Yaldhurst Air Quality Monitoring

22 December 2017 – 21 January 2018

9 February 2018

Prepared for
Environment Canterbury

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Client: Environment Canterbury

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Revision History

No.	Date	Author(s)	Reviewer(s)	Details
1	1 Feb 2018	**Paul Baynham** Senior Air Quality Specialist **Louise Wickham** Director & Senior Air Quality Specialist	**Brett Wells** Managing Director **Surekha Sridhar** Senior Air Quality Specialist	Draft report to client for comment
2	9 Feb 2018	As above		Final report

Contents

Contents continued

List of Figures

Contents continued

List of Figures

1.0 Background

In March 2017, Environment Canterbury in partnership with Canterbury District Health Board and Christchurch City Council initiated an air quality monitoring programme in Yaldhurst.[1] The programme arose in response to dust and health complaints from residents near a number of quarries in Yaldhurst.

The quarries in question are those in around the junctions of Old West Coast Road, Buchanans Road and Kirk Road, as bounded by West Coast Road, and include:

- Blakely Construction
- Fulton Hogan
- GBC Winstone
- KB Contracting and Quarries
- Ready Mix Concrete
- Road Metal Company
- Taggart Earthmoving

In July 2017, Mote Ltd and Emission Impossible Ltd were selected as preferred tenderers to undertake an ambient air quality monitoring programme in Yaldhurst.

Subsequently on 14 November 2017, Environment Canterbury contracted Mote Ltd to:

- Consult with residents adjacent to the Yaldhurst quarries and other property owners to identify locations suitable for the placement of air quality monitoring stations;
- Draft a report identifying suitable monitoring locations;
- Install, commission and operate ambient air quality monitors for particulate matter less than 10 micrometres in diameter (PM_{10}), respirable crystalline silica (RCS) and meteorology;
- Undertake ambient air quality monitoring for an initial 3-month air quality period with a view to extending this for a year subject to funding approval; and
- Provide real-time, monitoring data online and a monthly report summarising the results of the preceding month.

This report provides the first monthly report under this contract for the period of monitoring between 22 December 2017 and 21 January 2018.

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[1] Press release 10 Mar 2017. Available at: www.ecan.govt.nz/get-involved/news-and-events/2017/quarries-under-close-scrutiny/ Accessed 14 November 2017.

1.1 Terms of reference

The purpose of the Yaldhurst air quality monitoring programme[2] is to:

(i) Health: Determine if the levels of respirable crystalline silica (RCS) at residences in close proximity to the quarries in Yaldhurst exceed the annual ambient guideline for RCS; and

(ii) Research: Characterise the nature of particulate and RCS by measuring short-term (hourly) particulate levels in conjunction with (longer-term) RCS, and measuring different size fractions of particulate at multiple locations.

The annual ambient guideline for RCS is the chronic reference exposure level for silica (crystalline, respirable) of 3 micrograms per cubic metre (µg/m^3) from the California Office of Environmental Health Hazard Assessment (OEHHA, 2005). A chronic reference exposure level is an airborne level that would pose no significant health risk to individuals indefinitely exposed to that level.

The hourly suggested trigger level for PM_{10} is 150 µg/m^3 for dust nuisance (Ministry for the Environment MfE, 2016). This is based on international best practice for control of dust from construction and demolition activities (Greater London Authority, 2014). The intent behind this suggested trigger level is that once triggered, swift implementation of dust control measures should prevent exceedance of the national PM_{10} standard (MfE, 2016). However, it is a new guideline for dust nuisance and, as such, retains the title of 'suggested' trigger level.

The 24-hour average national PM_{10} standard is 50 µg/m^3 for "guaranteed level of public health protection" (MfE, 2011).

The 24-hour average national reporting guideline for $PM_{2.5}$ is 25 µg/m^3. This 'monitoring value' is for 'assessing monitoring results and to judge whether further investigations are needed to quantify $PM_{2.5}$ sources' (MfE, 2002). We note the reporting guideline is numerically equivalent to the World Health Organisation global ambient air quality guideline for $PM_{2.5}$ as a 24-hour average (WHO, 2006).

1.2 Monitoring locations

This section of the report details the monitoring locations, installation and operation for the first monthly reporting period.

To respect resident's privacy, this report will not disclose the exact locations of monitoring equipment on residents' private property. Their general locations may be typified as:

- **Site 1: East** - rural/residential location a few hundred metres to the east of the quarries
- **Site 2: North (east)** - rural/residential location a few hundred metres to the north of the quarries

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[2] Mote Ltd & Emission Impossible Ltd, 2018. *Yaldhurst Air Quality Monitoring Programme: Programme Design Recommendations*. Prepared for Environment Canterbury. 12 January 2018.

- **Site 3: South (east)** – rural location a few hundred metres in the prevailing wind direction to the south east of the quarries
- **Site 4: Background** - background (rural/residential) location
- **Site 5: South (west)** - rural location a few hundred metres to the south west of the quarries
- **Site 6: North (west)** - rural/residential location a few hundred metres to the north of the quarries

The sites general locations are in **Figure 1**.

Figure 1 Indicative (only) locations of monitoring sites

1.3 Monitoring methods

Nephelometer monitoring

An air quality nephelometer is an optical sensor that uses light scattering from particulate matter to provide a continuous real-time measurement of airborne particle mass. The light source is a visible laser diode and scattered light is measured in the near forward angle using focusing optics and a photo diode. The nephelometer has an on-board temperature sensor, which corrects for thermal drift, sheath air filter to keep the optics clean, automatic baseline drift correction and a fibre optic span system to provide a check of the optical components.

The near-forward nephelometers used in this study are more accurate that comparable side scattering nephelometers. However, as the near-forward scattering is less sensitive to particle size, they require a particle size inlet or sharp cut cyclone to provide a mechanical means of separating the size fraction prior to measurement. For this study, we have deployed a PM_{10} sharp-cut cyclone co-located with each nephelometer. We have also included a $PM_{2.5}$ sharp cut cyclone with an additional nephelometer at three sites (Sites 2, 3 and 4).

One of the disadvantages of collecting monthly RCS data is that there is limited information on the variability in RCS emissions during the month. However, if we are able to collect enough data we may be able to develop a sufficiently robust relationship[3] between optical mass and RCS concentration so that:

- We could potentially use nephelometer PM_{10} data as a proxy for RCS exposure. Nephelometer PM_{10} data is considerably easier and cheaper to obtain than RCS monitoring data.

- We could investigate how ambient residential RCS exposure changes over shorter temporal periods (within uncertainty bounds). While the annual (chronic) guideline is presently applicable, future research may identify guidelines for shorter (acute) periods of ambient exposure – this relationship could provide a method of assessing short-term exposure.

Our nephelometers take a reading once per second, we use a small single board computer to record these readings and calculate the average concentration each minute. The same single board computer uses a GPS to determine the local time very accurately – this way we can time stamp the data. Every 10 minutes, we transmit the previous data to our server using a cellular modem. We take the data and plot this on our website. Interested persons can access this data through a secure web-portal.

We have installed the nephelometers on poles and tripods at heights of between 1.5 and 2 metres above ground level. Excepting Site 2 and Site 4 (which are connected to mains power), the

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[3] There is no classical definition of a robust relationship. However, typically we would only consider a relationship to be robust if there was a mathematical correlation with a coefficient of determination (R^2) value >0.75. The coefficient of determination is the proportion of the variance in the dependent variable that is predictable from the independent variable(s).

remainder of nephelometers are powered using a 12 volt battery which itself is charged using solar panels. To assist with smooth site operation and data interpretation, we have mounted ultrasonic wind sensors on poles alongside the nephelometers.

The nephelometer utilises a heating control system based on relative humidity concentrations. When the relative humidity exceeds the set point (30% RH), the inlet heater switches on. This reduces the relative humidity down to below the set point at which point the heater switches off.

NB: Nephelometers are not reference instruments. This means we cannot directly compare PM_{10} data from nephelometers with the 24-hour average national PM_{10} standard. (For this reason, we have also co-located a Beta Attenuation Monitor (BAM) at Sites 2 and 4. PM_{10} data from a BAM can be directly compared with the 24-hour average national PM_{10} standard).

Figure 2, which follows, illustrates the types of nephelometers we have deployed around the Yaldhurst quarries.

Figure 2 Typical nephelometer installations. The unit on the left is mains powered, while the unit in the centre is battery powered. The unit on the right provides a close up.

Beta Attenuation Monitoring

A Beta Attenuation Monitor or BAM is a widely used air monitoring technique employing the absorption of beta radiation by solid particles extracted from airflow. We are using Thermo FH52 C14 beta attenuation monitors inside temperature-controlled enclosures. These are located at Site 2 (to the north of the quarries) and Site 4 (background site).

We operate the FH62 BAM in accordance with the Good Practice Guide for Air Quality Monitoring and Data Management (MfE, 2009) and in accordance with the standard method specified in the Resource Management (National Environmental Standards for Air Quality) Regulations 2004:

Australian/New Zealand Standard AS/NZS 3580.9.11:2008, Methods for sampling and analysis of ambient air—Determination of suspended particulate matter—PM_{10} beta attenuation monitors

Due to the power requirements of both the instrument and the temperature-controlled enclosure, both sites operate using mains power.

Figure 3, which follows, shows a typical BAM installation.

Figure 3 An example of a temperature controlled BAM enclosure with the doors open to illustrate the BAM inside

1.4 Monitoring summary

Table 1 presents a summary of monitoring undertaken around the Yaldhurst quarries for the period 22 December 2017 – 21 January 2018.

Table 1 Summary Yaldhurst Air Quality Monitoring: Dec 2017 – Jan 2018

Site	Location	Type	Monitoring
1	East	Rural/residential	Nephelometer PM_{10}
2	North (east)	Rural/residential	Nephelometer PM_{10} BAM PM_{10} Nephelometer $PM_{2.5}$ Meteorology
3	South (east)	Rural	Nephelometer PM_{10} Nephelometer $PM_{2.5}$
4	Background	Rural/residential	Nephelometer PM_{10} BAM PM_{10} Nephelometer $PM_{2.5}$
5	South (west)	Rural	Nephelometer PM_{10}
6	North (west)	Rural/residential	Nephelometer PM_{10}

1.5 Data validation

We undertook data quality assurance and validation in accordance with good practice (MfE, 2009). In summary, this involves:

- Data review to ensure no drift or baseline shift
- Examination of check and calibration records
- Removing data collected during calibration and maintenance, including sufficient time for instrument stabilisation
- Removing negative values (except where data within system uncertainty)
- Removing spurious positive/negative spikes[4]

[4] NB: Occasionally, large negative spikes may occur due to instrumental error. These negative (and positive) spikes are review during the data analysis process to evaluate whether they are real or spurious. Unless there is good evidence to remove a value, they are left in and a comment made in the metadata (MfE, 2009).

There will inevitably be differences between (raw, un-validated) data reported online and the data in this report. Some of these arise as a result of differences from data validation, as discussed above, and some are structural.

Structural differences arise from differences in the way the data are reported. For example, **Figure 4** provides a screenshot of nephelometer PM_{10} data from Site 1 for the month of January 2018.

