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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	24TH AUGUST 2017	ISSUED FOR COMMENT
REV01	31ST AUGUST 2017	REPORT REVISED TO AMEND PAGE 45 – GRAPH TITLE AND APPENDIX 2 – INSERTED RESULTS FOR METALS FOR BLANK FILTERS TO BETTER REFLECT THE RESULTS OBTAINED IN TABLES 24, 25 AND 26.

CONTENTS

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. In addition, personal monitoring was conducted in the saloon cars for simulated passenger journeys. Selected samples from the Train Operator monitoring were also analysed for crystalline silica and metals for particles of <2.5µm aerodynamic diameter. The samples were collected using respirable dust cyclone heads and cyclone inhalable samplers worn by, Train Operators and/or Station Staff during their shifts and by 4-RAIL Analysts undertaking passenger journeys.

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 Station Staff were not comfortable wearing 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 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 and passenger dust exposure monitoring was carried out on the District, Jubilee, Piccadilly, Victoria, Bakerloo, Central, Northern, Circle and Hammersmith & City lines.

For Train Operators, the highest respirable dust concentration measured was 0.49 mg/m^3 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 good general indication, the respirable dust concentration exposure levels for Train Operators were in general below those measured previously. The lowest dust levels were recorded for Train Operators working on the District and Circle Lines. For the simulated passenger's journeys, the results were all below or equivalent to 0.66 mg/m^3. The levels recorded for all lines were significantly less than the Workplace Concentration Exposure Limit of 4 mg/m^3 (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 3 times the long term exposure limit i.e. 12 mg/m^3 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.

For Station Staff on duty at Aldgate, Baker Street, Hampstead, Kings Cross and Tottenham Court Road Stations, the dust levels measured were well below the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour Time Weighted Average); with the highest being 0.50 mg/m^3. Where personal monitoring could not be carried out on the Station Staff, static monitoring was employed. The combined results of personal samples on Station Staff and the static monitoring from station Gate Lines samples indicate that the respirable dust concentrations at the stations assessed were also below the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour Time Weighted Average); highest concentration recorded was at Vauxhall station Gate Line (0.90 mg/m^3). The static samples were similar to those measured previously, with static samples situated on platforms giving the highest readings. Lower dust concentrations were recorded for personal samples taken on staff on gate line duties than for those on platform duties.

Selected samples taken from collectors worn by Train Operators were analysed for crystalline silica content by the Institute of Occupational Medicine (IOM). In the majority of cases, the levels found were same as or below the detection limit of <0.01 mg/filter, and therefore well below the Workplace Exposure Limit of 0.1 mg/m^3 (long term 8 hour Time Weighted Average). One sample from Piccadilly Train Operator's shift was found at 0.03 mg/ m^3. This concentration remains below the Workplace Exposure Limit.

The samples taken from PM2.5 collectors worn by Train Operators were analysed for metals. Generally, the levels of metals found were below or the same as the respective detection limits and in all cases, the results were well below the HSE workplace long term exposure limits.

1. Introduction

1.1 At the request of Mr Nick Wilson, London Underground Limited, personal monitoring for respirable airborne dust exposure was to be undertaken on LUL Train Operators whilst driving, on 4-RAIL Analysts undertaking passenger journeys and on Station Staff conducting gate line duties, platform duties (Station Assistant Trains, SATs) and other station duties. It should be noted that where personal monitoring could not be carried out on the London Underground Station Staff, static monitoring was conducted.

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 on the samples collected with the 2.5µm size selective head. In addition to this, a Grimm laser scatter dust monitor was to be used for one shift per line to gather data on the particle size distribution.

1.3 The specific stations and locations where personal and static monitoring was undertaken were:

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

Stations	Sampling Locations	Sample Type
Tottenham Court Road	Central and Northern lines platforms & Northern Gate line.	Static
	Gate line duties.	Personal
Vauxhall	Victoria line platforms	Static
Waterloo	Waterloo & City and Bakerloo line platforms	Static
Paddington	District & Circle, Bakerloo lines platforms	Static

1.4 Train operator and simulated passenger journey monitoring was to be carried out on the District, Jubilee, Piccadilly, Victoria, Bakerloo, Central, Northern and Circle lines.

1.5 Open sections of the District, Metropolitan and Hammersmith and City 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^3 and 10 mg/m^3 averaged over an 8-hour reference period (Health and Safety Executive Document EH40/05, 2nd Edition 2011). 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 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.

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^3 averaged over an 8-hour reference period (HSE Document EH40/05, 2nd Edition 2011).

2.5 Prolonged exposure to fine metal particles may also cause respiratory illnesses. The HSE Workplace Exposure Limits (WEL) 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^3
Copper dusts and mists (as Cu)		1	mg/m^3
Total Chromium		0.5	mg/m^3
Chromium (VI) compounds (as Cr)		0.05	mg/m^3
Nickel and its organic compounds	Water-soluble	0.1	mg/m^3
	Water insoluble	0.5	mg/m^3
Manganese and its inorganic compounds		0.5	mg/m^3
Zinc chloride fume		1	mg/m^3

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 or cyclone inhalable samplers as appropriate were worn by the Train Operators, Station Staff and Analysts on passenger journeys. The locations and location codes are given in the tables of results. Examples of a cyclone (respirable) dust head and a cyclone inhalable sampler to monitor particular matter of 2.5µm are shown in Figures 9 and 10.

3.3 Respirable airborne dust monitoring was carried out at each of the stations for one shift; timed to include the peak hours. Simulated passenger monitoring for respirable dust took place for one set of journeys on each of the eight lines, with minimum duration of 4 hrs per line, where possible.

3.4 The Train Operators monitoring was undertaken over three shifts on each line, again timed to include peak hours. The cyclone inhalable sampler was used in one of the shifts to monitor dust of 2.5 µm. Apart from personal dust exposure measurements, a Grimm laser scatter static dust monitor was also used during one of the shifts to take a continuous air sample. This instrument measures in real time different size particles by the physical principle of orthogonal light scattering. For this sampling programme the particle sizes chosen for measurement were 10 µm, 2.5 µm and 1 µm.

3.5 The personal samples were collected on 25 mm glass fibre type A/E filters for gravimetric analysis or 37 mm glass fibre type A/E filters for gravimetric analysis and subsequent analysis for metals by Mass Spectrometry; or 25 mm GLA 5000 PVC filters to allow both gravimetric analysis and then subsequent analysis for respirable quartz by infrared spectroscopy.

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 little or no duties on the platforms, static sampling pumps connected to cyclone heads loaded with 25 mm glass fibre type A/E filters were set up in strategic locations where possible. 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 2.5 µm dust samples, samples were submitted together with the blanks for 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 *4-RAIL Analyst simulating passenger journeys*

5.1.1 The respirable dust exposure levels assessed as representative for passengers travelling on the different lines are given in Table 1. Monitoring was undertaken on one set of journeys on each of the eight lines, between 9th and 20th June 2017.

The respirable dust results obtained were from 0.04 to 0.66 mg/m^3. The lines with highest results were the Victoria and Bakerloo lines with levels of 0.55 mg/m^3 and 0.66 mg/m^3 respectively. The Circle and District lines presented the lowest exposure results with respirable dust levels of 0.04 and 0.08 mg/m^3.

5.2 *Train Operators*

5.2.1 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 2 to 9.

- District Line

The respirable dust and PM2.5 exposure levels for the District Line measured on the 8th, 9th and 10th May 2017, are given in Table 2. The respirable dust results were both 0.05 mg/ m^3. The measured level of PM2.5 was 0.02 mg/m^3.

- Piccadilly Line

The respirable dust and PM2.5 exposure levels for the Piccadilly Line Train Operators measured on the 11th, 12th and 15th May 2017, are given in Table 3. The respirable dust results were 0.28 and 0.32 mg/m^3. The measured level of PM2.5 was 0.16 mg/m^3.

- Jubilee Line

The respirable dust and PM2.5 exposure levels for the Jubilee Line Train Operators measured on the 16th, 17th and 18st May 2017, are given in Table 4. The respirable dust results were 0.21 and 0.39 mg/m^3. The measured level of PM2.5 was 0.23 mg/m^3.

- Victoria Line

The respirable dust and PM2.5 exposure levels for the Victoria Line Train Operators measured on the 19th, 22nd and 23rd May 2017, are given in Table 5. The respirable dust results were 0.23 and 0.33 mg/m^3. The measured level of PM2.5 was 0.19 mg/m^3.

- Bakerloo Line

The respirable dust and PM2.5 exposure levels for the Bakerloo Line Train Operators measured on the 24th, 25th and 26th May 2017, are given in Table 6. The respirable dust results were 0.28 and 0.49 mg/m^3 and the PM2.5 result was 0.22 mg/m^3.

- Central Line

The respirable dust and PM2.5 exposure levels for the Central Line Train Operators measured on the 29th, 30th and 31st May 2017, are given in Table 7. The respirable dust obtained results were 0.16 and 0.24 mg/m^3 with a concentration of 0.12 mg/m^3 for the PM2.5 result.

- Northern Line

The respirable dust and PM2.5 exposure levels for the Northern Line Train Operators measured on the 1st, 2nd and 5th June 2017, are given in Table 8. The respirable dust results were 0.13 and 0.15 mg/m^3. The measured level of PM2.5 was 0.23 mg/m^3.

- Circle Line/ Hammersmith & City Line

The respirable dust and PM2.5 exposure levels for the Circle and H&C Line Train Operators measured on the 6th, 7th and 8th June 2017, are given in Table 9. The respirable dust results were 0.04 and 0.18 mg/m^3. The level of PM2.5 was 0.03 mg/m^3.

5.2.2 Selected respirable dust samples taken during the train operator monitoring across all of the different Lines, together with blanks, were submitted to the Institute of Occupational Medicine (IOM) for quartz analysis.

The results for each of the Lines are given in Table 23 and the certificates for the analysis of quartz are included in Appendix 1. For each filter the level of crystalline silica found <0.01 mg/filter. One filter (Ref. 160906/09) from Piccadilly Train Operator's journey was found with a level of crystalline found at 0.02 mg/filter. The calculated levels of airborne respirable crystalline silica was therefore 0.03 mg/m^3 when the volume of air sampled was accounted for.

5.2.3 The PM2.5 samples taken during the train operator monitoring across all of the different Lines and blanks were submitted for the analysis of metals. The results are given in Tables 24 to 26 and the certificates for the analysis of metals are included in Appendix 2.

For each filter, the levels of analysed metals were significantly lower than the HSE applicable Workplace Exposure Limits. For Nickel and Manganese, the concentrations were below the detection limit of the analytical method, between <0.001 and 0.002 mg/m^3. Chromium and Copper concentrations were found to be all below 0.001 mg/m^3. Iron and Zinc concentrations were found between 0.02 - 0.19 mg/m^3.

The calculated levels of 2.5 µm metals were all <0.20 mg/m^3 when the volume of air sampled was accounted for.

Zinc concentrations in Appendix 2 appear slightly elevated to the rest of the metals analysed, this is because the sample filter used contains zinc itself. This is corrected for in table in 24 by subtracting the field blank that was taken to site on each occasion.

5.2.4 The Grimm results are shown in graphs Figures 1 to 8.

Several peaks can be observed on all of the graphs; and these ranged from 58.9 µg/m^3 during sampling on District Line to 464.2 µg/m^3 during sampling on Jubilee Line. The Grimm monitor was disconnected during meal relieves and this can be also noted in some of the graphs where there was no data for a certain time period which correspond to the break time. Some peaks can be observed during this period; however this may coincide with the time when the 4-RAIL personnel and Train Operator were approaching the train environment, i.e. walking on the platform.

It can be deduced from the graphs that the Jubilee and Northern lines presented higher dust concentration than the rest of the lines. The District and Hammersmith & City and Circle lines had the lowest dust concentration due to their more frequent and longer open sections.

5.3 *Station Staff*

5.3.1 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. Six personal samples were collected on this occasion, from personnel carrying out gate line duties at Aldgate East, Baker Street, King's Cross, Hampstead and Tottenham Court Road stations.

