

Particle pollution episode in Autumn 2018

Smoke from hazard reduction burning, Sydney 26-29 May 2018

Synopsis

During 26-29 May 2018, PM_{2.5} particle pollution¹ at nine of 14 air quality monitoring stations in the Sydney region reached poor to hazardous levels on the NSW Air Quality Index (AQI)². Visibility was reduced to poor to hazardous levels each day, for five to 15 hours. The event was associated with smoke from several hazard reduction burns (HRBs) in bushland surrounding Sydney, to the north, north-east, west and south of the city. The HRBs covered over 2,500 hectares (ha) during 26-27 May and continued smouldering during 28-29 May 2018.

A strong high-pressure system over the Tasman Sea, with a broad ridge extending over New South Wales, favoured the formation of overnight and early morning temperature inversions in Sydney. Very light and variable winds during the day and down-valley winds (westerlies), overnight and in the early morning, helped to transport smoke from HRBs towards the city, reducing visibility and elevating PM_{2.5} levels. The afternoon sea breezes (north to north-easterly winds) also transported smoke from HRBs to the north and north-east of the city, contributing to the build-up of smoke. Under these calm conditions, smoke continued to elevate PM_{2.5} concentrations, especially closer to the HRBs in Sydney North-West during 26-29 May 2018. PM_{2.5} levels above the 24-hour national standard were recorded across the city, with most intense impacts in Sydney North-west (Figure 1). The passage of a cold front with stronger south-westerly winds assisted the dispersion of smoke on 30 May 2018.

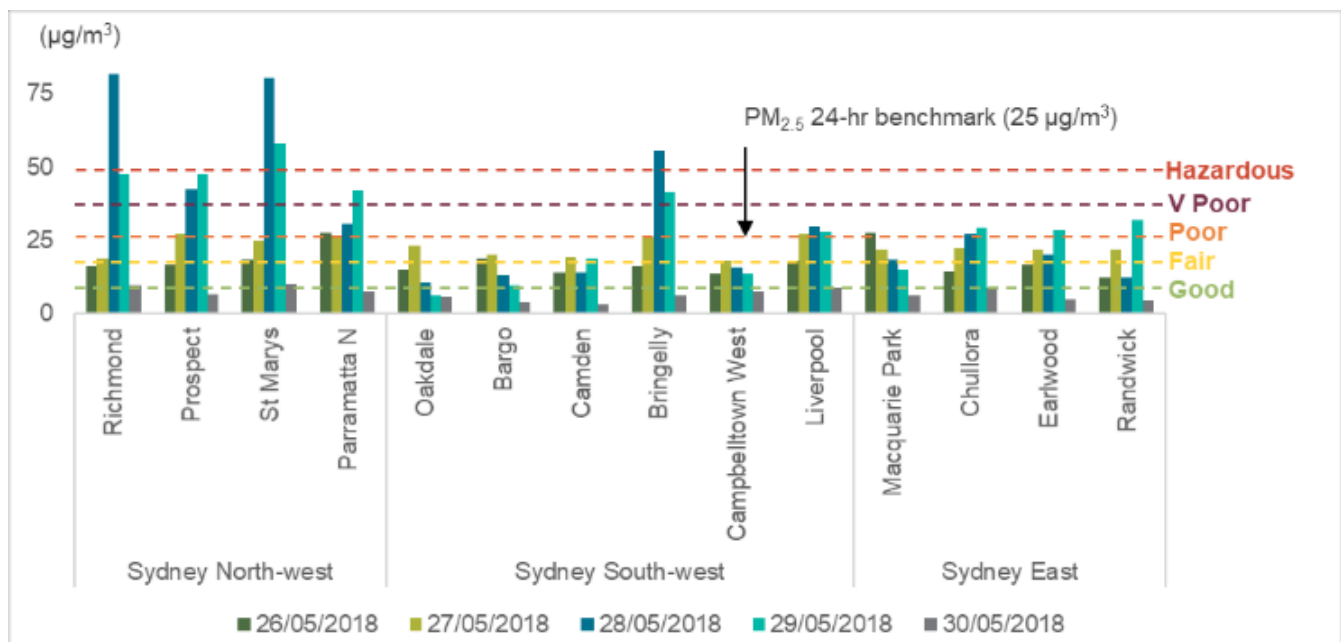


Figure 1 PM_{2.5} daily averages in the Greater Sydney Region, showing poor to hazardous air quality during 26-29 May 2018, with most intense impacts in Sydney North-west.

¹ PM_{2.5} refers to airborne particle matter less than or equal to 2.5 micrometres in diameter

² The NSW Air Quality Index uses colours and percentages, on a scale from very good to hazardous, to compare air pollution levels to national standards.

Episode analysis

The discussion below describes in more detail the build-up of pollution during 26-29 May and the return of good to very good air quality on 30 May 2018.

Recorded air quality

Error! Reference source not found. and Table 1 summarise the magnitude and distribution of maximum 24-hour PM_{2.5} levels across the region, during 26-30 May 2018. PM_{2.5} 24-hour concentrations above the national standard of 25 micrograms per cubic metre (µg/m³) were recorded at two stations on 26 May, five stations on 27 May, seven stations on 28 May and at nine stations on 29 May 2018. The maximum 24-hour PM_{2.5} levels ranged from 27 µg/m³ to 82 µg/m³ and were recorded in Sydney North-west, the region nearest the largest HRBs.