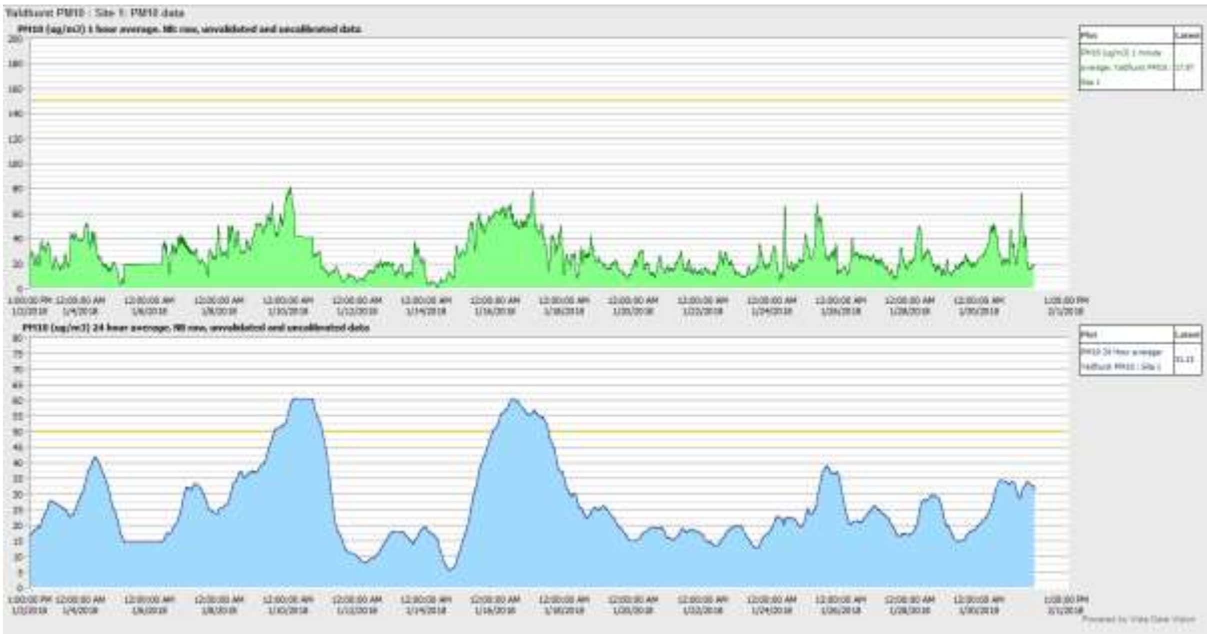

Figure 4 Screenshot of online nephelometer PM_{10} data for Site 1: East rural/residential 1:00 PM 2 Jan 2018 – 3:00 PM 31 Jan 2018

The top graph in **Figure 4** is hourly PM_{10}, and the hourly averages are updated each minute, hence the data have a spiky appearance. This will look different to the hourly data shown in **Figure 5**, which is updated once an hour and has a slightly smoother appearance.

Similarly, the daily PM_{10} averages in the bottom graph in **Figure 4** are updated every hour, each and every day. The rolling 24-hour average is thus a smooth line and looks very different to the bar chart in **Figure 6**, which presents true daily averages for each day (i.e. the full 24-hours of each day commencing at midnight, continuing through the early hours of the morning, noon and finishing at midnight that night).

Being raw, the data also include measurements during calibration and maintenance as well as site outages. Details of events that may impact the monitoring data are provided in Section 2.0.

2.0 Results

This section details installation, commissioning and operation for each site from project commencement. It also summarises monitoring results for the first contract month commencing 22 December 2017. Depending on the installation date, we also report additional, validated monitoring data collected prior to this period.

Time averages are retrospective. Thus, we report data collected between 2:00 PM and 3:00 PM as an hourly average for 3:00 PM. Similarly, a 24-hour average for Monday 25 December is for the full 24-hours of Monday commencing at (1 minute after) midnight Sunday 24 December and finishing at midnight on Monday 25 December.

Table 2 presents the data capture and per cent valid data obtained at each site during the monitoring period 22 December 2017 – 21 January 2018.

Table 2 Per cent valid monitoring data 22 Dec 2017 – 21 Jan 2018

Site	Monitoring	% Valid Data[1]	Comments
1	Nephelometer PM_{10}	98.8%	Rabbit chewed through power cable 4:00 AM 10 Jan 2018.
2	Nephelometer PM_{10}	100%	
	BAM PM_{10}	90.6%[2]	Memory chip failed 9 Jan 2018. Replaced 12 Jan 2012.
	Nephelometer $PM_{2.5}$	100%	
	Meteorology	100%	
3	Nephelometer PM_{10}	95.6%[2]	Rabbit chewed through power cable 8:00 PM 10 Jan 2018.
	Nephelometer $PM_{2.5}$	100%	
4	Nephelometer PM_{10}	100%	
	BAM PM_{10}	89.5%	Power surge 9 Jan 2018 that killed the BAM. Instrument replaced 12 Jan 2018.
	Nephelometer $PM_{2.5}$	100%	
5	Nephelometer PM_{10}	100%	
6	Nephelometer PM_{10}	*93.7%**	*Awaiting manual retrieval of data from 19 Jan 2018 due to poor cellular reception. Actual % valid will be higher than this value (100%).

Notes
[1] Calculated on hourly average data unless otherwise stated
[2] Calculated on 24-hour average data

Due to a delay in the manufacturer supplying filters suitable for measurement of respirable crystalline silica (RCS), this report includes ambient monitoring results for particulate monitoring and meteorology only.

NB: As noted above in Section 1.3, we cannot compare nephelometer PM_{10} data directly with the 24-hour average national PM_{10} standard. This is because nephelometer PM_{10} data are indicative only (for indicating dust nuisance and investigating spatial and temporal resolution). However, we can (and do) compare PM_{10} data measured by the beta attenuation monitor (BAM) directly with the 24-hour average national PM_{10} standard. BAMs are deployed at Site 2 (North) and Site 4 (Background).

2.1 Site 1: East rural/residential

PM_{10}

We installed and commissioned a nephelometer (PM_{10}) monitor at Site 1 on 7 December and it was fully operational from 8 December 2017.

There was a small amount of data loss from Site 1 on 10 January (4 am – 4 pm). A site visit that day revealed:

> *This site is powered by solar cells, which in turn charge a battery. It appears that at some point during the preceding day a small animal had partially chewed through the solar cell charging cable. While the damage did not sever the cable it was sufficient to significantly reduce the amount of charge the battery received. We have replaced the cable, added cable shielding and relocated the site a few metres further away to reduce shading from an adjacent shelterbelt. We are reasonably confident that this problem will not reoccur.*

No other data connectivity issues were noted with this site during this period.

Figure 5 presents hourly PM_{10}. There was one exceedance (185 µg/m^3) of the 1-hour suggested trigger threshold (150 µg/m^3) at 4 pm on 19 December 2017.

Figure 6 presents daily PM_{10} measured by the nephelometer between 8 December 2017 and 21 January 2018. The missing data on 10 January meant that there was insufficient data (<75%) to provide a valid 24-hour average for this period.

NB: Nephelometers are not reference instruments. This means we cannot directly compare PM_{10} data from nephelometers in **Figure 6** with the 24-hour average national PM_{10} standard.

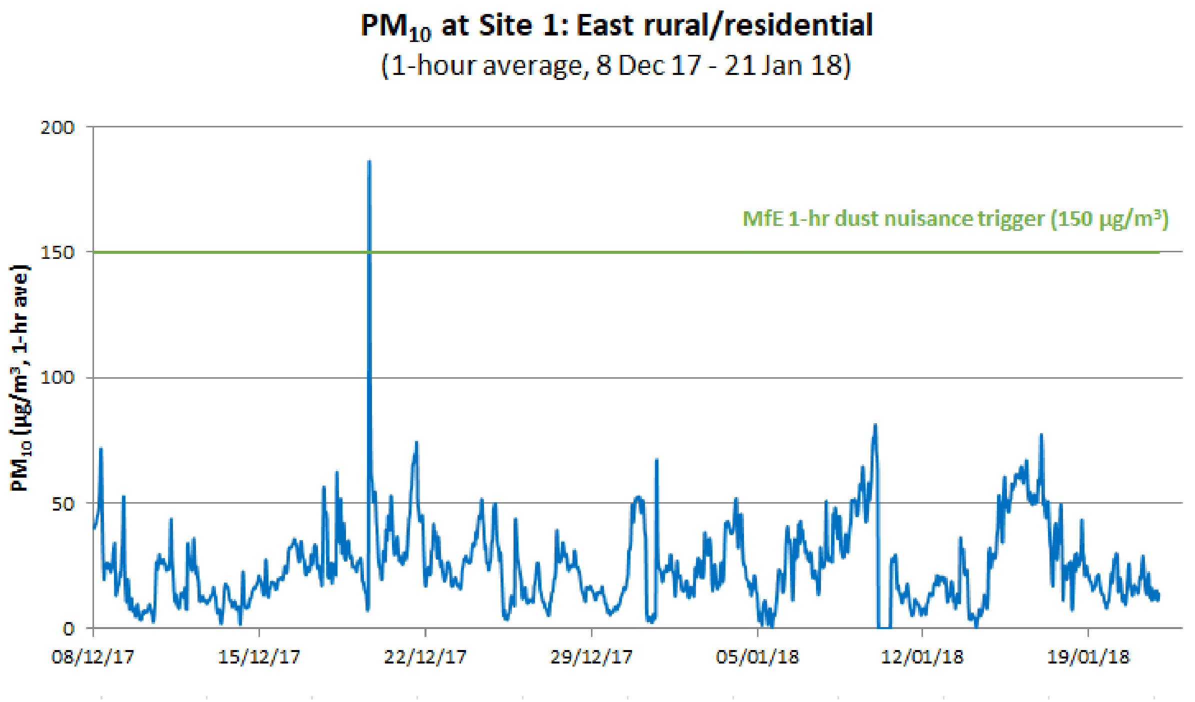

Figure 5 Hourly PM_{10} (nephelometer) at Site 1: East rural/residential for period 8 Dec 2017 – 21 Jan 2018

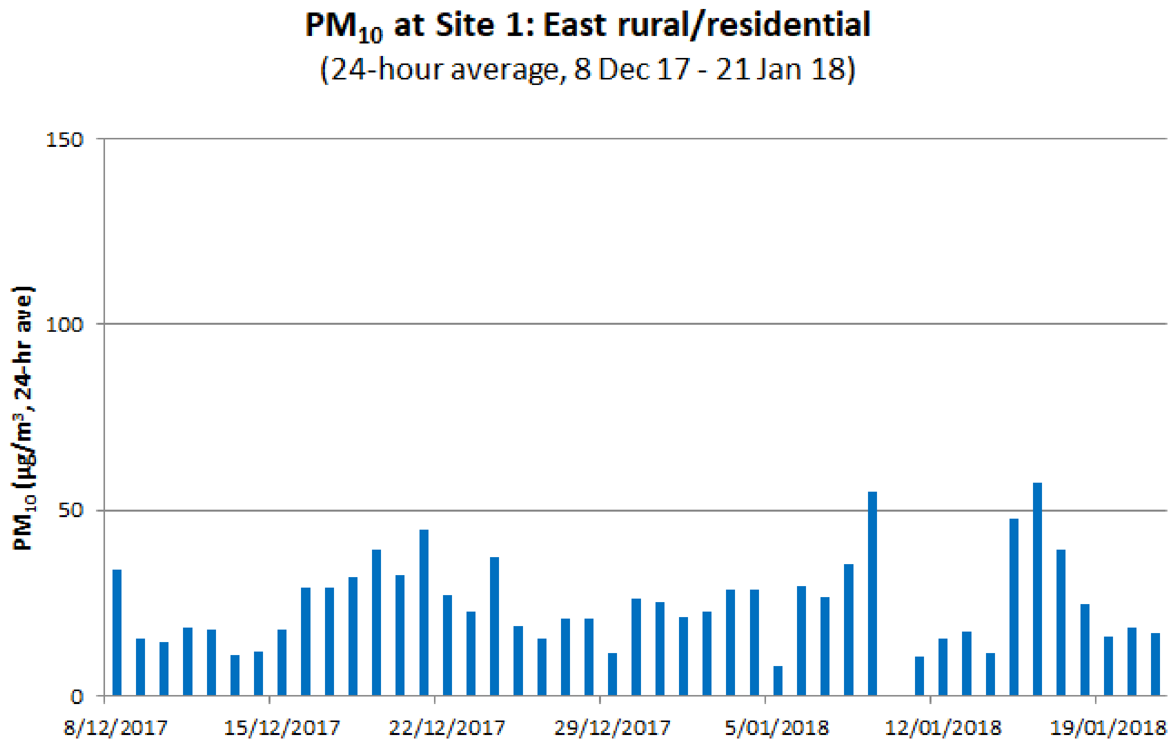

Figure 6 Daily PM_{10} (nephelometer) at Site 1: East rural/residential for period 8 Dec 2017 – 21 Jan 2018

2.2 Site 2: North (east) rural/residential

PM_{10} and $PM_{2.5}$

We installed and commissioned two nephelometer (PM_{10} and $PM_{2.5}$) monitors at Site 2 on 15 December. These were fully operational from 16 December 2017.

