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Report No. 4RS-APO-180487-R646826

**RESPIRABLE AIRBORNE DUST MONITORING AT VARIOUS  
LONDON UNDERGROUND STATIONS AND TRAIN LINES**

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Issue Date: 12<sup>th</sup> April 2019

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# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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REPORT REVISION	ISSUE DATE	REVISION DETAILS
INITIAL	1 <sup>ST</sup> APRIL 2019	DRAFT FOR COMMENT
FINAL	12 <sup>TH</sup> APRIL 2019	PERSONAL INFORMATION ON LUL STAFF REMOVED FROM REPORT

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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## Executive Summary

At the request of Mr Nick Wilson, Occupational Hygienist – Transport for London, personal dust monitoring for respirable dust exposure was undertaken on station staff and train operators at various stations and within train line cabins. Selected samples from the train operator monitoring were subject to crystalline silica and metals analyses. All of the samples were collected using respirable dust cyclone heads that would collect the respirable dust fraction.

Static air sampling was also undertaken to assist in the assessment of airborne dust levels in cases where little or no platform duties were carried out by station staff or where the station personnel were not comfortable wearing a personal sampler. The Grimm portable aerosol spectrometer was also used within the train cabs, to assess the dust size distribution and dust concentration in real time.

The selected stations where monitoring was carried out were Aldgate East, Baker Street, Elephant and Castle, Euston Square, Hampstead, King's Cross, Oxford Circus, Piccadilly Circus, Tottenham Court Road, Vauxhall, Waterloo and Paddington. The Train Operator dust exposure monitoring was carried out on the District, Piccadilly, Jubilee, Victoria, Bakerloo, Central, Northern, Circle lines.

For train operators, the highest respirable dust concentration measured was of 0.68 mg/m<sup>3</sup> for the Bakerloo Line, with most levels being below this value on the rest of the lines. Whilst these results are not directly comparable to previous dust monitoring exercises because train operator duties vary, as a general indication, the respirable dust concentration exposure levels were overall slightly elevated to those measured previously; Victoria, District and Circle were found with similar results from last round of sampling (Report ref. *4RS-APO-160906-R592277-Rev01*). The lowest dust levels resulted from sampling during train operators journeys were found for the personal samples taken on the District and Circle Lines. The levels recorded for all lines were significantly less than the Workplace Concentration Exposure Limit of 4 mg/m<sup>3</sup> (long term 8 hour Time Weighted Average). No defined short term exposure limits exist for airborne dust, but typically the short-term exposure limits are estimated to be approximately three times the long term exposure limit i.e. 12 mg/m<sup>3</sup> over a 15-minute period. Therefore, the levels measured for the Train Operators and passengers of the different lines were significantly below the inferred short-term workplace exposure limit.

Selected samples taken from collectors worn by train operators were analysed for crystalline silica content by the Institute of Occupational Medicine (IOM). The levels found were below the method detection limit of 0.01 mg/filter for all of the samples analysed. Therefore, all of the samples were well below the Workplace Exposure Limit of 0.1 mg/m<sup>3</sup> (long term 8-hour TWA) for respirable crystalline silica.

Similar findings were recorded following metals analysis of personal samples collected from the train operators during selected journeys. The majority of metals were found at concentrations below the method limit of detection of 0.001 mg/filter. Iron levels were found to vary from 0.011 mg/m<sup>3</sup>, from the personal sample collected on the District line train operator, to 0.202 mg/m<sup>3</sup>, from the personal sample collected on the Bakerloo line train operator.

For station staff carrying out customer assistant duties at Waterloo, Aldgate East, Hampstead, Kings Cross, Oxford Circus, Paddington, Piccadilly Circus and Vauxhall stations, the dust levels measured were below the Workplace Exposure Limit of 4 mg/m<sup>3</sup> (long term 8 hour Time Weighted Average); with the highest concentration recorded at 0.64 mg/m<sup>3</sup> for the personal sample collected from the gate line to Bakerloo platforms at Paddington station. Where both personal and static monitoring were carried out within the stations ticket halls or gate lines, the results showed similar concentrations between the two types of sampling.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

### 1. Introduction

- 1.1 At the request of Mr Nick Wilson, Transport for London (Rail and Underground), personal monitoring for respirable airborne dust exposure was to be undertaken on LUL Train Operators whilst driving and on Station Staff conducting gate line duties, platform duties (Station Assistant Trains, SATs) and other station duties.
- 1.2 Static monitoring for respirable airborne dust was also carried out at various platforms. A minimum of one sample for each Line, collected whilst monitoring Train Operator exposure, was to be analysed for respirable crystalline silica and for metals. In addition to this sampling, a Grimm laser scatter dust monitor was to be used for one shift per line to gather 'real time' data on the particle size distribution.
- 1.3 The specific stations and locations where personal and static monitoring was undertaken are listed as follows:

Stations	Sampling Locations	Sample Type
Aldgate East	Gate line/ platform duties.	Personals
	District line platforms.	Statics
Baker Street	Jubilee, Bakerloo, Hammersmith & City and Circle lines platforms, Ticket Halls and Gate lines.	Statics
Elephant and Castle	Bakerloo line platforms, Ticket Halls and Gate lines.	Statics
Euston Square	Circle and Hammersmith & City line platforms, Ticket Hall & Gate lines.	Statics
Hampstead	Northern line platforms & Ticket Hall, Gate lines.	Statics
	Gate line/ platform duties.	Personals
King's Cross	Piccadilly, Victoria, Northern, Hammersmith & City, Circle and Metropolitan lines platforms & Ticket Halls, Gate lines.	Statics
	Gate line/ platform duties.	Personals
Oxford Circus	Bakerloo, Central and Victoria lines platforms & Gate lines.	Statics
	Gate line/ platform duties.	Personals
Piccadilly Circus	Piccadilly line platforms & Main gate line.	Statics
	Gate line/ platform duties.	Personals
Tottenham Court Road	Central and Northern lines platforms & Northern Gate line.	Statics

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Stations	Sampling Locations	Sample Type
Vauxhall	Victoria line platforms and Ticket Hall.	Statics
	Gate line/ platform duties.	Personals
Waterloo	Waterloo & City and Bakerloo line platforms	Statics
	Gate line/ platform duties.	Personals
Paddington	District & Circle, Bakerloo lines platforms	Statics
	Gate line/ platform duties.	Personals

Table 1. Locations to be monitored.

- 1.4 Train operator leading cab journey monitoring was to be carried out on the District, Piccadilly, Jubilee, Victoria, Bakerloo, Central, Northern and Circle lines.
- 1.5 Open sections of the District lines were included in the respirable dust monitoring shifts, as they are representative to the Train Operator's duty/ journey, hence his/her exposure.

## 2. Technical Background

- 2.1 The health effects concerning inhalation exposure to dust are dependent upon the size, shape and composition of the particles. In occupational health, general dust is classified in terms of particle size, termed as inhalable, thoracic or respirable. The inhalable fraction of dust is defined as particles that can be inhaled and deposited throughout the respiratory tract, i.e. from the nasal to the alveolar region in the lungs. Thoracic dust is the fraction of inhaled airborne material penetrating beyond the larynx. Respirable dust is the term given to dust particles that are small enough to penetrate the deep lung and therefore largely deposit in the alveolar region where gas exchange takes place.
- 2.2 Respirable and inhalable dusts are currently assessed against the respective Workplace Exposure Limits (WEL's) of 4 mg/m<sup>3</sup> and 10 mg/m<sup>3</sup> averaged over an 8-hour reference period (Health and Safety Executive Document EH40/05, 3<sup>rd</sup> Edition 2018). Short-term exposure limits do not currently exist for airborne dust, but usually the short-term exposure limits are taken to be 3 times the long-term exposure limits.
- 2.3 The long-term 8 hour exposure limits are averages for an 8 hour shift. Consequently, if during a shift the operator is only exposed to a level of dust for 6 hours, to allow comparison with the HSE limits the 8 hour time weighted average (TWA) exposure needs to be calculated. For the example of 6 hours exposure in an 8 hour period the time weighted average is 3/4 of the level measured for the six hour period. The values quoted in the results tables are dust concentrations, therefore they are equivalent to 8 hours exposure in an 8 hour period.

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- 2.4 Prolonged exposure to respirable quartz may result in silicosis, a progressive and irreversible condition in which healthy lung tissue becomes replaced with areas of fibrosis. The HSE Workplace Exposure Limit (WEL) for respirable crystalline silica has been set at a level of 0.1 mg/m<sup>3</sup> averaged over an 8-hour reference period (HSE Document EH40/05, 3<sup>rd</sup> Edition 2018).
- 2.5 Prolonged exposure to fine metal particles may also cause respiratory illnesses. The HSE Workplace Exposure Limits for Iron, Zinc, Chromium, Copper, Nickel and Manganese are detailed within the following table:

Substance		Long - term exposure limit of (8-hour time weighted average)	Units
Iron salts (as Fe)		1	mg/m <sup>3</sup>
Copper dusts and mists (as Cu)		1	mg/m <sup>3</sup>
Chromium		0.5	mg/m <sup>3</sup>
Chromium <sup>VI</sup>		0.05	mg/m <sup>3</sup>
Nickel and its organic compounds	Water-soluble	0.1	mg/m <sup>3</sup>
	Water insoluble	0.5	mg/m <sup>3</sup>
Manganese and its inorganic compounds – respirable		0.05	mg/m <sup>3</sup>
Zinc distearate – respirable dust		4	mg/m <sup>3</sup>
Arsenic and arsenic compounds except arsine (as As)		0.1	mg/m <sup>3</sup>

Table 2. Workplace Exposure Limits set out in the HSE EH40/05, 3<sup>rd</sup> Edition 2018.

### 3. Method

- 3.1 Respirable dust levels were measured following the guidance set out in the Health & Safety Executive Document MDHS 14/4: General methods for sampling and gravimetric analysis of respirable, thoracic and inhalable aerosols, and in house test procedure 4R-E206 Issue 7.
- 3.2 Sampling pumps equipped with respirable dust cyclone heads were worn by the Train Operators, Station Staff and Analysts on train cabs journeys. The locations and location codes are given in the tables of results. Examples of a cyclone (respirable) dust head is shown in Figure 9.
- 3.3 Respirable airborne dust monitoring was carried out at each of the stations for one shift.
- 3.4 The Train Operators monitoring was undertaken over three shifts on each line. As well as personal dust exposure measurements, a Grimm laser scatter static dust monitor was also used during one of the shifts to take continuous measurements of different size particles by the physical principle of orthogonal light scattering. For the current monitoring programme the particles' diameter sizes chosen for measurement were PM 10 µm, 2.5 µm and 1 µm.

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- 3.5 The personal samples were collected on 25 mm GLA 5000 polyvinyl chloride (PVC) filters to allow both gravimetric analysis and then subsequent analysis for respirable crystalline silica (as quartz), by infrared spectroscopy, and for quantitative metals analysis.
- 3.6 One of the primary aims was to obtain personal monitoring data for a shift on each occasion. This was either achieved by one person wearing the monitoring pump for the duration of the shift or a sequence of individuals wearing the same sampling head, or each wearing a separate sampling head. Where separate sampling heads were used, each was run for sufficient time to allow the filter to make a measurable weight gain in order to ensure accurate results.
- 3.7 On stations where there would be limited or no duties on the platforms, static sampling pumps connected to cyclone heads loaded with PVC filters were set up in strategic locations where possible, generally at the end of each platform ('head wall' – where first the train enters the platform). This procedure was also adopted if station staff were not comfortable wearing personal sampler. However, it should be noted that static results are not the same as personal sampling results, although they can be indicative in some circumstances.
- 3.8 Sampling periods are chosen to obtain sufficient dust on the filters for reliable gravimetric analysis.

### **4. Analysis**

- 4.1 The samples taken on site were returned to the laboratory and gravimetric analysis was undertaken in accordance with MDHS 14/4.
- 4.2 Following gravimetric analysis of the personal respirable dust samples, selected personal respirable dust samples, together with blanks were submitted to the Institute of Occupational Medicine (IOM) for quartz analysis.
- 4.3 Following gravimetric analysis of the personal respirable dust samples, these were submitted together with the site blanks to the Institute of Occupational Medicine (IOM) for quantitative analysis of metals.
- 4.4 The Grimm laser scatter meter is factory calibrated to a synthetic dust comprising monodisperse 1µm latex and micro Dolomit DR80 polydisperse powder (0.2 – 80 µm).



## 5. Results

### 5.1 *Train Operators*

5.1.1 The monitored levels of respirable dust and of particulate matter of 2.5µm that Train Operators were exposed to during the train driving in each of the lines are given in Tables 3 to 10.

