and the settlements of Pheasant Creek and Kinglake. The fuel in these areas included dry pasture and pockets of native vegetation. The slopes of Mount Sugarloaf (west of Strathewen) and the Bowden Spur (east of Strathewen) are covered with a mixed species forest, dominated by Mesmate (stringy bark) and Peppermint (platy-bark) species of trees. The vegetation in the gullies includes significant areas of gum bark species.

[20] Crowe T10989:8 –T10989:13.
[21] Crowe T10989:24.
[22] Crowe T10989:28 – T10989:30.
[23] Crowe Ex 514, WIT.3004.022.0001, [98].

1.38 Mr Crowe explains that this complex landscape of gullies, fuel varieties and steep ridge lines led to the multiple spot fires that started in this area to run northwards, up the gully systems.[24] Some of the fires ran up to the ridge-tops from north-west to south-east and some even ran up to the ridge tops from south-east to north-west. Mr Crowe observed: '*Therefore, any resident or fire fighter in proximity of these events may have been under attack of fire from unexpected directions, because the fire would be expected to be traveling under the prevailing north-west wind when, in fact, the fire was traveling north-west and north within the localised environment*.'[25]

1.39 As with the Humevale Fires, the Strathewen and St Andrews fires quickly grew and combined to form junction zones adding to the fire intensity and potentially causing further spotting activity.

1.40 Mr Crowe refers to various evidence establishing that new fires started in or around Strathewan and St Andrews North between about 15:30 and 17:30.

1.41 In particular Mr Crowe refers to evidence of spot fires quickly developing into large and intense fires in their own right at places such as Eagles Nest Road and Wild Dog Creek Road. He notes that Eagles Nest Road, Strathewan is approximately 17 kilometres from Mount Disappointment and Wild Dog Creek Road, about 22 kilometres.

1.42 Firefighters and residents were understandably surprised by the ignition of these spot fires, their rapid growth and intensity.

1.43 It is therefore apparent that by 15:30 on 7 February 2009 the main fire front of the fire that started in Kilmore East was burning on the northern and western slopes of Mount Disappointment. The extraordinary weather conditions, fuel and terrain caused the ignition of separate fires, separated from the main fire by many kilometers, to the south-east. In particular those at Humevale and separate fires even further south-east in St Andrews and Strathewen, which developed into intense 'main' fires in their own right, spread according to terrain and fuel regardless of the prevailing wind direction.

1.44 Mr Crowe states: 'Most of the spot fires (Humevale, Strathewan and St Andrews) developed into large fires and quickly merged with others. Therefore in the time between approximately 15:30 and 17:00 there were at least three large masses of fire on the landscape between Mount Disappointment and St Andrews.' [26] Mount Disappointment and to its north, Humevale and Strathewen/St Andrews.

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[24] Crowe Ex 514, WIT.3004.022.0001, [107].
[25] Crowe Ex 514, WIT.3004.022.0001, [107].
[26] Crowe Ex 514, WIT.3004.022.0001, [182].

Steels Creek, Dixons Creek, Healesville and Yarra Valley areas fires

1.45 The Coldstream AWS records indicate that the wind direction between 15:30 and 17:34 on 7 February 2009 was between 350 degrees (northerly) and 320 degrees (north-westerly) and that the wind strength was from 27 to 30 kph with gusts up to 60 kph. At 17:40 the Coldstream AWS recorded the wind direction from 250 degrees (south-westerly). The Coldstream AWS is the closest official weather recording site to Steels Creek, Dixons Creek, Yarra Glen and Healesville and therefore is most relevant to these areas.