We installed and commissioned a beta attenuation monitor (BAM) reference method PM_{10} monitor at Site 2 on 20 December 2017. This was fully operational from 21 December 2017.

In the early hours of Monday morning 9 January 2018, we lost contact with the BAM at Site 2. We visited the site on Wednesday 10 January and established:

> *The BAM suffered an electrical fault (unrelated to the electrical fault on the same day at Site 4, refer Section 2.4). It appears the EPROM (instrument memory) chip failed. We replaced this part of the instrument on Friday 12 January. This type of failure is unlikely to reoccur.*

Following this outage between midnight 9 January to midday 12 January 2018, three days of 24-hour (reference) BAM PM_{10} data were lost.

Figure 7 presents hourly PM_{10} from the nephelometer (blue) and BAM (pink) for the period when both were monitoring side by side from 21 December 2017 – 21 January 2018. There were no exceedances of the 1-hour suggested trigger threshold (150 $\mu g/m^3$) during this monitoring period at Site 2.

Figure 8 presents daily PM_{10} measured by the nephelometer and the BAM (reference method) between 16 December 2017 and 21 January 2018 (excluding three days of lost BAM data as noted above). There were no exceedances of the NES for PM_{10} measured by the BAM during this period at Site 2.

Figure 9 presents PM_{10} measured by BAM as a function of PM_{10} measured by nephelometer for available validated days of data at Site 2. This correlation suggests the nephelometer is over-reading actual PM_{10} levels when compared with the reference method.

Figure 10 presents hourly $PM_{2.5}$ measured by nephelometer at Site 2 for the period of operation (16 December – 21 January 2017). **Figure 11** presents daily $PM_{2.5}$ at Site 2 for this same period.

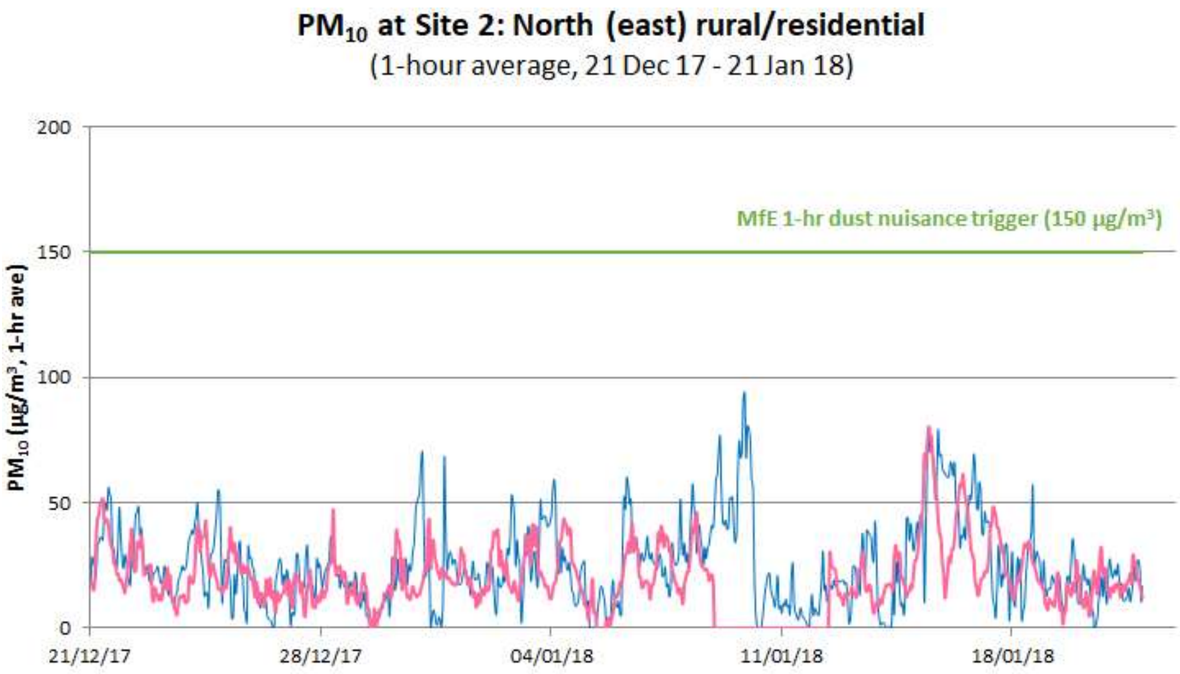

Figure 7 Hourly PM_{10} nephelometer (blue) and BAM (pink) at Site 2: North (east) rural/residential for period 21 Dec 2017 – 21 Jan 2018

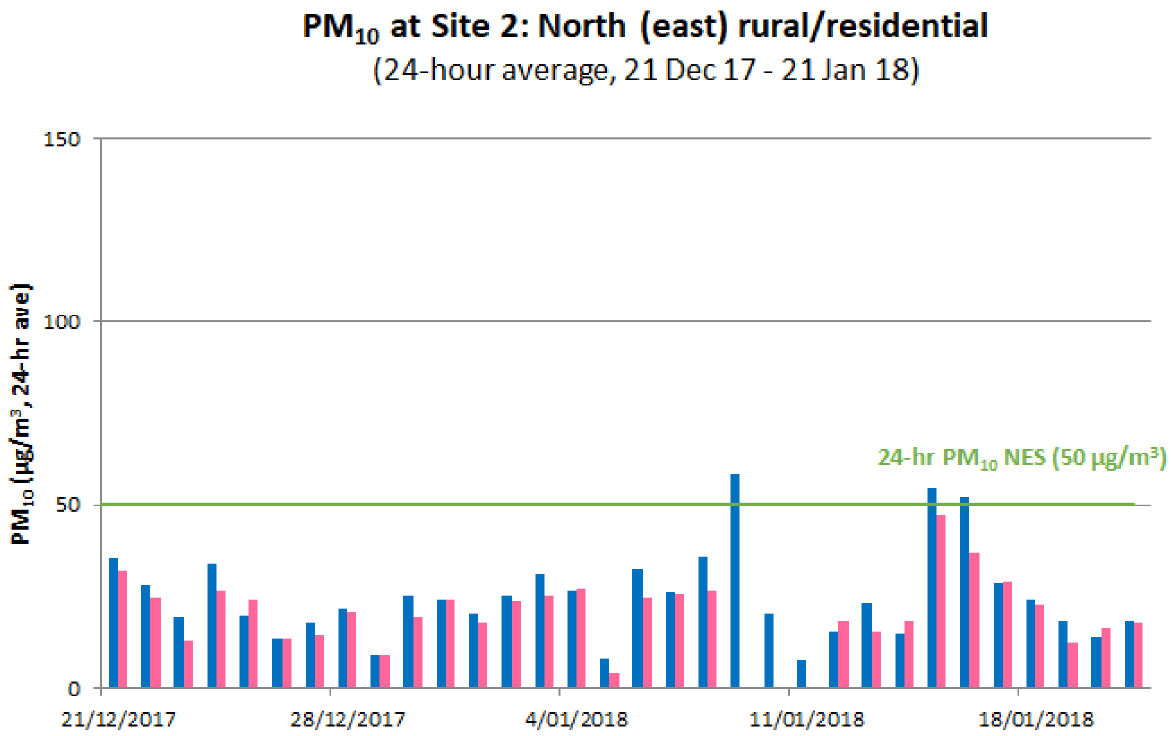

Figure 8 Daily PM_{10} nephelometer (blue) and BAM (pink) at Site 2: North (east) rural/residential for period 21 Dec 2017 – 21 Jan 2018

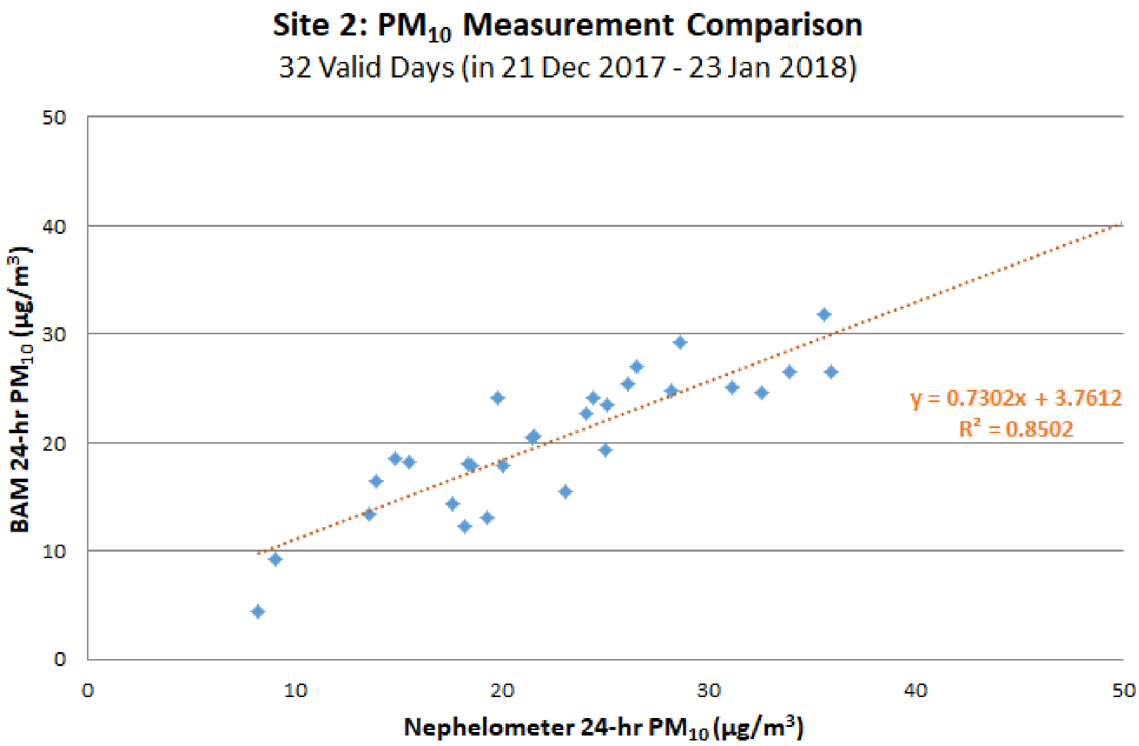

Figure 9 Daily PM_{10} measured by nephelometer as a function of daily PM_{10} measured by BAM at Site 2: North (east) rural/residential for (validated data) period 21 Dec 2017 – 23 Jan 2018