Where no platform duties were carried out or station staff were not comfortable wearing personal samplers, static samples were taken but these cannot directly replace personal samples. However, they do allow for an assessment of indicative personal exposure.

5.4 *Stations*

The results for the station monitoring are shown in Tables 10 - 21.

Aldgate East Station

The results for the monitoring at Aldgate East Station are given in Table 10. The monitoring was carried out on the 21st June 2017. The result for the personal sample was 0.50 mg/m^3. The results for the static samples at the ticket hall, westbound and eastbound platforms were 0.38, 0.33 and 0.46mg/m^3 respectively.

Baker Street Station

The results for the monitoring at Baker Street Station are given in Table 11. The monitoring was carried out on the 22nd June 2017. The result for the personal sample was 0.16 mg/m^3. The results for the static samples were between 0.06 and 1.30 mg/m^3. The highest dust concentrations recorded were on the Bakerloo and Jubilee Lines.

Elephant and Castle Station

The results for the monitoring at Elephant and Castle Street Station are given in Table 12. The monitoring was carried out on the 23rd June 2017. Only static monitoring was carried out. The results for the static samples at the platforms and gate lines were between 0.07 and 0.50 mg/m^3, with the highest recorded on the Bakerloo line southbound platform.

Euston Square Station

The results for the monitoring at Euston Square Station are given in Table 13. The monitoring was carried out on the 26th June 2017. Only static monitoring was carried out. The results for the static samples were between 0.06 and 0.43 mg/m^3 respectively.

Hampstead Station

The results for the monitoring at Hampstead Station are given in Table 14. The monitoring was carried out on the 27th June 2017. The result for the personal sample was 0.25 mg/m^3. The results for the static samples at the Northern Line platforms were 0.89 and 0.98 mg/m^3.

King's Cross Station

The results for the monitoring at King's Cross Station are given in Table 15. The monitoring was carried out on the 28th June 2017. Two personal samples were taken at this station. However, due to equipment technical issues, one result failed to be recorded (faulty air sampler – unknown volume of air sampled) and the second is indicative only (<0.02 mg/m^3). The results for the static samples throughout the station, on various train line platforms and ticket offices, were between 0.02 and 0.86 mg/m^3. The highest dust concentrations recorded were on the Piccadilly (W/B) and Victoria (S/B) Lines.

Oxford Circus Station

The results for the monitoring at Oxford Circus Station are given in Table 16. The monitoring was carried out on the 29th June 2017. The results for the static samples were between 0.21 and 1.12 mg/m^3, with highest results recorded at Bakerloo Line platforms.

Paddington Station

The results for the monitoring at Paddington Station are given in Table 22. The monitoring was carried out on the 30th June 2017. The results for the static samples at the platforms and gate lines were between 0.13 and 1.37 mg/m^3. The highest dust concentrations recorded were on the Bakerloo Line platforms.

Piccadilly Circus Station

The results for the monitoring at Piccadilly Circus Station are given in Table 18. The monitoring was carried out on the 3rd July 2017. The results for the static samples were between 0.2 to 1.02 mg/m^3, with highest results recorded at Northern Line platforms.

Vauxhall Station

The results for the monitoring at Vauxhall Station are given in Table 19. The monitoring was carried out on the 5th July 2017. The results for the static samples at the Victoria Line N/B platform and ticket hall were 0.77 and 0.90 mg/m^3.

Tottenham Court Road Station

The results for the monitoring at Tottenham Court Road Station are given in Table 20. The monitoring was carried out on the 7th July 2017. The result for the personal sample was 0.24 mg/m^3. The results for the static samples were between 0.16 to 1.39 mg/m^3 with highest result recorded at Central Line E/B platform.

Waterloo Station

The results for the monitoring at Waterloo Station are given in Table 21. The monitoring was carried out on the 6th July 2017. The results for the static samples throughout the station, on various train line platforms and ticket office were between 0.08 to 0.82 mg/m^3, with highest results recorded at Northern Line platforms.

6. Discussions and Conclusions

6.1 The levels of airborne respirable dust for the personal samples taken on Train Operators and on 4-RAIL analysts undertaking passenger journeys travelling on the following lines: District, Jubilee, Piccadilly, Victoria Bakerloo, Central, Northern, Circle and Hammersmith & City, were all below the Workplace exposure limit of 4 mg/m^3 for respirable dust (long-term 8 hour time weighted average).

6.2 The highest gravimetric result obtained was for the sample of a train operator on the Bakerloo Line and the lowest results were for the samples of the train operators on the District, H&C and Circle Lines. As a passenger, the higher levels were found on the Bakerloo and Victoria Lines. The Grimm laser scatter data showed that the Piccadilly, Northern and Central Lines presented higher dust concentration than for the other lines. The District, Circle and Hammersmith & City line had the lowest concentration.

6.3 The levels of airborne respirable dust measured for personal samples taken on staff carrying out platform/gate line/station check duties as part of their shifts at the following stations: Aldgate East, Hampstead, Kings Cross and Tottenham Court road were below the Workplace exposure limit of 4 mg/m^3 for respirable dust (long-term 8 hour time weighted average). Also, all the static samples at specific stations (platforms and gate lines) resulted in concentrations below the Workplace exposure limit. However, it was noted that the samples from Oxford Circus Station (0.21 – 1.12 mg/m^3) were significantly higher than previous round of monitoring (0.09 - 0.69 mg/m^3). Also, samples from Tottenham Court Road station's platforms – Central Line E/B, were significantly higher (1.39 mg/m^3) than the previous round of monitoring carried out in 2016 (1.15 mg/m^3).

6.4 It should also be noted that the respirable dust levels reported for the station personnel, 4-RAIL passengers and train operators are for the monitoring period in each case. Where a shift lasts for less than 8 hours, the 8 hours time weighted average exposure will be lower than the measured level so the results would all be further below the 4 mg/m^3 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^3 over a 15 minute period. Therefore, the levels recorded for the train operators, 4-RAIL passengers and station personnel were significantly below the short-term exposure limit.

6.5 The results of the static samples on the platforms would suggest that personal exposure to respirable dust on the platforms would be below the Workplace exposure limit for respirable dust of 4 mg/m^3 (long term 8 hour time weighted average). Generally the higher results (>1.3 mg/m^3) were found for the Bakerloo and Central Lines platforms at Paddington, Baker Street and Tottenham Court Road stations.

6.6 Quartz silica and metals results for the train drivers were all below the HSE applicable Workplace Exposure Limits.

6.7 Compared to the latest monitoring exercise (4RS-APO-153196-R517226-Rev01 issue 22nd September 2016) the majority of the metal analysis results for the Train Operators were similar and consistently lower than the HSE Workplace Exposure Limits (WEL) listed in paragraph 2.5 of this report. Iron levels decreased (0.02-0.12 mg/m^3) from last round of sampling in 2016 (0.02-0.334 mg/m^3).

6.8 In terms of personal monitoring, although not all of the duties and locations were monitored exactly the same as performed in 2011, 2013, 2014 and 2016 those that were repeated, in similar locations, generally gave similar results with no significant variations.

Table 1. 4-RAIL Analyst simulating LU Passenger Journeys

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^{N} (mg/m^3)	Route Covered
160906/49	RD	4RS49 - 4-RAIL Analyst, District Line	09/06/17	08:47	12:54	2.2	543.4	0.04	Train 101: Earl's Court - Upminster - Ealing Broadway - Upminster - Whitechapel - Ealing Broadway.
160906/50	RD	4RS50 - 4-RAIL Analyst, Piccadilly Line	12/06/17	08:20	12:26	2.2	541.2	0.36	Train 332: Earl's Court - Heathrow 1, 2, 3 & 5 - Arnos Grove. Train 331 to Northfields - Acton Town - Earl's Court.
160906/51	RD	4RS51- 4-RAIL Analyst, Jubilee Line	13/06/17	10:00	14:00	2.2	528	0.24	Train 316: Green Park - Stanmore - North Greenwich. Train 336 to Green Park.
160906/52	RD	4RS52 - 4-RAIL Analyst, Victoria Line	14/06/17	08:57	13:25	2.2	589.6	0.55	Train 223: Green Park - Walthamstow Central. Train 224 to Brixton. Train 225 to Walthamstow Central - Brixton. Train 217 to Walthamstow Central. Train 252 to Brixton. Train 241 to Walthamstow Central. Train 204 to Green Park.
160906/53	RD	4RS53- 4-RAIL Analyst, Bakerloo Line	15/06/17	10:22	14:24	2.2	532.4	0.66	Train from Baker Street - Harrow & Whealdstone - Elephant & Castle - Harrow & Whealdstone - Elephant & Castle - Baker Street.
160906/55	RD	4RS55 - 4-RAIL Analyst, Central Line	16/06/17	11:03	15:03	2.2	528	0.24	Train from Ruislip to Epping via Hainault - Ruislip
160906/56	RD	4RS56 - 4-RAIL Analyst, Northern Line	19/06/17	10:31	14:31	2.2	528	0.24	Train 146 to High Barnet via Bank – Kennington via Charring Cross – High Barnet via Charring Cross – Morden via Bank
160906/57	RD	4RS57 - 4-RAIL Analyst, Circle Line	20/06/17	09:20	13:25	2.2	539	0.08	Train 501 to Edgware Road (Eastbound) via Kings Cross (– 4 loops) as no Circle Line between Edgware Road and Hammersmith.

Table 2. 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^{N} (mg/m^3)	Route Covered
160906/01	RD	LU01 TO – Driver – Duties 208 & 326	08/05/17	09:32	15:11	2.2	745.80	0.05	Train 061: Earl's Court - Barking - Train 034 to Ealing Broadway - Earl's Court - Upminster - Acton Town

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^{N} (mg/m^3)	Route Covered
160906/04	RD	LU04 TO – Driver – Duties 208, 203 & 193	09/05/17	09:41	13:59	2.2	567.8	0.05	Train 061: Earl's Court - Barking - Train 034 to Ealing Broadway - Earl's Court - Train 064 - Wimbledon - High Street Kensington - Edgware Road - Train 075 to Edgware Road

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^{N} (mg/m^3)	Route Covered
160906/06	PM 2.5	LU06 TO – Driver – Duties 309 & 208	10/05/17	08:38	10:21	3.5	941.5	0.02	Train 061: Richmond - Barking - Train 034 to Ealing Broadway - Earl's Court - Train 050 to Ealing Broadway - Westminster
				10:48	12:29				
				13:37	14:42				

Table 3. 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^{N} (mg/m^3)	Route Covered
160906/07	RD	LU07 TO – Driver – Duty 625	11/05/17	10:06	12:06	2.2	484	0.28	Train 351: Northfields – Arnos Grove – Acton Town. Train 253 to Rayners Lane - Cockfosters
				13:05	14:45				

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^{N} (mg/m^3)	Route Covered
160906/09	RD	LU09 TO – Driver – Duty 624	12/05/17	09:37	12:04	2.2	741.4	0.32	Train 326: Acton Town - Cockfosters - Northfields - Train 232 to Heathrow - Cockfosters - Acton Town
				13:12	16:22				

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^{N} (mg/m^3)	Route Covered
160906/12	PM 2.5	LU12 TO – Driver – Duty 623	15/05/17	09:31	11:59	3.5	1148	0.16	Train 231: Acton Town - Rayners Lane - Cockfosters - Acton Town - Train 260 to Heathrow T1, 2, 3 & 5 - Cockfosters
				13:12	16:12				

Table 4. 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^{N} (mg/m^3)	Route Covered
160906/14	RD	LU14 TO – Driver – Duty Mr Lawrence	16/05/17	07:44 13:17	12:04 16:41	2.2	1020.8	0.21	Train 314: Stratford - Willesden Green-North Greenwich-Stanmore-Stratford-Wembley Park. Train 311: to Stanmore - Stratford - Stanmore - West Ham.

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^{N} (mg/m^3)	Route Covered
160906/15	RD	LU15 TO – Driver – Duty 023	17/05/17	09:02	13:06	2.2	536.8	0.39	Train 303: Stratford - Stanmore - North Greenwich - Stanmore - Stratford.