1.46 Mr Crowe sets out some of the evidence that establishes that between 16:00 and 18:00 fires started in the Steels Creek, Dixons Creek, Yarra Glen and Healesville areas.[27] The investigation by Mr Crowe and his team as summarised at paragraph 116 of his Supplementary Statement makes clear was that various fires including the Zonzo Winery Fire which commenced at about 16:00 was caused by burning embers carried by the prevailing winds and convection column from the Kilmore East Fire, a fire in Yarraview Road, Briarty Road and Don Road, Healesville likewise started by long distance spotting from the fire that started in Kilmore East.[28] Mr Crowe sets out the distance between Mount Disappointment and various fires that were ignited by long distance spotting from the Kilmore East Fire as being between approximately 28 and 47 kilometres.[29]

1.47 Mr Crowe observed that the burn and char patterns examined in the Steels Creek, Healesville and Yarra Valley areas suggested that there were numerous spot fires, in fact many more than could be properly investigated. He states that this was due primarily to the fact that the area was not examined soon enough after the event.[30]

Fire behaviour after the wind change

1.48 Mr Crowe also explained the fire behaviour after the south west wind change. Mr Crowe explained:

> 'The wind change caused the eastern flank of the main fire to become an extraordinarily wide fire front of increased intensity, ranging from very high to extreme. The burn and char patterns show that the fire burned more intensely along roadside reserves and in forested areas than it did through paddocks. This means that as the fire front moved north and north-easterly up the slopes and gullies through the settlements of Kinglake, Pheasant Creek and Kinglake West it advanced in a series of running tongues. It is consistent with the quantity, moisture content and arrangement of fine fuels found along the roadside reserves and within the forested

[27] Crowe Ex 514, WIT.3004.022.0001, [115].
[28] Crowe Ex 514, WIT.3004.022.0001, [116].
[29] Crowe Ex 514, WIT.3004.022.0001, [118] – [118.6].
[30] Crowe Ex 514, WIT 3004.022.0001, [129].

areas but which were not present in the paddocks. Such fuels contribute to increased intensity, rate of spread and spotting.'[31]

Mr Crowe went on to explain that within this area there are also pockets of many small burnt areas which is evidence of extensive spotting but the small spot fires appear not to have developed into more significant fires due to the lack of available fuel.

1.49 Also after the wind change, the eastern flank of the fire on Mt Disappointment was driven into a high intensity running fire in a north-easterly direction towards Hazeldene and Flowerdale. Mr Crowe was able to identify three points of reference as to the approximate location of the eastern flank of the fire that ran south-easterly from Mount Disappointment to Humevale and Kinglake West. Mr Crowe explains that it was the eastern flank of the Humevale Fires that had run to the Kinglake West area that impacted on the properties of numerous others in the Hazeldene and Flowerdale settlements after the south-westerly change.

1.50 Mr Crowe refers to the statement of David O'Halloran who went to the Flowerdale Hotel about 18 kilometres north of Kinglake West and described that at about 23:00 there was an ember attack which was able to be controlled and it was at about 23:20 when the actual fire front hit.[32]

1.51 Also after the wind change the spot fires that started in the Yarra Valley and Healesville areas ran under the influence of southerly and south-westerly winds up the slopes towards the settlements of Castella, Toolangi and Glenburn. Mr Crowe examined the areas adjacent to the Kinglake/Healesville Road between Castella and Toolangi and noted that the burn and char patterns indicated a very high intensity fire crossed the road in numerous places between Castella and Toolangi.[33]

1.52 Also after the south-westerly wind change Reedy Creek and Strath Creek and parts of Clonbinane were also impacted upon.

1.53 The wind change also caused resurgent fire activity at Kilmore East and Wandong and drove the fire north towards Broadford where it was contained before impacting upon the township.

1.54 As mentioned above, the Commission was not in possession of the evidence set out above for the purposes of its Interim Report.