The results from the monitoring programme showed that the levels of respirable dust were below the HSE workplace exposure limit (EH40/50) – 4 mg/m<sup>3</sup> over 8-hour TWA, throughout all lines and during all shifts. Details for each line monitored for dust concentrations within a train operator cab during his/ her duty are given as follows:

- District Line

The respirable dust exposure levels for the District Line measured on the shifts 14<sup>th</sup>, 15<sup>th</sup> and 16<sup>th</sup> January 2019 showed low dust concentrations varying between less than 0.02 and 0.05 mg/m<sup>3</sup>. Concentrations of PM2.5 given during GRIMM monitoring, were recorded between 1.6 and 19.3 µg/m<sup>3</sup>.

- Piccadilly Line

The respirable dust exposure levels for the Piccadilly Line measured on the shifts 17<sup>th</sup>, 18<sup>th</sup> and 21<sup>st</sup> January 2019 showed low dust concentrations varying between 0.30 and 0.38 mg/m<sup>3</sup>. Concentrations of PM2.5 given during GRIMM monitoring, were recorded between 20.7 and 271.3 µg/m<sup>3</sup>.

- Jubilee Line

The respirable dust exposure levels for the Jubilee Line measured on the shifts 22<sup>nd</sup>, 23<sup>rd</sup> and 24<sup>th</sup> January 2019 showed low dust concentrations varying between 0.21 and 0.35 mg/m<sup>3</sup>. Concentrations of PM2.5 given during GRIMM monitoring, were recorded between 8.8 and 177 µg/m<sup>3</sup>.

- Victoria Line

The respirable dust exposure levels for the Victoria Line measured on the shifts 25<sup>th</sup>, 28<sup>th</sup> and 29<sup>th</sup> January 2019 showed low dust concentrations varying between 0.28 and 0.33 mg/m<sup>3</sup>. Concentrations of PM2.5 given during GRIMM monitoring, were recorded between 15.9 and 337.3 µg/m<sup>3</sup>.

- Bakerloo Line

The respirable dust exposure levels for the Bakerloo Line, measured on the shifts 30<sup>th</sup> and 31<sup>st</sup> January 2019 and 1<sup>st</sup> February 2019, showed dust concentrations varying between 0.45 and 0.68 mg/m<sup>3</sup>. Concentrations of PM2.5 given during GRIMM monitoring, were recorded between 10.7 and 265.6 µg/m<sup>3</sup>.

- Central Line

The respirable dust exposure levels for the Central line measured on the shifts 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> February 2019 showed low dust concentrations varying between 0.22 and 0.54 mg/m<sup>3</sup>. Concentrations of PM2.5 given during GRIMM monitoring, were recorded between 7.0 and 201 µg/m<sup>3</sup>.

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- Northern Line

The respirable dust exposure levels for the Northern Line measured on the shifts 7<sup>th</sup>, 8<sup>th</sup> and 11<sup>th</sup> February 2019 showed dust concentrations varying between 0.20 and 0.35 mg/m<sup>3</sup>. Concentrations of PM<sub>2.5</sub> given during GRIMM monitoring, were recorded between 3.6 and 255.2 µg/m<sup>3</sup>.

- Circle Line

The respirable dust exposure levels for the Circle Line measured on the shifts 12<sup>th</sup>, 13<sup>th</sup> and 14<sup>th</sup> February 2019 showed dust concentrations varying between 0.04 and 0.12 mg/m<sup>3</sup>. Concentrations of PM<sub>2.5</sub> given during GRIMM monitoring, were recorded between 9.4 and 39.0 µg/m<sup>3</sup>.

- 5.1.2 The measurements for various dust size particulate matter (PM<sub>10</sub>, PM<sub>2.5</sub> and PM<sub>1</sub>), have been recorded using a scatter laser (GRIMM monitor) and the results are shown in graphs Figures 1 to 8.

In summary, the data collected for PM<sub>2.5</sub> showed very low concentrations for the sub-surface lines District and Circle Line, with maximum peaks of 19.3 and 39 µg/m<sup>3</sup>.

The deeper tunnel lines were recorded with peaks PM<sub>2.5</sub> concentrations between 201.0 µg/m<sup>3</sup> on Central line and 271.3 µg/m<sup>3</sup> on Piccadilly line. Victoria line was noted the highest dust concentration than the rest of the lines at 373.3 µg/m<sup>3</sup>, during the monitoring shift on 29<sup>th</sup> January 2019.

- 5.1.3 Selected respirable dust samples taken during the train operator monitoring across all of the different tube lines, together with site blank filters, were submitted to the Institute of Occupational Medicine (IOM) for quartz content analysis.

The results for each of the Lines are given in Table 23 and the certificate for the analysis of quartz are included in Appendix 1. For each filter the mass of crystalline silica found was below 0.01 mg/filter. The calculated levels of airborne respirable crystalline silica when the volume of air sampled was accounted for was less than 0.02 mg/m<sup>3</sup>. Therefore, all of the personal samples collected during train operators shifts were below 0.1 mg/m<sup>3</sup> (WEL for respirable crystalline silica, as quartz).

- 5.1.4 The respirable fraction dust samples taken from each 3<sup>rd</sup> shift during the train operator monitoring across all of the eight tube lines were submitted to the Institute of Occupational Medicine for the analysis of various metals, along with their respective site blank filters. The results are given in Tables 24 to 27 and the certificate for the analysis of metals included within Appendix 2.

For each sample, the levels of Nickel, Zinc, Arsenic, Copper, Chromium and Chromium<sup>VI</sup> were significantly lower than the detection limit and therefore well below the HSE applicable Workplace Exposure Limits.

For Manganese, all of the samples were found with concentrations below the detection limit of the analytical method (< 0.001 mg/m<sup>3</sup>), except for two filters - 180487/11 during Piccadilly shift on 21<sup>st</sup> January 2019 and 180487/29 during the Bakerloo line shift on the 1<sup>st</sup> February 2019 - both showed a concentration of 0.002 mg/m<sup>3</sup>.

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Iron concentrations were the lowest for samples collected from District and Circle line train operators at 0.011 mg/m<sup>3</sup> and 0.002 mg/m<sup>3</sup>. The highest iron concentration, 0.202 mg/m<sup>3</sup>, was calculated for filter 180487/29 collected from train operator during his duty on Bakerloo line.

### 5.2 **Station Staff**

- 5.2.1 The dust levels in stations are known to be highest on the station platforms and on some gate line areas where the air currents carry dust from the platforms and tunnels past the gate line. The aim of the monitoring is to ensure that exposure is ALARP (As Low As Reasonably Practicable) hence the monitoring was conducted primarily within gate line and platform areas.

Eight personal samples were collected on this occasion, from London Underground (LU) personnel carrying out mainly Customer Service Assistance (CSA) duties within ticket halls at Waterloo, Aldgate East, Hampstead, King's Cross, Oxford Circus, Paddington, Piccadilly Circus and Vauxhall stations.

The lowest dust exposure during this monitoring was noted during CSA duty at Vauxhall station ticket hall (Filter no. 180487/105), of 0.08 mg/m<sup>3</sup>. This is likely to be due to outside air circulating constantly through the ticket hall increasing the natural ventilation.

The highest respirable dust concentrations – 0.59 mg/m<sup>3</sup> and 0.64 mg/m<sup>3</sup> – were noted for the personal samples (Filter no. 180487/84 and 180487/97) collected from LU station staff carrying out CSA duties within ticket halls at Oxford Circus and Paddington (Gate line to Bakerloo line). During monitoring, it was observed and recorded visible dust at these locations.

### 5.3 **Stations**

The results for the station monitoring are shown in Tables 11 - 22.

#### **Waterloo Station**

The results for the monitoring at Waterloo Station are given in Table 11. The monitoring was carried out on the 15<sup>th</sup> February 2019. The results for the static samples throughout the station, on various train line platforms and ticket office were between 0.18 to 1.32 mg/m<sup>3</sup>, with highest concentration recorded on N/B platform of Northern Line. Jubilee line platforms were also noted with dust concentrations greater than 1 mg/m<sup>3</sup>. The static sample collected from the ticket hall/ gate line was calculated with a dust concentration of 0.28 mg/m<sup>3</sup> and the personal sample with 0.20 mg/m<sup>3</sup>.

#### **Aldgate East Station**

The results for the dust monitoring at Aldgate East Station are given in Table 12. The monitoring was carried out on the 18<sup>th</sup> February 2019. The results for the static samples at the ticket hall, westbound and eastbound platforms were found with concentrations between 0.26 and 0.58 mg/m<sup>3</sup>.

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### **Baker Street Station**

The results for the dust monitoring at Baker Street Station are given in Table 13. The monitoring was carried out on the 19<sup>th</sup> February 2019. The results for the static samples were found between 0.07 and 1.42 mg/m<sup>3</sup>. The highest dust concentrations recorded were noted on both Bakerloo Line platforms.

### **Elephant and Castle Station**

The results for the monitoring at Elephant and Castle Street Station are given in Table 14. The monitoring was carried out on the 20<sup>th</sup> February 2019. The results for the static samples were found between 0.09 and 0.69 mg/m<sup>3</sup>, with the highest recorded on the Northern line northbound (N/B) platform. Bakerloo line platforms recorded lower dust concentrations possibly due to slow train movement when entering the station, as this is the end of Bakerloo line on southbound (S/B).

### **Euston Square Station**

The results for the monitoring at Euston Square Station are given in Table 15. The monitoring was carried out on the 21<sup>st</sup> February 2019. The results for the static samples were found between 0.17 and 0.39 mg/m<sup>3</sup>. The highest dust concentrations recorded were noted on the platforms.

### **Hampstead Station**

The results for the monitoring at Hampstead Station are given in Table 16. The monitoring was carried out on the 22<sup>nd</sup> February 2019. The results for the static samples at the Northern Line N/B and S/B platforms showed dust concentrations of 1.06 and 1.12 mg/m<sup>3</sup>.

### **King's Cross Station**

The results for the monitoring at King's Cross Station are given in Table 17. The monitoring was carried out on the 25<sup>th</sup> February 2019. The results for the static samples throughout the station, on various train line platforms and ticket offices, were found between 0.11 and 1.24 mg/m<sup>3</sup>. The highest dust concentrations recorded were on the Piccadilly line platforms. There was no data collection possible for three static samples located on S/B platforms of Northern and Victoria lines, and E/B platform of Sub-Surface lines (Metropolitan, Circle, Hammersmith and City). This was due to technical issues experienced with the sampling equipment.

### **Oxford Circus Station**

The results for the monitoring at Oxford Circus Station are given in Table 18. The monitoring was carried out on the 26<sup>th</sup> February 2019. The results for the static samples were found between 0.78 and 1.72 mg/m<sup>3</sup>, with highest concentration recorded on Victoria Line S/B platform. All other platforms had dust concentrations greater than 1 mg/m<sup>3</sup>. The static sample collected from the main ticket hall was calculated with a dust concentration of 0.78 mg/m<sup>3</sup> and the personal sample with 0.59 mg/m<sup>3</sup>.

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### **Paddington Station**

The results for the monitoring at Paddington Station are given in Table 19. The monitoring was carried out on the 27<sup>th</sup> February 2019. The results for the static samples at the platforms and gate lines were between 0.34 and 1.36 mg/m<sup>3</sup>. The highest dust concentrations recorded were on the Bakerloo Line platforms. The static sample collected from the ticket hall (to Bakerloo line platforms) was calculated with a dust concentration of 0.67 mg/m<sup>3</sup> and the personal sample with 0.64 mg/m<sup>3</sup>.

### **Piccadilly Circus Station**

The results for the monitoring at Piccadilly Circus Station are given in Table 20. The monitoring was carried out on the 28<sup>th</sup> February 2019. The results for the static samples were found between 0.25 to 1.42 mg/m<sup>3</sup>, with the highest result recorded for the sample collected from Bakerloo Line S/B platform. The lowest concentration was calculated for the static sample within the ticket hall (0.25 mg/m<sup>3</sup>). The personal sample collected from within same location was 0.21 mg/m<sup>3</sup>.

### **Tottenham Court Road Station**

The results for the monitoring at Tottenham Court Road Station are given in Table 21. The monitoring was carried out on the 1<sup>st</sup> March 2019. The results for the static samples were between 0.05 to 1.45 mg/m<sup>3</sup>, with the highest result recorded for the sample collected from Central Line E/B platform.

### **Vauxhall Station**

The results for the monitoring at Vauxhall Station are given in Table 22. The monitoring was carried out on the 4<sup>th</sup> March 2019. The results for the static samples were between 0.06 and 0.87 mg/m<sup>3</sup>, with the highest concentration recorded on Victoria N/B platform.