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^{N} (mg/m^3)	Route Covered
160906/18	PM 2.5	LU18 TO – Driver – Duty Mr Lawrence Gill	18/05/17	07:40 13:17	12:04 15:06	3.5	1305.5	0.23	Train 314: Stratford - Willesden Green-North Greenwich-Stanmore-Stratford-Wembley Park. Train 311: to Stanmore - Stratford - Stanmore - West Ham.

Table 5. 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^{N} (mg/m^{3})	Route Covered
160906/19	RD	LU19 TO – Driver Duty	19/05/17	08:51 11:58	11:06 13:50	2.2	543.4	0.23	Train 206: Brixton - Walthamstow. Train 245 to Brixton. Train 201 to Northumberland Park Depot. Train 260 to Seven Sisters. Train 250 to Brixton. Train 213 to Walthamstow. Train 237 to 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^{N} (mg/m3)	Route Covered
160906/22	RD	LU22 TO – Driver Duty	22/05/17	08:33	12:35	2.2	532.4	0.33	Train 242: Brixton - Walthamstow. Train 221 to Brixton. Train 245 to Walthamstow. Train 246 to Brixton. Train 241 to Walthamstow. Train 204 to Brixton.

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^{N} (mg/m^{3})	Route Covered
160906/24	PM 2.5	LU24 TO – Driver Duty	23/05/17	08:26 10:30	09:46 14:04	3.5	1029	0.19	Train 214: Brixton - Walthamstow. Train 206 to Brixton. Train 211 to Walthamstow. Train 213 to Brixton. Train 237 to Walthamstow. Train 240 to Brixton. Train 212 to Walthamstow - Green Park.

Table 6. 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^{N} (mg/m^{3})	Route Covered
160906/25	RD	LU25 TO – Driver Duty 023	24/05/17	09:42 13:30	12:06 16:57	2.2	772.2	0.49	Train 221: Elephant & Castle to Queen's Park - Elephant &Castle - Train 213 to Queen's Park - Elephant & Castle. Train 202 to Harrow & Wealdstone - Elephant & Castle

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^{N} (mg/m^{3})	Route Covered
160906/27	RD	LU27 TO – Driver Duties 015 & 025	25/05/17	08:23	12:33	2.2	550	0.28	Train 227: elephant & Castle to Harrow & Wealdstone - Elephant & Castle. Train 240 to Harrow & Wealdstone - Elephant & Castle

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^{N} (mg/m^{3})	Route Covered
160906/30	PM 2.5	LU30 TO – Driver Duties 019 & 027	26/05/17	09:03 13:40	12:37 15:12	3.5	1071	0.22	Train 210: Elephant & Castle to Queen's Park - Elephant & Castle. Train 227 to Queen's Park - Elephant & Castle. Train 242 to Harrow & Wealdstone

Table 7. 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^{N} (mg/m^3)	Route Covered
160906/31	RD	LU31 TO – Driver Duties 512 & 916	29/05/17	09:00	10:01	2.2	580.8	0.16	Train 041: West Ruislip to Leytonstone - West Ruislip - White City - Epping
				10:39	12:18				
				12:35	14:19				

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^{N} (mg/m^3)	Route Covered
160906/33	RD	LU33 TO – Driver Duties 918 & 912	30/05/17	08:48	12:52	2.2	536.8	0.24	Train 011: West Ruislip to Epping - West Ruislip - Epping. Train 010 to Leytonstone

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^{N} (mg/m^3)	Route Covered
160906/36	PM 2.5	LU36 TO – Driver Duties 905 & 818	31/05/17	09:28	12:28	3.5	1312.5	0.12	Train 017: West Ruislip to Epping - West Ruislip. Train 026 to Epping
				13:26	15:41				

Table 8. 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^{N} (mg/m^3)	Route Covered
160906/38	RD	LU38 TO – Driver Duty 624	01/06/17	09:20	10:12	2.2	543.4	0.13	Train 011 Morden to Golders Green via Bank. Train 014 to Morden. Morden to Edgware via Bank and to Morden via Bank.
				11:00	14:15				

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^{N} (mg/m^3)	Route Covered
160906/40	RD	LU40 TO – Driver Duty 635	02/06/17	07:35	13:35	2.2	528	0.15	Train 111 Morden to High Barnet via Charring Cross - Kennington - High Barnet via Charing Cross - Morden via Bank.

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^{N} (mg/m^3)	Route Covered
160906/42	PM 2.5	LU42 TO – Driver Duty 628	05/06/17	06:45	10:03	3.5	1088.5	0.23	Train 007: Morden to Edgware via Bank - Morden via Charring Cross. Train 010 to Golders Green via Bank. Train 020 to Edgware - Morden via Bank – Edgware.
				10:55	12:48				

Table 9. Hammersmith & City and Circle Lines 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^{N} (mg/m^{3})	Route Covered
160906/44	RD	LU44 TO – Driver Duty 020	06/06/17	09:27	13:03	2.2	477.4	0.18	Train 261: Edgware Road to Barking - Hammersmith - Barking - Hammersmith - Edgware Road
				13:59	15:28				

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^{N} (mg/m^{3})	Route Covered
160906/46	RD	LU46 TO – Driver Duty 021	07/06/17	09:30	13:17	2.2	695.2	0.04	Train 210: Edgware Road - Hammersmith - Moorgate - Edgware Road via Paddington. Train 203 to Moorgate - Hammersmith - Edgware Road.
				14:13	15:42				

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^{N} (mg/m^{3})	Route Covered
160906/48	PM 2.5	LU48 TO – Driver Duty 010	08/06/17	07:10	11:00	3.5	1043	0.03	Train 212: Edgware Road - Hammersmith - Edgware Road - Edgware Road via Liverpool Street. Train 200 to Hammersmith - Edgware Road
				11:53	13:01				

Table 10. 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^{N} (mg/m^3)	Other Comments
160906/58	RD	Westbound Platform 1	21/06/17	09:34	13:44	2.2	550	0.33	Dust levels were visible and noted at the station throughout the whole period of sampling. Personal monitoring carried out on one of the LU Gate Line Staff.
160906/59	RD	Personal – Mr Singh – Gate Line Staff (Exits 1 & 2, 3 & 4))	21/06/17	09:24 13:05	11:30 13:54	2.2	385	0.50	
160906/60	RD	Eastbound Platform 2	21/06/17	09:40	13:55	2.2	561	0.46	
160906/61	RD	Gate Line – Exits 3 & 4	21/06/17	09:43	13:43	2.2	528	0.38	

Table 11. 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^{N} (mg/m^3)	Locations & Comments
160906/65	RD	Static - Metropolitan Line	22/06/17	10:45	15:14	2.2	591.8	0.07	Platforms 3 & 4 (E/B)
160906/66	RD	Static - Hammersmith & Circle Lines	22/06/17	10:40	15:10	2.2	594	0.15	Platform 6 (W/B)
160906/67	RD	Static - Hammersmith & Circle Lines	22/06/17	10:35	15:07	2.2	598.4	0.11	Platform 5 (E/B)
160906/68	RD	Static - Bakerloo Line	22/06/17	11:07	15:29	2.2	576.4	1.30	Platform 8 (S/B) High level of dust noted at this location.
160906/69	RD	Static - Bakerloo Line	22/06/17	11:01	15:25	2.2	580.8	1.13	Platform 9 (S/B) High level of dust noted at this location.
160906/70	RD	Static - Metropolitan Line	22/06/17	10:52	15:18	2.2	585.2	0.13	Platforms 1 & 2 (W/B)
160906/71	RD	Static - Jubilee Line	22/06/17	11:05	15:31	2.2	585.2	0.99	Platform 7 (S/B) High level of dust noted at this location.
160906/72	RD	Static - Jubilee Line	22/06/17	10:57	15:23	2.2	585.2	1.06	Platform 10 (W/B) High level of dust noted at this location.
160906/73	RD	Static - Ticket Hall	22/06/17	11:14	15:35	2.2	574.2	0.09	Madam Tussaud's Exit)
160906/74	RD	Static -Ticket Hall	22/06/17	11:26	15:38	2.2	554.4	0.06	Gate Line - Exit by Platform 6
160906/75	RD	Personal – Mr Soph Zanos	22/06/17	11:17	15:39	2.2	576.4	0.16	Personal monitoring carried out on LU Station staff during their job routine.

Table 12. 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^{N} (mg/m^3)	Locations & Comments
160906/76	RD	Static – Gate Line	23/06/17	09:09	13:09	2.2	528	0.41	Entry from London Road
160906/77	RD	Static – Bakerloo Line	23/06/17	09:17	13:17	2.2	528	0.07	Platform 4 Slight levels of dust noted by 4RS staff at the time of sampling.
160906/78	RD	Static – Bakerloo Line	23/06/17	09:21	13:21	2.2	528	0.20	Platform 4 Slight levels of dust noted by 4RS staff at the time of sampling.
160906/79	RD	Static – Northern Line	23/06/17	09:18	13:24	2.2	541.2	0.50	S/B Platform Slight levels of dust noted by 4RS staff at the time of sampling.
160906/80	RD	Static – Ticket Hall	23/06/17	09:35	13:35	2.2	528	0.12	Entry to Northern Line
160906/81	RD	Static Northern Line	23/06/17	09:25	13:27	2.2	532.4	0.29	N/B Platform Slight levels of dust noted by 4RS staff at the time of sampling.

*Note: Only static monitoring could be carried out as LU Station Staff shifts frequently changing at short periods of time; therefore not allowing for a larger sampling session for more accurate results.

Table 13. 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^{N} (mg/m^3)	Locations & Comments
160906/82	RD	Static – Hammersmith, Circle & Metropolitan Lines	26/06/17	11:56	16:03	2.2	543.4	0.33	Platform 2 – E/B Slight levels of dust noted at this location.
160906/83	RD	Static – Hammersmith, Circle & Metropolitan Lines	26/06/17	11:59	16:00	2.2	530.2	0.43	Platform 1 – W/B Slight levels of dust noted at this location.
160906/84	RD	Static - Ticket Hall	26/06/17	11:50	15:51	2.2	530.2	0.06	Warren Street Exit. No visible dust levels noted at this location.
160906/85	RD	Static – Ticket Hall	26/06/17	11:46	15:46	2.2	528	0.24	Euston Road Exit No visible dust levels noted at this location.

*Note: Only static monitoring was carried out as the Ticket Hall areas are located near the surface; therefore exposure to high levels of tunnel dust would be unlikely.

Table 14. 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^{N} (mg/m^3)	Locations & Comments
160906/86	RD	Static - Northern Line	27/06/17	10:35	14:37	2.2	532.4	0.98	N/B Platform 1 Moderate dust levels noted throughout the sampling session.
160906/87	RD	Static - Northern Line -	27/06/17	10:44	14:44	2.2	528	0.89	N/B Platform 1 Moderate dust levels noted throughout the sampling session.
160906/88	RD	Personal – Mr Kay Mandaviya	27/06/17	10:32	14:32	2.2	528	0.25	Ticket Hall/ LU Gate Line Staff Slight dust levels visible.