1.55 It is noted that Mr Rees endeavoured to explain what he understood to be the emerging analysis of the fire behaviour as set out above. Mr Rees endeavoured to explain that although significant spotting could

[31] Crowe, Ex 514 WIT 3004.022.0001, [146].
[32] Crowe, Ex 514 WIT.3004.022.0001, [166].
[33] Crowe, Ex 514 WIT.3004.022.0001, [170-171].

be anticipated nothing of the kind of what actually occurred was or could reasonably have been predicted. [34]

The evidence of Dr Tolhurst

1.56 Dr Kevin Tolhurst in his evidence to the Commission described an extraordinary and unprecedented confluence of events on 7 February 2009 in relation to the fire that ignited near Saunders Road, Kilmore East.[35] Dr Tolhurst described the weather conditions on 7 February and preceding it as leading to rapid and extreme drying of fuels bringing them closer to kindling temperature and 'primed for ignition which manifested itself in more explosive fire behaviour.'[36]

1.57 Dr Tolhurst explained that once the fires had ignited they created smoke plumes and convection columns which had an effect on increasing fire intensity. He also explained the unique weather circumstance of the passage of a low pressure trough across the Australian continent towards Victoria which 'certainly enhanced the intensity and the nature of the fires.' [37] He described the low pressure trough moving through the State of Victoria ahead of a cold front which in turn was moving more quickly than had originally been predicted.

1.58 Dr Tolhurst also explained the formation of the smoke plumes into a pyro-cumulus cloud the creation of which fires: 'don't necessarily have to under other circumstances but they did on 7 February.' [38] Dr Tolhurst explained the combination of factors which occurred with 'dramatic affect' [39] on the 7th of February.

1.59 Dr Tolhurst calculated that the formulation of the pyro-cumulus cloud from the smoke plume and the energy involved was likely to have doubled the intensity of the Kilmore East and Murrindindi Fires. He went on to explain that the convection column acted upon the travel of the fire giving rise to two distinct phenomena, firstly the predominance of spot fires being created to the north-east of the run of the fire and counter to the direction of the prevailing wind. He said that this tendency was assisted because the upper wind direction was different to the surface winds. He agreed that where one might expect spotting ahead of a fire traveling in a general southerly direction the phenomena he described in his report actually caused spotting back to the east.

1.60 Dr Tolhurst described, in accordance with the evidence of Mr Rees and Mr Crowe that in the mid afternoon while the fire front was still

[34] Rees T2688:20 – T2688:28.
[35] Tolhurst T1759:29 – T1760:14.
[36] Tolhurst T1760:1 – T1760:3.
[37] Tolhurst T1760:11 – T1760:14.
[38] Tolhurst T1760:23 – T1760:25.
[39] Tolhurst T1760:30 – T1760:31.

travelling south there were spot fires and fire brands being carried aloft in the easterly direction of Kinglake well before the south-westerly wind change.[40]

1.61 Dr Tolhurst also explained the phenomenon of the convection column dragging the run of the fire something like ten degrees or more in an easterly direction from that which it would have been predicted to travel on the basis of the prevailing wind in normal circumstances.

1.62 Dr Tolhurst was asked, 'Question: Again to take the Kilmore East Fire, an important aspect that affected the fire in your view was that the winds could actually change direction and speed depending on the elevation? Answer: Rather than say could, the evidence from the aerological diagram indicated that they were of different speed and direction with elevations, so there's direct evidence that they were in fact different. Question: So, for example, when the fire went up Mount Disappointment, it was met with stronger winds and winds of a more westerly nature? Answer: That's correct. Question: Which in addition to those matters I have already asked you about again pushing the fire in a more easterly direction? Answer: That's correct. Question: And those phenomena in combination have resulted in the fire being driven into the areas of Strathewen and Kinglake West rather than towards Whittlesea as might have been the typical path of the fire otherwise? Answer: That's correct '[41]

1.63 Dr Tolhurst candidly acknowledged: 'In our prediction of the spread of the fire from Kilmore, we actually assumed that the fire would persist more in a north/north-westerly direction so our use of the weather gave an error which showed it going further south as well, but I agree with your point that the fire would have been driven more towards Whittlesea, for example than it actually was because of the upper winds.'[42] Dr Tolhurst emphasised in respect of the Kilmore East Fire that the pronounced convection column and the phenomena of the low pressure trough coming in before the cold front caused the heat from the fire to enhance the prevailing weather conditions.