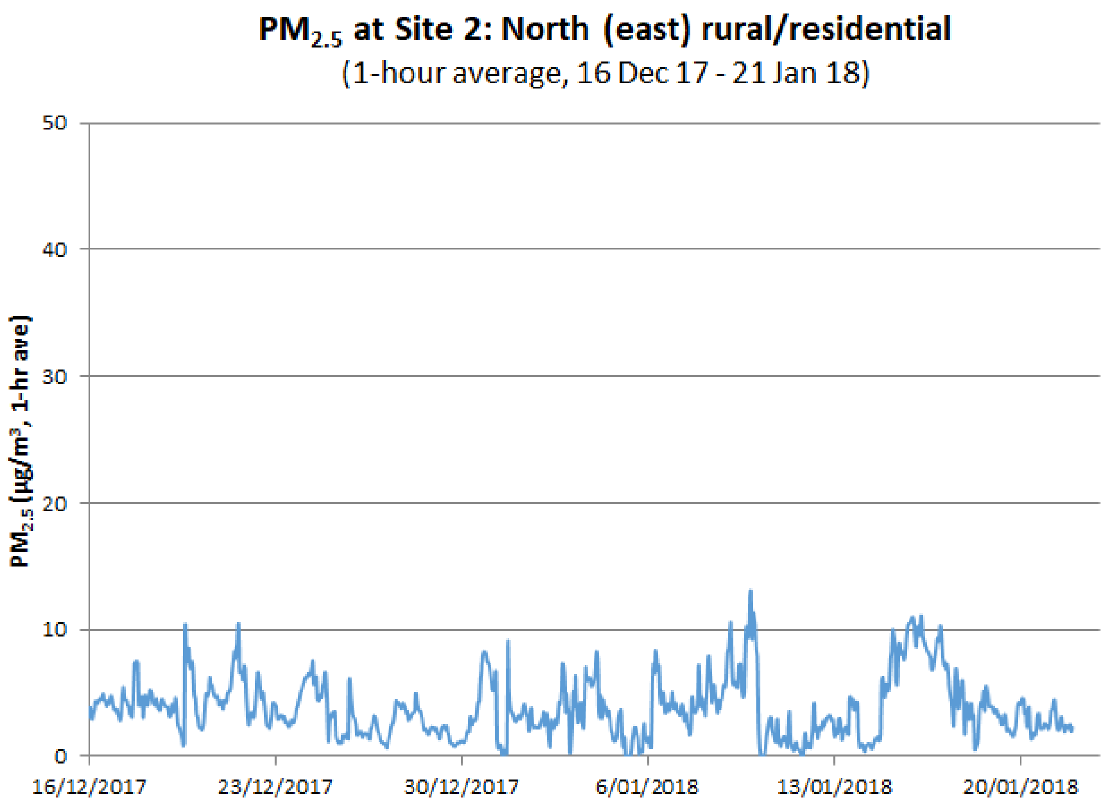

Figure 10 Hourly $PM_{2.5}$ nephelometer at Site 2: North (east) rural/residential 16 Dec 2017 – 21 Jan 2018

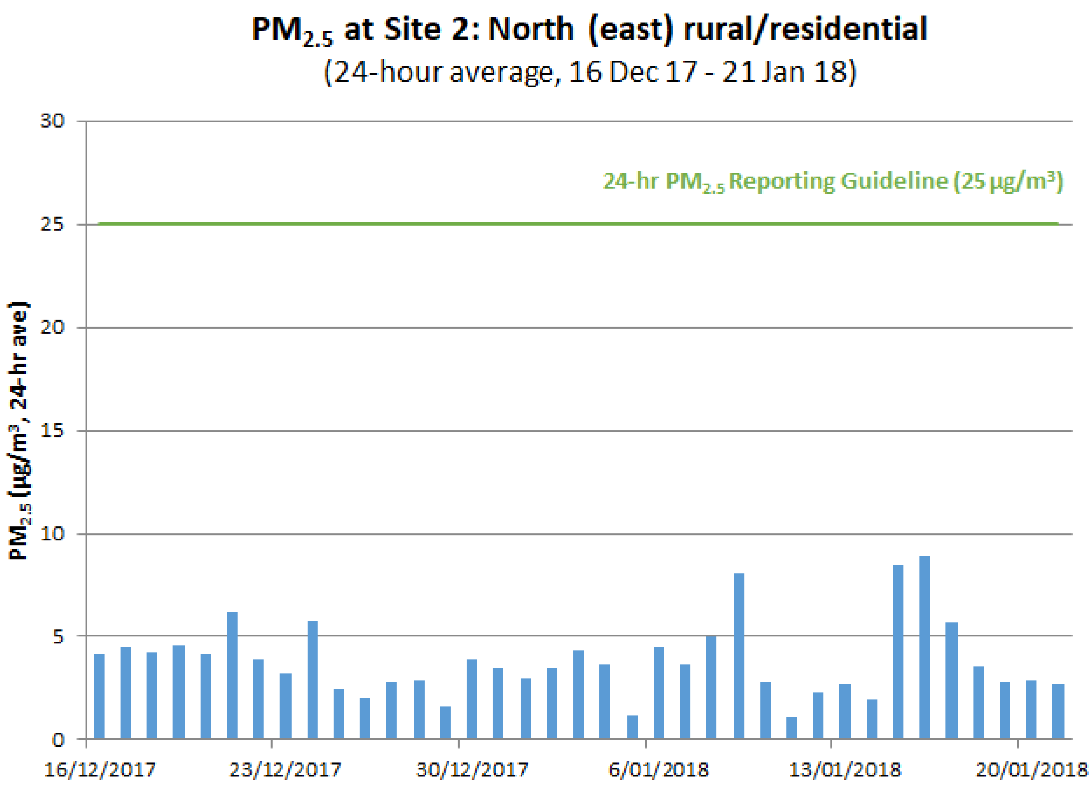

Figure 11 Daily $PM_{2.5}$ nephelometer at Site 2: North (east) rural/residential 16 Dec 2017 – 21 Jan 2018

Meteorology

We installed and commissioned a meteorological monitoring station at Site 2 on 21 December 2018. This was fully operational from 22 December 2017.

Figure 12 presents wind direction and wind speed measured at Site 2 for the period 22 December 2017 – 21 January 2018.

Figure 13 presents rain data measured at Site 2 for the same period.

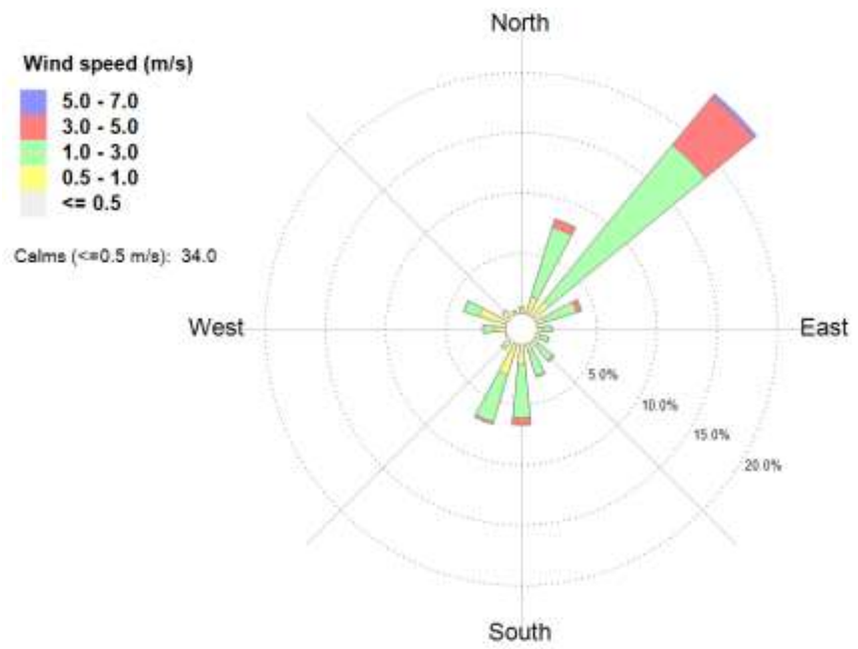

Figure 12 Wind direction and wind speed measured at Site 2: North (east) rural/residential for period 22 Dec 2017 – 21 Jan 2018

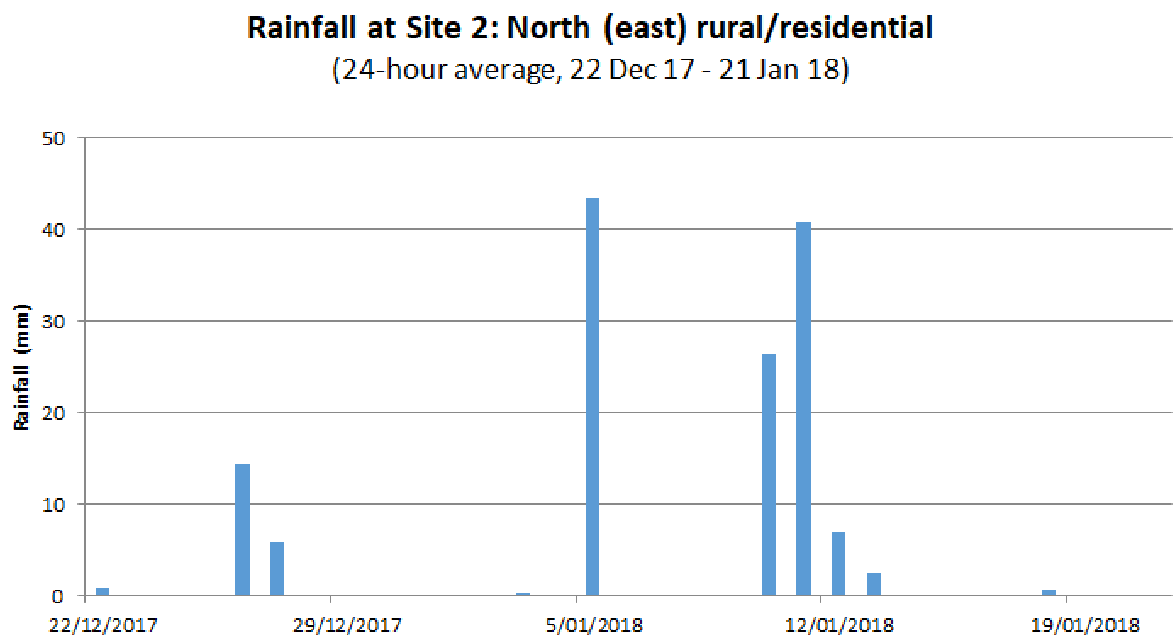

Figure 13 Bar chart of rainfall at Site 2: North (east) rural/residential for period 22 Dec 2017 – 23 Jan 2018

2.3 Site 3: South (east) rural

PM_{10} and $PM_{2.5}$

We installed and commissioned a PM_{10} nephelometer monitor at Site 3 on 15 December and it was fully operational from 16 December 2017. We installed and commissioned a $PM_{2.5}$ nephelometer on 21 December and it was fully operational from 22 December 2017.

The Site 3 PM_{10} nephelometer lost power at 8:00 PM on 10 January 2018. A site visit on 12 January revealed:

> *The power cable from the solar power array had been chewed and severed, presumably by a rabbit. Power was restored at 11:00 AM the following day and the cable was placed in a conduit to prevent the issue from occurring again.*

The Site 3 $PM_{2.5}$ nephelometer utilises a separate power supply (to avoid such issues) and lost no data. No other data connectivity issues were noted with this site during this period.

Figure 14 presents hourly PM_{10}. There were two exceedance (225 and 182 µg/m^3) of the 1-hour suggested trigger threshold (150 µg/m^3) at 11 am and midday on 19 December 2017. This was the same day that an exceedance of the suggested trigger threshold was measured at Site 1.

Figure 15 presents daily PM_{10} measured by the nephelometer between 16 December 2017 and 21 January 2018. NB: As noted above, daily PM_{10} measured by a nephelometer cannot be directly compared with the national environmental standard for PM_{10}.

Figure 16 and **Figure 17** present hourly and daily $PM_{2.5}$ for 22 December 2017 to 21 January 2018.