Table 15. 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^{N} (mg/m^3)	Locations & Comments
160906/89	RD	Static – Victoria Line S/B	28/06/17	11:14	15:14	2.2	528	0.71	Moderate levels of dust noted at these locations throughout the duration of sampling session.
160906/90	RD	Static – Piccadilly Line W/B	28/06/17	11:22	15:22	2.2	528	0.86	
160906/91	RD	Static – Northern Line S/B	28/06/17	11:24	15:34	2.2	550	0.52	
160906/92	RD	Static – Northern Line N/B	28/06/17	11:29	15:31	2.2	532.4	0.44	
160906/93	RD	Personal – Mr Aaron – Gate Line LU staff at Victoria Entrance	28/06/17	11:05	15:05	2.2	528	<0.02	The results are indicative only as the air sampler was found defective (On/ Off).
160906/94	RD	Static – Western Gate Line	28/06/17	11:41	15:42	2.2	530.2	0.12	No visible levels of dust noted at this location throughout the duration of sampling session.
160906/95	RD	Static – Piccadilly Line E/B	28/06/17	11:27	15:27	2.2	528	0.50	Moderate levels of dust noted at this location throughout the duration of sampling session.
160906/96*	RD	Personal – Mrs Iris – North Gate Line LU Staff*	28/06/17	11:08	-	-	-	-	The results couldn't be reported as the air sampler was found non-functional due to technical issues.
160906/97	RD	Static – Victoria Line – N/B	28/06/17	11:05	15:05	2.2	528	0.30	Moderate levels of dust noted at this location throughout the duration of sampling session.
160906/98	RD	Static – SSLs Platform 1	28/06/17	11:22	15:47	2.2	539	0.25	Slight levels of dust noted at these locations throughout the duration of sampling session.
160906/99	RD	Static – SSLs Platform 2	28/06/17	11:15	15:45	2.2	594	0.02	

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

Table 16. 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^{N} (mg/m^3)	Locations & Comments
160906/100	RD	Static – Victoria Line N/B	29/06/17	09:47	13:47	2.2	528	1.01	High levels of dust noted at these locations throughout the duration of sampling session.
160906/101	RD	Static – Bakerloo Line N/B	29/06/17	09:50	13:50	2.2	528	1.12	
160906/102	RD	Static – Central Line – W/B	29/06/17	09:40	13:40	2.2	528	1.07	
160906/103	RD	Static – Victoria Line –S/B	29/06/17	09:56	13:56	2.2	528	0.87	
160906/104	RD	Static – Bakerloo Line – S/B	29/06/17	10:00	14:00	2.2	528	1.05	
160906/105	RD	Static – Ticket Hall – Argyal Entrance	29/06/17	09:29	14:03	2.2	602.8	0.48	Slight levels of dust noted at this location throughout the duration of sampling session.
160906/106	RD	Static -Central Line – E/B	29/06/17	09:38	13:38	2.2	528	1.10	High levels of dust noted at this location throughout the duration of sampling session.
160906/107	RD	Static – Ticket Hall – Ball Ring Entrance	29/06/17	09:24	14:06	2.2	620.4	0.21	Slight levels of dust noted at this location throughout the duration of sampling session.

*Note: Only static monitoring could be carried out as LU Station Staff shifts frequently changing at short periods of time; therefore not allowing for a larger sampling session for more accurate results.

Table 17. 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^{N} (mg/m^3)	Locations & Comments
160906/108	RD	Static – Bakerloo Line S/B	30/06/17	11:50	15:44	2.2	514.8	1.33	High levels of dust noted at these locations throughout the duration of sampling session.
160906/109	RD	Static – Bakerloo Line N/B	30/06/17	11:44	15:38	2.2	514.8	1.37	
160906/110	RD	Static – District Line W/B	30/06/17	12:06	15:58	2.2	510.4	0.13	Slight levels of dust noted at these locations throughout the duration of sampling session.
160906/111	RD	Static – District Line E/B	30/06/17	12:10	16:00	2.2	506	0.22	
172041/32	RD	Static – Gate Line to Bakerloo Line	30/06/17	11:35	15:35	2.2	528	0.51	Slight levels of dust noted at these locations throughout the duration of sampling session.
172041/33	RD	Static – Gate Line to District Line	30/06/17	11:58	15:49	2.2	508.2	0.61	

Table 18. 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^{N} (mg/m^3)	Locations & Comments
160906/112	RD	Static – Bakerloo Line S/B (Head Wall)	03/07/17	11:37	15:37	2.2	528	0.94	High levels of dust noted at these locations throughout the duration of sampling session.
160906/113	RD	Static – Piccadilly Line E/B	03/07/17	11:31	15:31	2.2	528	0.53	
160906/114	RD	Static – Piccadilly Line /B	03/07/17	11:27	15:27	2.2	528	0.92	
160906/115	RD	Static - Northern Line	03/07/17	11:33	15:33	2.2	528	1.02	
160906/116	RD	Static - Northern & Central Gate Lines	03/07/17	11:23	15:23	2.2	528	0.20	Slight levels of dust noted at this location throughout the duration of sampling

Table 19. 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^{N} (mg/m^3)	Locations & Comments
160906/123	RD	Static – Ticket Hall/ Gate Line	05/07/17	11:36	15:48	2.2	554.4	0.90	High levels of dust noted at these locations throughout the duration of sampling session.
160906/124	RD	Static – Victoria Line N/B	05/07/17	11:41	15:42	2.2	530.2	0.77	
160906/125	RD	Static – Victoria Line S/B	05/07/17	11:45	15:45	2.2	528	Negative value	-

*Due to negative weight obtained when correcting for field blank, the actual dust concentration could not be calculated.

Table 20. 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^{N} (mg/m^3)	Locations & Comments
160906/117	RD	Static – Northern Line N/B	07/07/17	10:37	14:43	2.2	541.2	0.63	General dust conditions at these locations were noted as being moderate throughout the duration of sampling session.
160906/118	RD	Static – Northern Line N/B	07/07/17	10:41	14:46	2.2	539	0.82	
160906/119	RD	Static – Central Line E/B	07/07/17	10:48	14:50	2.2	532.4	1.39	
160906/120	RD	Static – Central Line W/B	07/07/17	10:54	14:55	2.2	532.4	0.97	
160906/121	RD	Static – Main Ticket Hall	07/07/17	11:02	15:02	2.2	528	0.16	Slight levels of dust noted at this location throughout the duration of sampling session.
160906/122	RD	Mrs Rosie Begum	07/07/17	11:05	15:08	2.2	534.6	0.24	LU Station Staff carrying out station duties.

Table 21. 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^{N} (mg/m^3)	Locations & Comments
160906/126	RD	Static - Main Ticket Hall	06/07/17	10:26	14:29	2.2	Negative value		Slight levels of dust noted at this location throughout the duration of sampling session.
160906/127	RD	Static - Waterloo & City Line – Departures	06/07/17	10:31	14:32	2.2	530.2	0.14	General dust conditions at these locations were noted as being slight to moderate throughout the duration of sampling session.
160906/128	RD	Static - Waterloo & City Line – Arrivals	06/07/17	10:36	14:37	2.2	530.2	0.70	
160906/129	RD	Static – Bakerloo Line S/B	06/07/17	10:41	14:42	2.2	530.2	0.72	Moderate levels of dust noted at these locations throughout the duration of sampling session.
160906/130	RD	Static – Bakerloo Line N/B	06/07/17	10:45	14:45	2.2	528	0.62	
160906/131	RD	Static – Northern Line S/B	06/07/17	10:49	14:49	2.2	528	0.77	Moderate levels of dust noted at these locations throughout the duration of sampling session.
160906/132	RD	Static – Northern Line N/B	06/07/17	10:52	14:33	2.2	468.2	0.82	
160906/133	RD	Static – Jubilee Line W/B	06/07/17	11:00	15:01	2.2	530.2	0.55	Moderate levels of dust noted at these locations throughout the duration of sampling session.
160906/134	RD	Static - Jubilee Line E/B	06/07/17	11:03	15:03	2.2	528	0.70	
160906/135	RD	Static - Gate Line – Jubilee Line	06/07/17	11:08	15:08	2.2	528	0.08	Slight levels of dust noted at this location throughout the duration of sampling

*Note: Only static monitoring could be carried out as LU Station Staff shifts frequently changing at short periods of time; therefore not allowing for a larger sampling session for more accurate results.

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^3)	Locations & Comments
160906/04	RD	District Line Train Operators Driving Trains	09/05/17	567.8	< 0.01	<0.02	Train 061: Earl's Court - Barking - Train 034 to Ealing Broadway - Earl's Court - Train 064 - Wimbledon - High Street Kensington - Edgware Road - Train 075 to Edgware Road
160906/09	RD	Piccadilly Line Train Operator Driving Trains	12/05/17	741.4	0.02	0.03	Train 326: Acton Town - Cockfosters - Northfields - Train 232 to Heathrow - Cockfosters - Acton Town
160906/15	RD	Jubilee Line Train Operator Driving Trains	17/05/17	536.8	< 0.01	<0.02	Train 303: Stratford - Stanmore - North Greenwich - Stanmore - Stratford.
160906/22	RD	Victoria Line Train Operators Driving Trains	22/05/17	532.4	< 0.01	<0.02	Train 242: Brixton - Walthamstow. Train 221 to Brixton. Train 245 to Walthamstow. Train 246 to Brixton. Train 241 to Walthamstow. Train 204 to Brixton.
160906/27	RD	Bakerloo Line Train Operators Driving Trains	25/05/17	550	< 0.01	<0.02	Train 227: elephant & Castle to Harrow & Wealdstone - Elephant & Castle. Train 240 to Harrow & Wealdstone - Elephant & Castle
160906/33	RD	Central Line Train Operator Driving Trains	30/05/17	536.8	< 0.01	<0.02	Train 011: West Ruislip to Epping - West Ruislip - Epping. Train 010 to Leytonstone
160906/40	RD	Northern Line Train Operator Driving Trains	02/06/17	528	< 0.01	<0.02	Train 111 Morden to High Barnet via Charring Cross - Kennington - High Barnet via Charing Cross - Morden via Bank.
160906/46	RD	Circle Line Train Operator Driving Trains	07/06/17	695.2	< 0.01	0.01	Train 210: Edgware Road - Hammersmith - Moorgate - Edgware Road via Paddington. Train 203 to Moorgate - Hammersmith - Edgware Road.

Table 24. Train Operator PM 2.5 Iron and Zinc Monitoring

Filter Number	Sample Type (Respirable Dust, RD, Inhalable Dust, ID)	Sample Location – Process Monitored	Date	Volume of air (litres)	Iron (mg/filter)	Zinc (mg/filter)	Iron conc. (mg/m^3)	zinc conc. (mg/m^3)	Locations & Comments
160906/06	PM 2.5	District Line Train Operators Driving Trains	10/05/17	941.5	0.017	Negative weight*	0.02	-	Train 061: Richmond - Barking - Train 034 to Ealing Broadway - Earl's Court - Train 050 to Ealing Broadway - Westminster
160906/12	PM 2.5	Piccadilly Line Train Operator Driving Trains	15/05/17	1148	0.10	Negative weight*	0.09	-	Train 231: Acton Town - Rayners Lane - Cockfosters - Acton Town - Train 260 to Heathrow T1, 2, 3 & 5 - Cockfosters
160906/18	PM 2.5	Jubilee Line Train Operator Driving Trains	18/05/17	1305.5	0.12	0.254	0.09	0.19	Train 314: Stratford - Willesden Green-North Greenwich-Stanmore-Stratford-Wembley Park. Train 311: to Stanmore - Stratford - Stanmore - West Ham.
160906/24	PM 2.5	Victoria Line Train Operators Driving Trains	23/05/17	1029	0.12	0.1	0.12	0.1	Train 214: Brixton - Walthamstow. Train 206 to Brixton. Train 211 to Walthamstow. Train 213 to Brixton. Train 237 to Walthamstow. Train 240 to Brixton. Train 212 to Walthamstow - Green Park.
160906/30	PM 2.5	Bakerloo Line Train Operators Driving Trains	26/05/17	1071	0.12	0.05	0.11	0.05	Train 210: Elephant & Castle to Queen's Park - Elephant & Castle. Train 227 to Queen's Park - Elephant & Castle. Train 242 to Harrow & Wealdstone
160906/36	PM 2.5	Central Line Train Operator Driving Trains	31/05/17	1312.5	0.07	Negative weight*	0.05	-	Train 017: West Ruislip to Epping - West Ruislip. Train 026 to Epping
160906/42	PM 2.5	Northern Line Train Operator Driving Trains	05/06/17	1088.5	0.10	0.223	0.09	0.2	Train 007: Morden to Edgware via Bank - Morden via Charring Cross. Train 010 to Golders Green via Bank. Train 020 to Edgware - Morden via Bank – Edgware.
16090648	PM 2.5	Hammersmith & City Line Train Operator Driving Trains	08/05/17	1043	0.02	0.03	0.02	0.03	Train 212: Edgware Road - Hammersmith - Edgware Road - Edgware Road via Liverpool Street. Train 200 to Hammersmith - Edgware Road