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### 6. Discussions and Conclusions

- 6.1 The levels of airborne respirable dust during personal monitoring undertaken on train operators during their duties on the following tube lines: District, Jubilee, Piccadilly, Victoria, Bakerloo, Central, Northern and Circle, were all below the WEL of 4 mg/m<sup>3</sup> for respirable dust (long-term 8 hour time weighted average).
- 6.2 The respirable dust concentrations calculated following personal sampling on train operators during their shifts found that the highest value was for the filter-sample collected from the train operator on the third shift of Bakerloo Line and the lowest dust levels were for the filter-samples collected from the train operators on the District and Circle Lines.
- 6.3 For the metal analysis results for the Train Operators all were below the relevant Workplace Exposure Limits as detailed in 2.5 of this report.
- 6.4 For respirable crystalline silica results for the Train Operators, all were below the Workplace Exposure Limit of 0.1mg/m<sup>3</sup>.
- 6.5 The data collected from the GRIMM laser scatter monitor during train operator duties within train cabs was analysed for various particulate matter concentrations, particular focus on PM<sub>2.5</sub>. Several elevated peaks were noted for Piccadilly, Bakerloo, Northern and Central Lines. The Victoria line recorded the highest PM<sub>2.5</sub> concentration, whilst the District & Circle lines the lowest concentrations.
- 6.6 The levels of airborne respirable dust measured for personal samples taken on staff carrying out Customer Service Assistance duties (to include platform/gate line/station checks) during their shifts at eight of the selected stations were below the workplace exposure limit of 4 mg/m<sup>3</sup> for respirable dust (long-term 8 hour time weighted average). However, it was noted that the personal samples collected from Paddington (gate line to Bakerloo line) and Oxford Circus Station were recorded with the most elevated dust concentration when compared to the other personal samples taken in other locations.

The respirable dust levels reported for the station personnel, and train operators are for the monitoring period in each case. Where a shift lasted for less than 8 hours, the 8-hrs TWA exposure will be lower than the measured level so the results would all be further below the 4 mg/m<sup>3</sup> limit. No limit exists for short-term exposure, but typically, short-term exposure limits are taken as three times the limit for long-term exposure i.e. 12 mg/m<sup>3</sup> over a 15 minute period. Therefore, the levels recorded for the train operators and station personnel were significantly below the short-term exposure limit.

- 6.7 All of the static samples taken at specifically selected stations, platforms and gate lines, also resulted in concentrations that would be below the workplace exposure limit. However, the static samples taken at Oxford Circus station, Victoria and Bakerloo line platforms, were found with significantly higher dust concentrations than all other stations.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 3. District Line Train Operators**

FILTER NUMBER*	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/01	RD	LU01 TO – Driver – Duties 198 & 206	14/01/19	12:18	13:05	2.20	532.40	0.03	Train 072: Earl's Court - Wimbledon - Earl's Court (duty change) Train 025 to Ealing Broadway - Earl's Court - Upminster - Earl's Court.
				13:53	17:08				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/03	RD	LU03 TO – Driver – Duties 195 & 328	15/01/19	11:11	15:25	2.2	558.8	< 0.02	Train 005: Earl's Court - Richmond (duty change at Earl's Court) - Upminster - Richmond - Earl's Court

FILTER NUMBER*	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/05	RD	LU05 TO – Driver – Duties 188 & 205	16/01/19	08:40	12:43	2.2	534.6	0.05	Train 074: Earl's Court - Wimbledon - Edgware Road (3x times) - Earl's Court (duty change) to Parsons Green.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 4. Piccadilly Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/07	RD	LU07 TO – Driver – Duty 615 & 617	17/01/19	08:05	12:15	2.2	550	0.30	Train 342: Acton Town - Arnos Grove - Acton Town - Heathrow T5 - Turnpike Lane

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/10	RD	4-Rail Analyst* - during duties 620 & 829	18/01/19	08:14	12:17	2.2	534.6	0.39	Train 304: Acton Town - Arnos Grove. Train 35 to Northfields - Arnos Grove - King's Cross (duty change).

\*Note: Air sampler failure during this shift. The results in this table are given for the 4-Rail Analyst shadowing the TO on their respective duties.

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/11	RD	LU12 TO – Driver – Duty 623	21/01/19	09:00	12:00	2.2	521.74	0.38	Train 231: Acton Town - Rayners Lane - Cockfosters - Acton Town - Train 260 to Heathrow T1, 2, 3 & 5 - Cockfosters (Monitoring complete at Acton Town)
				13:13	14:18				



## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 5. Jubilee Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/13	RD	LU13 TO – Driver – Duty 638	22/01/19	11:41	16:01	2.2	572	0.30	Train 355: Wembley Park - Stratford. Train 356 to Stanmore - Stratford. Train 301 to Wembley Park - Stanmore - Kingsbury.

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/16	RD	LU16 TO – Driver – Duty 627	23/01/19	06:50	10:16	2.20	536.80	0.35	Train 322: Wembley Park - Stanmore - North Greenwich - West Hampstead - Stratford. Train 312 to Wembley Park. Train 325 to Stratford (Monitoring complete at Bermondsey).
				11:22	12:00				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/17	RD	LU17 TO – Driver – Duty 510 & 524	24/01/19	10:23	14:30	2.2	543.4	0.21	Train 312: Wembley Park - Stanmore - Stratford. Train 342 to Stanmore - Stratford. Duty change. Train 315 to Stanmore (Monitoring complete at Neasden).

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 6. Victoria Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/19	RD	LU19 TO – Driver Duty 813	25/01/19	11:37	15:42	2.2	539	0.33	Train 224: Brixton - Walthamstow - Brixton. Train 236 to Walthamstow Central. Train 215 to Brixton. Train 242 to Walthamstow Central. Train 216 to Brixton. Train 225 to Walthamstow. Train 201 to Brixton - Pimlico.

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (L/MIN)	VOLUME OF AIR (LITRES)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/21	RD	LU21 TO – Driver Duty 820 & 539	28/01/19	10:58	15:00	2.2	532.4	0.28	Train 223: Brixton - Walthamstow. Train 244 to Brixton. Train 245 to Walthamstow. Duty change at Seven Sisters. Train 246 to Brixton (Significant dust level noted throughout the line). Train 230 to Walthamstow. Train 231 to Brixton - Oxford Circus.

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/23	RD	LU23 TO – Driver Duty 532, 508 & 517	29/01/19	08:56	12:58	2.2	532.4	0.29	Train 218: Walthamstow - Brixton (sidings). Train 245 to Walthamstow - Brixton. Train 252 to Walthamstow. Train 241 to Brixton. Train 204 to Walthamstow - Seven Sisters.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 7. Bakerloo Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/25	RD	LU25 TO – Driver Duty 017	30/01/19	08:37	11:04	2.2	539	0.51	Train 213: Elephant & Castle to Queen's Park - Elephant & Castle - Train 226 to Queen's Park - Elephant & Castle. Train 213 to Queen's Park - Elephant & Castle.
				12:08	13:46				

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/27	RD	LU27 TO – Driver Duties 021, 017, 016 & 026	31/01/19	09:49	13:51	2.2	532.4	0.68	Train 213: Elephant & Castle - Queen's Park - Elephant & Castle - Queen's Park - Elephant & Castle - Queen's Park - Elephant & Castle - Queen's Park.

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/29	RD	LU29 TO – Driver Duty 015	01/02/19	08:22	10:12	2.2	481.8	0.45	Train 227: Elephant & Castle - Harrow & Wealdstone - Elephant & Castle. Train 234: Elephant & Castle - Stonebridge Park - Elephant & Castle - Queen's Park - Marylebone (sampling complete).
				11:40	12:20				
				13:31	14:40				

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 8. Central Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/31	RD	LU31 TO – Driver Duties 922, 519 & 830	04/02/19	13:02	17:10	2.2	545.6	0.22	Train 023: West Ruislip - Epping - West Ruislip - Mile End

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/33	RD	LU33 TO – Driver Duties 810 & 817	05/02/19	10:41	14:41	2.2	534.6	0.54	Train 114: White City - Loughton -Northolt - Loughton - Liverpool Street

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/36	RD	4-Rail Analyst* - during duties 620 & 829	06/02/19	10:57	15:01	2.2	536.8	0.24	Train 115: White City - Loughton - Northolt - Loughton (and sidings) - Leytonstone

\*Note: Air sampler failure during this shift. The results in this table are given for the 4-Rail Analyst shadowing the TO on their respective duties.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 9. Northern Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180425/02	RD	LU02 TO – Driver Duty 420 & 425	07/02/19	11:34	15:36	2.2	532.4	0.35	Train 055: Golders Green - Edgware - Kennington - Edgware - Kennington - Edgware – Kennington.

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/37	RD	LU37 TO – Driver Duty 635	08/02/19	11:45	15:49	2.2	536.8	0.20	Train 030: Golders Green - Morden (Via Bank) - Edgware - Morden (Via Bank) - South Wimbledon

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/39	RD	LU39 TO – Driver Duty 628	11/02/19	12:40	16:48	2.2	545.6	0.34	Train 011: Golders Green - Edgware - Morden (via Bank) - Edgware - Morden (Via Bank) - South Wimbledon

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 10. Circle Line Train Operators**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/41	RD	LU41 TO – Driver Duty 020	12/02/19	13:04	17:16	2.2	550.36	0.04	Train 207: Edgware Road - Hammersmith (Inner - Anticlockwise) - Edgware Road (Outer - Clockwise) - Hammersmith (Inner - Anticlockwise) - High Street Kensington (Outer Via Kings Cross)

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/43	RD	LU43 TO – Driver Duty 021	13/02/19	11:06	15:08	2.2	524.28	0.12	Train 207: Edgware Road - Edgware Road (Outer - Clockwise) - Hammersmith (Inner - Anticlockwise) - Edgware Road (Outer - Clockwise) - Sloane Square (Inner - Anticlockwise)

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	ROUTE COVERED
180487/45	RD	LU45 TO – Driver Duty 010	14/02/19	11:17	15:18	2.2	525.42	0.05	Train number not taken: Edgware Road - Edgware Road (Outer - Clockwise) - Hammersmith (Inner - Anticlockwise) - Edgware Road (Outer - Clockwise) - Paddington (Inner - Anticlockwise)

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 11. Waterloo Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180217/121	RD	Static – Northern Line S/B	15/02/19	10:24	14:33	2.2	547.8	0.97	Moderate levels of dust noted at this location throughout the duration of sampling session.
180217/122	RD	Personal - LUL Station Staff - CSA2	15/02/19	09:58	13:59	2.2	530.2	0.20	Personal monitoring during gate line duty within main ticket hall.
180217/123	RD	Static - Waterloo & City Line – Arrivals	15/02/19	10:08	14:13	2.2	539	0.70	General dust conditions at this location were noted low.
180217/124	RD	Static – Northern Line N/B	15/02/19	10:31	14:35	2.2	536.8	1.32	Moderate levels of dust noted at this location throughout the duration of sampling session.
180217/125	RD	Static – Bakerloo Line S/B	15/02/19	10:37	14:42	2.2	539	0.98	
180217/126	RD	Static - Waterloo & City Line – Departures	15/02/19	10:04	14:17	2.2	556.6	0.18	General dust conditions at this location were noted low.
180217/127	RD	Static – Jubilee Line W/B	15/02/19	10:20	14:25	2.2	539	1.06	Moderate levels of dust noted at this location throughout the duration of
180217/128	RD	Static – Jubilee Line – Gate line	15/02/19	10:14	14:21	2.2	543.4	0.28	No visible dust at this location, as outside air flowing through constantly.
180217/129	RD	Static – Bakerloo Line N/B	15/02/19	10:41	14:45	2.2	536.8	0.83	Moderate levels of dust noted at this location throughout the duration of sampling session.
180217/130	RD	Static – Jubilee Line E/B	15/02/19	10:14	14:27	2.2	556.6	1.20	

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 12. Aldgate East Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)*	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	OTHER COMMENTS
180487/47	RD	Personal – LUL Station Staff	18/02/19	09:58	13:44	2.2	574.2	0.33	LUL gate line staff carrying out Customer Service Assistant Level 1 (CSA1) duties at: Gate line (09:50 – 10:25, 13:58-14:19), Ticket office (10:25-10:30, 13:37-13:57), Platform (12:00-12:15).
180487/48	RD	Static – Ticket Hall	18/02/19	10:02	14:07	2.2	539	0.26	Slight dust levels were visible and noted at the station throughout the sampling duration.
180487/49	RD	Static – District, Hammersmith and City Lines, E/B Platform 2	18/02/19	10:08	14:05	2.2	521.4	0.58	
180487/50*	RD	Static – District, Hammersmith and City Lines, W/B Platform 1	18/02/19	10:12	12:03	2.2	244.2	0.44	

\*Note: Air sampler failed to achieve the minimum 4-hour air collection. The accurate dust concentration could not be possible. This result is indicative only.



## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 13. Baker Street Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/51	RD	Static – Ticket Hall	19/02/19	09:19	14:00	2.20	552.20	0.07	Platforms 3 & 4 (E/B)
180487/52	RD	Static – Escalator Hall	19/02/19	09:53	14:03	2.20	550.00	0.20	Top of escalator to N/B Jubilee & Bakerloo lines
180487/53	RD	Static - Hammersmith & Circle Lines	19/02/19	09:57	14:07	2.20	550.00	0.29	Platform 5 (E/B)
180487/54	RD	Static - Hammersmith & Circle Lines	19/02/19	10:00	14:10	2.20	550.00	0.26	Platform 6 (W/B) Slight-moderate level of dust noted at this location.
180487/55	RD	Static - Jubilee Line	19/02/19	10:06	14:14	2.20	545.60	0.89	Platform 10 (W/B) Moderate-significant level of dust noted at this location.
180487/56	RD	Static - Jubilee Line	19/02/19	10:10	14:17	2.20	543.40	1.03	Platform 7 (S/B) Moderate-significant level of dust noted at this location.
180487/57	RD	Static - Bakerloo Line	19/02/19	10:13	14:18	2.20	539.00	1.42	Platform 8 (S/B) Moderate-significant level of dust noted at this location.
180487/58	RD	Static - Bakerloo Line	19/02/19	10:17	14:20	2.20	534.60	1.26	Platform 9 (N/B) Significant level of dust noted at this location.

\*Note: Only static monitoring could be carried out as LU Station Staff platform shifts not occurring during the sampling session.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 14. Elephant and Castle Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/59	RD	Static – Bakerloo line Ticket Hall	20/02/19	09:40	13:50	2.2	550	0.09	No visible dust levels noted as outside air circulating through constantly.
180487/60*	RD	Static – Northern line Ticket Hall	20/02/19	09:46	Pump failure		-		
180487/61	RD	Static – Northern Line S/B Platform 2	20/02/19	09:53	13:59	2.2	541.2	0.55	Moderate level of dust noted on these platforms.
180487/62	RD	Static – Northern Line N/B Platform 3	20/02/19	09:57	14:04	2.2	543.4	0.69	
180487/63	RD	Static – Bakerloo Line N/B Platform	20/02/19	10:01	14:07	2.2	541.2	0.27	Trains approaching the station at low speed unlikely to cause significant dust disturbance. Therefore the dust levels were noted to be slightly visible on both platforms.
180487/64	RD	Static – Bakerloo Line N/B Platform	20/02/19	10:05	14:09	2.2	536.8	0.20	

\*Note: Air sampler found non-functional. The result could not be reported due to insufficient data and air volume.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 15. Euston Square Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/65	RD	Static - Ticket Hall - Exit A	21/02/19	09:27	13:30	2.20	534.60	0.20	Slight levels of dust noted at these locations.
180487/66	RD	Static - Ticket Hall - Exit B	21/02/19	09:24	13:27	2.20	534.60	0.17	
180487/67	RD	Static - Hammersmith & Circle line W/B platform	21/02/19	09:20	13:24	2.20	536.80	0.34	Platform 2 – E/B Slight levels of dust noted at this location.
180487/68	RD	Static - Hammersmith & Circle line E/B platform	21/02/19	09:16	13:30	2.20	536.80	0.39	Platform 1 – W/B Slight levels of dust noted at this location.

\*Note: Only static monitoring was carried out as the station staff carry out platform duties only on request (e.g. for accompanying Visually Impaired Persons).

**Table 16. Hampstead Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/69	RD	Personal – LUL Station Staff	22/02/19	06:50	08:20	2.2	403.09	0.35	LU Station staff carrying out CSA1 duties at Gate line, with occasional 10 mins breaks.
				08:35	10:10				
180487/70	RD	Static - Northern Line – N/B Platform 1	22/02/19	07:00	11:10	2.2	544.72	1.06	Moderate dust levels noted throughout the sampling session.
180487/71	RD	Static - Northern Line – S/B Platform 2	22/02/19	06:56	11:11	2.2	555.61	1.12	

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 17. King's Cross Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/73	RD	Static - Exit from Circle line	25/02/19	09:36	13:37	2.20	519.95	0.15	Slight levels of dust noted at this location throughout the duration of sampling session.
180487/74	RD	Personal – LUL Station Staff	25/02/19	09:30	13:09	2.20	461.70	0.29	
180487/75	RD	Static - Main Ticket Hall	25/02/19	08:55	13:01	2.20	530.73	0.11	
180487/76	RD	Static - Piccadilly line E/B platform	25/02/19	08:59	13:06	2.20	532.89	0.83	Moderate levels of dust noted on the platforms throughout the duration of sampling session.
180487/77	RD	Static - Piccadilly line W/B platform	25/02/19	09:02	13:08	2.20	530.73	1.24	
180487/78	RD	Static - Northern line N/B platform	25/02/19	09:08	13:11	2.20	524.26	0.65	Moderate levels of dust noted on the platforms throughout the duration of sampling session.
180487/79*	RD	Static - Northern line S/B platform	25/02/19	09:11	Pump failure		-		
180487/80	RD	Static - Victoria Line N/B platform	25/02/19	09:15	13:17	2.20	522.10	0.70	Moderate levels of dust noted on the platforms throughout the duration of sampling session.
180487/81*	RD	Static - Victoria Line S/B platform	25/02/19	09:21	Pump failure		-		
180487/82	RD	Static - Hammersmith & Circle line W/B platform	25/02/19	09:26	13:29	2.20	524.26	0.21	Slight levels of dust noted at these locations throughout the duration of sampling session.
180487/83*	RD	Static - Hammersmith & Circle line E/B platform	25/02/19	09:33	Pump failure		-		

\*Note: Air sampler found non-functional. The result could not be reported due to insufficient data and air volume.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 18. Oxford Circus Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/84	RD	Personal – LUL Station Staff	26/02/19	08:34	12:47	2.20	557.13	0.59	LUL Station staff carrying out CSA duties on platform (approx. 10 mins monitoring), main ticket hall.
180487/85	RD	Static - Ticket Hall	26/02/19	08:46	12:49	2.20	535.11	0.78	Slight levels of dust noted at this location throughout the duration of sampling session.
180487/86	RD	Static - Central line E/B platform	26/02/19	08:16	12:20	2.20	537.11	1.27	Moderate levels of dust noted on all platforms throughout the duration of sampling session.
180487/87	RD	Static - Central line W/B platform	26/02/19	08:20	12:23	2.20	535.11	1.07	
180487/88	RD	Static - Victoria Line N/B platform	26/02/19	08:28	12:28	2.20	528.51	1.46	
180487/89	RD	Static - Bakerloo Line N/B platform	26/02/19	08:31	12:32	2.20	530.71	1.48	
180487/90	RD	Static - Victoria Line S/B platform	26/02/19	08:40	12:42	2.20	532.91	1.72	
180487/91	RD	Static - Bakerloo Line S/B platform	26/02/19	08:54	12:53	2.20	530.71	1.58	

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 19. Paddington Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/92	RD	Static – Bakerloo Line S/B Platform 4	27/02/19	09:09	13:14	2.20	539.00	1.28	Moderate – significant levels of dust noted on both platforms throughout the duration of sampling session.
180487/93	RD	Static – Bakerloo Line N/B Platform 3	27/02/19	09:13	13:18	2.20	539.00	1.36	
180487/94	RD	Static – Gate Line to Bakerloo Line	27/02/19	09:18	13:22	2.20	536.80	0.67	Slight – moderate levels of dust visible.
180487/95	RD	Static – Circle and District Line E/B Platform 2	27/02/19	09:32	13:32	2.20	528.00	0.19	Slight levels of dust noted at these locations throughout the duration of sampling session.
180487/96	RD	Static - Gate Line to District Line (Ticket Hall booth – door open)	27/02/19	09:34	13:34	2.20	528.00	0.34	
180487/97	RD	Personal LUL Station Staff – Gate Line to District Line	27/02/19	09:01	10:58	2.20	257.40	0.64	Slight – moderate levels of dust visible during the LU Station staff carrying out CSA duties.

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 20. Piccadilly Circus Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/98	RD	Personal – LUL Station Staff	28/02/19	09:08	12:59	2.20	508.20	0.21	LU Station Staff carrying out CSA1 duties during station checks (09:10-09:43), meal break (09:45-10:45) and assistance at gate line and ticket office (10:46-12:09).
180487/99	RD	Static – Main Ticket Hall	28/02/19	09:11	13:23	2.20	554.40	0.25	Slight dust levels noted at this location.
180487/100	RD	Static – Bakerloo Line N/B	28/02/19	09:20	13:26	2.20	541.20	0.93	Moderate – significant levels of dust noted on all platforms throughout the duration of sampling session.
180487/101	RD	Static – Bakerloo Line S/B	28/02/19	09:26	13:28	2.20	532.40	1.42	
180487/102	RD	Static – Piccadilly Line W/B	28/02/19	09:30	13:32	2.20	532.40	1.15	
180487/103	RD	Static – Piccadilly Line E/B	28/02/19	09:34	13:35	2.20	530.20	1.36	

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 21. Tottenham Court Road Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/108	RD	Static - Ticket Hall	01/03/19	07:59	12:33	2.20	602.80	0.05	No visible levels of dust noted at this location throughout the duration of sampling session.
180487/109	RD	Static - Central Line E/B	01/03/19	08:05	12:28	2.20	578.60	1.45	General dust conditions on all platforms were noted to be moderate throughout the duration of sampling session.
180487/110	RD	Static - Central Line W/B	01/03/19	08:09	12:30	2.20	574.20	0.82	
180487/111	RD	Static - Northern Line S/B	01/03/19	08:12	12:27	2.20	561.00	0.70	
180487/112	RD	Static- Northern Line N/B	01/03/19	08:24	12:25	2.20	530.20	0.69	

**Table 22. Vauxhall Station**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC <sup>N</sup> (MG/M <sup>3</sup> )	LOCATIONS & COMMENTS
180487/104	RD	Static – Main Ticket Hall	04/03/19	11:07	15:12	2.20	539.00	0.06	No visible dust levels noted as outside air circulating through constantly.
180487/105	RD	Personal – LUL Station Staff	04/03/19	11:04	14:53	2.20	503.80	0.08	
180487/106	RD	Static – Northern Line N/B	04/03/19	11:10	15:15	2.20	539.00	0.38	Slight - moderate levels of dust noted on all platforms throughout the duration of sampling session.
180487/107	RD	Static – Northern Line N/B	04/03/19	11:14	15:17	2.20	534.60	0.87	



## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 23. Train Operator Respirable Crystalline Silica Monitoring**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	CRYSTALLINE SILICA (mg/filter)	CRYSTALLINE SILICA (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
180487/03	RD	District Line Train Operators Driving Trains	15/01/19	558.8	< 0.01	<0.02	Train 005: Earl's Court - Richmond (duty change at Earl's Court) - Upminster - Richmond - Earl's Court
180487/07	RD	Piccadilly Line Train Operator Driving Trains	17/01/19	550.0	< 0.01	<0.02	Train 342: Acton Town - Arnos Grove - Acton Town - Heathrow T5 - Turnpike Lane
180487/16	RD	Jubilee Line Train Operator Driving Trains	23/01/19	536.8	< 0.01	<0.02	Train 322: Wembley Park - Stanmore - North Greenwich - West Hampstead - Stratford. Train 312 to Wembley Park. Train 325 to Stratford (stopped at Bermondsey).
180487/21	RD	Victoria Line Train Operators Driving Trains	28/01/19	532.4	< 0.01	<0.02	Train 223: Brixton - Walthamstow. Train 244 to Brixton. Train 245 to Walthamstow. Duty change at Seven Sisters. Train 246 to Brixton (Significant dust level noted throughout the line). Train 230 to Walthamstow. Train 231 to Brixton - Oxford Circus.
180487/27	RD	Bakerloo Line Train Operators Driving Trains	31/01/19	532.4	< 0.01	<0.02	Train 213: Elephant & Castle - Queen's Park - Elephant & Castle - Queen's Park - Elephant & Castle - Queen's Park - Elephant & Castle - Queen's Park.
180487/33	RD	Central Line Train Operator Driving Trains	05/02/19	534.6	< 0.01	<0.02	Train 114: White City - Loughton -Northolt - Loughton - Liverpool Street
180487/37	RD	Northern Line Train Operator Driving Trains	08/02/19	536.8	< 0.01	<0.02	Train 030: Golders Green - Morden (Via Bank) - Edgware - Morden (Via Bank) - South Wimbledon
180487/43	RD	Circle Line Train Operator Driving Trains	13/02/19	524.28	< 0.01	< 0.02	Train 207: Edgware Road - Edgware Road (Outer - Clockwise) - Hammersmith (Inner - Anticlockwise) - Edgware Road (Outer - Clockwise) - Sloane Square (Inner - Anticlockwise)

