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SQ2443 - Air Quality Monitoring Program,
RAAF Base Amberley

Department of Defence

15-Sep-2017

Air Quality Monitoring Annual Report 3

Australian Super Hornet Flying Operations - June 2016 to May 2017

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Australian Super Hornet Flying Operations - June 2016 to May 2017

Client: Department of Defence

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Prepared by

AECOM Australia Pty Ltd
Level 8, 540 Wickham Street, PO Box 1307, Fortitude Valley QLD 4006, Australia
T +61 7 3553 2000 F +61 7 3553 2050 www.aecom.com
ABN 20 093 846 925

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			Name/Position	Signature
0	15-Sep-2017	Initial Issue	Dave Claughton Senior Professional Engineer	

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Executive Summary

The Department of Defence (Defence) has engaged AECOM Australia Pty Ltd (AECOM, ABN 20 093 846 925) to undertake the implementation of the RAAF Base Amberley Australian Super Hornet Air Quality Monitoring Plan (AQMP). AECOM operates an ambient air quality monitoring station on behalf of Defence, measuring the parameters specified in the AQMP, and detailed in **Section 2.2** of this report. The purpose of this report is to present results of air quality monitoring undertaken on behalf of Defence by AECOM for the annual period starting 1 June 2016 and finishing 31 May 2017 inclusive in order to satisfy Condition 4a of the Environmental Protection and Biodiversity Act 1999 approval for the Super Hornet flying operations at RAAF Base Amberley (EBPC Reference: 2008/4410).

The data availability and corrected data capture rate exceeded the requirements listed in Section 4.5 of NEPM Technical Paper No. 5 and industry standards for collection of air quality monitoring data.

There was a single reportable exceedance of the Environmental Protection (Air) Policy 2008 (EPP(Air)) objective for $PM_{2.5}$ during the monitoring period, on 6 November 2016 where a concentration of 34.3 µg/m³ was recorded. There were no Australian Super Hornet movements reported on 6 November 2016. There were no other reportable exceedances of the EPP(Air) objectives.

With consideration of the three years of monitoring data collected between June 2014 and May 2017, and with reference to Section 26 of the AQMP, the following two recommendations are provided:

1. If Australian Super Hornet (ASH) movements **are not expected to increase** above the level of activity experienced over the past three years then the monitoring indicates that emissions from ASH are not significantly contributing to local air environment. Therefore the air quality monitoring program can be discontinued. The RAAF Base Amberley Australian Super Hornet Air Quality Monitoring Plan should be updated to reflect these changes.
2. If ASH movements **are expected to increase** above the level of activity experienced over the past three years then in accordance with section 26of the AQMP air quality monitoring and reporting should continue until validation of the PER can be conducted. The RAAF Base Amberley Australian Super Hornet Air Quality Monitoring Plan should be updated to reflect these changes.

Table 1 summarises measurements made during the annual monitoring period, comparing them to the relevant EPP(Air) objective, and **Table 2** compares measurements to reportable EPP(Air) annual objectives.

Table 1 Summary of annual period – June 2016 to May 2017

Parameter	Period	Annual average concentration	Maximum concentration	EPP(Air) objective	Reportable exceedances
CO	8 hours	0.089 ppm	1.199 ppm	9 ppm	0
NO_2	1 hour	4.8 ppb	40.1 ppb	120 ppb	0
O_3	1 hour	20.2 ppb	83.1 ppb	100 ppb	0
O_3	4 hour	*20.5 ppb* [a]	66.9 ppb	80 ppb	0
$PM_{2.5}$	24 hours	5.8 µg/m³	**34.3 µg/m³**	25 µg/m³	0
PM_{10}	24 hours	11.1 µg/m³	44.8 µg/m³	50 µg/m³	0
SO_2	1 hour	1.0 ppb	5.5 ppb	200 ppb	0
SO_2	24 hours	*1.0 ppb* [a]	2.2 ppb	80 ppb	0

[a] According to the National Environmental Protection Council's *National Environmental Protection (Ambient Air Quality) Measure: Technical Paper No. 5 – Data Collection and Handling*, annual averages are to be calculated from validated 1 hour average concentrations. The annual average concentration calculated from 4 hour O_3 and 24 hour SO_2 averages are presented here for comparative purposes only.

Table 2 Summary of annual period – reportable annual average concentrations – June 2016 to May 2017

Parameter	Annual average concentration	EPP (Air) annual objective	Result
NO_2	4.8 ppb	30 ppb	Not exceeded
$PM_{2.5}$	5.8 µg/m³	8 µg/m³	Not exceeded
SO_2	1.0 ppb	20 ppb	Not exceeded

1.0 Introduction

The Department of Defence (Defence) has engaged AECOM Australia Pty Ltd (AECOM, ABN 20 093 846 925) to undertake the implementation of the RAAF Base Amberley Australian Super Hornet Air Quality Monitoring Plan (AQMP). The AQMP was developed in response to the findings of the Australian Super Hornet Public Environment Report (PER).The purpose of the AQMP is to outline how Defence will comply with Condition 4 of the Environment Minister's approval of the Australian Super Hornet (ASH) flying operations at RAAF Base Amberley. Condition 4 of the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) approval of the Super Hornet flying operations at RAAF Base Amberley (EPBC Reference: 2008/4410) is as follows:

> *4. The person taking the action must provide for approval by the Minister an Air Quality Monitoring Plan that includes:*
>
> *a) Monitoring air quality near a sensitive receiver in close proximity to or on RAAF Base Amberley;*
>
> *b) A process for validation of the accuracy of Super Hornet air quality impacts modelled in the Public Environment Report of the action;*
>
> *c) Should the measured air quality values exceed relevant air quality objectives, a commitment to working with the relevant State authorities to determine sources of pollutants and potential mitigation measures;*
>
> *d) An undertaking to post the results of rain tank water quality testing conducted in accordance with the Public Environment Report on an appropriate website for public information;*
>
> *e) In the event that rainwater contamination is found to occur as a result of the proposal, identification and implementation of appropriate measures to mitigate the contamination.*

The purpose of this report is to present results of air quality monitoring undertaken on behalf of Defence by AECOM in order to satisfy Condition 4a. Reporting to satisfy Condition 4a comprises four quarterly reports per year of monitoring. The scope of works for the quarterly report is as follows:

- Presentation of all results for the quarterly monitoring period (including graphical representations).
- Comparison of results with standards and trigger values.
- Analysis of results at a quarterly scale, including running comparisons with previous results collected as part of the current program.
- Explanation/discussion of any exceedances detected during the reporting period.
- Identification of QA/QC and maintenance activities that took place during the month.

Following the four quarterly reports per year an annual monitoring report (this report) has been prepared. In addition to the information provided in the quarterly reports this annual reports includes the following:

- Presentation of full annual data sets, including the addition of meteorological data acquired from the Bureau of Meteorology.
- Examinations of annual trends and discussion on deviations and exceedances of standards.
- Examinations of longer term trends and, where available, compare current monitoring data to previous monitoring program data. For the first annual report (June 2014 to May 2015) of the current monitoring program no comparison with previous monitoring was undertaken. Subsequent annual reports include running comparisons with the previous annual report.
- A comparison and analysis of the annual monitoring data set alongside ASH air quality impacts modelled in the Public Environment Report. Analysis will be in order to satisfy Condition 4b of the ASH flying operations at RAAF Base Amberley EBPC Act approval.

2.0 Methodology

2.1 Location of monitoring station

The AQMP for the ASH operations at RAAF Base Amberley requires Defence to establish an air quality monitoring station near one of the sensitive receivers nominated in the PER. The AQMP also sets siting criteria for selecting a monitoring location out of the nominated sensitive receivers.

AECOM conducted an Air Quality Monitoring Station Site Selection analysis for ASH operations at RAAF Base Amberley (dated 23 May 2014). In accordance with the AQMP site selection criteria and the requirements of Australian Standard *AS/NZS 3580.1.1:2007 – Methods for sampling and analysis of ambient air Part 1.1: Guide to siting air monitoring equipment*, the site selection analysis nominated a preferred monitoring location. As a result of the site selection process, the preferred and selected location for the air quality monitoring station was identified as a grassed area on the western side of the parking lot behind building A052, shown as “Monitoring Location” in **Figure 1**. Coordinates of the monitoring station are: 27° 38’ 24.92” S, 152° 41’ 39.02” E.

Figure 1 Aerial of monitoring location

2.2 Parameters monitored

Monitored parameters as specified by Defence and the relevant standards under which they are monitored are detailed in **Table 3**.

Table 3 Summary of monitoring methodology

Parameter	Unit of reporting	Full scale range	Instrument	Relevant Standard	Uncertainty of method[1]
Carbon Monoxide	ppm by volume (ppm)	50 ppm	TAPI T300	AS/NZS 3580.7.1:2011	± 2.2 %
Nitrogen Dioxide	ppb by volume (ppb)	500 ppb	TAPI T200	AS/NZS 3580.5.1:2011	± 6.5 %
Ozone	ppb by volume (ppb)	500 ppb	TAPI T400	AS/NZS 3580.6.1:2016	± 2.9 %
Suspended particulate matter – PM2.5	µg/m³	5000 µg/m³	FH62-C14	AS/NZS 3580.9.12:2013	± 1.1 %
Suspended particulate matter – PM10	µg/m³	5000 µg/m³	FH62-C14	AS/NZS 3580.9.11:2016	± 1.1 %
Sulfur dioxide	ppb by volume (ppb)	500 ppb	TAPI T100	AS/NZS 3580.4.1:2008	± 6.0 %

[1] Uncertainty is expressed as a percentage of full scale range at a 95% confidence level with a coverage factor of 2

Monitoring of suspended particulate and gaseous parameters is continuous.

Two additional standards are referenced for the monitoring conducted for this report:

- Australian Standard *AS/NZS 3580.1.1:2016 – Guide to siting air monitoring equipment* details requirements for station siting which were addressed during site selection as detailed in Claughton and Manley (23 May 2014) *Air Quality Monitoring Station Site Selection*. As per the standard, the site is audited annually for continued compliance with the standard.
- Australian Standard *AS/NZS 3580.2.2:2016 – Preparation of reference test atmospheres – Compressed gas method* details requirements for preparation of reference test atmospheres for the calibration of the T100, T200 and T300 gas analysers.

2.3 Air quality objectives

Measured gas and particulate concentrations are compared against the air quality objectives for health and wellbeing detailed in Schedule 1 of the *Environmental Protection (Air) Policy 2008* (EPP (Air)) and detailed in **Table 4**.

Table 4 Air quality objectives for health and wellbeing, EPP (Air)

Parameter	Air quality objective	Period	Allowable exceedances of objective
Carbon monoxide (CO)	9 ppm	8 hours	1 day each year
Nitrogen dioxide (NO_2)	120 ppb	1 hour	1 day each year
	30 ppb	1 year	Nil
Ozone (O_3)	100 ppb	1 hour	1 day each year
	80 ppb	4 hours	1 day each year
$PM_{2.5}$ particulate ($PM_{2.5}$)	25 µg/m³	24 hours	Nil
	8 µg/m³	1 year	Nil
PM_{10} particulate (PM_{10})	50 µg/m³	24 hours	5 days each year
Sulfur dioxide (SO_2)	200 ppb	1 hour	1 day each year
	80 ppb	24 hours	1 day each year
	20 ppb	1 year	Nil

For some parameters the EPP(Air) allows for the air quality objective to be exceeded for a set number of days each year, as detailed in **Table 4**. Exceedances are only considered as **reportable exceedances** where the number of days on which the air quality objective is exceeded is greater than the allowable number of days in exceedance as specified in the EPP(Air).

Furthermore, results are graded according to the Queensland Department of Environment and Heritage Protection (DEHP) Air Quality Index (Queensland Government, *Air Quality Index*, retrieved 26 August 2014, http://www.qld.gov.au/environment/pollution/monitoring/air-monitoring/air-quality-index/). The air quality index comprises five colour coded categories, based upon the percentage of the air quality objective:

Air quality index value = (pollutant concentration ÷ air quality objective for the pollutant) × 100

Very Good (0-33%)	Good (34-66%)	Fair (67-99%)	Poor (100-149%)	Very Poor (>150%)

Air quality index values of "Poor" and "Very Poor" indicate exceedance of the EPP (Air) objective.

2.4 Data capture rate

Data capture is reported as follows:

- Raw data capture, also called data availability, being the percentage coverage of the total time in the current reporting period.
- Corrected data capture, being the percentage coverage of the current reporting period excluding data loss from routine operational events such as maintenance checks and calibrations.

Actual expected data loss varies from month to month (due to differing maintenance requirements over specified time periods, and the varying number of days in a month), but at a minimum the gaseous analysers require 5% down time per month for routine calibrations and servicing events, and the BAMs require a minimum of 1% downtime per quarter. Additional downtime is required on a yearly basis for preventative maintenance.

2.5 Data validation and handling

AECOM uses methodology outlined in the National Environmental Protection Council's *National Environmental Protection (Ambient Air Quality) Measure: Technical Paper No. 5 – Data Collection and Handling* ("Technical Paper No. 5"). Technical Paper No. 5 details basic data validation methodologies, methods for calculation of average data, and reporting requirements for data.

Data reported in this report have undergone AECOM's internal data validation process. This process is based upon the process detailed in Section 4.3 of Technical Paper No. 5, and the relevant Australian Standard for the parameter measured.

2.6 Reporting of results

2.6.1 Calculation and labelling of results

Concentrations quoted in this report are averages of validated 10 minute monitored data from the station data logger. Averages are calculated in accordance with Section 5 of Technical Paper No. 5, using the following definitions:

- "Average" means an arithmetic mean, reported at the frequency implied by the name of the dataset (for example, a single 24 hour average value is reported for each day).
- "Rolling average" means an arithmetic mean of the last *x* hours of the 1 hour average data set, reported at an hourly frequency (for example, an 8 hour rolling average consists of the arithmetic mean of eight 1 hour averages).
- A calculated concentration is considered "valid" where no less than 75% of the expected number of sample data points are present and valid for the averaging period (for example, for a valid 24 hour average to be reported it must be calculated from at least 18 valid 1 hour averages).

Results are reported in the units listed in **Table 3**, and are calculated using the source data and expressed using the timestamp listed in **Table 5**.

Table 5 Calculation and labelling of reported results

Dataset	Source data	Timestamp	Example
1 hour	Validated 10 minute dataset	Time ending	1 hour result labelled "10:00" is calculated from six 10 minute values (09:10 to 10:00)
4 hour	Rolling average of 1 hour data	Time ending	4 hour result labelled "10:00" is calculated from four 1 hour averages (07:00, 08:00, 09:00 and 10:00)
8 hour	Rolling average of 1 hour data	Time ending	8 hour result labelled "10:00" is calculated from eight 1 hour averages (03:00 to 10:00 inclusive)
24 hour	Average of 1 hour data	Time beginning	24 hour result labelled "01/06/2016" is calculated from 24, 1 hour averages (1 hour averages labelled 01/06/2016 01:00 to 02/06/2016 00:00 inclusive)
Annual	Average of 1 hour data	Time beginning	Annual result labelled "1 June 2016 to 31 May 2017" is calculated from 8760, 1 hour averages (1 hour averages labelled 01/06/2016 01:00 to 01/06/2017 00:00 inclusive)

2.6.2 Time zone and volumetric normalisation

All dates and times referenced in this report are reported in Australian Eastern Standard Time (UTC + 10 hours).

Particulate concentrations stated in this report are reported as micrograms per cubic metre (µg/m³) normalised to standard temperature and pressure (0 °C and 101.3 kPa).

3.0 Meteorological Analysis

3.1 Meteorological Station

Meteorological data were sourced from the nearest Bureau of Meteorology station, the Amberley AMO weather station, located approximately 2km to the north-east of the monitoring station at 27° 37' 47" S, 152° 42' 40" E. The location of the weather station relative to the monitoring station is illustrated in **Figure 1** in **Section 2.1**. Data for wind speed, wind direction, and rainfall was collated and summarised to provide a description of meteorological conditions during the monitoring period (1 June 2015 to 31 May 2016 inclusive). **Table 6** graphically illustrates the wind conditions during the entire annual period, while **Table 7** graphically illustrates conditions for each season of the year.

Table 6 Wind data from Amberley AMO – annual monitoring period 1 June 2016 to 31 May 2017 (inclusive)

Wind Speed and Direction at Amberley AMO – Monitoring Period 1 June 2016 to 31 May 2017 (inclusive)

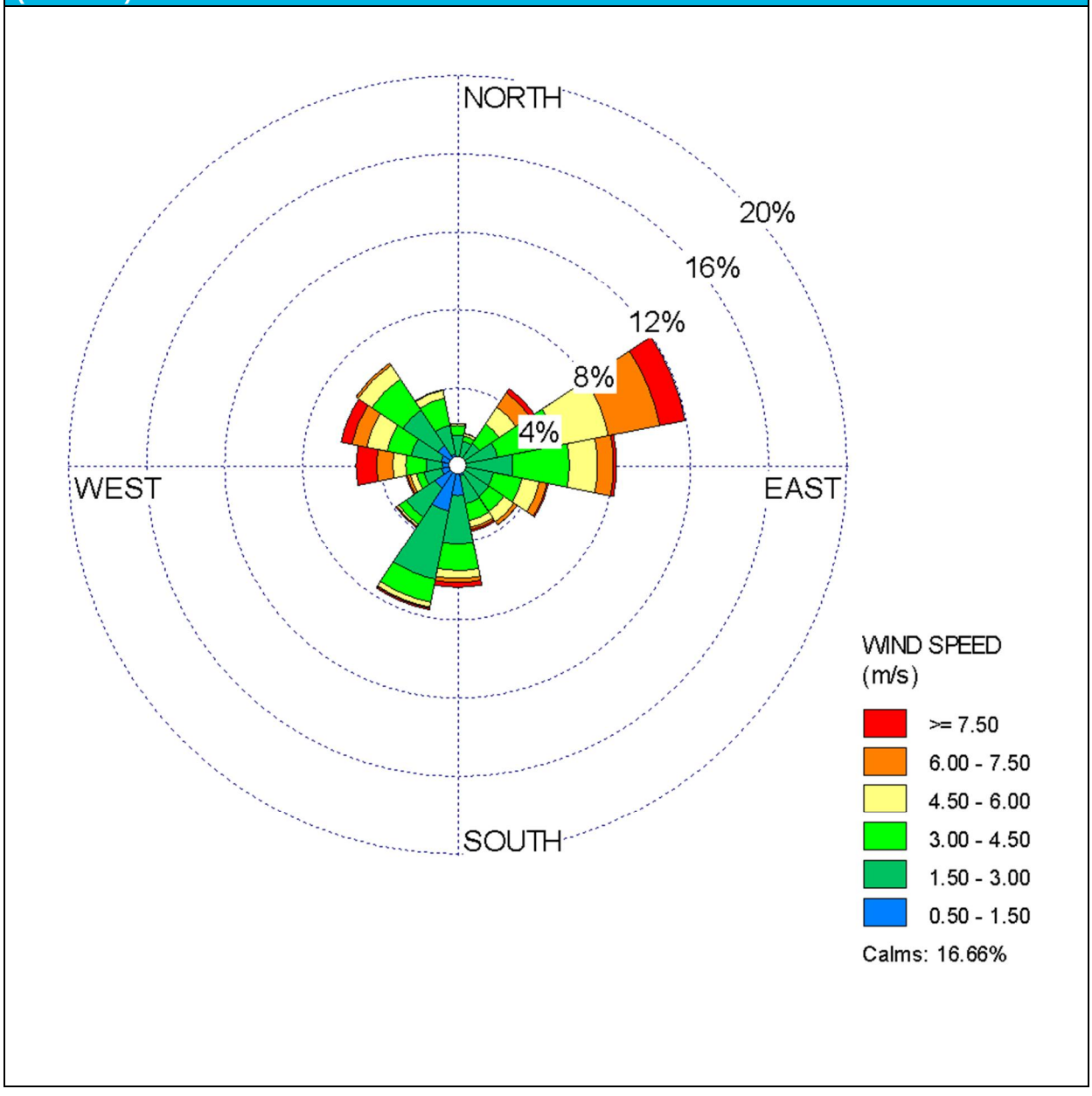
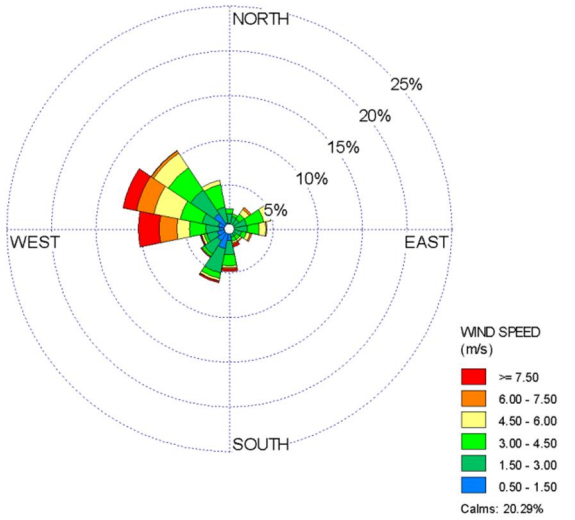
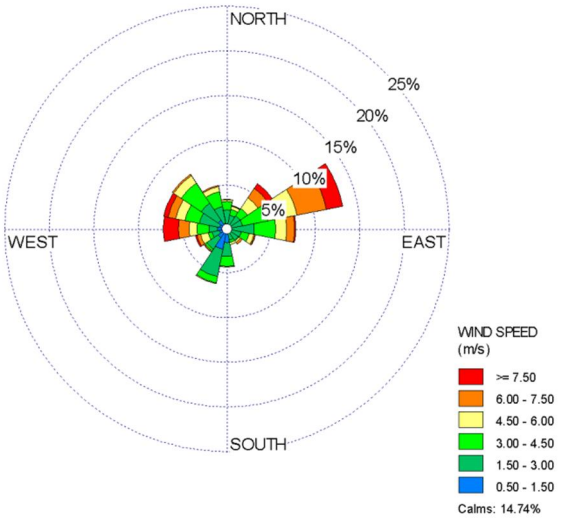
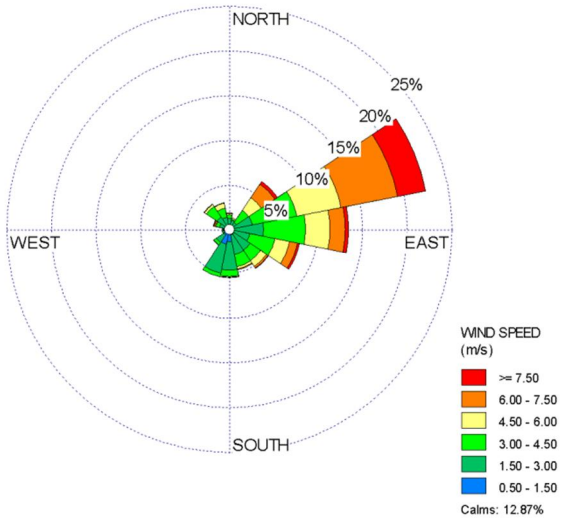
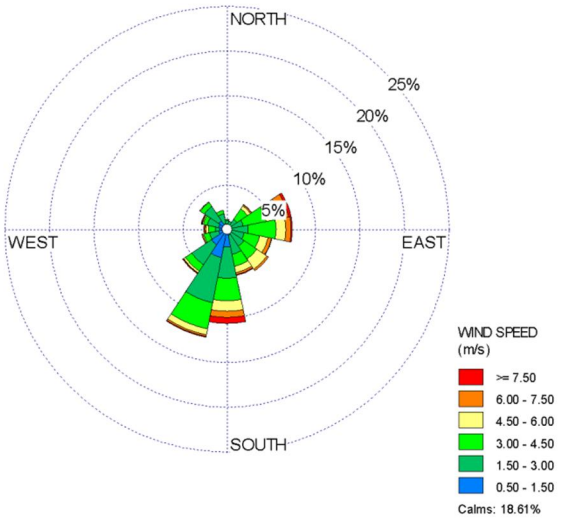