Table 1 Summary statistics for daily PM_{2.5} particle pollution, 26-30 May 2018

Date	Max 24-hour PM _{2.5} [#] (µg/m ³)	Max 24-hour PM _{2.5} site	Number of sites above the PM _{2.5} standard	Sydney North-west (NW)	Sydney South-West (SW)	Sydney East (E)
26/05/18	28	Macquarie Park (Sydney East)	2	1	0	1
27/05/18	27	Parramatta North (Sydney North-west)	5	3	2	0
28/05/18	82	Richmond (Sydney North-west)	7	4	2	1
29/05/18	58	St Marys (Sydney North-west)	9	4	2	3
30/05/18	10	St Marys (Sydney North-west)	0	0	0	0

Notes: [#]The PM_{2.5} levels in bold are above the 24-hour standard (25 µg/m³)

Table 2 shows reduced visibility, for five to 15 hours each day, during 26-29 May 2018.

Table 2 Summary statistics for maximum hourly reduced visibility[#], 26-30 May 2018

Date	Max 1-hour reduced visibility (Neph, b _{sp} ^{##})	Site with max 1-hour reduced visibility	Time of max 1-hour reduced visibility	No. of hours in the Sydney region above 1-hour standard for reduced visibility	No. of sites above 1-hour standard	Sydney North-west (NW)	Sydney South-West (SW)	Sydney East (E)
26/05/18	4.6	Macquarie Park, Sydney East	7 pm	9 hours mostly late afternoon to midnight	5	1	1	3
27/05/18	4.2	Macquarie Park, Sydney East	10 am	5 hours mostly morning to noon	8	3	1	4
28/05/18	15.2	Richmond, Sydney NW	5 pm	14 hours mostly noon-to midnight	8	4	2	2
29/05/18	8.2	St Marys, Sydney NW	1 am	15 hours mostly midnight to mid afternoon	10	4	2	4
30/05/18	1.5	St Marys, Sydney NW	6 am	1	1	1	0	0

Notes:

[#] Reduced visibility is recorded by a nephelometer, which measures light scattering due to airborne particles. Visibility is measured in units of light scattering potential, represented as b_{sp})

^{##} The nephelometer (Neph) levels in bold are above the NSW 1-hour standard (2.1 b_{sp}, units of reduced visibility, corresponds to visibility of approximately nine kilometres)

Event description

The most intense PM_{2.5} impacts occurred between mid-day 28 May to mid-day 29 May 2018 (Figure 2).

Day 1, Saturday, 26 May 2018:

Poor air quality (daily average PM_{2.5} concentrations at levels up to 50% above the national standard of 25 µg/m³) was recorded at two monitoring stations. Parramatta North in Sydney North-west and Macquarie Park in Sydney East, both recorded daily maximum PM_{2.5} levels of 28 µg/m³.

The highest hourly average PM_{2.5} concentrations peaked at 8 pm, with 92 µg/m³ and 64 µg/m³ at Parramatta North and Macquarie Park, respectively³.

Smoke from HRBs led to poor to hazardous visibility at three monitoring stations, for up to seven hours. Down-valley westerly air flows transported smoke across the city overnight. Reduced visibility was recorded in the evening, from 5pm to 8pm in Sydney North-west, from 6pm to midnight in Sydney East and at midnight in Sydney South-west. Reduced visibility was hazardous (visibility was reduced by more than twice the standard) at Macquarie Park and Parramatta North at 7pm. Very poor visibility was recorded at midnight at Oakdale in Sydney South-west, near to the major HRB at Oakdale, which burned over 75 ha⁴ (Figure 4)

Day 2, Sunday, 27 May 2018:

Poor air quality was recorded at four of 14 monitoring stations, two in Sydney North-west and two in Sydney South-west. The daily PM_{2.5} levels above the standard ranged from 26 µg/m³ at Bringelly (Sydney South-west) to 27 µg/m³ at Parramatta North (Sydney North-west).

The hourly PM_{2.5} levels peaked at 1 am, with 84 µg/m³ at Oakdale in Sydney South-west. The hourly PM_{2.5} levels at all air quality monitoring stations fell to lower levels during the afternoon. The light north-easterly sea breezes, generally up to two metres per second (m/s), may have assisted the dispersion of smoke. Hourly PM_{2.5} levels increased in the evening in Sydney South-west and Sydney North-west, due to transport of smoke, from the smouldering HRBs back into the city, by down-valley airflows.

Poor to very poor visibility was recorded for up to five hours at seven sites, three sites in Sydney North-west and four in Sydney-East. The early morning temperature inversion intensified the build-up of smoke. Reduced visibility was recorded in the morning from 8am to midday at Parramatta North in Sydney North-west and from 9am to 11am at Macquarie Park in Sydney-East.

Day 3, Monday, 28 May 2018:

This day recorded the highest 24-hour PM_{2.5} levels and the poorest visibility, during 26-29 May 2018. Smoke from the smouldering HRBs continued to build up across the city as the anti-cyclonic conditions persisted. Wind speeds were generally less than 1 m/s. Seven of 14 monitoring stations recorded PM_{2.5} levels above the 24-hour standard, four in Sydney North-west (poor to hazardous), two in Sydney South-west (poor to very poor) and one in Sydney East (poor). Daily PM_{2.5} levels ranged from 27 µg/m³ at Chullora (Sydney East) to 82 µg/m³ in Richmond (Sydney North-west).