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 24. Train Operator respirable dust fraction - Nickel and Zinc Monitoring**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	NICKEL (mg/filter)	ZINC (mg/filter)	NICKEL CONC. (mg/m <sup>3</sup> )	ZINC CONC. (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
180487/05	RD	District Line Train Operator Driving Trains	16/01/19	534.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 074: Earl's Court - Wimbledon - Edgware Road (3x times) - Earl's Court (duty change) to Parsons Green.
180487/11	RD	Piccadilly Line Train Operator Driving Trains	21/01/19	521.74	< 0.001	< 0.001	< 0.001	< 0.001	Train 231: Acton Town - Rayners Lane - Cockfosters - Acton Town - Train 260 to Heathrow T1, 2, 3 & 5 - Cockfosters (Monitoring complete at Acton Town)
180487/17	RD	Jubilee Line Train Operator Driving Trains	24/01/19	543.4	< 0.001	< 0.001	< 0.001	< 0.001	Train 312: Wembley Park - Stanmore - Stratford. Train 342 to Stanmore - Stratford. Duty change. Train 315 to Stanmore (Monitoring complete at Neasden).
180487/23	RD	Victoria Line Train Operators Driving Trains	29/01/19	532.4	< 0.001	< 0.001	< 0.001	< 0.001	Train 218: Walthamstow - Brixton (sidings). Train 245 to Walthamstow - Brixton. Train 252 to Walthamstow. Train 241 to Brixton. Train 204 to Walthamstow - Seven Sisters.
180487/29	RD	Bakerloo Line Train Operators Driving Trains	01/02/19	481.8	< 0.001	< 0.001	< 0.001	< 0.001	Train 227: Elephant & Castle - Harrow & Wealdstone - Elephant & Castle. Train 234: Elephant & Castle - Stonebridge Park - Elephant & Castle - Queen's Park - Marylebone (sampling complete).
180487/31	RD	Central Line Train Operator Driving Trains	04/02/19	545.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 023: West Ruislip - Epping - West Ruislip - Mile End
180487/39	RD	Northern Line Train Operator Driving Trains	11/02/19	545.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 011: Golders Green - Edgware - Morden (via Bank) - Edgware - Morden (Via Bank) - South Wimbledon
180487/45	RD	Circle Line Train Operator Driving Trains	14/02/19	525.42	< 0.001	< 0.001	< 0.001	< 0.001	Duties 017 & 023: Edgware Road - Edgware Road (Outer - Clockwise) - Hammersmith (Inner - Anticlockwise) - Edgware Road (Outer - Clockwise) - Paddington (Inner - Anticlockwise)

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 25. Train Operator respirable dust fraction - Arsenic and Copper Monitoring**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	ARSENIC (mg/filter)	COPPER (mg/filter)	ARSENIC CONC. (mg/m <sup>3</sup> )	COPPER CONC. (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
180487/05	RD	District Line Train Operator Driving Trains	16/01/19	534.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 074: Earl's Court - Wimbledon - Edgware Road (3x times) - Earl's Court (duty change) to Parsons Green.
180487/11	RD	Piccadilly Line Train Operator Driving Trains	21/01/19	521.74	< 0.001	< 0.001	< 0.001	< 0.001	Train 231: Acton Town - Rayners Lane - Cockfosters - Acton Town - Train 260 to Heathrow T1, 2, 3 & 5 - Cockfosters (Monitoring complete at Acton Town)
180487/17	RD	Jubilee Line Train Operator Driving Trains	24/01/19	543.4	< 0.001	< 0.001	< 0.001	< 0.001	Train 312: Wembley Park - Stanmore - Stratford. Train 342 to Stanmore - Stratford. Duty change. Train 315 to Stanmore (Monitoring complete at Neasden).
180487/23	RD	Victoria Line Train Operators Driving Trains	29/01/19	532.4	< 0.001	< 0.001	< 0.001	< 0.001	Train 218: Walthamstow - Brixton (sidings). Train 245 to Walthamstow - Brixton. Train 252 to Walthamstow. Train 241 to Brixton. Train 204 to Walthamstow - Seven Sisters.
180487/29	RD	Bakerloo Line Train Operators Driving Trains	01/02/19	481.8	< 0.001	< 0.001	< 0.001	< 0.001	Train 227: Elephant & Castle - Harrow & Wealdstone - Elephant & Castle. Train 234: Elephant & Castle - Stonebridge Park - Elephant & Castle - Queen's Park - Marylebone (sampling complete).
180487/31	RD	Central Line Train Operator Driving Trains	04/02/19	545.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 023: West Ruislip - Epping - West Ruislip - Mile End
180487/39	RD	Northern Line Train Operator Driving Trains	11/02/19	545.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 011: Golders Green - Edgware - Morden (via Bank) - Edgware - Morden (Via Bank) - South Wimbledon
180487/45	RD	Circle Line Train Operator Driving Trains	14/02/19	525.42	< 0.001	< 0.001	< 0.001	< 0.001	Duties 017 & 023: Edgware Road - Edgware Road (Outer - Clockwise) - Hammersmith (Inner - Anticlockwise) - Edgware Road (Outer - Clockwise) - Paddington (Inner - Anticlockwise)

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 26. Train Operator respirable dust fraction - Iron and Manganese Monitoring**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	IRON (mg/filter)	MANGANESE (mg/filter)	IRON CONC. (mg/m <sup>3</sup> )	MANGANESE CONC. (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
180487/05	RD	District Line Train Operator Driving Trains	16/01/19	534.6	0.0058	< 0.001	0.011	< 0.001	Train 074: Earl's Court - Wimbledon - Edgware Road (3x times) - Earl's Court (duty change) to Parsons Green.
180487/11	RD	Piccadilly Line Train Operator Driving Trains	21/01/19	521.74	0.0945	0.001	0.181	0.002	Train 231: Acton Town - Rayners Lane - Cockfosters - Acton Town - Train 260 to Heathrow T1, 2, 3 & 5 - Cockfosters (Monitoring complete at Acton Town)
180487/17	RD	Jubilee Line Train Operator Driving Trains	24/01/19	543.4	0.0508	< 0.001	0.093	< 0.001	Train 312: Wembley Park - Stanmore - Stratford. Train 342 to Stanmore - Stratford. Duty change. Train 315 to Stanmore (Monitoring complete at Neasden).
180487/23	RD	Victoria Line Train Operators Driving Trains	29/01/19	532.4	0.0568	< 0.001	0.107	< 0.001	Train 218: Walthamstow - Brixton (sidings). Train 245 to Walthamstow - Brixton. Train 252 to Walthamstow. Train 241 to Brixton. Train 204 to Walthamstow - Seven Sisters.
180487/29	RD	Bakerloo Line Train Operators Driving Trains	01/02/19	481.8	0.0974	0.001	0.202	0.002	Train 227: Elephant & Castle - Harrow & Wealdstone - Elephant & Castle. Train 234: Elephant & Castle - Stonebridge Park - Elephant & Castle - Queen's Park - Marylebone (sampling complete).
180487/31	RD	Central Line Train Operator Driving Trains	04/02/19	545.6	0.0594	< 0.001	0.109	< 0.001	Train 023: West Ruislip - Epping - West Ruislip - Mile End
180487/39	RD	Northern Line Train Operator Driving Trains	11/02/19	545.6	0.081	< 0.001	0.148	< 0.001	Train 011: Golders Green - Edgware - Morden (via Bank) - Edgware - Morden (Via Bank) - South Wimbledon
180487/45	RD	Circle Line Train Operator Driving Trains	14/02/19	525.42	0.001	< 0.001	0.002	< 0.001	Duties 017 & 023: Edgware Road - Edgware Road (Outer - Clockwise) - Hammersmith (Inner - Anticlockwise) - Edgware Road (Outer - Clockwise) - Paddington (Inner - Anticlockwise)

## Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

**Table 27. Train Operator respirable dust fraction – Chromium and Chromium VI**

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION – PROCESS MONITORED	DATE	VOLUME OF AIR (litres)	CHROMIUM (mg/filter)	CHROMIUM VI (mg/filter)	CHROMIUM CONC. (mg/m <sup>3</sup> )	CHROMIUM VI CONC. (mg/m <sup>3</sup> )	LOCATIONS & COMMENTS
180487/05	RD	District Line Train Operator Driving Trains	16/01/19	534.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 074: Earl's Court - Wimbledon - Edgware Road (3x times) - Earl's Court (duty change) to Parsons Green.
180487/11	RD	Piccadilly Line Train Operator Driving Trains	21/01/19	521.74	< 0.001	< 0.001	< 0.001	< 0.001	Train 231: Acton Town - Rayners Lane - Cockfosters - Acton Town - Train 260 to Heathrow T1, 2, 3 & 5 - Cockfosters (Monitoring complete at Acton Town)
180487/17	RD	Jubilee Line Train Operator Driving Trains	24/01/19	543.4	< 0.001	< 0.001	< 0.001	< 0.001	Train 312: Wembley Park - Stanmore - Stratford. Train 342 to Stanmore - Stratford. Duty change. Train 315 to Stanmore (Monitoring complete at Neasden).
180487/23	RD	Victoria Line Train Operators Driving Trains	29/01/19	532.4	< 0.001	< 0.001	< 0.001	< 0.001	Train 218: Walthamstow - Brixton (sidings). Train 245 to Walthamstow - Brixton. Train 252 to Walthamstow. Train 241 to Brixton. Train 204 to Walthamstow - Seven Sisters.
180487/29	RD	Bakerloo Line Train Operators Driving Trains	01/02/19	481.8	< 0.001	< 0.001	< 0.001	< 0.001	Train 227: Elephant & Castle - Harrow & Wealdstone - Elephant & Castle. Train 234: Elephant & Castle - Stonebridge Park - Elephant & Castle - Queen's Park - Marylebone (sampling complete).
180487/31	RD	Central Line Train Operator Driving Trains	04/02/19	545.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 023: West Ruislip - Epping - West Ruislip - Mile End
180487/39	RD	Northern Line Train Operator Driving Trains	11/02/19	545.6	< 0.001	< 0.001	< 0.001	< 0.001	Train 011: Golders Green - Edgware - Morden (via Bank) - Edgware - Morden (Via Bank) - South Wimbledon
180487/45	RD	Circle Line Train Operator Driving Trains	14/02/19	525.42	< 0.001	< 0.001	< 0.001	< 0.001	Duties 017 & 023: Edgware Road - Edgware Road (Outer - Clockwise) - Hammersmith (Inner - Anticlockwise) - Edgware Road (Outer - Clockwise) - Paddington (Inner - Anticlockwise)

Figure 1. GRIMM monitor dust concentration data at the District line on the 16<sup>th</sup> January 2019

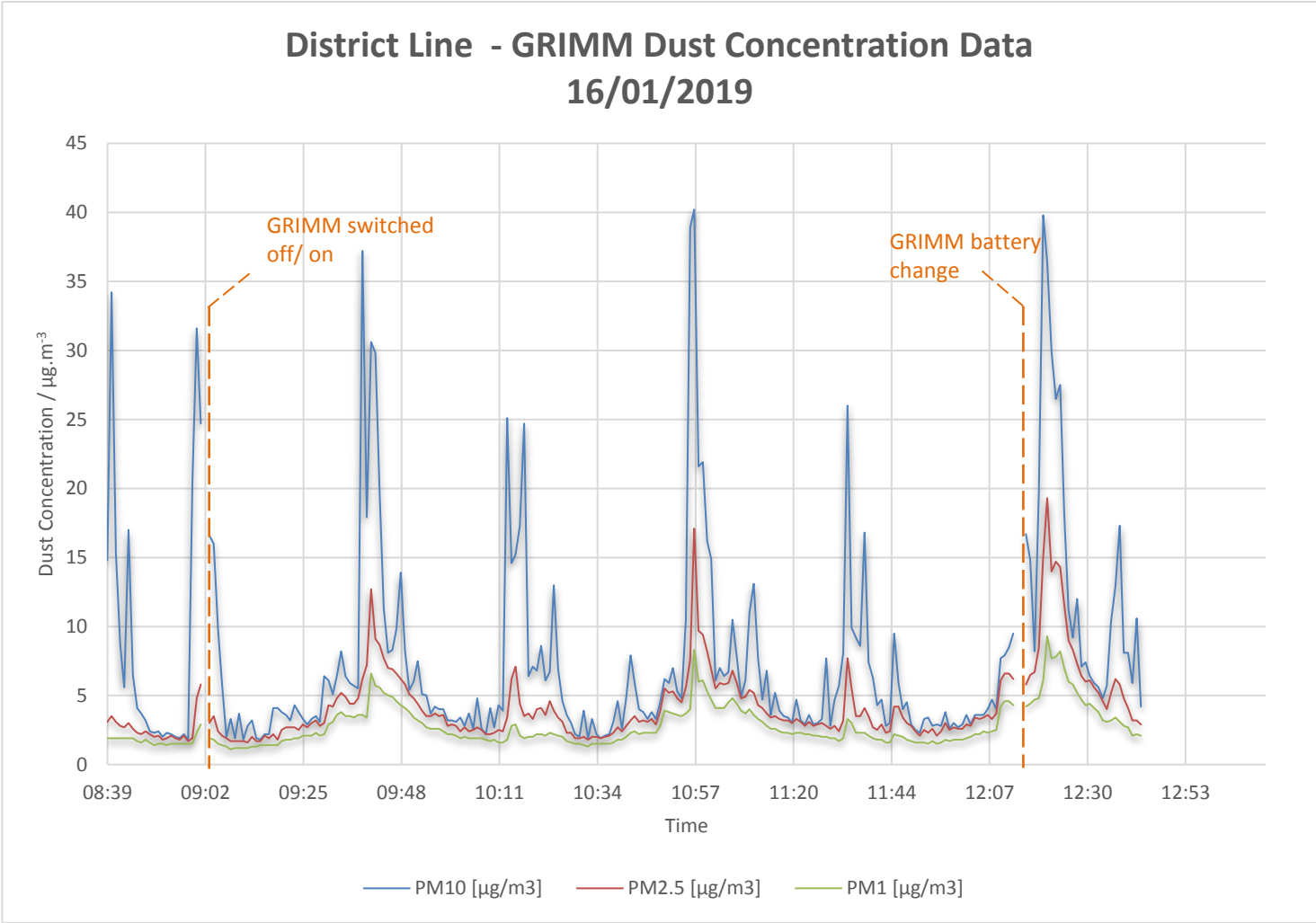


Figure 2. GRIMM monitor dust concentration data at the Piccadilly line on the 21<sup>st</sup> January 2019.