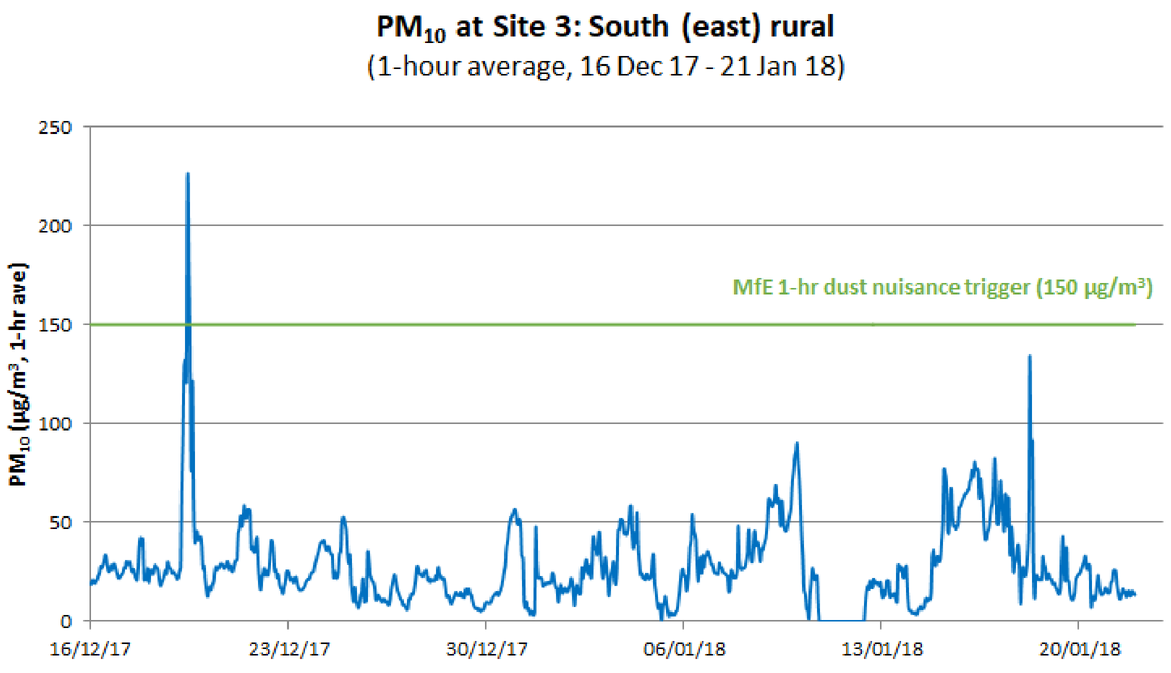

Figure 14 Hourly PM_{10} (nephelometer) at Site 3: South (east) rural for period 16 Dec 2017 – 21 Jan 2018

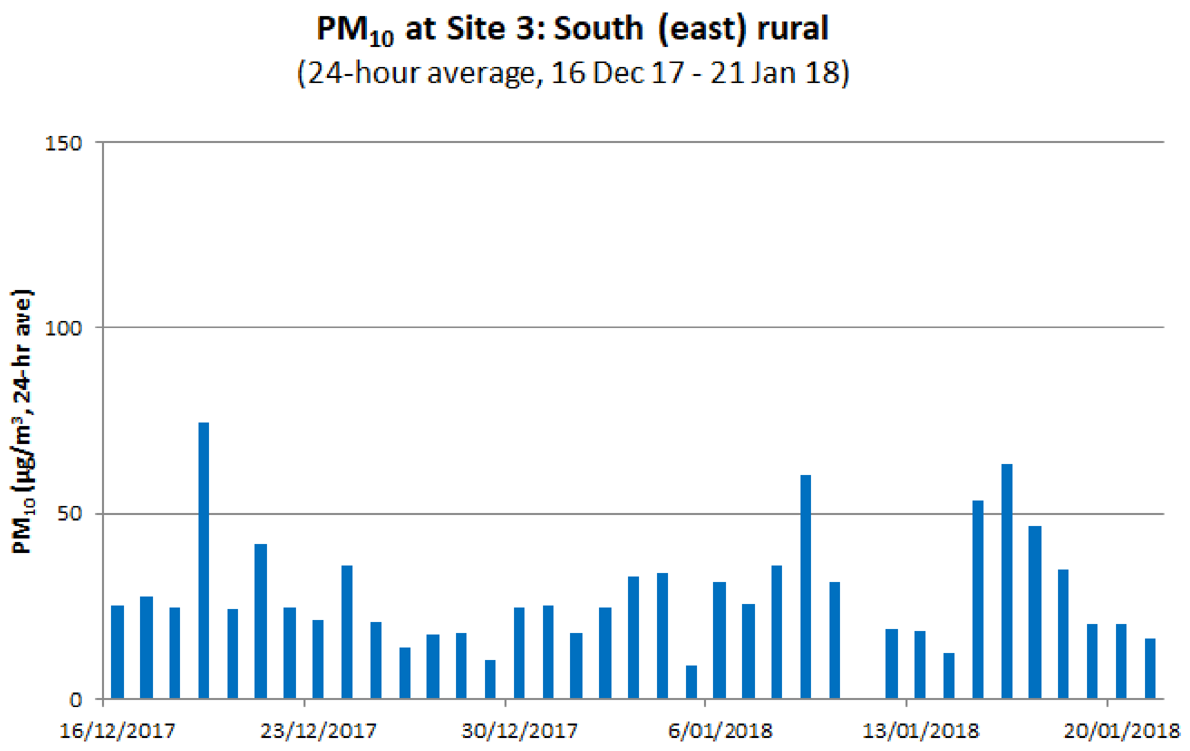

Figure 15 Daily PM_{10} (nephelometer) at Site 3: South (east) rural for period 16 Dec 2017 – 21 Jan 2018

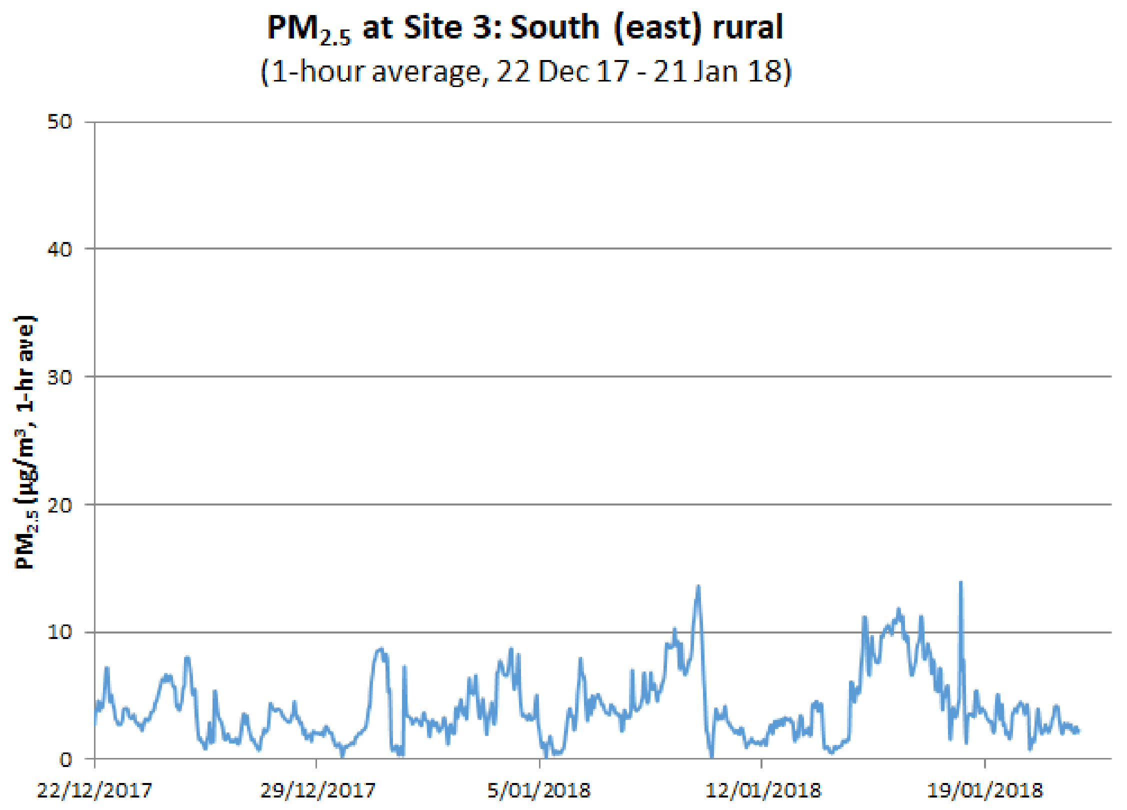

Figure 16 Hourly $PM_{2.5}$ (nephelometer) at Site 3: South (east) rural for period 22 Dec 2017 – 21 Jan 2018

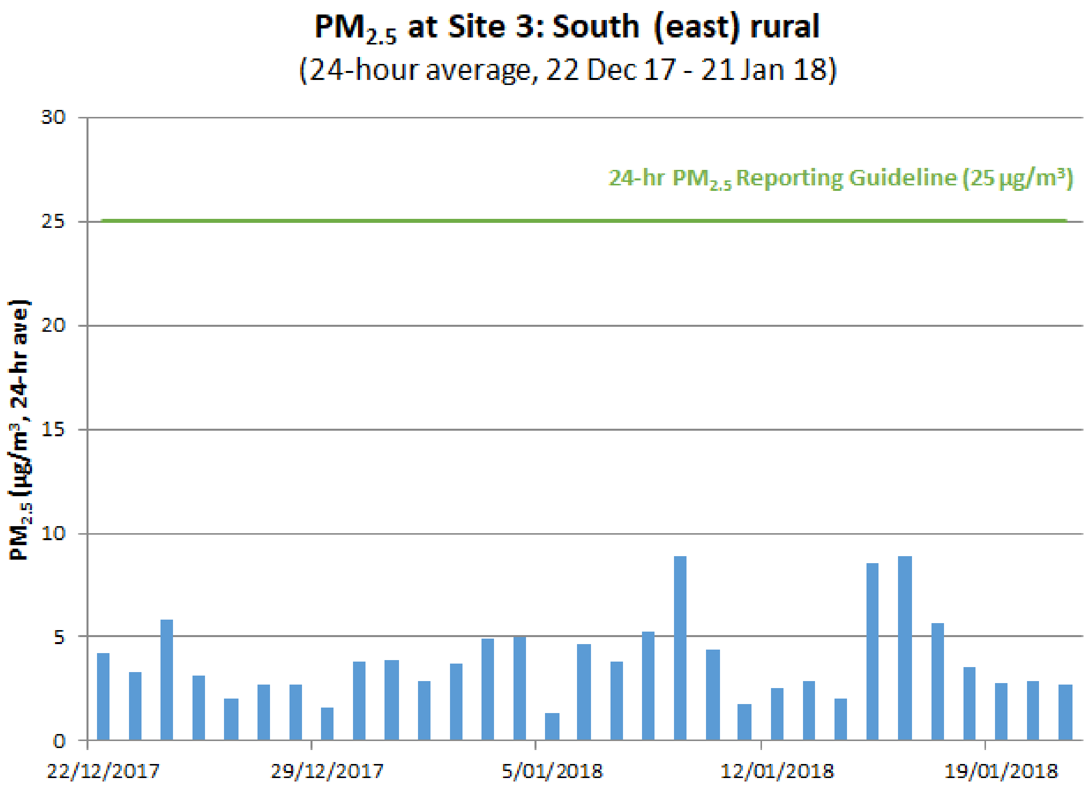

Figure 17 Daily $PM_{2.5}$ (nephelometer) at Site 3: South (east) rural for period 22 Dec 2017 – 21 Jan 2018

2.4 Site 4: Background rural/residential

PM_{10} and $PM_{2.5}$

We installed and commissioned a nephelometer (PM_{10}) monitor and BAM at Site 4 on 14 December. These were fully operational from 15 December 2017.

In the early hours of Monday morning 9 January 2018, we lost contact with the BAM at Site 4. Our site visit on 10 January revealed:

> *The site had been subject to powerful electrical surge. (This fault was unrelated to the fault on the same day at Site 2, refer Section 2.2). The surge by-passed the surge protector and seriously damaged the BAM rendering it inoperative. Due to the severity of the fault, we had to replace the instrument and the associated data logger. This was completed on Friday 12 January 2018 and the BAM has been functioning normally since. There was a three day period of data loss from the BAM (9-12 January).*

However, it further appeared that the electrical fault also affected the PM_{10} nephelometer as the following day (Tuesday 9 January 2018) we noticed a significant increase in the PM_{10} concentration recorded by the nephelometer at Site 4. The instrument was still reporting elevated PM_{10} concentrations during our visit on Wednesday 10 January 2018 at which time we were unable to identify any obvious external source for the elevated PM_{10} concentration. Furthermore, the $PM_{2.5}$ monitor at the same site was not recording elevated concentrations.