The 1-hour PM_{2.5} levels remained relatively lower from the early morning, until late afternoon. A sudden increase in hourly PM_{2.5} levels was observed across western Sydney after 5pm. In the early evening, very light air flows (generally less than 0.5 m/s) from the north to north-east assisted smoke to drift from smouldering HRBs in Colo Heights and North Turramurra, north and north-east of the city. Hourly PM_{2.5} levels peaked in Sydney North-west at St Marys at 6pm (199 µg/m³) and then further west, during 7pm to 8pm. Richmond recorded 206 µg/m³, in Sydney North-west and Bringelly recorded 157 µg/m³ in Sydney South-west.

The very light north to north-easterly airflows and the overnight temperature inversion trapped the smoke near ground level across the city. Poor to hazardous visibility was recorded for up to 14 hours, mostly from midday to midnight, at eight sites: four in Sydney North-west and two in Sydney South-west and Sydney-East. The most hazardous visibility was recorded in Sydney North-West, closest to the HRBs, where visibility was reduced by more than seven times the standard at Richmond from 4pm to 6pm.

³ There are no standards for 1-hour PM_{2.5} levels in the [National Environment Protection \(Ambient Air Quality\) Measure](#)

⁴ NSW Rural Fire Service ICON database, incident number 18052200648

Day 4, Tuesday, 29 May 2018:

This day recorded the most extensive poor to hazardous air quality and the most extensive reduction in visibility. Nine of 14 monitoring stations recorded PM_{2.5} levels above the standard, four in Sydney North-west, two in Sydney South-west and three in Sydney East. Daily PM_{2.5} levels ranged from 28 µg/m³ at Liverpool (Sydney South-west) to 58 µg/m³ in St Marys (Sydney North-west) (Figure 3, left). Light westerly airflows conducive to the transport and build-up of smoke across the city persisted during early to mid-morning. In the afternoon, a light north-easterly sea breeze (generally less than two m/s) assisted smoke to drift into the city from smouldering HRBs to the north-east (Figure 3, right and Figure 4).

Poor to hazardous visibility was recorded for up to 15 hours, from midnight to 1pm, at eight sites, four in Sydney North-west, two in Sydney South-west and four in Sydney-East. The poorest visibility was at 1am at St Marys in Sydney North-West, where visibility was reduced by almost four times the standard.

Day 5, Wednesday, 30 May 2018:

Winds changed from light westerlies to moderate south-westerlies during early to mid-morning, with light rainfall to 3.4 mm⁵, indicating the passage of a cold front. These conditions assisted the dispersion of smoke and the return of very good to good air quality at all 14 stations across the region.