Table 7 Wind data from Amberley AMO – seasonal wind data for monitoring period 1 June 2016 to 31 May 2017 (inclusive)

Wind Speed and Direction at Amberley AMO – Seasonal wind roses	
	
Winter 2016 – 1 June to 31 August 2016 (inclusive)	Spring 2016 – 1 September to 30 November 2016 (inclusive)
	
Summer 2016/17 – 1 December 2016 to 28 February 2017 (inclusive)	Autumn 2017 – 1 March to 31 May 2017 (inclusive)

4.0 Aircraft movements

4.1 Provided data

AECOM obtained aircraft movement data from Defence covering the annual reporting period starting June 2016. **Figure 2** graphically illustrates the supplied data, comparing the total number of aircraft movements to the number of ASH movements.

For the purposes of this analysis, an aircraft movement is defined as a reported departure from or arrival to RAAF Base Amberley. Due to a lack of available data, the analysis does not consider whether an arrival consisted of a full stop landing on arrival at the base, a series of circuits followed by a full stop landing, or a transit of Amberley controlled airspace. Therefore, no distinction is made between these types of activity and consequently all activity types are counted as a single movement.

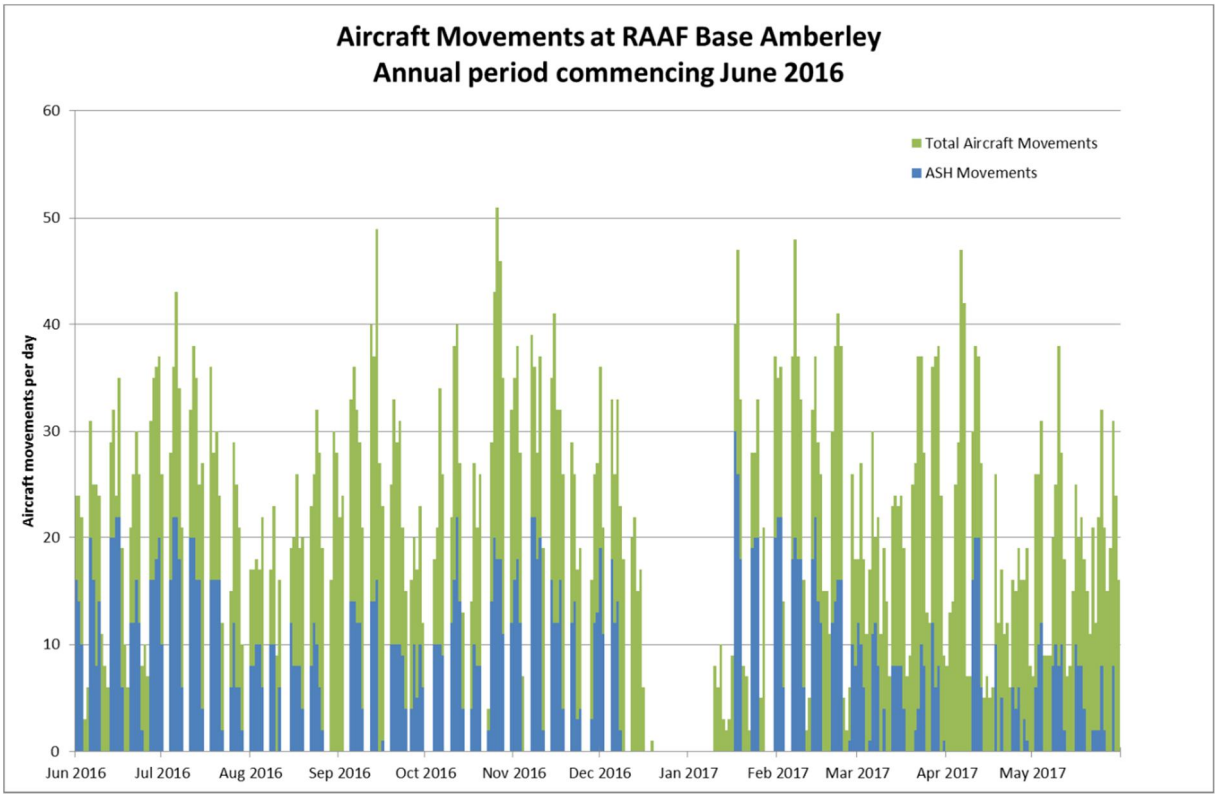


Figure 2 Graphical presentation supplied of aircraft movement data, 1 June 2016 to 31 May 2017 inclusive

4.2 Analysis of movement data

According to the data provided to AECOM, there were 6,482 aircraft movements at RAAF Base Amberley during the reporting period. Of these movements, 2,268 (or 35 %) were conducted by ASH aircraft.

The largest number of ASH movements in a single day was 30, recorded on 17 January 2017. The second highest number of ASH movements was 26, on 18 January 2017. On the day of the largest number of movements, 17 January 2017, there were two one hour periods, between 09:00 and 11:00, where there were seven ASH movements per hour, and two further one hour periods, between 13:00 and 15:00, where there were six movements per hour. Of all the aircraft movements reported on 17 January 2017, 75% were ASH aircraft.

There were three one hour periods during which eight ASH movements were recorded during the reporting period: 10:00 to 11:00 on 5 December 2016, 10:00 to 11:00 on 31 January 2017, and 10:00 to 11:00 on 6 February 2017.

5.0 Results

This report summarises and provides further analysis of the results previously provided in four quarterly monitoring reports

- Air Quality Monitoring Quarterly Report, Australian Super Hornet Flying Operations – June to August 2016, dated 2 November 2016
- Air Quality Monitoring Quarterly Report, Australian Super Hornet Flying Operations – September to November 2016, dated 6 February 2017
- Air Quality Monitoring Quarterly Report, Australian Super Hornet Flying Operations – December 2016 to February 2017, dated 30 March 2017
- Air Quality Monitoring Quarterly Report, Australian Super Hornet Flying Operations – March to May 2017, dated 25 August 2017.

Table 8 summarises measurements made during the annual monitoring period, comparing them to the relevant EPP(Air) objective, and **Table 9** compares measurements to reportable EPP(Air) annual objectives.

Table 8 Summary of annual period – reportable sub-annual average concentrations – June 2016 to May 2017

Parameter	Period	Annual average concentration	Maximum concentration	EPP(Air) objective	Reportable exceedances
CO	8 hours	0.089 ppm	1.199 ppm	9 ppm	0
NO_2	1 hour	4.8 ppb	40.1 ppb	120 ppb	0
O_3	1 hour	20.2 ppb	83.1 ppb	100 ppb	0
O_3	4 hour	*20.5 ppb* [a]	66.9 ppb	80 ppb	0
$PM_{2.5}$	24 hours	5.8 µg/m³	**34.3 µg/m³**	25 µg/m³	**1**
PM_{10}	24 hours	11.1 µg/m³	44.8 µg/m³	50 µg/m³	0
SO_2	1 hour	1.0 ppb	5.5 ppb	200 ppb	0
SO_2	24 hours	*1.0 ppb* [a]	2.2 ppb	80 ppb	0

[a] According to the National Environmental Protection Council's *National Environmental Protection (Ambient Air Quality) Measure: Technical Paper No. 5 – Data Collection and Handling*, annual averages are to be calculated from validated 1 hour average concentrations. The annual average concentration calculated from 4 hour O_3 and 24 hour SO_2 averages are presented here for comparative purposes only.

Table 9 Summary of annual period – reportable annual average concentrations – June 2016 to May 2017

Parameter	Annual average concentration	EPP (Air) annual objective	Result
NO_2	4.8 ppb	30 ppb	Not exceeded
$PM_{2.5}$	5.8 µg/m³	8 µg/m³	Not exceeded
SO_2	1.0 ppb	20 ppb	Not exceeded

5.1 Compliance with standards

5.1.1 Site compliance audit

The monitoring site was audited for compliance with Australian Standard *AS/NZS 3580.1.1:2007 – Guide to siting air monitoring equipment* during initial setup of the monitoring station on 30 May 2014, and again at the annual services on 4 June 2015 and 3 June 2016. A final audit was conducted against the 2016 revision of the Australian Standard, *AS/NZS 3580.1.1:2016 – Guide to siting air monitoring equipment*, on 9 June 2017. The station was found to be in compliance with the standard on all four occasions.

Table 10 summarises the requirements of *AS/NZS 3580.1.1:2016* for parameters monitored at RAAF Base Amberley, and lists the results of the site audits relevant to the period of monitoring discussed in this report (in this case, prior to the start and at the end of the second year of monitoring).

Table 10 AS/NZS 3580.1.1 Site Compliance

Item	Parameters	Results of audit – start of period (3 June 2016)	Results of audit – end of period (9 June 2017)
Clear sky angle of 120°	All parameters	Compliant	Compliant
Unrestricted airflow of 270° around inlet	All parameters	Compliant	Compliant
Inlet distance to supporting structure ≥ 1 m	All parameters	Compliant	Compliant
10 m from nearest object with height > 2m below sample inlet	All parameters	Compliant	Compliant
No extraneous sources nearby	$PM_{2.5}$, PM_{10}, CO, NO_x, SO_2	Compliant	Compliant
> 50 m from road	O_3, $PM_{2.5}$, PM_{10}	Compliant	Compliant
> 10 m from road	CO, NO_x	Compliant	Compliant

5.1.2 Site maintenance and calibrations

Commissioning, servicing and maintenance for the annual reporting period shown in **Table 11** was carried out in accordance with the relevant Australian Standards, listed in **Table 3** in **Section 2.2**. Class 1 calibration results remained within acceptance limits during the annual reporting period. Class 1 calibration results are detailed in the relevant quarterly report (as listed in **Section 5.0** above), and are omitted from this report for brevity.

Table 11 Site Maintenance Schedule for the annual reporting period June 2016 to May 2017

Required item	Nominal date	Performed	Comment
Annual maintenance including filter change	May 2016	2-10 June 2016	All parameters and calibrations within acceptance limits
Parameter check and filter change	June 2015	5 July 2016	All parameters within acceptance limits
Parameter check and filter change	July 2016	4 August 2016	All parameters within acceptance limits
Quarterly maintenance including filter change	August 2016	1 September 2016	All parameters and calibrations within acceptance limits
Parameter check and filter change	September 2016	29 September 2016	All parameters within acceptance limits
Parameter check and filter change	October 2016	2 November 2016	All parameters within acceptance limits
Quarterly maintenance including filter change	November 2016	15 December 2016	All parameters and calibrations within acceptance limits
Parameter check and filter change	December 2016	13 January 2017	All parameters within acceptance limits
Parameter check and filter change	January 2017	8 February 2017	All parameters within acceptance limits
Quarterly maintenance including filter change	February 2017	2 March 2016	All parameters and calibrations within acceptance limits
Parameter check and filter change	March 2016	29 March 2017	All parameters and calibrations within acceptance limits
Parameter check and filter change	April 2016	4 May 2017	All parameters within acceptance limits
Final Calibration Checks	May 2017	9 June 2017	All parameters within acceptance limits

5.2 Data capture

5.2.1 Data capture during the year commencing June 2016

All monitored parameters exceeded the industry-standard 90 % corrected data capture rate. All parameters also met the Technical Paper No.5 requirement for data availability (raw data capture rate) of greater than 75 % for each calendar quarter during the monitoring period, for the purposes of demonstrating annual compliance with air quality objectives.

The data capture rates for the monitored parameters are detailed in **Table 12**. Periods and causes of data loss during the year commencing June 2016, other than routine maintenance and calibration, are detailed in **Table 13**.

Table 12 Data capture during the annual reporting period June 2016 to May 2017

Parameter	Monitoring start date	Monitoring end date	Data availability	Corrected data capture
CO	1 June 2016	31 May 2017	87 %	99 %
NO_2	1 June 2016	31 May 2017	88 %	99 %
O_3	1 June 2016	31 May 2017	88 %	99 %
$PM_{2.5}$	1 June 2016	31 May 2017	96 %	100 %
PM_{10}	1 June 2016	31 May 2017	95 %	100 %
SO_2	1 June 2016	31 May 2017	87 %	98 %
Average of all collected monitoring data			**90 %**	**99 %**
Benchmark			**75 %**	**90 %**
Benchmark met or exceeded			**Achieved**	**Achieved**

Table 13 Causes of data loss during the annual reporting period June 2016 to May 2017

Parameter	Start of data loss	End of data loss	Cause
All parameters	8/11/2016 16:00	17/11/2016 11:00	Power cut to site
CO, NO_2, O_3, SO_2, PM_{10}	2/04/2017 17:00	4/04/2017 09:00	Storm tripped circuit breaker. Reset.
All parameters	4/05/2017 15:00	7/05/2017 02:00	Station logger failure. Logger replaced by external unit.

5.3 Carbon monoxide (CO) results

Carbon monoxide concentrations remained in the “Very Good” range throughout the annual reporting period. The highest recorded 8 hour rolling average concentration was 1.199 ppm recorded on 8 November 2016 at 07:00.

Results of the 8 hour rolling average concentration dataset are summarised in **Table 14**. A graphical presentation of concentrations over the current reporting period is presented in **Appendix A** as **Figure 3**, **Figure 4**, **Figure 5** and **Figure 6**, presenting concentration data for winter, spring, summer and autumn respectively.

Table 14 Carbon monoxide results – 8 hour rolling average concentrations

Season	Month	Average concentration	Maximum measured sample concentration	Number of exceedances of objective (9 ppm)
Winter	June 2016	0.114 ppm	0.327 ppm	0
	July 2016	0.107 ppm	0.389 ppm	0
	August 2016	0.108 ppm	0.227 ppm	0
Seasonal results		**0.110 ppm**	**0.389 ppm**	**0**
Spring	September 2016	0.113 ppm	0.215 ppm	0
	October 2016	0.123 ppm	0.243 ppm	0
	November 2016	0.175 ppm	1.199 ppm	0
Seasonal results		**0.133 ppm**	**1.199 ppm**	**0**
Summer	December 2016	0.049 ppm	0.208 ppm	0
	January 2017	0.031 ppm	0.106 ppm	0
	February 2017	0.016 ppm	0.162 ppm	0
Seasonal Results		**0.032 ppm**	**0.208 ppm**	**0**
Autumn	March 2017	-0.025 ppm	0.028 ppm	0
	April 2017	0.090 ppm	0.271 ppm	0
	May 2017	0.204 ppm	0.386 ppm	0
Seasonal results		**0.086 ppm**	**0.386 ppm**	**0**
Annual results		**0.089 ppm**	**1.199 ppm**	**0**

5.3.1 Negative average results

The average result for March 2017 is less than zero. Averages less than zero are required to be reported as the actual average of the measured value according to Section 3.4 of NEPM Technical Paper No. 5. Section 10.4 of *AS/NZS 3580.7.1:2011* requires adjustment of data if data falls outside the ± 2% (zero) or ± 5% (span) limits. CO calibrations for the reporting period were within these limits. It is noted that these negative values are within the uncertainty of the method of analysis which is ± 2.2 % of full scale range, or ± 1.1 ppm based on the 50 ppm full scale range of the instrument, as detailed in **Section 2.2**.

5.3.2 Comparison of carbon monoxide results with ASH movements

Results of carbon monoxide monitoring do not show a direct relationship to ASH movements. As illustrated in **Figure 3** to **Figure 6** in **Appendix A**, CO concentrations do not appear to be proportionally related to ASH movements.

5.4 Nitrogen dioxide (NO_2) results

Nitrogen dioxide concentrations ranged from “Very Good” to “Good” throughout the annual reporting period. The highest recorded 1 hour average concentration was 40.1 ppb recorded on 1 August 2016 at 22:00.

Results of the 1 hour average concentration dataset are summarised in **Table 15**. A graphical presentation of 1 hour average concentrations over the current reporting period is presented by season in **Appendix A** as **Figure 7**, **Figure 8**, **Figure 9** and **Figure 10**.