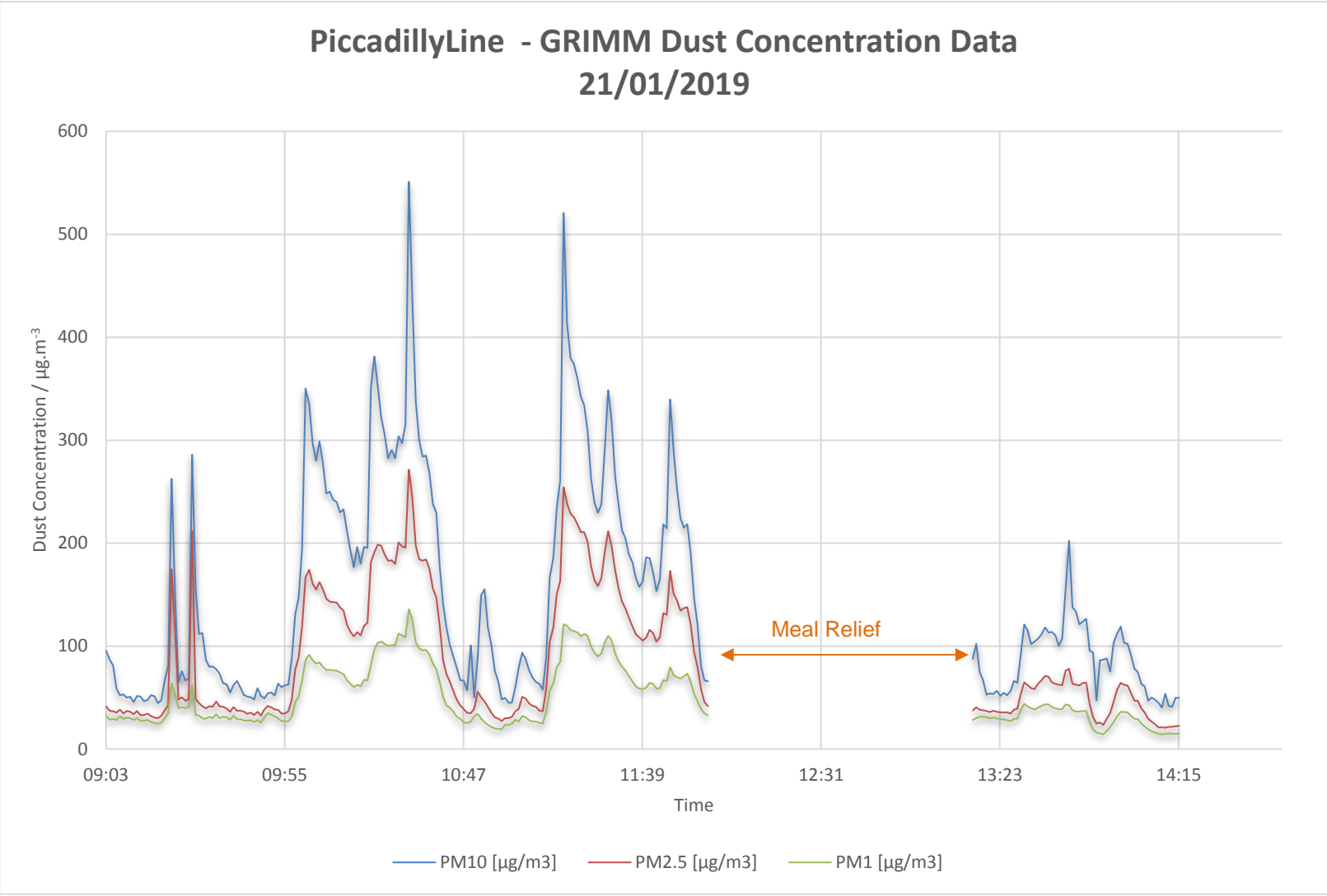


Figure 3. GRIMM monitor dust concentration data at the Jubilee line on the 24<sup>th</sup> January 2019.

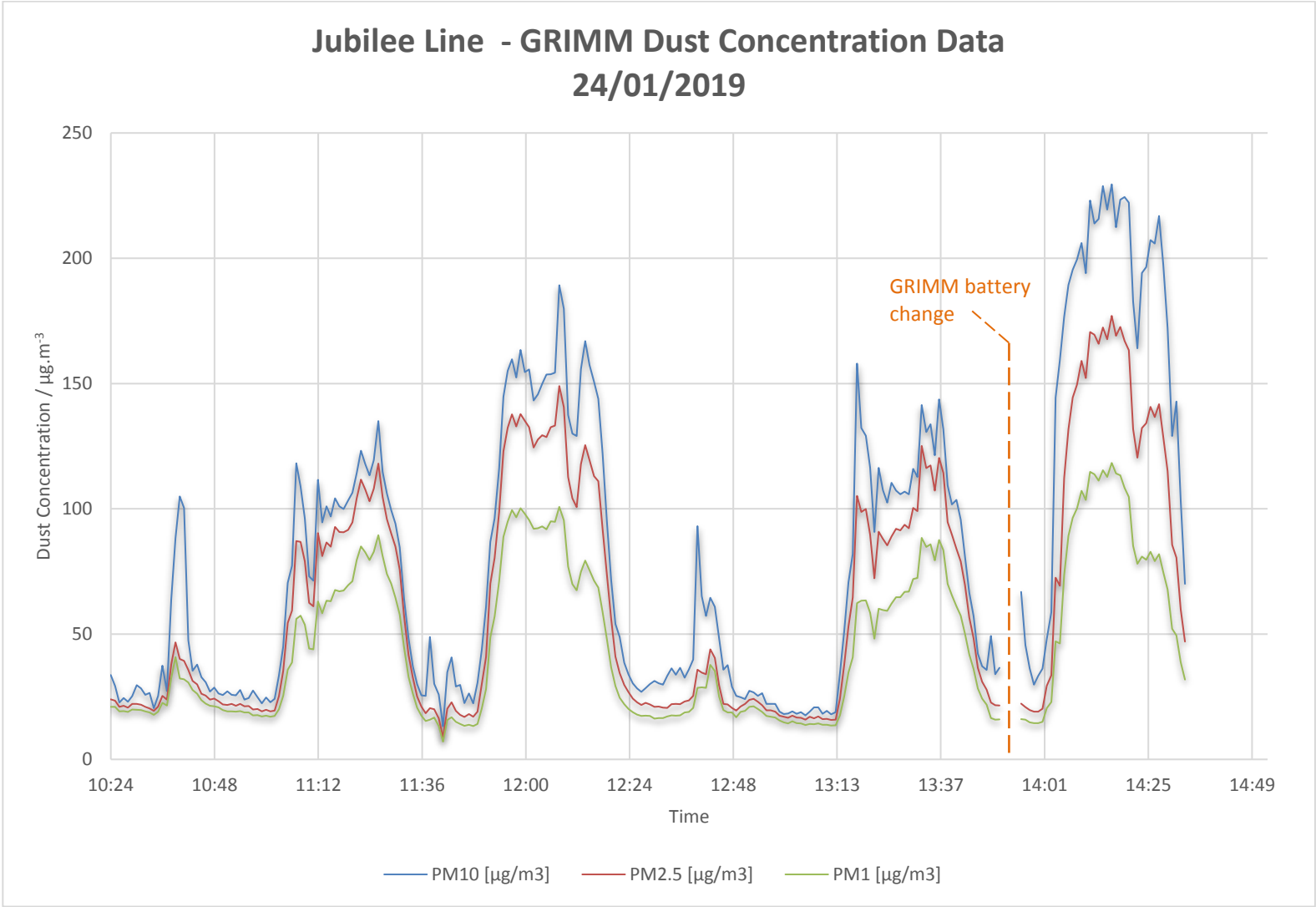




Figure 4. GRIMM monitor dust concentration data at the Victoria line on the 29<sup>th</sup> January 2019.

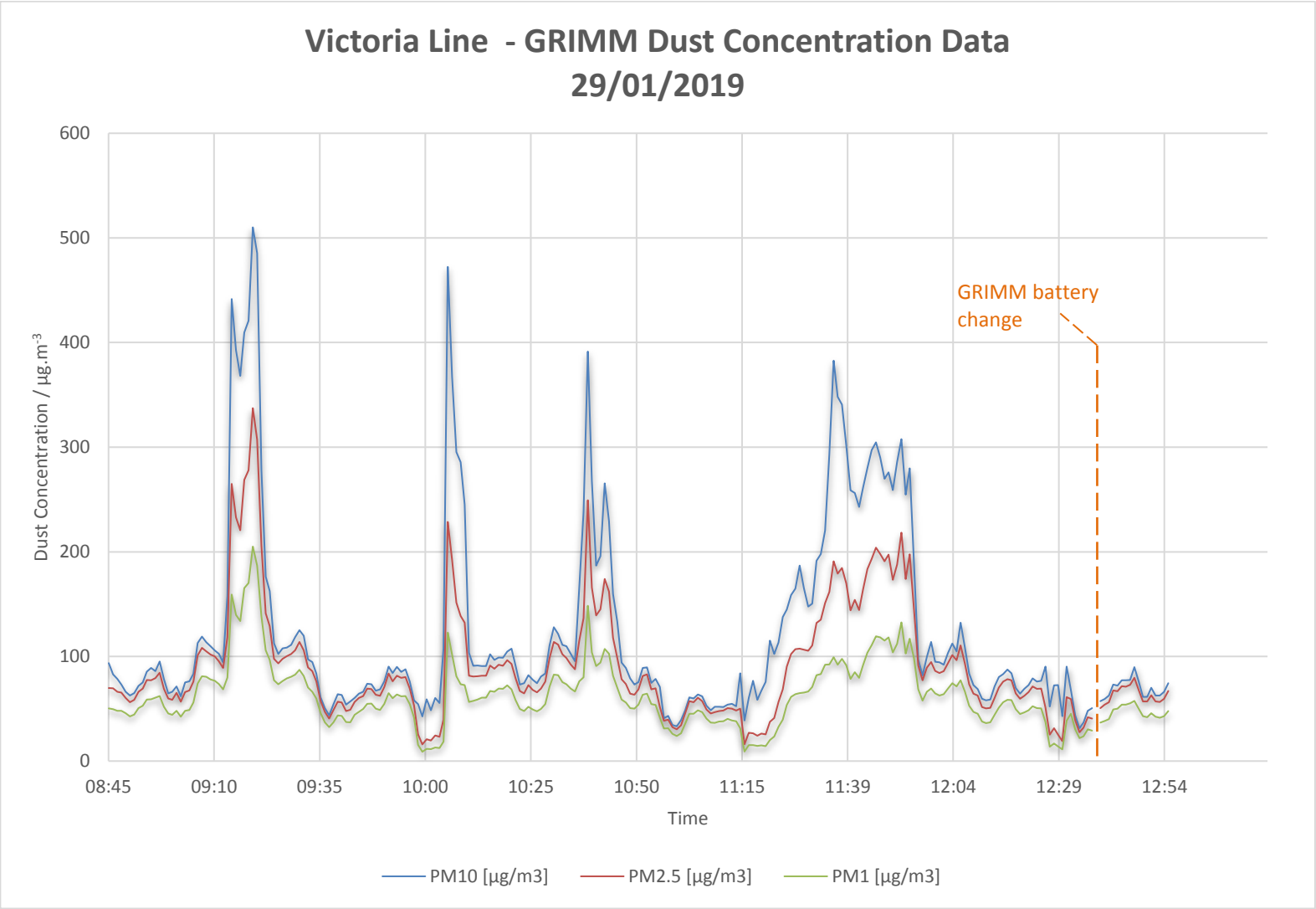


Figure 5. GRIMM monitor dust concentration data at the Bakerloo line on the 1<sup>st</sup> February 2019.