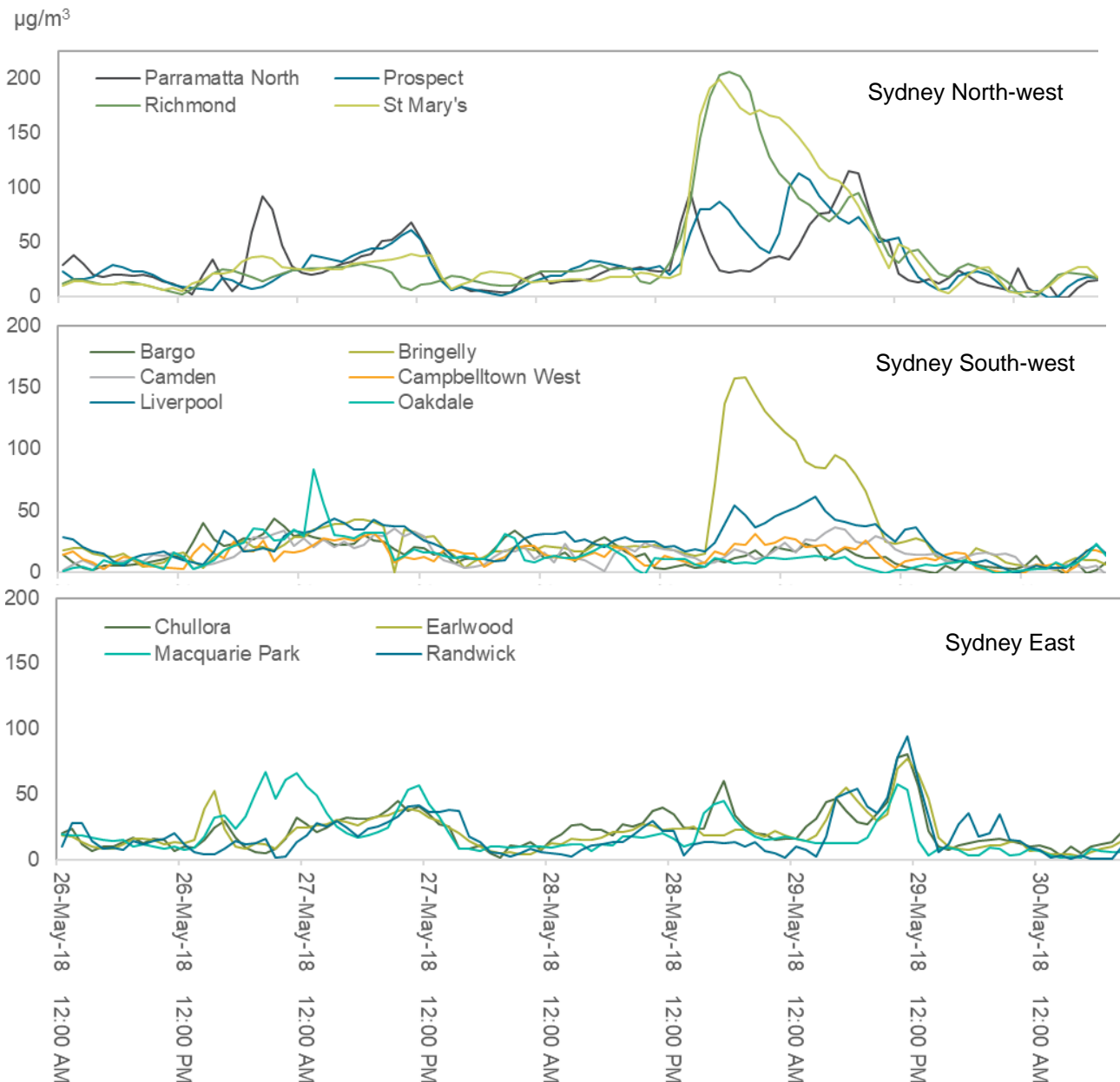


Figure 2 Time series plots of 1-hour average PM_{2.5} concentrations for Sydney North-west (top), Sydney South-west (middle) and Sydney East (bottom), 26-30 May 2018, showing the most intense impacts occurred generally from mid-day 28 May to mid-day 29 May 2018.

⁵ Sydney Observatory Hill rainfall observations 2018, Bureau of Meteorology, accessed June 2018.

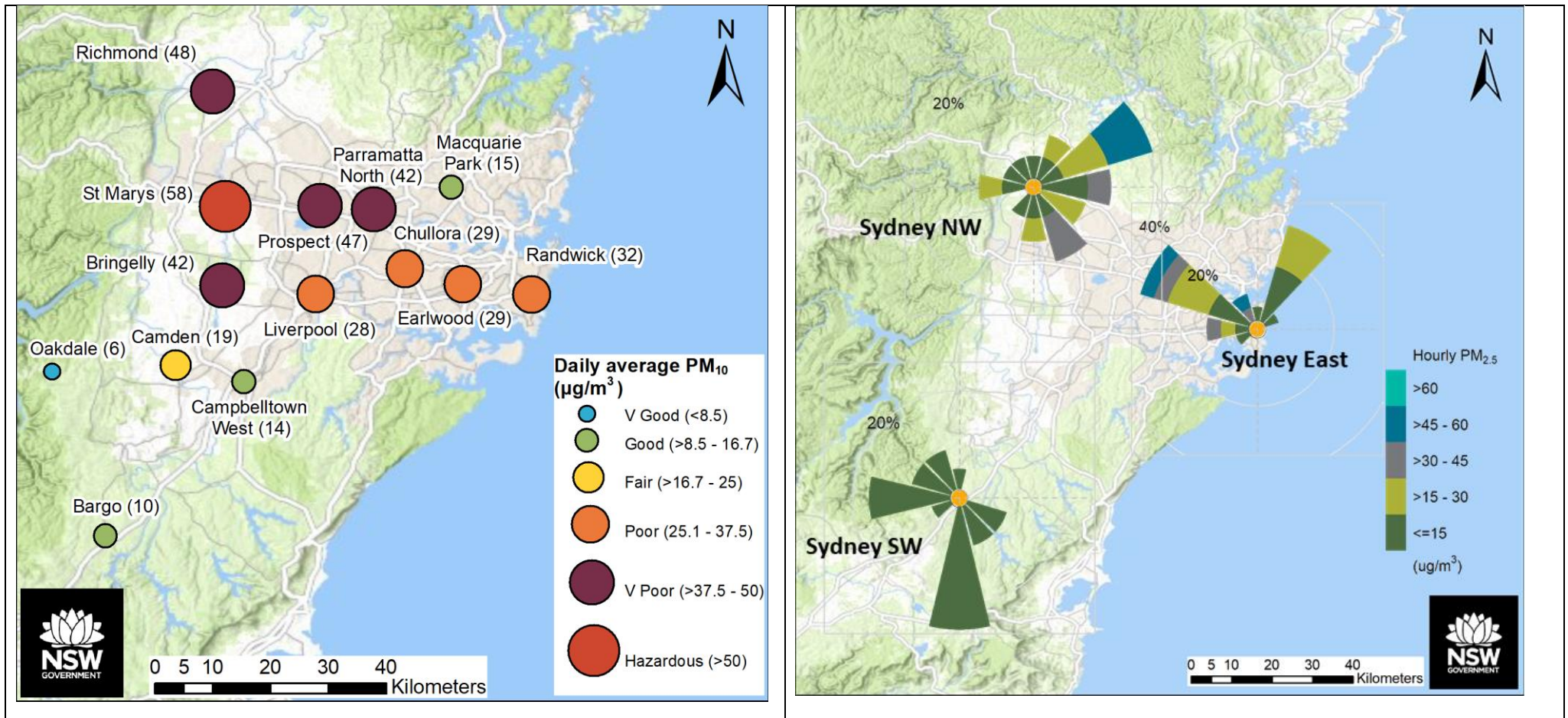


Figure 3 Daily PM_{2.5} levels showing nine of 14 stations across Sydney recorded poor to hazardous air quality (left) with highest hourly PM_{2.5} levels associated with north-westerly to north-easterly winds (right), on 29 May 2018.