Table 15 Nitrogen dioxide results – 1 hour average concentrations

Season	Month	Average concentration	Maximum measured sample concentration	Number of exceedances of objective (120 ppb)
Winter	June 2016	4.3 ppb	27.0 ppb	0
	July 2016	6.0 ppb	26.1 ppb	0
	August 2016	5.6 ppb	40.1 ppb	0
Seasonal results		**5.4 ppb**	**40.1 ppb**	**0**
Spring	September 2016	3.8 ppb	28.1 ppb	0
	October 2016	4.0 ppb	34.5 ppb	0
	November 2016	4.4 ppb	21.5 ppb	0
Seasonal results		**4.0 ppb**	**34.5 ppb**	**0**
Summer	December 2016	3.9 ppb	24.0 ppb	0
	January 2017	3.9 ppb	15.0 ppb	0
	February 2017	4.2 ppb	15.7 ppb	0
Seasonal Results		**4.0 ppb**	**24.0 ppb**	**0**
Autumn	March 2017	4.6 ppb	15.6 ppb	0
	April 2017	5.3 ppb	18.8 ppb	0
	May 2017	8.2 ppb	25.5 ppb	0
Seasonal results		**6.0 ppb**	**25.5 ppb**	**0**
Annual results		**4.8 ppb**	**40.1 ppb**	**0**

Table 16 Nitrogen Dioxide results – annual average concentration

Average period	Cumulative average concentration	EPP (Air) annual objective	Result
June 2016 to May 2017	4.8 ppb	30 ppb	Not exceeded

5.4.1 Comparison of nitrogen dioxide results with ASH movements

Results of nitrogen dioxide monitoring do not show a relationship to ASH activities. Nitrogen dioxide monitoring results appear to be driven by a seasonal variation due to more available oxides of nitrogen in the atmosphere during the winter months. This may be related to the generally fewer days of temperature inversion and better clearing of the airshed in summer months, leading to greater available oxides of nitrogen from regional combustion sources during the winter months.

5.5 Ozone (O_3) results

Ozone concentrations varied from “Very Good” to “Fair” throughout the reporting period. Ozone concentrations naturally follow a diurnal cycle, with peak concentrations coinciding with peak solar radiation input through the middle of the day. The highest recorded 1 hour average ozone concentration was 83.1 ppb recorded on 25 January 2017 at 15:00.

Results of the 1 hour average dataset are summarised in **Table 17**, and results of the 4 hour rolling average dataset are summarised in **Table 18**. A graphical presentation of 1 hour average concentrations over the current reporting period is presented by season in **Appendix A** as **Figure 11**, **Figure 12**, **Figure 13** and **Figure 14**.

Table 17 Ozone results – 1 hour average

Season	Month	Average concentration	Maximum measured sample concentration	Number of exceedances of objective (100 ppb)
Winter	June 2016	20.0 ppb	35.5 ppb	0
	July 2016	20.0 ppb	50.1 ppb	0
	August 2016	22.9 ppb	49.6 ppb	0
Seasonal results		**21.0 ppb**	**50.1 ppb**	**0**
Spring	September 2016	25.9 ppb	53.5 ppb	0
	October 2016	28.0 ppb	72.4 ppb	0
	November 2016	25.8 ppb	60.3 ppb	0
Seasonal results		**26.7 ppb**	**72.4 ppb**	**0**
Summer	December 2016	22.2 ppb	63.2 ppb	0
	January 2017	20.5 ppb	83.1 ppb	0
	February 2017	22.5 ppb	69.2 ppb	0
Seasonal Results		**21.7 ppb**	**83.1 ppb**	**0**
Autumn	March 2017	17.9 ppb	64.2 ppb	0
	April 2017	9.9 ppb	22.7 ppb	0
	May 2017	8.1 ppb	26.7 ppb	0
Seasonal results		**12.0 ppb**	**64.2 ppb**	**0**
Annual results		**20.2 ppb**	**83.1 ppb**	**0**

Table 18 Ozone results – 4 hour rolling average

Season	Month	Average concentration	Maximum measured sample concentration	Number of exceedances of objective (80 ppb)
Winter	June 2016	20.2 ppb	33.7 ppb	0
	July 2016	20.3 ppb	48.6 ppb	0
	August 2016	23.4 ppb	47.9 ppb	0
Seasonal results		**21.3 ppb**	**48.6 ppb**	**0**
Spring	September 2016	26.2 ppb	49.5 ppb	0
	October 2016	28.6 ppb	62.7 ppb	0
	November 2016	26.3 ppb	50.6 ppb	0
Seasonal results		**27.1 ppb**	**62.7 ppb**	**0**
Summer	December 2016	22.7 ppb	53.2 ppb	0
	January 2017	21.0 ppb	66.9 ppb	0
	February 2017	23.1 ppb	61.9 ppb	0
Seasonal Results		**22.7 ppb**	**66.9 ppb**	**0**
Autumn	March 2017	18.3 ppb	58.9 ppb	0
	April 2017	10.0 ppb	21.9 ppb	0
	May 2017	7.9 ppb	21.2 ppb	0
Seasonal results		**12.0 ppb**	**58.9 ppb**	**0**
Annual results		**20.5 ppb**	**66.9 ppb**	**0**

5.5.1 Comparison of ozone results with ASH movements

Results of ozone monitoring do not show a direct relationship to ASH movements. As illustrated in **Figure 13** in **Appendix A**, ozone concentrations continue a diurnal pattern in the absence of ASH movements.

5.6 Suspended Particulate – $PM_{2.5}$ results

Suspended particulate – $PM_{2.5}$ concentrations ranged from "Very Good" to "Poor" throughout the reporting period. The highest recorded 24 hour $PM_{2.5}$ concentration was 34.3 µg/m³ recorded 6 November 2016.

There was a single exceedance of the EPP(Air) $PM_{2.5}$ objective of 25 µg/m³, on 6 November 2016 where a concentration of 34.3 µg/m³ was recorded.

Results of the 24 hour average dataset are summarised in **Table 19**, and the annual average for the current reporting year is presented in **Table 20**. A graphical presentation of concentrations over the current reporting period is presented in **Appendix A** as **Figure 15**.

Table 19 $PM_{2.5}$ results – 24 hour average concentration

Season	Month	Average concentration	Maximum measured sample concentration	Number of exceedances of objective (25 µg/m³)
Winter	June 2016	3.9 µg/m³	7.5 µg/m³	0
	July 2016	5.7 µg/m³	12.4 µg/m³	0
	August 2016	6.0 µg/m³	11.3 µg/m³	0
Seasonal results		**5.3 µg/m³**	**12.4 µg/m³**	**0**
Spring	September 2016	5.5 µg/m³	14.5 µg/m³	0
	October 2016	6.4 µg/m³	13.6 µg/m³	0
	November 2016	9.4 µg/m³	**34.3 µg/m³**	**1**
Seasonal results		**6.8 µg/m³**	**34.3 µg/m³**	**1**
Summer	December 2016	7.5 µg/m³	18.2 µg/m³	0
	January 2017	5.1 µg/m³	11.9 µg/m³	0
	February 2017	5.5 µg/m³	11.4 µg/m³	0
Seasonal results		**6.0 µg/m³**	**18.2 µg/m³**	**0**
Autumn	March 2017	5.0 µg/m³	8.2 µg/m³	0
	April 2017	4.6 µg/m³	7.9 µg/m³	0
	May 2017	5.3 µg/m³	10.3 µg/m³	0
Seasonal results		**4.9 µg/m³**	**10.3 µg/m³**	**0**
Annual results		**5.8 µg/m³**	**34.3 µg/m³**	**1**

Table 20 $PM_{2.5}$ results – annual average concentration

Average period	Cumulative average concentration	EPP (Air) annual objective	Result
June 2015 to May 2016	5.8 µg/m³	8 µg/m³	Not exceeded

5.6.1 Comparison of $PM_{2.5}$ results with ASH movements

Results of $PM_{2.5}$ monitoring do not show a direct relationship to ASH movements. As illustrated in **Figure 15** in **Appendix A**, $PM_{2.5}$ concentrations do not appear to be proportionally related to ASH movements, with the highest recorded $PM_{2.5}$ concentration occurring on a day with no ASH movements, and the day with the highest number of ASH movements not recording a particularly high PM_{10} concentration.

The exceedance of the EPP(Air) objective for $PM_{2.5}$ occurred on a day where there were no ASH movements reported.

5.7 Suspended Particulate – PM_{10} results

Suspended particulate – PM_{10} concentrations ranged from "Very Good" to "Fair" throughout the reporting period. The highest recorded 24 hour PM_{10} concentration was 44.8 µg/m³ recorded on 6 November 2016.

Results of the 24 hour average dataset are summarised in **Table 21**. A graphical presentation of concentrations over the current reporting period is presented in **Appendix A** as **Figure 16**.

Table 21 PM_{10} results – 24 hour average concentration

Season	Month	Average concentration	Maximum measured sample concentration	Number of exceedances of objective (50 µg/m³)
Winter	June 2016	6.9 µg/m³	12.6 µg/m³	0
	July 2016	9.4 µg/m³	17.4 µg/m³	0
	August 2016	10.2 µg/m³	19.0 µg/m³	0
Seasonal results		**9.0 µg/m³**	**19.0 µg/m³**	**0**
Spring	September 2016	9.4 µg/m³	19.5 µg/m³	0
	October 2016	12.2 µg/m³	19.0 µg/m³	0
	November 2016	17.3 µg/m³	44.8 µg/m³	0
Seasonal results		**12.4 µg/m³**	**44.8 µg/m³**	**0**
Summer	December 2016	15.6 µg/m³	24.2 µg/m³	0
	January 2017	11.1 µg/m³	24.2 µg/m³	0
	February 2017	13.2 µg/m³	24.5 µg/m³	0
Seasonal results		**13.3 µg/m³**	**24.5 µg/m³**	**0**
Autumn	March 2017	9.9 µg/m³	23.3 µg/m³	0
	April 2017	9.0 µg/m³	16.6 µg/m³	0
	May 2017	9.4 µg/m³	18.3 µg/m³	0
Seasonal results		**9.5 µg/m³**	**23.3 µg/m³**	**0**
Annual results		**11.1 µg/m³**	**44.8 µg/m³**	**0**

5.7.1 Comparison of PM_{10} results with ASH movements

Results of PM_{10} monitoring do not show a direct relationship to ASH movements. As illustrated in **Figure 16** in **Appendix A**, PM_{10} concentrations do not appear to be proportionally related to ASH movements, with the highest PM_{10} concentration being recorded on a day with no ASH movements, and the day with the highest number of ASH movements not recording a particularly high PM_{10} concentration.

5.8 Sulfur dioxide (SO_2) results

Sulfur dioxide concentrations remained in the “Very Good” range throughout the reporting period. The highest 1 hour average sulfur dioxide concentration was 5.5 ppb recorded on 6 October 2016 at 19:00.

Results of the 1 hour average dataset are summarised in **Table 22** and results of the 24 hour average dataset are summarised in **Table 23**. The annual average for the current reporting year is presented in **Table 24**. A graphical presentation of 1 hour average concentrations over the current reporting period is presented by season in **Appendix A** as **Figure 17**, **Figure 18**, **Figure 19** and **Figure 20**.

Table 22 Sulfur Dioxide results – 1 hour average concentration

Season	Month	Average concentration	Maximum measured sample concentration	Number of exceedances of objective (200 ppb)
Winter	June 2016	0.7 ppb	4.9 ppb	0
	July 2016	1.1 ppb	4.8 ppb	0
	August 2016	1.0 ppb	4.6 ppb	0
Seasonal results		**1.0 ppb**	**4.9 ppb**	**0**
Spring	September 2016	1.0 ppb	4.7 ppb	0
	October 2016	0.8 ppb	5.5 ppb	0
	November 2016	0.8 ppb	5.1 ppb	0
Seasonal results		**0.9 ppb**	**5.5 ppb**	**0**
Summer	December 2016	0.8 ppb	3.4 ppb	0
	January 2017	1.2 ppb	3.6 ppb	0
	February 2017	1.1 ppb	2.2 ppb	0
Seasonal results		**1.0 ppb**	**3.6 ppb**	**0**
Autumn	March 2017	1.1 ppb	2.4 ppb	0
	April 2017	1.2 ppb	1.7 ppb	0
	May 2017	1.6 ppb	3.9 ppb	0
Seasonal results		**1.3 ppb**	**3.9 ppb**	**0**
Annual results		**1.0 ppb**	**5.5 ppb**	**0**

Table 23 Sulfur Dioxide results – 24 hour average concentration

Season	Month	Average concentration	Maximum measured sample concentration	Number of exceedances of objective (80 ppb)
Winter	June 2016	0.7 ppb	1.2 ppb	0
	July 2016	1.1 ppb	0.8 ppb	0
	August 2016	1.0 ppb	1.1 ppb	0
Seasonal results		**1.0 ppb**	**1.2 ppb**	**0**
Spring	September 2016	1.0 ppb	1.1 ppb	0
	October 2016	0.8 ppb	1.1 ppb	0
	November 2016	0.8 ppb	0.9 ppb	0
Seasonal results		**0.9 ppb**	**1.1 ppb**	**0**
Summer	December 2016	0.8 ppb	0.7 ppb	0
	January 2017	1.2 ppb	1.2 ppb	0
	February 2017	1.1 ppb	1.4 ppb	0
Seasonal results		**1.0 ppb**	**1.4 ppb**	**0**
Autumn	March 2017	1.1 ppb	1.2 ppb	0
	April 2017	1.3 ppb	1.0 ppb	0
	May 2017	1.6 ppb	1.4 ppb	0
Seasonal results		**1.3 ppb**	**1.4 ppb**	**0**
Annual results		**1.0 ppb**	**1.4 ppb**	**0**

Table 24 Sulfur Dioxide results – annual average concentration

Average period	Cumulative average concentration	EPP (Air) annual objective	Result
June 2014 to May 2015	1.0 ppb	20 ppb	Not exceeded

5.8.1 Comparison of sulfur dioxide results with ASH movements

Results of sulfur dioxide monitoring do not show a direct relationship to ASH movements. As illustrated in **Figure 17** to **Figure 20** in **Appendix A**, variance in sulfur dioxide concentrations is not directly related to movements, and continues during a period in December 2016 and January 2017 where there are no ASH movements.

6.0 Annual Findings

6.1 Comparison of monitoring data to EPP (Air) objectives

There was a single exceedance of the EPP (Air) 24 hour objective for $PM_{2.5}$ particulate on 6 November 2016. The $PM_{2.5}$ 24 hour average for Saturday 6 November 2016 was 34.3 µg/m³, which is greater than the EPP(Air) objective for $PM_{2.5}$ of 25 µg/m³. There were no ASH movements reported on Saturday 6 November 2016. The reported 9am and 3pm wind directions at the Amberley AMO weather station on 6 November 2016 were westerly.

6.2 Comparison of monitoring data to ASH movements

Table 25 compares the days with the twelve highest number of ASH movements with the highest pollutant concentrations recorded during the current reporting period. The only pollutant which recorded its highest concentration during a day of high ASH movement activity was CO, on 8 November 2016. At 07:00 on 8 November 2016 the CO 8 hour average concentration was 1.199, the highest recorded in the current monitoring period. There were no ASH movements recorded during the period 7/11/2016 23:00 to 8/11/2016 07:00, which is the period during which readings were collected for the calculation of the CO 8 hour average labelled 8/11/2016 07:00 (see **Section 2.6.1** for details on the calculation and labelling of averaged data). It is therefore unlikely that ASH movements significantly contributed to the CO 8 hour average concentration at 07:00 on 8 November 2016.

Table 25 Monitoring data on days with the largest number of ASH movements

Date	ASH movements	CO 8 hour max	NO_2 1 hour max	O_3 1 hour max	$PM_{2.5}$ 24 hour average	PM_{10} 24 hour average	SO_2 1 hour max
		ppm	ppb	ppb	µg/m³	µg/m³	ppb
Highest result in Year 3		1.199	40.1	83.1	34.3	44.8	5.5
17/01/2017	30	0.057	6.2	60.9	3.4	6.7	1.3
18/01/2017	26	0.081	15.0	56.7	6.0	12.5	2.6
15/06/2016	22	0.117	15.0	27.7	2.2	4.9	0.7
16/06/2016	22	0.173	27.0	32.2	4.2	9.9	1.5
5/07/2016	22	0.141	16.4	27.5	6.0	6.7	1.2
6/07/2016	22	0.121	4.3	28.5	2.3	3.4	1.1
12/10/2016	22	0.136	6.9	49.6	6.2	17.8	0.7
7/11/2016	22	0.545	18.5	49.6	20.0	31.3	1.9
8/11/2016	22	1.199	11.2	51.4	*Invalid*[1]	*Invalid*[1]	3.0
1/02/2017	22	0.162	8.5	52.8	8.4	15.8	1.8
2/02/2017	22	0.047	7.5	50.2	7.5	17.4	1.7
14/02/2017	22	0.077	15.7	30.1	7.8	17.4	0.9
EPP(Air) objective		**9**	**120**	**100**	**25**	**50**	**200**

[1] *Power was cut to the monitoring station during 8/11/2016, which led to too few valid data points being recorded for the calculation of 24 hour $PM_{2.5}$ and PM_{10} averages*

6.3 Current annual period trends

There was no general trend observed for any of the pollutant parameters monitored over the past 12 months, aside from normal seasonal variability. Furthermore, there was no correlation between ASH movement activities and pollutant concentrations observed at any time during the annual monitoring

period. Spikes in pollutant concentrations tended to be isolated and independent of ASH movements. Some individual parameters showed seasonal variation which is detailed below.

CO, $PM_{2.5}$ and PM_{10} showed elevated readings (above normally observed variation for this site) during the period 6 to 8 November 2016. There were no ASH movements on 6 November 2016. On 7 and 8 November there were 22 ASH movements reported for each day. There were eight other days during the current annual period where there were 22 ASH movements.

6.3.1 Carbon Monoxide trends

Carbon monoxide concentrations remained near the instrument baseline measurement for the majority of the hours in the monitoring period. Scaling the graphical figures to display resolution of this magnitude (the Y axis maximum being 20% of the EPP(Air) CO objective) shows normal instrument baseline drift and subsequent calibration adjustments to be a major contributor to variance in the readings over the period.

The air quality monitoring station is located approximately 10 m from a car park. There is insufficient information available to determine whether the proximity to the carpark has contributed to carbon monoxide concentrations during the monitoring period; however it is noted that the station location meets the siting requirements for carbon monoxide detailed in AS/NZS 3580.1.1.

Carbon monoxide concentrations show a period of readings away from baseline during 6 to 8 November 2016, however the maximum 8 hour average concentration recorded during this period was 1.199 ppm recorded on 8 November 2016 at 07:00. There were no ASH movements recorded during the period 7/11/2016 23:00 and 8/11/2016 07:00, which is the period during which readings were collected for the calculation of the CO 8 hour average labelled 8/11/2016 07:00 (see **Section 2.6.1** for details on the calculation and labelling of averaged data).

6.3.2 Nitrogen dioxide trends

Nitrogen dioxide concentrations were generally higher through the late autumn, winter and spring months, and generally lower during the summer and early autumn months. This is similar to the trend observed during previous years' monitoring at this site. As discussed in **Section 5.4.1**, there is no observable relationship between ASH movements and nitrogen dioxide concentrations. It is considered likely that seasonal weather conditions combined with local industrial emissions and ground transportation are the primary drivers of the seasonal variance in nitrogen dioxide concentrations.

6.3.3 Ozone trends

Ozone showed a typically diurnal pattern during the annual monitoring period. The average one hour and rolling four hour peak ozone concentration tended to be lower during the winter and autumn months compared to the spring and summer months, as expected.

6.3.4 Suspended particulates trends ($PM_{2.5}$ and PM_{10})

Average $PM_{2.5}$ and PM_{10} concentrations showed more variation than during the previous annual period. There was a period of generally higher suspended particulate 24 hour averages recorded during December 2016. The highest $PM_{2.5}$ and PM_{10} 24 hour averages (34.3 and 44.8 µg/m³ respectively) were recorded on Sunday 6 November 2017, a day when there were no recorded ASH movements.

6.3.5 Sulfur dioxide trends

The highest sulfur dioxide one hour average reading during the monitoring period was 5.5 ppb, which is approximately 3 % of the EPP(Air) objective of 200 ppb. This highest 1 hour average value of 5.5 ppb was recorded on 6 October 2016 at 17:00, and there were no ASH movements recorded between for this period.

The compression in the scale of the graphs presented in **Appendix A** makes relatively small variations in concentration appear more significant than they actually are, relative to both the instrument full scale range and the EPP(Air) objective for sulfur dioxide.

Like carbon monoxide, normal baseline drift and calibration adjustments cause dramatic changes in the graphs at the presented magnification.