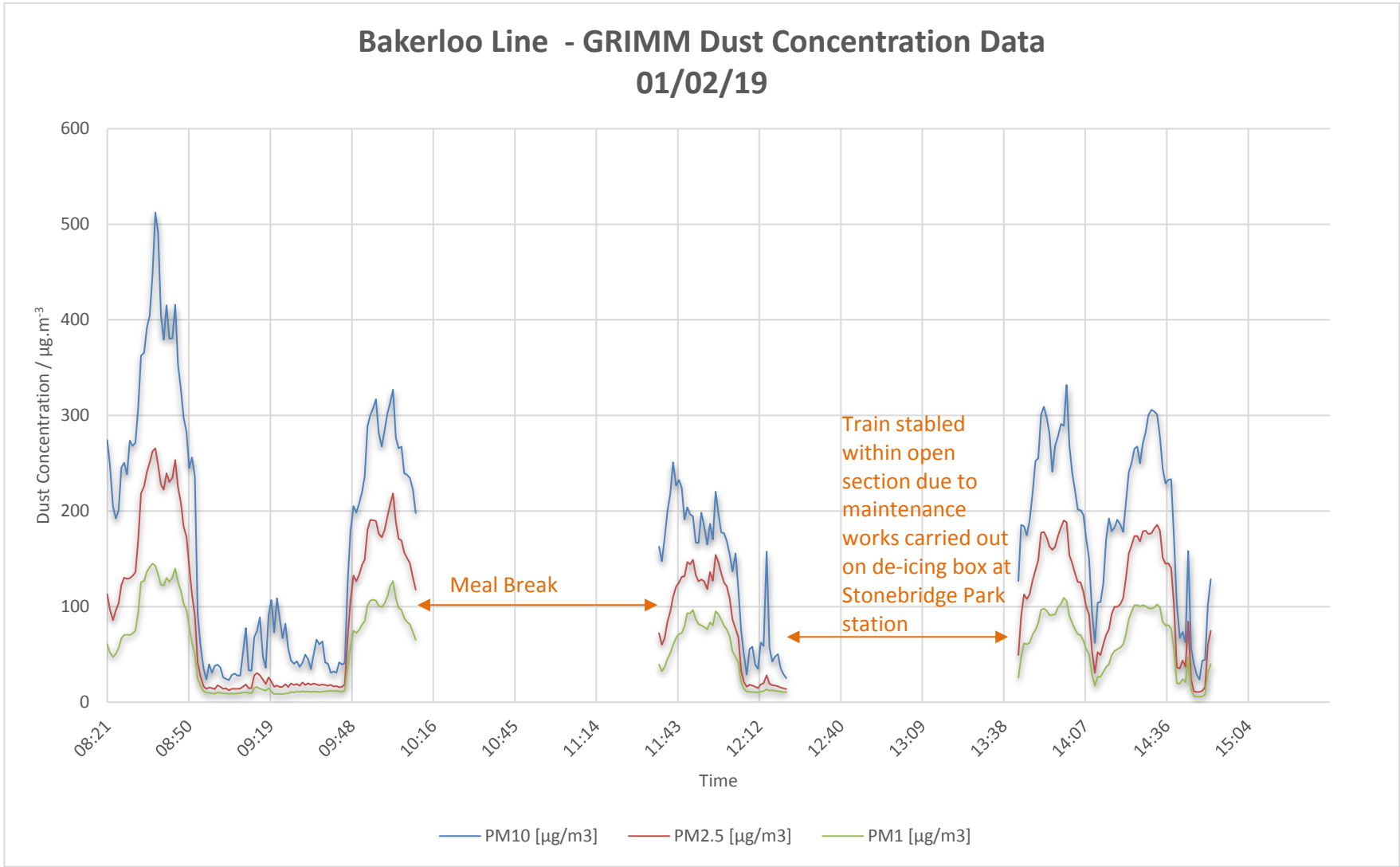


Figure 6. GRIMM monitor dust concentration data at the Central line on the 6<sup>th</sup> February 2019.

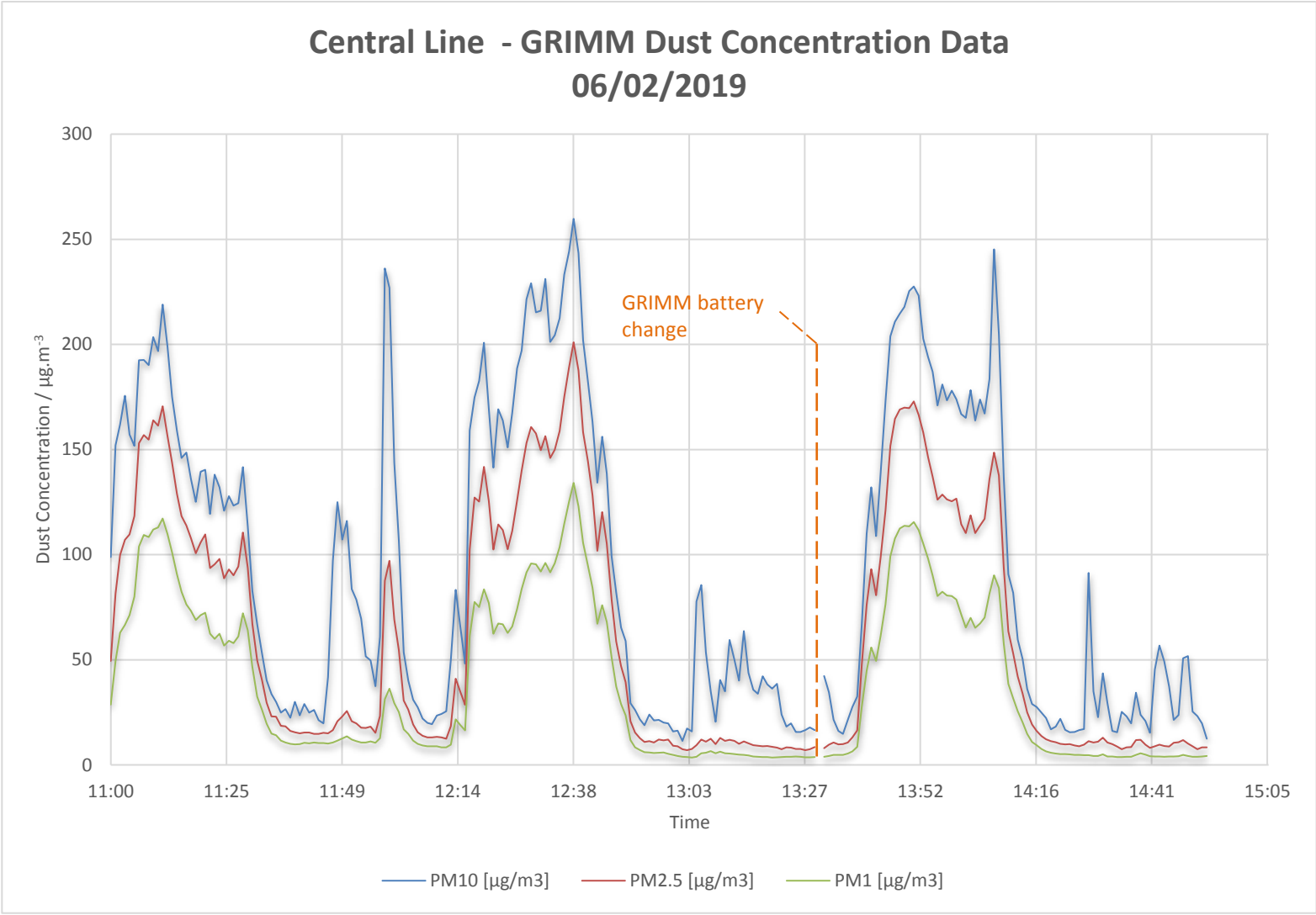


Figure 7. GRIMM monitor dust concentration data at the Northern line on the 11<sup>th</sup> February 2019.

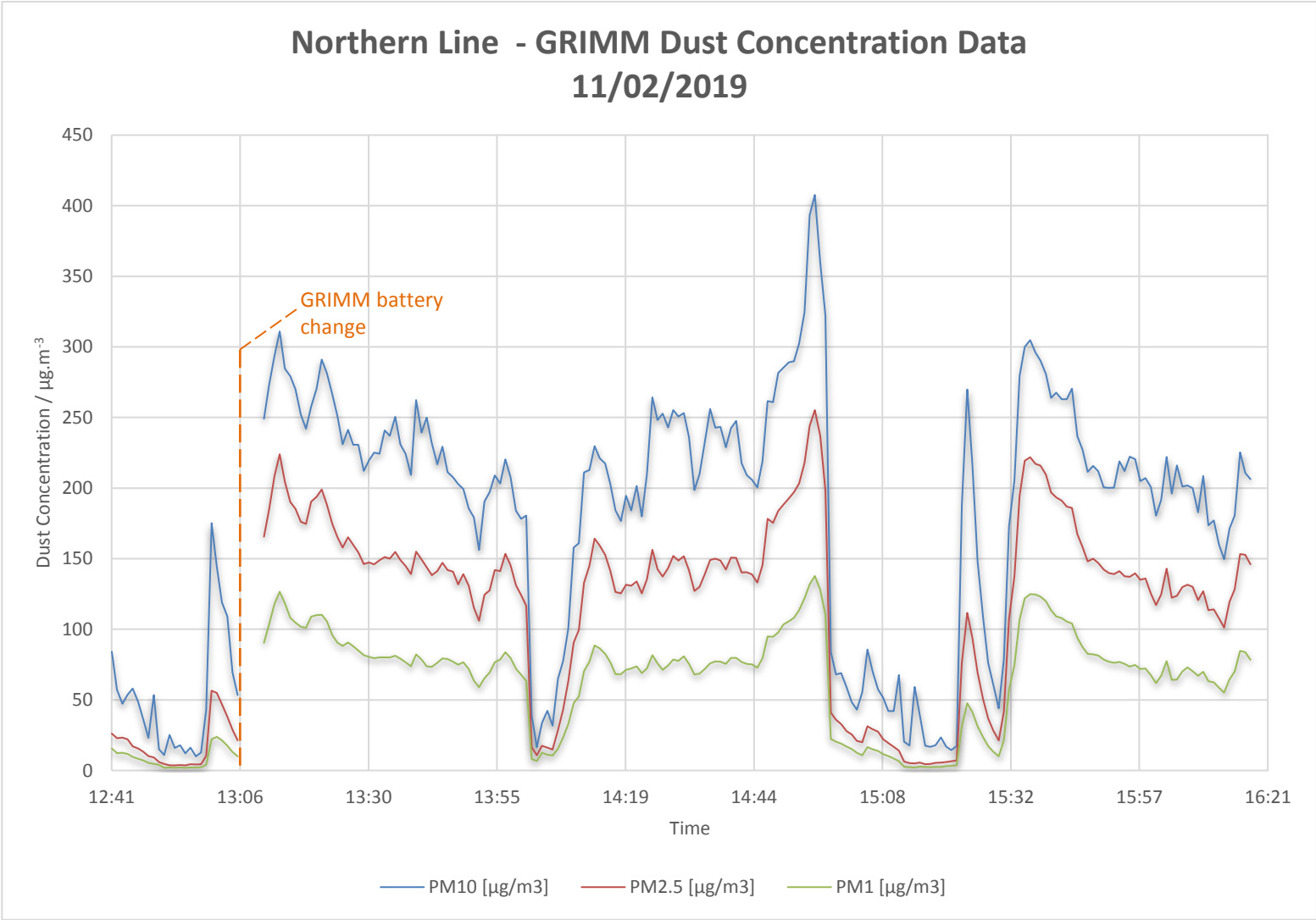
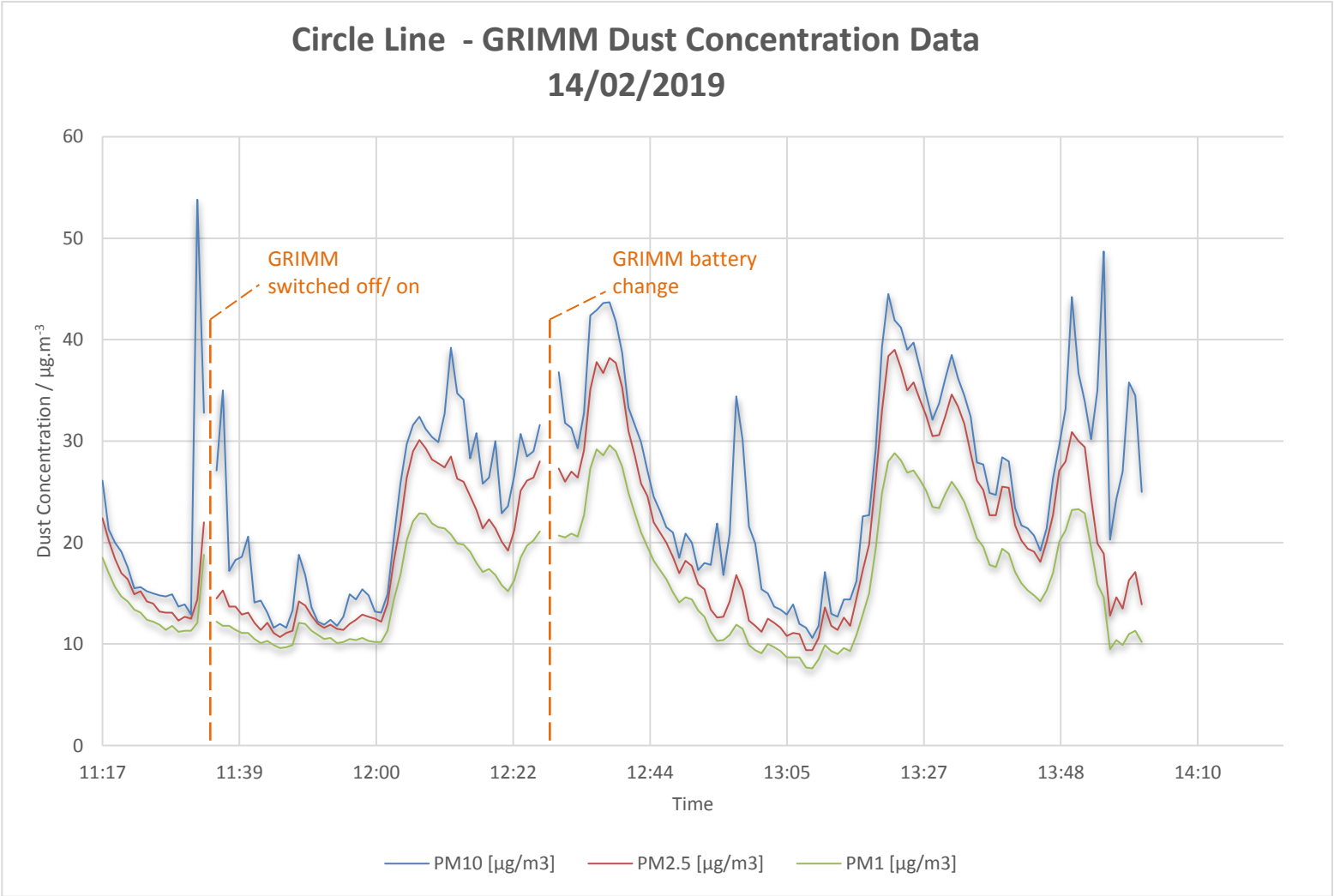