*Due to negative weight obtained when correcting for field blank, the actual metal concentrations could not be calculated. However, this usually indicates a minimal metal deposition

Table 25. Train Operator PM 2.5 Chromium and Copper Monitoring

Filter Number	Sample Type (Respirable Dust, RD, Inhalable Dust, ID)	Sample Location – Process Monitored	Date	Volume of air (litres)	Chromium (mg/filter)	Copper (mg/filter)	Chromium conc. (mg/m^3)	Copper conc. (mg/m^3)	Locations & Comments
160906/06	PM 2.5	District Line Train Operators Driving Trains	10/05/17	941.5	Negative weight*	<0.001	-	<0.001	Train 061: Richmond - Barking - Train 034 to Ealing Broadway - Earl's Court - Train 050 to Ealing Broadway - Westminster
160906/12	PM 2.5	Piccadilly Line Train Operator Driving Trains	15/05/17	1148	<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
160906/18	PM 2.5	Jubilee Line Train Operator Driving Trains	18/05/17	1305.5	<0.001	<0.001	<0.001	<0.001	Train 314: Stratford - Willesden Green-North Greenwich-Stanmore-Stratford-Wembley Park. Train 311: to Stanmore - Stratford - Stanmore - West Ham.
160906/24	PM 2.5	Victoria Line Train Operators Driving Trains	23/05/17	1029	<0.001	<0.001	<0.001	<0.001	Train 214: Brixton - Walthamstow. Train 206 to Brixton. Train 211 to Walthamstow. Train 213 to Brixton. Train 237 to Walthamstow. Train 240 to Brixton. Train 212 to Walthamstow - Green Park.
160906/30	PM 2.5	Bakerloo Line Train Operators Driving Trains	26/05/17	1071	<0.001	<0.001	<0.001	<0.001	Train 210: Elephant & Castle to Queen's Park - Elephant & Castle. Train 227 to Queen's Park - Elephant & Castle. Train 242 to Harrow & Wealdstone
160906/36	PM 2.5	Central Line Train Operator Driving Trains	31/05/17	1312.5	<0.001	<0.001	<0.001	<0.001	Train 017: West Ruislip to Epping - West Ruislip. Train 026 to Epping
160906/42	PM 2.5	Northern Line Train Operator Driving Trains	05/06/17	1088.5	<0.001	<0.001	<0.001	<0.001	Train 007: Morden to Edgware via Bank - Morden via Charring Cross. Train 010 to Golders Green via Bank. Train 020 to Edgware - Morden via Bank – Edgware.
16090648	PM 2.5	Hammersmith & City Line Train Operator Driving Trains	08/05/17	1043	<0.001	<0.001	<0.001	<0.001	Train 212: Edgware Road - Hammersmith - Edgware Road - Edgware Road via Liverpool Street. Train 200 to Hammersmith - Edgware Road

*Due to negative weight obtained when correcting for field blank, the actual metal concentrations could not be calculated. However, this usually indicates a minimal metal deposition

Table 26. Train Operator PM 2.5 Nickel and Manganese Monitoring

Filter Number	Sample Type (Respirable Dust, RD, Inhalable Dust, ID)	Sample Location – Process Monitored	Date	Volume of air (litres)	Nickel (mg/filter)	Manganese (mg/filter)	Nickel conc. (mg/m^3)	Manganese conc. (mg/m^3)	Locations & Comments
160906/06	PM 2.5	District Line Train Operators Driving Trains	10/05/17	941.5	<0.001	<0.001	<0.001	<0.001	Train 061: Richmond - Barking - Train 034 to Ealing Broadway - Earl's Court - Train 050 to Ealing Broadway - Westminster
160906/12	PM 2.5	Piccadilly Line Train Operator Driving Trains	15/05/17	1148	<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
160906/18	PM 2.5	Jubilee Line Train Operator Driving Trains	18/05/17	1305.5	<0.001	0.001	<0.001	0.001	Train 314: Stratford - Willesden Green-North Greenwich-Stanmore-Stratford-Wembley Park. Train 311: to Stanmore - Stratford - Stanmore - West Ham.
160906/24	PM 2.5	Victoria Line Train Operators Driving Trains	23/05/17	1029	<0.001	0.001	<0.001	0.001	Train 214: Brixton - Walthamstow. Train 206 to Brixton. Train 211 to Walthamstow. Train 213 to Brixton. Train 237 to Walthamstow. Train 240 to Brixton. Train 212 to Walthamstow - Green Park.
160906/30	PM 2.5	Bakerloo Line Train Operators Driving Trains	26/05/17	1071	<0.001	0.002	<0.001	0.002	Train 210: Elephant & Castle to Queen's Park - Elephant & Castle. Train 227 to Queen's Park - Elephant & Castle. Train 242 to Harrow & Wealdstone
160906/36	PM 2.5	Central Line Train Operator Driving Trains	31/05/17	1312.5	<0.001	<0.001	<0.001	<0.001	Train 017: West Ruislip to Epping - West Ruislip. Train 026 to Epping
160906/42	PM 2.5	Northern Line Train Operator Driving Trains	05/06/17	1088.5	<0.001	0.001	<0.001	0.001	Train 007: Morden to Edgware via Bank - Morden via Charring Cross. Train 010 to Golders Green via Bank. Train 020 to Edgware - Morden via Bank – Edgware.
16090648	PM 2.5	Hammersmith & City Line Train Operator Driving Trains	08/05/17	1043	<0.001	<0.001	<0.001	<0.001	Train 212: Edgware Road - Hammersmith - Edgware Road - Edgware Road via Liverpool Street. Train 200 to Hammersmith - Edgware Road

Figure 1. GRIMM monitor dust concentration data at the District line on the 10th May 2017

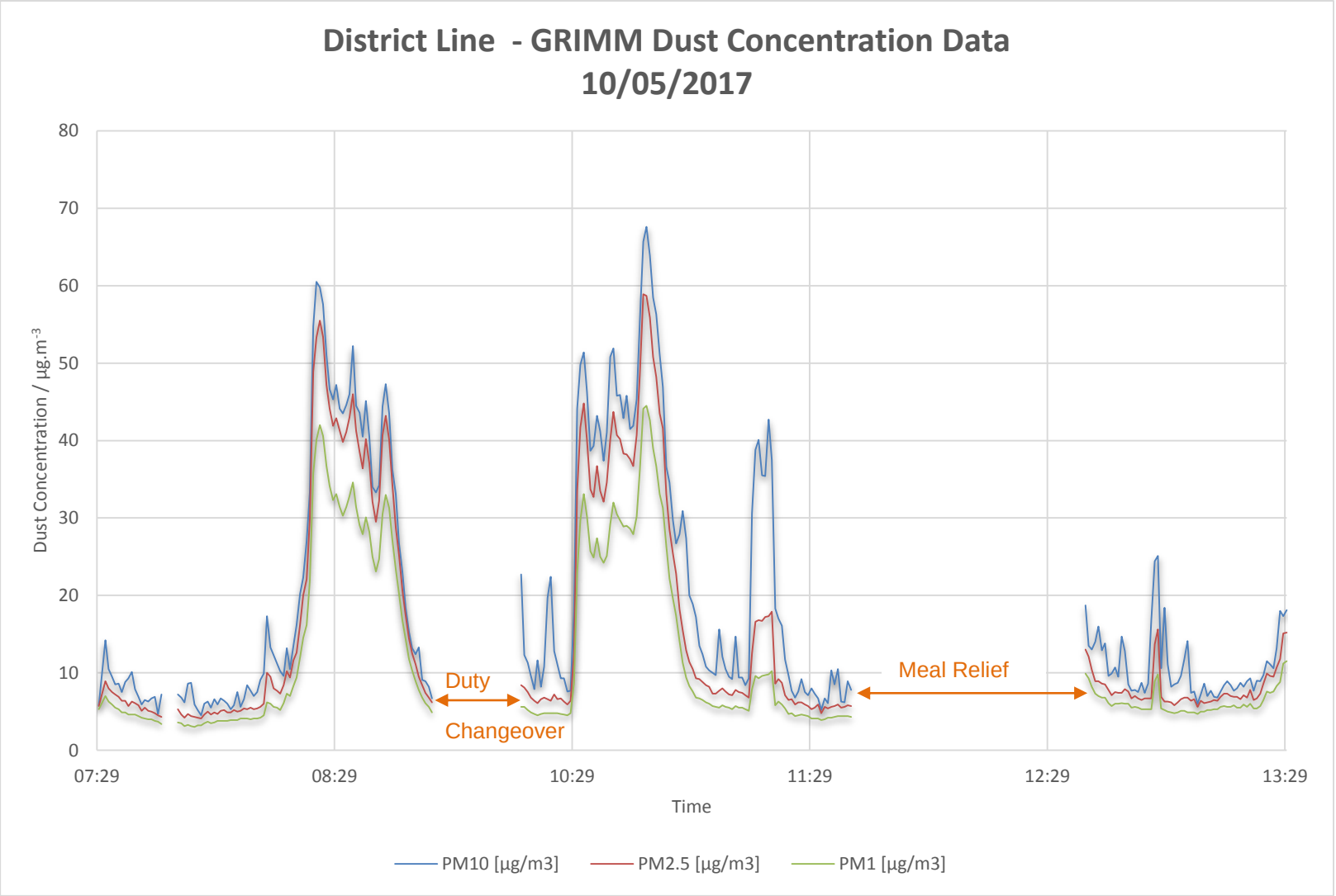

Figure 2. GRIMM monitor dust concentration data at the Piccadilly line on the 15th May 2017.

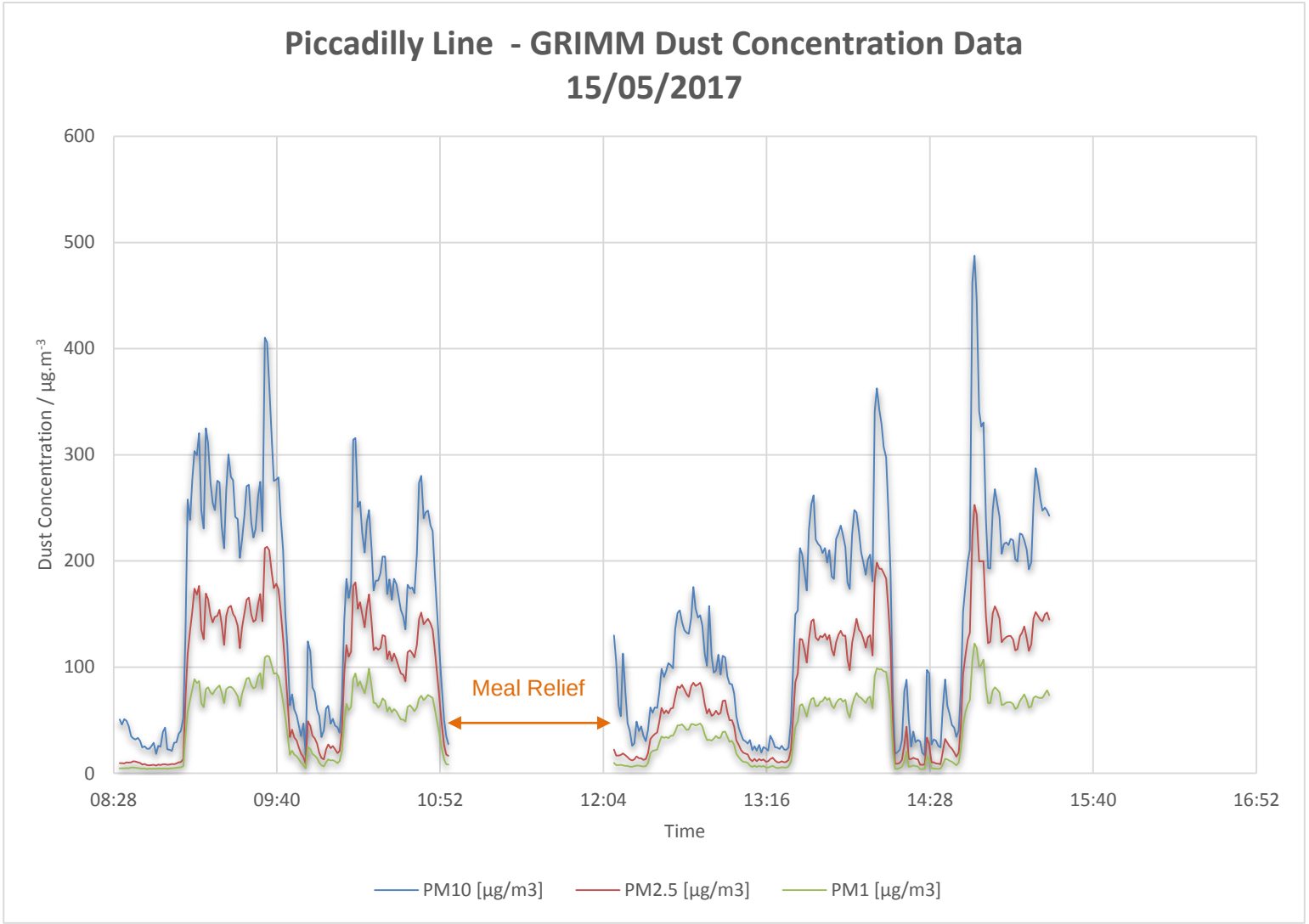

Figure 3. GRIMM monitor dust concentration data at the Jubilee line on the 18th May 2017.