6.4 Comparison to previous years

This section compares the current annual reporting period, June 2016 to May 2017 (referred to in this section as "Year 3") to the previous annual reporting periods (June 2014 to May 2015, "Year 1", and June 2015 to May 2016, "Year 2"), presented in the previous annual reports:

- Air Quality Monitoring Annual Report – Australian Super Hornet Flying Operations – June 2014 to May 2015, dated 26-Aug-2015
- Air Quality Monitoring Annual Report 2 – Australian Super Hornet Flying Operations – June 2015 to May 2016, dated 31-Oct-2016

6.4.1 Aircraft activity

Table 26 compares reported aircraft movements at RAAF Base Amberley over the three annual periods. In each of the three years of monitoring, movements of ASH aircraft have made up more than a third of all movements reported at RAAF Base Amberley. Reported ASH activity during Year 3 was less than that during Year 2, and greater than that during Year 1.

Table 26 Reported Aircraft Movements at RAAF Base Amberley

Annual period	Dates covered	Total movements	ASH movements	Percentage of total movements by ASH
Year 1	June 2014 to May 2015	5,833	2,011	34 %
Year 2	June 2015 to May 2016	7,212	2,588	36 %
Year 3	June 2016 to May 2017	6,482	2,268	35 %
Totals	**June 2014 to May 2017**	**19,527**	**6,867**	**35 %**

6.4.2 Comparison of monitoring data – Years 1, 2 and 3

A comparison of maximum concentrations measured during the three years of monitoring at RAAF Base Amberley is presented below as **Table 27. Table 28** compares annual average concentrations across monitored parameters.

During the three years of monitoring there has been a single exceedance of the EPP(Air) objective for $PM_{2.5}$, which occurred in the third year of monitoring.

Table 27 Comparison of three years' maximum concentrations

Parameter	Period	Year 1 maximum concentration	Year 2 maximum concentration	Year 3 maximum concentration	EPP(Air) objective
CO	8 hours	1.985 ppm	0.268 ppm	1.199 ppm	9 ppm
NO_2	1 hour	62.5 ppb	39.3 ppb	40.1 ppb	120 ppb
O_3	1 hour	107.7 ppb [a]	85.1 ppb	83.1 ppb	100 ppb
O_3	4 hour	81.3 ppb [a]	70.9 ppb	66.9 ppb	80 ppb
$PM_{2.5}$	24 hours	20.5 µg/m³	16.2 µg/m³	**34.3 µg/m³** [b]	25 µg/m³
PM_{10}	24 hours	32.5 µg/m³	24.9 µg/m³	44.8 µg/m³	50 µg/m³
SO_2	1 hour	5.1 ppb	3.9 ppb	5.5 ppb	200 ppb
SO_2	24 hours	1.8 ppb	1.4 ppb	2.2 ppb	80 ppb

[a] EPP(Air) allows for one day in exceedance of the numerical objective. Peak ozone concentrations were measured on one day, and therefore the exceedances of the 1 and 4 hour average objectives are **not reportable exceedances**.
[b] There was a single exceedance of the EPP(Air) objective for $PM_{2.5}$ recorded on 6 November 2016.

Table 28 Comparison of three years' average concentrations

Parameter	Year 1 annual average concentration	Year 2 annual average concentration	Year 3 annual average concentration	EPP (Air) annual objective
CO	-0.020 ppm	-0.003 ppm	0.089 ppm	*No annual objective*
NO_2	3.8 ppb	4.8 ppb	4.8 ppb	30 ppb
O_3	21.7 ppb	20.4 ppb	20.2 ppb	*No annual objective*
$PM_{2.5}$	4.9 µg/m³	5.4 µg/m³	5.8 µg/m³	8 µg/m³
PM_{10}	11.1 µg/m³	9.8 µg/m³	11.1 µg/m³	*No annual objective*
SO_2	0.5 ppb	0.5 ppb	1.0 ppb	20 ppb

6.4.3 Comparison of maximum recorded concentrations against movement data

Over the three years of monitoring data collected since monitoring began on 1 June 2014 there has been limited observable correlation between the highest recorded concentrations and the number of ASH movements during the averaging period of the concentration. Only the 1 and 24 hour SO_2 maximums and the 4 hour O_3 maximum correspond to periods where there were any ASH movements at all. **Table 29** compares the actual highest recorded concentrations of the reportable parameters against the reported number of ASH movements during the averaging period applicable to the parameter as detailed in **Section 2.3**.

Table 29 Comparison of actual highest recorded concentrations against PER model predictions

Parameter	Period	Highest recorded concentration	Date and time of highest recorded concentration	Number of ASH movements during period
CO	8 hours	1.985 ppm	4/07/2014 21:00	0
NO_2	1 hour	62.5 ppb	5/06/2014 01:00	0
O_3	1 hour	107.7 ppb	20/03/2015 17:00	0
O_3	4 hour	81.3 ppb	20/03/2015 17:00	2 *(14:00 to 17:00)*
$PM_{2.5}$	24 hours	34.3 µg/m³	6/11/2016	0
PM_{10}	24 hours	44.8 µg/m³	6/11/2016	0
SO_2	1 hour	5.5 ppb	6/10/2016 19:00	2
SO_2	24 hours	2.2 ppb	1/08/2016	8

7.0 Validation Analysis of PER Predicted Impacts

As discussed in **Section 1.0**, the air quality monitoring at RAAF Base Amberley is conducted to address Condition 4 of the EPBC Act approval of the Super Hornet flying operations. Condition 4b of the approval identifies the requirement of a validation procedure for the predicted air quality impacts as presented in the PER. Condition 4b is as follows:

> *4. The person taking the action must provide for approval by the Minister an Air Quality Monitoring Plan that includes:*
>
> *b. A process for validation of the accuracy of Super Hornet air quality impacts modelled in the Public Environment Report of the action;*

An AQMP was developed in response to the findings of the Australian Super Hornets PER. The purpose of the AQMP is to outline how Defence will comply with condition 4 of the EPBC Act approval of Super Hornet flying operations at RAAF Base Amberley. The AQMP sets the following guidance around a validation process of the accuracy of the PER predictions about Super Hornet air quality impacts:

> *24. Consultants will be engaged by Defence to collect, evaluate and report the air quality data collected from the air quality monitoring station. The results will be the production of an Air Quality Monitoring Report which is planned to be published annually, during testing periods. The report will evaluate the accuracy of the predictions about Super Hornet air quality impacts as modelled in the PER….*

This section of the report is intended to address the requirement to evaluate the accuracy of the predictions about Super Hornet air quality impacts as modelled in the PER. AECOM did not undertake independent investigations to verify the accuracy of the information contained within the PER. However a comparison of key variables used in the predictive modelling in the PER have been compared to actual conditions over the monitoring period (1 June 2016 to 31 May 2017 inclusive). The key variables used in the predictive modelling in the PER are as follows:

- Worst Case ASH movement data
- Meteorological conditions, primarily wind direction.

Both these variables need to be consistent between the PER and the conditions experienced during the current monitoring period for a direct comparison of monitoring results and predicted impacts in the PER.

7.1 Worst Case ASH Movements

To predict the possible worst case hourly air quality emissions the modelling undertaken in the PER had to assume a worse case ASH movements per hour. A summary of the assumed ASH movements used in the PER modelling and the actual most intensive hour of ASH movements is provided in **Table 30**.

Table 30 Comparison of PER Modelled vs. Actual: ASH Movement Data

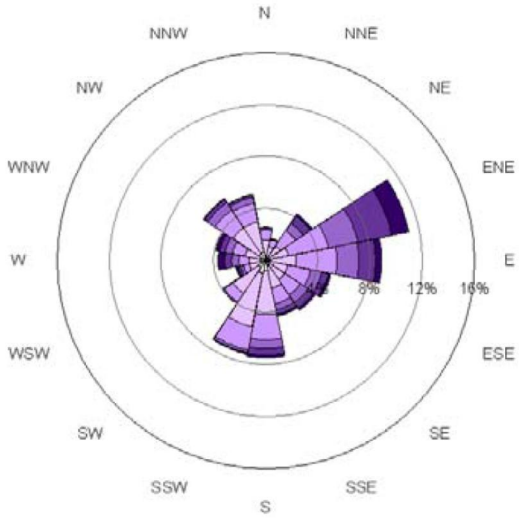
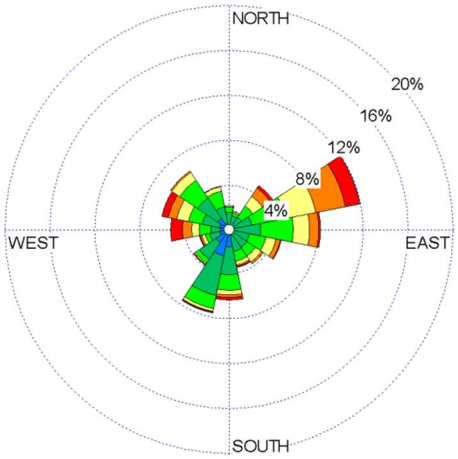
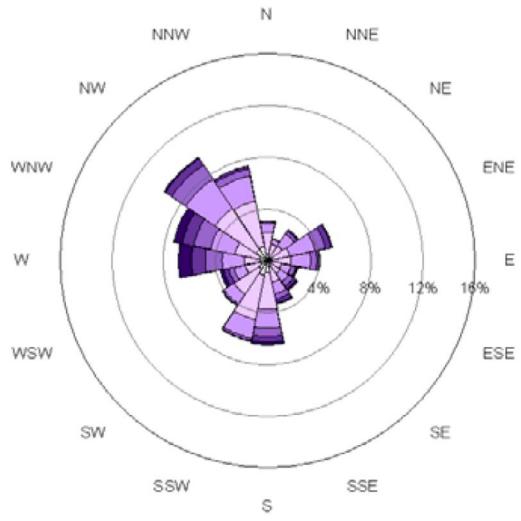
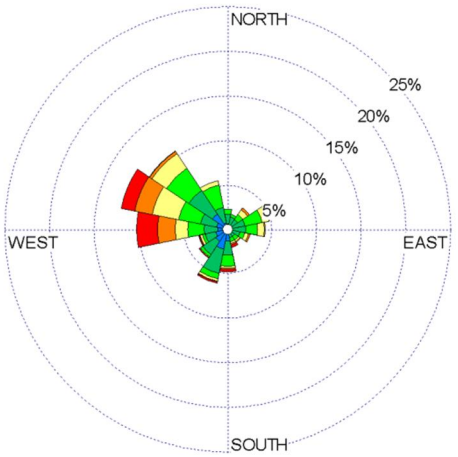
Scenario	Modelled PER	Actual: June 2015 – May 2016
Worst Case	*"The worst-case intensive hour for operations at RAAF Base Amberley is 14 aircraft taking-off in one hour, to occur anytime between 7 am and 12 pm" (PER, 2009)*	As discussed in **Section 4.2**, the largest number of ASH movements in a day was 30. The most intense hours saw eight ASH movements (57% of the modelled worst case).

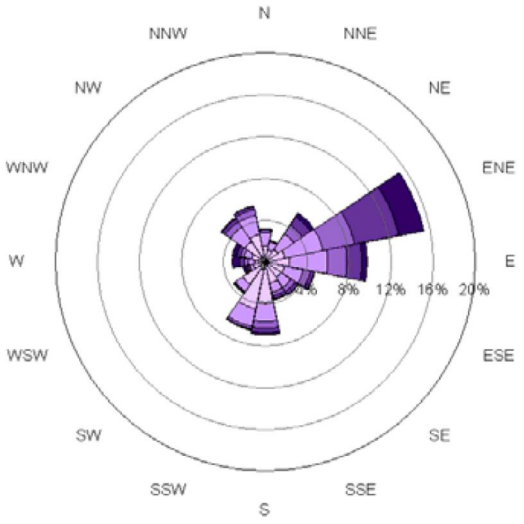
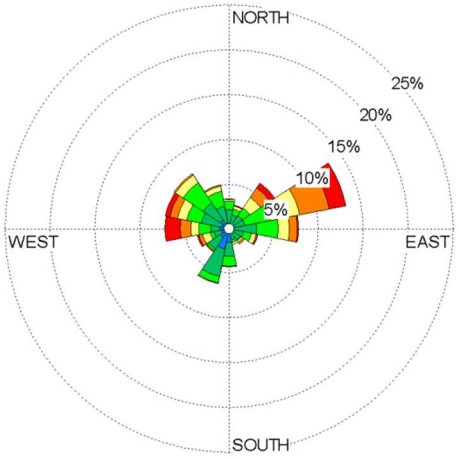
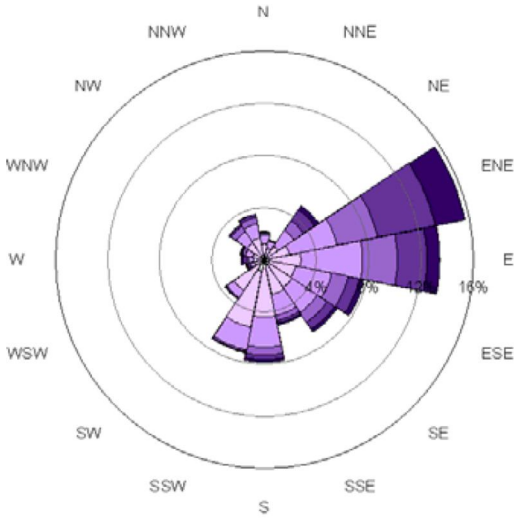
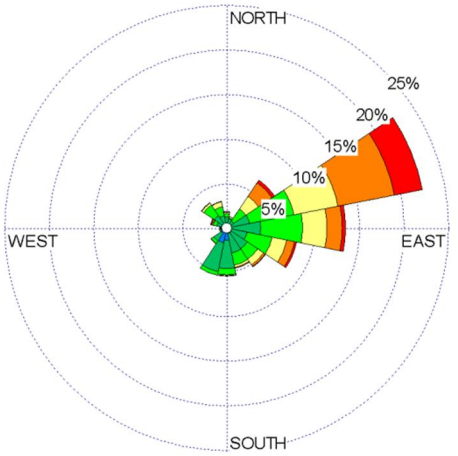
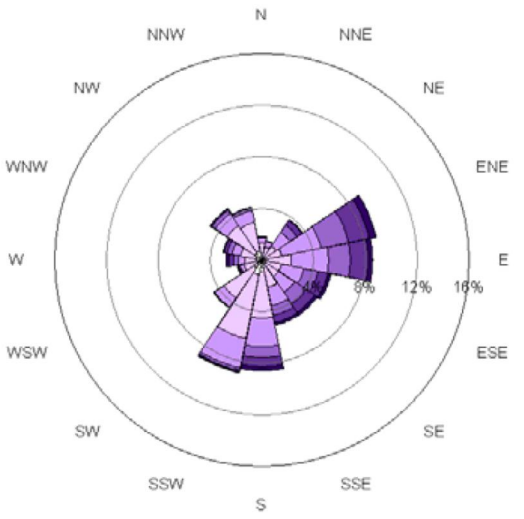
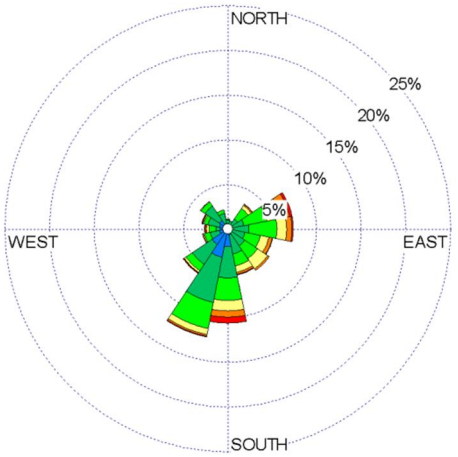
The modelled PER assumed a worst case of up to 14 ASH movements within an hour. During the monitoring period the most intensive hours of ASH movements involved only eight ASH movements consisting of both departures and arrivals. Therefore it is considered likely that modelled PER and monitoring period pollutant concentrations may not be directly comparable.

7.2 Meteorological Conditions

After the initial pollutant emissions due to ASH movements are considered the potential for dispersion due to prevailing winds needs to be considered. As discussed in **Section 3.0** the closest BOM site to the RAAF Base Amberley that records hourly meteorological data is at the Amberley AMO. A seasonal comparison between the prevailing winds for the PER Modelling and the Amberley AMO station during monitoring period is provided in **Table 31**.

Table 31 Comparison of PER Modelled vs. Actual: Prevailing Winds

Period	Modelled conditions in PER (Figure 8.3)	Amberley AMO: June 2016 – May 2017
Annual		
Winter		

Period	Modelled conditions in PER (Figure 8.3)	Amberley AMO: June 2016 – May 2017
Spring		
Summer		
Autumn		

Overall, the wind roses indicate that the wind directions experienced at Amberley AMO during the monitoring period were similar to the modelled PER. Due to the monitoring station being located to the west of the RAAF Base Amberley runways the proportion of easterly winds are of particular interest. In an annual context the winds from the east-northeast and east contributed 12% and 8% respectively, with a total combined contribution of approximately 20% from the east-northeast and east directions for both the PER modelling and the Amberley AMO station during monitoring period. The prevailing easterly wind directions at the Amberley AMO station appear consistent with those used in the PER modelling. Therefore the frequency of time the air quality monitoring station was downwind of the RAAF Base Amberley runways during the current monitoring period was similar to the PER modelling.

The air quality monitoring station is located on the western side of RAAF Base Amberley, therefore wind directions in the east-northeast quadrant (approximately from 30° to 110° degrees) are most likely to carry pollutants from airside activities such as take-offs to the monitoring station.

7.3 Comparison of Monitoring Results and PER Predicted Impacts

The PER assessed potential ASH air quality impacts at the nearest sixteen sensitive receivers to RAAF Base Amberley. Because Condition 4b of the Super Hornet flying operations at RAAF Base Amberley EBPC Act approval necessitates the validation of the modelled air quality impacts in the PER, a representative monitoring site is limited to being at or near one of the sixteen PER sensitive receivers. To select a representative monitoring location AECOM conducted an Air Quality Monitoring Station Site Selection analysis for ASH operations at RAAF Base Amberley (dated 23 May 2014). As a result of the site selection process, the preferred and selected location for the air quality monitoring station was identified as being representative of the PER sensitive receptor 1 - Amberley State School.

7.3.1 Comparison of Current Annual Period (Year 3) results with PER modelling

Table 32 provides a comparison between the modelled PER air quality impacts and the measured concentrations for the current monitoring period, while **Table 33** and **Table 34** present results from the busiest days in the reporting period for comparison against the PER predictions.

On 6 November 2016 the 24 hour average PM_{10} concentration was 44.8 µg/m³, which is greater than the PER “worst case” prediction of 43.0 µg/m³. This is also the highest 24 hour average PM_{10} concentration recorded since monitoring commenced on 1 June 2014. There were no ASH movements on Sunday 6 November 2016.

On Monday 7 November 2016 there were 22 ASH movements, and the wind direction was consistently within the 30° to 110° arc during the period 11:00 to 22:00 when the ASH movements occurred. The 24 hour average PM_{10} concentration for 7 November 2016 was 31.3 µg/m³. The maximum number of ASH movements in an hour on 7 November 2016 was 5, which is 36% of the PER “worst case” of 14 ASH movements in a single hour.

It is also noted that on the busiest day of ASH activity, 17 January 2017, the PM_{10} concentration was 6.7 µg/m³ which is 16% of the PER “worst case” prediction. During this day there were two hours of 7 reported ASH movements, which is 50% of the “worst case” prediction, and during one of those hours (11:00) the reported wind direction was favourable in terms of pollutants from ASH activities being brought to the monitoring location (wind direction at Amberley AMO was 38°).