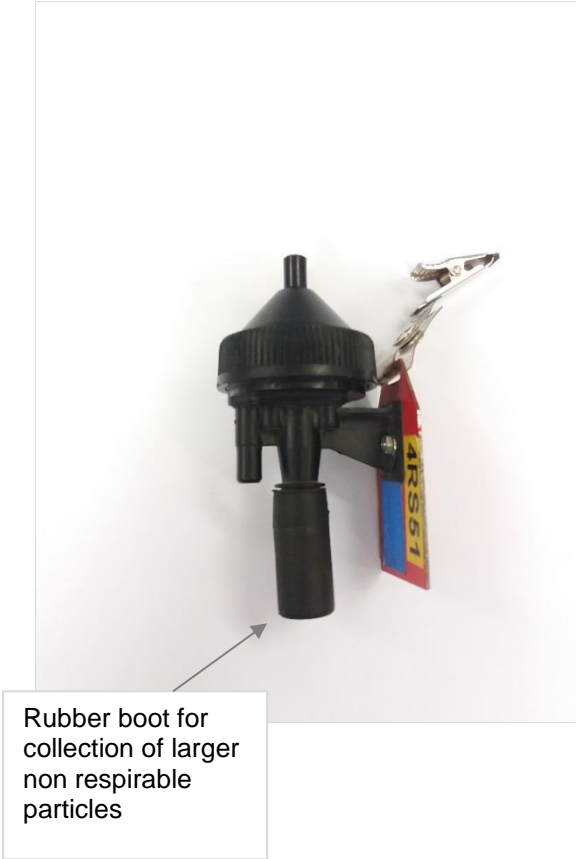
Figure 8. GRIMM monitor dust concentration data at Circle line on the 14<sup>th</sup> February 2019.



**Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines**

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**Figure 9. Cyclone Dust Head to monitor Respirable Dust.**



# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

## Appendix 1. Laboratory certificates for crystalline Respirable Silica results.



### CERTIFICATE OF ANALYSIS

**ANALYSIS REQUESTED BY:** 4-Rail Services Ltd  
Unit 11  
Ironbridge Close  
Great Central Way  
London  
NW10 0UF

**CONTRACT NO:** S04030  
**DATE OF ISSUE:** 26.02.19

**DATE SAMPLES RECEIVED:** 25.02.19

**DATE SAMPLES ANALYSED:** 26.02.19

**SAMPLES:** 25mm PVC filters

**NO. OF SAMPLES:** Sixteen

**ANALYSIS REQUESTED:** Respirable Crystalline Silica (as Quartz)

**METHOD:** The samples were analysed using an in-house method described in IOM instruction manual number 2 (IM2) using a modification of the following method;

**MDHS 101/2:** Health and Safety Executive (2014). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy or X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101/2. HMSO, London.

[www.iom-world.org](http://www.iom-world.org) 

**Registered Address:** Research Avenue North, Riccarton, Edinburgh, EH14 4AP, United Kingdom  
**Tel:** 0131 449 8000 **Fax:** 0131 449 8084 **Email:** [iom@iom-world.org](mailto:iom@iom-world.org)

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# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines



**CONTRACT NO:** S04030  
**DATE OF ISSUE:** 26.02.19

## RESULTS:

Sample Reference	Quartz Weight (mg)
180487/03	<0.01
180487/B4	<0.01
180487/07	<0.01
180487/B10	<0.01
180487/16	<0.01
180487/B22	<0.01
180487/21	<0.01
180487/B31	<0.01
180487/27	<0.01
180487/B40	<0.01
180487/33	<0.01
180487/B49	<0.01
180487/37	<0.01
180487/B55	<0.01
180487/43	<0.01
180487/B64	<0.01

Our detection limit for quartz using this method is 0.01mg.

## COMMENTS:

IOM Consulting cannot accept responsibility for samples that have been incorrectly collected or despatched by external clients.

Any opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

A handwritten signature in black ink that reads "Steve Clark".

AUTHORISED BY: .....

**S Clark**

*Mineralogy Section Manager*



# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

## Appendix 2. Laboratory certificates for respirable fraction - metal results (Arsenic, Copper, Iron, Manganese, Zinc, Chromium, Nickel).



### CERTIFICATE OF ANALYSIS

**ANALYSIS REQUESTED BY:** Rosanna Smart  
4 Rail Services Ltd  
Unit 11 Ironbridge Close  
Great Central Way  
London  
NW10 0UF

**CONTRACT NO:** S04065-1 of 2

**DATE OF ISSUE:** 07/03/2019

**DATE SAMPLE(S) RECEIVED:** 25/02/2019

**DATE SAMPLE(S) ANALYSED:** 01/03/2019

**DESCRIPTION OF SAMPLE(S):** Sixteen 25 mm PVC filters (GL2)

**ANALYSIS REQUESTED:** Iron (Fe), copper (Cu), chromium (Cr), zinc (Zn), arsenic (As), nickel (Ni) and manganese (Mn).

**METHOD** The samples were prepared for analysis of their metal content in accordance with IM 7 using a modification of NIOSH 7300 and analysed by Inductively Coupled Plasma/ Atomic Emission Spectrometry (ICP/AES).

**NIOSH 7300:** "Elements by ICP" (Nitric/Perchloric Acid Ashing) Issue 3 2003

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# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines



**CONTRACT NO:** S04065-1 of 2

**DATE OF ISSUE:** 07/03/2019

**RESULTS:**

Sample	Metal Weight (µg)*						
	As	Cr	Cu	Fe	Mn	Ni	Zn
180487/05	<0.3	0.3	<0.3	5.8	0.3	<0.3	<0.3
180487/B7	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
180487/11	<0.3	0.5	0.3	94.8	1.0	<0.3	<0.3
180487/B16	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
180487/17	<0.3	<0.3	<0.3	50.8	0.5	<0.3	<0.3
180487/B25	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
180487/23	<0.3	0.3	<0.3	56.8	0.6	<0.3	<0.3
180487/B34	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
180487/29	<0.3	0.4	<0.3	97.4	1.0	<0.3	<0.3
180487/B43	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
180487/31	<0.3	0.3	<0.3	59.4	0.5	<0.3	<0.3
180487/B46	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
180487/39	<0.3	0.3	<0.3	81.0	0.7	<0.3	<0.3
180487/B58	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
180487/45	<0.3	<0.3	<0.3	9.9	<0.3	<0.3	<0.3
180487/B67	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

\*UKAS accreditation for this work is restricted to results obtained directly from the analysis. Calculated results based on sampling information provided by the client are outside the scope of this accreditation.

# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines

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**CONTRACT NO:** S04065-1 of 2

**DATE OF ISSUE:** 07/03/2019

**COMMENTS:**

The reporting limit for metals by this method is 0.3 µg.

Results have been blank and spike corrected using laboratory filters.

Filter samples were halved for analysis, results have been scaled up accordingly.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

IOM Consulting cannot accept responsibility for samples that have been incorrectly collected or despatched.

**AUTHORISED BY:**

**Carolyn McGonagle**  
*Section Head*

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## Appendix 3. Laboratory certificates for respirable fraction - metal results (Chromium VI)



### **CERTIFICATE OF ANALYSIS**

**ANALYSIS REQUESTED BY:** Rosanna Smart  
4 Rail Services Ltd  
Unit 11  
Ironbridge Close  
Great Central Way  
London  
NW10 0UF

**CONTRACT NO:** S04065-2 of 2

**DATE OF ISSUE:** 10/03/2019

**DATE SAMPLES RECEIVED:** 25 February 2019

**DATE SAMPLES ANALYSED:** 01 March 2019

**DESCRIPTION OF SAMPLES:** Sixteen 25 mm PVC filters

**ANALYSIS REQUESTED:** Hexavalent Chromium (Cr<sup>VI</sup>) Analysis.

**METHOD:** The samples were prepared for analysis using a modification of **NIOSH 7600** and analysed by Ultraviolet Spectrometry.

**NIOSH 7600:** Chromium, Hexavalent

[www.iom-world.org](http://www.iom-world.org) 

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# Respirable Airborne Dust Monitoring At Various London Underground Stations And Train Lines



**CONTRACT NO:** S04065-2 of 2

**DATE OF ISSUE:** 10/03/2019

## RESULTS:

Sample	Cr <sup>VI</sup> Weight (µg)
180487/05	<0.13
180487/B7	<0.13
180487/11	<0.13
180487/B16	<0.13
180487/17	<0.13
180487/B25	<0.13
180487/23	<0.13
180487/B34	<0.13
180487/29	<0.13
180487/B43	<0.13
180487/31	<0.13
180487/B46	<0.13
180487/39	<0.13
180487/B58	<0.13
180487/45	<0.13
180487/B67	<0.13

## COMMENTS:

The reporting limit for Cr<sup>VI</sup> by this method is 0.13 µg.

Samples were halved for analysis, results have been scaled up accordingly.  
Sample results have been blank and spike corrected using appropriate laboratory filters.

IOM Consulting cannot accept responsibility for samples that have been incorrectly collected or despatched by external clients.

A handwritten signature in black ink, appearing to read 'Carolyn McGonagle'.

**AUTHORISED BY:**

**Carolyn McGonagle**  
Section Head

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