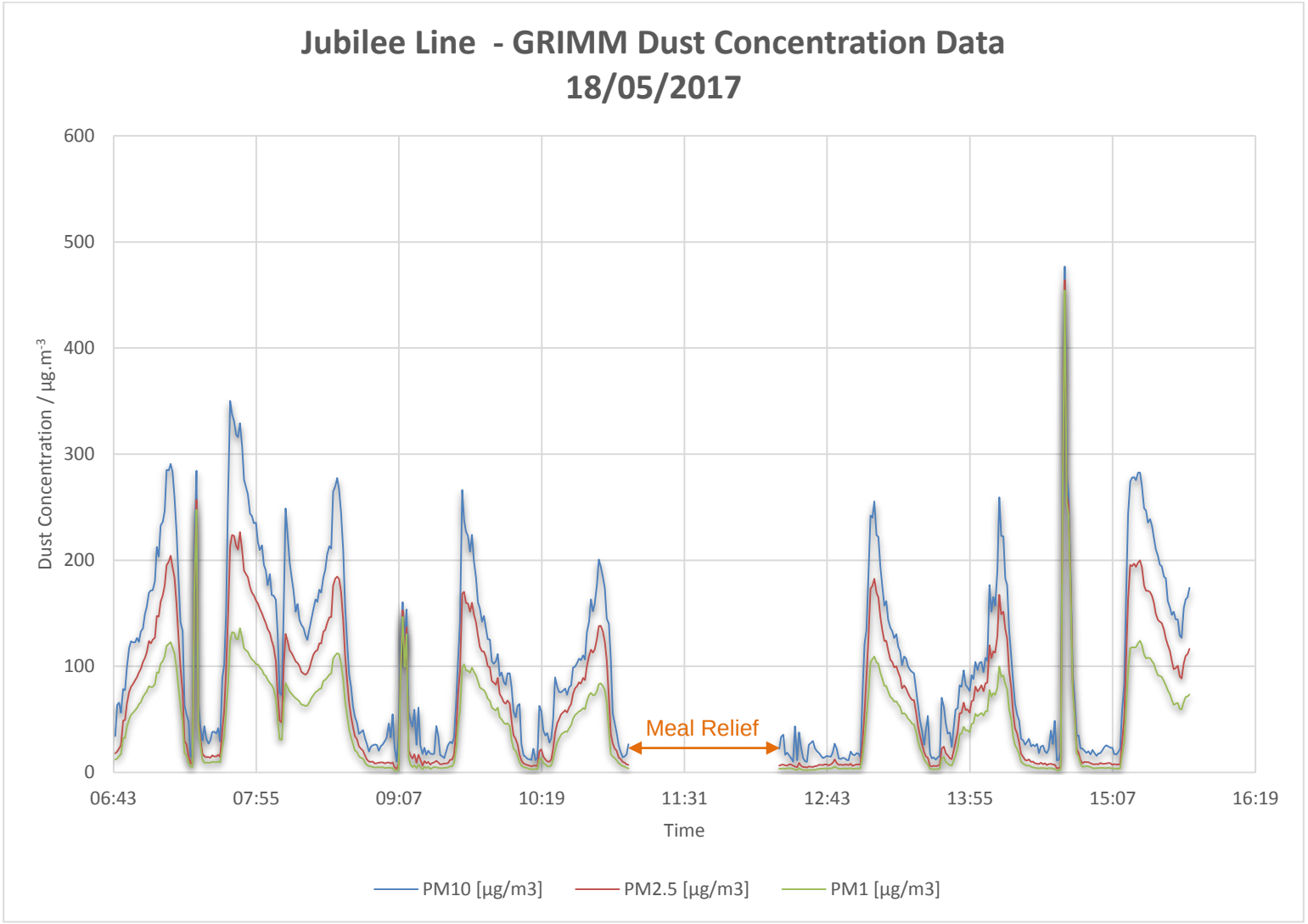

Figure 4. GRIMM monitor dust concentration data at the Victoria line on the 23rd May 2017.

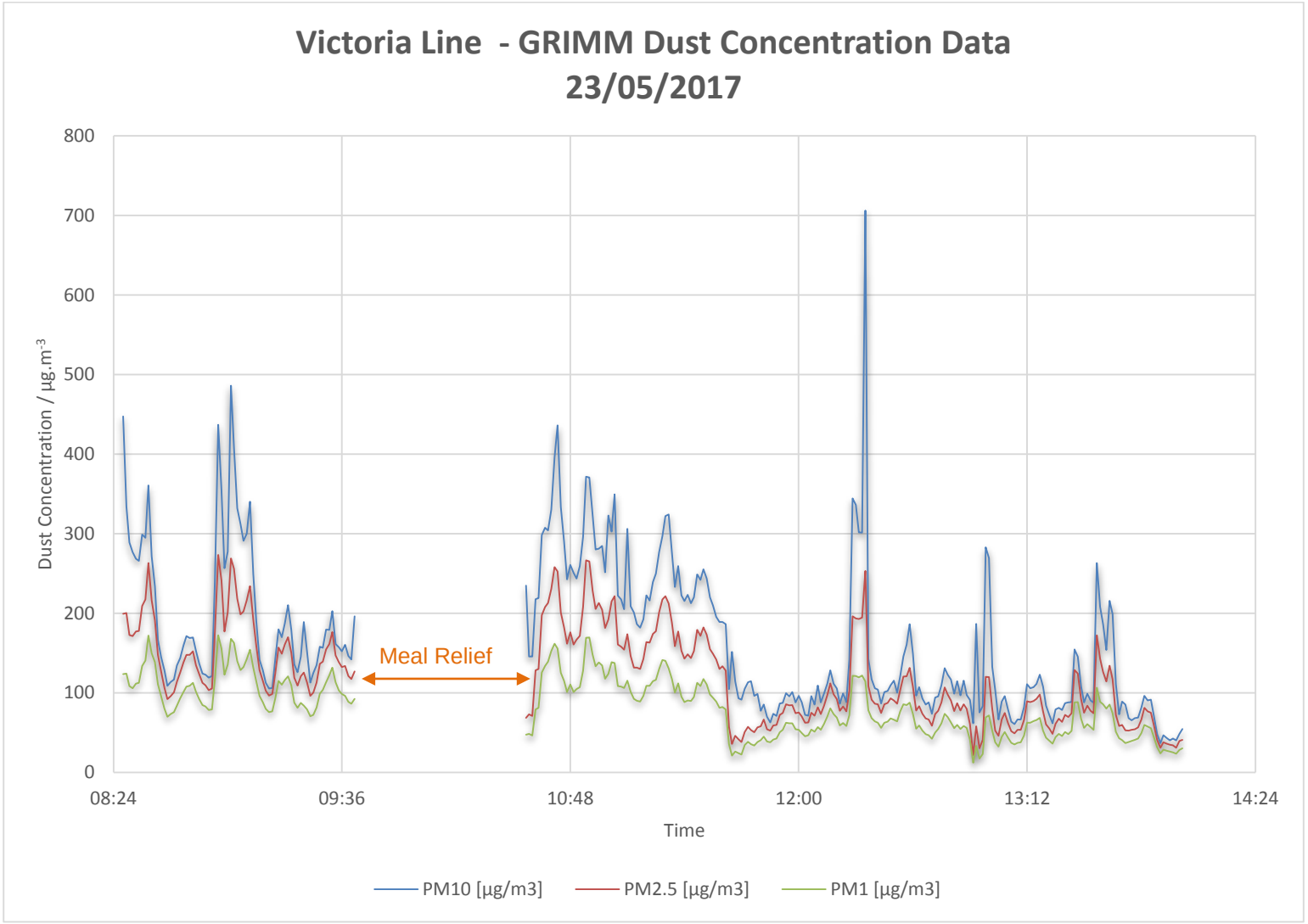

Figure 5. GRIMM monitor dust concentration data at the Bakerloo line on the 26th May 2017.

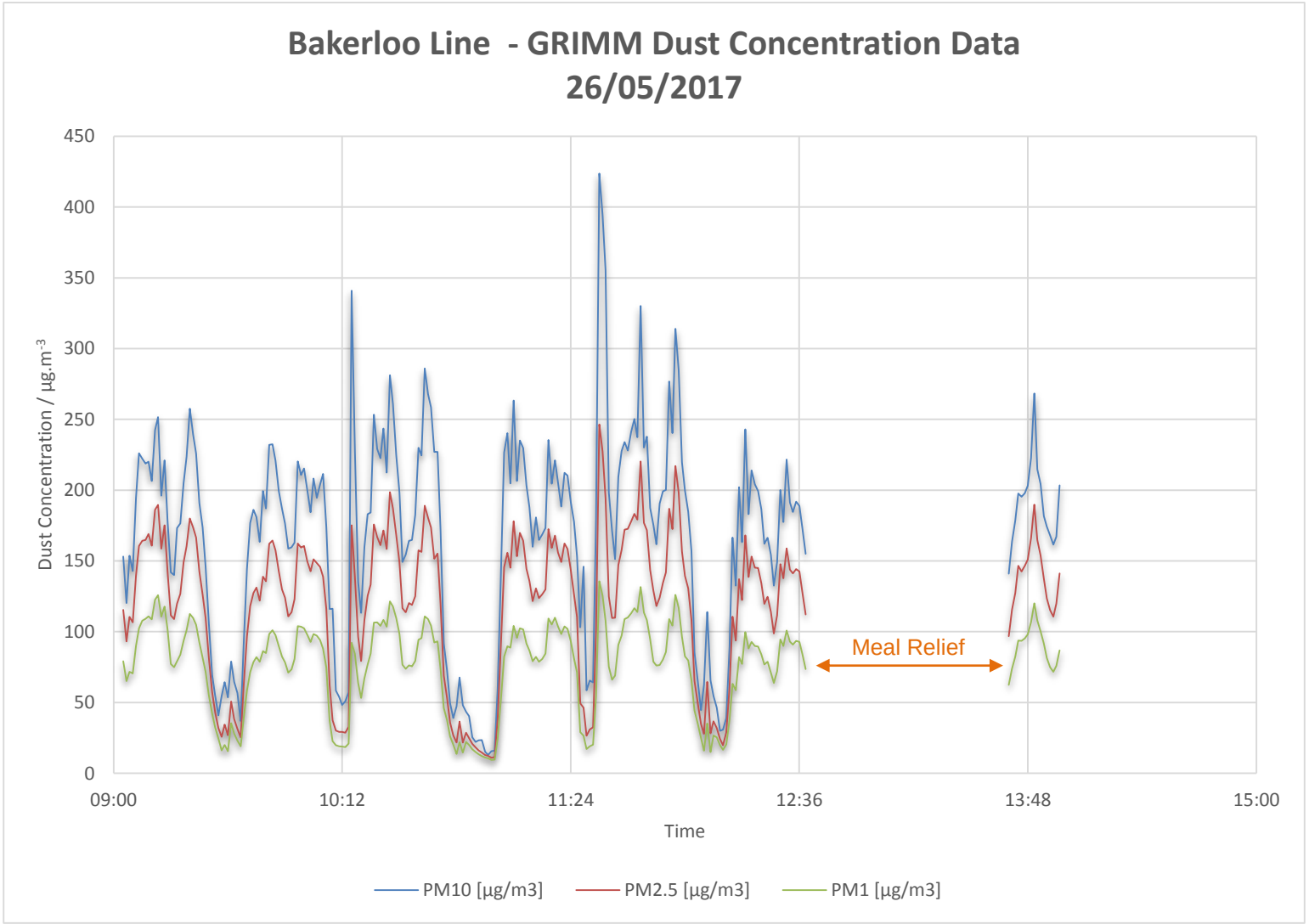

Figure 6. GRIMM monitor dust concentration data at the Central line on the 31st May 2017.