Appendix

Hazard Reduction Burning 26-29 May 2018

Figure 4 shows numerous HRBs in the Greater Sydney Region conducted by the NSW Rural Fire Service (RFS) during 26-27 May 2018, burning approximately 2,500 hectares (ha). The largest HRB was in Colo Heights State Forest (1,966 ha). Two smaller HRBs were at North Turramurra (120 ha) and Jessica Gardens (100 ha). Several HRBs (20 to 164 ha) were conducted in national parks in the Blue Mountains and to the north, south-east and south-west of the region.

The Colo Heights HRB continued smouldering during 28-29 May. The HRB activities were identified by the hot spots in MODIS satellite imagery⁶ (Figure 5).



Figure 4 Hazard reduction burns during 26-27 May 2018 (NSW RFS)

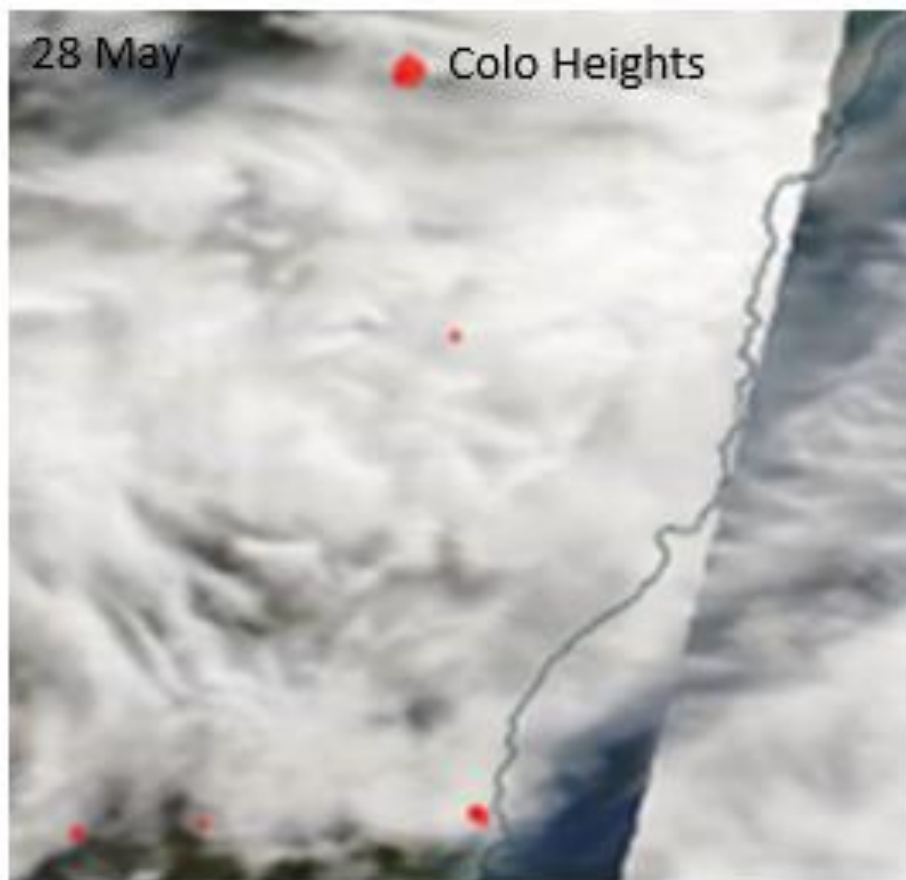
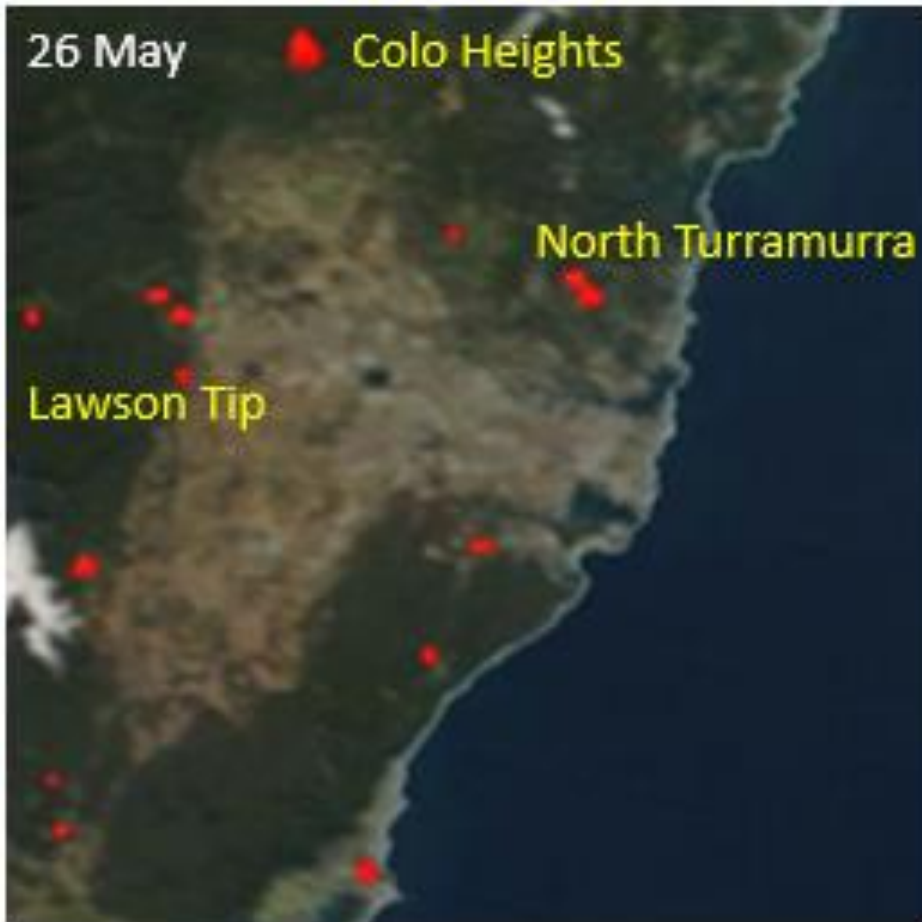