Table 32 Comparison of PER Modelled vs. Year 3 monitoring: Pollutant concentrations

Parameter	Period	Modelled PER		Measured		EPP(Air) Objective
		Contribution	Cumulative	Average	Maximum	
CO	8 hr	0.08 ppm	4.08 ppm	0.089 ppm	1.199 ppm	9 ppm
NO_2	1 hr	18.5 ppb	47.7 ppb	4.8 ppb	40.1 ppb	120 ppb
PM_{10}	24 hr	3.0 µg/m³	43.0 µg/m³	11.1 µg/m³	44.8 µg/m³	50 µg/m³
SO_2	1 hr	1.4 ppb	14.3 ppb	1.0 ppb	5.5 ppb	200 ppb

Table 33 Comparison of PER Modelled vs Year 3 monitoring: Pollutant concentrations during hours of highest activity

Observation/Prediction	ASH Movements	NO_2 Concentration	SO_2 Concentration	Wind Direction at Amberley AMO
5/12/2016 11:00	8	1.9 ppb	0.6 ppb	311°
31/01/2017 11:00	8	1.9 ppb	1.3 ppb	60°
6/02/2017 11:00	8	3.5 ppb	1.5 ppb	65°
Modelled PER (cumulative)	14	47.7 ppb	14.3 ppb	n/a
EPP(Air) Objective	n/a	120 ppb	200 ppb	n/a

Table 34 Comparison of PER Modelled vs Year 3 monitoring: Pollutant concentrations on two days of highest activity

Observation/Prediction	ASH Movements *(total for day)*	CO Concentration (*max 8 hour average during 24 hour period)*	PM_{10} Concentration (*24 hour average)*
17/01/2017	30	0.057 ppm	6.7 µg/m³
18/01/2017	26	0.081 ppm	12.5 µg/m³
Modelled PER (cumulative)	14 max in one hour	4.08 ppm	43.0 µg/m³
EPP(Air) Objective	n/a	9 ppm	50 µg/m³

7.3.2 Comparison of all three years of monitoring with PER modelling

The AQMP sets the following guidance around the reporting of the validation of the accuracy of the PER predictions about Super Hornet air quality impacts:

> 26. *The air quality monitoring and reporting will occur for a minimum period of 3 years. Following publication of the third annual Air Quality Monitoring Report, it is expected there will be sufficient information to determine the accuracy of the air quality impacts predicted in the PER. A failure to validate the accuracy of the air quality impacts published in the PER would warrant the air quality monitoring and reporting to continue.*

The results of all three years of air quality monitoring at RAAF Base Amberley have been assessed against the PER modelling.

The meteorological conditions during each of the three years were similar to those modelled in the PER. However, at no point during the monitoring program has the intensity of movements approached that modelled in the PER. **Table 35** presents a comparison of PER modelled vs actual measured pollutant concentrations during hours in the monitoring program where there were eight ASH movements (these hours being the equal busiest during the three years of monitoring). **Table 36** compares CO and PM_{10} results on the four days of highest ASH activity (these being the first and equal-second highest days of activity) against the PER modelled predictions. Finally, **Table 37** compares actual highest monitored concentrations against the worst case PER model predictions.

Both NO_2 and PM_{10} maximum measured concentrations are greater than the PER model predicted "worst case" concentrations. However, during the periods that both the highest NO_2 and PM_{10} concentrations were recorded, there were no ASH movements.

There were six hours since the commencement of the monitoring program in June 2014 where the NO_2 1 hour average concentration was greater than the PER modelled "worst case" concentration. There were no ASH movements reported during any of these hours, therefore they are not considered to be caused by ASH movement activity. **Table 38** details the hours during the monitoring program where the NO_2 concentration was greater than the PER modelled "worst case".

Table 35 Comparison of PER Modelled vs actual: Hourly pollutant concentrations during highest activity (2014-2017)

Observation/Prediction	ASH Movements	NO_2 Concentration	SO_2 Concentration	Wind Direction at Amberley AMO
18/08/2015 11:00	8	5.8 ppb	0.7 ppb	211°
17/11/2015 15:00	8	2.1 ppb	0.9 ppb	49°
1/04/2016 11:00	8	4.0 ppb	0.8 ppb	62°
5/12/2016 11:00	8	1.9 ppb	0.6 ppb	311°
31/01/2017 11:00	8	1.9 ppb	1.3 ppb	60°
6/02/2017 11:00	8	3.5 ppb	1.5 ppb	65°
Modelled PER (cumulative)	**14**	**47.7 ppb**	**14.3 ppb**	**n/a**
EPP(Air) Objective	**n/a**	**120 ppb**	**200 ppb**	**n/a**

Table 36 Comparison of PER Modelled vs actual: Pollutant concentrations on the four days of highest activity

Observation/Prediction	ASH Movements *(total for day)*	CO Concentration *(max 8 hour average during 24 hour period)*	PM_{10} Concentration *(24 hour average)*
24/11/2014	26	0.023 ppm	16.8 µg/m³
3/05/2016	26	0.032 ppm	6.8 µg/m³
17/01/2017	30	0.057 ppm	6.7 µg/m³
18/01/2017	26	0.081 ppm	12.5 µg/m³
Modelled PER (cumulative)	**14 max in one hour**	**4.08 ppm**	**43.0 µg/m³**
EPP(Air) Objective	**n/a**	**9 ppm**	**50 µg/m³**

Table 37 Comparison of actual highest recorded concentrations against PER model predictions

Parameter	Period	Maximum actual concentration	Date and time recorded	Number of ASH movements during period	Modelled PER (cumulative)
CO	8 hours	1.985 ppm	4/07/2014 21:00	0	4.08 ppm
NO_2	1 hour	62.5 ppb	5/06/2014 01:00	0	47.7 ppb
PM_{10}	24 hours	44.8 µg/m³	6/11/2016	0	43.0 µg/m³
SO_2	1 hour	5.5 ppb	6/10/2016 19:00	2	14.3 ppb

Table 38 Details of hours where measured NO_2 concentrations were greater than PER "worst case" of 47.7 ppb

Date and time	NO_2 1 hour average concentration (ppb)	Number of ASH movements during period
4/06/2014 02:00	55.2	0
4/06/2014 05:00	56.5	0
5/06/2014 01:00	62.5	0
5/06/2014 02:00	57.5	0
5/06/2014 07:00	55.1	0
5/06/2014 08:00	50.7	0

7.3.3 Conclusions on comparison of monitoring data with PER monitoring

As discussed in **Section 7.1**, the modelled PER and monitoring period pollutant concentrations is not directly comparable due to differences in PER modelled ASH movements compared to actual ASH movements during the monitoring period. Notwithstanding the differences between the PER assumed worst case ASH movements and the actual most intensive hours of ASH movements, the following observations can be made:

- Maximum and average CO monitoring results for the monitoring period are below the PER modelled concentrations.
- Maximum and average NO_2 monitoring results for the monitoring period are below the PER modelled concentrations. The highest six NO_2 1 hour average concentrations recorded since monitoring started on 1 June 2014 are greater than the PER “worst case”, however there were no ASH movements during any of these hours.
- The maximum PM_{10} monitoring result for the monitoring period exceeded the PER modelled concentration, however there were no ASH movements during the 24 hour period.
- Maximum and average SO_2 monitoring results for the monitoring period are below the PER modelled concentrations.
- Measured concentrations on the hours and days of highest ASH movement activity are below the PER modelled concentrations for CO, NO_2, SO_2 and PM_{10}, for all three years of monitoring.
- There appears to be no correlation between the number of ASH movements and the air quality monitoring results measured during periods of elevated activity in the reporting period. However, ASH activity did not approach levels assumed by the modelling conducted for the PER. The equal busiest hours of ASH activity only recorded eight movements, which is 57% of the modelled "worst case” activity level of 14 movements within one hour.
- In the three years of data collected since the monitoring program started on 1 June 2014, the highest concentrations for all measured parameters corresponded to periods where there were minimal or no ASH movements reported, as discussed in **Section 6.4.3**. Additionally, during periods where the NO_2 and PM_{10} average concentrations were greater than the PER “worst case” predictions, there were no ASH movements reported during the averaging period, as discussed in **Section 7.3.2**. This indicates that the primary contributors to the air environment at the monitoring location are local and/or regional emitters other than ASH aircraft.
- The three years of air quality monitoring (June 2014 to May 2017) indicates that ASH movements have not reached the intensity assessed in the PER therefore a full and accurate validation of the accuracy of the air quality impacts published in the PER cannot be conducted. However the monitoring does indicate that for periods of high ASH activity (approximately 57% of the PER activity) emissions from ASH are not significantly contributing to local air environment.

8.0 Conclusion

Monitoring of parameters specified by Defence in order to meet the requirements of the RAAF Base Amberley Australian Super Hornet Air Quality Monitoring Plan (AQMP) was conducted for the annual period starting 1 June 2016 and finishing 31 May 2017 inclusive. The data availability and corrected data capture rate exceeded the requirements of NEPM Technical Paper No. 5 and industry standards for collection of air quality monitoring data.

There was a single reportable exceedance of the Environmental Protection (Air) Policy 2008 (EPP(Air)) objective for $PM_{2.5}$ during the monitoring period, on 6 November 2016 where a concentration of 34.3 µg/m³ was recorded. There were no ASH movements on 6 November 2016. There were no other reportable exceedances of the EPP(Air) objectives.

Analysis of the three years of monitoring data collected since the monitoring program began on 1 June 2014 suggest ASH movements have not reached the intensity assessed in the PER therefore a full and accurate validation of the accuracy of the air quality impacts published in the PER cannot be conducted. However the monitoring does indicate that for periods of high ASH activity (approximately 57% of the PER activity) emissions from ASH are not significantly contributing to local air environment.

Section 26 of the AQMP provided the following guidance for the conclusion of the PER validation.

> *…A failure to validate the accuracy of the air quality impacts published in the PER would warrant the air quality monitoring and reporting to continue.*

With consideration of the past 3 years' worth of monitoring and Section 26 of the AQMP the following two recommendations are provided:

1. If ASH movements **are not expected to increase** above the level of activity experienced over the past three years then the monitoring indicates that emissions from ASH are not significantly contributing to local air environment. Therefore the air quality monitoring program can be discontinued. The RAAF Base Amberley Australian Super Hornet Air Quality Monitoring Plan should be updated to reflect these changes.
2. If ASH movements **are expected to increase** above the level of activity experienced over the past three years then in accordance with Section 26 of the AQMP air quality monitoring and reporting should continue until validation of the PER can be conducted. The RAAF Base Amberley Australian Super Hornet Air Quality Monitoring Plan should be updated to reflect these changes.

Appendix A

Graphical Results Presentation

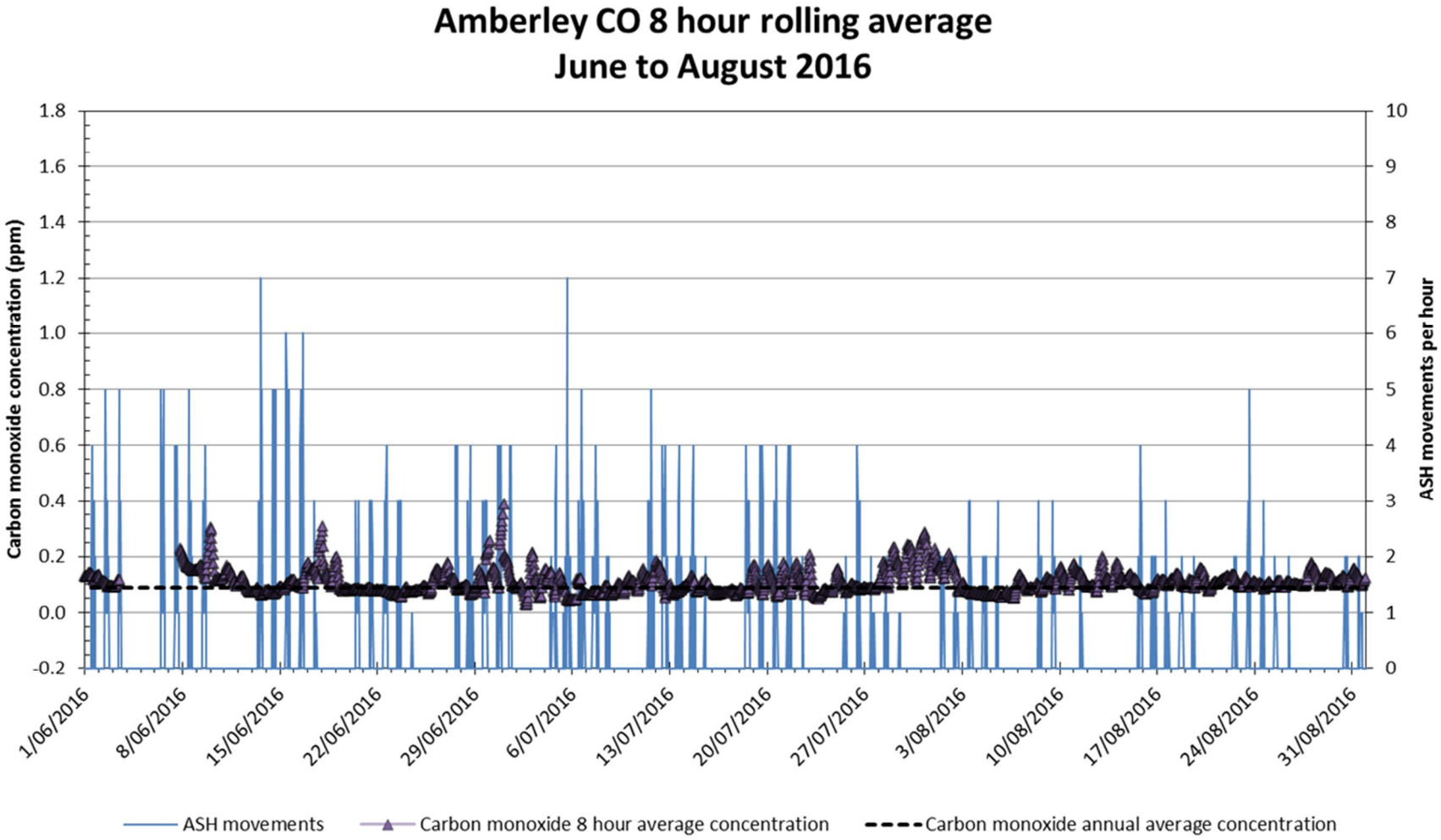


Figure 3 Carbon Monoxide results, June to August 2016

Note: The EPP (Air) objective of 9 ppm CO (8 hour rolling average concentration) is not shown on the graph.

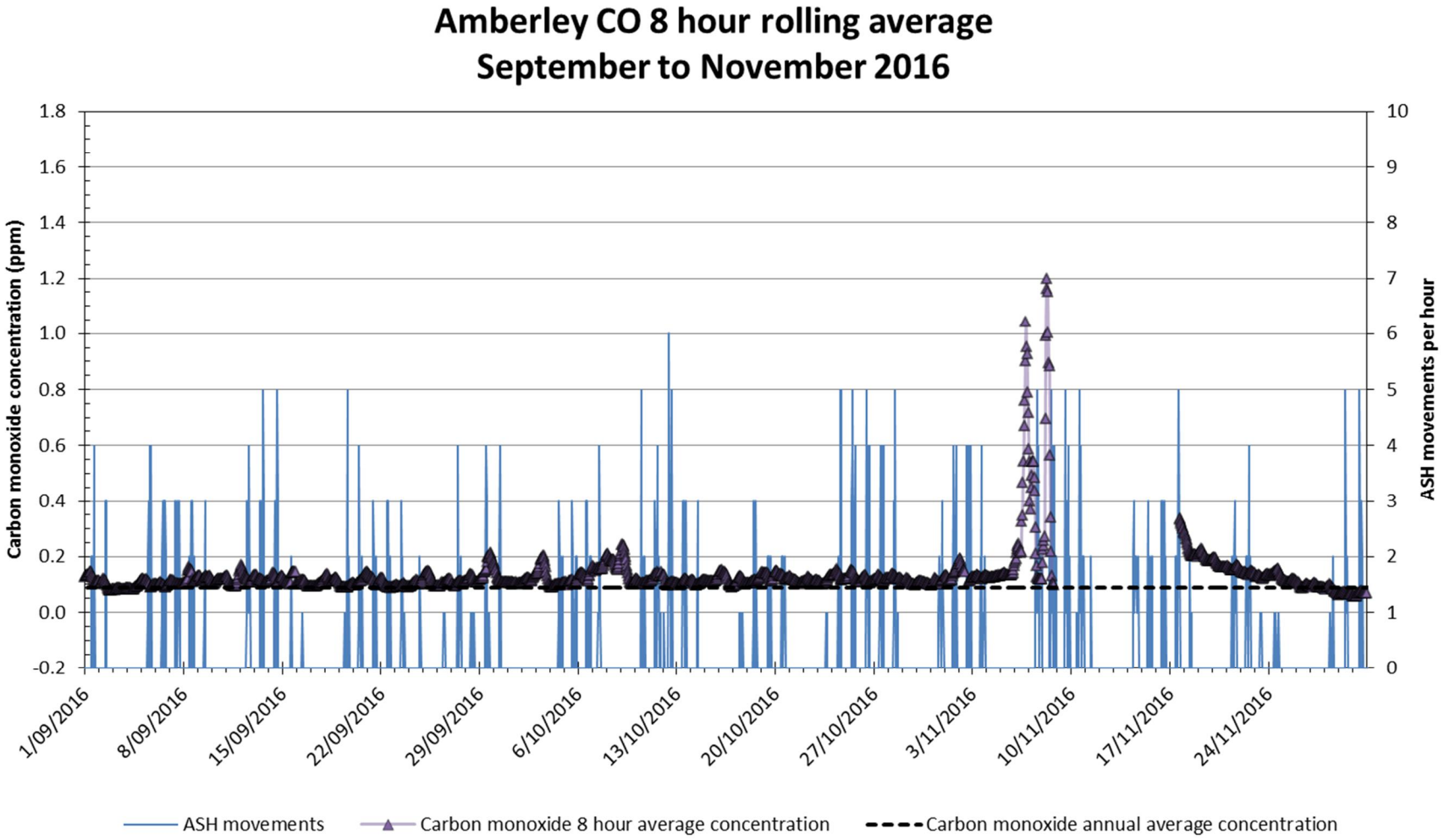


Figure 4 Carbon Monoxide results, September to November 2016

Note: The EPP (Air) objective of 9 ppm CO (8 hour rolling average concentration) is not shown on the graph.

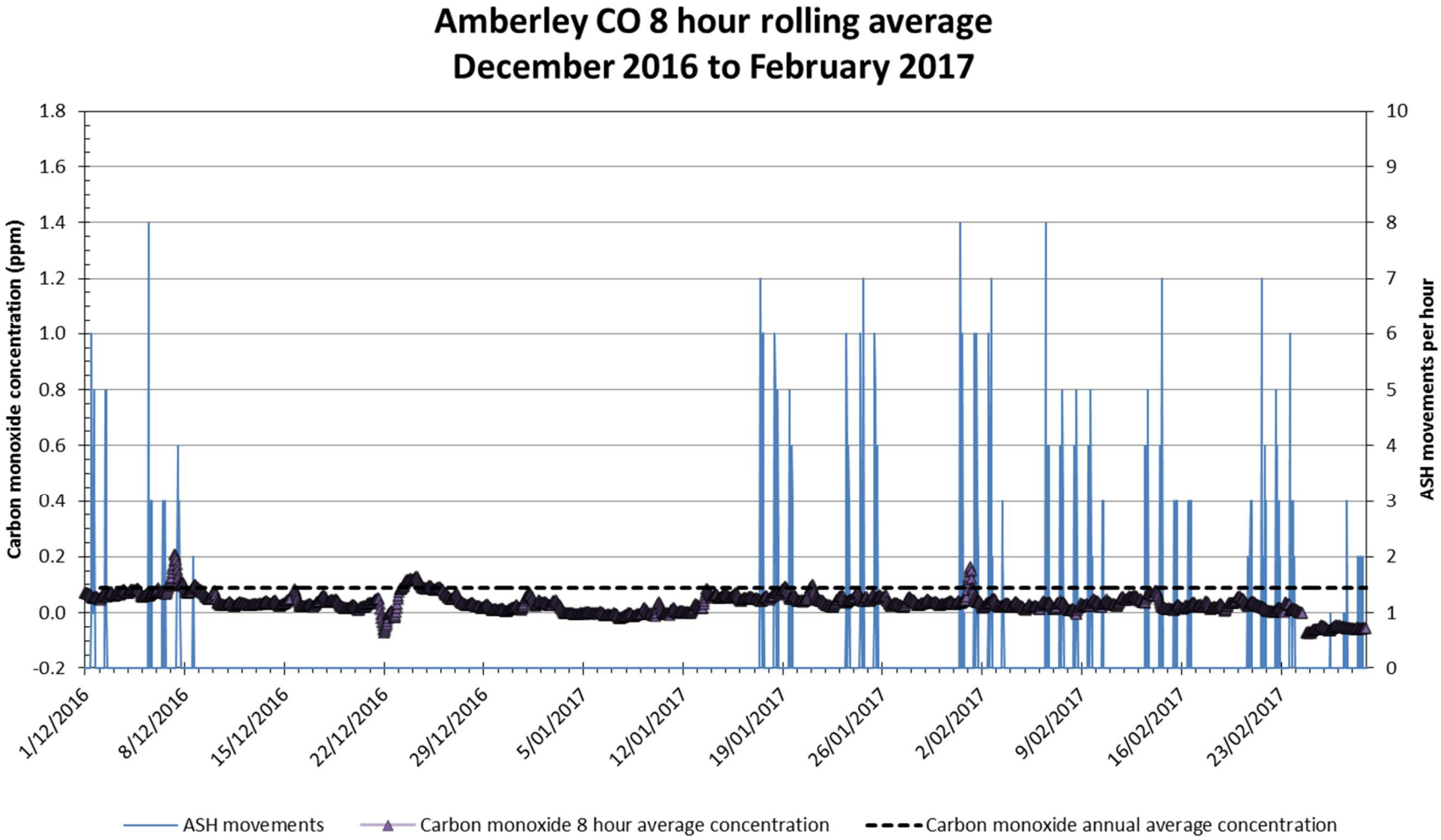


Figure 5 Carbon Monoxide results, December 2016 to February 2017

Note: The EPP (Air) objective of 9 ppm CO (8 hour rolling average concentration) is not shown on the graph.