Further inspection of the monitor determined that the heater element on the inlet was not operating optimally. We therefore installed a second PM_{10} nephelometer at Site 4 on 11 January 2018. We now have sufficient co-location data from Site 4 to identify the date/time point at which the original PM_{10} nephelometer developed a heating fault. We intend to remove the faulty nephelometer soon. Due to the successful co-location, there has been no data loss for the nephelometer during this monitoring period.

Figure 18 presents hourly PM_{10} from the nephelometer (blue) and BAM (pink) for the period 15 December 2017 – 21 January 2018. There were no exceedances of the 1-hour suggested trigger threshold (150 µg/m^3) during this monitoring period at Site 4.

Figure 19 presents daily PM_{10} measured by the nephelometer and the BAM (reference method) between 15 December 2017 and 21 January 2018 (excluding four days of lost BAM data as noted above). There were no exceedances of the NES for PM_{10} measured by the BAM during this period at Site 4.

Figure 20 presents PM_{10} measured by BAM as a function of PM_{10} measured by nephelometer for available validated days of data at Site 4. This correlation suggests the nephelometer is over-reading actual PM_{10} levels when compared with the reference method.

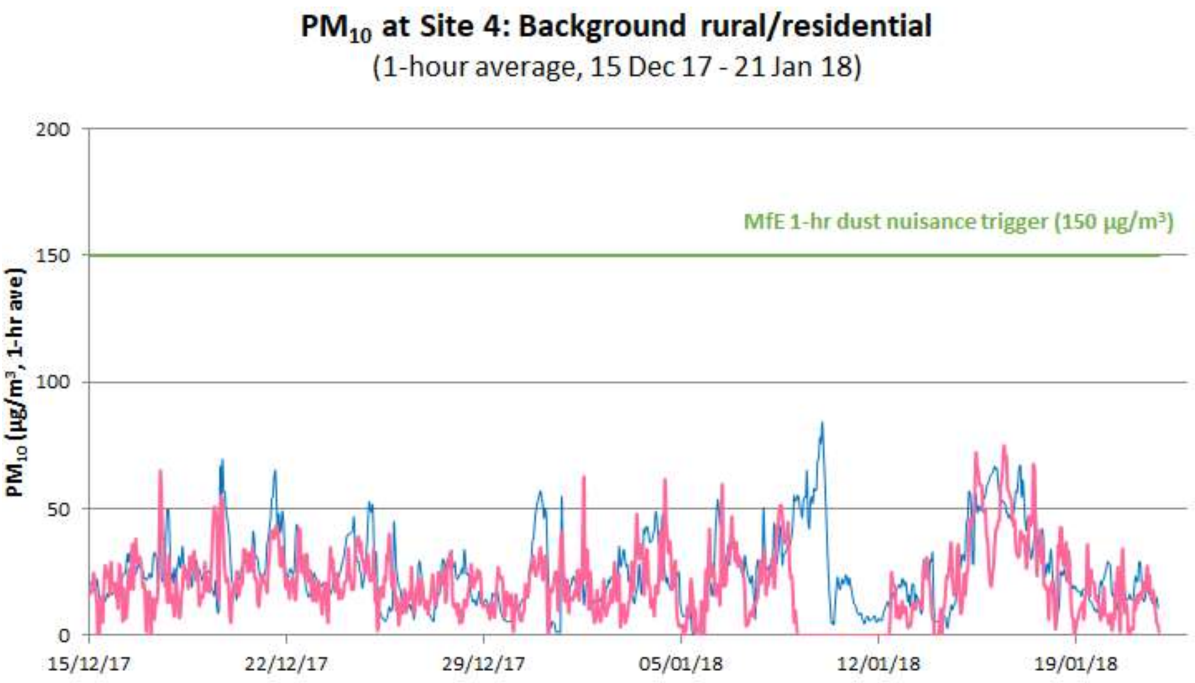

Figure 18 Hourly PM_{10} nephelometer (blue) and BAM (pink) at Site 4: Background rural for period 15 Dec 2017 – 21 Jan 2018

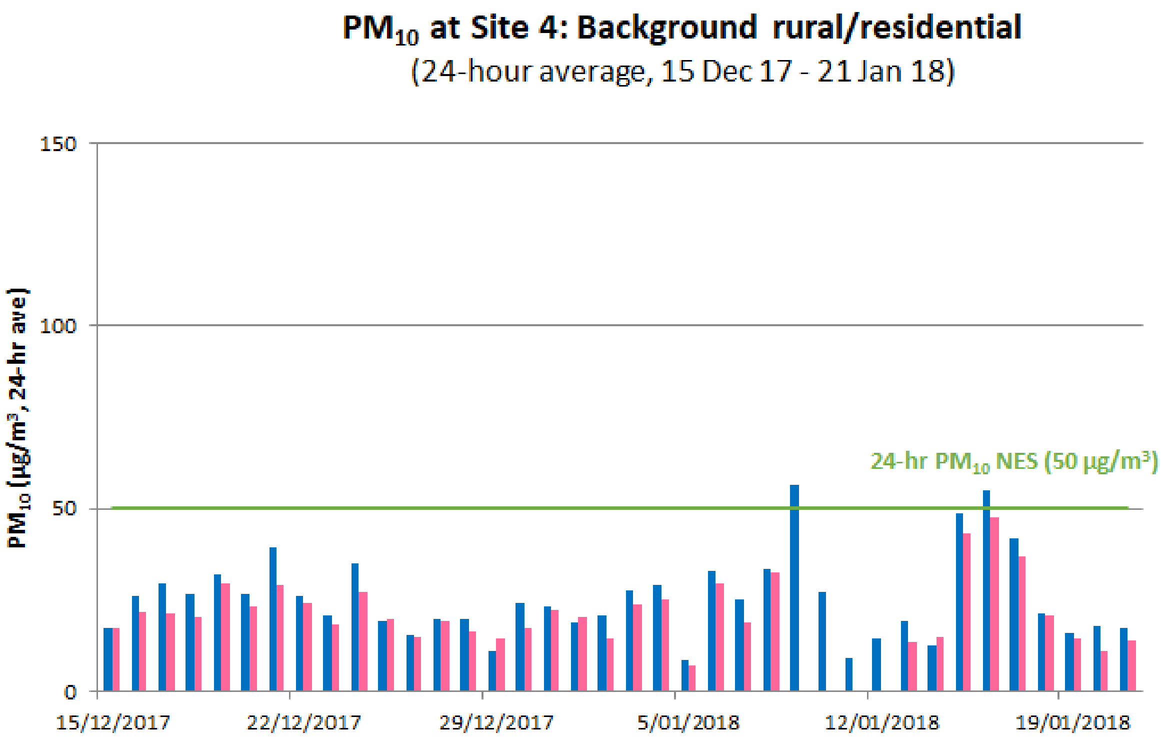

Figure 19 Daily PM_{10} nephelometer (blue) and BAM (pink) at Site 4: Background rural for period 15 Dec 2017 – 21 Jan 2018

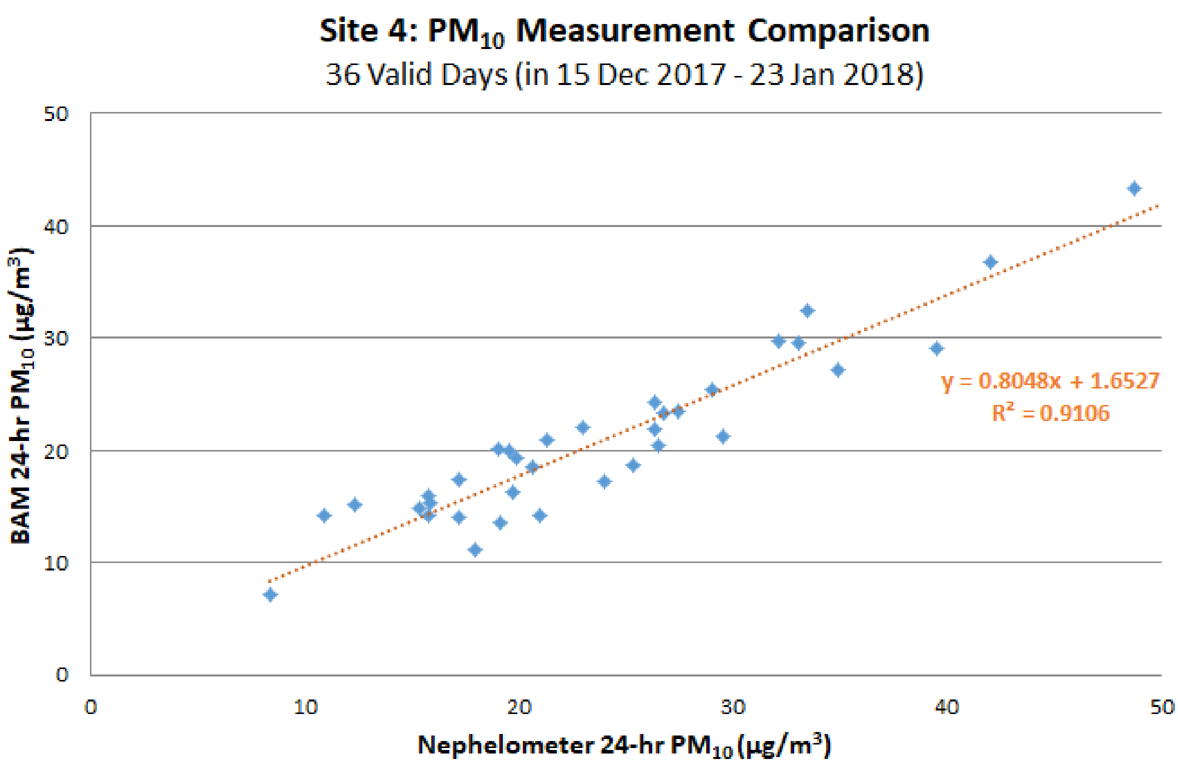

Figure 20 Daily PM_{10} measured by nephelometer as a function of daily PM_{10} measured by BAM at Site 4: Background rural/residential for (validated data) period 16 Dec 2017 – 23 Jan 2018

Figure 21 presents hourly $PM_{2.5}$ measured by nephelometer at Site 4 for the period of operation (15 December – 21 January 2018).

Figure 22 presents daily $PM_{2.5}$ measured by nephelometer at Site 4 for the period of operation (15 December – 21 January 2018). There was one exceedance (27 µg/m^3) of the MfE reporting guideline (25 µg/m^3) on 9 January 2018.