1.64 Dr Tolhurst stated: 'The conditions that we saw on 7 February were as extreme as we have ever seen them and I guess all the factors that come to play we have seen play out before. I guess it's the combination of those conditions all occurring at the same time and the same place that's led to the severity of the fires that we saw on 7 February.'[43]

1.65 In his expert report Dr Tolhurst noted that, 'Fire weather conditions were two to three times worse than those experienced in the legendary

[40] Tolhurst T1761:23 – T1761:28.
[41] Tolhurst T1764:11 – T1764:27.
[42] Tolhurst T1764:30 – T1765:5.
[43] Tolhurst T1765:21 – T1765:26.

'Black Friday' fires of 1939 and significantly more severe than the conditions of the more recent 'Ash Wednesday' fires in 1983.'[44]

1.66 He said that the rates of spread of the fires in forest equalled the maximum previously recorded on 'Ash Wednesday' averaging 12 kph for an hour in the case of the Kilmore East Fire. According to Dr Tolhurst, it was the extent and proliferation of spot fires that made the behaviour of these fires unique. The very hot and dry conditions were conducive to keeping the fire brands alight for longer than normal and upper winds of around 100 kph carried fire brands and started spot fires up to 35 kilometres ahead of the fire front. The previous authenticated spotting distance was 30 kilometres (Luke and McArthur 1978)[45]

1.67 Dr Tolhurst noted that the rate of spread of the fire for shorter periods of time would have been much faster than the hourly average. Prolific short distance spotting was occurring about 10 minutes before the arrival of the main fire, i.e. about one kilometer ahead of the main fire front. Black smoke indicated that the burning efficiency of the fire was very poor due to the air/fuel mixture being too rich to burn. This resulted in fire flares and what have been described as 'fire balls' where parcels of flammable gases released from the forest fuels have been blown ahead or above the fire and when they have mixed with sufficient air (oxygen) they ignite. This phenomenon could occur several hundred metres ahead of the fire front. Modelling of these fires using phoenix rapid fire indicated that fires could have spread as fast as 60 kph in grassland and 40 kph in forest for 100th of an hour – about half a minute. The fire then effectively moves in pulses where several hundreds of metres of forest can be set alight and then it takes a few minutes for the fuel to be fully incorporated into the fire and then it pulses again. The rate at which these pulses move could be as fast as the prevailing winds, which in the case of Black Saturday was 50 to 60 kph.

1.68 Flames were observed to leap 100 metres or more into the air. Radiation from the flames would make survival within a distance of three to four times this flame height difficult except for short exposures[46]

1.69 The total amount of heat released from the fires on Black Saturday would have been sufficient to provide the total energy needs for all Victorian domestic and industrial use for a year. This energy was released in just a few hours. The energy of the fires was equivalent to

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[44] *Report on the Physical Nature of the Victorian Fire occurring on 7th February 2009*, Ex 32, EXP.003.001.0017, [13].
[45] *Report on the Physical Nature of the Victorian Fire occurring on 7th February 2009*, Ex 32, EXP.003.001.0017, [13].
[46] *Report on the Physical Nature of the Victorian Fire occurring on 7th February 2009*, Ex 32, EXP.003.001.0017, [13].

more than 1,500 atomic bombs the size of the one used at Hiroshima, which devastated an area equivalent to 2,000 hectares, but bushfires release their energy in a 'storm' not a 'blast'. This gives an indication of the destructive power of these fires.'

1.70 Dr Tolhurst, in his report, said under the heading *Conclusions*: 'The fires on Black Saturday were exceptional in their severity and the manner in which they spread. The spread pattern they showed was typical of many previous fire events but there were some key spread characteristics which were magnified.'[47]

1.71 The pulsating nature of the fire spread with the accompanying propagation by spotting and wind blown volatile gases needs better description and research. These are important characteristics that need to be communicated to the public and taken into account in building design and land use planning.'[48]

[47] *Report on the Physical Nature of the Victorian Fire occurring on 7th February 2009*, Ex 32, EXP.003.001.0017, [16].
[48] *Report on the Physical Nature of the Victorian Fire occurring on 7th February 2009*, Ex 32, EXP.003.001.0017, [16].