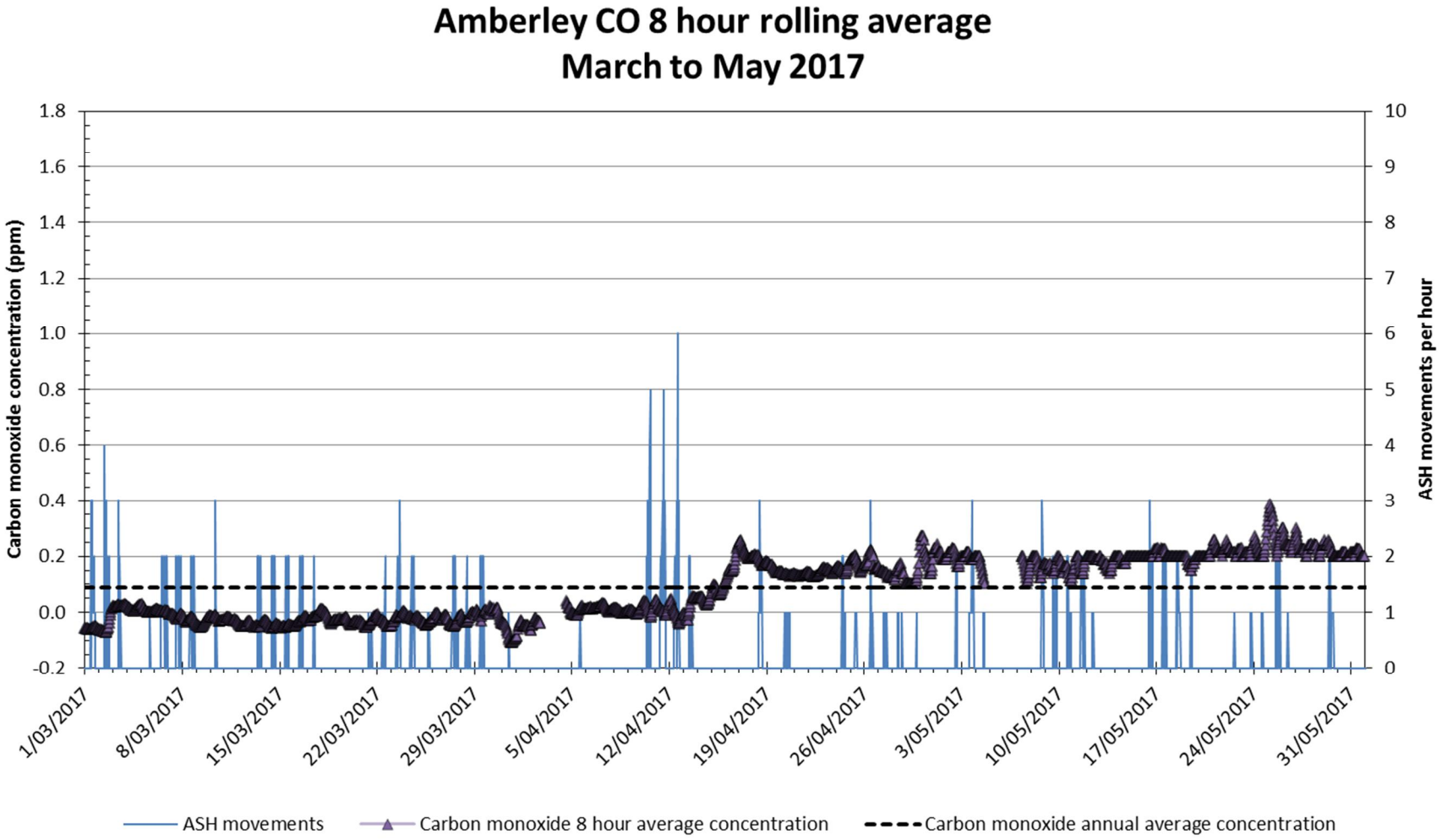


Figure 6 Carbon Monoxide results, March to May 2017

Note: The EPP (Air) objective of 9 ppm CO (8 hour rolling average concentration) is not shown on the graph.

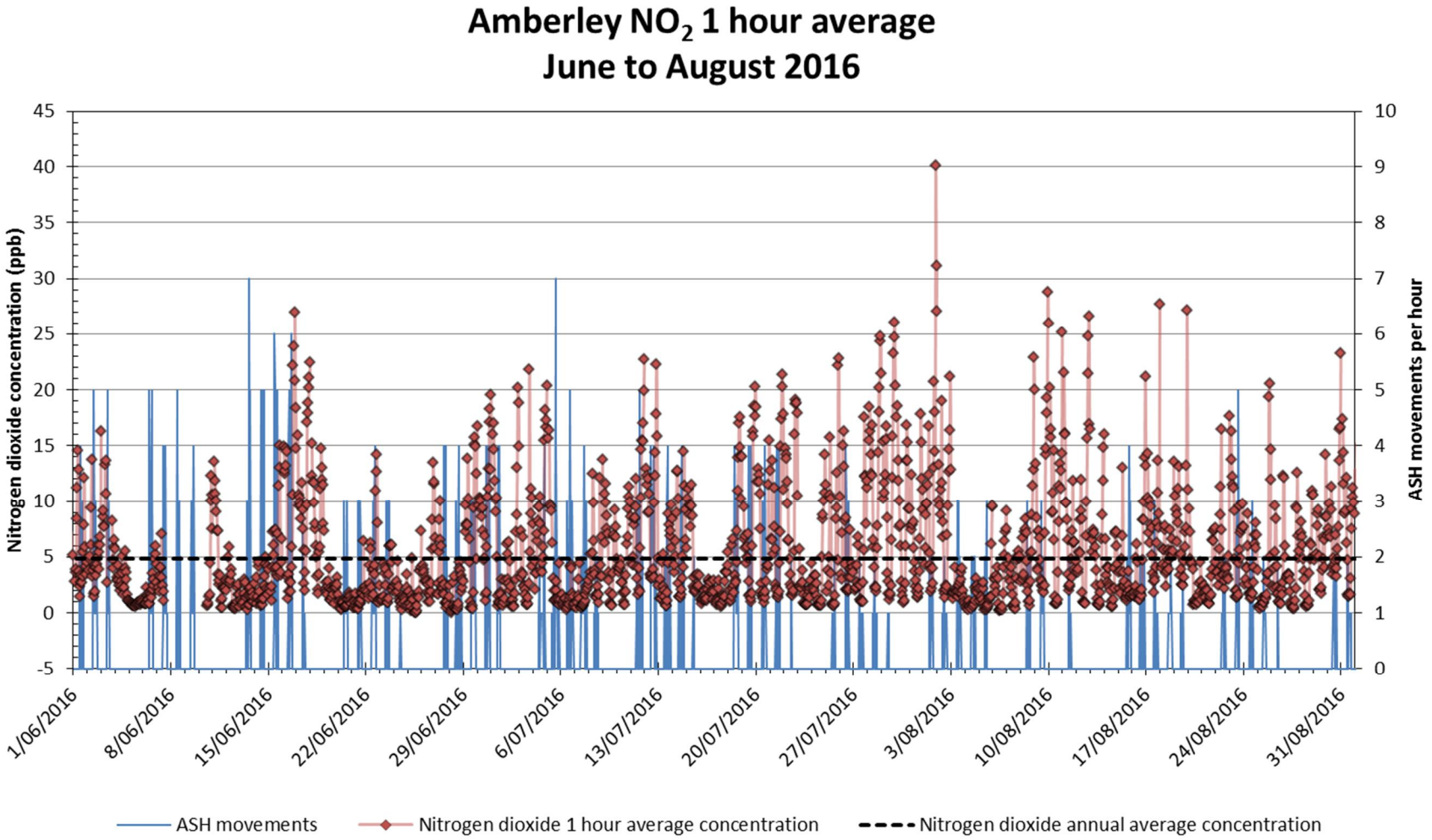


Figure 7 Nitrogen Dioxide results, June to August 2016

Note: The EPP (Air) objective of 120 ppb NO_2 (1 hour average concentration) is not shown on the graph.

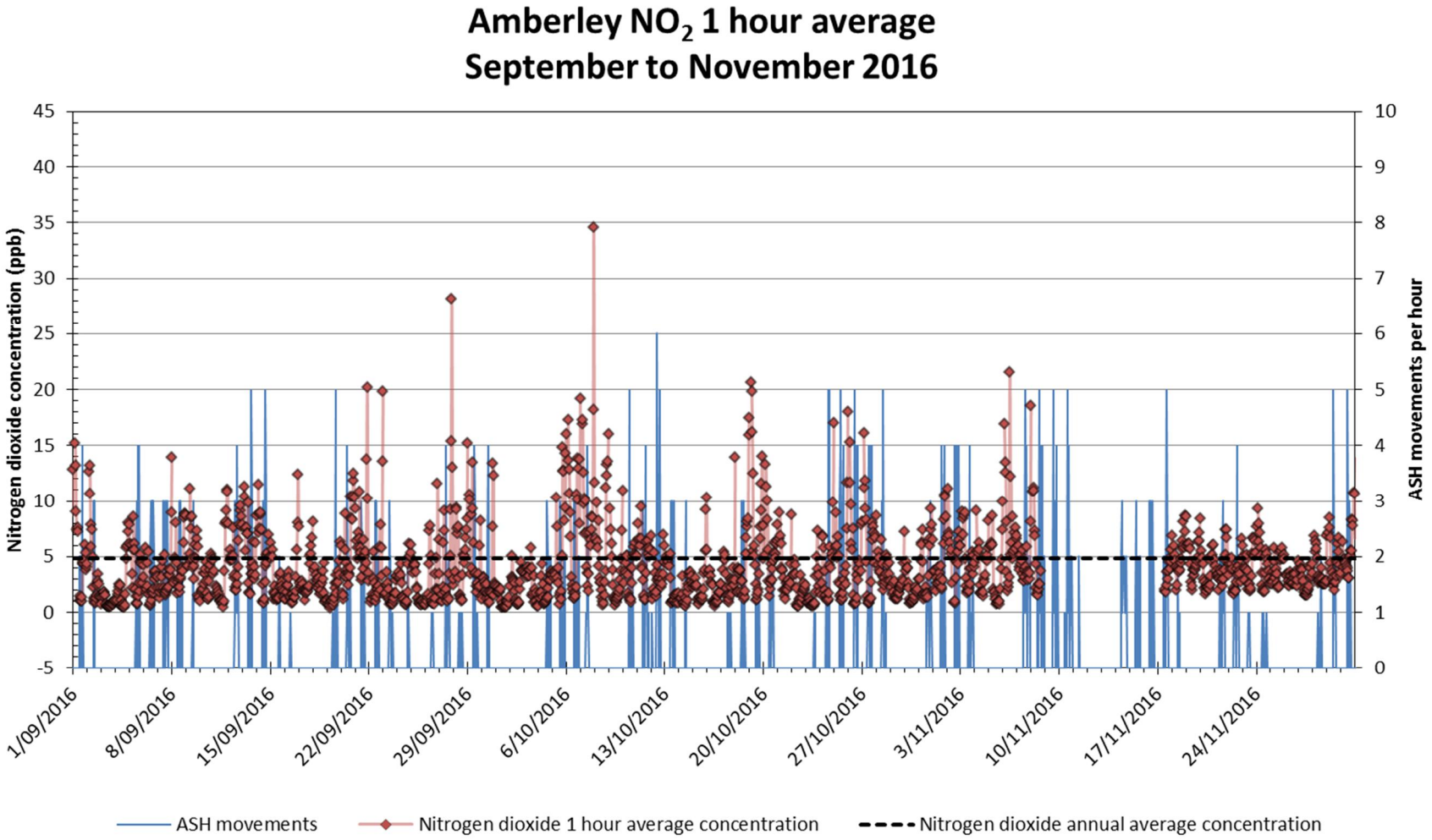


Figure 8 Nitrogen Dioxide results, September to November 2016

Note: The EPP (Air) objective of 120 ppb NO_2 (1 hour average concentration) is not shown on the graph.

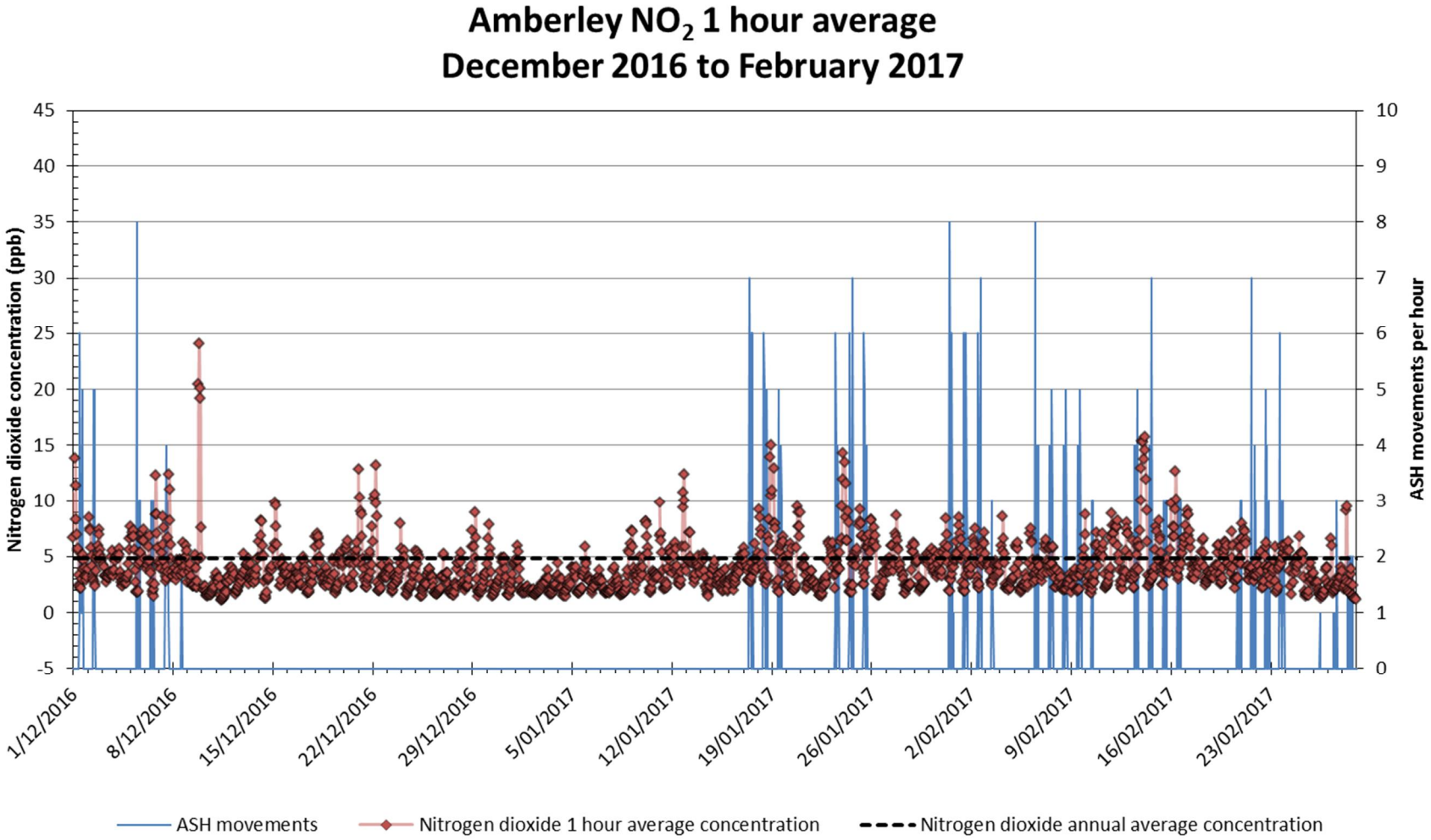


Figure 9 Nitrogen Dioxide results, December 2016 to February 2017

Note: The EPP (Air) objective of 120 ppb NO_2 (1 hour average concentration) is not shown on the graph.

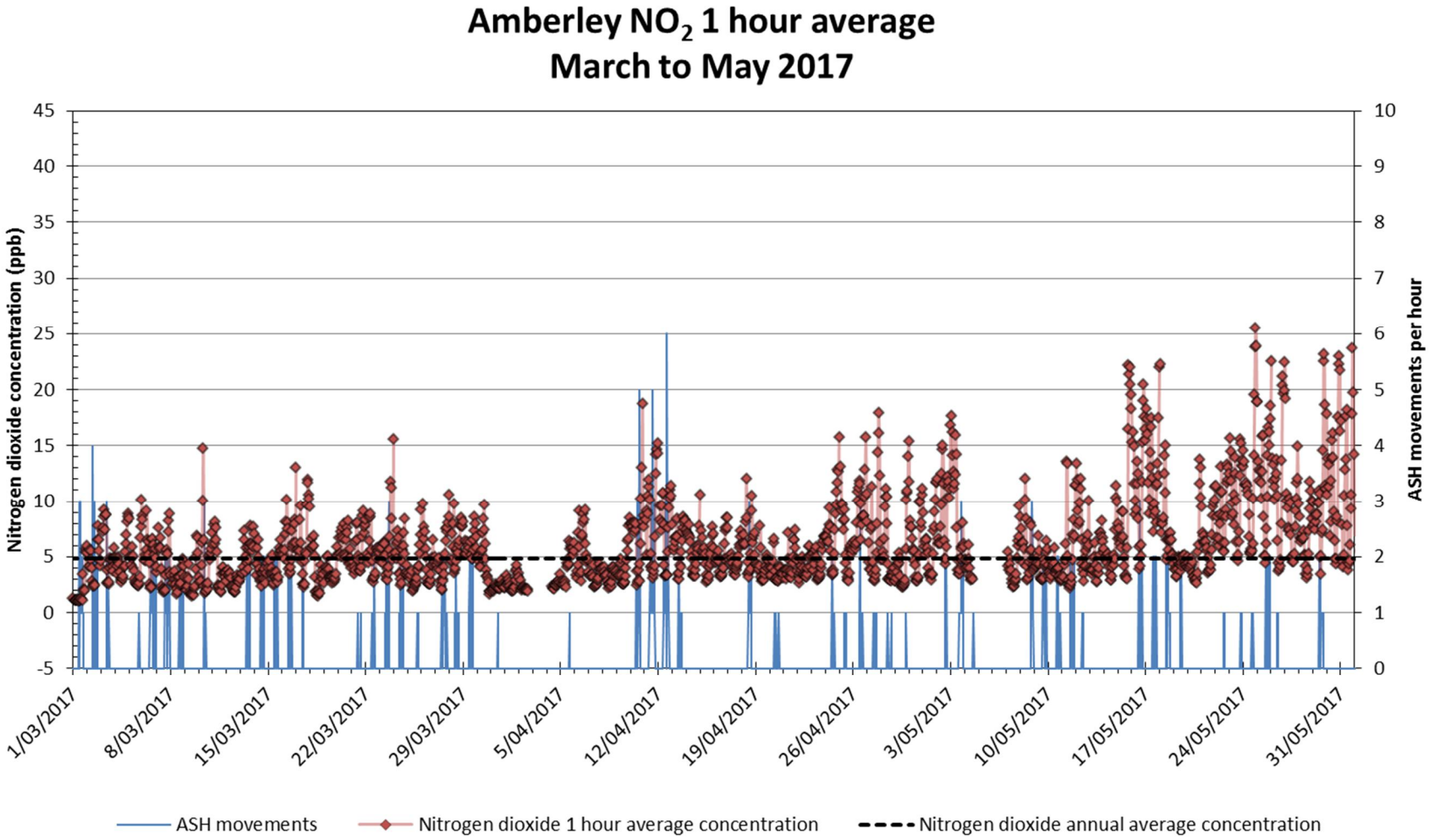


Figure 10 Nitrogen Dioxide results, March to May 2017

Note: The EPP (Air) objective of 120 ppb NO_2 (1 hour average concentration) is not shown on the graph.