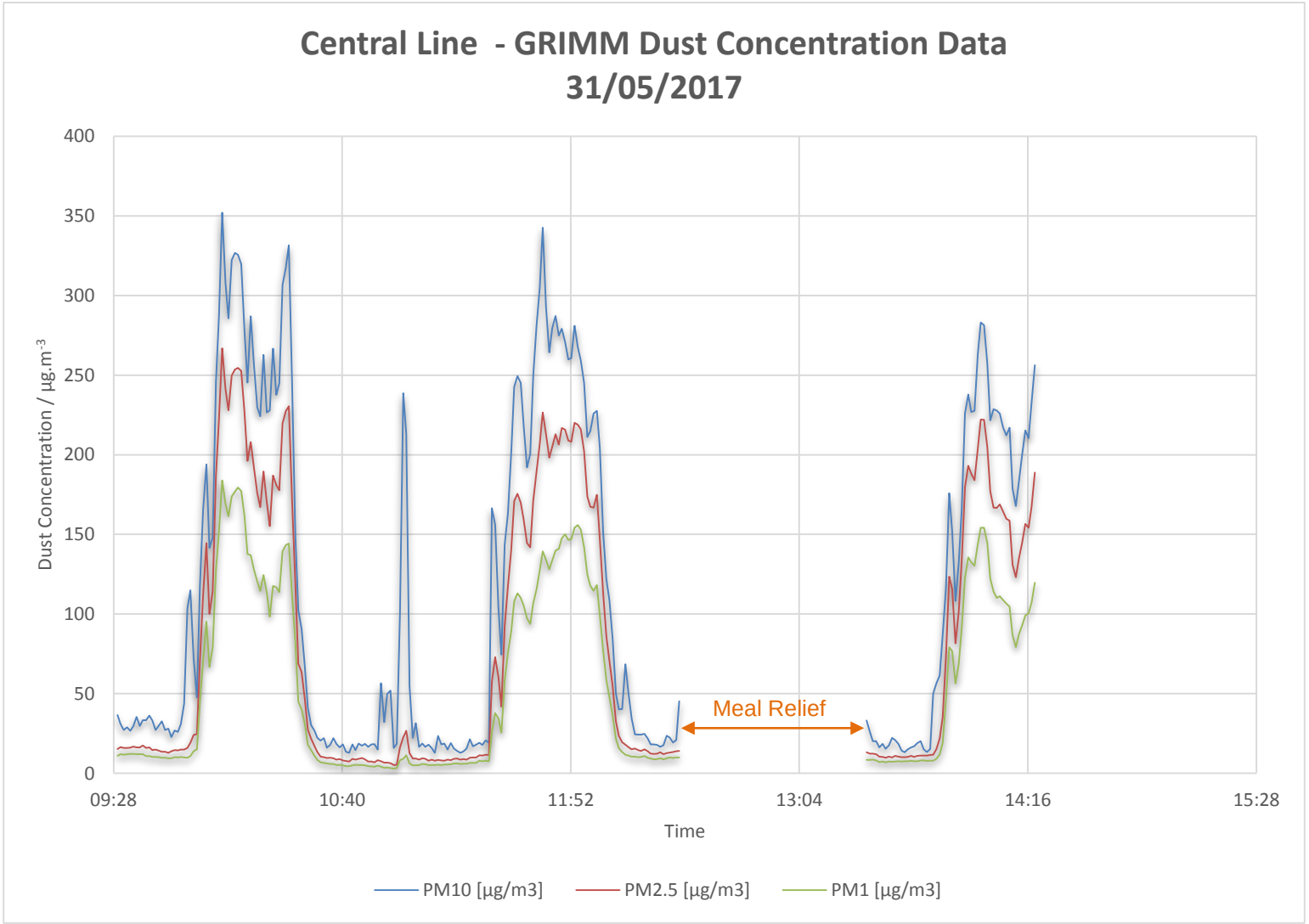

Figure 7. GRIMM monitor dust concentration data at the Northern line on the 5th June 2017.

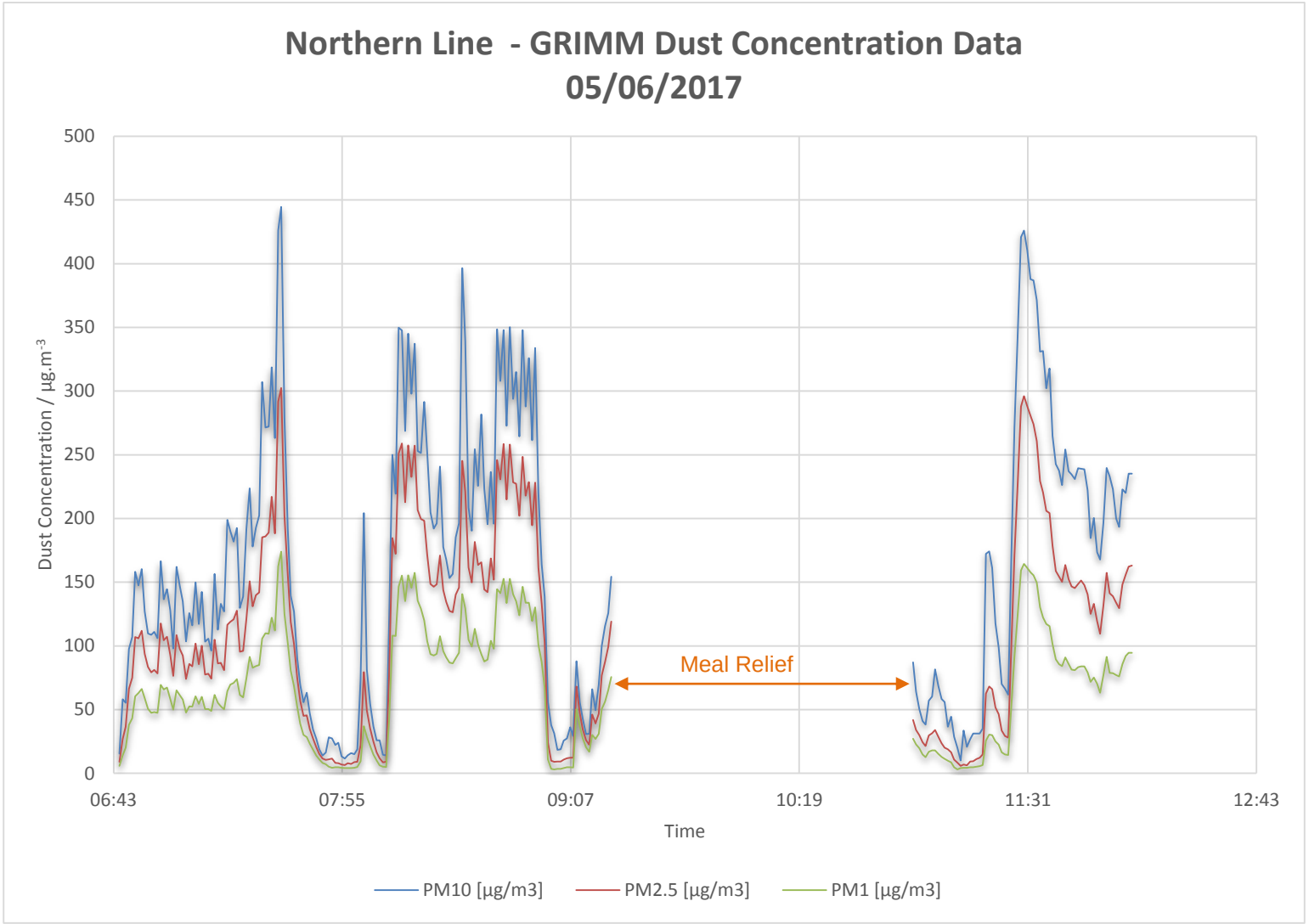

Figure 8. GRIMM monitor dust concentration data at the Hammersmith & City and Circle lines on the 8th June 2017.

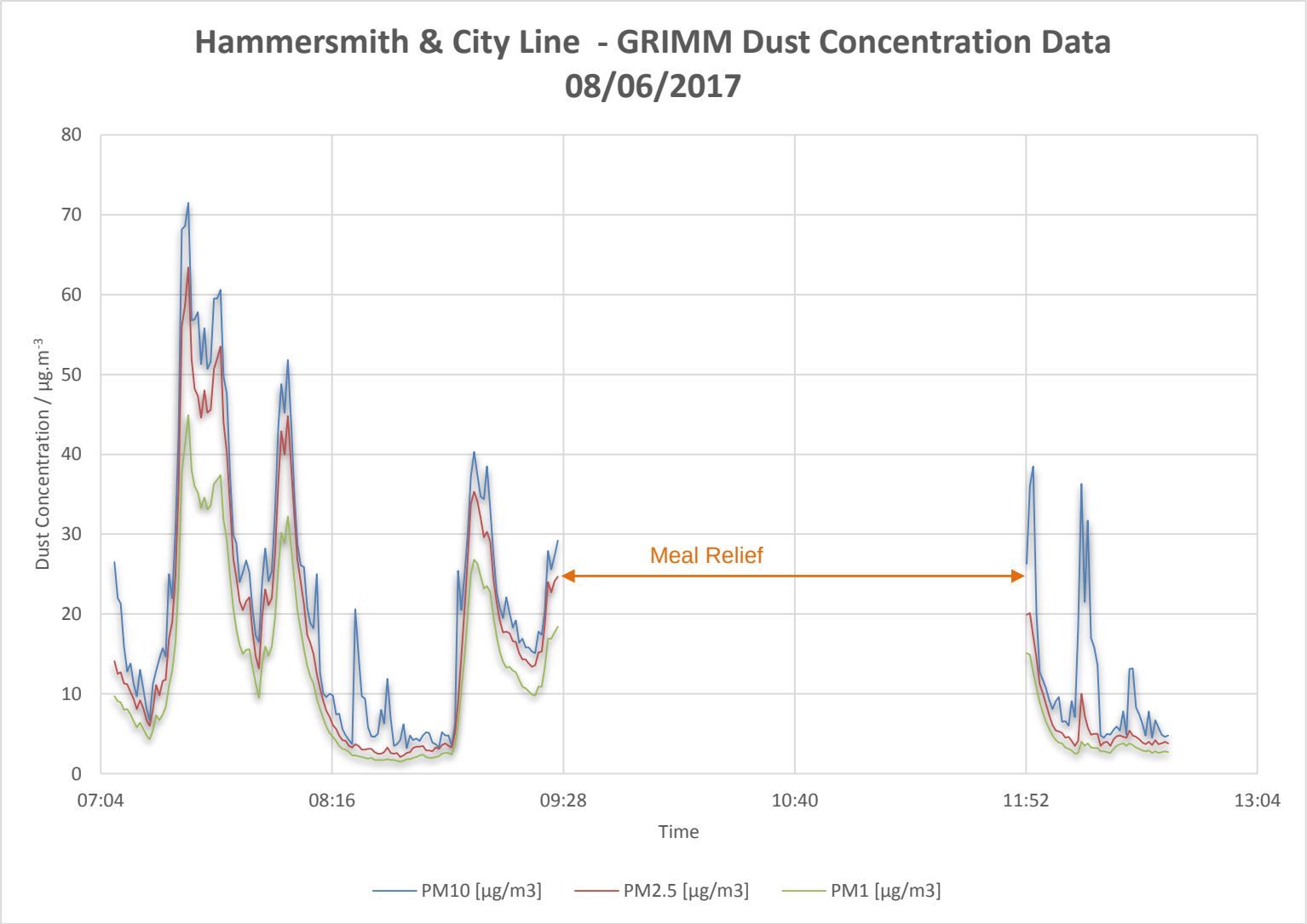

Figure 9. Cyclone Dust Head to monitor Respirable Dust.