Figure 5 MODIS⁶ satellite imagery showing fire hot spots on 26 and 28 May 2018

⁶ MODIS (Moderate Resolution Imaging Spectroradiometer) satellite imagery service, United States National Aeronautics and Space Administration (NASA) accessed June 2018

Weather conditions

Figure 6 shows the strong high-pressure system over the Tasman Sea on 26 May, which extended a broad ridge over New South Wales on 28 May 2018. These anti-cyclonic conditions, with clear skies, light winds and stable subsiding air were conducive to the formation of overnight temperature inversions, during 26 to 29 May 2019 (Figure 7). The passage of a cold front brought higher wind speeds and showers to the Sydney region, on 30 May 2018.

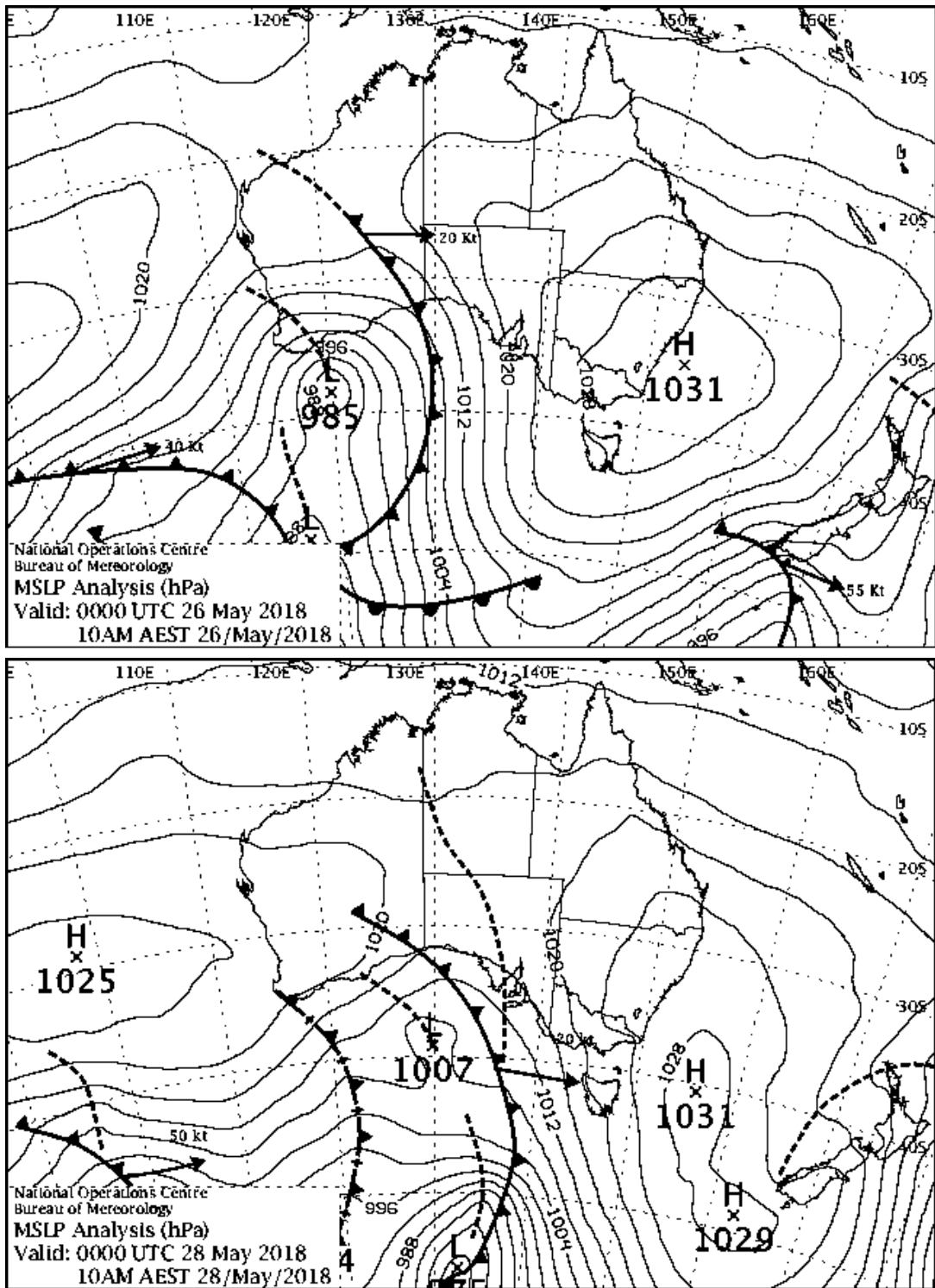