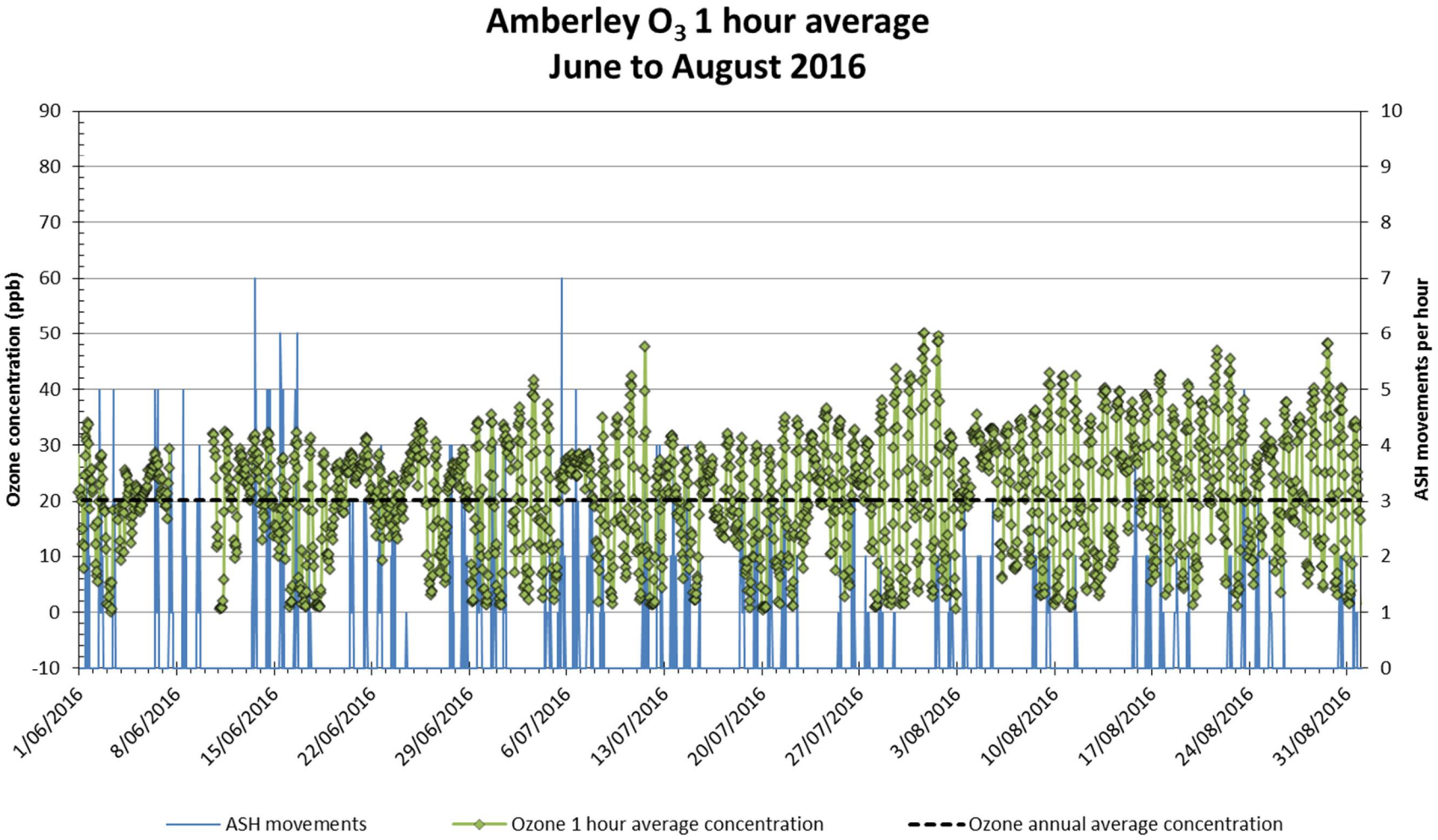


Figure 11 Ozone results, June to August 2016

Note: The EPP (Air) objective of 100 ppb O_3 (1 hour average concentration) is not shown on the graph.

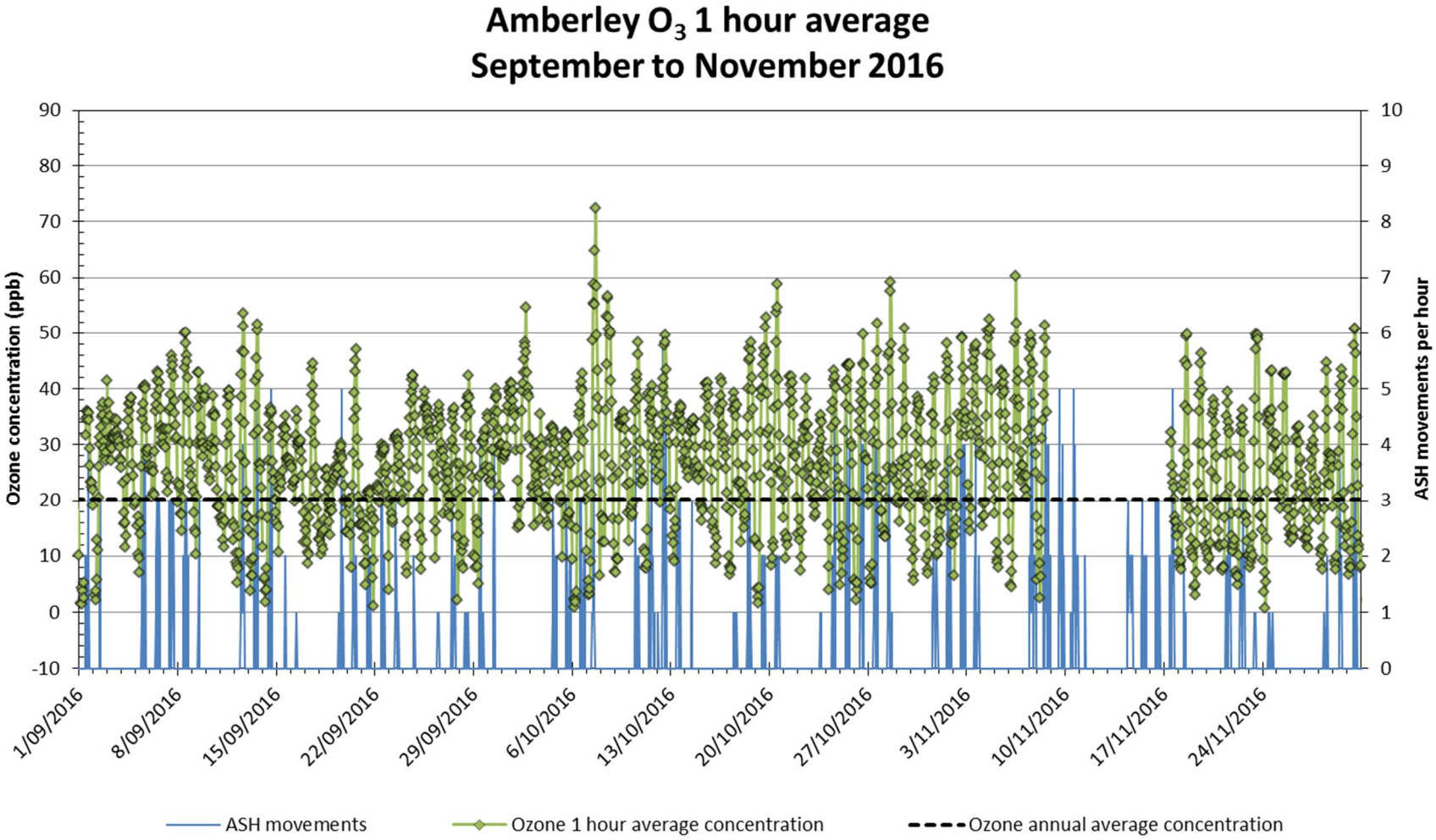


Figure 12 Ozone results, September to November 2016

Note: The EPP (Air) objective of 100 ppb O_3 (1 hour average concentration) is not shown on the graph.

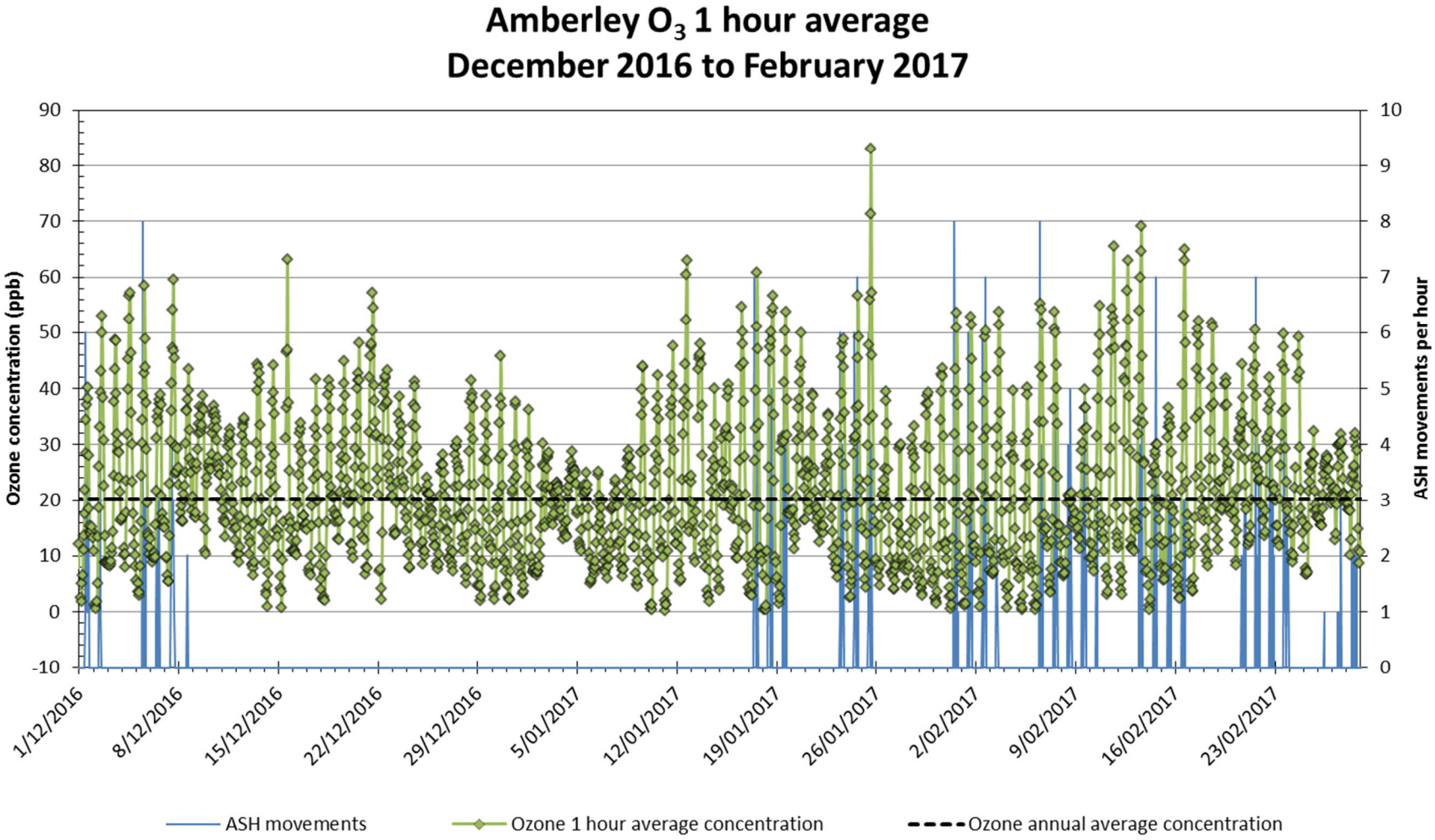


Figure 13 Ozone results, December 2016 to February 2017

Note: The EPP (Air) objective of 100 ppb O_3 (1 hour average concentration) is not shown on the graph.

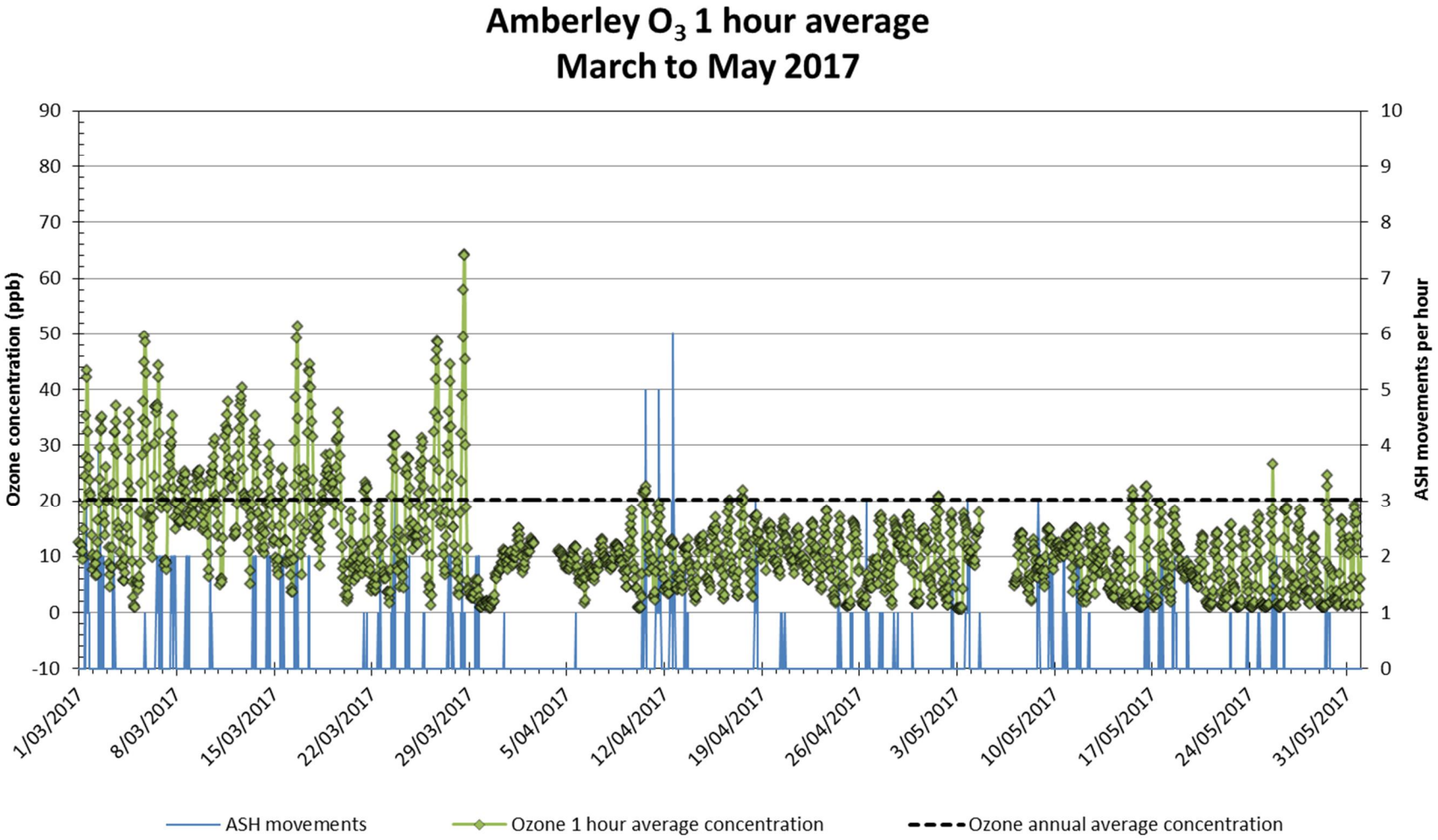


Figure 14 Ozone results, March to May 2017

Note: The EPP (Air) objective of 100 ppb O_3 (1 hour average concentration) is not shown on the graph.