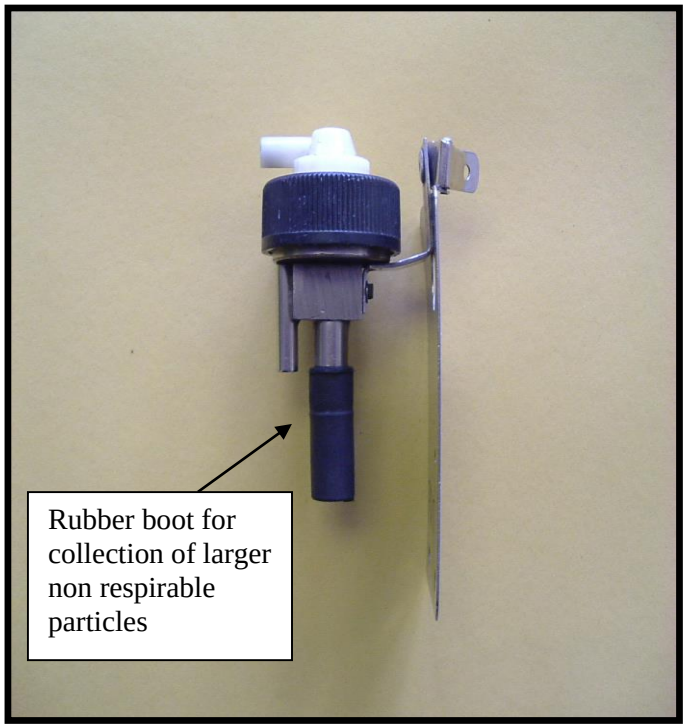

Figure 10. Cyclone Inhalable Sampler to monitor PM 2.5.

Appendix 1. Laboratory certificates for crystalline Respirable Silica results.

IOM
WORKING FOR A HEALTHIER FUTURE

CERTIFICATE OF ANALYSIS

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

CONTRACT NO: 53740

PROJECT NO: 610

DATE OF ISSUE: 20.06.17

DATE SAMPLES RECEIVED: 12.06.17

DATE SAMPLES ANALYSED: 16.06.17

SAMPLES: 25mm "GLA-5000" PVC filters

NO. OF SAMPLES: Ten

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
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Tel: 0131 449 8000 Fax: 0131 449 8084 Email: iom@iom-world.org
IOM CONSULTING LIMITED, registered in Scotland No. SC205670

UKAS TESTING
0374

CONTRACT NO: 53740
PROJECT NO: 610
DATE OF ISSUE: 20.06.17

RESULTS:

Sample Reference	Quartz Weight (mg)
160906/04	<0.01
160906/09	0.02
160906/15	<0.01
160906/22	<0.01
160906/33	<0.01
160906/B3	<0.01
160906/B5	<0.01
160906/B9	<0.01
160906/B15	<0.01
160906/B21	<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.

AUTHORISED BY:

S Clark
Mineralogy Section Manager

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WORKING FOR A HEALTHIER FUTURE

CERTIFICATE OF ANALYSIS

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

CONTRACT NO: 53827

PROJECT NO: 610

DATE OF ISSUE: 20.06.17

DATE SAMPLES RECEIVED: 16.06.17

DATE SAMPLES ANALYSED: 20.06.17

SAMPLES: 25mm PVC filters

NO. OF SAMPLES: Six

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.

Page 1 of 2

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IOM CONSULTING LIMITED, registered in Scotland No. SC205670

UKAS TESTING
0374

CONTRACT NO: 53827
PROJECT NO: 610
DATE OF ISSUE: 20.06.17

RESULTS:

Sample Reference	Quartz Weight (mg)
160906/27	<0.01
160906/40	<0.01
160906/46	<0.01
160906/B17	<0.01
160906/B25	<0.01
160906/B29	<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.

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Page 2 of 2

Appendix 2. Laboratory certificates for 2.5 µm metal results.

South East Water Scientific Services
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south east water
scientific services

ANALYTICAL REPORT

Page 1 of 1

4 Rail Services Ltd
Unit 11 Iron Bridge Close
Great Central Way
London
NW10 0UF

Certificate Number: 396101-1 Final

Order Number:

Task Number: 1342

Date Received: 13/06/2017

Date Reported: 15/06/2017

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165784	Description: 060906/06 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.36	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	17.19	µg/filter	*
		doc	Manganese	0.33	µg/filter	*
		doc	Nickel	0.15	µg/filter	*
		doc	Zinc	721.46	µg/filter	*

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south east water
scientific services

ANALYTICAL REPORT

4 Rail Services Ltd
Unit 11 Iron Bridge Close
Great Central Way
London
NW10 0UF

Certificate Number: 396106-1 Final

Order Number:

Task Number: 1342

Date Received: 13/06/2017

Date Reported: 15/06/2017

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165789	Description: 060906/B4 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.37	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	7.35	µg/filter	*
		doc	Manganese	<0.18	µg/filter	*
		doc	Nickel	<0.06	µg/filter	*
		doc	Zinc	786.68	µg/filter	*

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south east water
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ANALYTICAL REPORT

4 Rail Services Ltd
Unit 11 Iron Bridge Close
Great Central Way
London
NW10 0UF

Certificate Number: 396102-1 Final

Order Number:

Task Number: 1342

Date Received: 13/06/2017

Date Reported: 15/06/2017

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165785	Description: 060906/12 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.64	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	108.30	µg/filter	*
		doc	Manganese	1.25	µg/filter	*
		doc	Nickel	0.11	µg/filter	*
		doc	Zinc	868.58	µg/filter	*

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south east water
scientific services

ANALYTICAL REPORT

4 Rail Services Ltd
Unit 11 Iron Bridge Close
Great Central Way
London
NW10 0UF

Certificate Number: 396106-1 Final

Order Number:

Task Number: 1342

Date Received: 13/06/2017

Date Reported: 15/06/2017

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165789	Description: 060906/B4 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.37	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	7.35	µg/filter	*
		doc	Manganese	<0.18	µg/filter	*
		doc	Nickel	<0.06	µg/filter	*
		doc	Zinc	786.68	µg/filter	*

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scientific services

ANALYTICAL REPORT

4 Rail Services Ltd
Unit 11 Iron Bridge Close
Great Central Way
London
NW10 0UF

Certificate Number: 396103-1 Final

Order Number:

Task Number: 1342

Date Received: 13/06/2017

Date Reported: 15/06/2017

Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165786	Description: 060906/18 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.82	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	123.52	µg/filter	*
		doc	Manganese	1.33	µg/filter	*
		doc	Nickel	0.25	µg/filter	*
		doc	Zinc	845.06	µg/filter	*

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ANALYTICAL REPORT

4 Rail Services Ltd
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Certificate Number: 396108-1 Final

Order Number:

Task Number: 1342

Date Received: 13/06/2017

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165791	Description: 060906/B12 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.28	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	5.20	µg/filter	*
		doc	Manganese	<0.18	µg/filter	*
		doc	Nickel	0.08	µg/filter	*
		doc	Zinc	590.78	µg/filter	*

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ANALYTICAL REPORT

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Certificate Number: 396104-1 Final

Order Number:

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165787	Description: 060906/24 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.79	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	129.39	µg/filter	*
		doc	Manganese	1.31	µg/filter	*
		doc	Nickel	0.15	µg/filter	*
		doc	Zinc	991.74	µg/filter	*

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ANALYTICAL REPORT

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Certificate Number: 396109-1 Final

Order Number:

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165792	Description: 060906/B16 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.44	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	11.61	µg/filter	*
		doc	Manganese	<0.18	µg/filter	*
		doc	Nickel	0.07	µg/filter	*
		doc	Zinc	889.82	µg/filter	*

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ANALYTICAL REPORT

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Certificate Number: 397160-1 Final

Order Number: 27243

Task Number: 1342

Date Received: 16/06/2017

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2168862	Description: 160906/30 Sample Type: FILTER Received Date: 16-JUN-17 Sampling Date: 15-JUN-17	doc	Chromium	0.72	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	125.21	µg/filter	*
		doc	Manganese	1.53	µg/filter	*
		doc	Nickel	0.15	µg/filter	*
		doc	Zinc	728.78	µg/filter	*

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ANALYTICAL REPORT

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Certificate Number: 397163-1 Final

Order Number: 27243

Task Number: 1342

Date Received: 16/06/2017

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2168866	Description: 160906/B20 Sample Type: FILTER Received Date: 16-JUN-17 Sampling Date: 15-JUN-17	doc	Chromium	0.39	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	7.37	µg/filter	*
		doc	Manganese	<0.18	µg/filter	*
		doc	Nickel	<0.06	µg/filter	*
		doc	Zinc	674.42	µg/filter	*

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ANALYTICAL REPORT

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Certificate Number: 396105-1 Final

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165788	Description: 060906/36 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.59	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	82.13	µg/filter	*
		doc	Manganese	0.90	µg/filter	*
		doc	Nickel	0.12	µg/filter	*
		doc	Zinc	866.84	µg/filter	*

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2165793	Description: 060906/B24 Sample Type: FILTER Received Date: 13-JUN-17 Sampling Date: 06-JUN-17	doc	Chromium	0.44	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	8.18	µg/filter	*
		doc	Manganese	<0.18	µg/filter	*
		doc	Nickel	0.08	µg/filter	*
		doc	Zinc	890.96	µg/filter	*

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Certificate Number: 397161-1 Final

Order Number: 27243

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2168863	Description: 160906/42 Sample Type: FILTER Received Date: 16-JUN-17 Sampling Date: 15-JUN-17	doc	Chromium	0.66	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	101.07	µg/filter	*
		doc	Manganese	1.16	µg/filter	*
		doc	Nickel	<0.06	µg/filter	*
		doc	Zinc	827.56	µg/filter	*

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2168867	Description: 160906/B28 Sample Type: FILTER Received Date: 16-JUN-17 Sampling Date: 15-JUN-17	doc	Chromium	0.39	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	7.41	µg/filter	*
		doc	Manganese	<0.18	µg/filter	*
		doc	Nickel	<0.06	µg/filter	*
		doc	Zinc	605.06	µg/filter	*

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2168864	Description: 160906/48 Sample Type: FILTER Received Date: 16-JUN-17 Sampling Date: 15-JUN-17	doc	Chromium	0.44	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	24.50	µg/filter	*
		doc	Manganese	0.31	µg/filter	*
		doc	Nickel	<0.06	µg/filter	*
		doc	Zinc	789.90	µg/filter	*

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Lab Ref.	Sample Details	Method	Test	Result	Units	Flag
2168869	Description: 160906/B32 Sample Type: FILTER Received Date: 16-JUN-17 Sampling Date: 15-JUN-17	doc	Chromium	0.40	µg/filter	*
		doc	Copper	<0.80	µg/filter	*
		doc	Iron	6.83	µg/filter	*
		doc	Manganese	<0.18	µg/filter	*
		doc	Nickel	<0.06	µg/filter	*
		doc	Zinc	760.40	µg/filter	*

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