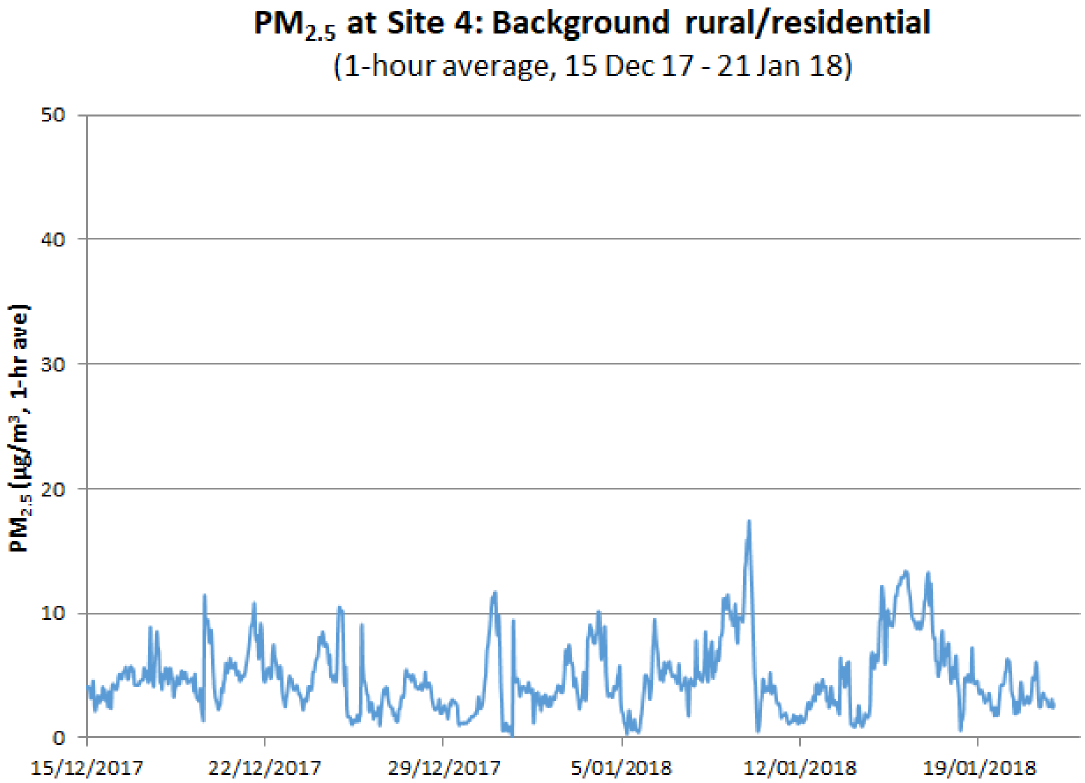

Figure 21 Hourly $PM_{2.5}$ nephelometer at Site 4: Background rural/residential for period 15 Dec 2017 – 21 Jan 2018

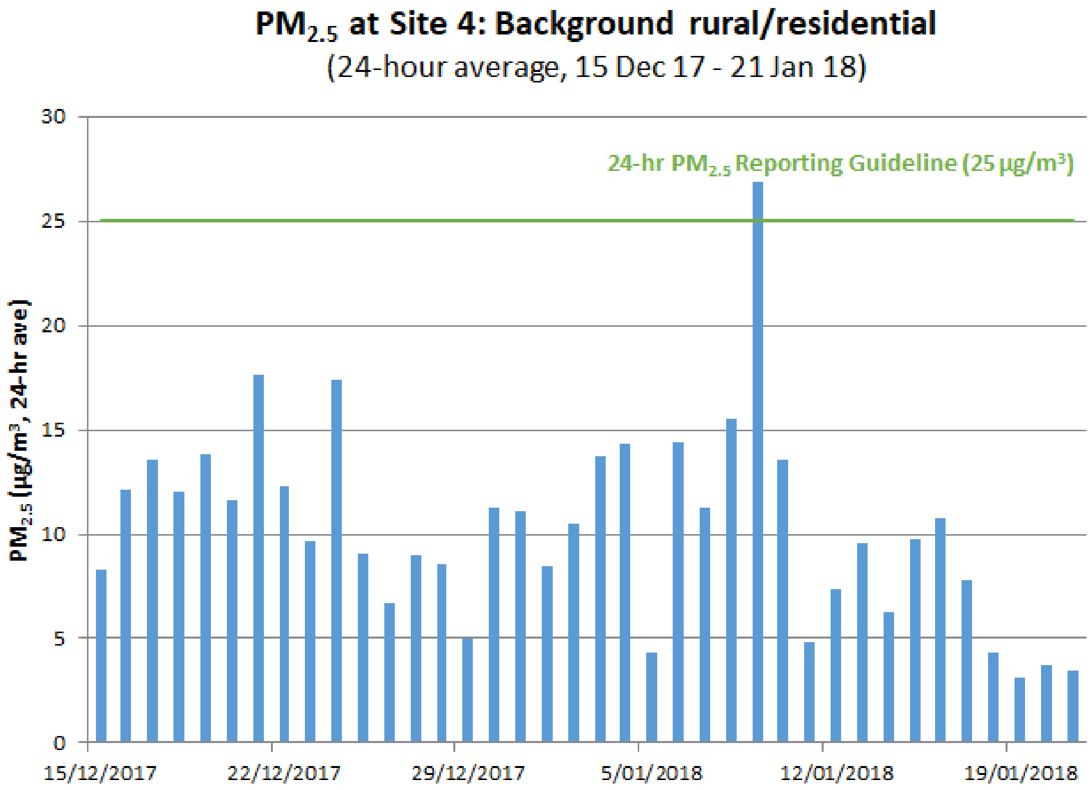

Figure 22 Daily $PM_{2.5}$ nephelometer at Site 4: Background rural/residential for period 15 Dec 2017 – 21 Jan 2018

2.5 Site 5: South (west) rural

We installed and commissioned a PM_{10} nephelometer monitor at Site 5 on 15 December and it was fully operational from 16 December 2017. There were no data connectivity issues with this site for the period ending 21 January 2018.

Figure 23 presents hourly PM_{10}. There were no exceedances of the 1-hour suggested trigger threshold (150 µg/m^3) during this monitoring period at Site 5.

Figure 24 presents daily PM_{10} measured by the nephelometer between 16 December 2017 and 21 January 2018. NB: As noted above, daily PM_{10} measured by a nephelometer cannot be directly compared with the national environmental standard for PM_{10}.

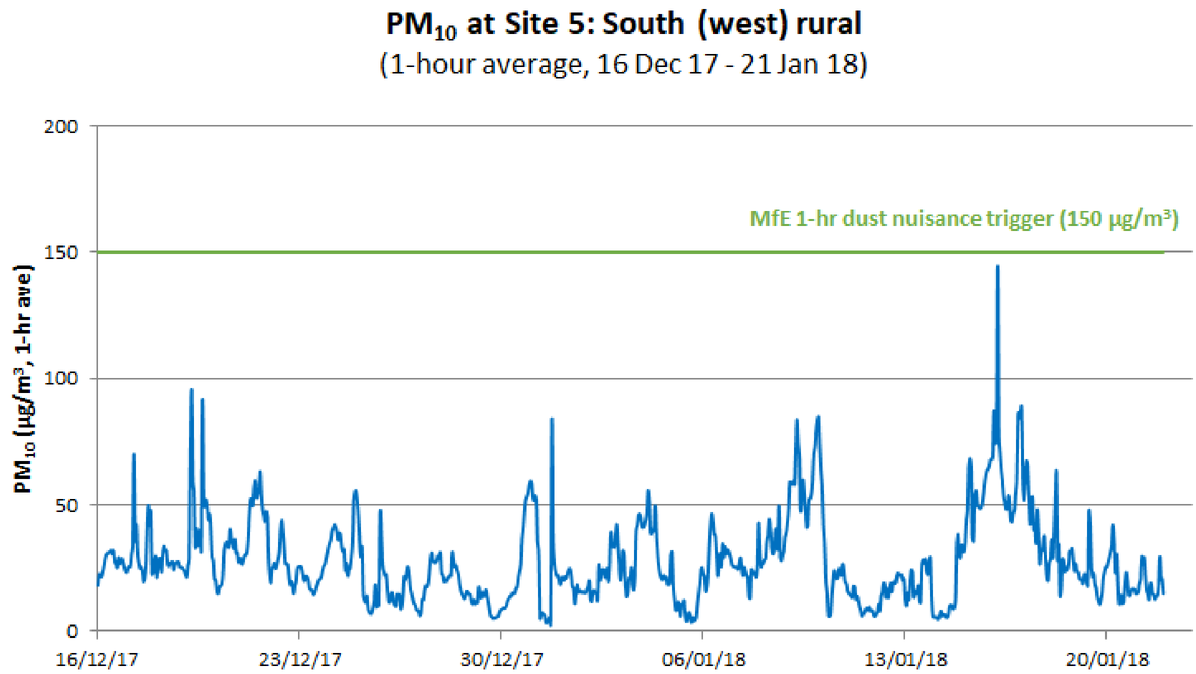

Figure 23 Hourly PM_{10} (nephelometer) at Site 5: South (west) rural for period 16 December 2017 – 21 January 2018

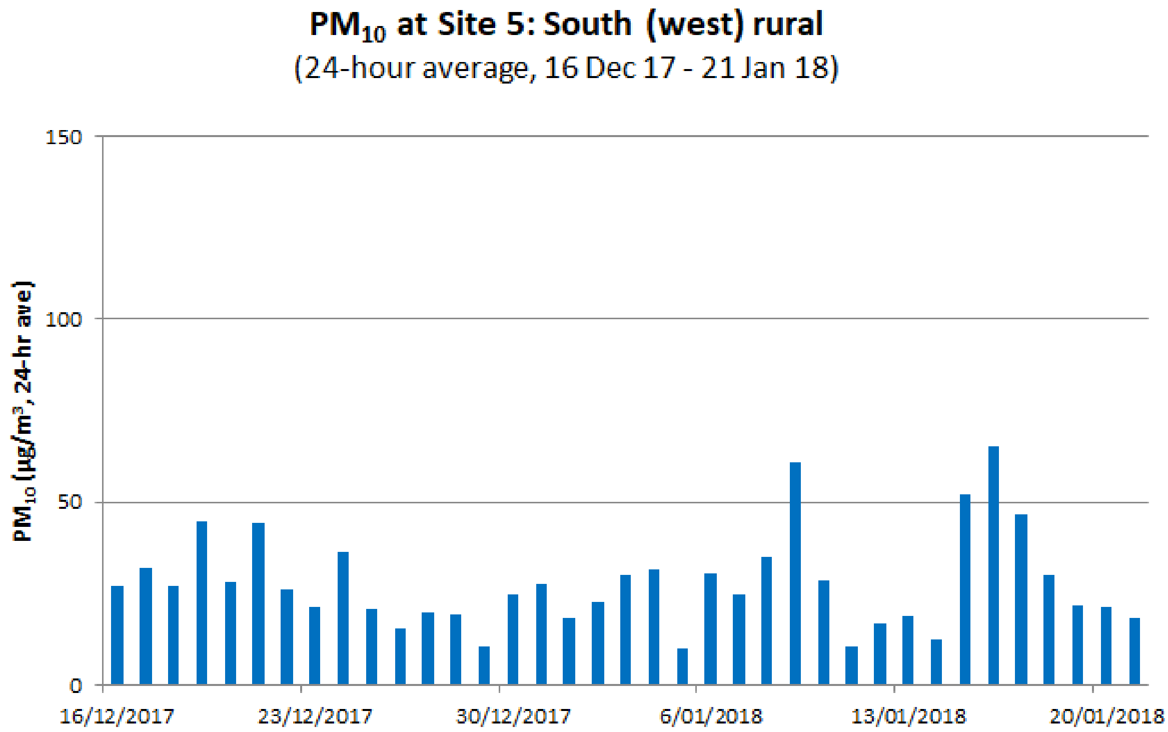

Figure 24 Daily PM_{10} (nephelometer) at Site 5: South (west) rural for period 16 December 2017 – 21 January 2018

2.6 Site 6: North (west) rural/residential

Installation of a PM_{10} nephelometer at Site 6 was initially delayed through a communication error (our email went into the residents spam filter). A follow-up visit saw the successful installation of a nephelometer on 22 December 2017. Unfortunately, however, cellular reception was insufficient for the modem to transmit data.

On Friday 12 January 2018 we installed a passive gain antennae, however while the signal strength improved, it was insufficient for data transmission.

The following week (Friday 19 January) we raised the height of the antenna and installed an active gain antenna to compensate for the increase in cable length. Unfortunately, we were unable to obtain sufficient signal strength at Site 6 to permit cellular communication. This is unusual as installing a pole mounted active antennae usually resolves such problems.

Whilst we checked cellular reception prior to recommending this location, the issue arose from a small change in the monitoring site location at the request of the homeowner. It was not until we commenced commissioning that we encountered the challenges involved with poor cellular reception. It was similarly, unusual not to be able to resolve this through installing an active gain antennae, or by raising the antennae height.

We manually retrieved the data from the nephelometer on 19 January 2018 and plan to retrieve the remainder of the data for this monitoring period in our next sit visit (scheduled for 1 February 2018). Irrespective of the issues with connectivity, there were no data loss issues with this site.