Figure 6 Synoptic charts⁷ on 26 and 28 May, showing a strong high-pressure system, with a broad ridge extending over New South Wales on 28 May 2018.

⁷ Sourced from the Bureau of Meteorology Analysis Chart Archive website (accessed June 2019)

The aerological diagram for Sydney Airport, on 28 May 2018, shows a strong temperature inversion near ground level and very light north to north-west winds (Figure 7). Similar conditions were recorded every morning during 26-29 May 2018. The increase in temperatures with altitude and very light air flows near ground level indicate calm conditions, conducive to the build-up of smoke.

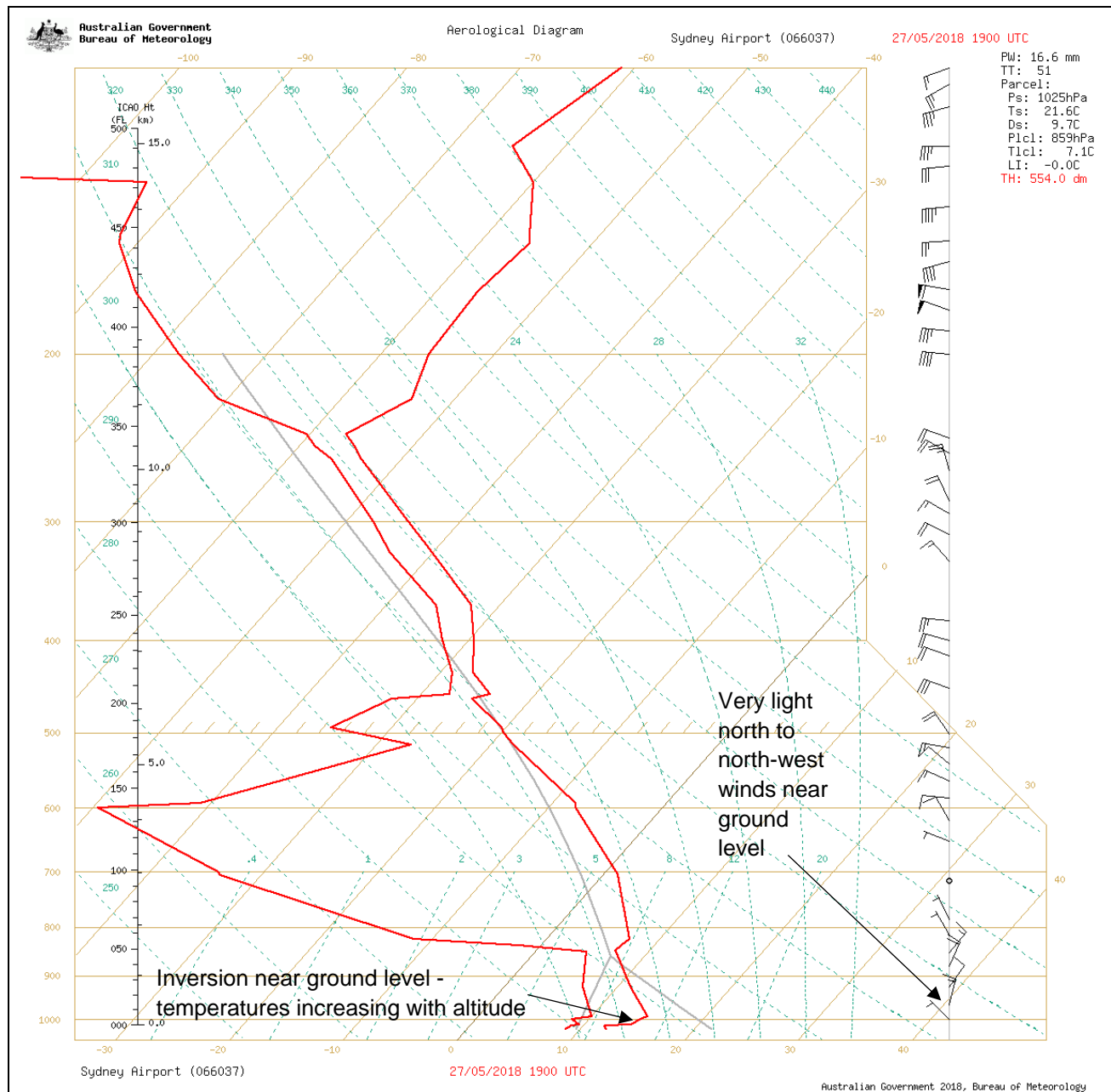


Figure 7 Sydney Airport Aerological Diagram, at 5am, 28 May 2018⁸, showing a temperature inversion and very light air flows near ground level, conducive to the build-up of smoke.