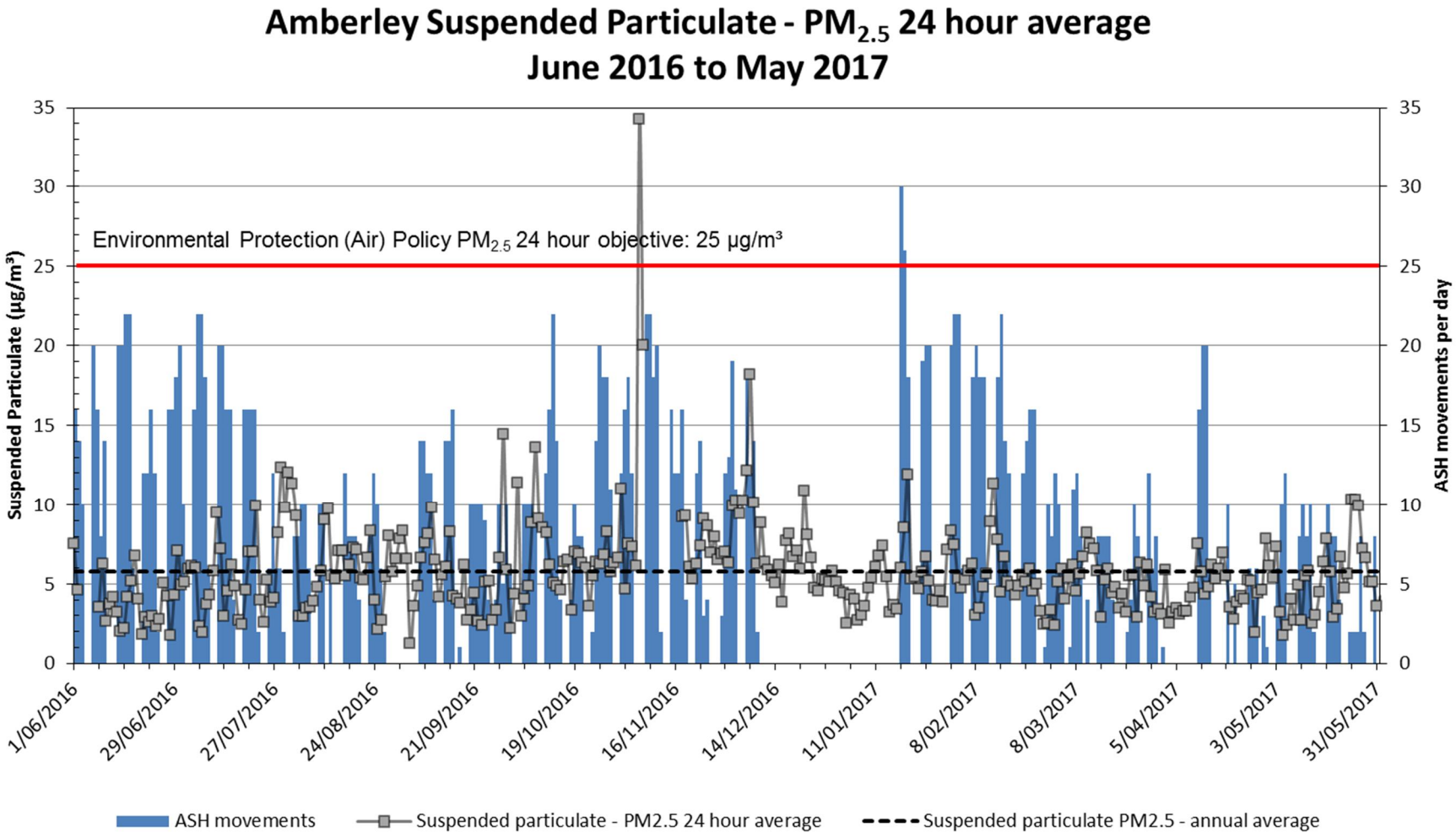


Figure 15 Suspended Particulate – $PM_{2.5}$ results, June 2016 to May 2017

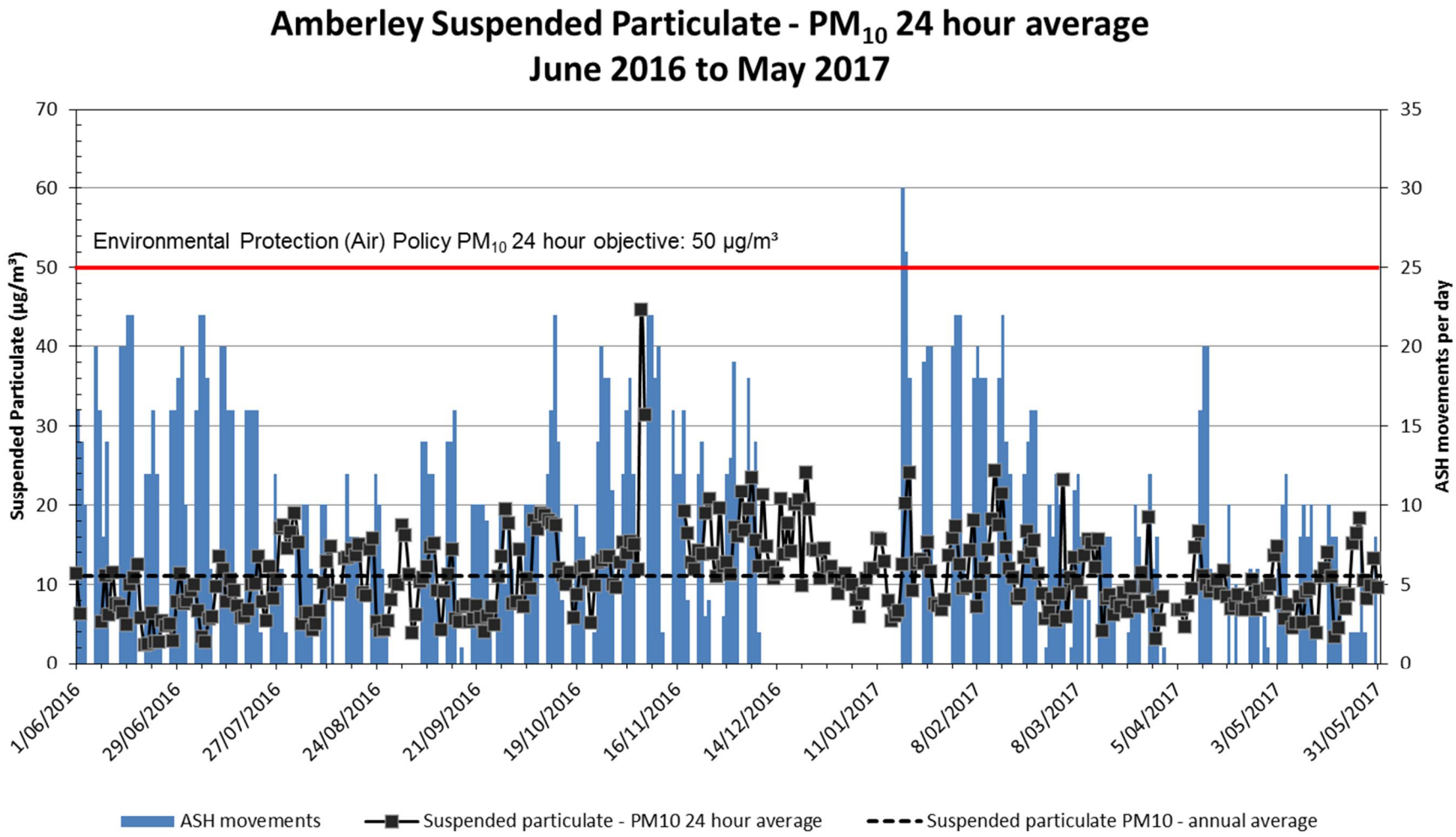


Figure 16 Suspended Particulate – PM_{10} results, June 2016 to May 2017

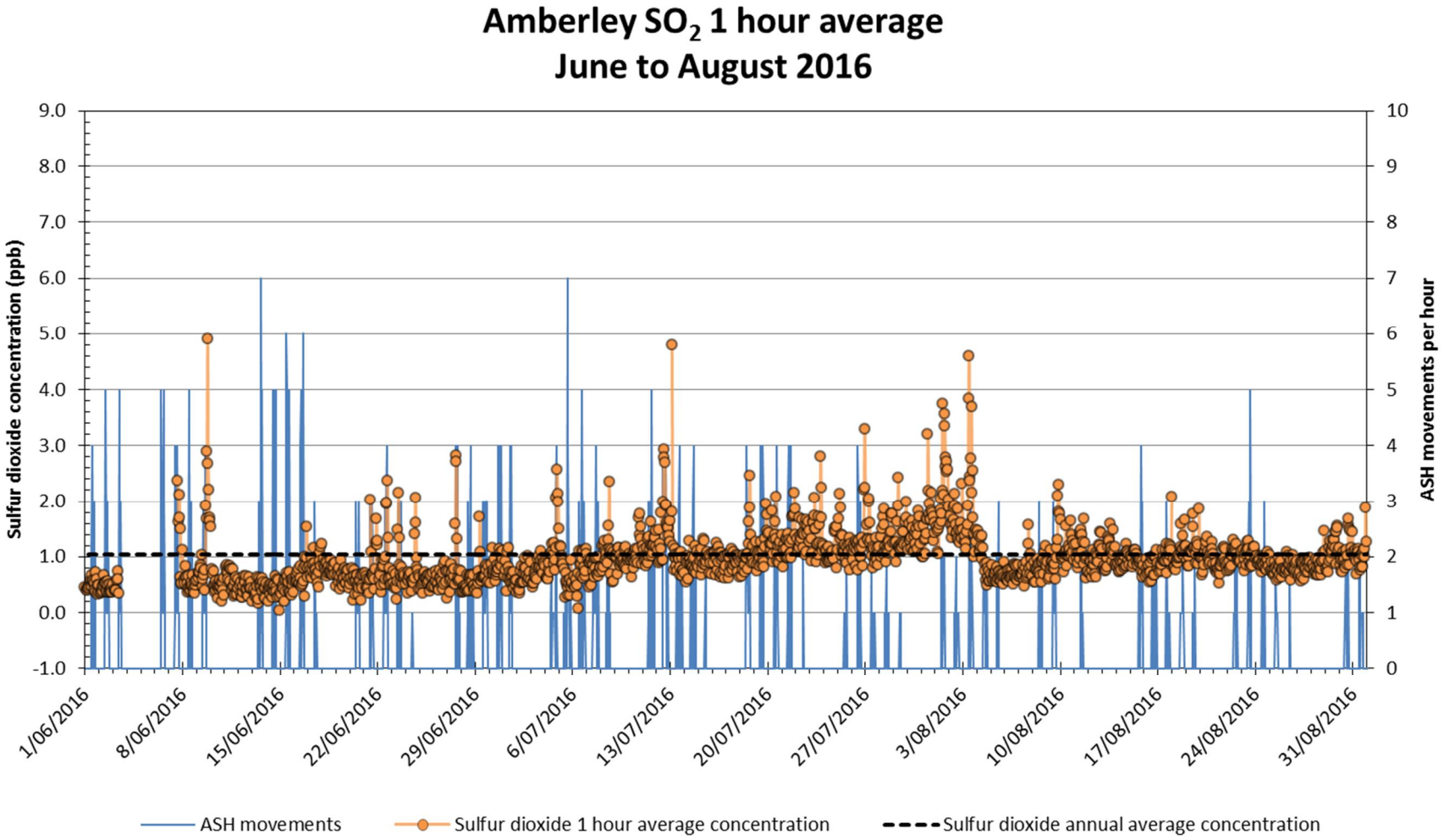


Figure 17 Sulfur Dioxide results, June to August 2016

Note: The EPP (Air) objective of 200 ppb SO_2 (1 hour average concentration) is not shown on the graph.

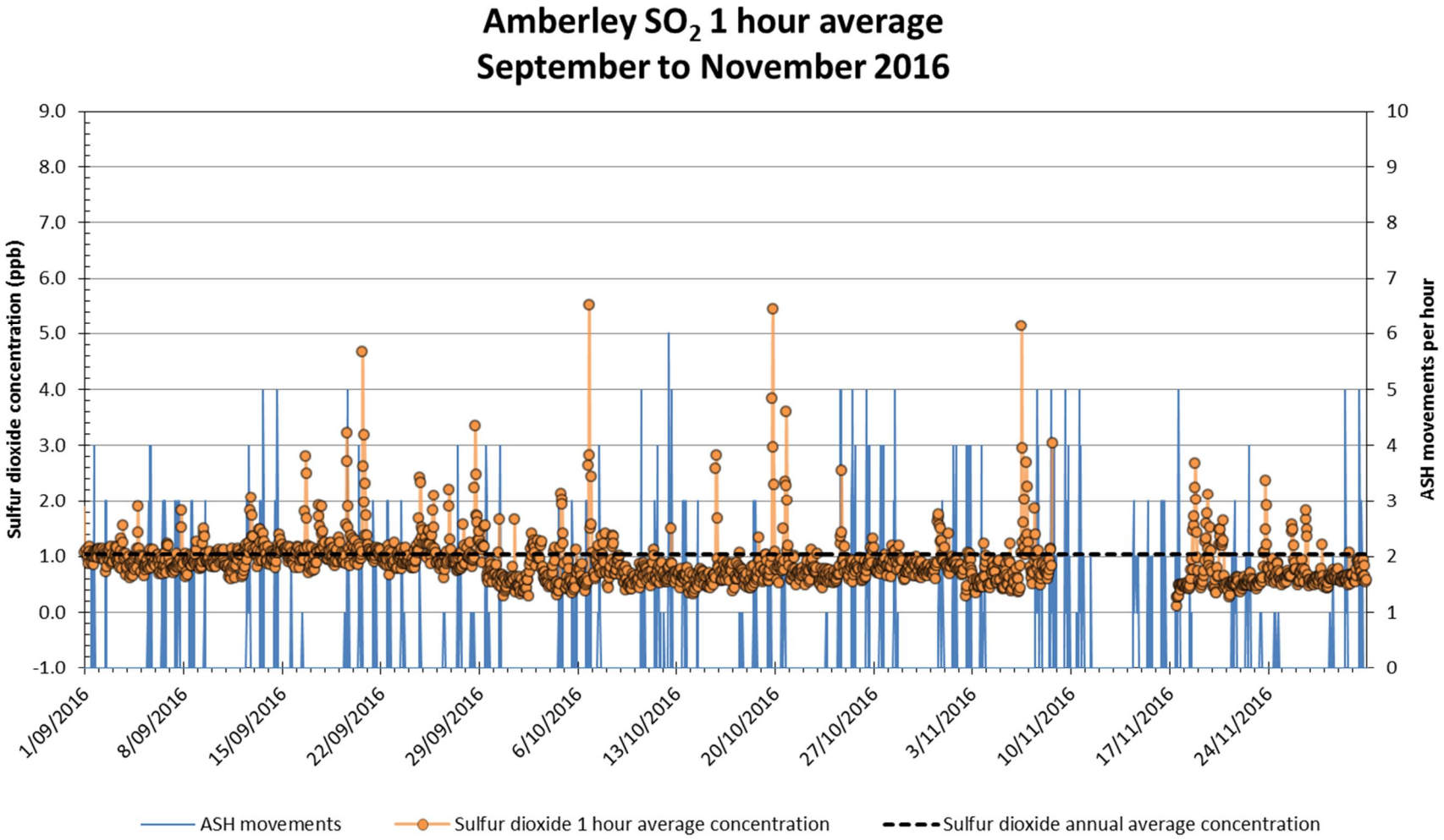


Figure 18 Sulfur Dioxide results, September to November 2016

Note: The EPP (Air) objective of 200 ppb SO_2 (1 hour average concentration) is not shown on the graph.

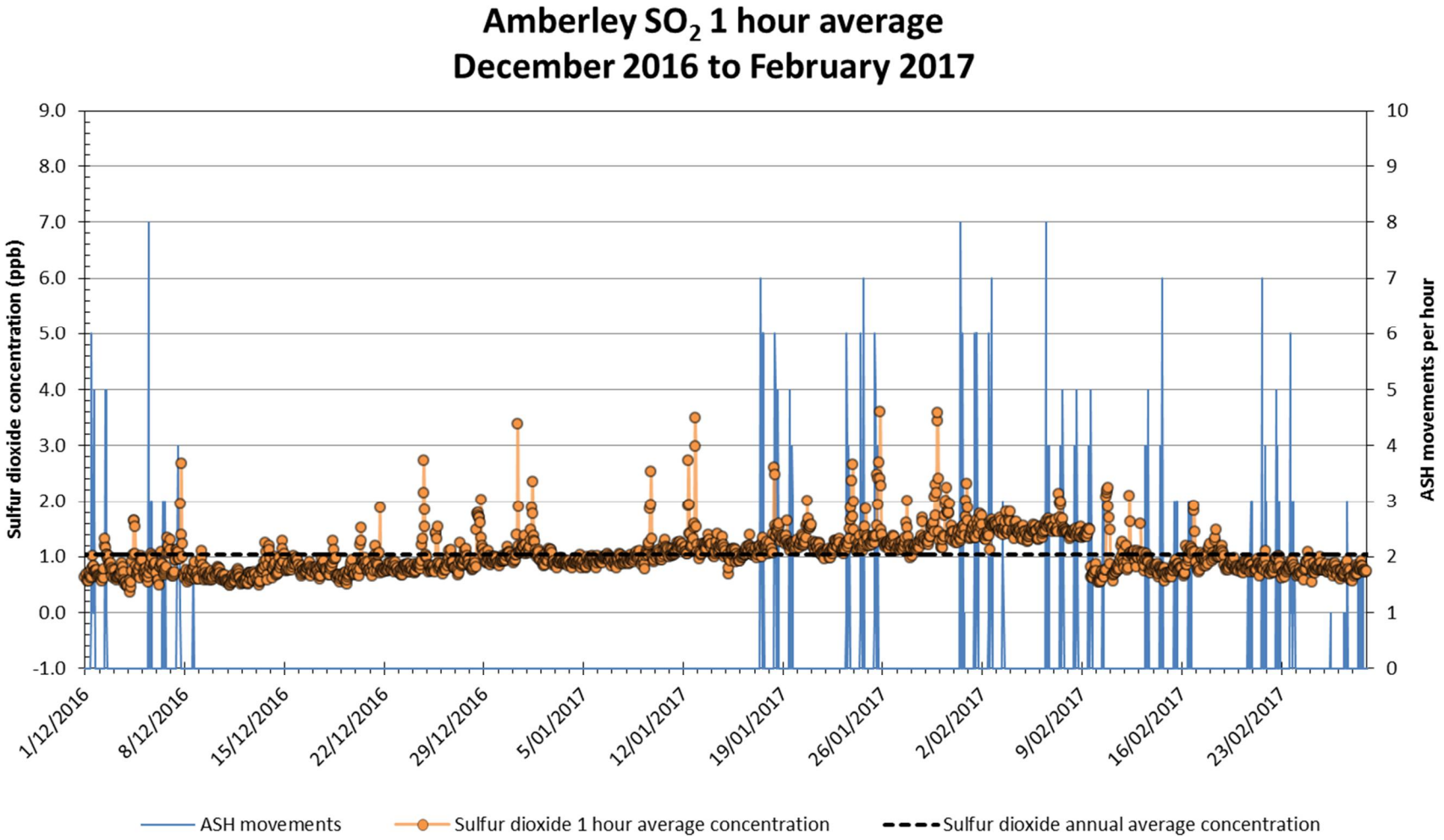


Figure 19 Sulfur Dioxide results, December 2016 to February 2017

Note: The EPP (Air) objective of 200 ppb SO_2 (1 hour average concentration) is not shown on the graph.

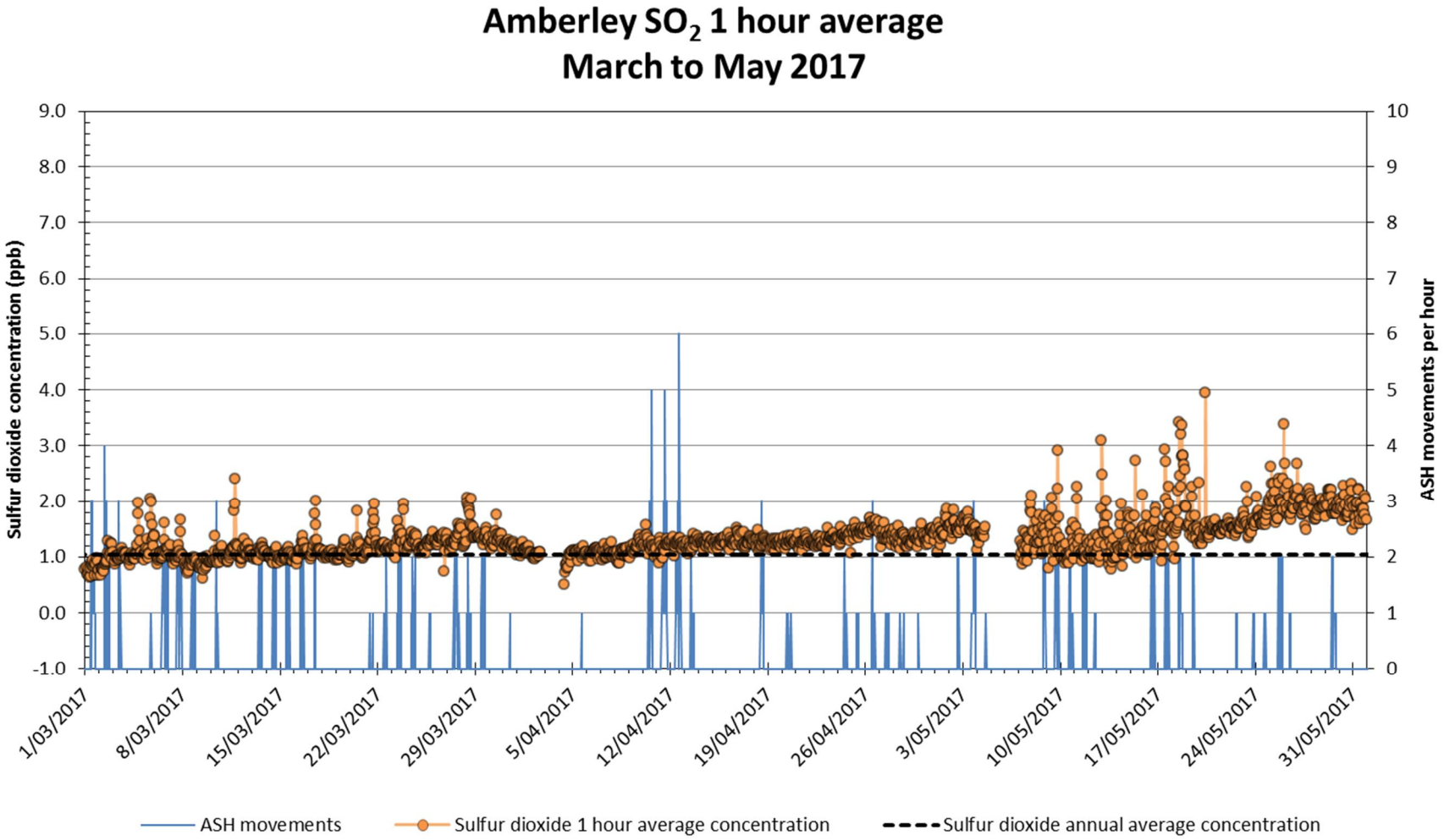


Figure 20 Sulfur Dioxide results, March to May 2017

Note: The EPP (Air) objective of 200 ppb SO_2 (1 hour average concentration) is not shown on the graph.

AECOM
AECOM Australia Pty Ltd
ABN 20 093 846 925