On 22 January 2018, we notified Environment Canterbury that this site was non-functional and received approval to relocate the nephelometer and RCS monitoring to a new site as soon as possible. The new Site 6A is sufficiently close (< 300 metres) that the location for Site 6 shown in **Figure 1** is still indicative.

Figure 25 presents hourly PM_{10} for Site 6. There were no exceedances of the 1-hour suggested trigger threshold (150 µg/m^3) between 16 December 2017 and 21 January 2018.

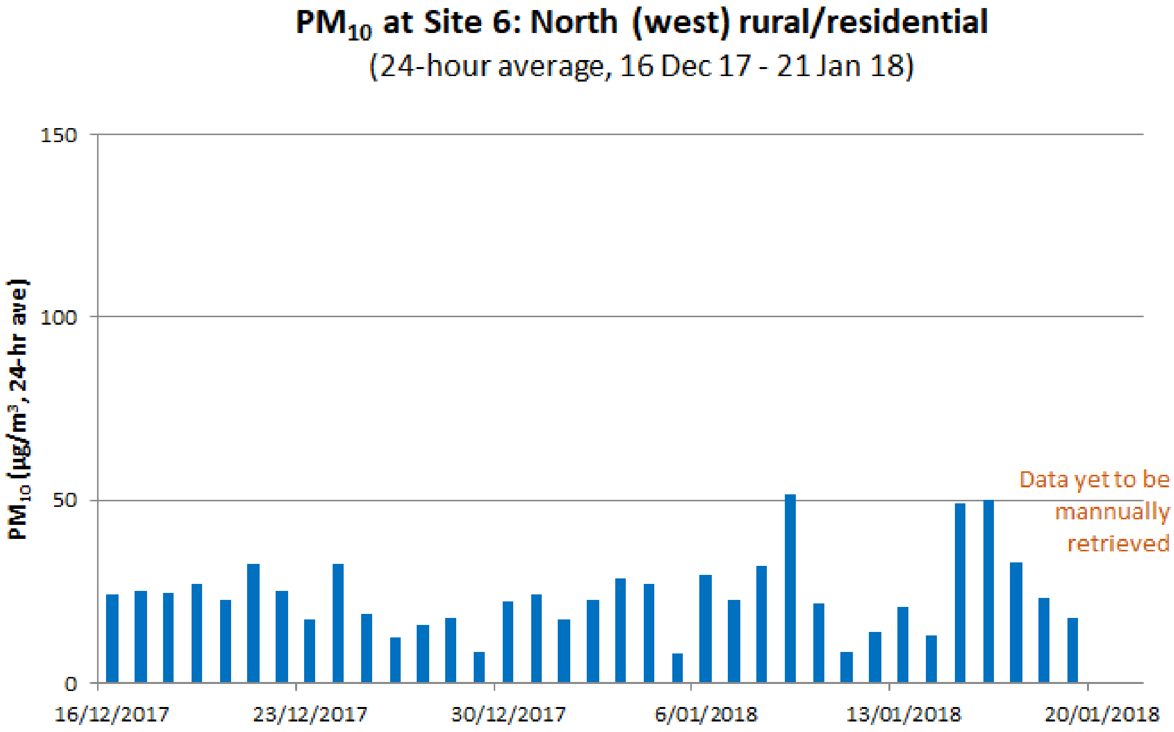

Figure 26 presents daily PM_{10} measured by the nephelometer at Site 6 for this period. NB: As noted above, daily PM_{10} measured by a nephelometer cannot be directly compared with the national environmental standard for PM_{10}.

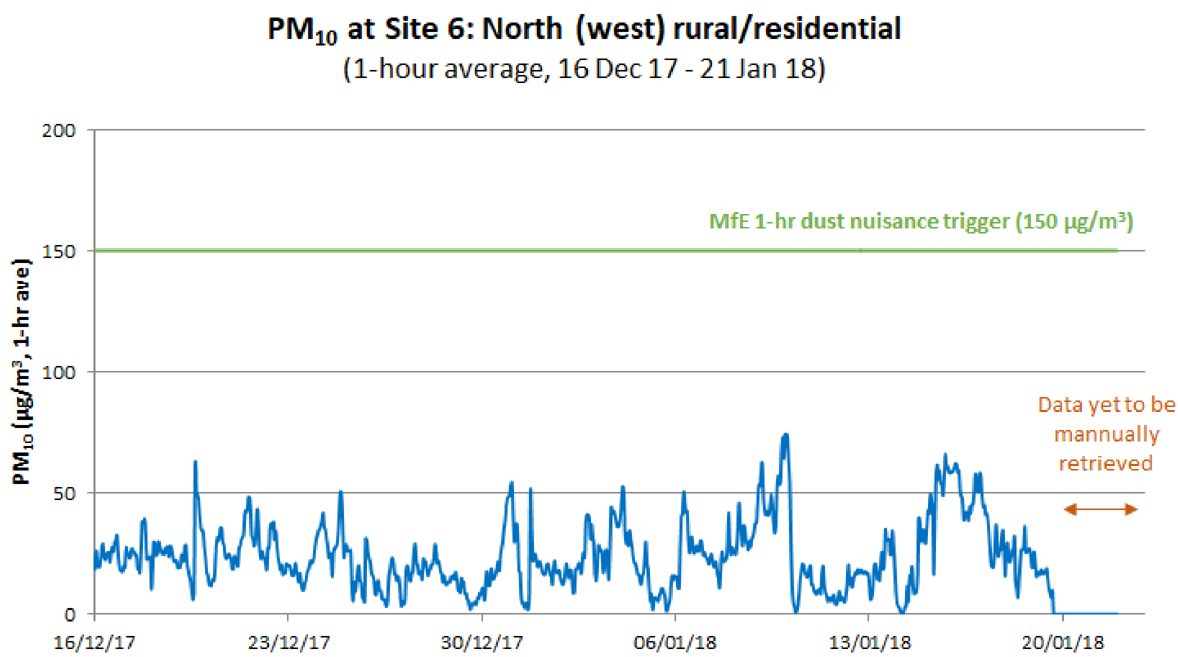

Figure 25 Hourly PM_{10} (nephelometer) at Site 6: North (west) rural/residential for period 16 Dec 2017 – 21 Jan 2018

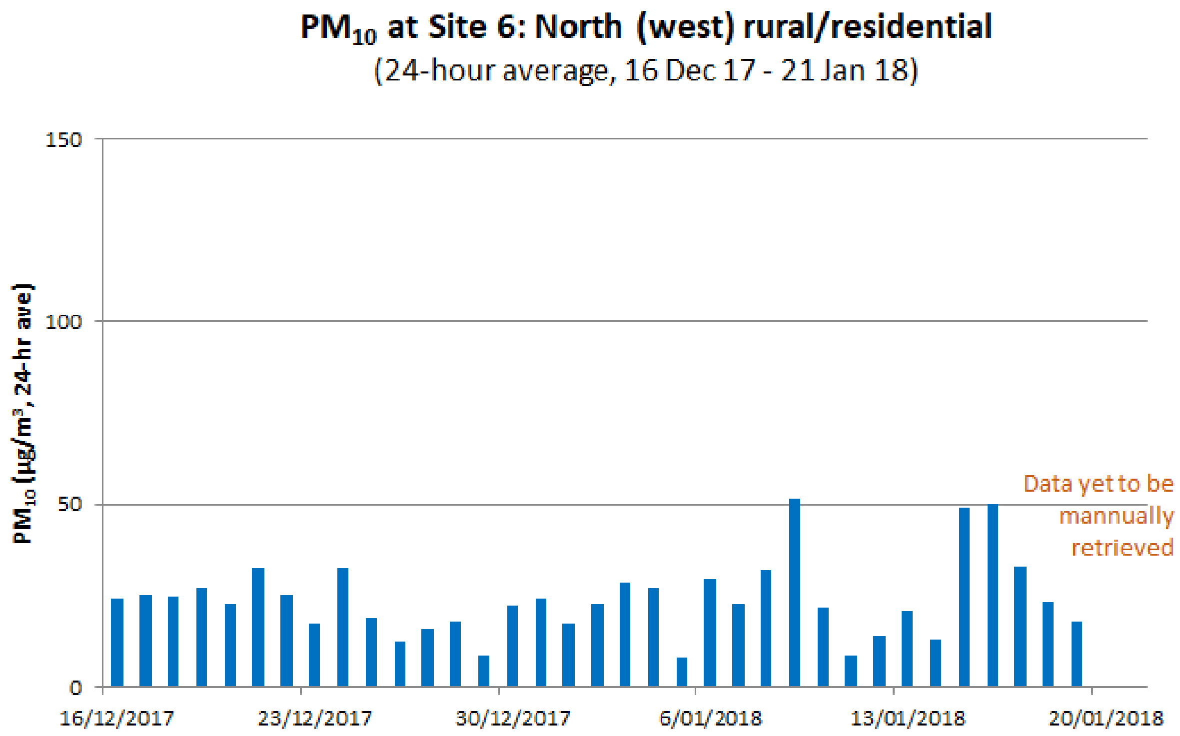

Figure 26 Daily PM_{10} (nephelometer) at Site 6: North (west) rural/residential for period 16 Dec 2017 – 21 Jan 2018

2.7 Quarry Operations

At our meeting with the quarries on 7 November 2017 (refer Section2.1) we requested monitoring and operational data to inform the Yaldhurst monitoring programme. The quarry representatives responded positively to this request.

However, we have been unable to obtain operational data from the quarries to date.

2.8 Complaints data

Table 3 presents Environment Canterbury's record of dust complaints during the monitoring period.

Table 3 Dust complaints received by Environment Canterbury 8 Dec 17 – 21 Jan 18

Complaint Received Date	Incident Start Date	Incident Start Time	Description of Incident	No. Complaints	General Location Description
14 Dec 17	12 Dec 17	08:00	14/12/2017 04:23PM Caller reports dust coming from the access way... large amounts of dust has accumulated and is blowing both ways down ... Guys Road... Has been an issue for today 8am-now and on 13/12/2017 and 12/12/2017.	1	Guys Road
15 Jan 18	15 Jan 18	18:00	15/01/2017 6:05pm - [Dust Old West Coast Road and the Main West Coast Road, Yaldhurst] ... there is very visible dust in the air over our area Old West Coast Road and the Main West Coast Road. **2nd Incident Report** - 15/01/2018 6:00pm - ... a massive haze of dust…	2	Old West Coast Road and the Main West Coast Road, Yaldhurst, Christchurch
17 Jan 18	15 Jan 18	08:00	17/1/2018 04:16pm - .... dust has been going everywhere over the last three days... 17/01/2018 05:11pm - EMAIL received:... along Guys Rd and a ... truck was coming out of quarry onto the road in front of me. I was literally swallowed up in dust and my visibility was zero."	2	Conservators Road, Yaldhurst, Christchurch
19 Jan 18	19 Jan 18	13:00	18/01/2018 6:00pm - ...massive dust clouds coming from the trucks that travel along here. ... dust they are sending into the air	1	Dust on Guys Road

3.0 Conclusions

Six ambient air quality monitoring sites have been installed and operated for a period of one month 22 December 2017 – 21 January 2018.

Three exceedances of the hourly suggested trigger threshold for dust nuisance (150 µg/m^3, MfE 2016) were recorded at two monitoring locations on the same day (19 December 2017):

- Site 1 (East) 4 pm (185 µg/m^3)
- Site 3 (South) 11 am (225 µg/m^3)and midday (182 µg/m^3)

Dust complaints recorded by Environment Canterbury do not coincide with these exceedances.

There were no exceedances of the national environmental standard for PM_{10} recorded by the reference method monitors at Site 2 (North rural/residential) or Site 4 (Background rural/residential) during this period.

Co-located monitoring for PM_{10} using nephelometers and beta attenuation monitors (BAM) at two monitoring locations (Site 2 and Site 4) has provided good correlations between the methods. The data to date suggest the nephelometers are over-reading actual PM_{10} levels when compared with the reference method.

Co-located monitoring for $PM_{2.5}$ using nephelometers also appears to be providing robust, realistic ambient data.

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