⁸ Bureau of Meteorology, sourced May 2018.

Liverpool was chosen for a panel plot to show the influence of wind speed and direction on visibility and PM_{2.5} particle levels during 26-30 May 2018 (Figure 8).

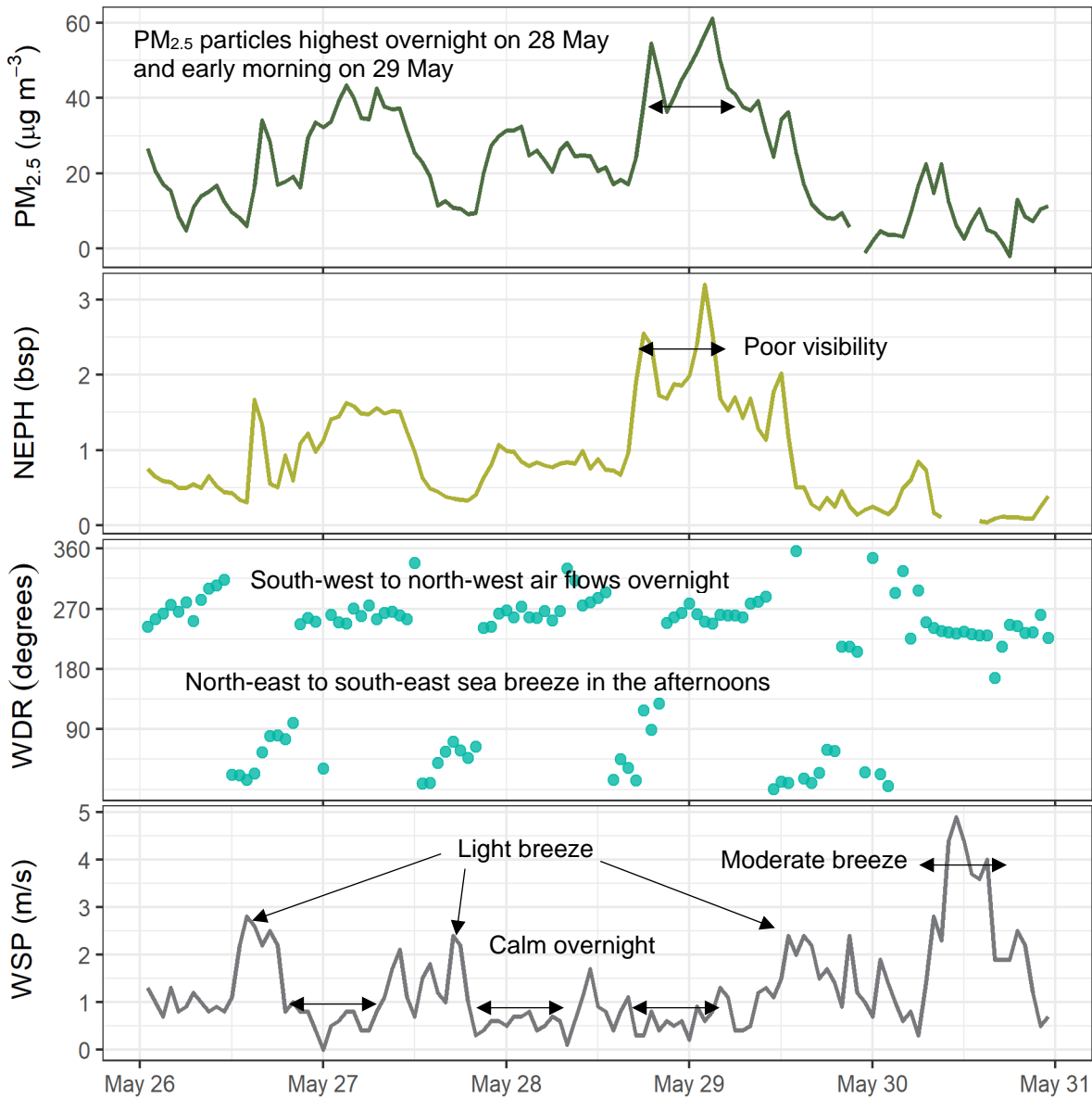


Figure 8 Panel plot of 1-hour averages for PM_{2.5} (top), Nephelometer (visibility) (second from top), wind direction (third from top) and wind speed (bottom), at Liverpool in Sydney South-west, during 26-30 May 2018

The plot identifies the following key associations between meteorological conditions, visibility and and particle levels.

- Before and during the period of high nephelometer readings (low visibility), there were very calm conditions (wind speeds less than two m/s) and a strong temperature inversion occurred overnight. These conditions were conducive to the build-up of smoke.
- The light westerlies (down-valley air flows) generally dominated during late night into mid-day, which transported smoke from the HRBs to the west of the city. The light north to north-easterlies (sea breezes, less than three m/s) generally prevailed in the afternoon, transporting smoke in to the city from HRBs to the north and north-east of the city. This caused a build-up of smoke and resulted in high particle levels and reduced visibility in across the city.
- On 30 May 2018, the stronger south-westerly to south-easterly winds, associated with passage of a cold front, helped to disperse smoke and particles over the ocean waters. Lower levels of particles were recorded across the city.

The evidence provided by the panel plot supports with the analysis discussed above.

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